Wireless World

March 1970 3s 6d

London's new colour TV centres

Constructional articles

Ultra-low distortion amplifier

80-metre s.s.b. receiver

Wireless World

Electronics, Television, Radio, Audio

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This month's cover illustrates a fish-eye view of the master control room at the new London headquarters of Thames Television; one of three new colour television centres in the capital (see p.104).

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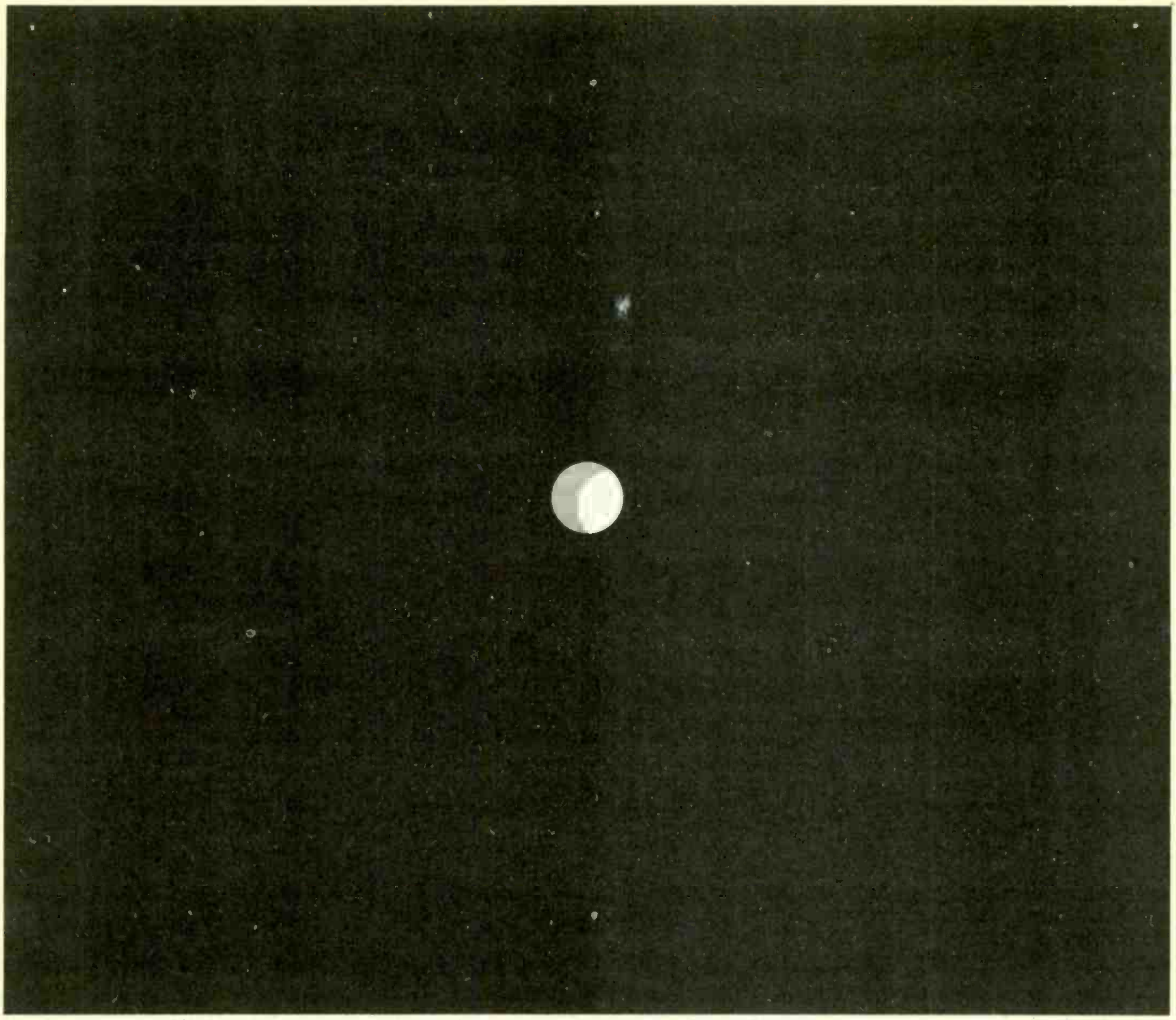


Wireless World

Government and industrial research

"The use a nation makes of its skilled manpower . . . profoundly affects the kind of society in which we live. . . . Despite heavy national spending on research and development in Britain we have not profited fully from this investment, for our rate of economic growth has been running at a lower level than that of many of our competitors." This is how the Minister of Technology opens his foreword to a recently published Green Paper ("Industrial Research and Development in Government Laboratories") which outlines a Government proposal to set up a new Corporation, outside the Civil Service, to run civil research and development laboratories of the Atomic Energy Authority and of the Ministry of Technology under a single management. The Minister concluded his foreword by saying that the 20-page Green Paper is published to provide a basis "for wide public debate before decisions are taken by the Government".

The proposed new body would be a statutory corporation possibly called the British Research and Development Corporation the aims and functions of which would be:

(i) to encourage and support the development and application of innovation and technological improvement in industry for the benefit of the U.K. economy; and to carry out research and development for this purpose, both itself and in collaboration with industry and on repayment;

(ii) to carry out research programmes necessary in the public interest, including basic research, and other specific programmes of work required by Government departments and other public authorities; and

(iii) to exploit where appropriate innovations resulting from Government-financed programmes carried out by other agencies.

It will be recalled that the Department of Scientific & Industrial Research formed in 1916, fulfilled a similar function to that envisaged for the new Corporation. It was, to some extent, due to the initiative of the D.S.I.R. that a scheme was launched for co-operative industrial research associations (of which there are now 43).

The fragmentation and "lack of the driving force of a common management orientated to the requirement of its customers" is put forward as the weakness of the present Government-financed research laboratories and the *raison d'être* for setting up the B.R.D.C.

The organizations which would come under the direct management of the B.R.D.C. include five Mintech industrial research establishments (among them the National Physical Laboratory, and the National Engineering Laboratory), the A.E.A's research and reactor groups, and the National Research Development Corporation. In all they employ nearly 5,000.

It is proposed that, while the cost of "basic research, advisory services and statutory work" might be met by a Government grant-in-aid, specific projects for Government departments would be charged at full cost. This contractural relationship could and should have a marked effect on the attitude of both the supplier and the customer. In addition the corporation would be free to undertake on its own initiative work on which it expected to recover its costs. Having said that, however, one sees the dead hand of bureaucracy falling upon the proposed organization in the phrase "It would however be required to operate within the general framework of the Government's industrial policies".

No mention is made in the list of establishments coming under the jurisdiction of the B.R.D.C. of such places as R.R.E. Malvern, where so much valuable research in our particular field has been done. The Royal Aircraft Establishment, Farnborough, is mentioned but only to record that the "aerospace establishments of which R.A.E. is the largest", are being reduced in size, are inextricably part of the Ministry's defence procurement organization and that no change in this relationship is proposed.

When we consider the number of Government-sponsored projects which have been still-born because of bureaucratic bungling we are not enamoured of the idea of still greater Government control. There is a certain type of person who finds his spiritual home in the Civil Service type organizations (e.g. the Post Office and the B.B.C.) and another type who thrives on the cut-and-thrust of industry and commerce. Both have their qualities, but to provide the "driving force" for the B.R.D.C. mentioned above surely the second type of person is needed more than the first. The question is whether a new corporation set up by a government will be able to stand sufficiently far away from the Civil Service to prevent a wholesale transmigration of souls.

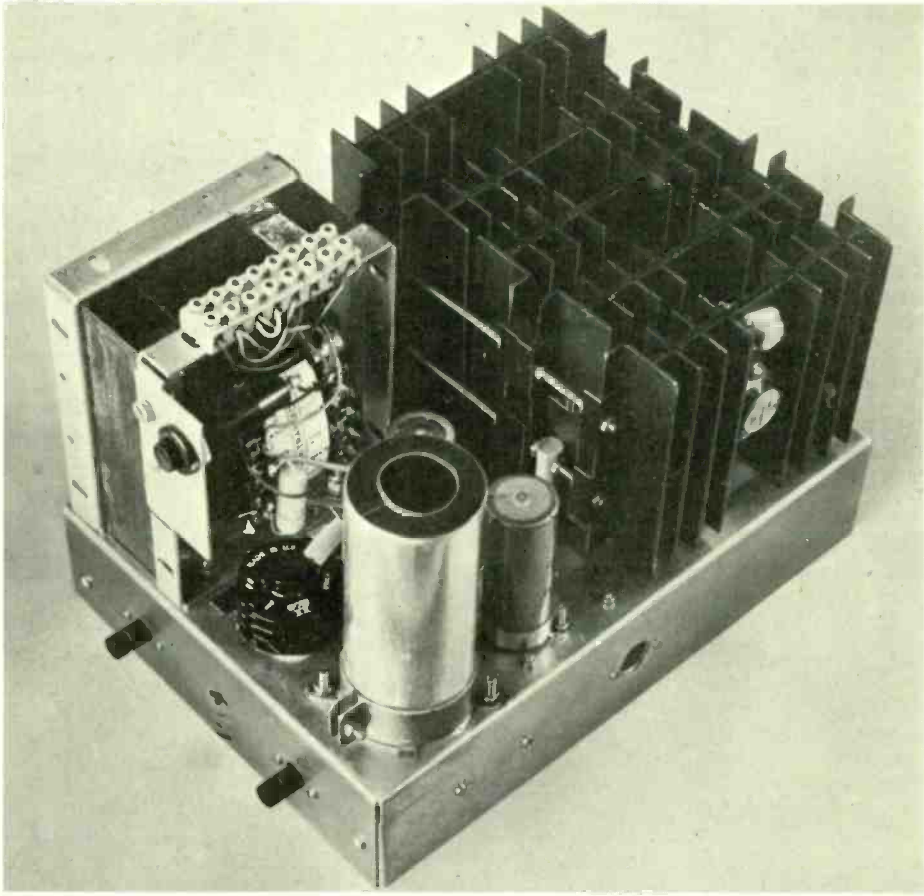
Ultra-low Distortion Class-A Amplifier

A design using feedback to control the gain and the levels of voltage and current in the output stage

by L. Nelson-Jones, M.I.E.R.E.

There is in the design to be described nothing very revolutionary, but rather an attempt to get a little nearer to perfection, in the power amplifier section of an audio system. Like Mr. Linsley Hood,[1] the author has long felt that the slight extra cost and power consumption that class A implies, is well worth while, and that its advantages are not as marginal as has often been supposed.

The most often quoted advantage of class-A operation is the elimination of cross-over distortion, but there are other factors other than this which give rise to distortion in a class-B stage, especially at the upper frequency limit of the audio range, among them hole storage and inequality of high frequency performance of the two halves of the output stage.



Circuit design

The perfect power amplifier will convert its input signal to a higher power level, which is an exact replica of the input. It will have zero output impedance, but will not be damaged by a short circuit of its output terminals. It will have a flat gain-frequency response over the whole of the audio band, but will not respond to frequencies greatly outside this band. It will give its full rated power over the whole audio band. It should preferably drive capacitive loads, so that it may be used with an electrostatic speaker. It should be driven from a signal source whose bandwidth does not exceed that of the power amplifier, so that on transients in particular the power amplifier is not required to produce an output in excess of its capabilities.

No mention has been made of the input impedance of such an amplifier, this is because whilst some prefer a voltage input (high impedance), others prefer a current input (low impedance), and there is in any case no magic in this aspect. The degree of input impedance only decides the design of the output stage of the pre-amplifier, and to some extent alters the problems of stray couplings in the leads between these two sections. With low impedance, hum pick-up is most likely to be due to magnetic induction in the wiring, whilst with high impedance, it will more likely be due to electrostatic causes. The author's preference is for a high input impedance, mainly because he has more experience with such circuits, and in addition most signal sources and test equipment are rated for voltage output rather than current.

Now to the actual design, and firstly to underline what J. L. Linsley Hood said in a recent article[1] – "... the basic linearity of the amplifier should be good, even in the absence of feedback" so that the feedback is used to obtain the desirable attributes of a good amplifier and not to overcome the shortcomings of a poor design.

Output stage

The use of the simplest circuit is very desirable, if only because it reduces the number of components which can cause phase shift at the higher frequencies, with consequent difficulty in stabilization of the overall loop. In this respect Linsley Hood's circuit[1] is excellent, but the author has found that despite its good performance, the need to select the resistors in certain parts of this amplifier and its reliance on the stability of current gain of the output transistors to set the operating current, went very much "against the grain" after years of designing equipment for production runs.

In order to get a more acceptable overall loop gain, it was decided to use transistor pairs for both halves of the output stage, with the result that higher values of resistor may be used in the driver stage. Fig. 1 illustrates three possible output stages considered. Fig. 1(a) uses complementary transistors and is truly symmetrical, but is not as efficient as that of (b) which has a lower saturation voltage for each half as well as local feedback through the common emitter resistor of the first pair of transistors. Fig. 1(c), is the commonly used quasi-complementary type of output stage, which is in effect one half of Fig. 1(a), together with half of Fig. 1(b). Using this arrangement it is necessary for

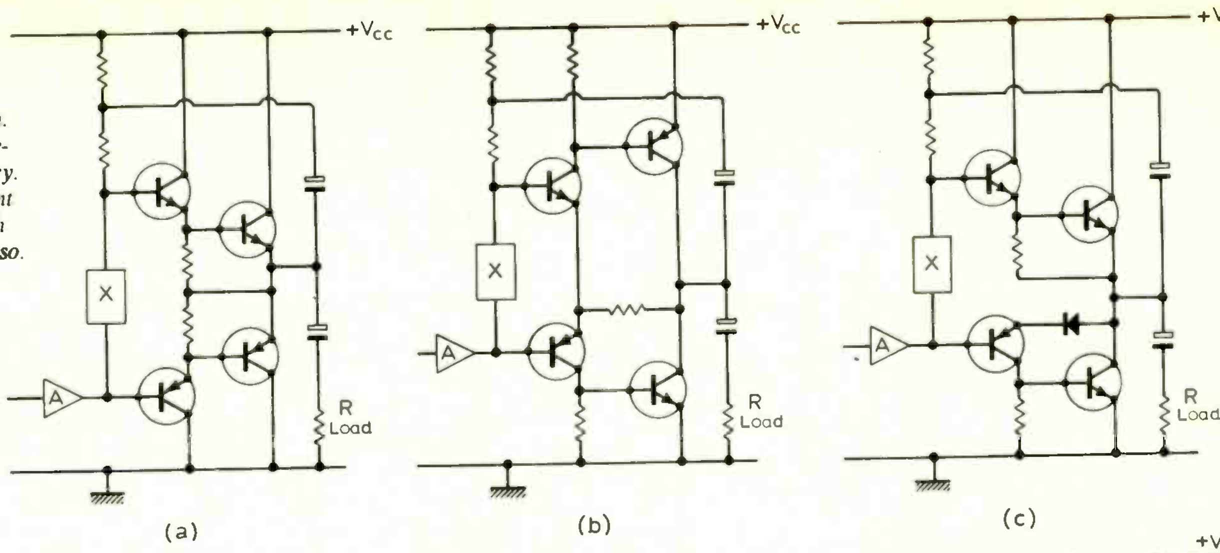


Fig. 1. Possible output stages considered for class A operation. (a) Fully complementary symmetry. (b) More efficient arrangement with local feedback also. (c) Quasi-complementary output with equalizing diode.

the best results to include a diode in the emitter of the lower p–n–p transistor so that looking into the base of each half of the output stage the driving source sees two forward biased junctions having fairly equal transfer characteristics for each half. The use of such a diode is particularly necessary in class-B stages as discussed in a recent article[2] and a letter[3]. The design described here uses the circuit of Fig. 1(c) mainly because of the better availability of n–p–n power devices.

In the three output stages of Fig. 1 box X is the source of bias for the output stage. To ensure true class-A operation, with repeatability of operation from one amplifier to another, it was decided to use feedback to control the operating current. To achieve this the circuit of Fig. 2 was evolved. It will be seen that two additional transistors Tr_7, and Tr_8 have been added, together with a current sensing resistor R_{11}. The action of the circuit is to hold the current through the output pair such that the drop across R_{11} is equal to the forward bias requirements of Tr_8 (approximately 500 mV). Any increase in the output stage current will cause Tr_8 to pass a greater current, which in turn will increase the conduction of Tr_7, thus reducing the potential difference between the bases of Tr_3 and Tr_5, i.e. the bias of the output stage, and hence reducing the current in this stage. The input to Tr_8 is filtered to remove audio components, so that the control circuit establishes the correct mean current irrespective of the signal present. The *RC* filter used for this purpose (R_{10} C_6) must have values such that adequate filtering is achieved, yet the drop in R_{10} must not be large or the current level of the output stage will vary with the current gain of Tr_8. This effect can be minimized by the use of a high gain transistor for Tr_8. The capacitor C_6 will be operated with only 500 mV polarization, which is insufficient to maintain the characteristics of a normal aluminium electrolytic. To overcome this problem a "solid" tantalum capacitor is specified, whose dielectric film of tantalum pentoxide is permanent. "Solid" aluminium capacitors also exist such as Mullard C415 and C121. These are not to be confused with "dry" electrolytics, which are wet types with the electrolyte in the form of a paste, (as are almost all aluminium electrolytics currently in use).

The operation of the output stage, with the bias network included, is at first hard to understand, since it at first appears that the drive to the base of Tr_3 is reduced by the presence of Tr_7, whose collector-emitter impedance is fairly high. This reasoning ignores the effect of C_3 and C_5, which results in the drives to the bases of Tr_3 and Tr_5 being almost equal. At low frequencies the circuit works well without C_5, but with increasing frequency, phase shift in the power stage results in slight side effects which can be removed by the use of C_5. By connecting the capacitor between the base and collector of Tr_7 its effective value as seen between the emitter and collector of Tr_7 is multiplied by the gain of this transistor, and thus a value of 0·22 μF proved quite adequate. Alternatively to revert to a more conventional circuit Tr_7 could by bypassed by a normal 250 μF 6 V capacitor as shown dotted in Fig. 2, to ensure equal drive to both halves of the output stage, at all audio frequencies.

Input and driver stages

These follow the well known arrangement of p–n–p input stage, with n–p–n driver stage. The feedback is arranged to be 100% at d.c. by connecting the 3·3 kΩ feedback resistor (Fig. 3) direct to the emitter of Tr_1. This feedback is reduced at audio frequencies by the attenuator formed by the 3·3 kΩ and 220 Ω resistors, but not at d.c. because of the 250 μF blocking capacitor.

The action of the d.c. feedback is to keep the midpoint of the output stage at a potential equal to the voltage at the base of Tr_1 plus the base-emitter potential of Tr_1 and the voltage drop in the feedback resistor (approximately 300 mV). Slight adjustment of the voltage of the bias chain feeding the base of Tr_1 allows the mid-point of the output stage to be set for symmetrical clipping at the onset of overload. The mid-point level will vary slightly with temperature due to the 2 mV/°C change in V_{be} of Tr_1, but this will be added to the effect of increase of current gain in the two input transistors, resulting in a drop in the collector current of Tr_1, and hence a drop in the potential across the 3·3 kΩ feedback resistor. However the total change over the range 0–40°C is only some 200 mV, and is thus of little consequence, in relation to the level of 14 V.

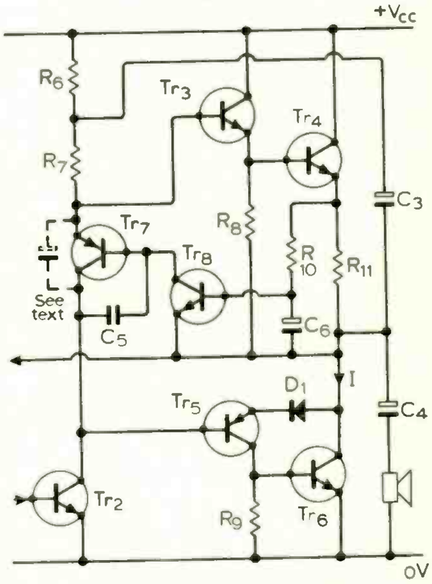


Fig. 2. Circuit chosen to allow feedback control of the operating current.

Power supply

In order to ensure the greatest possible freedom from hum and similar problems it was decided that the extra cost of a fully regulated power supply was justified, in relation to the high performance being aimed at.

The series stabilizer is quite conventional except for the generation of the pre-regulator supply (+60 V). This supply is generated by a Cockroft voltage-doubler circuit which is connected to the main rectified supply, so that the outputs of both circuits add. The input (peak) voltage to the voltage doubler is only half that across the main bridge rectifier, since on negative half cycles, the arm of the bridge between the input to the voltage doubler and the 0 V line, is conducting, clamping the point near 0 V, whilst on positive half cycles it is non-conducting allowing this point to rise. The connection of the anode of D_2 to the main rectified supply has the effect of increasing the voltage across the two capacitors by the voltage of the main supply, but does not affect the a.c. conditions in the circuit.

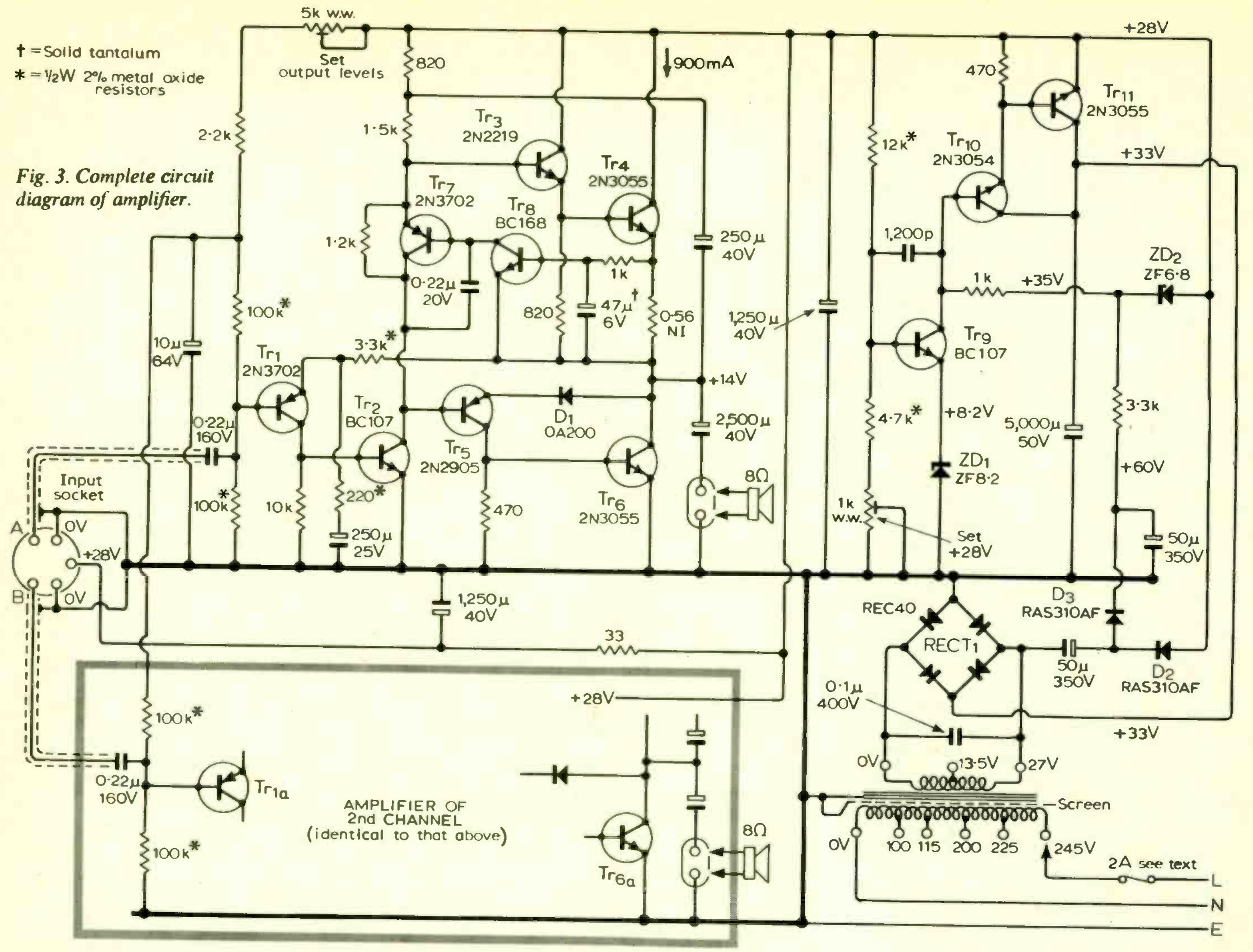


Fig. 3. Complete circuit diagram of amplifier.

The main supply is a normal bridge rectifier with capacitance smoothing. The value of this capacitor is decided by the maximum permissible ripple, which in turn depends on the minimum mains voltage allowable and the minimum voltage across the regulator series transistors at which the regulator still retains full control.

The actual pre-regulator supply generated by the voltage-doubler circuit is used to supply a zener diode (6·8 V) connected to the regulated supply, thus making a d.c.-coupled bootstrap connection for the collector load of the amplifying stage of the regulator (Tr_9), and giving a considerable increase in gain, within the regulator loop. The loop is stabilized by the 1200 pF capacitor across the base and collector of Tr_9, and the output impedance rise that this causes at the higher frequencies, is removed by the connection of the 1250 μF capacitor across the regulated line, in accordance with normal practice in such regulators.

The performance of this regulator is excellent and the only additional smoothing needed is the 10 μF capacitor in the base bias network of Tr_1. An output for the pre-amplifier and tuner etc. is available (via a low value decoupling resistor and a 1250 μF capacitor) at the input plug.

Overload protection

This is inherent in the action of the current control circuit, which prevents the output stage mean-current from varying. A full short-circuit can be sustained without damage. The current in the output stage remains correct as regards mean level but due to the high value of loop gain the current waveform becomes a square wave on heavy overload and as a consequence the dissipation in the current-sensing resistor doubles to approximately 1 W.

Frequency response

At low frequencies three capacitors determine the basic response. The input capacitor to the base of Tr_1, the d.c. blocking capacitor of the feedback loop, in the emitter circuit of Tr_1, and the capacitor feeding the load. The cut-off frequencies due to each alone, are 14, 3 and 8 Hz respectively. The combined effect was measured, and gave a "cut-off" at 15 Hz (−3 dB). In the author's opinion it is important that the main limitation of the bandwidth at low frequencies should be due to the input capacitor, so that the amplifier will not be overloaded by frequencies outside the useful audio-range. It is also important that the output capacitor is sufficiently large to allow the very low output impedance, obtained by high degrees of negative feedback, to damp the fundamental resonance of the loudspeaker cone. The values given are a good compromise, and provide an adequate bass response. For a lower cut-off, all three capacitors should be changed by the same factor.

No specific steps have been taken to limit the high-frequency response, which is found to be level to 15 kHz, −1 dB at 54 kHz, and −3 dB at 92 kHz, above which it falls rapidly.

Noise and distortion

Clipping at the overload point is clean and symmetrical, as shown in Fig. 5(a) for a 1 kHz sinewave. The normal method of adjusting the bias of the amplifier is to adjust the "Set O/P Levels" control for symmetry of clipping, having previously set the supply regulator for a reading of +28 V.

Distortion was measured—with some difficulty—at 1 kHz, when it was found that it was almost entirely 3rd harmonic in nature, and of very low level, only reaching 0·015% at the onset of clipping, so that at normal listening levels it would be quite insignificant.

Such a low level of distortion is not surprising when one considers the facts. The loop gain is measured as 4750 times, with the closed-loop figure of 16 times. The reduction in gain, and hence also in distortion is therefore 297 times or −49·5 dB, implying a basic open-loop distortion of around 5%, a reasonable figure for a basically linear amplifier. The output of the amplifier operated under loop conditions at just under full output is shown in Fig. 5(b). The variation with output level of the distortion under closed-loop conditions is shown in the graph of Fig. 4(c).

Due to the use of a regulated supply the noise and hum levels are of a very low value. Hum components alone (50 and 100 Hz) are −83 dB relative to full output. Wideband noise, ignoring hum components, is approximately −100 dB below full output, rising very slightly if the input is open circuit. The result is a background level that is completely inaudible.

Response to square wave input, and to capacitive loads

The effect of capacitive loads is shown in Fig. 5(c) and 5(d). The capacitor was a 1 μF paper type, and little difference in waveform is noticeable, whether or not, the 8-Ω resistive load is connected in parallel. The ring frequency induced is at approximately 200 kHz for a 1-μF capacitor but reduces somewhat with larger values of capacitor.

Fig. 5(e) shows the response to a steep input edge the total rise time is around 0·5 μs, giving a slewing rate of 40 V/μs. Fall time is similar.

Input impedance

Due to the high degree of series feedback employed, the input impedance is almost entirely that of the base bias network, i.e. the two 100-kΩ resistors effectively in parallel. The value was measured and was found to be such, namely 50 kΩ.

Current sensing resistor

It is desirable that this should be of a non-inductive type in order not to introduce high frequency effects, which might limit the available power at that end of the spectrum, and also cause stability problems in the loop. The requirement for a non-inductive resistor is more important in class B amplifiers, but is by no means unimportant in class A applications (see "Letters to the Editor", F. Butler and Arthur Bailey, *Wireless World*, December 1966, pp. 611–614). The construction of the resistors used in the prototype is shown in Fig. 6. An alternative would be to use Eureka wire to connect the emitter of Tr_4 to the remainder of the circuit, using a single straight length of a suitable gauge (probably 26 s.w.g.). In this case the wire should be covered with high temperature sleeving, say silicone rubber, or glass fibre. The 1 kΩ resistor feeding the base of Tr_8 would then be connected direct to the emitter of Tr_4.

Heatsinks

In the prototype, finned extruded aluminium heatsinks of approximately 4 in × 4 in are used for each of the output transistors. A similar heatsink is used for the series transistors of the regulator. In each case no insulation is used between the transistors and the heatsink, which is live to the collector in each case. This course of action was taken to maximize the efficiency of the heatsinks, and these must therefore be separately insulated from their mountings. The method used in the prototype is to cut slots in the edge of the heat sinks (0·25 in deep, 0·25 in wide), which then enable the heatsinks to be mounted on 4BA studding using Transiblocks, details of which are to be found in the constructional section below. Silicone grease is used to ensure a good thermal connection between the heat sink and the power transistors.

The amplifier must not be used in confined surroundings such that free air circulation is impeded, as some 60 W of heat have to be dissipated by the complete stack of heat sinks. The cabinet in which the amplifier is mounted should therefore be well ventilated, and in particular the author has found that a larger area of vent is required at the top of such a cabinet than at the bottom in order to stop the build up of a cushion of hot air at the top. The maximum rise in the centre of the heat sink stack, gives a case temperature for the power transistor which is approximately 40°C above ambient. The junction temperature with the dissipation occurring in each transistor will be a further 20°C higher in the worst case. Thus at 20°C in free air the maximum junction temperature will be 80°C, allowing a considerable amount of leeway for both raised ambient temperature and less than free air circulation. It is recommended that the maximum case temperature of the power transistors should not be allowed to exceed 100°C in use, and in the cabinet in which it is to be mounted, so that a reasonable degree of reliability is achieved.

Adjustment of design for other than 8-Ω load

Referring to Fig. 2 again, we will first calculate the supply voltage required for any given load. (The number suffixes given refer to the transistor numbering in Fig. 2.)

Output voltage swing (pk–pk)

$$= V_{cc} - \{V_{ce\cdot sat_3} + V_{be_4} + V_{ce\cdot sat_6} + (I + \hat{I})R_{11}\}$$

Also, power output (sinewave)

$$= \frac{(\text{output voltage swing})^2\ pk\text{–}pk}{8R_{load}}$$

Since V_{out} (r.m.s.) $= \dfrac{V_{pk-pk}}{2\sqrt{2}}$ (for a sinewave),

$$V_{out}\,(pk\text{–}pk) = \sqrt{8R_{load}\cdot P_{out}}$$

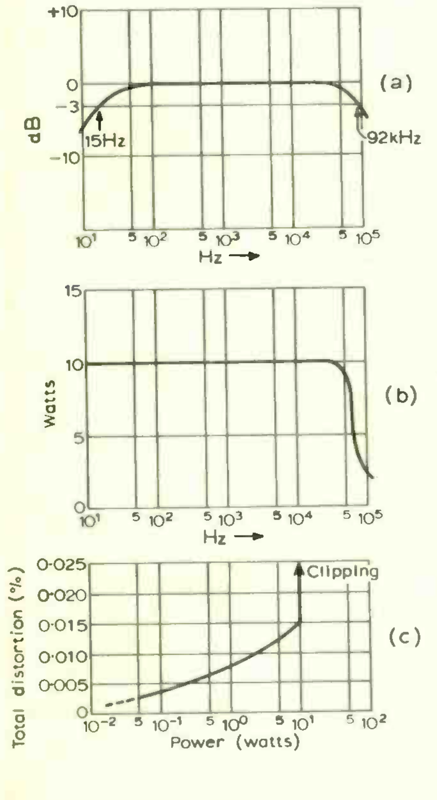


Fig. 4. Performance curves.

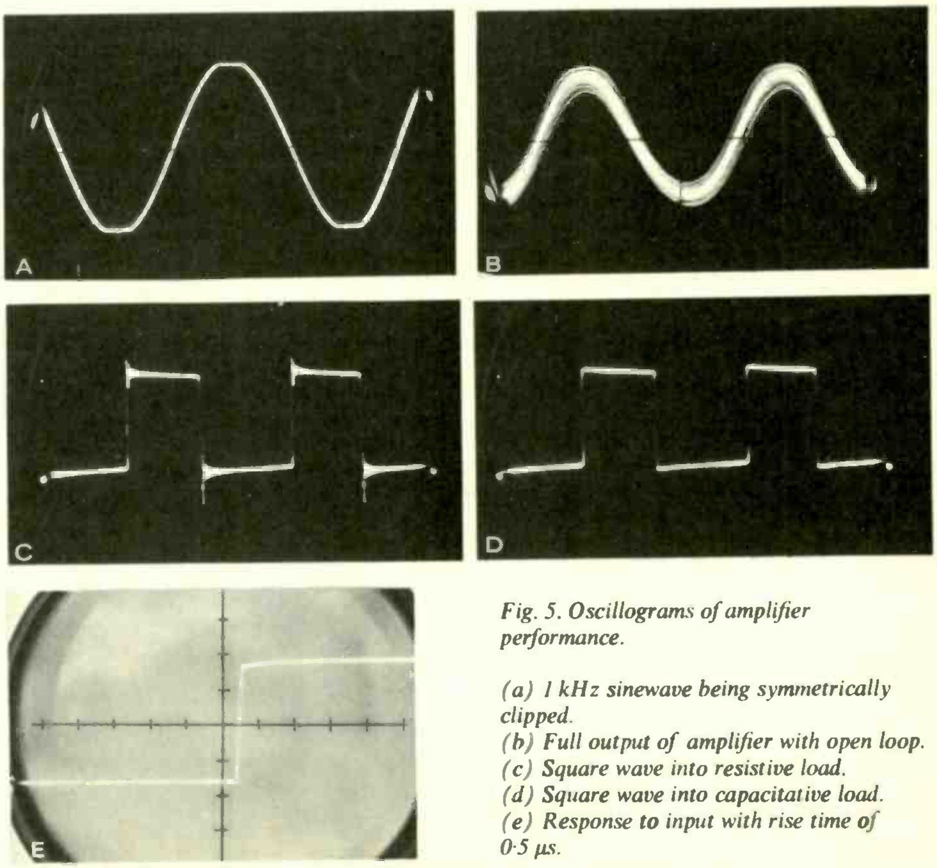


Fig. 5. Oscillograms of amplifier performance.

(a) 1 kHz sinewave being symmetrically clipped.
(b) Full output of amplifier with open loop.
(c) Square wave into resistive load.
(d) Square wave into capacitative load.
(e) Response to input with rise time of 0·5 μs.

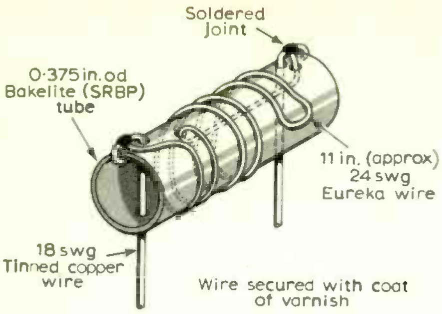


Fig. 6. Construction of 0·56 Ω 5% non-inductive resistors.

and therefore

$$V_{cc} = \sqrt{8R_{load} \cdot P_{out}} + V_{ce\cdot sat_3} + V_{be_4} + V_{ce\cdot sat_6} + (I+\hat{I})R_{11}, \text{ minimum.}$$

The standing current must exceed $\frac{V_{pk-pk}}{4R_{load}}$ in order to achieve the required voltage swing, and for its satisfactory safety margin it should exceed $V_{cc}/4R_{load}$.

Taking typical values for the circuit given using an 8-Ω load, and 10-W output level we get $V_{cc} = \sqrt{640} + 0{\cdot}25 + 1{\cdot}0 + 0{\cdot}5 + (0{\cdot}90 + 0{\cdot}79)\,0{\cdot}56 = 28$ V.

$$I_{min} = \frac{28}{4 \times 8} = 875 \text{ mA}$$

(a value of 900 mA being actually used.)

For a 3-Ω load and 10-W output we get figures of 19·5 V for V_{cc}, and 1·63 A for I_{min}. (Total power 31·8 W, 31·5% efficient).

For a 15-Ω load and 10-W output we get figures of 36 V for V_{cc}, and 0·6 A for I_{min}. (Total power 21·5 W, 46·4% efficient)

From these figures it is apparent that the rise in $V_{ce\cdot sat}$, and V_{be} figures with the current used in a 3-Ω amplifier seriously reduces the overall efficiency. In the case of the 15-Ω load on the other hand, the efficiency is not far short of the theoretically possible figure of 50% for a class A stage. The efficiency of the 8-Ω stage is 39·8%.

Details of value changes for 3-Ω, and 15-Ω circuits are given with the constructional details below.

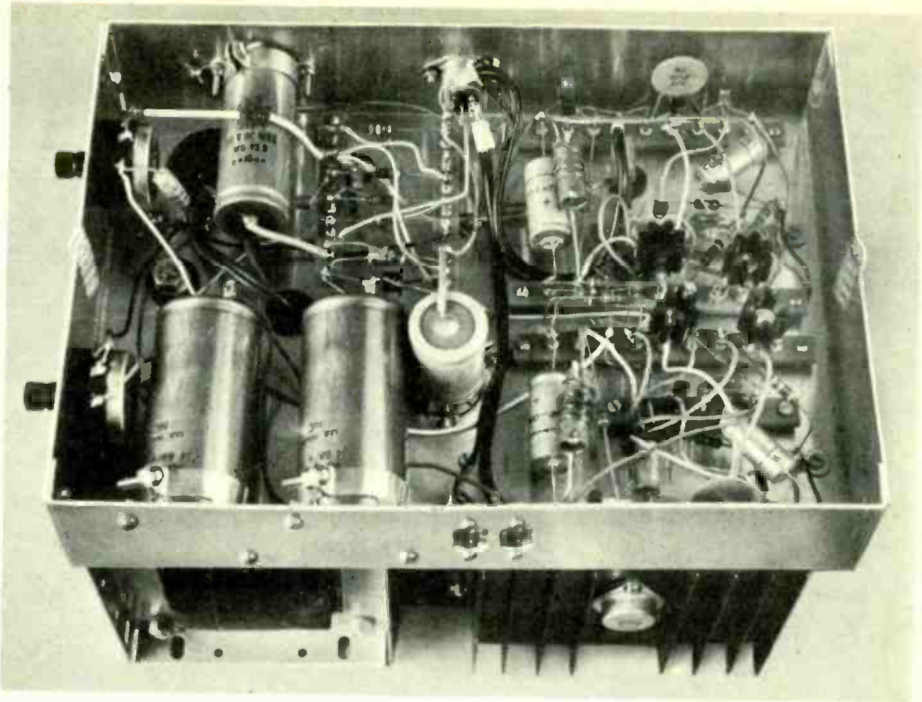


Fig. 7. View of underside of amplifier chassis.

Performance of 8-Ω version

Output (at commencement of clipping)	10 W
Frequency response	36 Hz–54 kHz (−1 dB)
	15 Hz–92 kHz (−3 dB)
Power bandwidth	Full power 15 Hz–30 kHz −3 dB (half power) at 60 kHz
Hum level	−83 dB relative to 10 W
Noise level	−100 dB relative to 10 W (ignoring hum components)
Rise time	0·5 μs
Input impedance	50 kΩ
Input sensitivity	0·56 V r.m.s. for 10 W (gain 16)
Open loop gain	4750
Feedback gain reduction	−49·5 dB (297 times)
Distortion	0·015% at 1 kHz, 10-W output (almost entirely 3rd harmonic) 0·01% at 2·5 W 0·005% at 350 mW
Channel separation	−43 dB at 20 Hz rising to greater than −60 dB at 1 kHz and above

Constructional details

Fig. 7 shows the construction of the underside of the chassis of the 10+10-W amplifier. The layout is shown in greater detail in the sketch of Fig. 8—the two amplifiers being constructed as mirror images, as can be seen in the photograph.

To avoid large circulating currents the loudspeaker return leads should be wired to the earth tags of their respective amplifiers, as shown in Fig. 8. The negative lead of the rectifier bridge should be connected to the same earth tag as the negative connection of the 5000 μF main smoothing capacitor, together with the negative connection of the second 50 μF smoothing capacitor of the voltage doubler.

Providing the layout given is followed, and the precautions listed over earth tags are followed, no problems should be encountered.

Layout of the series regulator components is entirely non-critical and uses similar tag strips to those in the power amplifiers.

Fixed resistors

With the exception of the current sensing resistors R_{11}, R_{11a} and those marked with * in the circuit of Fig. 3, all resistors are solid carbon moulded ½ W 10%. All resistors marked * are ½ W 2% metal oxide (Electrosil TR5, Welwyn MR5, Radiospares "½ W oxide"). See Fig. 6 for details of the construction of R_{11}.

Variable resistors

Both are wirewound Radiospares type "presets" (set +28 V and set output levels). Any good wirewound types such as those quoted of 1 W rating or above are suitable.

Non-electrolytic capacitors

0·22 μF 160 V input capacitor Wima Tropyfol M (160 V) or Mullard C296AA/A220 K. Radiospares also make a suitable type 250 V PDC.

0·22 μF 20 V ceramic disc (base-collector Tr_7). Radiospares 20 V discs, or use polyester 160 V type as above.

1200 pF tubular ceramic (1000 pF can be used). The capacitor used in the prototype is now obsolete; Radiospares suggest as alternatives "discs 0·001 μF" or "Hi-K 0·001 μF" (tubular).

0·1 μF 400 V (across bridge rectifier, necessary to prevent the generation of mains-borne interference due to hole storage effects in the rectifiers), Wima Tropyfol M (400 V), Mullard C296AC/A100K. Radiospares 400 V PDC.

Electrolytic capacitors

47 μF 6 V (base-emitter Tr_8). This must be solid tantalum type. The Radiospares type used in the prototype is discontinued but is apparently identical to Union Carbide "Kemet E". Alternatives are S.T.C. 472/LWA/401CA (metal case), S.T.C. TAG47/3 (3 V rating similar to Kemet E), Mullard

C421AM/BP47 (metal case), C415AP/C50 (50 μF, 6·4 V solid aluminium type).
10 μF 64 V (input bias chain) Mullard C426AR/H10.
250 μF 25 V (feedback blocking capacitor) Mullard C437AR/F250.
250 μF 40 V (bootstrap capacitor) Mullard C437AR/G250.
1250 μF 40 V (across 28 V supplies) Mullard C431BR/G1250.
2500 μF 40 V (output capacitor) Mullard C431BR/G2500.
5000 μF 50 V (main smoothing) Daly type obtained from Electrovalue. Nearest Mullard type C432FR/G5600 (5600 μF 40 V).
50 μF 350 V (voltage doubler) Radiospares "tubes 50 μF 350 V". Alternative types of not less than 100-V rating may be used. Caution should be exercised in the selection of suitable types for the main smoothing capacitor because of the high ripple rating required. The Radiospares type "Cans 5000 μF 50 V" is not suitable on this account. The Daly type has a ripple rating of 4·3A.

Transformer

Radiospares "27 V rec trans" Prim. 0–100–115–205–225–245 V 50/60 Hz. Sec. 27 V at up to 3A rectified d.c.

Fuse

2A normal or 750 mA "anti-surge" delay type.

Heatsinks

Power transistors mounted on 5 Radiospares heatsinks, which are equivalent to "Marex" (Marston–Excelsior) type 10D—4 in long. S.T.C. supply a similar type, code HSC4 and a clip for insulated mounting (but not as in photos) FP2551 (Electroniques). Heatsinks mounted on 4BA studding using four transiblocks per heatsink. Transiblocks are made by Industrial Instruments Ltd, Stanley Road, Bromley, Kent. Farnell Instruments Ltd (Industrial Supplies Division) also stock these items.

The TO-5 transistors (Tr_3, Tr_5), are fitted with cooling clips—Redpoint 5F, available from Electrovalue and Electroniques. A similar type—"Sinks TO-5"—is available from Radiospares.

Sundries

Chassis size 7 in × 10 in × 2 in (sheet aluminium type).

The input socket is a 5 pin "DIN" audio connector. The loudspeaker sockets are Radiospares miniature non-reversible 2-way plugs, and sockets. Non-reversibility is essential to preserve the phasing of the outputs to the speakers. It is convenient to mount the fuseholder (Radiospares panel fuse holders or Belling-Lee L.1348, L.1382, L.1744) on a panel attached to the side of the mains transformer, with a strip on top of the transformer for connection of the mains lead, mains switch, etc., as shown in the photograph.

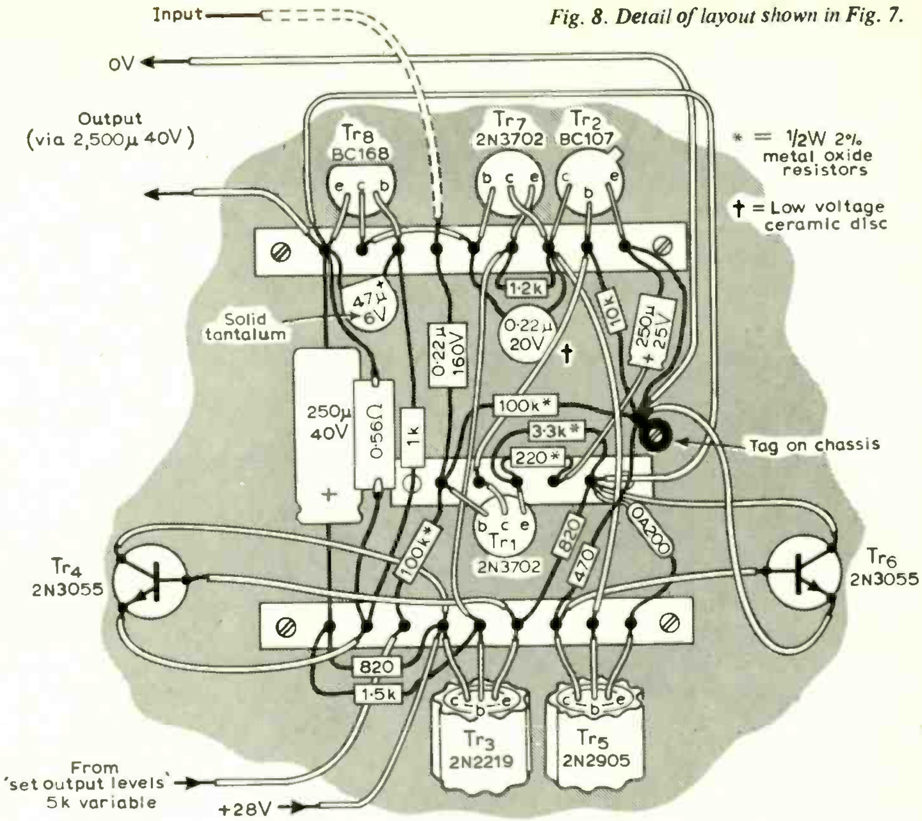


Fig. 8. Detail of layout shown in Fig. 7.

Semiconductors

Tr_1, Tr_7	2N3702	(BCY70)
Tr_2, Tr_9	BC107	(BC108 suitable for Tr_9)
Tr_3	2N2219	
Tr_5	2N2905	
Tr_4, Tr_6, Tr_{11}	2N3055	
Tr_{10}	2N3054	
Tr_8	BC168	(BC108)
D_1	OA200	(HS1010, OA202)
D_2, D_3	RAS310AF	(Radiospares REC51A, 1N4005, BY103)
ZD_1	ZF8.2	(Radiospares "MZ–E 8.2 V", Mullard BZY88–C8V2, Texas 1S2068A)
Rect. 1	Radiospares REC.40. 5A bridge 200 V (p.i.v.)	

Modifications for 3-Ω output

R_{11} and R_{11a} must be reduced to 0·31 Ω (5%) each. The mains transformer will require to be 21 V r.m.s. 3·5 A d.c. rectified rating. The output capacitor feeding the loudspeaker must be 5,000 μF 25 V. The 12-kΩ resistor in the regulator will reduce to 7·5 kΩ, and the 3·3 kΩ resistor feeding the 6·8 V zener diode will reduce to 2·2 kΩ. The main smoothing capacitor should be raised to 7,000 μF at not less than 30 V working. The collector resistors of Tr_2 should be dropped from 820 Ω, 1·5 kΩ and 1·2 kΩ to 470 Ω, 820 Ω, and 680 Ω respectively.

Modifications for 15-Ω output

R_{11} and R_{11a} must be increased to 0·84 Ω (5%) each. The mains transformer must be 34 V r.m.s. 1·5 A d.c. rectified rating. The 12-kΩ resistor in the regulator must be increased to 17 kΩ which is not a standard value, alternatively the 4·7 kΩ may be dropped to 3·6 kΩ which is a standard value. The 3·3-kΩ resistor feeding the 6·8-V zener diode should be raised to 3·9 kΩ. The collector resistors of Tr_2 may be raised if desired but this is not necessary. Tr_9 must be BC107 since BC108 has an inadequate voltage rating. Tr_3 may be 2N2219A or 2218 A which have a higher voltage rating than 2N2219. However if 2N2218 A is used then Tr_5 should be changed to 2N2904, to preserve some equality of current gain. If a transistor tester is available then samples of 2N2219 may be selected for V_{ceo} of above 40 V instead (normal minimum is 30 V).

It should be noted that the output to pre-amplifier and tuners will alter, being + 19·5 V for the 3-Ω version, and + 36 V for the 15-Ω version.

It is expected that the distortion of the 3-Ω version will be two to three times greater than that quoted for the 8-Ω version, with similar or slightly better figures for the 15-Ω version. In the author's opinion, since very few speakers deserving the title high-fidelity, have a 3-Ω voice coil, the 3-Ω version of the amplifier is not worth considering unless no other choice presents itself.

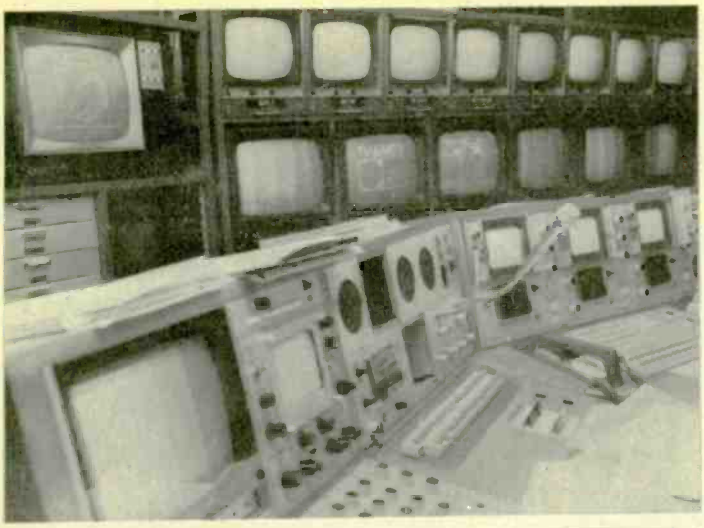
REFERENCES

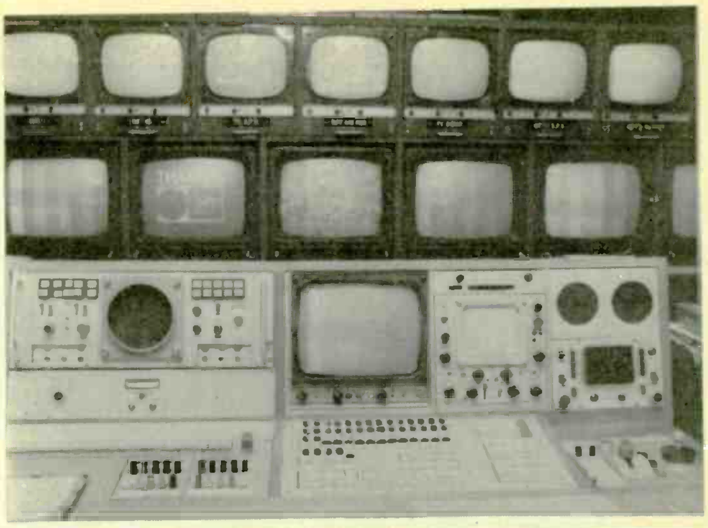
1. J. L. Linsley-Hood, "Simple Class A Amplifier", *Wireless World*, April 1969.
2. I. M. Shaw, "Quasi-Complementary Output Stage Modification", *Wireless World*, June 1969.

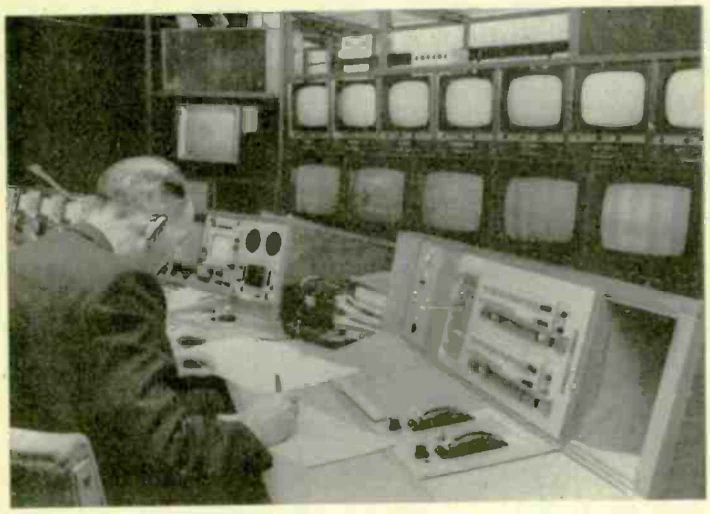
London's New Colour TV Centres

A pictorial look behind the cameras

One of two news studios (top left) at the recently built Television News Spur at the B.B.C. Television Centre. Amid the jungle of lights the four Mk. VII Marconi colour cameras can be seen. These are controlled remotely from control desks from which the operator can adjust pan, tilt, focus, zoom and camera height using simple potentiometers. Two banks of ten push-buttons, positioned one above the other, enable the operator to store up to twenty camera positions. Pressing any one of these buttons causes digital information describing the camera settings to be stored in a ferrite core store. Re-pressing the same button causes the camera to instantly take up the same position again. A "fader" control causes the camera to move between a position set up on one of the top row of buttons to a position which has been set up on the bottom row of buttons. The camera control system was designed by Evershed Power-Optics Ltd. The news announcer sits in front of a screen which is saturated-blue in colour. The output of the blue gun of the main camera looking at the announcer can be made to switch an auxiliary camera the output of which is mixed with the main camera. If the auxiliary camera is looking at an outdoor scene, whenever the main camera is scanning the blue background the outdoor scene will appear on the screen. When the main camera scans the announcer very little blue signal will be picked up, the auxiliary camera will be switched out and the main camera will provide the vision signal. The effect on the television screen will be to have a picture of the announcer against a background of the outdoor scene. The sub-central apparatus room (top right) which routes all the incoming and outgoing sound and vision signals to and from the B.B.C's news centre. In addition to this the C.A.R. provides communication facilities and can either route synchronizing pulses from the main television centre or generate its own for the rest of the news complex. The main sound routing system has 100 sources, any of which can be sent to any of 60 destinations. Remote controls also exist for the camera in the parliamentary studio. Part of the telecine area (bottom left) and one of the two telecine control desks (bottom right). Altogether there are nine 16-mm colour machines, two of which are multiplexed to deal with 8mm and super-8mm film from amateur sources, and two 16-mm monochrome machines. If necessary the colour quality of material from the telecines can be corrected.







The master control desk at Thames Television's new centre in Euston is boomerang-shaped and has positions for the lines engineer (top left), the engineer in charge who performs a quality control function (top right), and the network switcher (bottom left). The monitor bank facing the desk has a row of 14-in. monochrome monitors and a row of colour monitors underneath. These preview incoming sources, check the passage of signals through the system and view the outputs. The lines engineer has a monitor-switching system controlling the input to an 11-in. Pye picture monitor and a 529 Tektronix 'scope. Communications and sound monitoring take up the rest of his desk. The central position for the engineer-in-charge has very comprehensive monitoring and switching facilities which include a vectorscope and a subcarrier phase meter (by Michael Cox Electronics) seen below the vectorscope. The network switcher and the presentation mixer were built by Thames using E.M.I. vision matrices and Neve sound matrices. The presentation control room (bottom right) is separated from master control by a glazed screen so that visual contact can be maintained. The transmission controller sits centrally before the monitor bank, clocks, telephones and talkback keys on the desk before him.

ITN's new studios Wells St., London, were officially opened by the Queen on the 20th of November last year. The control room can be seen (left). Beneath the clock is the colour transmission monitor with colour preview pictures on either side. To the left of the clock are the monitors for telecine and video tape recorders. Below the transmission monitor are the four studio camera monitors. Sitting from left to right: vision mixer, director, production assistant, and producer, rehearsing NEWS AT TEN. Far left are the monitors for engineers controlling the quality of the picture. The 24-channel sound mixing and production desk in studio No. 1 is shown in the right photograph. This equipment, together with the turntables in the foreground, was supplied by Elcom.

80-metre S.S.B. Receiver

A limited coverage receiver of straightforward design for amateur use

by W. B. de Ruyter, PAOPRW

Since f.e.ts are now available at low-cost it is possible to build a stable receiver with a performance similar to good valve receivers with the attendant advantages of low-power consumption and the absence of self-generated heat. The receiver described here operates on a 12-V supply and consumes only about 35mA.

Stability is such that the receiver stayed within 3Hz of zero-beat for several days when tuned to a standard frequency transmission. Detuning in the prototype due to supply voltage variation was about 50Hz/V making mobile operation using a good 12-V car battery possible. Due to the excellent square law characteristic of the f.e.t., cross-modulation properties are good. In a test, a 60mV unwanted signal spaced 100kHz from a weak wanted signal did not result in any harmful cross-modulation.

The sensitivity of the circuit depends almost entirely on the Q-factor of the input coil. It was noticed that practically no change in signal-to-noise ratio resulted when the aerial circuit was fed straight into the mixer instead of to the r.f. amplifier. However, the r.f. amplifier is needed to improve image rejection, reduce 455kHz interference and to provide adequate automatic gain control.

Circuit description

A block diagram is shown in Fig. 1 and the complete circuit diagram of the receiver is given in Fig. 2. The f.e.t./bipolar transistor r.f. stage, Tr_1 and Tr_2, does not require neutralizing if due care and attention is taken with screening. Provided that the v.f.o. circuit is properly constructed, mechanical rigidity being important here, a good waveform and a stability approaching that of a crystal oscillator will be attained. The v.f.o. operating frequency is arranged to be 455kHz above the signal frequency (3.955 to 4.455 MHz).

All the r.f. coils employed in the prototype were of the type intended for valve trawler-band receivers for tuning between 60 and 180 metres.

The 4 to 40pF main tuning capacitor used in the prototype was salvaged from a Government surplus type 31 receiver and was complete with a 36:1 reduction gear box and trimmer capacitors. In fact constructors who are not too keen on "metal bashing" will find, as the author did, that the type 31 receiver cabinet makes an ideal case for the receiver described here.

The author considers that the money spent on the relatively expensive mechanical filter is more than justified when looked at in terms of receiver performance. An added advantage is that i.f. alignment is reduced to trimming for maximum input to, and output from, the mechanical filter. The cascode i.f. amplifier is designed to properly match the mechanical filter and also incorporates the simple S-meter circuitry.

The use of a Colpitts oscillator for the b.f.o. eliminated the need for any coils in this part of the circuit. The b.f.o. operates below the bandpass of the mechanical filter.

A square law heterodyne detector is employed and it is necessary to adjust the i.f. output coil, L_5, for optimum reception quality.

After a d.c. coupled a.f. pre-amplifier stage, Tr_8, the a.f. signal divides into two. One path is to a two stage f.e.t./bipolar a.f. amplifier via the a.f. gain control. This amplifier develops more than enough power to drive a pair of 150-Ω headphones. Some readers might prefer to incorporate a simple a.f. power amplifier for loudspeaker reception. The second path from the d.c. coupled a.f. pre-amplifier goes via an impedance converting emitter-follower, Tr_{10}, to the a.g.c. rectifier and smoothing capacitor. The a.g.c. performance is such that the heterodyne detector is not overloaded on even very strong signals. The switch S_1 is connected to the negative terminal of a suitable battery providing an r.f./i.f. manual gain control. The positive terminal of the battery is, of course, connected to earth (power supply negative).

The f.e.t. in the Tr_7 position, i.f. amplifier, must be selected for a certain value of pinch-off voltage, 3V being the target figure. It is best to obtain a good supply of these components so that suitable devices can be selected. A test circuit that will perform this task is given in Fig. 3; the meter will indicate pinch-off voltage. It is advisable to use an f.e.t. in the r.f. amplifier, Tr_2, with a pinch-off voltage half a volt or so higher than the f.e.t. in the i.f. amplifier, Tr_7. This will ensure that the a.g.c. cannot cut off the i.f. amplifier.

Construction

The author assumes that a type 31 receiver will be used as the basis for construction. The first step is to remove all the components from the chassis except the five-gang tuning capacitor and its associated reduction gearing. A small mA meter, which serves as the S-meter, is mounted in the position that was occupied

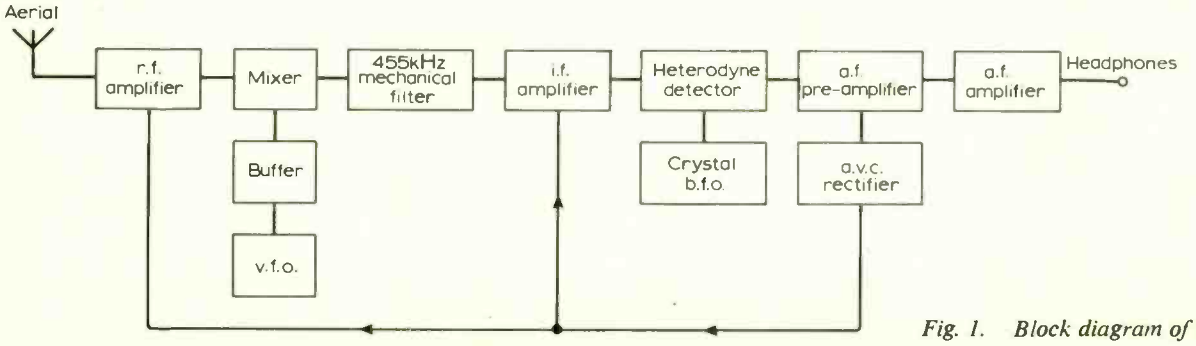


Fig. 1. Block diagram of the complete receiver.

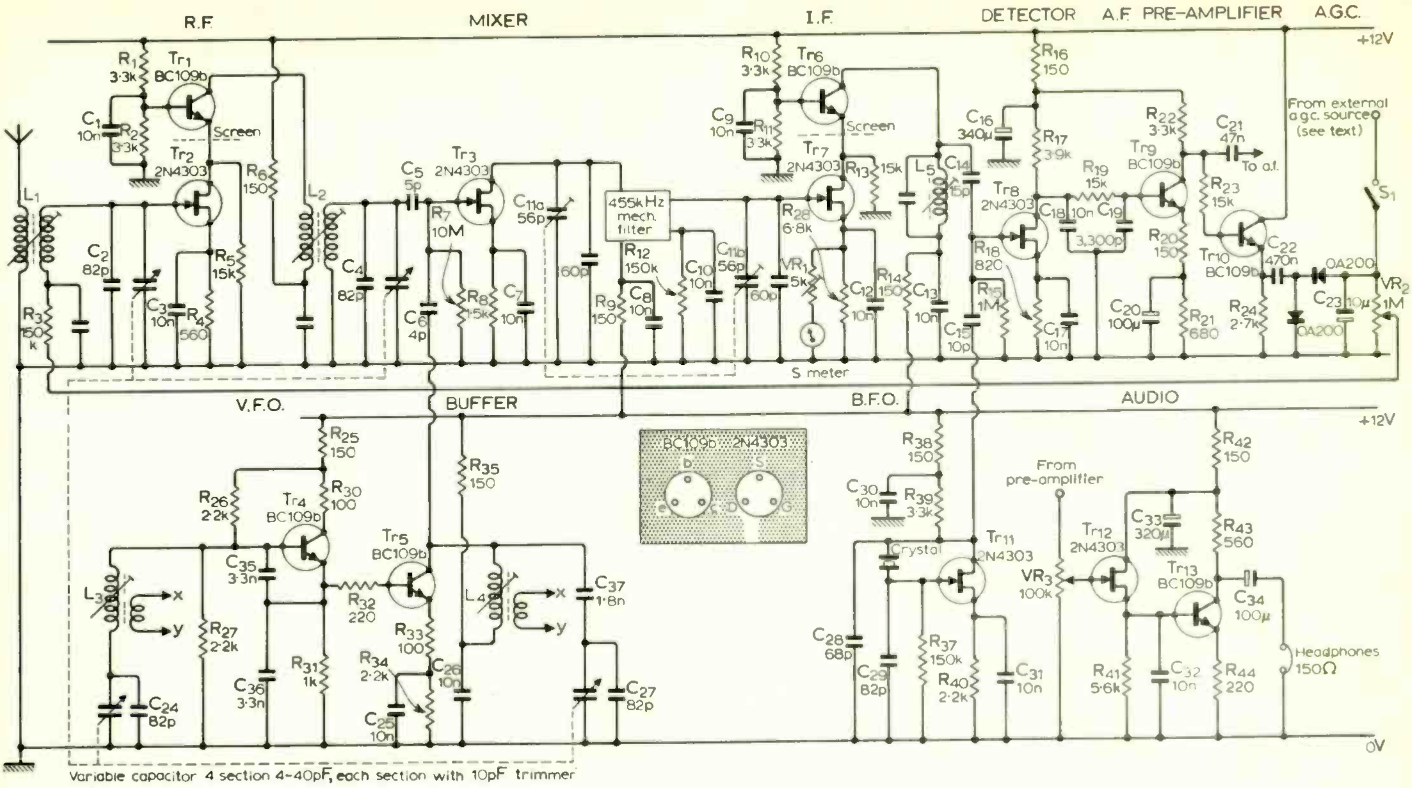


Fig. 2. The circuit. A power supply is not included in this description, but a car battery or almost any mains 12V power pack will suffice.

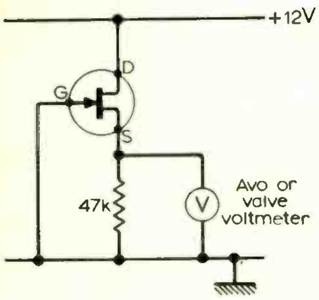


Fig. 3. Circuit for measuring f.e.t. pinch-off voltage.

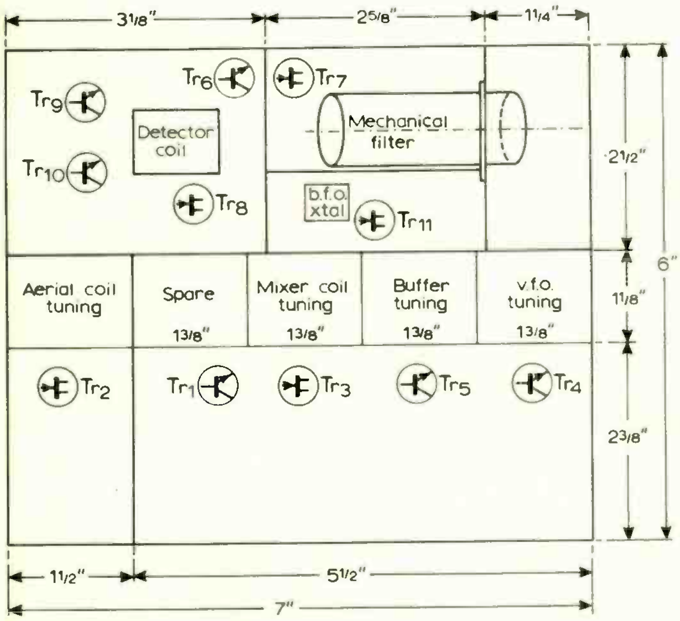


Fig. 4. Skeleton mechanical layout showing position of main components.

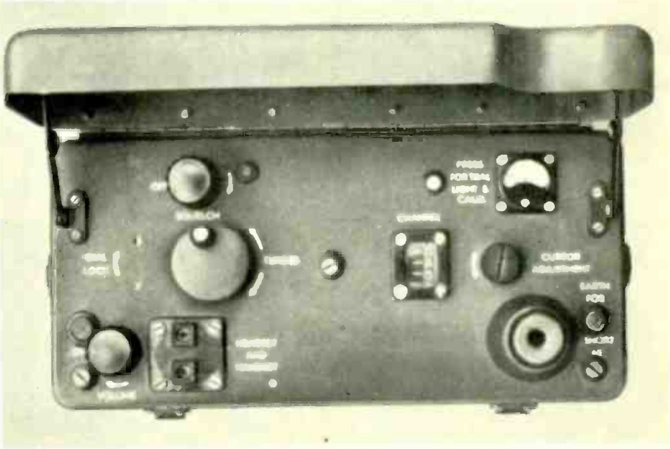


Fig. 5. Front view of the prototype.

by the dial-light knob, and the original squelch control knob becomes the a.g.c. control. The a.f. gain control is retained in its original position.

It was found that the 10-ft collapsible whip aerial supplied with the 31 set performed very well even without grounding the receiver.

The excessively large holes which now decorate the chassis are blanked-off with plates made from brass sheeting.

As previously stated any 60 to 180 metre trawler band coils can be used. The prototype employed Philips coils; type A3 125-34 for the aerial and mixer coils and type A3 125-68 for the v.f.o. and buffer. Only four of the sections of the five-section main tuning capacitor are used in the circuit; readers may find the fifth section useful for tuning a loop aerial.

The importance of rigid mechanical construction and good screening between stages cannot be overstressed as is normal with r.f. circuitry. It is a wise constructor who gives careful attention to these points. In particular excessive stray coupling between the input and output of the mechanical filter will seriously degrade the performance. Figs 4, 5 and 6 indicate the positions of the main components.

The first task is to check the source voltage of the f.e.ts is

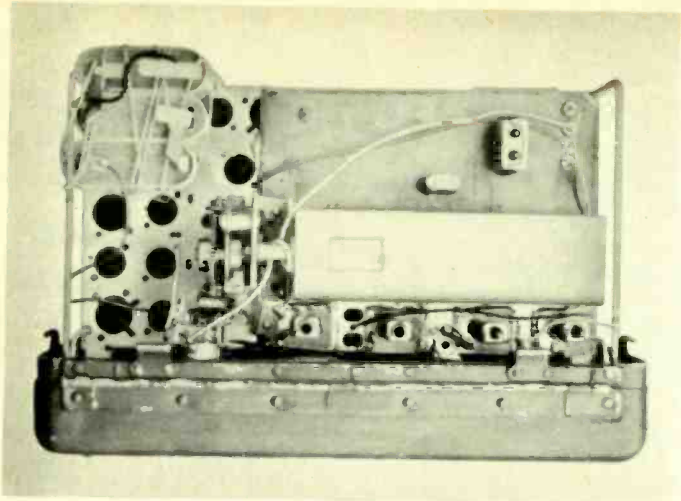


Fig. 6. Upper chassis view.

between 1.5 and 2V. Alignment of the receiver is not difficult and follows conventional practice; a crystal calibrator is of great value when carrying out this task.

The tuning range is set by adjusting the trimmer capacitors with a 3.5MHz input and the inductors with an input of 4MHz for maximum output. This procedure is repeated for the v.f.o. and the buffer circuitry. Due to the limited coverage very good tracking can be achieved. Finally the preselection circuits are adjusted and L_5 set for optimum sound quality.

Conclusion

The prototype receiver performed well and the author considers that its construction is good training for those who wish to construct the receiver designed by D. R. Bowman, which was described in the July, August and September 1969 issues of *Wireless World*. The frequency coverage of this receiver can be extended using crystal converters; however, the performance will not match Bowman's design under these conditions.

Components List

Resistors

In this list the prefix *R* and the symbol Ω have been omitted.

1—3.3k	12—150k	23—15k	35—150
2—3.3k	13—15k	24—2.7k	37—150c
3—150k	14—150	25—150	38—150
4—560	15—1M	26—2.2k	39—3.3k
5—15k	16—150	27—2.2k	40—2.2k
6—150	17—3.9k	28—6.8k	41—5.6k
7—10M	18—820	30—100	42—150
8—1.5k	19—15k	31—1k	43—560
9—150	20—150	32—220	44—220
10—3.3k	21—680	33—100	—
11—3.3k	22—3.3k	34—2.2k	—

all above resistors $\frac{1}{8}$ watt.

VR_1—5kΩ preset potentiometer; set S-meter sensitivity.
VR_2—1MΩ potentiometer; a.g.c. control (r.f.—i.f. gain).
VR_3—100kΩ potentiometer; a.f. gain.

Capacitors

In the list below the prefix *C* and the suffix F have been omitted.

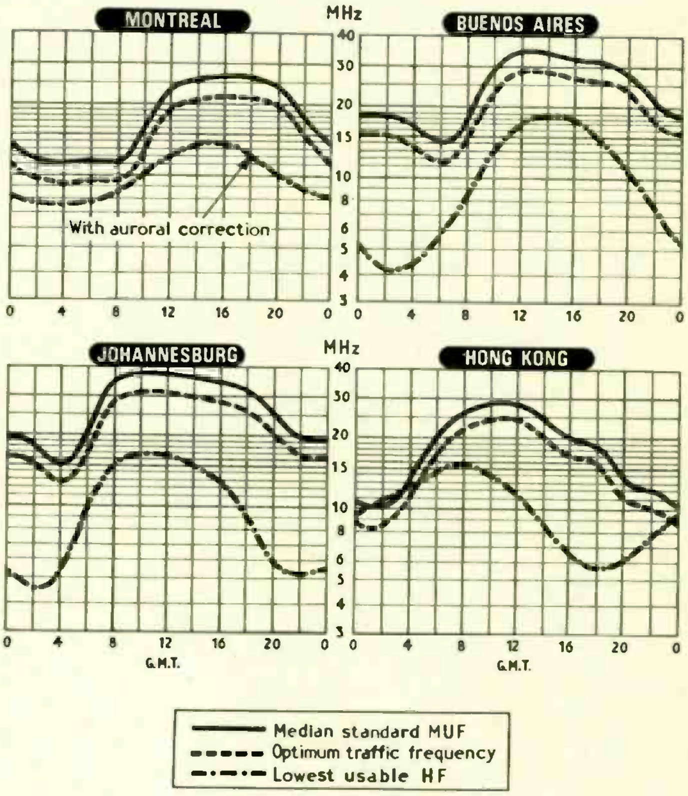
1—10n	10—10n	19—3,300p	28—68p
2—82p	11—56p	20—100μ	29—82p
3—10n	12—10n	21—47n	30—10n
4—82p	13—10n	22—470n	31—10n
5—5p	14—15p	23—10μ	32—10n
6—4p	15—10p	24—82p	33—320μ
7—10n	16—340μ	25—10n	34—100μ
8—10n	17—10n	26—10n	35/36—3.3n
9—10n	18—10n	27—82p	37—1.8n

All capacitors should be ceramic with the exception of the 82pF components, which should be silver mica with a slightly positive temperature coefficient, and the electrolytic capacitors which should be at least 15V working types.

Other components

L_1 & L_2—Trawler band aerial coils.
L_3 & L_4—Trawler band oscillator coils.
L_5 /C_{28}—455kHz tuned circuit.
f.e.ts—2N4303
bipolar transistors—BC109b
455kHz Collins N20 mechanical filter
b.f.o. crystal—453.7kHz.

H.F. Predictions—March



The charts show median standard MUF, optimum traffic frequency (FOT) and lowest usable frequency (LUF) for reception in this country. LUFs were calculated by Cable & Wireless Ltd for specific point-to-point telegraph circuits. LUFs for domestic reception of high-power broadcast transmissions would be slightly higher and those for the amateur bands considerably higher, especially during daylight.

Commercial working frequencies are kept below FOT to allow for day-to-day variations in the ionosphere and the seasonal trend over the month. Amateur 'openings' can be expected in bands up to 15% above MUF. It may be recalled that March 1969 showed a sudden increase in solar activity, the measured IF2 index value being 127. The forecast value for this month's predictions is 98.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Capacitor-discharge ignition

I was very interested to read R. M. Marston's article in the January *Wireless World* but I was unable to convince myself that the storage capacitor C_1 will charge in 1.6 msec. To either substantiate or disprove this I constructed a test circuit (Fig. 1). The switch simulates the s.c.r. and being two-pole enables the oscilloscope to be triggered at the moment of turn-off. It was found, using three different iron-cored mains transformers (two standard units and one wound as suggested), that the converter did not actually stop oscillating on short circuit but continued at a high frequency (approx. 20kHz dependent on the transformer). This is due to the transformer leakage inductance, a property which Mr. Marston's transformer obviously had, since he used the overshoot it causes to advantage. The current taken in this condition rose to approx. 2.5 amps. At first I thought that this high-frequency mode would enable the capacitor to charge in the time claimed but operating the switch revealed with these transformers the rise-time was never better than 3 msec. The current available from the converter under short-circuit conditions was approx. 20mA, which is enough to hold on the s.c.r., but the backswing from the ignition coil (Fig. 2) passes through diodes D_3 to D_6 for a period over 0.1 msec enabling the s.c.r. to turn off and partially recharging C_1. Thus this system has the same disadvantage as the more usual capacitive-discharge system (Fig. 3) has, i.e. without the backswing the s.c.r. may latch on.

To ensure that the converter truly stops oscillating I wound a transformer on a Mullard Vinkor FX2243 core since this would result in low leakage inductance. The low primary inductance of this transformer resulted in a natural operating frequency of approx. 2kHz and it did stop under short-circuit conditions. Unfortunately the time taken for the oscillator to restart and charge the capacitor resulted in a charge time of approx. 25 msec.

Mr. Marston's system would seem to charge up the capacitor in a short time when the energy is not all used in the coil resulting in a large backswing which will recharge C_1 (Fig. 2). When the energy is all used the capacitor will have to charge from zero volts and take some time in excess of 3 msec. This method of utilizing the backswing to recharge the capacitor is also possible in the normal system simply by placing an ordinary 500-V diode across the s.c.r. in the reverse direction (D_1 Fig. 3).

Considering the action of the rest of the circuit, when the contact breaker points close, with C_2 charged to 12 volts, a reverse voltage of 12 volts is applied to Tr_3 base which will break down at typically 8 volts. Since this happens every time the points close it will probably result in premature failure of this device.

Another small point in the article is that the standard ignition coil for a 12-volt system without a ballast resistor usually has a 50:1 ratio and not 100:1 as implied in the article, resulting in half the voltage expected.

For the most effective spark it is necessary for the sparking plug tip to be negatively polarized whereas the configuration used by R. M. Marston will result in a positively polarized tip. This can be easily remedied of course by reversing the C.B. and S.W. connections.

I. M. SHAW,
Ferranti Ltd.,
Chadderton,
Lancs.

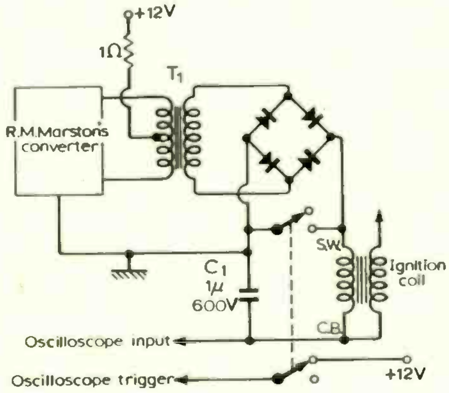


Fig. 1.

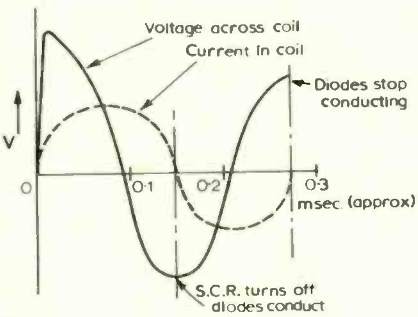


Fig. 2.

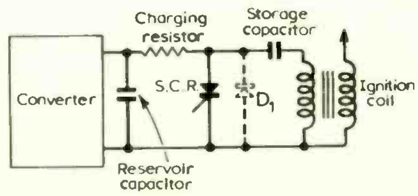


Fig. 3.

May I raise a few points on Mr. R. M. Marston's article on a capacitor-discharge ignition system?

The resonant frequency of 1600Hz quoted corresponds to an inductance of about 10mH in series with capacitor C_1, as the equivalent inductance of a coil. 10mH is approximately the magnetizing inductance of the primary of a conventional ignition coil. During discharge, the secondary is more or less short-circuited, and the relevant inductance is the leakage inductance—approximately 1mH. This gives a resonant frequency of about 5000Hz.

The inverter design is based on a figure of 7.9 turns per volt, and a supply of 16V. Centre-tapping the transformer will halve the turns per volt, and hence double the frequency, with double the hysteresis losses. I realize that the 1 ohm resistor to the centre tap will slightly increase the turns per volt, when on load.

The power transistors will suffer from excessive heat dissipation, as during ignition and most of the charging cycle they will not be saturated. Base drive is not removed during ignition, and the only resistance load during charging is the 1Ω resistance plus the winding resistances in the transformer. The mica-washer, plus insulating varnish, will limit the cooling the transistors can receive. A 2k Ω or 3k Ω wire-wound resistor in series with the secondary winding of the transformer would probably help greatly without excessively increasing the charging time-constant.

J. F. HENDERSON,
Oadby,
Leicester.

In the article on capacitor-discharge ignition the author describes a system where the firing of the s.c.r. short-circuits the secondary of the inverter transformer and stops the inverter oscillation. In my experience this is an unsafe procedure for two reasons: first of all the resistance of the transformer secondary may be sufficiently large for the inverter not to stop oscillating, in which case at the very least excessive power may be consumed and the inverter transistors and the s.c.r. may be damaged by overheating, secondly when an inverter is started the first cycle is often abnormal in containing parasitic oscillations or excess ringing and if the s.c.r. stops the inverter every time it is fired the

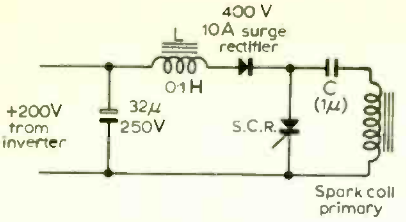


Fig. 1. Inductive charging circuit.

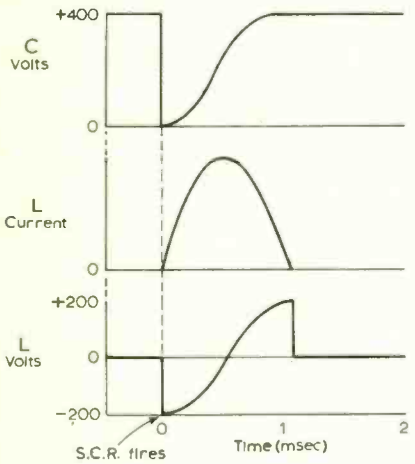


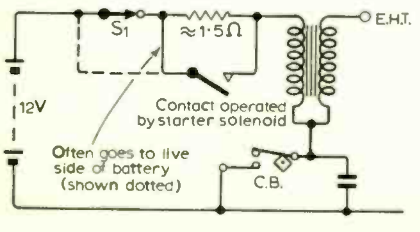
Fig. 2. Waveforms in above circuit.

majority of inverter cycles will be first cycles.

I would suggest instead that the inverter voltage be reduced to 200V and a 32-μF reservoir capacitor follow the bridge rectifier (which now need be only 200V rating) and that the spark capacitor be charged through a 0.1-H choke and a 400-V rectifier as in Fig. 1. The circuit performs as follows: when the s.c.r. is fired C_0 discharges through the spark coil very quickly and the resultant ringing turns off the s.c.r. There is now 200V across the choke and the current in it starts to rise; the series resonant circuit *LC* then oscillates at its fundamental frequency of about 500Hz for half a cycle when the capacitor is at 400V and the current in the choke tries to reverse itself, which it cannot do because of the rectifier (which should have a high surge rating), and the voltage on the choke collapses leaving the capacitor charged to 400V. (Fig. 2.) The advantage of this resonance, besides the voltage doubling, is that there is no series resistance and hence no dissipation—all the power taken from the reservoir capacitor ends up in the spark capacitor. It is also faster.

JAMES M. BRYANT,
Cheltenham,
Gloucester.

Thank you for publishing an electronic ignition system. I hope it does not suffer from the shortcomings of some of the other designs that have appeared, e.g.



s.c.r. 'lock on' due to converter not being turned off, with consequent self-destruction; and relatively large delays (500μs or more) being incorporated in the trigger circuit so as to overcome points-bounce (Mr. Marston's design certainly appears to overcome the second example).

Regarding Fig. 1 of the article, the conventional circuit, many modern cars do not have quite this circuit, but the one shown below. The primary of the coil is rated at about 7 to 8V and a 1.5Ω series resistance is added. The ballast resistor is sometimes in the form of resistive cable from the ignition switch to the coil.

This circuit is used to improve starting, the ballast resistor being short-circuited as the starter solenoid operates. Thus the e.h.t. voltage is much higher than would be the case with the conventional ignition when starting and in theory still gives a good output when the battery voltage drops considerably when starting on a very cold morning.

When using Mr. Marston's circuit with this type of coil, a higher e.h.t. voltage will be obtained and the period of oscillation may be much less than the 600μs quoted (I believe the inductance of the primary of the coil is lower). The ballast resistor must be remembered as the performance will obviously be derated otherwise. Possibly, if it is of the resistive cable type, rather than adding another lead from the ignition switch, it could replace R_6 in the circuit; it would then be in series with the whole circuit. Would this then cause trouble in the triggering circuit?

M. J. MEADOWS,
Bishop's Stortford,
Herts.

The author replies to these and other correspondents:

A large number of letters have been received regarding my "Capacitor-Discharge Ignition System" article, and many different points have been raised. I will try to answer each of these under a suitable heading.

Converter action: In the original article I stated that, when the s.c.r. is on, the converter turns off. This is an over-simplification of circuit action. The converter has a typical output impedance of 3kΩ, so when its output is shorted by the s.c.r. it in fact continues to operate, but does so in a different mode and at a high frequency (typically at tens of kHz); it returns to 50Hz operation within a few μsec of the short being removed. This 'two mode' operation is intentional; converters that are designed to stop completely when their outputs are shorted in this type of application usually have long restart times, and are prone to total restart failure; this point should be self-evident when it is remembered that C_1 is effectively connected across the converter's output, and that C_1 acts as a virtual short circuit when it is fully discharged!

Converter power losses: Under normal running conditions in a 4-cylinder vehicle, the converter consumes roughly 12 watts from the car battery. Under worst-case conditions (at 6000 r.p.m. in a 12-cylinder vehicle), consumption rises to roughly 24 watts. These power levels are well within the handling capabilities of the 2N3055 transistors, and will not result in 'excessive' heat dissipation, as claimed by Mr. Henderson. When the converter output is shorted, current consumption rises to 2.5 amps; the 2N3055 transistors have maximum collector current ratings of 15 amps. At normal running speeds the converter output is shorted for less than 1% of each ignition cycle; the relatively high short-circuit currents thus cause negligible increase in the *mean* current of the converter.

The converter transformer: I designed the converter section around a more-or-less standard type of l.t. transformer because this component is cheap, readily available, and is naturally suited to the two-mode method of operation. I do not recommend the use of ferrite-cored transformers in this application; they may fail to give good restart operation, and may give insufficient overshoot to give good cold-starting characteristics to the vehicle.

Use of a reservoir capacitor: Mr. Bryant recommends the use of a reservoir capacitor across the converter output, and Mr. Shaw shows the same component in his diagram (Fig. 3) of the 'usual' C–D system. The use of such a capacitor is emphatically *not* recommended, since it partially nullifies the effects of backswing and almost invariably results in eventual lock-on of the s.c.r.

C_1 and ignition coil resonant frequency: In the original article I stated that, when the s.c.r. is on, C_1 and the ignition coil form a resonant circuit with a typical resonant frequency of 1600Hz. I quoted this figure because it is the 'conventional' one given in most papers on the subject; the precise figure is of negligible importance. The only important point here is that the spark resulting from the C_1 discharge must be of sufficient duration to ensure proper ignition of the compressed gases in the engine's cylinders. My own investigations in this respect indicate that the minimum acceptable spark times are 20μs; since the spark lasts for roughly one quarter of a resonant cycle, it is evident that the resonant frequency becomes critical only when it exceeds 10kHz. 'Ideal' resonant frequencies, giving good spark generation with minimum power losses, lay between 1.25 and 5kHz (this figure is based on published research data).

C_1 charge time: The *measured* charge time of C_1 is 1.6ms. The capacitor charges from two sources. One of these is the converter, which, with its output impedance of 3kΩ, gives a charge time of 3ms. The second source is the backswing of the C_1-ignition coil resonant circuit. As Mr. Shaw observes, the unit makes use of the backswing or current reversal of the resonant circuit to partially recharge C_1 via the D_3-D_6 network after the s.c.r. has turned off. This backswing gives a considerable reduction in total C_1 charging time, gives substantial energy conservation, and ensures reliable turn-off of the s.c.r. Backswing utilization is virtually standard practice in the U.S.A., where many new vehicles are fitted with C-D ignition as standard equipment; it thus seems strange that Mr. Shaw should refer to backswing utilization as a 'disadvantage'!

Breakdown of Tr_3: Mr. Shaw's point about the possible breakdown of Tr_3 is a fair one, although in practice the absolute peak reverse base current will not exceed 80mA; this is within the device capability when operated in the zener mode, however, so damage is unlikely to result. The risk of damage can be eliminated, if required, by wiring a 180 ohm resistor in series with Tr_3 base.

Ignition coil turns ratio: In the original article I implied a 100:1 turns ratio for the ignition coil, since this is the 'conventional' ratio quoted in most articles. The precise ratio is of little importance, since all coils are (in general terms) designed to give an adequate spark voltage (depending on the individual vehicle's compression ratio) with 300 volts on the primary winding.

Spark plug polarization: The centre electrode of a spark plug is hotter than the outer electrode under normal running conditions; if the centre electrode is negatively polarized, thermionic emission takes place and reduces the plug's ionization voltage by (typically) 30%. In conventional ignition systems this is a mainly academic point, since the benefit is not available under cold start conditions (where it would be of most value), and the available spark voltage is so greatly in excess of engine needs under normal running conditions that the 30% reduction is superfluous. The majority of the world's vehicle manufacturers thus ignore the effect, and use positively polarized plugs. The point is even more academic when the C–D ignition system is used, since the secondary voltage is even more in excess of engine needs. No practical benefit will thus result from modifying the circuit to give negative polarization of the plug electrodes.

Effect of a ballast resistor: As Mr. Meadows points out, the majority of modern vehicles have a ballast resistor wired in series with the ignition coil primary. In conventional (I–D) systems, of course, the coil functions both as an energy store (it passes a typical current of 4.5 amps) and as a step-up transformer; in the energy storage mode the ballast resistor has a considerable effect on the available secondary voltage. In the C–D system, on the other hand, the coil is used purely as a step-up pulse transformer, and primary currents are relatively low; the ballast resistor thus has negligible effect on the secondary voltage, and it makes little difference to the circuit if the ballast resistor is wired in series with the ignition coil or not.

Modifying for 6-volt operation: The unit is designed for 12-volt operation only; it cannot be readily modified for 6-volt operation, and I can give no further information on this subject.

Vehicles with electronic tachometers: Many modern vehicles are fitted with electronic tachometers; in the general case, these devices will operate perfectly well if the vehicle is fitted with the C–D ignition system, but it may be necessary to modify the tachometer connections. I regret, however, that I am unable to give any practical information on this subject.

Supply of components: All components used in the C–D system are available from L.S.T. Components, 7 Coptfold Road, Brentwood, Essex.

Radio interference: A great deal of correspondence has appeared in American journals recently concerning the radio interference that is generated by C–D ignition systems. Interference levels are, of course, affected by the positioning of the C–D unit, and by the type of radio aerial used. Naturally, some correspondents claim that the system gives greater interference than I–D ignition, and others claim that it gives less. The general opinion (by four to one), however, seems to be that C–D ignition gives a lower interference level than I–D ignition.

R. M. MARSTON.

In praise of capacitor-discharge ignition

I read with great interest the article by Mr. Marston on capacitor-discharge ignition in the January issue, as I had been trying, with only limited success, to make up a somewhat similar system published elsewhere several years ago. Since I had already most of the components available, I was quickly able to build up two units and have already fitted them to both my cars. I can confirm several of the author's claims regarding improvement of general performance, but in particular cold starting is outstandingly good on both cars, one having four cylinders and the other six cylinders. No doubt all the other improvements will follow.

I may be able to help other readers contemplating making up the ignition unit but who are daunted by the prospect of (a) finding and (b) re-winding a suitable transformer. From my earlier experiments I already had two ready-made transformers, namely the TT 51/A, made by Repanco and which I bought a few months ago from Henry's Radio at 32s 6d each. It is not quite capable of 400V at 12 battery volts, but is nevertheless quite suitable for the purpose. The actual output voltages range from 200V d.c. at 8V input up to 350V at 13.8V input. On a bench-rig, I could achieve ½in long sparks from an ordinary ignition coil right down to 5V input! At a nominal 12V input, the spark output, which is intense, easily jumps a 1-in gap to earth. In fact, if one motorizes the make-and-break under bench conditions, the resulting high-energy sparking causes quite a concentration of ozone in the room.

An alternative thyristor is the RCA type 40379, which is obtainable in small-order quantities from one of the official agents, Roberts Electronics, of Hitchin, price about 17s. The use of cheap thyristors is not, unless one is lucky enough to get a good one, worth wasting time and money on. The 40379 has the same voltage ratings as the 3525 recommended by Mr. Marston, but is possibly easier to install as it is a wire-in 'low-profile' version.

I would emphasize that the discharge capacitor(s) must have an adequate voltage rating, 600V d.c. being the minimum. A 400V unit will soon fail because of the high-voltage peaks. A final constructional note: all the circuit components, with the exception of the power transistors and the transformer, fit neatly on to a p.c.b. measuring 4½ × 3¾in.

May I offer my thanks to Mr. Marston for his ingenious and reliable s.c.r. firing circuit, which overcame all my earlier troubles with DISCAP ignition, which, to be viable, must offer at least the same reliability as conventional ignition.

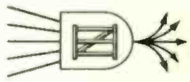
D. E. BOLTON,
Seaford,
Sussex.

New logic symbols?

The article on Logic Symbols in the December issue has prompted me to enclose some new symbols which may be strangers to some of your readers.

E. A. FOULKES,
Billericay,
Essex.

PROPAGATE (Read it aloud): a stream of particles (sheep or cattle) emanating from a single source (or field) and broadcast in independent outputs, offering random impedance to traffic.



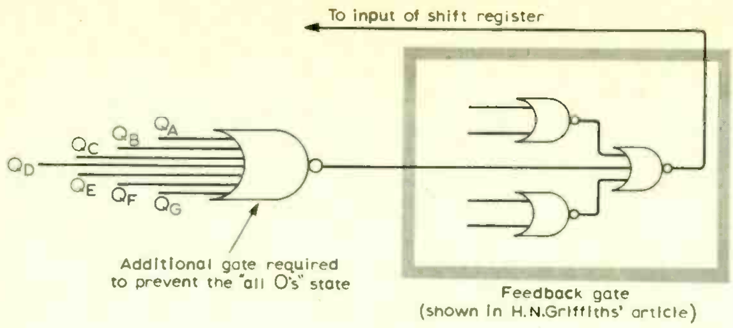
LYCHGATE: a number of inputs and the same number of outputs, except for one which is negated.

COW "AND" GATE: the output is measured in units of pINTAS.

A digital Christmas tree

I was very interested to see the circuit of the pseudo-random sequence generator which was described in the January issue of the *Wireless World* (page 35). I recently constructed a similar unit using SGS RTμL elements (μL914 in the oscillator and feedback gate, μL923 in the shift register, and μL900 as the clock pulse driver), and the following points may be of interest to readers.

First, it is possible to increase the number of outputs to the drivers by two by utilizing the signals which are applied to the J_A and K_A input lines of the shift register. Secondly, the unit will not



function if (on switching on) all the Q outputs are zero. This would be very unusual but it may happen; no matter what one does with the inter-connections between the flip-flops in this type of sequence generator, there will always be one code combination which "locks", and if this is allowed to occur (as it may on switch-on) then the combination firmly refuses to budge. If this occurs, the most satisfactory solution is to employ a circuit to force (at the instant of switch-on) one of the flip-flops to generate a logic 1 signal at its Q output terminal. One possible way of achieving this end is shown in the accompanying figure.

N. M. MORRIS,
North Staffordshire Polytechnic,
Stoke-on-Trent.

Measuring crossover distortion

Mr. Gordon J. King's letter in the October issue states that it is impossible to measure an amplifier's non-linear distortion at low output levels because of the masking effect of residual noise. This is untrue for the orders of noise level and harmonic content cited in his letter.

The "conventional" method of measurement that he refers to (more commonly known as distortion-factor measurement) is essentially a measurement of total impurity rather than of harmonic content alone, so that it is not the most suitable method for assessment of crossover distortion.

Distortion factor may be defined as the ratio between the r.m.s. sum of the impurity components and the r.m.s. value of the total signal; i.e.,

$$DF = \frac{\sqrt{N^2 + D^2}}{S}$$

where S is the total signal voltage, N is the noise voltage, and D is the r.m.s. sum of the harmonic voltage components. Clearly the total harmonic distortion is calculable if the noise level is known. $D/S = \sqrt{DF^2 - (N/S)^2}$. In practice, however, measurement errors become very significant if the noise exceeds the harmonic distortion level by more than about 3dB.

But, as Mr. King states, most of the noise output is amplified noise originating in the early stages; so why does he base his argument on measurements made with the gain control set to maximum? Crossover distortion is entirely a function of the output stage, and, provided earlier stages are not overloaded, there is no reason why the tests should be made at maximum gain.

Applying sufficient test signal input to produce the rated output at full gain, and then turning back the volume control to reduce the output power to 10mW, would reduce the noise together with the signal. The full-power signal-to-noise ratio would be retained at the low level, and a reasonably accurate assessment of the non-linearity could be obtained from a distortion factor measurement. With a signal-to-noise ratio of only 57dB, 0.1% distortion could easily be measured, provided the necessary calculations were made.

The normal test method in a well-equipped laboratory, however, would be that of harmonic analysis; i.e., measurement of each harmonic separately with a wave analyzer.

A good quality wave analyzer normally has a 3dB bandwidth less than 10Hz. This approximates very closely to its noise bandwidth. Since the total noise bandwidth of the amplifier is likely to be at least 30Hz, the noise power in the measurement channel would be some 35dB less than the total noise power. Thus, even if the overall signal-to-noise ratio at the measurement level were as low as 40dB, individual harmonics of less than 0.1% of the fundamental could easily be measured with negligible error from noise interference.

An even more revealing test would be an intermodulation analysis, using a two-tone test signal. For it is surely the intermodulation products that offend Mr. King's sensitive ear rather than the harmonics of 20kHz, which he mentions in his letter.

J. F. GOLDING,
St. Albans,
Herts.

Doctors in industry

In your editorial "Is there a doctor in the house?" you refer to a Royal Society Report entitled "Postgraduate Training in the United Kingdom, Engineering and Technology". Your readers may not be aware that this is a somewhat controversial report prepared by a group of four professors, all of whom are at one London college.

The important practical questions are the prospects for an engineer with a doctorate and the need of industry for such people, which are mentioned in your penultimate paragraph. It is clear that industry does not at present feel a real need for many Ph.Ds, but there are two factors which must be considered. The first is that a generation ago considerable sections of the engineering industry would not tolerate the employment of a university graduate, and the real needs of industry for qualified personnel are not always the same as its immediate wants. The second factor is that the purpose of taking a higher degree should be an improvement in general capability plus training in research methods (the latter is specifically quoted by the Science Research Council as the reason for giving research studentships). It is commonly thought that the effect of taking a higher degree is to narrow a man's interest to the particular specialized topic which forms the subject of his thesis. This ought not to be so, but there is little doubt that it does sometimes happen. We must all continue to be on our guard against it.

D. A. BELL,
Professor of Electronic Engineering,
The University of Hull.

Relay contact symbols

In his article on Graphical Symbols in the February issue, Mr. Amos does not comment on the fact that in his Figs. 8 and 9 the relay contacts are drawn differently from those presented in BS 3939. The British Standard (which states that it coincides with I.E.C. on this point) shows the make and the break contacts both as solid triangles. Mr. Amos shows a solid triangle for the break contact and a hollow triangle for the make contact.

The difference is of no importance if contacts are drawn only for the case where all relay coils are unenergized; there may be redundancy but there is no conflict with the British Standard. However, it is often useful when analysing a system to draw the circuit for various particular states, such as standby, forward run, etc. Here it is of great value to have this convention of a hollow triangle for the make contact so as to be able to show clearly which contacts are in the operated condition.

This is a well-known convention of long standing which for some reason has been ignored in the current edition of BS 3939. To preserve uniformity it should be defined and given in the Standard as a permissible alternative.

JAMES M. LITTLE,
Welwyn Garden City,
Herts.

The author replies:

I am grateful to Mr. Little for pointing out my oversight. To agree with BS 3939, make and break contacts should be shown as solid triangles in Figs. 8 and 9. As Mr. Little implies there is, in general, no need to have different symbols for make and break contacts because the distinction is normally indicated: (a) by the position of the contact symbol relevant to that of the lead to the moving spring, and (b) by the standard convention that moving springs are drawn in the positions they take up when relay coils are unenergized, i.e. make contacts are shown open and break contacts closed.

On the infrequent occasions when make contacts must be shown made and break contacts open, hollow and solid triangles could be used as Mr. Little suggests. B.S.I. considered this suggestion, but decided in the Guiding Principles to BS 3939, due for publication shortly, to recommend that all contacts should be represented by solid triangles and that on any diagram where contact symbols do not follow the normal convention, attention should be drawn to this, e.g. by a note. This decision was adopted because of the tendency in reproduction of diagrams from microfilm for hollow triangles to become solid and, in other reprographic processes, for solid triangles to become hollow.

S. W. AMOS.

Simple linear a.c. voltmeter

On page 578 of your December 1969 issue there appears an article by G. W. Short entitled "Simple Linear A.C. Voltmeter". This describes the connection of a rectifier-type meter between the collector and base of a transistor (via a d.c. blocking capacitor) for the purpose of attaining an almost linear meter scale calibration.

This proposal was made in 1962 by me and is the subject of British Patent No. 1020154 granted to Creed and Co. Ltd. (now ITT Creed) on 27th June 1963. The basis of the proposal is that, if the transistor has a high enough current gain, the current in the feedback path from collector to base is substantially equal to the current flowing from the input terminal to the base, irrespective of the resistance of the feedback path, within the constraint that the d.c. supply voltage is sufficient to permit the collector potential to rise high enough to drive the current through the feedback path.

Since the current in the feedback path, for a given input current, is independent of the resistance of this path, the path can include elements whose resistance depends on current without any effect on the current value. Hence, in the arrangement described, in which the input path is of virtually constant resistance, the current in the feedback path (and thus in the meter) will be proportional at all instants to the potential applied to the input terminal, despite the concomitant variations in rectifier resistance.

There are two minor differences between the diagram in Patent No. 1020154 and that shown in the article. These concern the point of connection of the base-bias resistor (to d.c. supply, or to collector, respectively) and the point of connection of the base-end of the feedback path (to R_{in}/C_1 junction, or to base, respectively). These differences have no significant effect on the principle of operation or on practical performance.

The circuit values quoted in the Specification, merely as an example for a 1 mA f.s.d. movement, were: R_{in} 10kΩ; C_1 8μF; R_1 100kΩ (chosen to give Class A conditions); R_2 10kΩ; C_2 25μF; transistor: current gain not less than 30; meter diodes: OC81; battery: 9 volts, 5mA drain; meter: 1 mA f.s.d.

In practical tests, this circuit provided a 10-volt f.s.d. instrument with an almost undiscernible deviation from linearity, usable also for any multiple of 10 volts without change of scale. By change of resistor R_{in} a 1-volt f.s.d. is attained in which the non-linearity is less than that normally associated with a 40-volt f.s.d. rectifier voltmeter. Further, by use of a lower value of R_{in} a 100 mV f.s.d. is attained in which the non-linearity is only about as much as is normally associated with a 5-volt f.s.d. rectifier voltmeter.

The upper frequency limit of use is set by the transistor and diodes and stray capacitances, while the lower frequency limit is set by the capacitors. It is interesting to note that to a significant extent the increasing impedance presented by C_2 as the frequency drops is catered for in the same way as variation in diode resistance change. If electrolytic capacitors are used the leakage of C_1 must be watched, particularly if the alternating potential to be measured is riding on a d.c. component. It will be necessary to ensure that such a d.c. component polarizes C_1 in the permitted sense, or that C_1 is of the reversible type.

FREDERICK P. MASON,
ITT Creed,
Burgess Hill,
Sussex.

The author replies:

I wasn't aware of Mr. Mason's patent: all honour to him for thinking of it first. He does well to point out the danger of depolarizing C_1. This component is to be regarded, in my voltmeter, as a device for keeping the right d.c. conditions at the base of the transistor rather than a d.c. block to external potentials. For many applications an extra capacitor will have to be added temporarily, or the design modified by substituting a non-polarized capacitor of adequate working voltage. The value of R_2 in Mr. Mason's circuit should, presumably, be 1kΩ, since 10kΩ would absorb too much voltage. Placing C_1 inside the feedback path has the advantage of extending the l.f. response. Connecting R_1 between base and collector makes it unnecessary to adjust the value, if a close-tolerance transistor is used and some slight deviation from optimum d.c. conditions is permissible. C_2 must not present too high an impedance at the lowest frequency of interest, because although the feedback will maintain the response to l.f. signals the risk of peak clipping increases as the impedance of the feedback path increases.

Finally, may I correct a printer's error in the design data in my article? Step (4) should read: $R_2 = (V_{CC} - V_{CE})/I_C$.

G. W. SHORT.

The engineer in State and private enterprise

Contrary to what Mr. Clarke suggests in his letter in the February issue, I have not found that whether a person is an engineer or a technician has much to do with his quality as a person or as an employee. I have known many chartered engineers who do not appear to be able "to apply their training to the solution of any engineering problem", and are only moderately expert in a few special techniques. In contrast to this, I find that the well-trained technician with a broad-based education is often extremely adaptable, and is able to use his training to approach new technical problems with a confidence and lack of conservatism that would be a credit to any chartered engineer.

Perhaps some chartered engineers are "loyal", "outspoken" and "obstinate". The choice of words is curious. I would prefer to hear a good technician, or an engineer for that matter, described as dedicated, reliable or dependable in his work, and tenacious and resourceful in solving problems in his work. I would expect that he would go about his business quietly, and that his standard of social and ethical conduct would be no worse than that of any other section of the community. What differentiates the engineer from the technician is the "nature" of his employment and training, and not the extent to which he is a specialist. It is a serious fault in the order of society that academic achievement continues to be confused with personal quality and high moral calibre. Thus the question of social and ethical standards is irrelevant and ought not to arise.

The question of specialization, on the other hand, is important, as it bears heavily on the kind of training needed by engineers and technicians alike. Insofar as bona-fide technician courses are concerned, I can assure Mr. Clarke that specialist techniques occupy only about 15% of the total time in a five-year part-time course. I suspect that this is a smaller proportion than in a typical engineers' training course.

If more lecturers in technician courses would put away their engineering notes and if more prominent senior **technicians** with vision and insight into a technician's training needs were consulted at the syllabus writing stage, then I see no reason why future technicians should not be every bit as broad-based as the best of engineers. Perhaps it is not too much to hope that this is what Dr. Hazelgrave's committee had in mind.

A. J. SARGENT,
Carshalton,
Surrey.

Swings and Roundabouts

A bottoms up (meaning fundamental) view of the LC circuit

by Thomas Roddam

We have seen in a previous article ("Time", February 1970 issue) that an examination of the way in which current flows in a circuit consisting of one resistor and either one capacitor or one inductor leads us to a simple equation:

$$\frac{dy}{dt} = -\frac{1}{\tau}\cdot y$$

This is the defining equation of a function which turns out to be the exponential function and which, we may as well note now, is defined for all values of the constant τ.

At this stage of our studies we need to keep things simple. The object is, in case you have forgotten, to look fairly closely at some of the concepts we take for granted. We can stick to only two circuit elements by considering a circuit containing only inductance and capacitance. It is not tremendously important how we get charge moving in this circuit, but the arrangement of Fig. 1 will, I hope, lead us to a differential equation rather than an integral equation.

The current source, a high voltage and high resistance, has set up a current $I = I_0$ through the inductor before we start. The contact S_2 is closed, so that there is no charge on the capacitor. And now, at time $t = 0$, we open S_2 and close S_1, leaving the LC circuit isolated. The current in the inductor continues to flow: nothing has yet shown cause why it should not. Thus current flows into the capacitor. Now:

$$\frac{dV}{dt} = \frac{I}{C}$$

The appearance of V is a reason why I should change, and since V will be growing in the sense which opposes the current

$$\frac{dI}{dt} = -\frac{V}{L}$$

We differentiate this to get

$$\frac{d^2I}{dt^2} = -\frac{1}{L}\cdot\frac{dV}{dt} = -\frac{1}{LC}\cdot I$$

If we had chosen a different approach, the integral equation approach, we should have needed to take the boundary conditions in at this stage. They are special to the starting situation and much better forgotten for the moment. We can write this equation conveniently as

$$\frac{d^2I}{dt^2} = -K^2 I.$$

Now we start guessing, or, as it is expressed more elegantly, we use the heuristic method of solution. With L and R we get an exponential function: with C and R we get an exponential function: with L and C, if there is any justice we should get an exponential function, or, perhaps, a pair of them. So we write*:

$$I = \exp mt$$

giving $$dI/dt = m \exp mt$$
$$d^2I/dt^2 = m^2 \exp mt$$

Comparison shows that this works, provided that

$$m^2 = -K^2$$

Don't make a dash for freedom by writing $m = jK$, where j is the well-known square root of -1. (If you use i you are a mathematician and have no business here.) $m = -jK$ is also satisfactory. We keep both forms, since both are good, writing

$$I = \exp(+jKt) + \exp(-jKt)$$

There are some constants to be slipped in, the constants which disappear when you differentiate. These represent, in plain language, the range of the meter used for monitoring I and the time interval between operating the switches and starting the clock. We shall be just as much in need of extra constants if we write:

$$I = \tfrac{1}{2}[\exp(jKt) + \exp(-jKt)]$$

Let us substitute $\zeta = Kt$. Then we have an expression

$$\tfrac{1}{2}[\exp j\zeta + \exp -j\zeta]$$

of which I find Hardy (Pure Mathematics, p. 415) saying: "We are therefore naturally led to adopt the formulae (1) (that is this expression) as the *definition* of cos ζ for all values of ζ." This means that ζ may be real or complex. So now

$$I = \cos(Kt) = \cos[t/(LC)^{\frac{1}{2}}].$$

The conclusion we reach is that the cosine function is the function which is produced by an LC circuit swinging away free. There is, however, an important extra feature which is left out in the beginners' account of this circuit. We have kept matters just formal enough to include the possibility of K being a complex number.

We saw that CR is a time, and L/R is a time, so quite clearly $(CR\,.\,L/R)^{\frac{1}{2}}$ is a time, too. The final form of our current equation is therefore

$$I = \cos(t/\tau)$$

and we have, for the LC circuit, a time constant $\tau = (LC)^{\frac{1}{2}}$.

At this point I feel some sympathy for the young man who once explained to me why he could not design the aerial system I wanted. He agreed that it was described by certain mathematical functions, but, he said hotly: "There's no function theory, only tables." It is not necessary to go through the theory, but it can be shown that for this general function cos ζ the ordinary equations of elementary trigonometry still hold. Cheating slightly, because there is an exponential definition,

$$\sin\zeta = -\cos(\zeta + \pi/2)$$
and $$\cos\zeta = +\sin(\zeta + \pi/2)$$
so that $$\cos(\zeta + \pi) = -\cos\zeta$$
and $$\cos(\zeta + 2\pi) = \cos\zeta$$

With this in mind, we write $1/\tau = f$, and

$$2\pi f = \omega \qquad t' = 2\pi t$$

Finally, then, the old familiar

$$I = \cos(\omega t')$$

Looking back, we have an equation

$$V = -L\, dI/dt,$$

and making use of what we have shown, and the familiar ordinary equations we get

$$V = L \sin(\omega t').$$

Again a familiar result: we are not worrying about scale constants, and we can see that for shape

$$I_{t'} = \cos(\omega t') = \sin(\omega t' + \pi/2)$$
$$= V \sin[\omega(t' + \pi/2\omega)]$$
$$= V_{(t' + \pi/2\omega)}$$

and so on.

* It is easier to type exp (y) than e^y, and in printing it means that y, the bit which really matters, is in type which you can read.

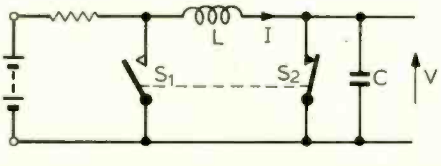


Fig. 1. At $t = 0$, S_1 is closed and S_2 opened.

V reaches a maximum when I is zero: I is a maximum when V is zero, and since energy must be conserved (for sines and cosines go on for ever)

$$LI_{max} = CV_{max}$$

Also, from the equation

$$\cos^2 x + \sin^2 x = 1$$
$$LI^2 + CV^2 = \text{const.}$$

There are several ways in which the practical engineer must concern himself with the facts revealed by this analysis. First of all, what is happening is that energy is stored by the inductor and the capacitor in the way that one holds a hot chestnut, tossing it from hand to hand. We get a similar situation in some active RC systems, where we have two stores, here both capacitors, with an active element to restore the energy lost in the shifting process. This turn and turn about arrangement, in one sense, gives the "tuned circuit" behaviour. There is, however, another way of considering active circuits which we must leave until later.

A second "practical" point is this: for about one-quarter of the characteristic time most of the energy is stored in element A; for the next one-quarter in element B, and then back again. This energy may be considerable, but I am not sure that we know enough yet to do the calculations.

Perhaps the best next step is to find a new function. We have the exponential and the cosine, produced by using two elements at a time. Now let us take three elements, in the circuit of Fig. 2. As before, we get a current I_0 flowing before we start, and then close S_1 and open S_2. As before,

$$\frac{dV}{dt} = \frac{I}{C}$$

Now, however, the voltage drop across the resistor will help to reduce the current through the circuit, and so, of course, will any voltage across the capacitor.

$$L\frac{dI}{dt} = -RI - V$$

Thus $$V = -L\frac{dI}{dt} - RI$$

and $$\frac{dV}{dt} = -L\frac{d^2I}{dt^2} - R\frac{dI}{dt}$$

giving the equation:

$$\frac{d^2I}{dt^2} + \frac{R}{L}\frac{dI}{dt} + \frac{I}{LC} = 0$$

Guessing $I = \exp mt$ we get

$$m^2 + \frac{R}{L}m + \frac{1}{LC} = 0$$

as the defining equation for m. The solution is, of course

$$m = \frac{1}{2}\left[-\frac{R}{L} \pm \sqrt{\frac{R^2}{L^2} - \frac{4}{LC}}\right]$$

There are three possible conditions. If R^2/L^2 is greater than $4/LC$, or, rearranging things, $L/C < R^2/4$, the term under the square root is positive, and so the square root has no j in it. If $L/C = R^2/4$ the two roots run together, a slightly awkward situation. If $L/C > R^2/4$ we have our j term. Let us move the $\frac{1}{2}$ and write:

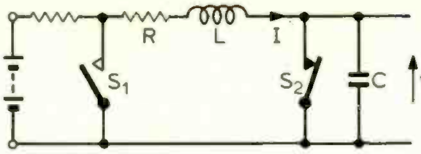


Fig. 2. The circuit of Fig. 1, with resistance added.

$$m = -\frac{R}{2L} \pm j\left[\frac{1}{LC} - \left(\frac{R}{2L}\right)^2\right]^{\frac{1}{2}}$$

Now let us take

$$\left[\frac{1}{LC} - \left(\frac{R}{2L}\right)^2\right]^{\frac{1}{2}} = \omega$$

and then twist things around again:

$$m = \pm j\left[\omega - j\frac{R}{2L}\right]$$

And so $I = \cos(\omega \pm jR/2L)t$, excluding integration constants. As you see, we have progressed from the real circular function, the ordinary cosine, to the general circular function, the cosine of a complex number. The very practical man might say that as he cannot produce ideal inductors and capacitors, this waveform is the one he will use. It is, of course, a damped cosine wave. Before you reject this view, remember just what a spark transmitter produces: that's where our business began.

The more familiar form for the response of the RLC circuit is the form $I = \varepsilon^{-\alpha t}\cos\omega t$, a combination of the two functions we have already encountered. We find that as we add more inductors, capacitors and resistors we do not introduce new functions, but more of the same kind. In the world of passive networks it really is true that electricity comes in sine waves: this is a fundamental dogma of the electric motor designer, who bends only to admit that European and American sine waves do have different frequencies. Notice, though that he designs for sine waves because that is what comes down the wire: what I have tried to show here is that our circuit elements make it natural for us to send sine waves down the wire.

Now we can safely write, for our energy source,

$$V = V_0 \sin\omega t.$$

This is a reasonable sort of basic signal to use, the language of the country. If we apply this signal to an inductor, we have

$$L\frac{dI}{dt} = V = V_0 \sin\omega t$$

and

$$I = -\frac{V_0}{\omega L}\cos\omega t = \frac{V}{\omega L}\sin\left(\omega t - \frac{\pi}{2}\right)$$

Observe how unwieldy this result is. There are two ways of making life a little easier. One is to use the Argand diagram and get the familiar $j\omega$ in by that route. The other is more formal, but does strengthen the foundations. It is the second path which we shall take.

When we took Hardy's definition of the cosine function I did not include his definition of sin ζ. In fact,

$$\cos\zeta = \tfrac{1}{2}(\exp(j\zeta) - \exp(-j\zeta))$$

and

$$\sin\zeta = -\tfrac{1}{2}j(\exp(j\zeta) - \exp(-j\zeta))$$

and

$$\cos\zeta + j\sin\zeta = \exp(j\zeta)$$

The basic signal which we use to test our circuit is, reasonably, $V = V_0 \sin\omega t$, or equally, reasonably $V = V_0 \cos\omega t$. If we apply a combination of these two signals together, $V = V_0(\cos\omega t + j\sin\omega t)$ we can write for our inductor

$$L\frac{dI}{dt} = V_0 \exp(j\omega t)$$

$$I = \frac{V_0}{j\omega L}\cdot\exp(j\omega t) = \frac{V}{j\omega L}$$

This, as you would expect, is the familiar general form of Ohm's Law. We could, in the same way, arrive at $V/I = 1/j\omega C$. There is only the worrying feeling that somehow, in adopting the $\cos + j\sin$ approach there is a slight swindle. What is the hidden catch?

The astute reader will have spotted the catch. The basic signal we have used for mathematical purposes is a fiction. What we actually see on the oscilloscope is $\cos\omega t$ or $\sin\omega t$. Plumping for cos, what we see is

Real Part of $\exp(j\omega t)$,

and so, in fact

$$I = \frac{V_0}{\omega L} \times \text{R.P. of}\left(\frac{\exp j\omega t}{j}\right)$$
$$= \frac{V_0}{\omega L} \times \text{R.P. of}\left(\sin\omega t + \frac{1}{j}\cos\omega t\right)$$
$$= \frac{V_0}{\omega L}\cdot\sin\omega t$$

That j in $j\omega L$ is not really there; you only imagined it. However, this is not a lot of airy-fairy nonsense. There are some pretty real implications. As a simple example, we have seen that the mathematics of the LC circuit throws up a time constant $(LC)^{\frac{1}{2}}$, which we write as $1/\omega$. But in fact the solution is not just one angular frequency ω, but two, $+\omega$ and $-\omega$. In many modulator problems we find that if we forget the $-\omega$ term we finish up with some unwanted products in the working frequency band. These products arise from the simple fact that

$\cos(-\omega t)$ looks just the same as $\cos(\omega t)$ to the load.

The choice of $\exp(j\omega t)$ is, in a way, a simplification, a throwing away of one of the frequencies, $-\omega$, which the natural circuit demands. The price paid for this simplification is that at the end of the day we must pay the bill by taking the real part of the solution. The important thing is that you do not need to pay until the end of the day, and very often you do not realize that you have paid at all.

Let us consider the circuit made up of resistance and inductance in series. Normally we just write down the impedance

$$Z = R + j\omega L$$

If we force a current I through this, we get a voltage $V = ZI$ across the terminals. Now, if we write R.P. on the slate, and

$$I = I_0(\cos \omega t + j \sin \omega t) = I_0 \exp (j\omega t)$$

$$V = I_0[R \cos \omega t + jR \sin \omega t + j\omega L \cos \omega t - \omega L \sin \omega t]$$

$$= I_0[R \cos \omega t - \omega L \sin \omega t + j(R \sin \omega t + \omega L \cos \omega t)]$$

Here we pay the real part bill and say

$$V = I_0(R \cos \omega t - \omega L \sin \omega t)$$

$$= I_0(R^2 + \omega^2 L^2)^{\frac{1}{2}} \times \left[\frac{R}{(R^2+\omega^2L^2)^{\frac{1}{2}}} \cos \omega t - \frac{\omega L}{(R^2+\omega^2L^2)^{\frac{1}{2}}} \cdot \sin \omega t\right]$$

$$V = I_0 \cdot (R^2 + \omega^2 L^2)^{\frac{1}{2}} \cdot \cos (\omega t + \phi)$$

where

$$\cos \phi = R/(R^2 + \omega^2 L^2)^{\frac{1}{2}}$$

We need not have put in this real part step, if we had started with

$$I = I_0(\exp (j\omega t) + \exp (-j\omega t))$$

Then the terms $\cos \omega t$ and $\omega \sin \omega t$ would have remained, but

$$\sin (\omega t) + \sin (-\omega t)$$

and $\omega \cos \omega t + (-\omega \cos (-\omega t))$

both vanish, eliminating the imaginary part automatically. The use of the real part operation simply enables us to cut our expressions down in size while we are manipulating them.

At this stage we can summarize our results so far as revealing to us the idea of a characteristic time, or time constant, for *RL* or *RC* circuits, a characteristic frequency, $1/\sqrt{LC}$, for *LC* circuits, which is actually a frequency pair, $\pm\omega$. For the *RLC* circuit we have a rather more complicated looking characteristic frequency pair, $\pm(\omega - jR/2L)$. The rather special behaviour of the pure *LC* circuit has the practical advantage that since it goes on and on it is very convenient for circuit testing. If we choose to make use of this special case we get some rather simple concepts, like reactance, with nice simple expressions like $R + j\omega L$. We evolve procedures which enable us to dodge, most of the time, the debt we owe for this simplicity. Fourier analysis and the superposition theorem justify us, in general terms, but philosophically it is a bit thin. A single pure tone is meaningless. Its message is zero. One hundred such tones together: one hundred times nowt, in my part of the world, is still nowt. One might say that it is the small print well along in the Fourier series which really carries the information which matters.

I am labouring this point because I feel that the experimental and theoretical simplicity of the sine-wave analysis tend to turn it into a closed technique. You get to this point, you can bash away with the $j\omega$ terms and watch the pretty sine waves on the scope, and there it all is. All there is to stop you is the sheer labour of handling the long expressions you get with a dozen or so mixed circuit elements. If you regard it as a closed technique you need a lot of mental energy to break out of the circle. Your elders and betters knew this and made "Don't fence me in" their theme song.

Implicitly we have been assuming that *R* was the resistance of an ordinary passive resistor. When this is so, the closed circle of sine-wave users is justified, because with any other waveform, or almost any other, the transient at $t = 0$, the time we switch on, may dominate the behaviour until the decaying drive is too small to be useful for measurement. If, however, we make *R* a negative quantity, by tricks with active elements, we get a signal which grows exponentially out of the inherent circuit noise. Behaviour under these conditions may be studied more easily by using the complex frequency concept.

In the end, however, the real point is that the complex frequency concept is just the beginning of a whole field of circuit studies. It is to this subject that I shall turn in another article.

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Further details are obtainable from the addresses in parentheses

LONDON

Mar. 2-5 Alexandra Palace
Physics Exhibition
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Mar. 10-12 Camden Town Hall
Sound '70 International
(Association of Public Address Engineers, 394 Northolt Rd., South Harrow, Middx.)

Mar. 17-19 Savoy Place
Electrical Methods of Machining, Forming and Coating
(I.E.E., Savoy Pl., London W.C.2)

BRIGHTON

Mar. 2-6 Exhibition Halls
Engineering Design Show
(Business Conferences & Exhibitions, Mercury House, Waterloo Rd., London S.E.1)

CAMBRIDGE

Mar. 19-22 Churchill College
Television Tomorrow
(Royal Television Society, 166 Shaftesbury Ave., London W.C.2)

CRANFIELD

Mar. 23-26 College of Aeronautics
Aerospace Instrumentation Symposium
(N. O. Matthews, Dept. of Flight, College of Aeronautics, Cranfield, Beds.)

EDINBURGH

Mar. 17-20 The University
Management and Economics in the Electronics Industry
(D. J. T. Williams, Ferranti Ltd., Ferry Rd., Edinburgh 5)

OVERSEAS

Mar. 5-10 Paris
Audio Festival
(Fed. Nat. des Ind. Electroniques, 16 rue de Presles, Paris 15)

Mar. 11-13 Zurich
Digital Processing of Analogue Signals
(E. H. Rothauser, I.B.M. Research Lab., Zurich)

Mar. 11–13 Washington
Scintillation and Semiconductor Counter Symposium
(Louis Costrell, Radiation Physics Inst. Section, N.B.S., Washington, D.C. 20234)

Mar. 17–19 Freiburg
Field Effect Transistors
(H. H. Burghoff, Stresemann Allee 21, 6 Frankfurt/Main)

Mar. 18–21 Nairobi
Electro 70 Show
(Electronics Institution of East Africa, P.O. Box 9690, Nairobi, Kenya)

Mar. 23–26 New York
I.E.E.E. Convention & Exhibition
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

Simple Active Filters

Design procedure

by M. Bronzite, B.Sc.

In recent years there has been much work on low-frequency active filters using twin-tee, op-amps, n.i.cs, and gyrators. For all of these, the calculation of the necessary frequency selective components can be tedious, and some knowledge of filter theory is desirable in order to match the chosen type of filter to the particular requirement. It is, perhaps, time to re-examine a simpler structure using unity-gain amplifiers[1,2], which lends itself to rapid design without the use of precision components, yet is stable and may be readily "bread-boarded".

This design of a low- or high-pass filter will rely on evaluating three dependent variables, any two of which may be used to determine the third: (1) the pass-band ripple (m dB), which constitutes the variation in output over the whole of the pass-band with a constant amplitude input; (2) the reject-band attenuation, one useful measure of this being the attenuation one octave away from the pass-band limit; and (3) the order of the filter (N) which is the number of filter elements required to achieve a given performance. Given, say, (1) and (2), this article will describe how the rest of the design may be accomplished.

The filter itself consists of simple units which are added together to provide the required complexity, and these units are shown in Fig. 1 along with the pertinent design equations. With types (a) and (d) the first set of components (R_1C_1) may be designed independently of the second set (R_2C_2), whereas in types (b) and (e) the series elements are equal in value, giving an advantage of one less active element being used at the cost of reduced component flexibility. Due to the amplifier isolation, each unit can be considered without regard to the requirements of other units and can even be separated from them by intervening linear circuitry without degrading the overall performance. In many cases, a value of C is chosen and the value of R is calculated on the grounds of restricted capacitor availability, and this tends to favour the use of units (a) and (e) for low- and high-pass filters respectively, since (b) requires two capacitor values and (d) requires two amplifiers. The unity gain amplifiers can consist of any available active element with a gain of $1 \pm 0{\cdot}05$ assuming the filter performance is not required to be too stringent. (Naturally, a very "tight" specification would demand both precision components and an accurate amplifier). Thus op-amps and emitter followers are of immediate application but some care must be taken with the design of source and cathode followers since their transmission characteristics can be significantly less than 0·95. The drive capability will depend on the source and load presented to the amplifier; i.e., using unit (d) from Fig. 1, if R_2 is much larger than R_1, then a Darlington pair would be used for the second amplifier, but if R_2 is very roughly equal to or smaller than R_1 then a simple emitter follower is suitable.

Now a filter pass-band limit may be defined as either the frequency at which the output has diminished by m dB (f_m) or the frequency where it has diminished by 3 dB (f_{3dB}) and obviously the attenuation in the first octave after this point will depend on which criterion is chosen. In the latter case, the filter performance is related to f_{3dB} and it is necessary to generate the equivalent value of f_m in order to apply the design equations given in Fig. 1. This is done by means of a coefficient β which is given in Table 3 for various values of ripple and order of filter, and the appropriate conversion equations are appended to the table. The calculation of β itself is derived from ref. 3.

The only matter outstanding to finish the design is the value of T_n and this is given in Tables 1 and 2, with an outline of its derivation given in the appendix. The tables contain nine groups of figures of which the first eight generate a Chebychev response ($m \neq 0$) and the last one generates a Butterworth response ($m = 0$ and $f_m = f_{3dB}$). The figures quoted in the attenuation column cater for the two different cases discussed above, and it would seem practical to use the first when m is large and the second when m is small. In any case, these attenuation figures were extrapolated from graphical sources[1,4,5] and can only be considered as approximate with a maximum error of $\pm 5\%$ on the quoted figure. While on the subject of attenuation it should be recalled as a rough rule of thumb that all the filters have a roll-off of $6N$ dB/octave after the first octave. Thus a five element 1-dB low-pass filter with a pass-band limit of 1 kHz will be 1 dB down at 1 kHz, 45 dB down at 2kHz (from Table 1), 75 dB down

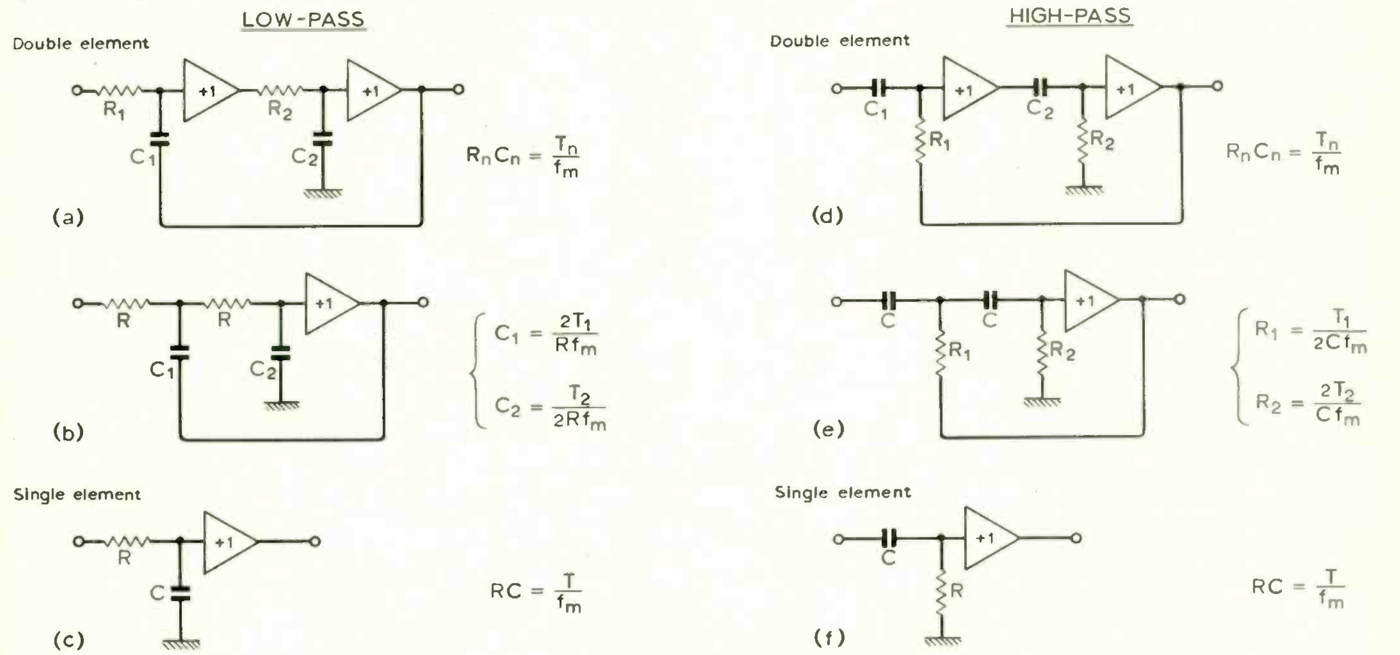

Fig. 1. Block configurations.

at 4 kHz (45+6×5), and so on. For more accurate figures, refs. 1 and 4 may be consulted, although the values given in the tables will be found adequate in the majority of case.

Having covered the process of design, two examples will be given to illustrate the approach. The first concerns a low-pass filter with a maximum permitted in-band variation of 2%, f_{3dB} = 4·5 kHz, and the first octave attenuation must be in excess of 50 dB. Now 2% is approximately 0·2 dB so $m = 0{\cdot}1$. Examination of Table 1 gives a value of $N = 6$ for 52 dB of attenuation. Moving to Table 3, for the given values of m and N it is found that $\beta = 1{\cdot}093$, and this in turn gives $f_m = 4{\cdot}5/1{\cdot}093 = 4{\cdot}12$ kHz. Returning to Table 1, $T_1 = 0{\cdot}69383$ for the first Double . . . and the rest of the design is straightforward, having agreed on which unit to use. The second example will be worked out in full and consists of a high-pass filter with a pass-band ripple of less than 10%, f_m = 100 Hz, and 50 Hz rejection must be better than 35 dB. Selecting $m = 0{\cdot}5$ (6%) gives the required order as $N = 5$ with 42 dB attenuation. It was arbitarily decided to use a 0·1-μF capacitor throughout, and the filter would consist of two (e) units with one (f) unit. Thus, with T_n selected from Table 2, for the first unit, D_1, $R_1 = 0{\cdot}0356/(2\times0{\cdot}1\times10^{-6}\times100) = 1{\cdot}78$ kΩ, $R_2 = 2\times0{\cdot}736/(0{\cdot}1\times10^{-6}\times100) = 147{\cdot}2$ kΩ; for D_2, $R_1 = 0{\cdot}0933/(2\times0{\cdot}1\times10^{-6}\times100) = 4{\cdot}66$ kΩ, $R_2 = 2\times0{\cdot}129/(0{\cdot}1\times10^{-6}\times100) = 25{\cdot}8$ kΩ; and for the (f) unit $R = 0{\cdot}0577/(0{\cdot}1\times10^{-6}\times100) = 5{\cdot}77$ kΩ. The final circuit is shown in Fig. 2 where the resistors are 5% and the capacitors are 10% tolerance. As this is a high-pass filter it is a good practice to decouple the h.t. lines, although it is hardly ever necessary for the low-pass circuits. The performance is shown in Fig. 3, and owing to the use of a relatively high distortion input signal there was some 2nd harmonic breakthrough below 30 dB which reduced the effective accuracy of measurement.

With the design established, some of the limitations of the filter will now be discussed and these should be borne in mind when considering a given filter for a given application. In the first place, no mention has been made of the pulse response of these filters and in general it can be said that the higher the ripple, and the higher the order, the more the overshoot on the output to a square-wave input. Where the matter is critical then Thomson filters[6, 7] should be used, and using say, the values given in ref. 7, and applying the method given in the Appendix, values of T_n suitable for a maximally-flat delay filter may be readily found. On a more mundane subject care must be taken that the input amplitude does not approach that of the h.t. supplies. Apart from the problem that the emitter followers will have a large variation in output current (this can be minimized by using constant-current generators as emitter loads), amplification occurs in the heart of the filter, especially near the pass-band limit, which is not seen either at the input or output. Again, the higher the ripple, and the higher the order, the more the gain, and in practice, gains in the order of 6 dB or more may be encountered. However, an empirical approach will soon establish the extent of the problem and the permitted input levels for a given supply may be easily found. The choice of active element will depend to a certain extent on the frequency of operation envisaged. At the v.l.f. end, in order to keep the size of capacitors to reasonable proportions (and with exact requirements it is far easier to obtain low value precision capacitors), Darlington pairs of f.e.ts should be used which permit resistors in excess of 10 MΩ. At the h.f. end, high f_T transistors permit reliable operation up to, say, 10 MHz, in direct contradistinction to op-amp filters where 100 kHz represents a sensible limit. With this range, and using high density packaging for the active elements, video band-pass amplifiers without transformers or chokes become a distinct possibility. Again, d.c. offsets may dictate the selection of components; e.g., in a digital filter where

TABLE 1
Low-pass coefficients

Ripple order	Elements	Att. 1st octave		D_1		D_2		D_3		Single
m dB	N	m dB	3 dB	T_1	T_2	T_1	T_2	T_1	T_2	T
3·000	2	17	17	0·24679	0·14498					
	3	28	28	0·53297	0·05664					0·53297
	4	39	39	0·93434	0·03002	0·38701	0·33397			
	5	51	51	1·45056	0·01866	0·55407	0·12126			0·89650
	6	62	62	2·08158	0·01274	0·76191	0·06371	0·55776	0·51140	
	7	75	75	2·82735	0·00927	1·00907	0·04002	0·69830	0·17759	1·25829
2·000	2	14	16	0·19800	0·15543					
	3	26	27	0·43142	0·06626					0·43142
	4	38	37	0·75870	0·03595	0·31426	0·36378			
	5	48	49	1·17961	0·02255	0·45057	0·14299			0·72904
	6	60	60	1·69411	0·01548	0·62009	0·07665	0·45393	0·55843	
	7	73	72	2·30217	0·01129	0·82164	0·04852	0·56859	0·20976	1·02456
1·000	2	11	15	0·14499	0·15847					
	3	22	26	0·32207	0·07911					0·32207
	4	34	36	0·57030	0·04502	0·23623	0·38378			
	5	45	47	0·88955	0·02881	0·33978	0·17365			0·54977
	6	57	58	1·27977	0·01998	0·46843	0·09696	0·34291	0·59233	
	7	70	69	1·74096	0·01466	0·62134	0·06239	0·42998	0·25563	0·77480
0·500	2	8	14	0·11164	0·14965					
	3	19	24	0·25406	0·08727					0·25406
	4	30	34	0·45381	0·05248	0·18798	0·37808			
	5	42	44	0·71075	0·03441	0·27148	0·19570			0·43927
	6	54	55	1·02482	0·02416	0·37511	0·11445	0·27460	0·58755	
	7	67	66	1·39602	0·01786	0·49823	0·07511	0·34479	0·28938	0·62129
0·100	2	3	13	0·06709	0·11393					
	3	12	22	0·16418	0·09131					0·16418
	4	23	31	0·30125	0·06322	0·12478	0·32588			
	5	35	40	0·47785	0·04436	0·18252	0·21824			0·29533
	6	47	52	0·69383	0·03233	0·25396	0·14323	0·18591	0·51735	
	7	61	62	0·94915	0·02443	0·33875	0·09928	0·23442	0·32722	0·42241
0·050	2	2	12	0·05509	0·09839					
	3	10	21	0·13996	0·08858					0·13996
	4	21	30	0·26049	0·06523	0·10790	0·29955			
	5	33	39	0·41602	0·04728	0·15890	0·21876			0·25711
	6	45	50	0·60633	0·03510	0·22193	0·15075	0·16246	0·48102	
	7	57	60	0·83134	0·02683	0·29670	0·10721	0·20533	0·33048	0·36998
0·010	2	0·5	12	0·03572	0·06802					
	3	5	20	0·10014	0·07721					0·10014
	4	15	28	0·19368	0·06519	0·08023	0·24303			
	5	27	37	0·31514	0·05112	0·12037	0·20768			0·19477
	6	39	47	0·46410	0·03978	0·16987	0·15882	0·12436	0·40265	
	7	51	58	0·64039	0·03133	0·22855	0·12006	0·15816	0·32024	0·28500
0·005	2	0·1	12	0·02982	0·05762					
	3	3	19	0·08757	0·07137					0·08757
	4	12	27	0·17258	0·06366	0·07148	0·22170			
	5	24	36	0·28339	0·05166	0·10825	0·19980			0·17515
	6	36	46	0·41950	0·04107	0·15355	0·15905	0·11241	0·37299	
	7	48	56	0·58069	0·03280	0·20725	0·12339	0·14342	0·31121	0·25843
0·000	2		12	0·11254	0·22508					
	3		18	0·15916	0·15916					0·15916
	4		24	0·08613	0·29408	0·20795	0·12181			
	5		30	0·09836	0·25752	0·25752	0·09836			0·15916
	6		36	0·08238	0·30746	0·11254	0·22508	0·30746	0·08239	
	7		42	0·08832	0·28679	0·12763	0·19846	0·35762	0·07083	0·15916

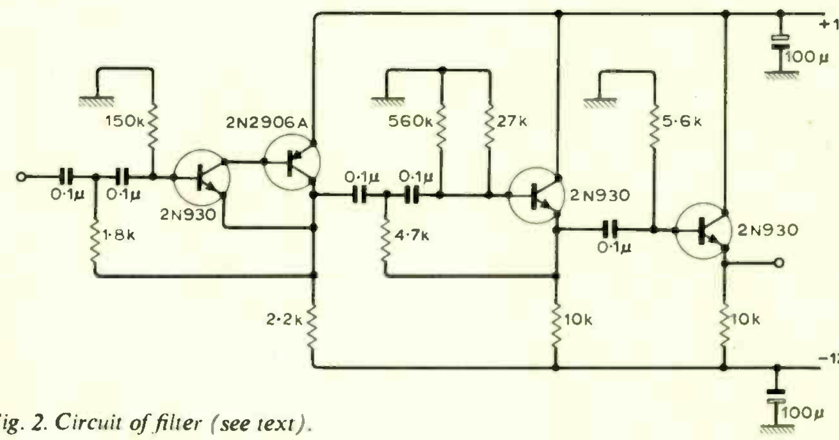

Fig. 2. Circuit of filter (see text).

TABLE 2
High-pass coefficients

Ripple order	Elements	Att. 1st octave		D1		D2		D3		Single
m dB	*N*	*m* dB	3 dB	T_1	T_2	T_1	T_2	T_1	T_2	T
3·000	2	17	17	0·10264	0·17472					
	3	28	28	0·04753	0·44725					0·04753
	4	39	39	0·02711	0·84379	0·06545	0·07585			
	5	51	51	0·01746	1·35776	0·04572	0·20889			0·02825
	6	62	62	0·01217	1·98755	0·03325	0·39758	0·04541	0·04953	
	7	75	75	0·00896	2·73259	0·02510	0·63295	0·03627	0·14263	0·02013
2·000	2	14	16	0·12793	0·16297					
	3	26	27	0·05871	0·38228					0·05871
	4	38	37	0·03339	0·70458	0·08060	0·06963			
	5	48	49	0·02147	1·12319	0·05622	0·17714			0·03474
	6	60	60	0·01495	1·63643	0·04085	0·33047	0·05580	0·04536	
	7	73	72	0·01100	2·24373	0·03083	0·52206	0·04455	0·12076	0·02472
1·000	2	11	15	0·17471	0·15985					
	3	22	26	0·07865	0·32020					0·07865
	4	34	36	0·04442	0·56261	0·10723	0·06600			
	5	45	47	0·02848	0·87916	0·07455	0·14587			0·04607
	6	57	58	0·01979	1·26791	0·05407	0·26125	0·07387	0·04276	
	7	70	69	0·01455	1·72822	0·04077	0·40602	0·05891	0·09909	0·03269
0·500	2	8	14	0·22690	0·16927					
	3	19	24	0·09970	0·29025					0·09970
	4	30	34	0·05582	0·48264	0·13475	0·06700			
	5	42	44	0·03564	0·73618	0·09330	0·12943			0·05766
	6	54	55	0·02472	1·04842	0·06753	0·22132	0·09224	0·04311	
	7	67	66	0·01814	1·41851	0·05084	0·33725	0·07347	0·08753	0·04077
0·100	2	3	13	0·37757	0·22233					
	3	12	22	0·15429	0·27742					0·15429
	4	23	31	0·08408	0·40067	0·20300	0·07773			
	5	35	40	0·05301	0·57100	0·13878	0·11607			0·08577
	6	47	52	0·03651	0·78360	0·09974	0·17685	0·13625	0·04896	
	7	61	62	0·02669	1·03689	0·07478	0·25515	0·10806	0·07741	0·05997
0·050	2	2	12	0·45981	0·25745					
	3	10	21	0·18098	0·28595					0·18098
	4	21	30	0·09724	0·38834	0·23476	0·08456			
	5	33	39	0·06089	0·53570	0·15941	0·11579			0·09852
	6	45	50	0·04178	0·72162	0·11414	0·16803	0·15591	0·05266	
	7	57	60	0·03047	0·94402	0·08537	0·23627	0·12337	0·07665	0·06846
0·010	2	0·5	12	0·70912	0·37242					
	3	5	20	0·25296	0·32806					0·25296
	4	15	28	0·13078	0·38858	0·31574	0·10423			
	5	27	37	0·08038	0·49548	0·21043	0·12197			0·13005
	6	39	47	0·05458	0·63671	0·14911	0·15949	0·20369	0·06291	
	7	51	58	0·03955	0·80839	0·11083	0·21098	0·16015	0·07910	0·08888
0·005	2	0·1	12	0·84936	0·43959					
	3	3	19	0·28925	0·35493					0·28925
	4	12	27	0·14678	0·39787	0·35436	0·11426			
	5	24	36	0·08938	0·49034	0·23401	0·12678			0·14462
	6	36	46	0·06038	0·61675	0·16497	0·15926	0·22535	0·06791	
	7	48	56	0·04362	0·77218	0·12222	0·20528	0·17662	0·08139	0·09802
0·000	2		12	0·22508	0·12254					
	3		18	0·15916	0·15916					0·15916
	4		24	0·29408	0·08613	0·12181	0·20795			
	5		30	0·25752	0·09836	0·09836	0·25752			0·15916
	6		36	0·30746	0·08238	0·22508	0·11254	0·08239	0·30746	
	7		42	0·28679	0·08832	0·19846	0·12763	0·07083	0·35762	0·15916

a number of identical low-pass units are used, and any offsets would constitute a serious noise problem. In this case, a first order palliative would be to use p-n-p alternating with n-p-n transistors for the first and second amplifiers ("throwing in" an extra emitter follower if N is odd), but if this is not good enough then it will be necessary to revert to feedback amplifiers to provide the unity gain.

Appendix

The following analysis will indicate the way in which T_n has been calculated for Tables 1 and 2, and will show how the method may be used for creating other types of filters (such as Thomson). Considering unit (a) in Fig. 1:

Assume $\left.\begin{aligned} 1/R_{in} &= 0 \\ R_0 &= 0 \\ \text{Gain} &= 1 \end{aligned}\right\}$ for the amplifiers,

and v_{in} = input voltage
v_0 = output voltage of second amplifier
v_1 = output voltage of first amplifier
G = transmission function of unit

and let $p_n = \omega C_n R_n$

then $$v_1 = \frac{v_{in} - v_0}{1 + jp_1} + v_0 = \frac{(v_{in} + jp_1 v_0)}{1 + jp_1}$$

and $$v_0 = \frac{v_{in} + jp_1 v_0}{(1 + jp_1)(1 + jp_2)}$$

i.e. $$v_0 = \frac{v_{in}}{(1 + jp_1)(1 + jp_2) - jp_1}$$

or $$G = \frac{1}{-p_1 p_2 + jp_2 + 1}$$

Putting $s = j\omega$ and $t_n = R_n C_n$

then $$G = \frac{1}{s^2 t_1 t_2 + st_2 + 1}$$

or $$G = \frac{1/(t_1 t_2)}{s^2 + s/t_1 + 1/(t_1 t_2)}$$

and similar expressions can be developed for the other double units. Now, any filter with zeroes at infinity can be expressed as

$$G = [(s^2 + as + b)(s^2 + cs + d) \ldots]^{-1} \times \alpha$$

where $\alpha = 1$ for low-pass filters and $\alpha = s^N$ for high-pass filters, and the values of a, b, c, d, ... can be found from the mathematical formulation of the filter under consideration. (Thus for a Butterworth two-element network, $a = 1{\cdot}414$ and $b = 1{\cdot}000$, while for a Thomson four-element network $a = 5{\cdot}792$, and $b = 9{\cdot}140$, and so on.)

Then, taking the first quadratic expression and equating coefficients,

$$a = 1/t_1$$
$$b = 1/(t_1 t_2)$$

i.e., $$t_1 = 1/a$$
$$t_2 = a/b$$

But the above expressions are related to the angular frequency $\omega = 1$, and must be converted to $f = f_m$, giving

$$t_1 = 1/(2\pi f_m a)$$
$$t_2 = a/(2\pi f_m b)$$

i.e., $R_1 C_1 = T_1/f_m$ where $T_1 = 1/(2\pi a)$
$R_2 C_2 = T_2/f_m$ where $T_2 = a/(2\pi b)$

TABLE 3
Value of coefficient β for $f_{3\,dB}$ filters

	m = 0·500	0·100	0·050	0·010	0·005
N = 2	1·390	1·943	2·268	2·867	3·903
3	1·167	1·389	1·512	1·728	2·075
4	1·093	1·213	1·278	1·390	1·566
5	1·059	1·135	1·175	1·245	1·351
6	1·041	1·093	1·121	1·168	1·240
7	1·030	1·068	1·088	1·122	1·175

Low-pass: $f_m = f_{3\,dB}/\beta$
High-pass: $f_m = f_{3\,dB}\,\beta$

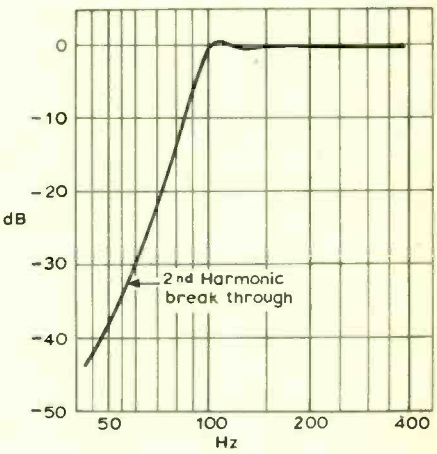

Fig. 3. Performance of filter

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News of the Month

Mediator cleared for take-off in 1971

Mediator, the computer-assisted air traffic control system, will go into service at West Drayton (West London) early in 1971 and will replace existing facilities now being used at Heathrow airport.

Following the publicity given to the recent near collision of two aircraft the press were invited to have a look at the preparations being made for Mediator, and other a.t.c. systems, at the College of Air Traffic Control and the Air Traffic Control Evaluation Unit at Bournemouth airport.

Arnold Field, director of the National Air Traffic Control Service, likened a.t.c. to a high-speed game of three-dimensional chess. The magnitude of the problem, discussed in *Wireless World* (Nov. 1969, p.511), was vividly demonstrated in a speeded up film of a radar display covering the London area. Incoming, outgoing and over-flying aircraft looked like a swarm of angry bees round a jam-pot.

At the present time controllers from Heathrow are being brought to Bournemouth for a course in using the Mediator system. The method employed to realistically simulate air movements during these courses is of great interest. However, the simulator is not only used for teaching, it was, and still is being, used in evaluating and developing Mediator procedures.

The simulator consists of three distinct sections: a Ferranti 1600 Hermes computer, the "pilots" who have alphanumeric displays and key boards, and the trainee controllers who have a radar display of the area they are covering. The computer drives the "pilots" alphanumeric displays and the controllers radar displays. Simulated r.t. communication is provided between the controllers and the "pilots". In practice one person will act as pilot for several "aircraft".

A program containing the detailed flight plans of up to 80 aircraft, any of which can fall into one of ten performance categories, is fed to the computer. The computer also simulates four radar stations and 500 navigational beacons; each "radar station" can consist of one primary and one secondary radar installation. The radar displays are presented to the controllers in standard form.

If left unattended the computer will fly the programmed aircraft through the airspace in accordance with the flight plans; either landing, taking-off or overflying as the case may be. The controllers get a radar picture of all the aircraft in the airspace and can contact the "pilot" of any aircraft on one of the nine available r.t. frequencies.

There are therefore nine pilot positions and one "pilot" will handle all the aircraft on a particular r.t. frequency.

The system works as follows. As soon as the program flies an "aircraft" into the controlled air space a blip will appear on the appropriate radar display in the correct position. At the same time one of forty buttons available to each "pilot" lights up. The "pilot" presses the button and an alphanumeric display gives all the details, to the "pilot" only, of the aircraft. These details include the call-sign, position, speed, height, type, etc, of the simulated aircraft. The pilot labels the button he has pressed with the aircraft call-sign. Repressing this button at any time lets the "pilot" see the current position of the aircraft he is "flying".

As the program continues more and more aircraft enter the airspace and the computer allocates a "pilot's" button for each; the particular "pilot" selected by the computer depends on the "aircraft's" r.t. frequency. The controllers have to ensure that all the aircraft are properly spaced out and that none of the current air traffic regulations are contravened. If a hazardous situation is developing the appropriate controller contacts the "pilot" on the correct r.t. frequency in the same way as is done in real life. The "pilot" then presses the button allocated to the aircraft by call sign and obtains an alphanumeric display of the aircraft's current situation from which he can give the information requested by the controller. If the controller requests say a course or altitude change the "pilot" can feed this information into the computer via a key-board. The computer alters its program in accordance with the instructions and controls the radar and alphanumeric displays appropriately.

The system simulates accurately air traffic control problems as far as the controller is concerned and can lead to some quite heated situations. After an exercise the results of particular actions can be studied and analysed.

This is only one facet of the great variety of work being carried out at the Bournemouth establishment and airline passengers can rest assured that a large number of people are working very hard to ensure their safety.

Controllers at work during a Mediator simulation. Recently the equipment was used to determine which was the best site for London's third airport from an air traffic control point-of-view; Foulness came out tops.

New weather satellite

In January, almost ten years after the first operational weather satellite, TIROS-1, was launched (April 1960), the first of a new series of weather satellites, called ITOS (Improved TIROS Operational Satellite), went into orbit. Hundreds of

One of the TV cameras used in the satellite TIROS-M which is now providing weather information for the world's meteorological centres. TIROS-M was built by R.C.A. under the direction of N.A.S.A's Goddard Space Flight Centre

receiving stations, belonging to many nations, are using information from TIROS transmissions for their weather forecasting services and an unknown number of amateurs, who have designed and built their own equipment, receive the pictures regularly.

The first satellite in the ITOS series, called TIROS-M, was launched using a two-stage Delta-N vehicle with six additional solid-fuel rockets attached to give extra thrust on lift-off. The rocket also carried the 39-pound amateur satellite OSCAR-5 into orbit which is described in this month's "World of Amateur Radio" section.

TIROS-M contains two distinct camera systems. The first of these, the A.V.C.S. (advanced vidicon camera sub-system), takes a series of wide-angle, high-resolution, cloud cover pictures of the earth and stores these in a tape recorder for replay on command from a ground station. A picture sequence lasts about 48 minutes and consists of eleven pictures taken at 260 second intervals. The initiation of a picture sequence is controlled from the ground.

The second camera sub-system is called A.P.T. (automatic picture transmission), and like the A.V.C.S. takes a series of wide-angle, high-resolution photographs. Once a sequence has been started, as dictated by a ground station, up to eleven pictures, at the rate of one every 260 seconds, can be taken. The exact number of pictures taken is under the control of the ground station and a sequence may consist of between one and eleven photographs. The pictures taken by this system are transmitted at the time, i.e. in real time, and are not recorded in the space-craft. A high-persistence vidicon is employed that allows the use of fairly simple receiving equipment.

The remaining item of primary measuring equipment is a scanning radiometer which takes infra-red pictures of the earth during both day and night. Data from this sub-system is recorded on board the satellite and transmitted in real-time as well.

Secondary equipment consists of a solar proton monitor to measure proton fluxes encountered in orbit and a flat plate radiometer to measure the amount of heat being radiated into space by the earth.

Plotting the stars

The first machine to bring automation to optical astronomy has been installed at the Royal Observatory, Edinburgh. It is called Galaxy (General Automatic Luminosity And XY measuring machine), and was originally conceived by Dr. P. B. Fellgett, now professor of cybernetics and instrument physics at Reading University. The design and construction of the machine was entrusted to the Scientific Instrument Control Department of Ferranti at Dalkeith, now Faul Coradi Scotland Ltd, in 1965.

Astronomers have had at their disposal for many years an instrument, called a Schmidt telescope, which enables photographs to be taken of areas of the sky a few times larger than the moon. Each photograph contains the images of tens of thousands of stars and can provide a wealth of information, if that information can be extracted. Precise measurements that have to be made are the position of each star relative to the others and the brightness of the stars. Comparison of two photographs of the same area taken at different times enable angular motion, velocity and distance to be calculated. Galaxy determines the position of each star image on the photograph to within 1 micron, it measures the size of the images to within 0.25 microns and in addition it measures the density of each image.

Measurements are carried out in two distinct operations. First, in the search mode, a flying-spot c.r.t. scanner is used to determine the approximate X and Y co-ordinates of every image on a photograph; the co-ordinates are punched out on eight-hole paper tape. This search-scan is carried out by movement of both the c.r.t. spot and a carriage which holds the photograph.

For the second stage of the operation, which is the actual measurement, the system operates at a high magnification. The c.r.t. spot, which is only 1 micron in diameter, is made to scan in a spiral which is 256 microns in diameter.

Under the control of the paper tape produced in the first operation each image is brought by the carriage servo mechanisms approximately to the centre of the spiral scan. Control of the servos, which up until this stage has been digital, is handed over to the analogue signals from a photo-multiplier which "looks" through the film at the c.r.t.

If the image is not centred in the spiral there will be more light output from one side of the image than the other so the servos move the carriage until equality results. The density profile of the image is then compared with 1024 standard profiles held in a core store. The address of the matching profile together with the co-ordinates of the image centre (carriage position) within one micron are punched out on paper tape for computer analysis.

Galaxy was first switched on in June 1969 and, after a few minor modifications had been made, it has performed well since. Ferranti "Micro-spot" cathode-ray tubes are used and the carriage measuring system was originally designed by Ferranti for industrial use. The problem now is to programme a computer to make maximum use of the output from Galaxy.

It is predicted that Galaxy, as well as being of value to astronomers, will have applications in medical and industrial fields.

Omega for Q.E.2

On the introduction of the Omega 1 relative navigation receiver (the commercial version of the equipment designed by the Northrop Corporation for the United States Navy) the Cunard Steam-Ship Co., was one of the first to consider the possibilities of using the system. Arrangements were therefore made with the Marconi International Marine Co.,

The Omega navigation receiver fitted to the Q.E.2 which provides position fixing to an accuracy of two miles who market the new Omega receivers in the U.K., to install one on board the liner *Queen Elizabeth-2* to enable Cunard to carry out extensive trials of the system during a number of voyages.

Following an evaluation period of several months Cunard have now decided to retain the Omega receiver for regular use in the navigation of the *Queen Elizabeth-2*, and have accordingly purchased the equipment from Marconi Marine.

With four shore transmitting stations currently operating, the Omega system provides full coverage of the North Atlantic and of the eastern North Pacific. The addition of four more shore transmitters, which should be in operation before the end of 1972, will give full global coverage.

I.T.T.-S.T.C. Semiconductors forecast 44% growth in 1970

"If you don't want to sell a product in the semiconductor business you just stop lowering the price. This is just one way of shutting down unprofitable production lines," says Joseph Hurley, general manager of I.T.T.-S.T.C. Semiconductors. In the past few years I.T.T. semiconductor companies throughout the world have undergone a major rationalization and in this country S.T.C. have shut down several lines that were not profitable or that were duplicating work done elsewhere.

As a result of these and other moves sales of the group expanded by 53% last year and I.T.T. predicted a further expansion of 44% next year.

I.T.T.-S.T.C. calculated that in the U.K. they were in fourth position as far as sales are concerned at the end of 1969 and expect to move into third position by mid-1970. The company estimate that the total sales of semiconductors in the U.K. during 1970 will be about £115M.

An interesting prediction made by Mr Hurley is that in America 25% of i.c. production by 1971 will be for the consumer market with the same sort of percentage being reached in the U.K. a year or two later.

Britain at Hanover Fair

The British contingent of electronic and electric component and equipment manufacturers will share a common stand at the forthcoming Hanover Fair (March 1-10). The exhibit, which is made up of 25 firms, is being sponsored by the British Electrical and Allied Manufacturers' Association.

Trainee awards

The annual presentation of prizes to trainee technologists and technicians completing their final year of training with a member company of the Telecommunication Engineering and Manufacturing Association was made during the Association's annual dinner on February 3rd. The first prize is £50 and the second £20 in each class. Prizewinners in the technologist class (students who have obtained a degree or equivalent qualification or are completing their final year in a degree course) were 1st. M. W. Brown (GEC/AEI), 2nd. A. R. Riddiough (Plessey Telecomms). Technician prizewinners were 1st. D. Smith (Plessey Telecomms) and tied 2nd. R. A. Cooper (GEC/AEI) and V. W. Smith (Creed). Candidates have to write a technical essay on some personal aspect of his training or work related to the T.E.M.A. side of the activities of his company.

Film and television training committee formed

Concern in matters relating to training for film and television production has led the British Kinematograph Sound and Television Society (B.K.S.T.S.) to set up a special committee to deal with training and education. The film and television industries have no nationally recognized training schemes, nor are covered by an industrial training board.

The B.K.S.T.S. Education & Training Committee will be concerned with varying requirements over a wide range of operations throughout the industry. Activities of the Committee will include the appraisal of existing training schemes, investigation into the present and future needs of employers, the giving of advice and information, and the possibility of introducing professional qualifying structures.

New names for SI units

Two more famous scientist/engineers of the past, Siemens and Pascal, are honoured in suggestions for short names for SI (Systéme International) units of measurement. The name siemens (symbol, S) is proposed for the unit of conductance, and the name pascal (symbol, Pa) for the newton-per-square-metre unit of pressure. These are being put forward by an advisory body on units for consideration by the International Committee for Weights and Measures (C.G.P.M.).

Electronic information service

INSPEC, the I.E.E's information service in physics, electrotechnology and control, has introduced a service which will provide selected information on electronic literature published in English (including translations). Called S.D.I. (selective dissemination of information), the service will give information on only the new literature which is of interest to the particular subscriber (£45 per individual or £65 for a group).

For the last year the I.E.E. has operated an S.D.I. service to 600 research and development workers as part of an information research project which is supported by the Office for Scientific and Technical Information. The service proved so successful that it has now been made generally available a year earlier than was originally planned.

The amount of material available to the service is being expanded as a result of a new agreement between the I.E.E. and the I.E.E.E. in which an exchange of information from the institutions' "data pools" is to take place. Readers interested in the service should contact: The Manager, INSPEC SDI Investigation, I.E.E., 26 Park Place, Stevenage, Herts.

Physics exhibition

The Physics Exhibition is to be held from the 2nd to the 5th of March at Alexandra Palace, London. Tickets may be obtained from The Exhibitions Officer, Institute of Physics and the Physical Society, 47 Belgrave Square, London, S.W.1, price 5s each.

Faraday lecture "down under"

The 1968 Faraday Lecture, entitled "Microelectronics", which was presented in the U.K. by the I.E.E., is to be given in Australia under the auspices of the Institution of Radio and Electronic Engineers of Australia in conjunction with Mullard Australia Pty Ltd, and Mullard Ltd.

The lecture, which will be the first of an annual series, will be given by Edward T. Emms of the Mullard Control Application Laboratory. In addition to the lectures being held in Sydney, Melbourne, Adelaide and Canberra plans are being made for a deputy to deliver the lecture in other major Australian cities including Hobart, Perth and Brisbane, and at two or three centres in New Zealand.

At the output interface

One of the big problems in industrial control systems is finding ways of controlling large loads from low-level control circuitry and sensing transducers. For many years the relay has reigned supreme in this field and, in fact, has much to commend it. Even so, very often some amplification is needed to drive the relay.

In recent years the thyristor, and later the triac, have challenged the relay with fast switching speeds, low weight, high-current handling, no moving parts and no contacts to weld together or become dirty.

Even using these devices interface circuitry between the control circuitry or sensor and the switching component is necessary with the attendant printed circuit boards, wiring costs, etc.

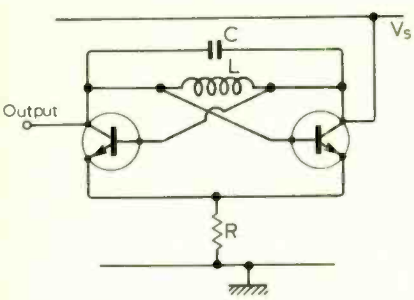
FR Electronics, a department of Flight Refuelling, has produced a range of modules containing the switching device and the necessary interface circuitry. These are available to replace ordinary relays or to provide timing or comparator functions.

WW250 FOR FURTHER DETAILS

Circuit Ideas

Long-tailed pair *LC* oscillator

Oscillation is maintained by a positive feedback loop consisting of an emitter follower and a common-base stage (like an emitter coupled multivibrator), but with a tuned circuit to fix the oscillation frequency. The collector-emitter bias is set by the base-emitter bias to about 0.7 volt for a typical silicon transistor, and the peak to peak output is limited to twice this. Only three cheap components are used apart from the tuned circuit. As there are no inductors or capacitors in these additional components, the circuit will operate over a very wide range



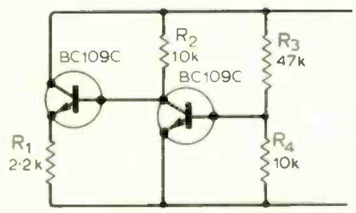
Sinewave oscillator.

of frequencies with a suitable change in the tuned circuit. Predictable oscillation level is approximately $1\frac{1}{2}$ V pk–pk, and predictable d.c. current is $(V_S - 0.7)/R$. The circuit is relatively unaffected by changes in supply voltage. With a suitable value of R the circuit will work with any supply from 1 V upwards. A current of 1mA is generally suitable. Operation should be restricted to frequencies for which C is large compared with the emitter-base capacitance, which is commonly 20–40 pF.

D. T. SMITH,
Clarendon Laboratory,
Oxford.

Mock tunnel diode

The combination of two transistors and four resistors shown above simulates a tunnel diode. Below a certain voltage, R_3 and R_4 divide the V_{cc} such that there is less than 0.6V on the base of Tr_2—hence no current flows through Tr_2. But Tr_1 is turned on by R_2 and this current flows through the circuit. If the voltage across



Transistor circuit operating as a tunnel diode.

the circuit is increased, current starts to flow through Tr_2 reducing the current through Tr_1. Thus the total current through the circuit decreases with increasing V_{cc}. The negative resistance may be reduced by increasing R_2, and the ratio of peak-to-valley current may be changed to some extent by varying R_1. With the circuit shown peak and valley voltages were 3.4V and 3.9V respectively. The "device" will operate to beyond 1MHz.

D. BLOOMER,
Derby.

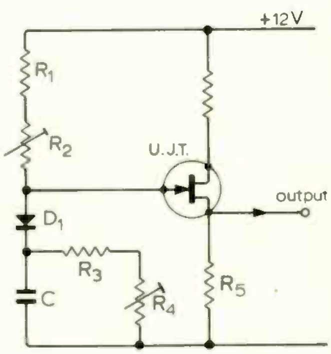
Combined low-pass and high-pass filter

The circuit employed for magnetic-pickup equalization in my pre-amplifier design (July 1969) can be modified to provide simultaneous low distortion low-pass and high-pass filtering. The capacitor value given (5% tolerance) can be altered proportionately for other turn-over frequencies. Mid-point gain is 50 and the filter slopes 18dB/octave.

J. L. LINSLEY HOOD,
Taunton,
Somerset.

Square pulse from unijunction transistor

In the circuit shown below, C charges via R_1, R_2 and D_1 until the potential at the anode of D_1 switches the unijunction transistor into conduction. The potential at the emitter now drops and D_1 is reverse biased so that C cannot discharge via



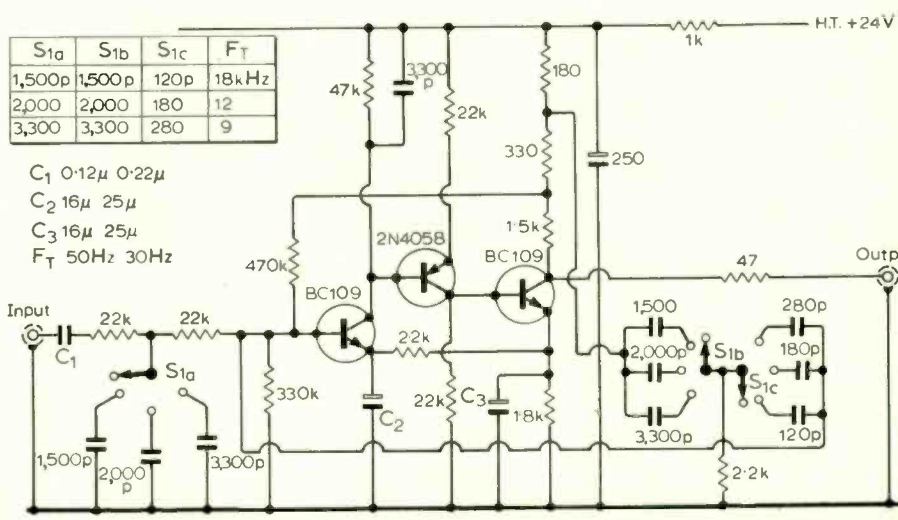
Modified unijunction transistor oscillator.

the transistor which continues to conduct whilst C discharges through the relatively high resistance R_4. The on-time of the transistor is dependent on the time constant $C R_4$ which is made large in comparison with that of $C R_5$—itself limited by the necessarily low value of R_2. The off-time is controlled similarly by R_2. The pulse was used repeatedly to turn on a transistor for a period sufficiently long to energize a solenoid type of motor vehicle petrol pump—it replaced an unreliable mechanical system.

G. M. PAUL,
Whitstable,
Kent.

S1a	S1b	S1c	FT
1,500p	1,500p	120p	18kHz
2,000	2,000	180	12
3,300	3,300	280	9

C1 0·12μ 0·22μ
C2 16μ 25μ
C3 16μ 25μ
FT 50Hz 30Hz



Low-pass and high-pass filter circuit.

Tone-balance Control

A different kind of characteristic, to suit "difficult" programme material

by R. Ambler, B.Sc., Ph.D.

It seems to the writer that there are occasional programme sources, both records and radio, that do not sound correctly balanced as between bass and treble, yet there is no obvious harmonic distortion and the condition cannot be satisfactorily corrected by the usual type of bass and treble tone controls.

If the bass is originally too strong and the treble too weak, normal bass cut and treble boost may be applied: however this removes too much of the extreme bass, provides too much extreme treble, and still leaves the bass in general too strong and the treble in general too weak. The opposite effect may also occur, when the bass is originally too weak and the treble too strong. These effects are more often but not invariably found when the programme source is on older or cheaper gramophone record, or a radio programme from one of the less usual concert halls involving land-lines which may be longer or less well equalized.

The type of tone control usually included in a high-fidelity audio assembly always operates more powerfully on the extreme bass and treble parts of the audio spectrum than on the less extreme parts. This characteristic is shown by both the passive type of network exemplified by Williamson's circuit[1] and by the feedback type of system such as Baxandall's.[2] In both these circuits separate bass and treble controls are provided.

It occurred to the writer that a tone-balance control would be useful in the circumstances described above, which at one end of its range boosts the whole of the bass fairly uniformly, slopes across the middle frequencies, and cuts the whole of the treble fairly uniformly. At the centre of its range it should provide a flat frequency response and unity gain, and at the other end of its range bass cut, slope across the middle, and treble boost. A negative-feedback system would be preferred, to minimize distortion.

A basic tone-balance control system which meets these requirements is shown in Fig. 1(a). At low frequencies where the admittance of the capacitors has become negligibly small, the circuit reduces to that shown in Fig. 1(b). Moving the potentiometer slider to the left reduces the input resistance and increases the feedback resistance, hence giving a uniform boost at these

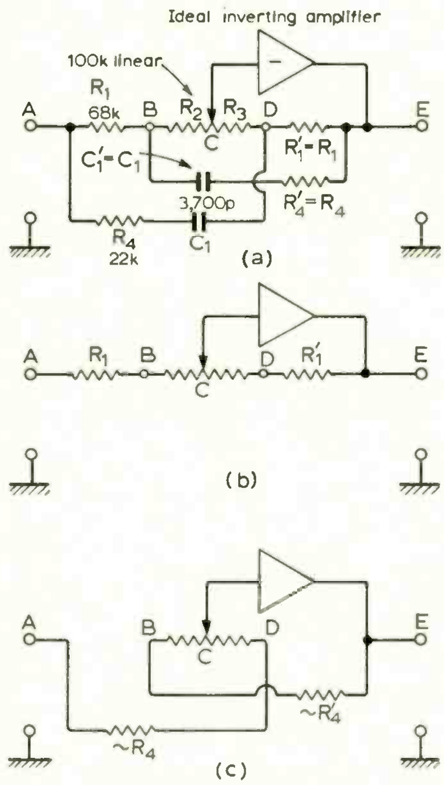


Fig. 1. Basic tone balance control system (a); exact equivalent at low frequencies (b); and approximate equivalent at high frequencies (c).

low frequencies. Moving the slider to the right gives a uniform bass cut. At high frequencies, where the impedance of the capacitors has become negligibly small, the circuit approximates to that shown in Fig. 1(c), as R_4 has a lower value than R_1. Here the "input" and "feedback" ends of the potentiometer have been reversed, so movement of the slider to the left gives a uniform treble cut to go with the bass boost and movement to the right gives a uniform treble boost to go with the bass cut. It seems reasonable to assume a smooth transition between the cut and boost conditions at any one setting of the potentiometer as the frequency is varied, and also that the system gain will be equal to (-1) at all frequencies with the potentiometer centred, and hence with the input/feedback network symmetrical. These assumptions are in fact confirmed by a detailed analysis.

If the usual assumption is made that the amplifier is an ideal inverting amplifier so that its input voltage and input current are both negligibly small, it can be shown by consideration of the voltage at each junction point and current in each arm of the network that system gain equals

$$\frac{V_E}{V_A} = -\frac{R_1R_2+(R_1+R_3)(R_4+1/j\omega C_1)}{R_1R_3+(R_1+R_2)(R_4+1/j\omega C_1)} \quad (1)$$

from which

$$\frac{V_E}{V_A} = -\sqrt{\left[\frac{(R_1R_2+R_1R_4+R_3R_4)^2+(R_1+R_3)^2/\omega^2C_1^2}{(R_1R_3+R_1R_4+R_2R_4)^2+(R_1+R_2)^2/\omega^2C_1^2}\right]} \quad (2)$$

If $\frac{V_E}{V_A} = -1$, equation (2) reduces to

$$0 = (R_3-R_2)(2R_1+R_2+R_3)\left[\frac{1}{\omega^2C_1^2}+R_4^2-R_1^2\frac{R_2+R_3+2R_4}{R_2+R_3+2R_1}\right] \quad (3)$$

There are two practical conditions for unity gain. The first is $R_2 = R_3$; i.e., with the potentiometer centred. This is independent of frequency. The second is with the right-hand bracket equal to zero and it shows a unity gain crossover frequency which is independent of the setting of the potentiometer.

The component values required to give the desired response were calculated from equations (2) and (3). After choosing (somewhat arbitrarily) a value of 100 kΩ (linear) for the potentiometer R_2+R_3, the value of R_1 was calculated to frequencies at four different potentiometer settings: these results are shown graphically in Fig. 2 together with the flat response produced with the potentiometer centred.

It is obvious that a lower impedance level could be used in the input feedback network, but there are disadvantages in going too low. A potentiometer value of 20 kΩ or 50 kΩ would be satisfactory, with the other values altered to suit. The value of 100 kΩ arose when the circuit was first being developed and tested. A greater maximum boost or cut was originally allowed for, and then found in practice to be unnecessary and indeed undesirable. The values given are perfectly satisfactory, however, with a suitable amplifier. The system requires to be fed from a fairly low impedance source (say < 1 kΩ) to avoid degradation of its response, and itself has a low output impedance (< 1 kΩ).

The tone balance control has been incorporated in an experimental mono tone control system, the circuit of which is shown in Figs. 3–5. The input stage Fig. 3 is a slightly modified version of that published by Bailey[3] adjusted to suit the writer's signal sources. After the volume control, Fig. 4, comes an impedance conversion stage, followed by Baxandall type bass and treble controls, then the tone balance control, and finally a feedback amplifier stage to raise the output level to the 4 volts peak-to-peak maximum needed to drive the Williamson amplifier[4] which the writer is still using. Like Mr. Linsley Hood[5] the writer has not come across any other amplifier which actually sounds better when driving moving-coil loudspeakers. A signal level through the control system of 200 mV peak maximum is convenient, being well below the overload point and above the noise level.

The final stage in the control unit could be omitted if a more sensitive power amplifier were used, and the impedance conversion stage after the volume control could be omitted at the cost of a slight degradation of the response, particularly if treble boost is called for in the Baxandall tone control. However this impedance converter is a convenient point at which to insert a stereo balance control, as indicated in Fig. 4.

It should be noted that the whole of the signal network after the volume control in Fig. 4 is floating at a level of about +6 V d.c. This has the advantage of saving capacitors. The savings are cost, space, and fewer unwanted phase shifts. There appears to be no significant disadvantage even with a series of stages in cascade, as in the present circuit: capacitors are needed only at the beginning and end of the series. The bypass capacitor in the bias network of each amplifier may be omitted if desired: the change in response is small as the bias

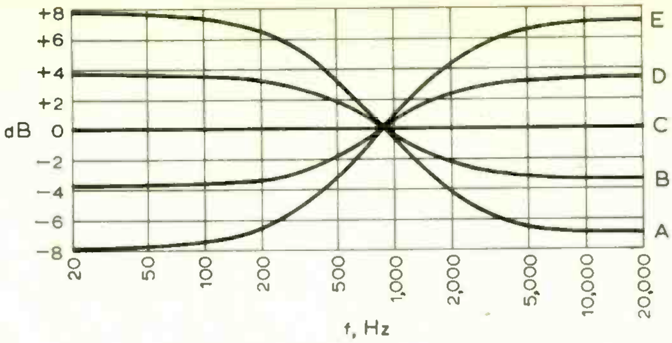


Fig. 2. Calculated frequency response of tone balance control circuit shown in Fig. 1(a). $A-R_2 = 0, R_3 = 100\,k\Omega$; $B-R_2 = 25\,k\Omega$; $R_3 = 75\,k\Omega$; $C-R_2 = R_3 = 50\,k\Omega$; $D-R_2 = 75\,k\Omega, R_3 = 25\,k\Omega$; and $E-R_2 = 100\,k\Omega, R_3 = 0$.

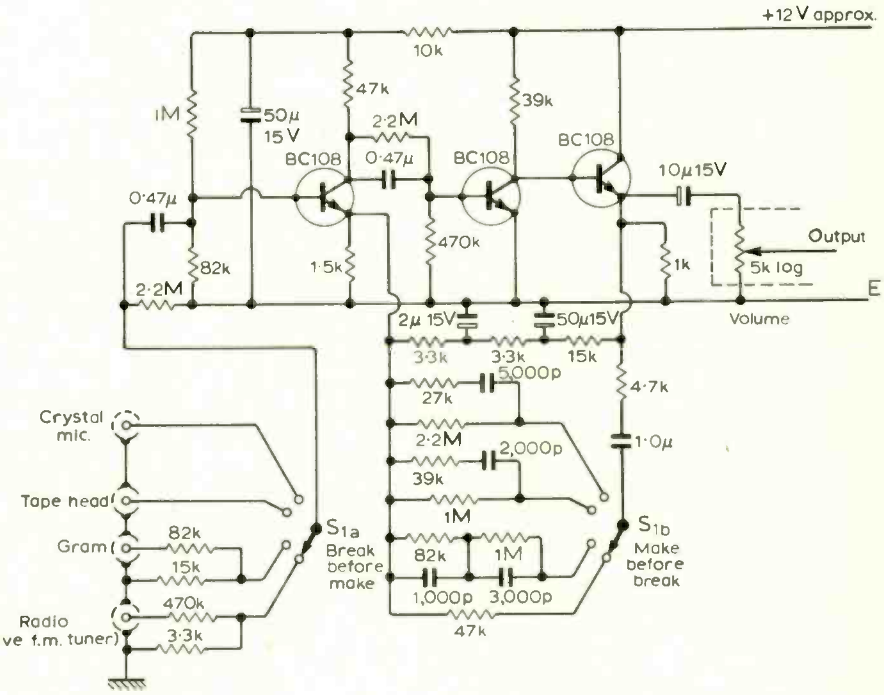


Fig. 3. Input stage (modified Bailey).

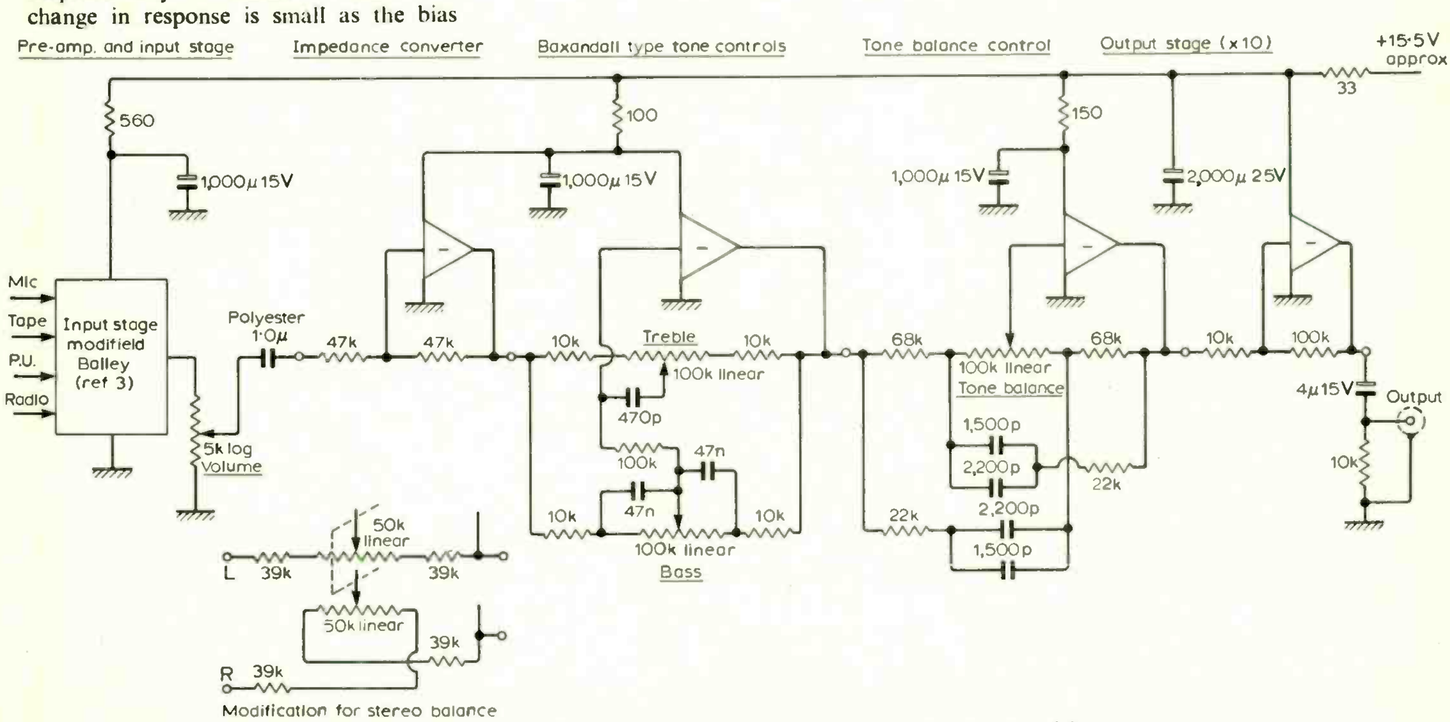


Fig. 4. Control unit incorporating tone balance control. Details of op. amps. and input stage in Figs. 5 and 3.

resistors become a minor adjustment to the audio feedback network. The op. amps. shown in Fig. 4 have the circuit of Fig. 5.

The layout does not appear to be critical: in the trial equipment the signal network is mounted between the tags on the potentiometers and tags on a tag strip: the amplifier sections are built on Radiospares miniature 18-way group boards. The bias resistors marked 1·41 MΩ* in Fig. 5 are each made up of three resistors in series, the values being selected on trial to give a d.c. level of 6 V±0·2 V at the output point with a supply voltage of 12, 1·41 MΩ being the calculated value. This method of adjustment is cheap and not seriously time-consuming or inconvenient for the home constructor: otherwise a variable resistor of 1 MΩ in series with a fixed resistor of 820 kΩ or 1 MΩ could be used. Half-watt moulded carbon resistors have been used throughout, with no apparent disadvantages.

Power is obtained from a small commercial stabilized supply unit: this is not strictly essential provided there is good smoothing, but it is a very convenient way of providing the smoothing and obtaining the correct operating voltage.

The tone balance control performs satisfactorily the function for which it was intended and which cannot be performed by the normal Baxandall bass and treble controls. It compensates quite accurately (judging by ear) for some of the variations in recording characteristics used in the early days of l.p. records and for similar sounding, probably fortuitous, variations in some more recent records: it even enables reasonably well-balanced results to be obtained from a variety of 78 r.p.m. records reproduced through the current standard l.p. playback characteristic, with some help from the normal treble control. It compensates satisfactorily most (but not all) of the "off-balance" radio programmes mentioned earlier.

The approximate equality of maximum bass boost or cut and treble cut or boost, together with the choice of 800–880 Hz for the centre frequency, ensures that the general volume level remains reasonably constant when the tone balance control is adjusted. The frequency of 800 Hz is a reasonable compromise between the geometric mean of the audio spectrum (630 Hz), the nominal bass-to-middle crossover of the writer's speaker system (750 Hz), the nominal bass boost hinge frequency of commercial records (500 Hz) and the nominal treble cut hinge frequency of records (2 kHz).

The tone balance control has been found to have additional uses. On the writer's equipment its normal setting is one giving a little bass boost and treble cut, to compensate for a slightly lower sensitivity in the bass speaker compared with the middle speaker. The control also seems able to provide a useful single-knob tone control in moderate quality systems of slightly restricted frequency range, simulated on a wide-range system by the application of some bass cut and treble cut with the normal Baxandall controls.

It is not suggested that the tone balance control supersedes the Baxandall circuit in high-fidelity equipment; it has a different function. In fact the best results and the widest range of control and compensation are obtained by providing both the Baxandall type of control and the new one. If this is done there is some advantage in adjusting the characteristics of the Baxandall system to leave a slightly wider "flat" gap than would normally be provided between the bass and treble characteristics. It would also seem desirable to provide both low-pass and high-pass variable filters but the writer has not yet done this.

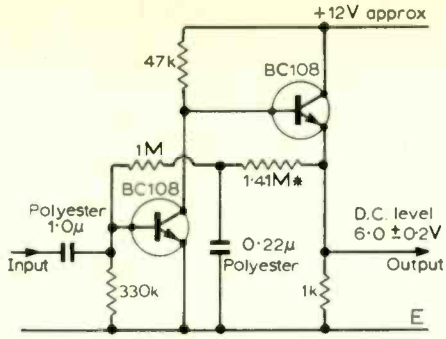


Fig. 5. Circuit of each op. amp. in Fig. 4. Resistor marked "1·41 M" to be adjusted on trial—see text.*

REFERENCES

1. D. T. N. Williamson, "Design of Tone Controls and Auxiliary Gramophone Circuits," *Wireless World*, October, November 1949.
2. P. J. Baxandall, "Negative-Feedback Tone Control," *Wireless World*, October 1952.
3. A. R. Bailey, "High Performance Transistor Amplifier" (Control Unit), *Wireless World*, December 1966.
4. D. T. N. Williamson, "Design for a High-Quality Amplifier," *Wireless World*, May 1947, August 1949.
5. J. L. Linsley Hood, "Simple Class A Amplifier," *Wireless World*, April 1969.

Announcements

The series of **Electronic Instruments Exhibitions** initiated in Manchester in 1967 will again be held at the Hotel Piccadilly from September 8th to 11th this year. A second will be held at the Skyway Hotel, Southampton, from September 22nd to 24th. Organizers are Industrial Exhibitions Ltd, 9 Argyll Street, London W1V 2HA.

Standard Telephones & Cables has received orders totalling more than £12M for three **submarine telephone cables** into the Spanish mainland. Two of these will link the Canary Islands and the Balearic Islands with the mainland and will employ over 150 transistor repeaters. The third, a 640 circuit cable with 51 transistor repeaters, will connect Spain with the United Kingdom.

Applied Research Laboratories Ltd, of Wingate Road, Luton, Beds., have sold two electronic systems, valued at about **£60,000, to the Soviet Union.** The systems automatically determine the precise chemical composition of metallic and non-metallic substances and print out the results within seconds.

Multitone Electric Co. Ltd. has announced that the New York Stock Exchange have placed a contract with Multitone Electronics Inc., their wholly owned U.S. subsidiary, to install a **pocket paging system** in the Wall Street building.

U.K. orders totalling in excess of £140,000 for seven Philips EM 300 **electron microscopes** have been received by Pye Unicam of Cambridge during the first week of 1970.

The marine division of Redifon Ltd has won a £24,500 order to supply **marine radio equipment** to the Lloyd Brasileiro shipping line, Rio de Janeiro.

Gelman-Hawksley, of 12 Peter Road, Lancing, Sussex, have signed a three-year agreement for an exclusive dealership for the products of **Royco Instruments Inc,** of California. Royco manufacture particle counting systems.

Rastra Electronics Ltd, 275 King Street, Hammersmith, London W.6, have been appointed distributors for the products of **Silicon General Inc,** of California, U.S.A.

Sharp Corporation, of Japan, has formed a wholly owned subsidiary, Sharp Electronics (U.K.) Ltd, at Derby Street, Manchester, to handle the distribution and marketing of Sharp equipment throughout the United Kingdom.

Standard Telephones and Cables Ltd will combine **Submarine Cables Ltd,** whom they recently acquired from Associated Electrical Industries, with their submarine systems group.

Coutant Electronics have appointed Polyamp A.B. of Stockholm as their exclusive **agents in Sweden.**

Henry & Thomas Ltd, Yeo Street, Bow Common, London E.3, have signed an agreement with the Hirose Electric Company Ltd, of Tokyo, which gives the British company sole marketing rights in the U.K. for the complete range of **Hirose connectors.**

A range of semiconductor devices manufactured by **Philco Ford** will now be available in the U.K. through Auriema Ltd, 23-31 King Street, London W.3.

The full range of potentiometers made by the **Clarostat Manufacturing Co. Inc.,** of the United States, is now available in the U.K. exclusively from Welwyn Electric Ltd, Bedlington, Northumberland.

Impectron Ltd, 29-31 King Street, London W.3, have been appointed sole representatives for **Sylvania's semiconductor components** in the U.K., Northern Ireland and Eire.

Ates Electronics Ltd, the recently formed British company of the Italian semiconductor manufacturer, is moving to Mercury House, Park Royal, London W.5 (Tel: 01-998 6171).

F.W.O. Bauch Ltd, has moved to premises at 49 Theobald Street, Boreham Wood, Herts. (Tel: 01-953 0091).

The group headquarters and registered office of **The Morgan Crucible Company Ltd,** are now at 98 Petty France, London S.W.1 (Tel: 01-222 7212).

Digitally-controlled Tape-recorder Pre-amplifier

An accurate system for automatically optimizing recording level to obtain maximum dynamic range

by P. C. Grossi, B.Sc., and C. Marcus, B.Sc.

In the course of developing semi-professional tape-recording systems the authors realized the importance of optimizing recording levels. In order that the full dynamic range of the recording medium can be exploited, modulation must be maximized but kept below a preset level which is determined by the saturation flux density of the tape.

An automatic system was developed to replace the conventional meter and a potentiometer with which the authors were dissatisfied because of the inherent inaccuracies involved; one of the most significant of these resulting from the slow response time of the meter. Also, due to observational difficulties, the recording level usually cannot be set more accurately than 5dB. In addition, one must often consider cost, panel space and convenience of operation.

The automatic system does not operate on the same principles as automatic volume controls, which merely restrict the dynamic range without effectively eliminating tape overmodulation. The system is best described with the aid of the block diagram (Fig. 1). The input signal is fed to a variable gain amplifier. If the peak level of the output is excessive a series of pulses is generated by the peak-level sensor, which, through the action of the pulse counter, reduces the amplifier gain.

The variable-gain amplifier consists of six cascaded stages. The voltage-gain of each stage may have either of two preset values, selected by a transistor switch. The output signal is fed to the peak-level sensor which generates pulses whenever the output voltage exceeds a preset level; these pulses are counted by the gain-control pulse counter which consists of a set of six cascaded bistables which determine the state of the above mentioned transistor switches.

It was decided that 1V r.m.s. insignificantly distorted output should be obtainable for any input between 1mV and 1V r.m.s.; this necessitates a control range of at least 60dB. Since an accuracy of better than 1dB is not required, this can be accomplished by the use of six amplifiers whose greatest voltage gains form a binary progression.

It is necessary to have two switches in the system. One of them—possibly a push button—resets the bistables so that the amplifier gives full gain. Since the signal level cannot cause the amplifier gain to be increased, the switch must be operated each time a new signal is to be controlled. Another switch is incorporated which disconnects the pulse input from the bistables. Thus once the greatest input signal has been controlled the bistable input can be manually disconnected; this prevents motor switching and other sources of undesired transients from progressively reducing the amplifier gain. The two switches can be incorporated into a single three-position mechanism should panel space be at a premium.

The prototype illustrates that this system is capable of truly high-fidelity operation as the bandwidth at full gain was 25Hz to 100kHz −1dB; the noise output was less than 1mV (unweighted) for a source impedance of 100kΩ and for a bandwidth of 60kHz. At unity voltage gain the bandwidth was 2Hz to 200kHz ±3dB and the noise figure was

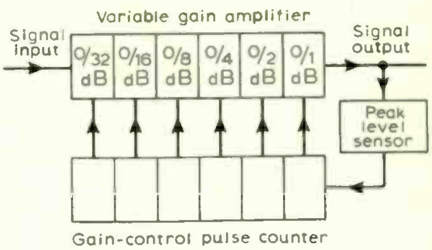
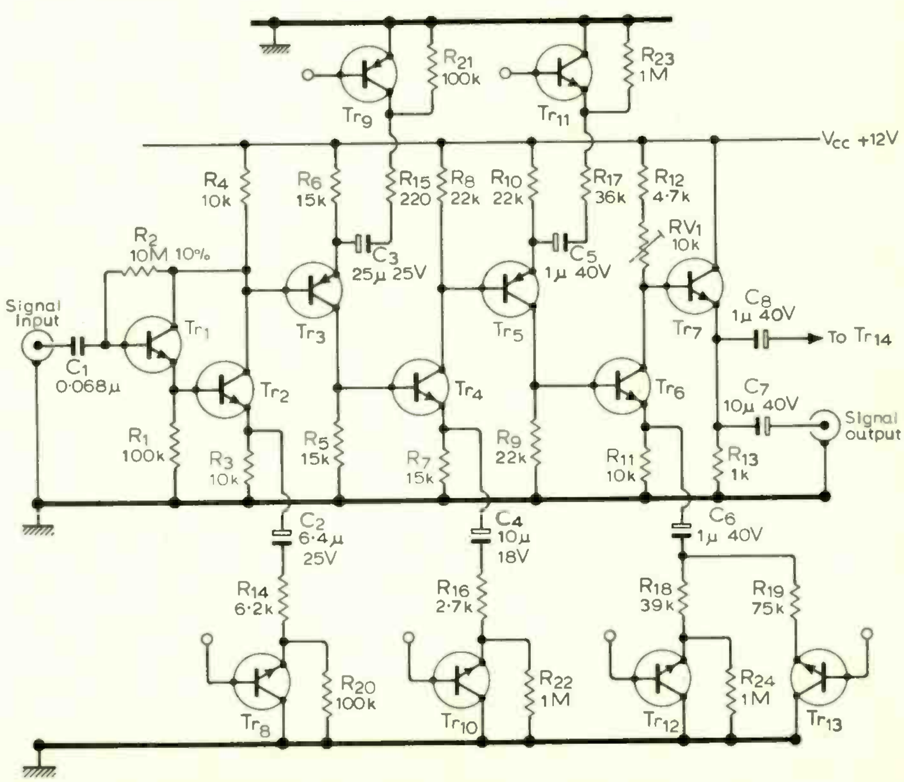


Fig. 1. Block diagram of system.

Fig. 2. Circuit diagram of the pre-amplifier. Tr_1 and Tr_2 can be any high-gain silicon transistor, e.g. BC109, 2N3707; Tr_3—2N4058, 2N4286, etc; Tr_4—BC108, 2N2925, etc; Tr_5—2N4062, 2N4289, etc; Tr_6 and Tr_7—2N2926, BC168, etc; and Tr_8 to Tr_{13}—2N706, 2N708, 2N2926, etc.



considerably improved. The maximum distortion occurred at unity voltage gain and was less than 0.05% for an output of 1V r.m.s. For a heavy overload the gain reduced at the rate of 4000dB per second and the greatest gain reduction step was less than 2dB. The prototype was constructed for less than £5 10s using components as advertised in *Wireless World* and was placed in an aluminium box measuring approx. 100 × 150 × 65mm (4 × 6 × 2½ in).

The amplifier

The complete circuit diagram of the amplifier is shown in Fig. 2. Direct coupling is used throughout as it avoids the use of large and costly electrolytic capacitors. However, this means that a low-impedance stabilized power supply must be used.

The input stage is similar to a Darlington pair for high input impedance but R_1 has been added to improve the gain of Tr_1. Each of the following stages derives its bias conditions from those of the previous stage. Emitter and collector resistors are approximately equal—the difference being to compensate for the base-emitter potential of each stage, hence increasing the signal handling capability.

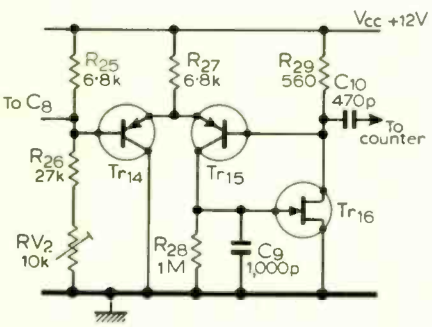


Fig. 3. Peak-level sensor circuit. Tr_{14} and Tr_{15} can be 2N3702 or 2N4289; and Tr_{16}—TIS43 or 2N2646.

The amplifier terminates in an emitter-follower stage for low output impedance.

To minimize noise, the high-gain stages should be placed near the input; however, the first stage should be of low gain for high input impedance. The best compromise was achieved by placing the 8dB stage at the input, followed by the 32dB stage, then the 16dB 4dB 2dB and 1dB stages in that order.

The voltage gain of each stage is given by R_c/R_E, where R_c is the collector load, taking into account the loading of the next stage, and R_E consists of three component parts. R_e, the total external emitter resistance; r_s, the reflected source impedance, given by the source impedance divided by the transistor current gain (β); and r_e, the internal emitter resistance of the transistor, given by $26/I_E\Omega$ for the emitter current in milliamps.

The a.c. voltage gain of each stage is increased if the emitter resistor is shunted by a network comprising a d.c. isolating capacitor in series with another resistor. The gain is selected by the action of a transistor switch (Tr_{8-13}). The shunt resistor values are calculated using the formulae shown above. By means of a simple calculation it can be shown that, to the required accuracy, R_{18} and R_{19} can both be connected to the same stage, since they each involve only a small increase in gain. The purpose of VR_1 in the prototype was to adjust the d.c. gain to be exactly unity.

Each transistor switch is operated such that when it is 'on' it is heavily saturated with a base current of 1mA. This gives a very low a.c. bilateral impedance. In order to turn a switch 'off' the base must be reverse biased by several volts to prevent emitter-base conduction on large signals at the emitter. Each switch is shunted by a large resistor so that the charge on the isolating capacitor does not change significantly during switching; the switches themselves are operated in inverse mode as the d.c. offset voltage is reduced. These precautions ensure that large switching transients do not appear at the output.

Peak-level sensor

With reference to Fig. 3, it can be seen that Tr_{14} and Tr_{15} are connected as a long-tail pair. By means of the divider R_{25}, R_{26}, VR_2 the base of Tr_{14} is held at a quiescent potential 1.4V lower than that of Tr_{15}. Hence Tr_{14} normally conducts and Tr_{15} is normally cut off. The output signal is fed to the base of Tr_{14} through C_8; if the peak amplitude of this is less than 1.4V then Tr_{14} will remain conducting. If, however, the positive signal excursion exceeds 1.4V, then a sharp transition will take place turning Tr_{15} 'on' and Tr_{14} 'off'. This state will be maintained until the positive signal excursion no longer exceeds 1.4V.

When Tr_{15} is conducting it acts as a current source linearly charging C_9. When the emitter potential of Tr_{16} reaches triggering potential, C_9 is rapidly discharged and a negative pulse is fed through C_{10} to the first bistable. When the potential across C_9 reduces below a critical level the emitter conduction in Tr_{16} ceases and the initial conditions are restored. This cycle is repeated until Tr_{15} is turned 'off'.

Due to the large tolerance on the inter-base resistance of unijunction type TIS43, a variable resistor (VR_2) should be incorporated in the base bias chain of Tr_{14}. By this means the stabilized output level can be adjusted. Tr_{15} is biased from R_{29} in order to minimize the effects of temperature changes. The purpose of R_{28} is to ensure that the leakage current of Tr_{15} does not cause any significant charge to be placed on C_9.

Gain-control pulse counter

This consists of a set of six bistables, cascaded in the usual manner. A resistor is connected to one collector of each

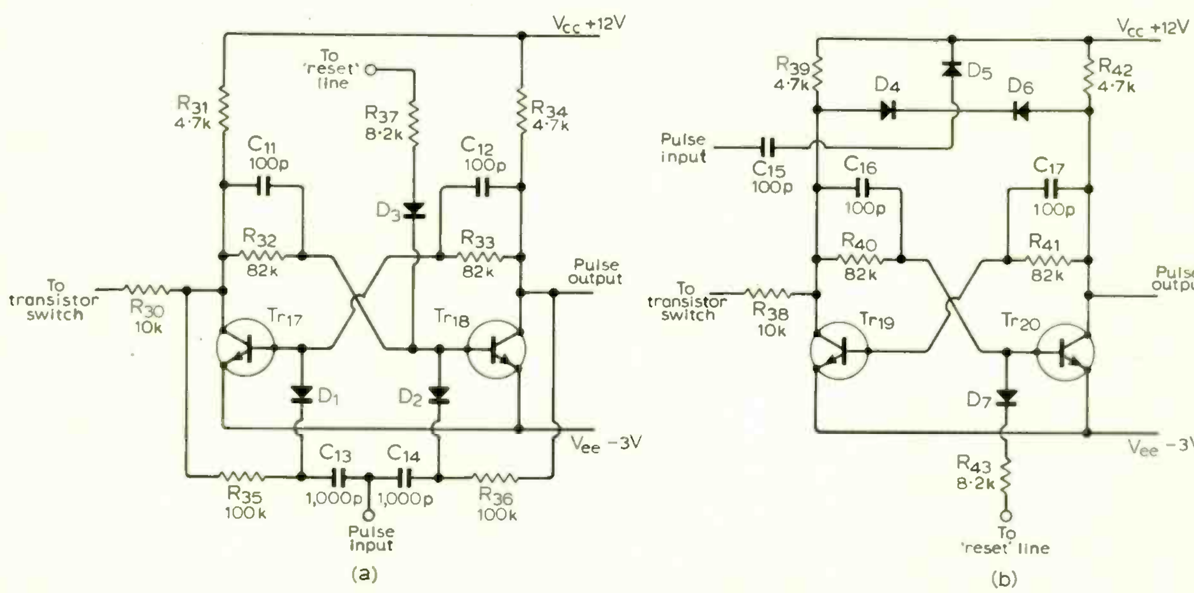


Fig. 4 (a). First bistable. Diodes are germanium types, e.g. OA81, OA91, IN914. Tr_{17} and Tr_{18} can be 2N3708, BC108, etc. (b). Circuit for remaining five bistables. Diodes and transistors as for first bistable.

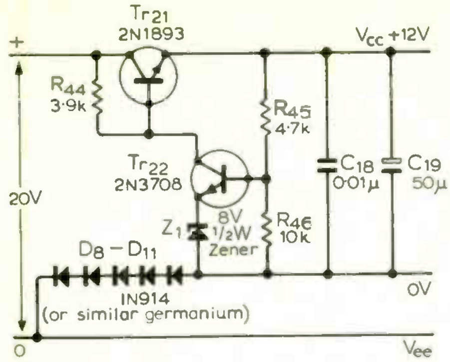
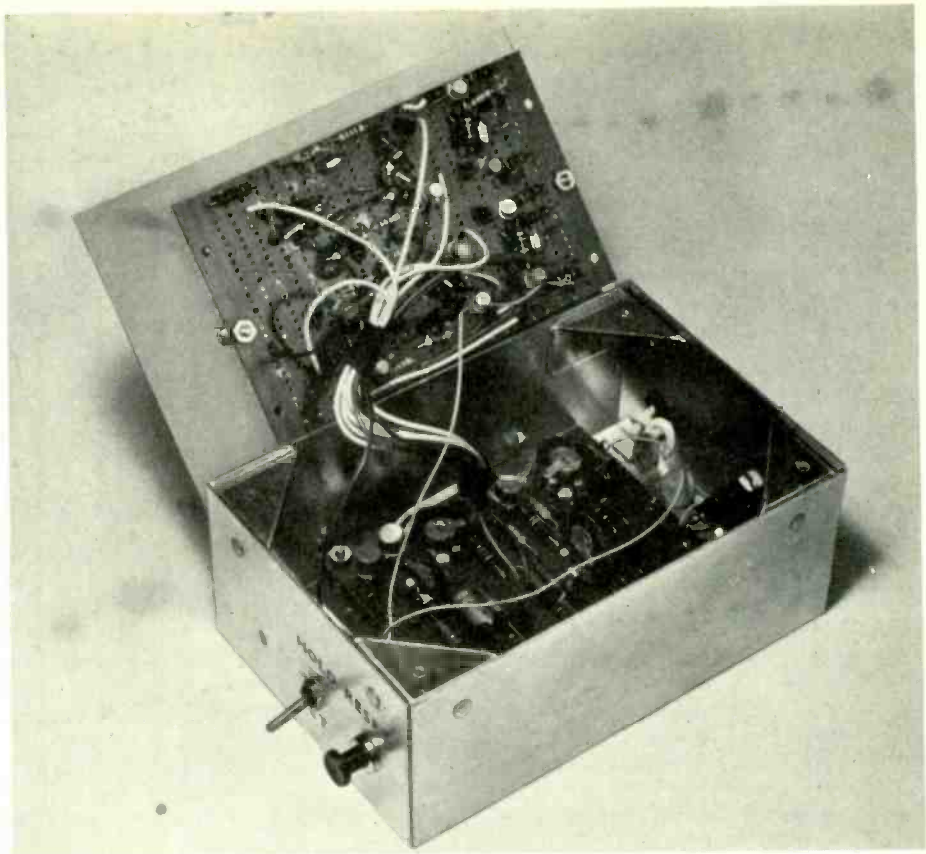


Fig. 5. A suitable power supply.

bistable to drive a transistor switch. Although the amplifier and counter may share a common positive rail, separate negative rails are used so that the transistor switches can be back biased when they are required to be 'off'.

The circuit diagram of the first bistable is shown in Fig. 4(a); it can be seen that base triggering is used here as the input pulses are too small to give reliable collector triggering. The remaining five bistables are as shown in Fig. 4(b) where collector triggering is used as it is less critical of pulse amplitude. The bistables were designed to use components already in the authors' possession, and were found to be entirely suitable for this application. Provided they will correctly drive the transistor switches (as mentioned above), any form of bistable can be used; some constructors may wish to use integrated circuits.

To ensure that the amplifier is giving sufficient gain for a new signal, it must first be restored to full gain; this will be appropriately reduced by the automatic system. In the prototype this was accomplished by connecting the 'reset' line to the positive rail; a large base current then flows into one transistor of each bistable, ensuring that the transistor switches are all turned 'on'. The 'reset' line, switches and pulse outputs must be connected as in Fig. 4; if this is not so, either the amplifier will not be reset to full gain or the gain will not reduce each time a pulse is fed to the bistables.



The components of the digitally-controlled pre-amp. need take up little space—the aluminium case shown measures only 6in × 4in × 2½in. The bistables are mounted on the board attached to the lid of the container, the other board carrying the amplifier and the peak-level sensor. Amplifier input and output are carried by screened leads. The bunch of unscreened leads joining pulse counter to the amplifier carries switching signals only. The power supply is external.

Construction

The prototype was built on two boards. One held the gain-control pulse counter, and the other the amplifier and peak-level sensor.

The gain control pulse counter was built on 0.2in matrix copper clad wiring board measuring 120 × 75mm (4¾ × 3in). Since the device operates at audio frequencies, the layout of this is not at all critical; the constructor will wish to adopt a layout most suited to the size of available components and the allotted space. Any n-p-n silicon transistors with β greater than 30 may be used here and any diode with a reverse breakdown voltage greater than 30V; the resistors and capacitors may be of large tolerance.

The layout of the prototype is shown in the photograph. No trouble was experienced with instability in the prototype, but it is recommended that the usual precautions for high-gain, wideband amplifiers should be taken. A layout similar to the circuit diagram should be adopted, with input and output leads well separated and completely screened.

Very high-gain transistors must be used throughout the amplifier, but low-noise devices need only be used in the first three stages. Any audio transistor may be used as a switch provided the base-emitter reverse breakdown voltage is greater than 4V. All the amplifier resistors should be of close tolerance (2% or better).

Although the above theory is sufficiently accurate, preferred resistor values are not always yielded; hence the constructor may find it convenient to obtain the correct shunt resistor values by means of series or parallel combinations, which should be checked empirically. If the resistor values are in error such that the gain of any stage is too large, the range of control will be increased but several large gain steps may be introduced. If a stage gain is too small, the range of control will be reduced but some of the gain steps will be smaller. If a range of control less than 63dB can be tolerated, the latter type of error is preferable as the regulation is improved.

Although it was stated that VR_2 could be used to adjust the output signal level, it is recommended that an output level close to 1V r.m.s. should be selected. Outputs greater than 1.4V r.m.s. will suffer severe distortion due to clipping, and temperature effects in the unijunction transistor make small outputs impracticable.

The power supply shown in Fig. 5 was designed to operate the amplifier. However any power supply with an output impedance less than 1Ω and delivering the specified voltages may be used.

Acknowledgments

The authors would like to thank Professor G. D. Sims, of the Department of Electronics, Southampton University, for laboratory facilities. They are also grateful for the encouragement and interest shown by Dr. A. R. Brunnschweiler and Mr. A. P. Dorey.

Pulse Generator Using Integrated Circuits

A versatile two-channel instrument using only three integrated circuits

by C. Djokic, M.Sc., M.I.E.R.E.*

The pulse generator described in this article was designed for use in a University teaching laboratory but may well be used for many other applications.

The repetition rate may be altered from 1Hz to 1MHz in six decades, with a continuous fine control covering each decade. In addition there is provision for operating the pulse generator from an external source and a single shot facility is available in the form of a push-button mounted on the front panel. The pulse generator has two independent positive outputs which are continuously adjustable in amplitude from 0-10V and have an output impedance of approximately 50Ω. The pulse width of either channel may be varied from 1 sec to 1μ sec in six decades with a continuously variable fine width control covering each decade.

The output of channel A may be delayed with respect to that of channel B and to a pre-trigger output pulse, by an amount variable from 1 sec to 1μ sec in six decades with a fine delay adjustment. In addition the unit may be operated with the two output pulses in coincidence.

A pre-trigger positive output pulse of approximately 3V across a low impedance is provided at 0.5μs before each channel B output pulse. In addition the output of both channels may be inhibited by the application of a 3V positive level. With this facility the instrument may be used as a burst pulse generator. The output pulses are practically free from overshoot and have rise and fall times of 25ns, when measured into a 50-Ω load.

The satisfactory performance of the instrument is best illustrated by the typical output waveforms shown in Fig.1. In Fig.1 (a) the two outputs are shown with that from channel A delayed by 50μ sec. with respect to channel B Fig.1(b) shows the rise time of the output pulses from the two channels and illustrates that true time coincidence may be obtained. Finally, in Fig.1(c) the inhibit pulse is illustrated.

Operation of the instrument is best understood by considering the block diagram shown in Fig.2 in conjunction with the complete circuit diagram as shown in Figs.4 and 5. All the integrated circuits employed contain four two-input NOR gates the circuit diagrams of which in discrete component form with the pin connection details, are given in Fig.6. The integrated circuits are all of the same type and are from the Motorola range of plastic encapsulated, medium power, r.t.l. Two types may be employed, the MC724P

* Birmingham University

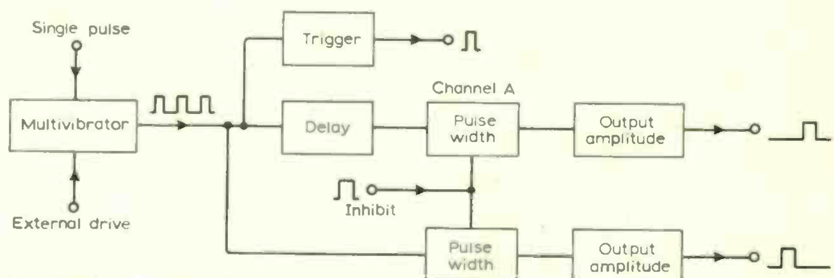


Fig. 2. Block diagram of the instrument.

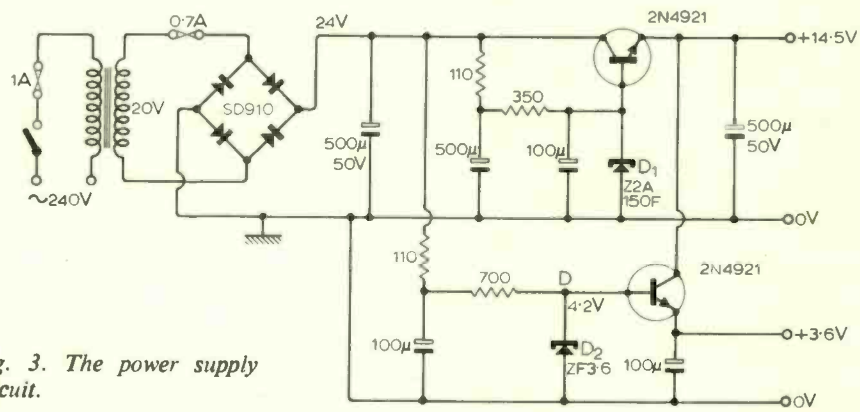


Fig. 3. The power supply circuit.

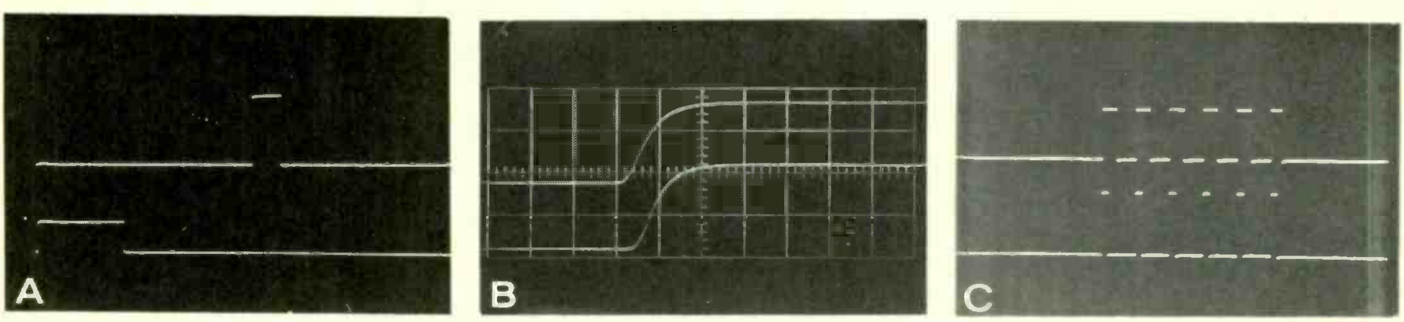
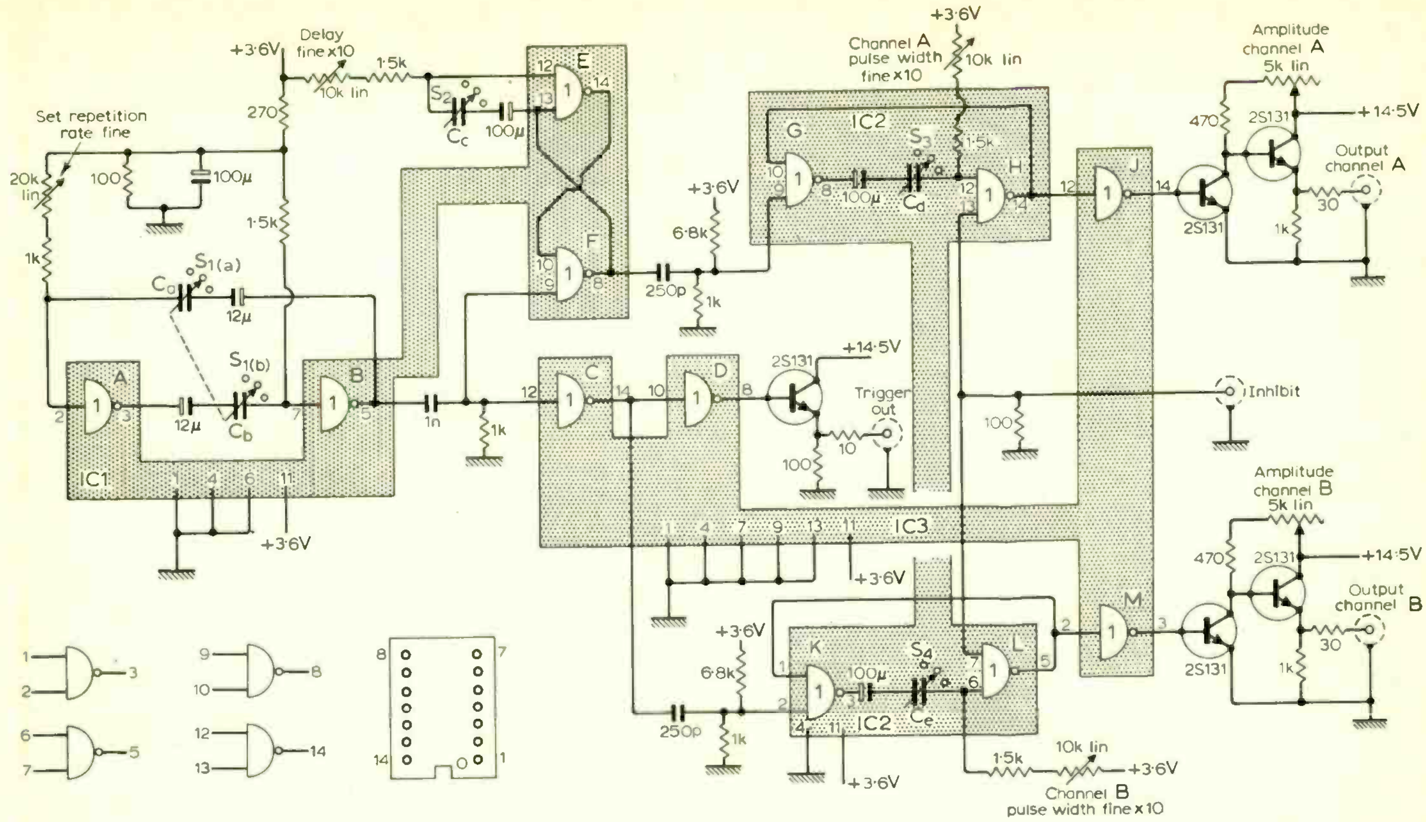


Fig. 1. (a) Output pulses with channel A delayed (vertical gain: 2V/div.; timebase: 10μ s/div.). (b) Rise time of both channels showing that time coincidence can be achieved (Vertical gain: 2V/div.; time base: 50ns/div.). (c) The action of the inhibit pulse (vertical gain: 2V/div.; timebase: 0.5ms/div.).



(+15 to 75°C) or the MC824P (0 to 75°C).

The repetition rate generator is a cross-coupled multivibrator formed by gates A and B. With the fine repetition rate control potentiometer set to minimum resistance the output is a square-wave and by setting this potentiometer to maximum resistance, a mark to space ratio of 1:20 is obtainable.

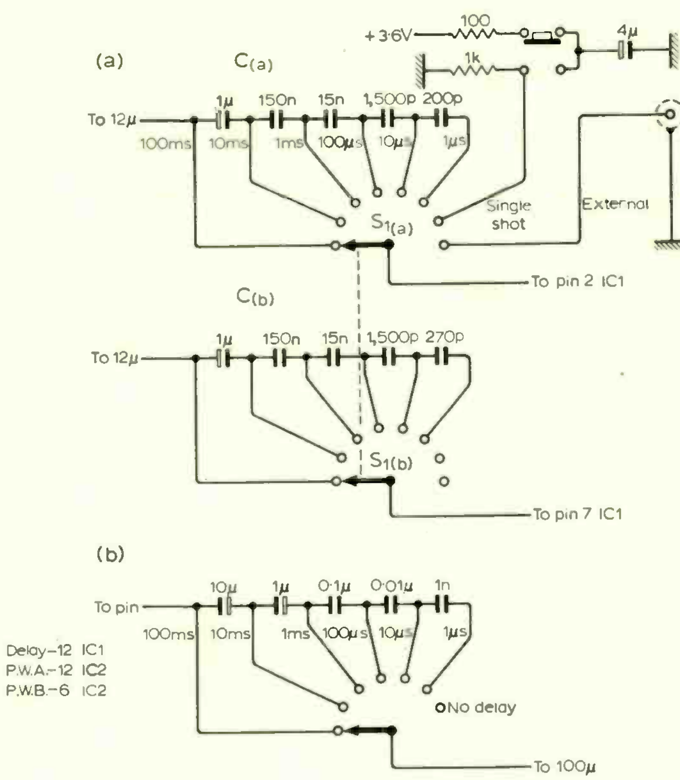
The differentiated output of the multivibrator is fed to the delay monostable, formed by gates E and F, in channel A, and also via a double inverter, gates C and D, to the pulse width monostable in channel B (Gates K and L). The double inverter isolates the pre-trigger output pulse from the rest of the circuit and by differentiating the output of the first inverter and using this pulse to drive the pulse width monostable in channel B, the gate propagation delay across gates E and F may be equalled thus providing true time coincident output pulses in channels A and B when desired.

The output of the delay generator (gates E and F) is differentiated and fed to the channel A pulse width monostable (gates G and H). Both the pulse width monostables may be inhibited by the application of a positive pulse or level greater than 1.5V to the inhibit terminal.

The outputs of the pulse width monostables are inverted (gates J and M) and fed to the output amplifier input transistors. These transistors are run under saturated condition with the collector potentials set by the amplitude control potentiometers. The output from these transistors is fed to emitter followers to provide low-impedance outputs. The series resistance (30 Ω) ensures that the output transistors are protected against accidental earthing of the output terminal.

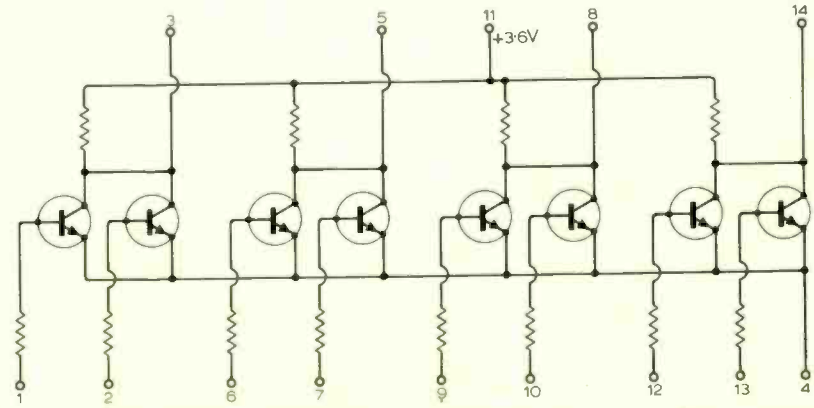
The power supply (Fig.3) uses a conventional bridge rectifier circuit with zener diode voltage reference levels controlling the series stabilizer transistors.

(Above) Fig. 4. The circuit diagram. The shaded areas represent the three dual-in-line packages.



(Left) Fig. 5 (a) Circuitry of the switch S_1 and the capacitor C_a: (b) circuitry of the remaining switches and switched capacitors S_2/C_c, S_3/C_d and S_4/C_e, which are identical. Some experiment will be required to find exact values for the range capacitors due to component tolerances etc.

(Below) Fig. 6. The circuit of the MC724P and the MC824P.



World of Amateur Radio

Slow-scan amateur TV

Despite the efforts of the British Amateur Television Club to popularise long-distance h.f. transmission of slow-scan television pictures, there remains a paucity of British activity in this field. Progress continues to be made in this interesting form of video communication by amateurs in the United States, Canada, Sweden, Belgium and Italy, yet so far as can be ascertained there are currently no British amateurs equipped to receive slow-scan TV pictures to the American standards established in 1961. These are: 120 lines, 1:1 aspect ratio; horizontal frequency, 16.666 Hz, vertical 7.2 seconds per picture, horizontal 5msec, vertical sync pulse 30msec, f.m. subcarrier (sync 1200 Hz, black level 1500 Hz, peak white 2300 Hz). The video transmissions to this standard can be sent over conventional s.s.b. or a.m. channels and can be recorded on an audio tape recorder. One of the main enthusiasts for slow-scan TV in Britain is C. Grant Dixon, G6AEC/T and G8CGK, of Kyrle's Cross, Peterstow, Ross-on-Wye, Herefordshire, but he is not licensed for h.f. operation and is anxious to hear from any h.f. amateur interested in experimenting with this mode of television. Live scenes can be transmitted as a series of 8-sec stills, while the system is also suitable for slides and photographs. Typically the pictures can be received on 5FP7 long-persistence radar c.r.ts with the bright blue trace filtered out, leaving the yellow afterglow to provide the picture. A recent technique, according to S. Horne, VE3EGO, of Ottawa, takes the output from a "fast scan" camera and samples the output to produce a picture at slow scan rate—sampling type s.s. television cameras are used at stations VE3EGO, W9NTP and WB6ZYE. A slow-scan net is understood to operate on 14230 kHz at 19.00 G.M.T. on Saturdays.

Typical slow-scan picture received on 14 MHz over a 9800-mile contact from Indiana, U.S.A., to Melbourne, Australia. (Courtesy of British Amateur Television Club.)

Australis Oscar 5 launched

Australis Oscar 5, an amateur radio beacon satellite, was successfully launched into polar orbit on January 23rd. The satellite, built by an amateur team at Melbourne University, was launched from the Western Test Range by N.A.S.A., as a secondary payload to a TIROS weather satellite, as a result of the efforts of AMSAT (Radio Amateur Satellite Corporation).

Oscar 5 carries two beacon transmitters radiating about 50 mW on 144.050 MHz and 150 mW on 29.450 MHz. Transmissions are automatically keyed to send "HI" in Morse, as well as telemetry data of temperature, spin rate and battery performance by varying audio tones. Power is derived from 28 alkaline manganese cells with an estimated life of about two months.

Beacon transmissions began 66 minutes after launch, and have since been heard by many amateurs, including a number in the U.K. where signals are usually weak. Regular bulletins of orbital data are being transmitted by the A.R.R.L. over W1AW on 14.020 MHz at 19.00 G.M.T. on weekdays.

The satellite, box-shaped 12 by 17 by 6 inches and weighing 39 pounds, is orbiting at about 910 miles and has a periodicity of 115 minutes. This is the first amateur satellite to be launched by N.A.S.A. although four previous Oscars (Orbiting Satellite Carrying Amateur Radio) have been launched by the U.S. Air Force; the last about 1965.

Construction of the satellite started in 1966 by Project Australis, a group formed by the Melbourne University Astronautical Society; it is the first amateur satellite to incorporate simple attitude control, and the transmissions are intended to provide amateur training in satellite tracking as well as permitting propagation experiments.

The successful launching of Australis lends further encouragement to the new British Project Trident group members of which are working on plans for the construction in the U.K. of an active satellite transposer which would accept 144-MHz amateur signals and re-transmit them on about 432 MHz. Detailed work is being undertaken by a group of South Coast v.h.f. enthusiasts and a number of British electronics firms have already romised support.

50 years of callsigns

The Ministry of Posts and Telecommunications has recently begun issuing Class A amateur licences in the G3ZAA series—the final letter sequence of the G3-three-letter callsigns which have been used for all new standard licences since 1946. It thus seems likely that a start will be made this year on G4-four-letter callsigns. This year also marks the fiftieth anniversary of the modern form of amateur callsigns introduced in Britain in 1920—the pre-1914 callsigns consisted of three letters one of which was always "X" to indicate an "experimental" station. Details of the "new" licences were announced at the first annual conference of amateur wireless societies of the Royal Society of Arts on February 27th, 1920 when it was also revealed that "wireless receiving licences would be issued freely to all approved persons".

In Brief: Brian Armstrong, GEDD, has been elected 1970 executive vice-president of the R.S.G.B. . . . The annual R.S.G.B. amateur radio exhibition this year is to be held from August 19th to 22nd instead of the usual October or November date. . . . A new 70-cm beacon station, GB3SC, at the B.B.C. Sutton Coldfield station operates on 433.5 MHz. . . . A 70.69 MHz beacon, GB3SX, is to be sited at Crowborough, Sussex. . . . It is planned to establish two beacon stations on 23 cm, one on the South Coast, another in London. . . . The 33rd BERU h.f. contest will be held from 00.01 G.M.T. March 7th to 23.59 G.M.T. March 8th for amateurs throughout the British Commonwealth. . . . The second sections of the A.R.R.L. DX Contests are March 7th to 8th (phone) and March 21st to 28th (c.w.). . . . Two Russian stations of interest on 14 MHz recently have been UPOL16, an Arctic weather station giving the location as 84° N, 162° W and temperature around − 26° C, and UWOIH/M a ship in the Antarctic . . . . YU stations are this year using the prefix YT to mark 25 years of Yugoslav independence. . . . The prefix 3B has replaced VQ8 for the group of islands which includes Mauritius and Chagos.

PAT HAWKER, G3VA

Personalities

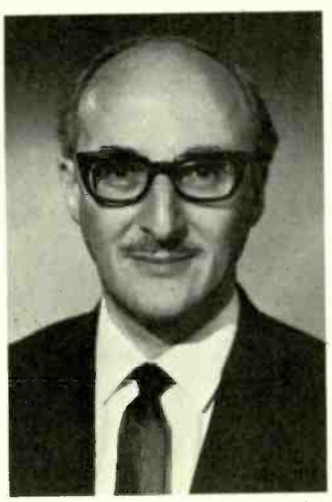
Donald Rowley, M.A., executive director of British Aircraft Corporation's Electronic and Space Systems Group, Bristol, has been appointed chairman of the National Industrial Space Committee—the professional industrial organization sponsored by the Society of British Aerospace Companies, the Electronic Engineering Association and the Telecommunication Engineering Manufacturing Association. Mr. Rowley had been acting as chairman of N.I.S.C. since **Group Captain E. Fennessy,** C.B.E., resigned last summer on joining the Post Office Corporation. Mr. Rowley will head the organization in co-ordinating and representing to the Government the considered views of the aerospace, electronics and telecommunications industries in space matters. Mr. Rowley, who is 43, and a graduate of Selwyn College, Cambridge, joined the Guided Weapons Department of the Bristol Aeroplane Company in 1949 and, on the formation of B.A.C's guided weapons division in 1963, was appointed chief engineer of the Bristol Works. In April last year he became executive director, Electronics and Space Systems.

Peter Bettridge, A.M.I.E.E., has joined the board of Elremco Sales Ltd. He is also general marketing and sales manager of Electrical Remote Control Co., Ltd and its subsidiaries. His appointment follows the tragic death of **Roy Martin** in a motor car accident. Mr. Bettridge, who is 39, has served with E.M.I. Research Laboratories Ltd, Research and Control Instruments Ltd, Sperry Gyroscope Co., Ltd, and Associated Automation Ltd.

Dr. John V. N. Granger, chairman of the board of Granger Associates at Palo Alto, California, and also chairman of the British subsidiary, has been elected president of the Institute of Electrical and Electronics Engineers for 1970. Dr. Granger was at one time teaching fellow in physics and communications at Harvard University, instructing in the pre-radar school for Army and Navy officers. During World War II he served the U.S. Ninth Air Force and the First Tactical Air Force in planning and evaluating radar counter measures. Returning to Harvard, he became a research fellow in electronics. His doctoral thesis was on low-frequency aircraft aerials. Dr. Granger joined Stanford Research Institute in 1949 to organize and supervise the aerial research programme. He resigned in 1956 to form Granger Associates.

Brookdeal Electronics, signal recovery instrument manufacturers, who recently moved from Lewisham to Bracknell, Berks, have announced two appointments. **John Roberts,** aged 39, and formerly sales promotion manager with Hewlett-Packard, has joined the company as sales manager. **Cedric Shore,** who is 32, has been appointed production manager. He was formerly senior project engineer with the Data Recording Instruments Division of I.C.L.

Mullard recently announced the appointment of three new directors, **C. Barwell, J. A. F. van Dijk,** M.Sc., and **J. A. Jenkins,** M.A., A.Inst.P. Mr. Barwell joined the company in 1932, was head of Central Marketing Services from 1963-68, and since September 1968 has been head of the company's Industrial Electronics Division, the three main product areas of which are semiconductors (including i.cs), passive components (including magnetic materials), and valves and tubes. Mr. van Dijk was born in Rotterdam and obtained his degree in engineering at Delft University, Holland. He joined Mullard's Blackburn (Lancs) plant in 1948 as chief valve engineer, becoming manager of the Valve Division five years later. He has been plant director at Blackburn since 1963. Mr. Jenkins, who graduated in mathematics and natural philosophy at Glasgow University, joined Mullard Research Laboratories in 1947 and subsequently took charge of the photo-electronics division. In 1955 he established the company's semiconductor manufacturing division. On the formation of Associated Semiconductor Manufacturers Ltd at Southampton he was appointed to the board as general manager and in 1967 was made managing director.



C. Barwell

J. A. F. van dijk

J. A. Jenkins

The Radio Industries Club has nominated as its 1970/71 president **Dr. F. E. Jones,** M.B.E., F.R.S., managing director of Mullard Ltd. Dr. Jones, who is 56 and a graduate of King's College, London, where he also obtained his Ph.D., led the team in the Ministry of Aircraft Production which developed the OBOE blind bombing system used by the R.A.F. during World War II. In 1952 Dr. Jones was appointed deputy director of the Royal Aircraft Establishment, Farnborough, and four years later joined Mullard as technical director. He has been managing director of the company since 1964, and also a director of the British Space Development Company since 1965. Dr. Jones has served on many government and industrial committees and was chairman of the Working Group on Migration (the Brain Drain enquiry), the report of which is colloquially known as the Jones Report.

"For his many contributions to the development of microwave valves and particularly for his outstanding leadership of the team at Cambridge University responsible for the development of the scanning electron microscope" **Professor C. W. Oatley,** O.B.E., F.R.S., has been awarded the 48th Faraday Medal by the I.E.E. Professor Oatley, who is 66, graduated at St. John's College, Cambridge, and subsequently became a lecturer in the Department of Physics at King's College, London. After wartime service at the Radar Research & Development Establishment he became a lecturer in the Department of Engineering at Cambridge University in 1945. He has been professor of electrical engineering since 1960.

Dr. Dennis Gabor, F.R.S., has been awarded the I.E.E.E. Medal of Honour "for his ingenious and exciting discovery and verification of the principles of holography". Dr. Gabor is Professor Emeritus, Department of Electrical Engineering at Imperial College of the University of London and is also staff scientist for CBS Laboratories at Stamford, Connecticut, where he is a member of the team which developed Electronic Video Recording. Dr. Gabor will receive the bronze medal at the Institute's annual banquet on March 25th during the International Convention. Born in Hungary in 1900, Dr. Gabor studied in Berlin where he received his doctorate. He came to England in 1934 and worked in the B.T.H. Research Laboratory, Rugby, until joining the staff of Imperial College, London, in 1949. It was in 1948 that he discovered how to reconstruct objects from their light-wave interference patterns.

Norman King, aged 33, has been promoted to marketing manager of the Instrument Division of Cossor Electronics Ltd. Mr. King has been sales manager of the Division since last March.

Active Filters

8. The two-integrator loop, continued

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

The versatility of the two-integrator loop is illustrated by descriptions of its application to selective circuits of very low frequency, a tunable crossover filter, a two-phase low-frequency oscillator, a frequency discriminator, and to an electronically-tuned oscillator and self-tuning filter.

Compensation of q for finite gain

When A is finite and the ideal design values do not give the required q to a close enough approximation, a new (higher) value of q_i may be set into the design; and it follows from equn. (28) of Part 7 that the appropriate new value is given by

$$\frac{1}{q_i} = \frac{1}{q} - \frac{1}{q_r}. \qquad (1)$$

Alternatively the positive damping attributable to finite gain,

$$\frac{1}{q_r} = \frac{1}{A_1} + \frac{1}{A_2} \qquad (2)$$

$$= \frac{2}{A}, \text{ when } A_1 = A_2 = A, \qquad (3)$$

can be counterbalanced by an equal negative damping. Since the inner feedback loop, Fig. 1(a), produces positive damping, a similar loop giving feedback of the opposite sign is required. This is shown in Fig. 1(b), where only the relevant parts of the circuit of Fig. 1(a) are reproduced. As the scaling factor of the positive damping loop is $1/q_i$, the scaling factor for the negative damping (or positive feedback) should be $1/q_r$, so that

$$\frac{1}{q} = \left(\frac{1}{q_i} + \frac{1}{q_r}\right) - \frac{1}{q_r} = \frac{1}{q_i} \qquad (4)$$

An essentially equivalent method of compensation is to apply positive feedback to the integrator amplifiers individually so that the zero-frequency gain of each becomes approximately infinite.

However, these methods of compensation, which are not self-adjusting but based on a supposed constant value of gain, give no reduction in sensitivity to changes in gain. From this point of view equn. (4) may be written

$$\frac{1}{q} = \text{constant} + \frac{1}{q_r}. \qquad (5)$$

* Royal Radar Establishment.

Hence, since relative changes in q_r are proportional to relative changes in A, equn. (3), sensitivity of q to relative changes in A can be reduced only by making $1/q_r$ a smaller fraction of $1/q$, i.e. by increasing A. This may be expressed

$$\frac{\Delta q}{q} = \frac{\Delta A}{A} \cdot \frac{q}{q_r}. \qquad (6)$$

The above discussion refers to finite gain in the integrator amplifiers. Provided the inverting amplifier that closes the main feedback loop gives no appreciable phase shift, changes in its internal gain cause only an indirect and very small change in q by causing a small change in resonant frequency and consequently a small change in the Q's of the integrators; and similarly changes in the internal gain of the amplifier (if any) in the damping loop cause only a small change in q by making a small change in q_i. It follows that these amplifiers need not be of particularly high gain for a high value of q_r; and the small effects of their finite gain can, moreover, be corrected by adjusting the values of appropriate resistors in the circuit, e.g. one of the resistors R'. But phase defects in the integrators cannot be so corrected.

Compensation of the phase errors caused by finite gain

As well as lowering the Q factor of the circuit, the less than 90° phase shift given by a finite-gain integrator also modifies the characteristic shape of many of the various filter responses available, and the most serious effect can be noticed in the symmetrical notch response. Clearly a transmission zero can be obtained only when V_C and V_L are exactly out of phase, so that their addition is in effect a subtraction. This condition exists when $A \rightarrow \infty$ and the total phase shift for the two integrators is 180°. When A is finite V_L may be resolved into a component exactly out of phase with V_C and a quadrature component, which remains at the notch output when V_C and the out-of-phase component cancel—and so prevents the notch going to zero. Its magnitude at ω_c relative to V_C and V_L is $2/A$. But at this frequency V_C and V_L have magnitude qV_{in}. If then, for example, $q = 10$ and $A_1 = A_2 = A = 100$, the minimum of the notch will be approximately $V_{in}/5$, -14dB, not a very satisfactory attenuation.

Now because the feedback integrators give inversion in addition to integration the quadrature component causing the imperfection is approximately out of phase with the voltage qV_R at the tuned-circuit (or band-pass) output, Fig. 2. It follows, since the relative magnitudes of V_C and V_L change with frequency, that the output V_N

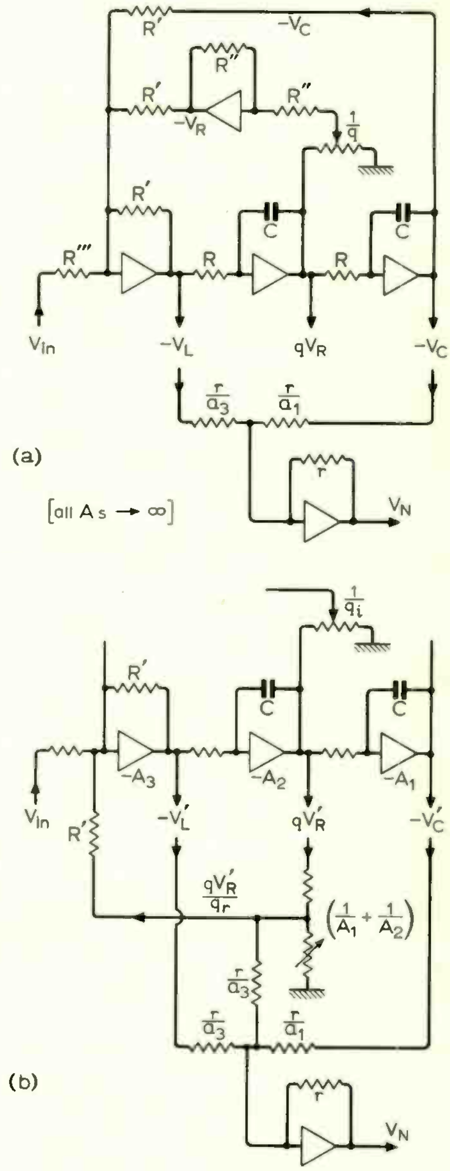


Fig. 1. (a) Ideal two-integrator system. (b) Showing a method of correcting Q factor and notch response when integrators have finite gain.

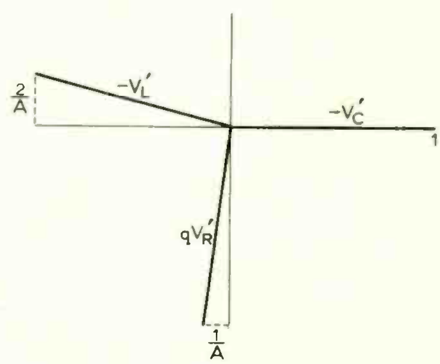


Fig. 2. Relative phases of three primary responses at ω_c.

will be exactly out of phase with qV_R at a frequency close to ω_c. This offers the possibility of producing a perfect notch by adding a fraction of qV_R, as the following analysis confirms.

Let the finite-gain responses be distinguished from the ideal responses by added primes, V_C' etc., Fig. 3(a). Then we know from the analysis of a loop containing two lags and gain that V_C' retains perfect low-pass form,

$$V_C' = \frac{1}{1+pT/q+p^2T^2}V_{in} \qquad (7)$$

though q is lower than the ideal value, and also T is a little affected by finite A_1, A_2, A_3, and is only approximately equal to CR.

The band-pass and high-pass outputs, if factors of the type $A/(A+1)$ are ignored, are given by

$$qV_R' = \left(\frac{1}{A_1}+pT\right)V_C' \qquad (8)$$

$$V_L' = \left(\frac{1}{A_2}+pT\right)qV_R' \qquad (9)$$

$$= \left\{\frac{1}{A_1A_2}+\left(\frac{1}{A_1}+\frac{1}{A_2}\right)pT+p^2T^2\right\}V_C'. \qquad (10)$$

Thus it is seen that the tuned-circuit response qV_R' levels off on the low-frequency side of resonance to V_{in}/A_1, and the high-pass response to V_{in}/A_1A_2. These characteristics, which are also apparent from inspection of the equivalent passive network, Fig. 4(a), are sketched in Fig. 4(b). With reasonably high values of A_1 and A_2 the departures from the ideal forms do not usually matter much; but Fig. 3(b) shows how corrections can be made if required, the extra linkages serving to cancel the unwanted terms in equns. (9) and (10).

The removal of the quadrature component from $-V_L'$ can, however, give a useful improvement in the notch response. For this purpose the significant correcting term is the fraction of qV_R' added to the high-pass output, which leads to the arrangement shown in Fig. 1(b). The fraction is the same as that needed to restore the Q factor, equn. (2), and both compensations may be made simultaneously as shown in the figure. Provided the various resistors are reasonably accurate, observation of a null at V_N provides the most direct indication of correct adjustment, although it is not necessary to the formation of a deep notch that q should also be compensated. Because of the approximations made, and because no notice has been taken of possible tolerance in the passive components, the analysis given is not exact. However, with amplifiers of gain say 100, the compensation will typically increase the depth of the notch by 20dB.

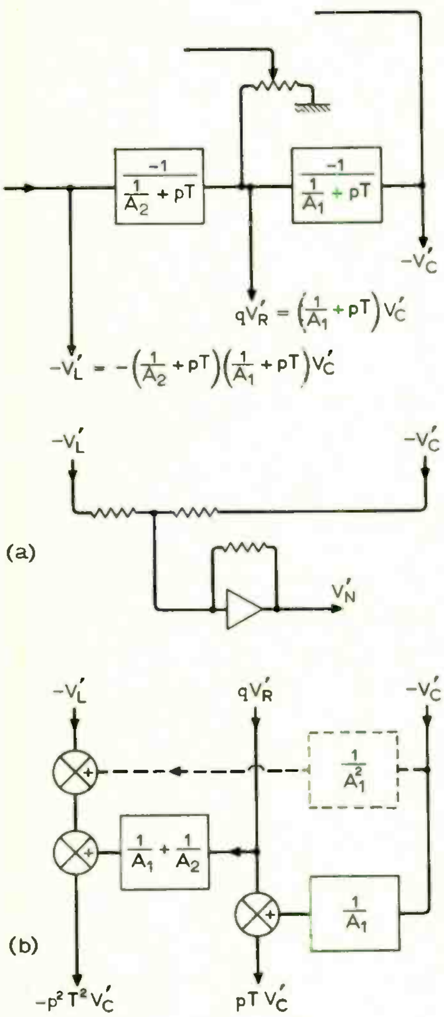


Fig. 3. (a) Analysis of system with finite-gain integrators.
(b) Method of compensation.

Frequency shift caused by finite gain

If A_1, A_2, A_3 are all $\gg 1$, the frequency shift caused by finite gain in the three amplifiers is given by

$$\frac{1}{\omega_c^2} \simeq \frac{\left(1+\frac{1}{A_1}\right)\left(1+\frac{1}{A_2}\right)\left(1+\frac{n}{A_3}\right)}{\left(1+\frac{1}{q_iA_1}\right)}T^2 \qquad (11)$$

where n is the number (or equivalent number) of equal resistors connected to the input of the A_3 amplifier. When q_iA_1 is so large that the second term of the denominator can be neglected, the equation shows that finite gain in any of the three amplifiers moves ω_c to a value lower than $1/T$. Thus, if $A_1 = A_2 = A_3 = 100$, $q_iA_1 \gg 100$, and $n = 4$, the shift is about 3%.

The second term of the denominator arises from the fact that when A_1 is finite qV_R' is not exactly in quadrature with $-V_C'$. To obtain equn. (11) accurate expressions for the voltage transfer ratio of each stage must be used, e.g.

$$\frac{A_1}{1+(A_1+1)pT}.$$

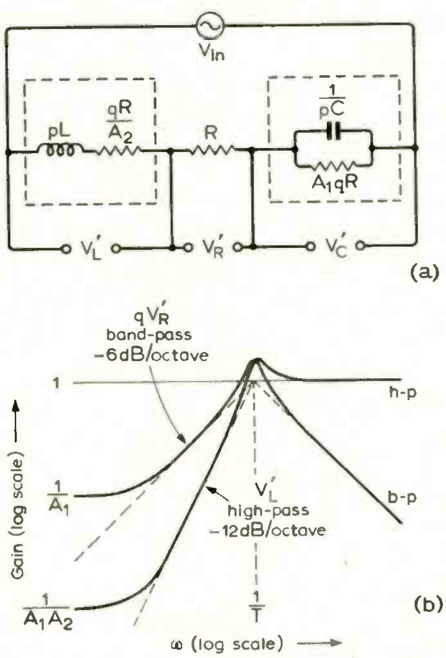


Fig. 4. (a) Equivalent circuit of system with finite-gain integrators.
(b) Uncompensated responses.

High Q circuits

Because of the small phase margin, the greatest scope for realising high Q factor in a predictable and stable manner is at low frequencies, where unwanted phase shifts can be kept low. The problem of unwanted phase shifts is also less severe in a fixed-tuned circuit, where they will be more constant. With conventional techniques $q = 10$ can be obtained with reasonable constancy in a variably-tuned circuit with an upper frequency of about 100 kHz. For an upper limit of 10 kHz the maximum value of q might be raised to 25 or 50. The increase will not be quite in inverse ratio to the upper frequency, because amplifiers of higher gain are needed if q is not to be sensitive to changes in amplifier gain, and this calls for more severe curtailment of bandwidth to obtain Nyquist stability. It is clear, of course, that upper frequency limits may be increased considerably by improvements in micro-electronic techniques.

For stable values of q greater than 100, high-gain amplifiers are needed; but this is no difficulty at low frequencies. Secondly the Q of the capacitors must be considered. A lossy capacitor shows a phase angle of less than 90° between current and voltage; so even if everything else is perfect each integrator has a phase defect of this amount, and the Q factor of the loop is limited to a value given by

$$\frac{1}{q} = \frac{1}{Q_{C1}}+\frac{1}{Q_{C2}} = \frac{1}{Q_C} \qquad (12)$$

if $Q_{C1} = Q_{C2} = Q_C$.

Some better quality dielectrics are polycarbonate, mica, silicon dioxide, polystyrene. Capacitors with the latter dielectric are usually stated to have a maximum power factor of 0·05%, i.e. $Q_C = 2000$ minimum. In practice at very low frequencies, using amplifiers with $A = 10{,}000$ approx. and no intentional damping, values of q of 1,500 and more are found, suggesting that $Q_C \geq 4{,}000$.

Very low frequencies

A loop with $f_c = 1/6{\cdot}3$ Hz ($\omega_c = 1$ radian/second) calls for $T = 1$ second. If the capacitors are to be of good quality and not too bulky, they must be of comparatively low capacitance, say 0·1 μF. The resistors must therefore have a resistance of 10 MΩ, and if the gain of the integrator amplifiers is not to be considerably eroded their input resistance should be much greater than this. By using amplifiers with field-effect transistors at the input this requirement is easily met, and by using m.o.s.f.e.ts amplifiers suitable for use with very high values of resistance can be made. Thus a circuit was made with $C = 1\ \mu F$ and $R = 1{,}000\ M\Omega$ ($T = 1{,}000$ seconds, $2\pi T = 2$ hours approx.) and set ringing by charging one of the capacitors from a battery. The time of decay to half amplitude was about 7 days; so the decay time constant was about 10 days. This is just over 800×10^3 seconds, and therefore corresponded to a Q factor of over 400. The capacitors were polycarbonate dielectric. The Q factor of such a circuit is not, of course, well controlled, as it depends entirely on imperfections such as capacitor leakage and amplifier open-loop gain.

2nd- and higher-order band-pass filters

If good rejection at frequencies somewhat removed from the wanted frequency is required, rather than sharpness at the peak; or if to obtain the required selectivity with a 1st-order tuned-circuit filter, an uncomfortably high Q factor would be needed; a higher-order filter should be used.

A conventional way of setting up a band-pass filter of 2nd-order is to cascade two stages with tuned-circuit response, and to stagger their centre frequencies suitably to either side of the specified centre frequency. Clearly this method can be followed using two two-integrator loops. A rather more convenient method, however, is to use two synchronously tuned stages, and to apply overall feedback (negative) to obtain the required bandshape. This is an analogue of a two-lags-and-feedback low-pass filter. For a 3rd-order filter a third tuned-circuit section can be added in cascade, a 4th-order filter can be made as a cascade of two 2nd-order loops, and so on. This method of design will be treated in detail in later parts.

Cross-over filters

To separate a broad band of frequencies into upper and lower parts, for example in a sound reproducing system when a separate loudspeaker is used for the higher frequencies, two complementary filters, one high-pass and one low-pass, are generally used, Fig. 5. The responses are arranged to cross over at the half-power points, and usually Butterworth, or maximally flat, response is chosen for each. On a power basis (V^2) the sum of the responses of two complementary Butterworth filters is constant, Fig. 6. This follows from the defining equations:

$$G_1(\omega) = \frac{1}{[1+(\omega T)^{2n}]^{\frac{1}{2}}} \quad \text{(low-pass)} \qquad (13)$$

$$G_2(\omega) = \frac{(\omega T)^n}{[1+(\omega T)^{2n}]^{\frac{1}{2}}} \quad \text{(high-pass)} \qquad (14)$$

$$\text{whence } [G_1(\omega)]^2+[G_2(\omega)]^2 = 1. \qquad (15)$$

If therefore, the cross-over networks are passive, as in Fig. 5, and the Ls and Cs are lossless and the load resistances are equal, the input impedance of the combination is a pure resistance of equal value.

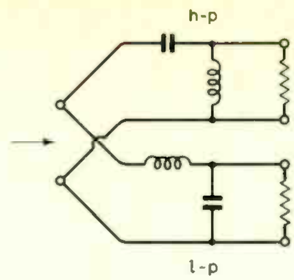


Fig. 5. 2nd-order passive crossover filter.

For 2nd-order Butterworth response, $q = 1/\sqrt{2}$, i.e.

$$G_1(p) = \frac{1}{1+\sqrt{2}pT+p^2T^2} \qquad (16)$$

$$\text{and} \quad G_2(p) = \frac{p^2T^2}{1+\sqrt{2}pT+p^2T^2}. \qquad (17)$$

Clearly a two-integrator loop is not needed for such a low Q factor, but its use may be justified, especially for experimental purposes:

- The low-pass and high-pass outputs come from the same circuit, so the corner frequencies are automatically the same.
- Variable tuning over a wide range may be had by varying either two Rs or two Cs.

The obvious disadvantage is that when the loads are, for example, loudspeakers, two power amplifiers are needed.

The basic circuit arrangement for simultaneous l-p and h-p output has already been given. If 3rd-order Butterworth response is wanted, the damping of the loop is altered to $q = 1$, and a lag, $1/(1+pT)$, and a lead, $pT/(1+pT)$, are connected as shown in Fig. 7. The two responses are not now entirely tuned by the same components; but the extra components can hardly need to be accurate to better than a few per cent. and continuously variable tuning is still possible if a four-gang potentiometer is accepted. Probably for most purposes incremental tuning with a switch would be sufficient. For versatility buffer amplifiers after the added networks may be thought advisable, so that response is not dependent on the input impedance of the amplifiers following. The difference between 2nd- and 3rd-order Butterworth response is shown in Fig. 6.

Two-phase low-frequency oscillator

The selectivity of the frequency-selective network in a conventional CR oscillator is low. For example, the Q factor of a conventional Wien-bridge network is $\frac{1}{3}$. Consequently the amplitude-limiting device must be linear at the oscillation frequency, since any harmonics generated would not be attenuated very much relative to the fundamental. This means the limiting device must be slow-acting relative to the period of the oscillation and respond only to the average amplitude of oscillation over many cycles; since otherwise the amplitude would be modulated at oscillation frequency (or twice it), a non-linear process generating harmonics. Such a slow-acting limiter is unacceptable at very low frequencies.

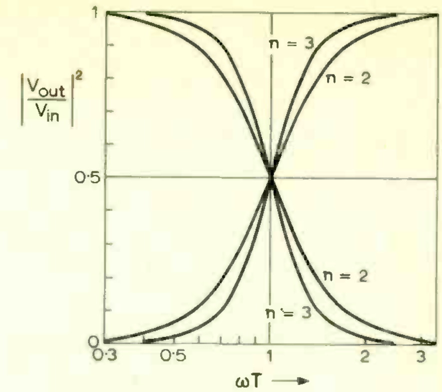


Fig. 6. Power responses of 2nd- and 3rd-order crossover filters with Butterworth response.

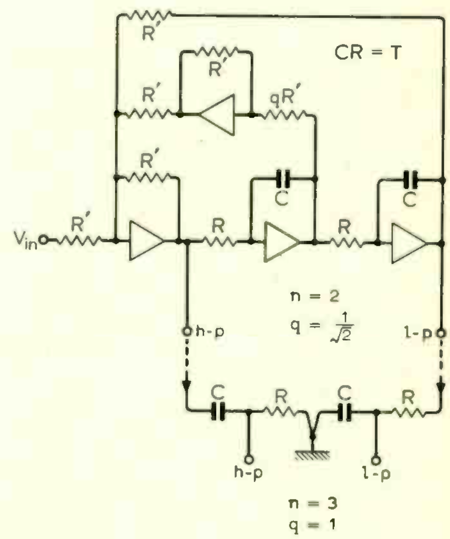


Fig. 7. Two-integrator system as crossover filter.

An LC oscillator can use an effectively instantaneous limiter. This distorts the waveform, reducing it to pulses. But the Q factor of the LC circuit can be high, giving good discrimination against the harmonics generated, so the output waveform can be a good sine wave.

Clipping diodes are an example of an instantaneous limiter, and if clipping is hard and symmetrical the output from the limiter approximates to a square wave, the Fourier analysis of which shows that it consists of the fundamental and odd harmonics in relative amplitudes inversely as their order:

$$v = \frac{4E}{\pi}\left\{\sin \omega t + \tfrac{1}{3}\sin 3\omega t + \tfrac{1}{5}\sin 5\omega t \ldots\right\} \qquad (18)$$

Now tuned-circuit response when q is high, see Fig. 8, multiplies the fundamental by q and the harmonics by $n/(n^2-1)$ approximately. So if $q = 10$, for example, the relative amplitude of the third harmonic is changed from $\frac{1}{3}$ to

$$\tfrac{1}{3} \times \tfrac{1}{10} \times \tfrac{3}{8} = 1{\cdot}25\%,$$

the fifth harmonic from $\frac{1}{5}$ to

$$\tfrac{1}{5} \times \tfrac{1}{10} \times \tfrac{5}{24} = 0{\cdot}4\%, \text{ etc.}$$

Thus the square wave becomes a fairly good sine wave even with this not very high

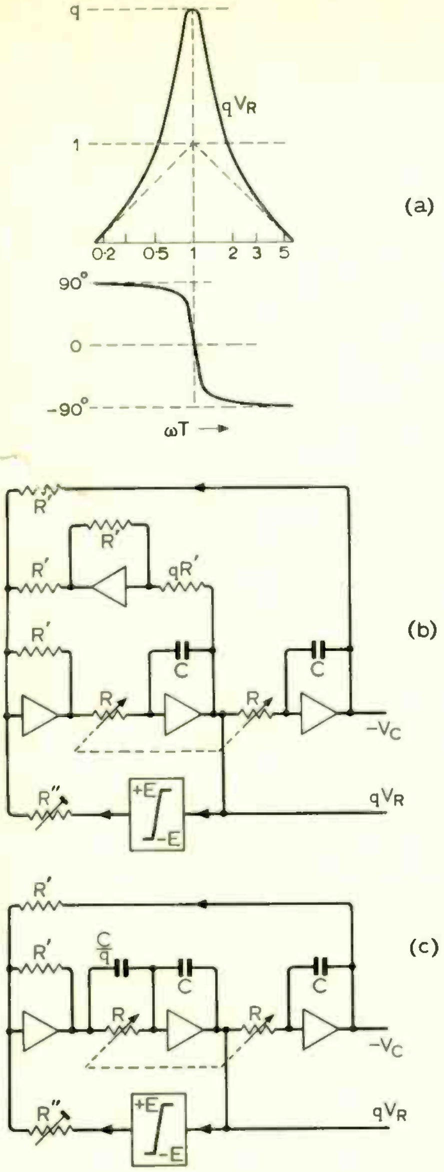


Fig. 8. Two-phase low-frequency oscillator.

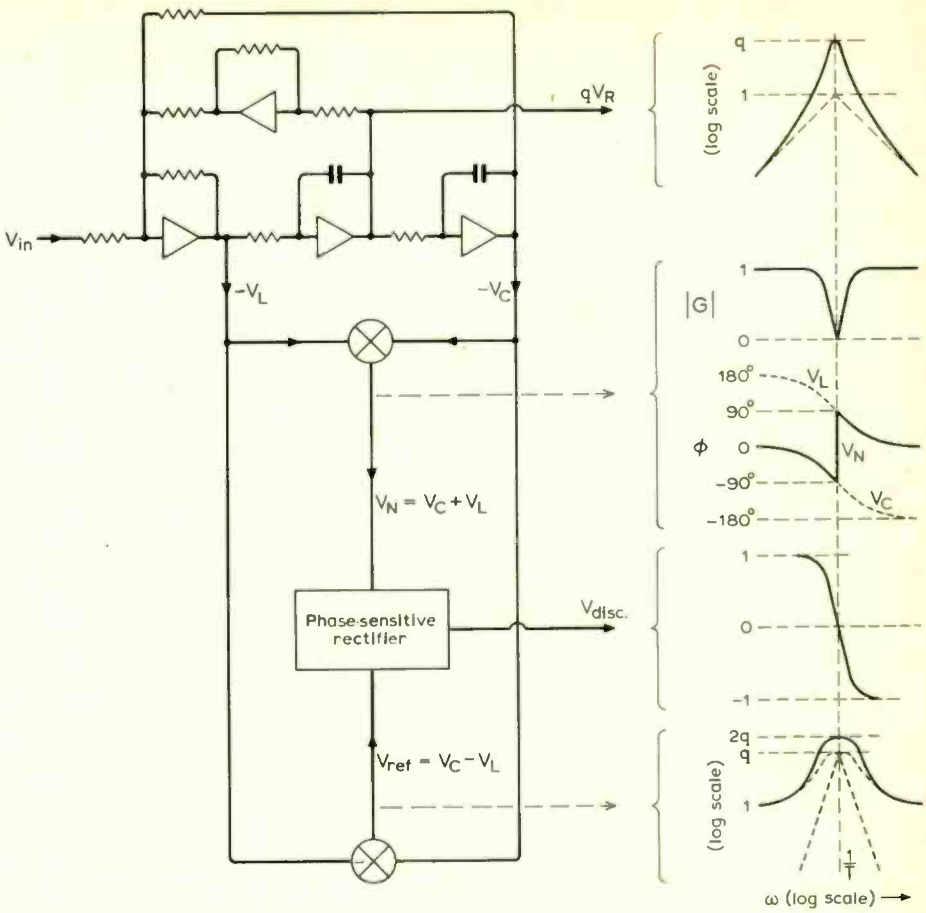


Fig. 9. Frequency discriminator.

value of q. But the two-integrator loop can do better than this.

Besides the tuned-circuit output there is the low-pass output, which, because of the integrator between, is the tuned-circuit output multiplied by $1/pT$ or $1/j\omega T$. At this output, therefore, the harmonics are further attenuated by a factor n; so for $q = 10$ the third-harmonic content becomes about 0·4% and the fifth-harmonic content less than 0·1%.

To turn the circuit into an oscillator the input must come from a source within the circuit itself, and consideration of the phase response shows that at the resonant frequency the voltage at the tuned-circuit output is in phase with the input voltage, Fig. 8(a). The oscillation loop may be closed, therefore, by connecting the input of the limiter to the tuned-circuit output, as shown in Fig. 8(b). If oscillation is to start and restart reliably, transmission through the limiter for amplitudes below the clipping level must give enough positive feedback to overcome all damping and make the circuit regenerative. Then the amplitude of oscillation will build up until, because of the clipping, a condition of balance is reached where the output from the limiter is just sufficient to maintain a steady level of oscillation. If the output from the limiter is effectively a square wave, and the two-integrator loop has ideal component values and $R'' = R'$, the magnification for the fundamental is q, and the voltage at both outputs (less harmonics) is $4qE/\pi$ peak or $2\sqrt{2}qE/\pi$ r.m.s.

When the A of the second integrator is high, and also the Q of the capacitor, or if compensation is used, the low-pass output is almost exactly at 90° phase angle with respect to the tuned-circuit output. This is of practical value, particularly in making phase measurements.

If the circuit is to be used as an oscillator and versatile filter, an independent damping loop is used, Fig. 8(b). If the circuit is to be used only as an oscillator, however, the method of damping shown in Fig. 8(c) may be used, in which capacitance C/q is placed across the R of the first integrator. This also allows the convenience of tuning with a two-gang variable resistor, and when q is high makes a negligible change in the responses at the two outputs.

Use as a frequency discriminator

Some applications require that a bandpass filter be tuned to the frequency of an input signal, while others, conversely that an input signal be adjusted to the frequency of a filter. Either type of operation may be performed under the control of the output from a frequency discriminator. The two-integrator loop can be arranged to combine the functions of selective amplifier and frequency discriminator. The feature that makes it attractive in this dual role is that the cross-over frequency of the discriminator is tuned by the same components that determine the resonant frequency of the filter. It follows that the cross-over of the discriminator will move in sympathy with any variation in the tuning of the filter and also that any change to the bandwidth of the filter is accompanied by a corresponding change in the discriminator slope.

Figure 9 is a block diagram of the essential features of the arrangement. The tuned-circuit response, qV_R, provides the characteristic for the selective amplifier. The symmetrical notch response, $V_N = V_C + V_L$, provides the basis for the discriminator.

It will be remembered that the notch response carries the phase of the low-pass response below the notch frequency and the phase of the high-pass above. At the notch frequency there is an abrupt change of phase through 180°. Thus, for example, if the output at V_N is phase-sensitively rectified using the output at V_C as reference, the resulting voltage will have a d.c. component whose polarity will depend upon the sense of the error between the input frequency and the notch frequency. The magnitude of the d.c. component will indicate the magnitude of error, approximately linearly for small errors. However, the rapid rate of attenuation given by the low-pass response restricts the range of operation, and usually a better reference can be formed by subtracting the high-pass response from the low-pass, i.e.

$$V_{ref} = V_C - V_L.$$

This subtraction brings the high-pass response into phase with the low-pass so that, in effect, the two responses add, yielding a symmetrical response as sketched in the diagram.

Tuning an integrator

There is often a need to vary the effective 'T' of an integrator. Obviously in Figs. 10(a) and (b) varying either C or R varies T. Since there is no change in zero-frequency gain with variation of C, the Q factor of the integrator is unaffected, i.e. $Q = A\omega CR$. The same is true for variation of R provided $R' \gg R$. But there are practical limits to the values of C and R if the tuning is to be continuously variable.

The method of Fig. 10(c) gives $T = k_1CR$ approx.; for, if $Ak_1 \rightarrow \infty$, the voltage across the capacitor (and hence the current through it) is k_1 times what it would be if the capacitor were joined directly across the amplifier, and so the equivalent capacitance is k_1C. This method is used to good effect in the well known Baxandall tone-control circuit. As operation of the potentiometer does not reduce the zero-frequency gain, there is in principle no loss of Q. For this to be true in practice it is necessary for r to be effectively zero so that no appreciable unwanted resistance appears in series with C. If, at any particular setting, the potentiometer has output resistance r_o, i.e. $r_o = k_1(1-k_1)r$, there is a fall in Q caused by the introduction of a term $(1+pCr_o)$ into the numerator of the transfer function. This advances the phase and so increases the phase margin. At frequencies where $Cr_o \ll 1/\omega$ this increase in phase margin, measured in radians, is given by ωCr_o, and hence, even when $A \rightarrow \infty$ the Q factor of such an integrator is limited to $Q = 1/\omega Cr_o$. With A finite (and since losses add as the reciprocals of Qs) the Q factor may be written down approximately as

$$\frac{1}{Q} = \frac{1}{A\omega k_1CR} + \omega Cr_o. \qquad (18)$$

The maximum value of r_o is $r/4$ (at $k_1 = \frac{1}{2}$), and if then the second term on the r.h.s. of equn. (18) is too great to be neglected, an emitter follower or other buffer amplifier may be interposed between the slider of the potentiometer and the capacitor.

The method shown in Fig. 10(d) gives $T = CR/k_2$, so now the potentiometer effectively increases CR. As the zero-frequency gain is k_2A there is a fall in Q when $k_2 < 1$ (except in the ideal case where $A = \infty$). It is often a convenient arrangement, however, if used with care. If $R \gg r$, k_2 is the off-load attenuation ratio of the potentiometer, but, if this condition is not met, the output resistance of the potentiometer merely increases R and distorts the tuning law.

Fig. 10(e) shows graphically the essential effects of tuning a finite-gain integrator by a potentiometer.

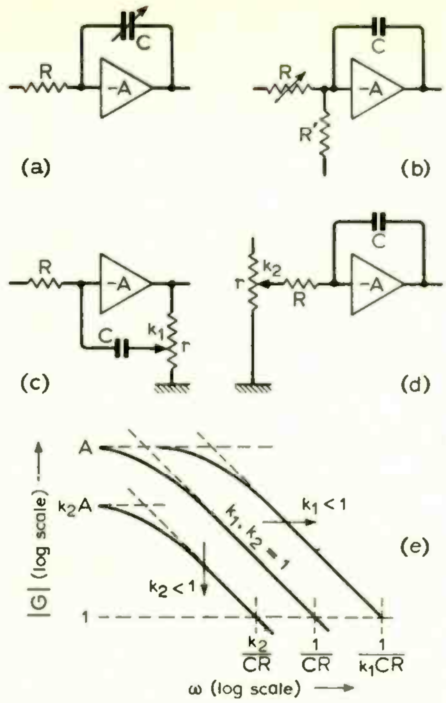


Fig. 10. Some methods of tuning an integrator.

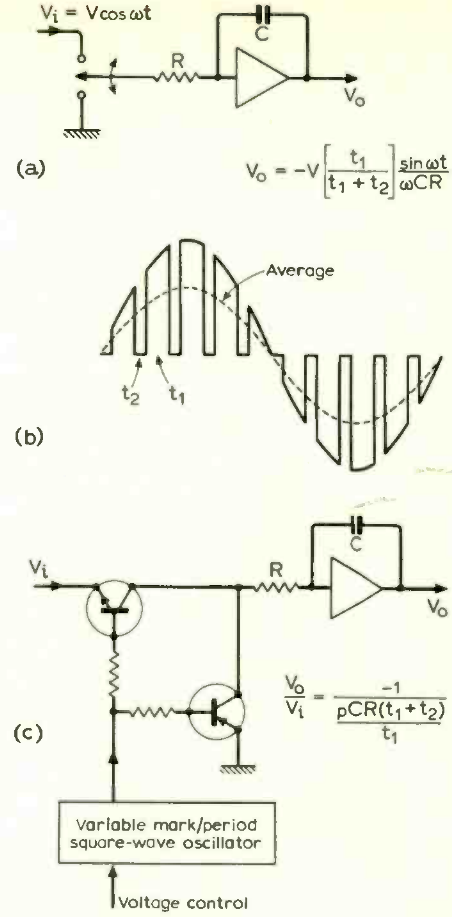


Fig. 11. Electronic tuning of an integrator.

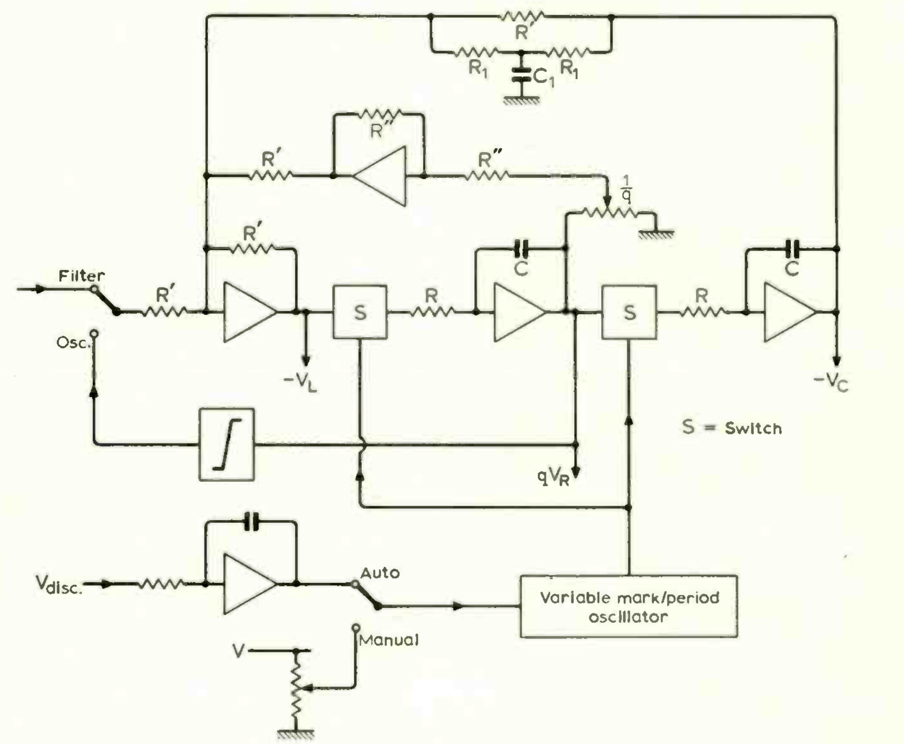


Fig. 12. Electronic tuning applied to a two-integrator system.

Voltage controlled tuning

The continuous tuning of higher order filters, requiring a large number of variables, is generally impracticable using ganged potentiometers or capacitors, and even switched tuning with a large number of banks is not always convenient. Voltage controlled tuning offers an alternative solution. A scheme suggested and used some years ago by a colleague, Dr R. L. Ford, is described here for the purpose of illustration.

In Fig. 11(a) the potentiometer used in Fig. 10(d) has been replaced by a switch which periodically connects the integrator to the input voltage source for a time t_1 and to earth for a time t_2. If the frequency of operation of the switch, $1/(t_1+t_2)$, is greater than the effective upper limit of the spectrum of the input voltage V_i, then the input to the integrator may be taken to be the smoothed average $V_it_1/(t_1+t_2)$. This is illustrated in Fig. 11(b). Alternatively the integrator 'T' may be regarded as being $CR(t_1+t_2)/t_1$. By making the switching frequency sufficiently high the unwanted products of the sampling process can be made negligible at the filter output. However, in order to avoid possible intermodulation problems, it is advisable to restrict the bandwidth of the input signal (by means of an additional simple fixed tuned filter if necessary) so that no appreciable signal is present at the switching frequency. Fig. 11(c) shows an electronic version of the switch, driven by a square-wave generator. It is fairly easy to make such a generator have a waveform with its mark-to-period ratio directly proportional to a d.c. control voltage. Since the switching waveform is common to all integrators the tracking accuracy will be good as long as the transistor switching times are short relative to the minimum pulse width.

Since this method of tuning causes an effective reduction in zero-frequency gain, losses will increase as the tuning decreases the frequency. Dr Ford has shown how compensation can be applied in respect of applications using the two-integrator loop. This is provided by the network consisting of R_1 and C_1, shown in Fig. 12, which progressively shunts the outer feedback loop as the frequency decreases. The design requires that the lag network should give nearly 90° of the phase shift at the lowest tuning frequency and that

$$C_1R_1^2 = AR'RC/2 \qquad (19)$$

Over a 10 to 1 tuning range and using a nominal value of $q = 20$, amplitude variations are reduced from 15% to 1% when $A = 2{,}000$.

Using this technique the two-integrator loop can be used as a voltage controlled filter or oscillator, as indicated in Fig. 12, or as a self-tuning filter using the output from the frequency discriminator, Fig. 9, to control the variable mark/period oscillator. (An integrator is shown notionally in the loop to reduce steady-state tracking errors.)

March Meetings

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

LONDON

3rd. I.E.E./I.E.R.E.—Discussion on "Indirect pressure measurement" at 17.30 at Savoy Pl., W.C.2.

4th. I.P.P.S./I.E.E.—Symposium on "Electroluminescent solid state devices" at 10.00 at Savoy Pl., W.C.2.

4th. I.E.R.E.—"The continuing education and development of professional electronic engineers" by Dr K. G. Stephens at 18.00 at 9 Bedford Sq., W.C.1.

4th S.E.R.T.—"Closed circuit educational television" by E. Wykes at 19.30 at the Educational TV Centre, Battersea.

5th. I.E.E.—Appleton Lecture "Radar meteorology" by Dr. E. Eastwood at 17.30 at Savoy Pl., W.C.2.

5th. I.E.R.E.—"Direct digital control without a computer" by C. C. Lawson at 18.00 at 9 Bedford Sq., W.C.1.

9th. I.E.E.—"Training—a systems approach" by Capt. G. Huggett, R.N., at 17.30 at Savoy Pl., W.C.2.

9th. I.E.E.T.E.—"Problems of starting up colour television programmes" by F. H. Steele at 18.00 at the I.E.E., Savoy Pl., W.C.2.

10th. I.E.R.E.—"Management effectiveness for engineers" by H. Makepeace at 18.00 at 9 Bedford Sq., W.C.1.

11th. I.E.E.—"Electronics in cars" by L. G. Cripps at 17.30 at Savoy Pl., W.C.2.

16th. I.E.E.—"Sonar" by T. N. Reynolds at 17.30 at Savoy Pl., W.C.2.

16th. R.Inst.—"The Parliamentary and Scientific Committee" by R. Gresham Cooke at 17.30 at 21 Albemarle St. W.1.

18th. I.E.R.E.—"Electronic engineering in the solution to harbour approach problems for large ships" by T. W. Welch at 18.00 at 9 Bedford Sq., W.C.1.

19th. R.Soc.—"Electronic aids to night vision" by P. Schagen at 16.30 at 6 Carlton House Terrace, S.W.1.

19th. I. Electronics.—"Flexible printed circuits" by P. B. Ryman at 18.30 at the London School of Hygiene & Tropical Medicine, Keppel St, W.C.1.

20th. I.E.E.—Discussion on "Microwave filters" at 17.30 at Savoy Pl., W.C.2.

20th. I.E.E.—"Technological forecasting and corporate long-range planning" by Dr. B. C. Lindley at 17.30 at Savoy Pl., W.C.2.

25th. I.E.R.E./I.E.E.—Colloquium on "Peripheral development and information flows inside systems" at 14.30 at 9 Bedford Sq., W.C.1.

25th. I.E.E.—Discussion on "Silicon imaging devices" at 14.30 at Savoy Pl., W.C.2.

AYLESBURY

3rd. I.E.E.—"Pulse code modulation" by G. H. Bennett at 19.15 at Aylesbury College of Further Education.

BASILDON

11th. I.E.R.E.—"Electronic production in the 1970s" by P. Newell at 19.30 at the Bull's Eye.

BATH

4th. I.E.R.E./I.E.E.—"Underwater acoustics and sonar" by Prof. D. G. Tucker at 19.00 at the Technical College.

BIRMINGHAM

18th. R.T.S.—"Colour film for colour television" by Dr. G. B. Townsend and C. B. Wood at 19.00 at ATV Network, Paradise Centre.

BOURNEMOUTH

5th. I.E.R.E.—"Computers for engineers" by T. Matthews at 19.00 at the College of Technology.

BRISTOL

18th. I.E.R.E./B.C.S.—"Computer typesetting" by R. Chapman at 19.00 at the University.

CAMBORNE

10th. I.E.R.E.—"Training technician engineers for the future" by Dr. H. L. Haslegrave at 19.00 at the College of Technology.

CARDIFF

12th. R.T.S.—"Modern video recorders" by W. Silvie at 19.00 at B.B.C., Llandaff.

23rd. I.E.R.E./I.E.E.—"Digital filters" by R.C.V. Macario at 18.30 at the University of Wales Inst. of Science and Technology.

CHELTENHAM

17th. I.E.R.E.—"Training of professional engineers and technicians" by R. E. Stevenson at 19.00 at the Government Communications Headquarters, Oakley.

COVENTRY

12th. I.E.R.E./I.E.E.—"Integrated circuits" by D. Grant at 18.30 at the Lanchester College of Technology.

EDINBURGH

11th. I.E.R.E./I.E.E.—"Inertial navigation" by J. T. Summers at 19.00 at Napier College of Science and Technology, Colinton Rd.

19th. I.E.E.—Faraday Lecture "People communications and engineering" by J. H. H. Merriman at 14.00 (students) and 19.00 (public) at Usher Hall.

GLASGOW

12th. I.E.R.E./I.E.E.—"Inertial navigation" by J. T. Summers at 19.00 at the Institution of Engineers and Shipbuilders in Scotland, 183 Bath St., C2.

HORNCHURCH

24th. I.E.R.E.—"Automation in air traffic control" by A. Hartley-Smith at 18.30 at Havering Technical College, Ardleigh Green Rd.

HULL

19th. I.E.R.E./I.E.E.—"Doppler aims for berthing large tankers" by Dr. W. P. Williams at 18.30 at the Yorkshire Electricity Board Offices, Ferensway.

LEICESTER

10th. R.T.S.—"The B.R.C. 3000 colour TV chassis" by C. R. West at 19.30 at Vaughan College, St. Nicholas Circle.

18th I.E.E.T.E.—"Storage of sight and sound" by J. E. Shepherd at 18.30 at the Polytechnic, the Newark.

LIVERPOOL

18th. I.E.R.E.—"The development and application of integrated circuits" by T. Urwin at 19.00 at the University's Dept. of Electrical Engineering.

MAIDSTONE

2nd. I.E.E.—"Stereophonic transmission" by Dr. G. J. Phillips at 19.00 at the Royal Star Hotel.

MANCHESTER

9th. I.E.E.T.E.—"Electronics in industry" by K. Varley at 19.30 at the Education and Training Dept., GEC-AEI Ltd., Trafford Park.

17th. I.E.R.E./I.E.E./R.T.S.—"Space communications" by J. M. Brown at 19.15 at the Renold Bldg, U.M.I.S.T.

NEWCASTLE-UPON-TYNE

11th. I.E.R.E.—"High speed data communications over telephone lines" by C. B. Stuttard at 18.00 at Rutherford College, the Polytechnic.

17th. I.E.E.—Faraday Lecture "People, communications and engineering" by J. H. H. Merriman at 14.15 (students) and 19.15 (public) at City Hall.

NEWPORT, MON.

18th. I.E.E.T.E.—"From the Albert Hall to the Festival Hall—the adventures of an electrical engineer in the realms of acoustics" by James Moir at 19.30 at the College of Technology, Allt-Yr-Yn Avenue.

PLYMOUTH

17th. I.E.R.E.—"Training technician engineers for the future" by Dr. H. L. Haslegrave at 19.00 at the College of Technology.

READING

19th. I.E.R.E.—"Laser applications in electronics" by Prof. W. A. Gambling at 19.30 at J. J. Thomson Laboratory, the University, Whiteknights Park.

RUGELEY

5th. I.E.R.E.—"Satellite power supplies" by P. S. Woodcock at 19.00 at the Shrewsbury Arms Hotel, Market St.

SWINDON

3rd. I.E.R.E./I.E.E.—"Stereo sound broadcasting" by J. H. Brooks at 18.15 at the College.

Literature Received

ACTIVE DEVICES

A series of data sheets describing the new range of m.t.n.s. (metal-thick-oxide-nitride-silicon) medium scale integration devices is available from General Instrument Microelectronics, Stonefield Way, Ruislip, Middlesex, HA4 OJT. Called the "Giant" range, the devices have inputs and outputs compatible with d.t.l./t.t.l. and m.o.s. circuitry without any interface components. A single-phase d.t.l./t.t.l. clock line is all that is required.

m.t.n.s. price list WW401
reliability aspect of low voltage nitride WW402
RA-6-4803, 32-bit random access memory WW403
SS-6-8211, dual 16-bit d.c. shift register WW404
SS-6-8212, dual 16-bit d.c. shift register WW405
SL-6-4025/32, quad 25/32-bit static shift register WW406
MU-6-2281, 10-channel multiplexer WW407
SL-6-2064, dual 64-bit static shift register WW408
SL-6-2050, dual 50-bit static shift register WW409
SS-6-1032, 32-bit static shift register WW410
SS-6-2004, dual 4-bit shift register WW411
SS-6-2021, 21-bit static shift register WW412
MU-6-8571, 16-way shift register controlled multiplexer WW413
AX-6-8591, presettable reversible b.c.d. counter, store, 10-line decode, display drive, with zero detect and display blanking WW414

We have received two loose-leaf binders containing literature from Marconi-Elliott Microelectronics Ltd, Witham, Essex:

Digital and linear microcircuits, data WW415
Application notes WW416

The hybrid microcircuit facilities of Racal Research Ltd, Newtown, Tewkesbury, Glos., are described in a leaflet available from them WW417

The 1970 edition of "Abridged Valve Data" may be obtained from English Electric Valve Co. Ltd, Chelmsford, Essex WW418

The SG7520/25 series of high-speed sense amplifiers manufactured by Silicon General Inc., 7382 Bolsa Avenue, Westminster, California 92683, U.S.A., is described in an eight-page leaflet WW421

Transitron Electronic Ltd, Gardner Rd, Maidenhead, Berks., give details of a 64-bit, word addressed, integrated circuit memory cell in a leaflet WW422

Data is available on a 6A, 1,400V, rectifier (type S6) in a four-page booklet (4450-50/S6) from A.E.I. Semiconductors Ltd, Carholme Rd, Lincoln WW423

The following literature has been produced by the National Semiconductor Corporation and is available from Athena Semiconductor Mktg. Co. Ltd, 140 High St, Egham, Surrey.

t.t.l. cross reference guide WW424
t.t.l. series 54/74 (NS) performance guide WW425

PASSIVE COMPONENTS

"Electronic Components, Accessories and Materials" is the title of a directory and product guide published by the Radio and Electronic Component Manufacturers' Federation, Mappin House, 4 Winsley St, London WIN ODT. It lists details of 195 manufacturing firms and includes a product guide in English, French, German and Spanish. Copies are available price 6s each to U.K. residents or free of charge to overseas companies.

The 1970 "Constructors Catalogue" from Electroniques, Edinburgh Way, Harlow, Essex, unlike last year's catalogue, is devoted entirely to electronic components and equipment; it costs 10s plus 3s postage and packing.

Crystals, resistors, magnetic materials, infra-red filters and capacitors are listed in "Passive Components Summary" (6000/301) obtainable from ITT Components Group Europe, Standard Telephones and Cables Ltd, Edinburgh Way, Harlow, Essex WW426

Now obtainable is the "Microwave Associates Master Catalog" from Microwave Associates Ltd, Cradock Rd, Luton, Beds. WW427

Sub-miniature indicator lamps (3mm) are the subject of a leaflet from Vitality Bulbs Ltd, Beetons Way, Bury St. Edmunds, Suffolk .. WW428

The Sprague range of "Tantalex" tantalum electrolytic capacitors is described in a booklet from WEL Components Ltd, 5 Loverock Rd, Reading, Berks WW429

A leaflet produced by A. F. Bulgin and Co., Bye Pass Rd, Barking, Essex, describes some of their indication, connection and switching compoments WW430

The transformer design and production facilities of Gresham Transformers Ltd, Hanworth Trading Estate, Feltham, Middlesex, are detailed in a leaflet WW431

If it's rotary switches you are interested in you will find the latest catalogue from Lorlin Electronic Co. Ltd, Billinghurst, Sussex, of value. WW432

An eight-page catalogue describing coaxial directional couplers is available from Radiall, 1 Rue Jacquard, 93-Rosny, S/Bois, France WW433

EQUIPMENT

The "High-Fidelity and General Audio Equipment" catalogue from Henry's Radio Ltd, 303 Edgware Rd, London W.2, consists of 120 pages and costs 5s plus postage and packing.

The 1970 edition of Lasky's "Audiotronics" catalogue is now available free of charge (1s 6d required for postage and packing) from Lasky's Radio, 3-15 Cavell St, Tower Hamlets, London E.1.

The range of temperature control and measuring instruments, chart recorders and other industrial instrumentation manufactured by FAS Automazioni Strumenti of Italy is described in a catalogue. FAS Automazioni Strumenti, Via F. Koristka, 8/10., I 20154 Milan, Italy. WW449

A full range of accessories for Philips oscilloscopes is described in an eight-page brochure available from Pye Unicam Ltd, York St, Cambridge WW442

GENERAL INFORMATION

The "Miniflux Manual" is a 131-page book devoted to the replay of tape recordings. The theory is discussed and a number of practical circuits are given including a stereo pre-amplifier using integrated circuits. Price 31s 6d from: Miniflux Electronics Ltd, 8 Hale Rd, London, N.W.7.

The B.B.C., Broadcasting House, London W1A 1AA, has produced the following two information sheets:

2701(17) Television interference from distant transmitting stations.
1102(5) V.H.F. radio receiving aerials.

The following publications are available from the British Standards Institution, 2 Park St, London W1Y 4AA:

BS 9110: Metric Units: Specification for fixed resistors of assessed quality: generic data and method of test .... price 16s.
BS 9111: Metric Units: Rules for the preparation of detail specifications for fixed non-wirewound resistors, film type (type 1) of assessed quality .... price 12s.

"Automation Matters" is the title of a booklet published by Sira for the U.K. Automation Council. The subject dealt with is "Cost reduction by thickness measurement and control". The booklet can be obtained from Sira, South Hill, Chislehurst, Kent, price 10s.

Test Your Knowledge

Series devised by L. Ibbotson, B.Sc., A.Inst.P., M.I.E.E., M.I.E.R.E.

22. Rectifier Circuits

Figures 1, 2 and 3 show three simple rectifier circuits, each supplied from the mains, and each feeding a resistive load *R*. Unless otherwise stated it is to be assumed that the components are ideal.

1. The current in each diode flows for half of an input cycle:
   (a) in all three circuits
   (b) in the circuit of Fig. 1 only
   (c) in the circuit of Fig. 2 only
   (d) in the circuit of Fig. 3 only.

2. In each circuit the direct voltage appearing across *R* will consist of a steady voltage with a ripple superimposed. The fundamental ripple frequency is 50 Hz:
   (a) for the circuit of Fig. 1 only
   (b) for the circuits of Figs. 1 and 3 but not Fig. 2
   (c) for all three circuits
   (d) for none of the circuits.

3. In the circuit of Fig. 1, if for a given load-resistor the value of the capacitor *C* is increased, the amplitude of the ripple will be reduced. In a practical circuit the maximum value of capacitor which may be used is determined by:
   (a) the time constant *CR* which must not exceed 1/50 second
   (b) the physical size of the capacitor
   (c) the maximum rated instantaneous current for the diode
   (d) the maximum rated diode reverse voltage.

4. In the circuit of Fig. 2, increasing the value of *L* will decrease the amplitude of the ripple. The limit to the size of inductor used in a practical circuit is determined by:
   (a) the time constant *L/R* which must not exceed 1/100 second
   (b) the resistance of the inductor, which will be greater for larger values
   (c) the maximum rated instantaneous diode current
   (d) the maximum rated diode reverse voltage.

5. If in the three circuits similarly labelled components have the same values, the amplitude of the ripple voltage across the load:
   (a) will be the same for all three circuits
   (b) will be least for the circuit of Fig. 1
   (c) will be least for the circuit of Fig. 2
   (d) will be least for the circuit of Fig. 3.

6. Assuming that the component values in the three circuits are such that the ripple amplitude is small compared to the steady output voltage, the ripple waveform appearing across the load will be approximately saw-tooth:
   (a) in all three circuits
   (b) in the circuit of Fig. 1 only
   (c) in the circuit of Fig. 2 only
   (d) in the circuit of Fig. 3 only

7. Assuming small ripple amplitude, the magnitude of the steady output voltage will be:
   (a) the same for all three circuits
   (b) least for the circuit of Fig. 1
   (c) least for the circuit of Fig. 2
   (d) least for the circuit of Fig. 3.

8. The magnitude of the steady output voltage for the circuit of Fig. 2 will be:
   (a) 340 volts
   (b) $340/\pi$ volts
   (c) 680 volts
   (d) $680/\pi$ volts

9. Assuming that the ripple amplitude is small in each case, the maximum reverse voltage appearing across each diode is:
   (a) the same in all three circuits
   (b) least for the circuit of Fig. 1
   (c) least for the circuit of Fig. 2
   (d) least for the circuit of Fig. 3.

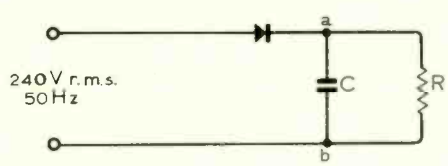


Fig. 1

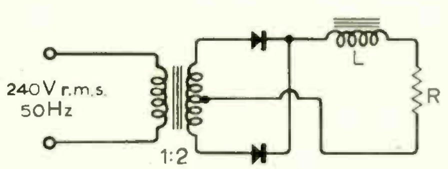


Fig. 2

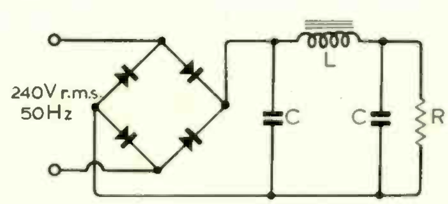


Fig. 3

10. Assuming small ripple amplitude the value of the maximum reverse voltage appearing across the diode in Fig. 1 is approximately:
   (a) 340 volts
   (b) $340/\pi$ volts
   (c) 680 volts
   (d) $680/\pi$ volts

11. The simple inductor smoothing used in Fig. 2:
   (a) could also be used in a half-wave rectifier or a bridge rectifier circuit
   (b) could not be used in either a half-wave rectifier or a bridge rectifier circuit
   (c) could be used in a half-wave rectifier circuit, but not in a bridge rectifier circuit
   (d) could be used in a bridge rectifier circuit, but not in a half-wave rectifier circuit.

12. For three practical circuits, of the forms of Figs. 1, 2 and 3, designed to feed the same load, the voltage regulation over the working range will probably be:
   (a) the same for all three
   (b) best for the circuit of Fig. 1
   (c) best for the circuit of Fig. 2
   (d) best for the circuit of Fig. 3

13. In the circuit of Fig. 1 the current in the branch containing the capacitor:
   (a) flows in the direction *ab* at all times
   (b) flows in the direction *ba* at all times
   (c) flows in the direction *ab* when the diode is conducting, in the direction *ba* when it is not
   (d) flows in the direction *ba* when the diode is conducting, in the direction *ab* when it is not.

14. If in the circuits of Fig. 1 and 2 the load resistance *R* is increased in value, the amplitude of the ripple voltage across the load will:
   (a) increase in both cases
   (b) decrease in both cases
   (c) increase for the circuit of Fig. 1, decrease for the circuit of Fig. 2.
   (d) increase for the circuit of Fig. 2, decrease for the circuit of Fig. 1.

15. In the circuit of Fig. 3:
   (a) the reactances of the inductor and of the capacitors should be as large as possible
   (b) the reactances of the inductor and of the capacitors should be as small as possible
   (c) the reactance of the inductor should be as large as possible; the reactances of the capacitors should be as small as possible
   (d) the reactance of the inductor should be as small as possible; the reactances of the capacitors should be as large as possible.

Answers and comments, page 147

* West Ham College of Technology, London E.15.

New Products

Magnetic Cartridge

The American ADC 25 stereo pickup, available in the U.K. from K.E.F., is an induced magnetic cartridge with three interchangeable stylus assemblies. Two of the styli are elliptical (0.0009 × 0.0003in, and 0.0007 × 0.0003in) and the third is spherical (0.0006in). It is claimed that this choice allows the user to obtain the best reproduction from records having different groove characteristics. No harm can be done to any record with any of the styli in the recommended tracking pressure range of 0.5 to 1.25g. Each stylus is predicted to last indefinitely 'with clean records and proper use'. Price £81 12s plus £18 19s purchase tax. K.E.F. Electronics Ltd, Tovil, Maidstone, Kent.
WW 328 for further details

Universal Bridge

A new a.f. bridge from Wayne Kerr, model B224, measures components singly or in any combination, and provides four-figure readings of the real and imaginary terms simultaneously. Seven of the ten ranges are for two- or three-terminal connections, accuracy being 0.1% or better. The remaining three ranges provide four-terminal connections to ensure accurate (0.3%) measurements of all impedances below 10Ω. Operation can be at any frequency between 200Hz and 20kHz. The internal detector covers this range and an oscillator is built in for normal operation at 10^4 radians/sec (1592Hz). Simplicity of operation is assured by a functional layout of the controls and by the logarithmic amplitude response of the detector amplifier. This ensures rapid selection of the correct range, easy determination of a first balance and automatic increase in sensitivity as the final balance point is approached. Operation is from 110 or 240V a.c. or from the internal rechargeable battery. This latter facility simplifies connection of the bridge measurement leads to circuits where one terminal is grounded. Overall coverage is 200 attofarads (0.0002pF) to 5 farads, 2 picomhos to 50 kilomhos, 2 nanohenry's to 5 megahenrys and 2 micro-ohms to 500 gigohms. The B224 is 19in wide, 12in high and 6in deep (482 × 311 × 152mm). It weighs approximately 22lb (10kg) and will sell in the U.K. at £340. Wayne Kerr Co. Ltd., New Malden, Surrey.
WW 301 for further details

High-current Power Supply

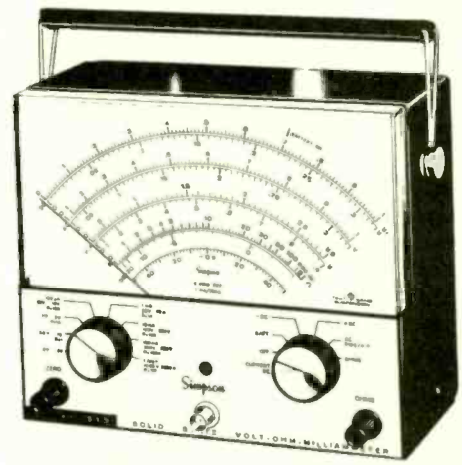
The Lambda LK361 power supply can deliver 50A at 0–36V and is convection cooled. It has line and load regulation of 0.015%, ripple 500mV r.m.s., is completely programmable, and can be used in the constant-voltage or constant-current mode with automatic crossover. The unit may be used for series or parallel operation and is guaranteed for five years. Lambda Electronics, 21 Aston Road, Waterlooville, Portsmouth, Hants.
WW 306 for further details

Camera Tube

The XQ1071 is a sensitive, one-inch, Plumbicon tube from Mullard for use in cameras of industrial closed-circuit television systems. It will give acceptable pictures under normal lighting conditions, and has a rapid response, greatly reducing the smear obtained when the camera is focused on moving objects. The tube has a resolution of 600 lines, and uses magnetic focusing and deflection. The maximum operating voltage is 1100V, and the heater supply required is 6.3V at 95mA. The capacitance between the target and the other electrodes is only 4.5pF. It is intended for use in monocrome television cameras: three other versions suitable for use with red, green and blue light are available; these are distinguished by the suffixes R, G and B after the type number XQ1071. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW 308 for further details

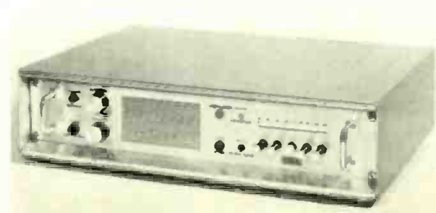
Electronic Multimeter

Electronic multimeter model 313 from Bach-Simpson has an input impedance of 11MΩ on d.c. and 10MΩ on a.c. ranges. It has a frequency response of ±0.5dB from 20Hz to 100kHz (10kHz to 250MHz with external probe) and seven resistance ranges which provide internal resistance measurements up to 1000MΩ. Other special features include centre-zero facility, r.m.s. and peak-to-peak a.c. scales together with a dB scale. A 7-in scale enables currents of 5 μA or less to be read. Bach-Simpson Ltd., 331 Uxbridge Road, Rickmansworth, Herts.
WW 305 for further details



U.H.F. Receiver

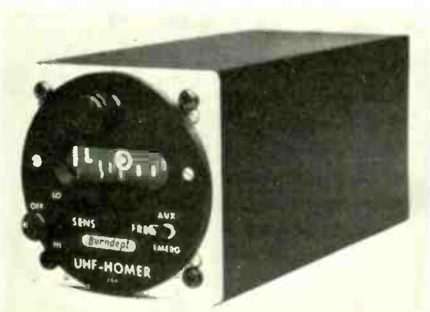
The Decca type RU.3911, receiver unit is fully transistorized and will demodulate u.h.f. 625-line PAL colour television signals in the range 470/860 MHz received "off-air", or distributed on a channel-selective or wideband closed circuit system, to provide a high-quality video and audio output signal at standard levels for immediate display, further processing, or remodulation. The standard unit is contained in a case measuring 19¼ × 4¾ × 13¾ in but is also suitable for mounting on a



19-in rack, for which purpose a separate dust cover is provided. Manual tuning of the four pre-set channels, selected by push-buttons, is by means of a separate control, but an effective switchable automatic frequency-control circuit is also provided. There are six independent video outputs of 1V into 75Ω, and one balanced audio output of 1mW into 600Ω. A monitor loudspeaker is provided on the front panel. Price £89 10s 8d (including purchase tax). Decca Radio & Television, Ingate Place, Queenstown Road, London, S.W.8.
WW 317 for further details

Aircraft 'Homer'

Burndept Electronics (E.R.) is marketing a homing instrument manufactured in West Germany for fixed or rotary wing aircraft which, when used with the company's personal and flotation beacons or similar equipment gives a ground/air range of 150/200 miles at 30,000ft (60/80 miles at 10,000ft). It will pick up any radio distress signals on 121.5 or 243MHz. A safety feature of the homing device (type BE 373) is its independence from the main aircraft communications system; only a connection to the usual 28V d.c. supply is required. A pair of $\frac{1}{4}$-wave radio aerials with balanced 50-Ω feeder cables is supplied, and an alternative version for vehicle or ship 12-V operation is available. In normal



operation, the emergency channel is preset to the v.h.f. or u.h.f. international aviation distress frequency; an auxiliary channel can be used to within ± 2.5MHz (v.h.f.) or ± 5MHz (u.h.f.) for training and/or tactical purposes. The homer provides 'left/right' indications from the received signal. Audio outputs to the aircraft intercom system are provided. The unit costs under £500, plus installation. Burndept Electronics (E.R.) Ltd, St. Fidelis Road, Erith, Kent.
WW 322 for further details

V.H.F. A.M. Radiotelephone

A range of v.h.f. a.m. mobile radiotelephones (the Star AM7 series), has been introduced by S.T.C. The AM7 is available in low-, mid- and high-band versions, covering all the v.h.f. frequencies available for use in the U.K. Single-channel and four-channel models are available, employing 12.5kHz channel spacing. The equipment, which is completely solid state, has no relays or

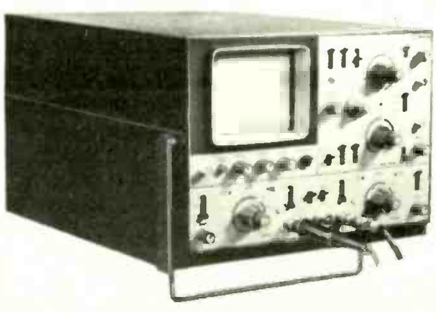
moving parts. The output power is 5–7 watts, and receiver sensitivity is 0.5μV to open squelch. Audio output is 2.5 watts into 3Ω. Power requirements (from 12V vehicle battery) is 1.9A on transmit (full modulation) and 0.2A on standby. Standard Telephones and Cables Ltd, S.T.C. House, 190 Strand, London, W.C.2.
WW 309 for further details

Modular Noise Source

The NS 110A module provides 0.5V r.m.s. of random noise in the range 500Hz–1MHz ($\pm$ 1dB). In the range 50Hz–5MHz the output is level to within ± 5dB. The module requires a supply of 9V at 10mA. Provision is made for an attenuator or filter to be inserted between the separate internal amplifiers. The output amplifier (A_2) has a 600-Ω short-circuit proof output terminal (OP_2). The module is suitable for use as a broadband source for telephone-line noise simulation, intermodulation and cross-talk tests, frequency response measurements and noise interference tests. The noise level is sufficiently flat in the audio region to permit assessments to be made of loudspeaker response and room acoustics including sound attenuation and reverberation. ADM Electronics, P.O. Box 3, Merthyr Tydfil, Glam.
WW 307 for further details

50-MHz Oscilloscope

A 50MHz dual-trace general-purpose oscilloscope from Pye Unicam, known as the Philips PM 3250, combines a 2mV input sensitivity with a 50MHz bandwidth, and 200μV when a 5MHz bandwidth is used. It is capable of simultaneously displaying the differential signal (A-B) with one of the original signals. The Y-amplifier can be set from 2mV/cm to 20V/cm using a thirteen-position calibrated control and $\times$ 10 gain magnifier gives the 200μV/cm sensitivity at the reduced bandwidth of 5MHz. Full overload protection is provided on both channels and at maximum input sensitivity 400V can be applied to either input without damage. Sweep speeds pro-



vided on the main timebase cover the range 1s/cm to 50ns/cm in 23 calibrated ranges and a $\times 5$ magnifier permits a 10ns/cm speed to be used. The timebase can operate in the triggered, automatic or single-shot modes, and triggering can be from either input channel or an external source. A delayed timebase provides sweep speeds of from 0.5s/cm to 50ns/cm in 22 calibrated steps and also employs a magnifier to give 10ns/cm. This timebase can be triggered immediately after a delay by either the main sweep or the measuring signal. The instrument is mains powered and measures 22 $\times$ 32 $\times$ 48cm. Pye Unicam Ltd., York Street, Cambridge.
WW 302 for further details

Beam Tetrode

The TT100 beam tetrode from The M-O Valve Co., is primarily intended for use as a class AB power amplifier for s.s.b. transmitters in ships. It will give a p.e.p. output of 100W with intermodulation products of -42dB for an h.t. of only 600V, while 200W p.e.p. is available for an h.t. of 850V. The stated output powers are maintained

up to at least 20MHz, while at 30MHz the output is greater than 85% of the low frequency value. (Anode dissipations significantly greater than these values are permissible for short periods). Class AB2 operation is recommended and is made possible by the very low grid interception of the valve. The M-O Valve Co. Ltd, Brook Green Works, London W.6.
WW 319 for further details

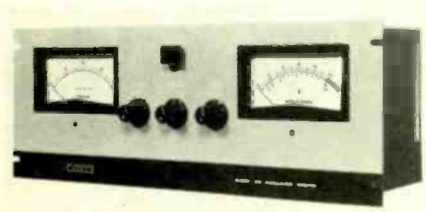
Cassette Tape Editing Kit

A cassette tape editing and joining kit from Multicore enables cassette tapes to be joined if they have been broken or edited because it is desired to remove unwanted sections which have been recorded. It may also be used, under certain circumstances, to add tape from one cassette to another. The kit comprises: Bib tape splicer with chromium plated clamps; two razor cutters (1 spare); splicing tape on dispenser; tape piercer; three tape extractor and winder

cards (two spare); and ten cassette and container labels (self adhesive). The main difference between editing $\frac{1}{4}$-in tape and $\frac{1}{8}$-in tape is that with a reel-to-reel machine the non-oxide side of the tape is available for marking with a chinagraph pencil. The tape in a cassette is wound the other way round, i.e. with the oxide side outwards. If the oxide side was marked with a chinagraph pencil the marking would not be visible when the tape was mounted in the channel on the splicer with the oxide side downwards. Obviously, the splicing tape must be applied to the non-oxide side of the tape. A method of marking simultaneously both sides of the tape has been devised. Although the joining and editing processes are relatively simple, a comprehensive 6-page instruction leaflet is included in the kit. The price is 29s. The Bib Division of Multicore Solders Ltd, Hemel Hempstead, Herts.
WW 323 for further details

A.M. Monitor

A solid-state a.m. monitor for transmissions in the frequency range 540kHz to 30MHz has been introduced by Gates Radio Company. The monitor is said to meet or exceed all requirements for measuring modulation percentages, and is suitable for proof-or-performance measurements. The monitor's solid-state circuits are not affected by ageing and measurement accuracy is said to be retained indefinitely. Correct positive or negative peak indications are given even on programme bursts as short as 40 to 90 milliseconds. The over-modulation flasher light also has the same accuracy as



the meter. For aural monitoring there is a 600-Ω output. Three functional monitoring controls are located on the front panel: (1) carrier-level setting, (2) a range selector covering negative peak percentages, and (3) a modulation meter switch for chosing either negative or positive peaks. For obtaining modulation readings by meter and flasher at a distant location, there is an optional remote meter panel available. Gates Radio Company, 123 Hampshire Street, Quincey, Illinois, U.S.A.
WW 327 for further details

Six-decade Resistance Box

A resistance range of 1 Ω to 1 MΩ in 1-Ω steps is provided by Resistance box type GE 6000, from Guest International. Very high precision is obtained through the use of 0.5% metal film resistors on the 10-Ω decade and above. These resistors provide protection during overload conditions and

have low self-inductance. The dimensions are 343 × 63.5 × 70mm, and the price is £22. Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey.
WW 326 for further details

Voltage Triplers

A range of voltage triplers, announced by General Instrument (U.K.), employs matched silicon diodes and ceramic capacitors to provide e.h.t. for various applications. A typical unit in the new range is the TVM25 which converts 8.3kV from the flyback transformer to 25kV for a colour-tube anode and provides a separate focusing voltage. The peak input voltage is 12kV, output voltage is 30kV, normal output current is 1.5mA d.c. and the short circuit overload rating is 50mA for 30 seconds. The operating temperature range is −50° to +85°C. Operating frequency is 15.750Hz. Input capacitance is less than 30pF for zero bias voltage. Individual capacitors used in the TVM25 are rated at 1,000pF at 10kV with leakage current less than 1.0μA at 10kV working voltage and 85°C ambient temperature. The tripler is totally encapsulated in epoxy resin which is flame resistant and has negligible corona potential. General Instrument (U.K.) Ltd, Stonefield Way, Victoria Road, South Ruislip, Middx.
WW 312 for further details

Miniature Variable D.C. Power Supply

The TF 2150 power supply from Marconi Instruments provides continuous control of both current and voltage with a maximum output of 25W. The range is 0-30V and 0-1.25A. Regulation is better than 0.05%, and ripple less than 400μ V. There is non-re-entrant current protection. The accuracy of full scale volts is ±2%. It may also be operated as a pulsed power source, linear d.c. power amplifier, threshold switch, or temperature regulator. It may be remotely programmed (external

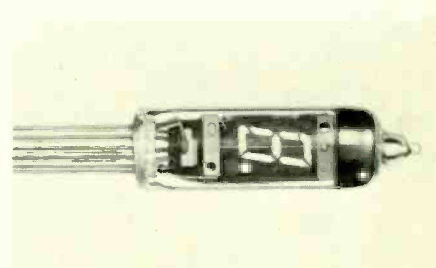
resistor) and operated in series or parallel, grounded or ungrounded. The unit weighs 2.3kg, measures 190 × 80 × 160mm, and costs £39 10s. Marconi Instruments Ltd, Longacres, St. Albans, Herts.
WW 325 for further details

½-kW Power Supply

Robin Telephones have developed a low-ripple high-efficiency stabilized power supply capable of delivering 10A at 50V. Stability is achieved by a variable inductance, which is controlled by a semiconductor circuit. The output is monitored by two meters which can be scaled to customers' requirements. The stability is such that at 1A ripple is 7mV (voltage 50.5V) and at 10A ripple is 92mV (voltage 50.0V). Supplies with other voltage and current ratings are available. Price £58. Robin Telephones Ltd., 5 & 6 Wandsworth Place, London S.W.18.
WW 304 for further details

Low-voltage Indicator Tube

Counting Instruments are marketing a miniature Itron (Japanese) low-voltage indicator tube. The display is green. Heater



requirement is 50mA at 0.7V, and the maximum d.c. level for the display segments is 25V d.c. Counting Instruments Ltd, 5 Elstree Way, Boreham Wood, Herts.
WW 324 for further details

700V 6A Transistor

Available from GDS (Sales) Ltd is a power transistor with 700V V_{CES} and 325V V_{CEO} ratings, 1. μs maximum fall time and 2V maximum saturation voltage, both measured at a collector current of 6A. Supplied in the TO-3 package and rated at 125W at 25°C case temperature, the Motorola MJ9000 is capable of carrying up to 10A continuous collector current. Also announced is the Motorola MJ8400 which is rated at 600V V_{CEO} and 1400V V_{CES} and

has 1.1μs maximum fall time at 3A. Both transistors can be used in c.r.t. deflection systems. Cost of the MJ9000 is 72s 4d and the MJ8400, 86s 2d. GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.
WW 314 for further details

Transistor Tester

Both field effect and bipolar transistors can be tested under small signal a.c. conditions at a nominal frequency of 1kHz with the Bournlea Dynamic transistor tester. For depletion mode f.e.ts the measurement range of zero-bias transconductance (g_{mo}) is from 0.5 to 75 mmho. For bipolar transistors the measurement range of current gain (beta) is from 5 to 750. Devices of either

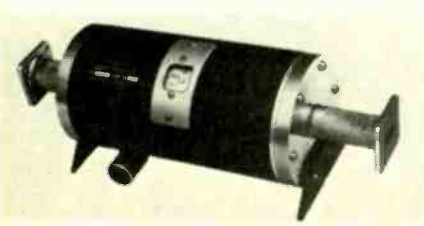
polarity can be tested. Terminals on the side of the instrument enable any sensitive multi-range meter to be used for a variety of additional tests on diodes and transistors, including f.e.t. zero bias drain current (I_{DSS}) and f.e.t. pinch-off voltage (V_p). The Cardon Instrument Co., Earls Colne, Colchester, Essex.
WW 310 for further details

Encapsulated Single-phase Bridge

International Rectifier are producing low-cost, encapsulated single-phase bridge rectifier assemblies rated at 1.6A. The series, designated BSB, whilst compact in size, displays high single-cycle surge and repetitive current ratings and offers an operating temperature range of −40° to 150°C. It is available in the range of 75 to 600V r.m.s. International Rectifier, Hurst Green, Oxted, Surrey.
WW 313 for further details

Direct Reading Attenuators

A range of fourteen simple direct reading attenuators has been introduced by Flann Microwave Instruments, for isolating poor s.w.r.s. All models in the range are frequency insensitive and display an s.w.r. of less than 1.25 over their calibrated atten-



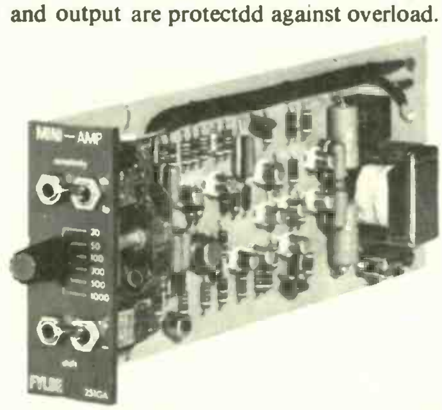
uation range of 30dB. There are 13 calibrations ranging from attenuations of 0.1 to 30.0dB. Calibration accuracy is 5% or 0.25dB, whichever is the greater. Phase shift varies from under 3° to less than 5°, depending on model. Frequency range varies from 2.6-3.95GHz to 92-138GHz, and power rating from 0.3W to 8W, depending on model. Flann Microwave Instruments Ltd, 9 Old Bridge Street, Kingston-upon-Thames, Surrey.
WW 334 for further details

Miniature Terminals

Specially designed for miniature circuitry, Vero Electronics have introduced a terminal (part no. MT/11081) which holds up to five leads using three possible directions. With a hand tool these terminals are easily inserted into 0.052-in diameter holes, yet may be re-used if desired by simply pulling them out of the board. The miniature terminals are produced from beryllium copper sheet, and finished in tin. Staking is not essential but the terminal may be staked by flaring the bottom end using needle nose pliers. Vero Electronics Ltd, Chandler's Ford, Hampshire.
WW 320 for further details

Instrument Amplifier

Intended as an instrument pre-amplifier, the FE-251-GA from Fylde has a wide gain range, with internal damping and variable sensitivity for electrically damped galvanometers. Shift facilities are built in, and there is output sensitivity control. Gain is switched between 20 and 1000, and input impedance is greater than 2MΩ. Both input and output are protectdd against overload.



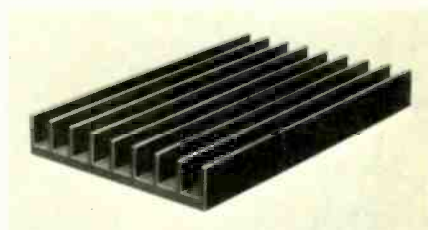
Output capability is ±8V at up to 1.5mA and common mode rejection is greater than 100dB. Full shift of the output is possible, and wideband noise is less than 10mV pk-pk, referred to output. Bandwidth may be adjusted, from d.c. to between 100Hz and 100kHz. A monolithic input stage produces drift performance better than 5_uV/°C, referred to input. Fylde Electronic Laboratories Ltd, 6/16 Oakham Court, Preston, PR1 3XP.
WW 329 for further details

Pulse Generating System

Two addition modules are available for Farnell's modular pulse-generating system. The PO/V variable slope module is an alternative to the standard output module, for applications requiring variable rise and fall times or higher output voltages. Rise and fall times can be varied between 1ns/V and 10ms/V (minimum rise time approximately 10ns) with maximum peak-to-peak amplitudes of 40V into open circuit, 20V into 50Ω. Separate controls enable the pulse level to be set between −3V to +20V (positive level) or +3V to −20V (negative level) into open circuit. Total perturbations 10%, overshoot and ringing 10% of maximum amplitude and output impedance 50Ω ±5%. Price: £45. The frequency divider module PF/D operates over the range 0–1MHz and divides the frequency obtained from the P.R.F. Generator Module PF/A by either 10 or 100, thus enabling repetition rates as low as 0.01Hz to be obtained. Price: £28. Farnell Instruments Ltd, Sandbeck Eay, Wetherby, LS22 4DH, Yorkshire.
WW 311 for further details

Flat-based Heat Sink

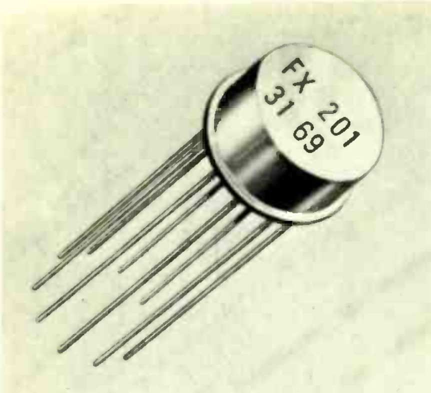
Jermyn Industries have added to their range of power heat sinks the type 'MF' which is a flat-based aluminium extrusion with nine equally spaced fins. This extrusion is $\frac{11}{16}$in high, $3\frac{1}{2}$in wide, and has a base thickness of $\frac{3}{16}$in. Type MF-25U is $2\frac{1}{2}$in in length and has a



thermal impedance of 3.3°C/W. The other standard stock version, MF-56U is $5\frac{5}{8}$in long and has a thermal impedance of 1.75°C/W. These two standard types are available black-anodized, but undrilled. Other lengths can be made available to special order. This range of heat sinks is suitable for mounting TO-66, TO-3 and many other sized devices on the flat face, and may be utilized to replace one side of a module's container due to its thin section and low weight. Jermyn Industries, Vestry Estate, Sevenoaks, Kent.
WW 316 for further details

Frequency-selective Microcircuit

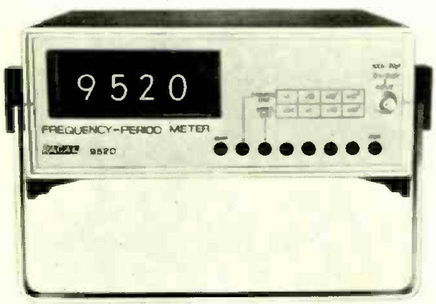
A frequency sensitive switch, type FX-201, is now available from Consumer Microcircuits. Employing low-voltage m.o.s./m.s.i. microcircuits in a TO-5 case the device operates as two independent frequency selective switches. It accepts sine-wave and pulse input signals—the operating frequencies and bandwidths being determined by means of a few externally connected resistors and capacitors, and adjustable over a very wide working range. The band frequencies are adjustable



between 10Hz and 30kHz, bandwidths and separation between the two bands are adjustable from 1% to 50% and band-edge 'slope' is typically better than 0.1% (effective Q exceeds 1,000). The response time is approximately 1.8 milliseconds at 5kHz. The device operates from input signals between 20mV and 20V pk-pk, requires only 2mA of operating current from a nominal 9/12V supply (excluding switched load currents), and is immune to random signal noise and harmonics. Consumer Microcircuits Ltd., 142/146 Old Street, London E.C.1.
WW 303 for further details

Frequency-period Meter

The 9520 frequency-period meter, from Racal, covering the frequency range 5Hz to 10MHz, can measure periods from 1μs to 0.2s and gives a four-digit in-line display. The gate times of 1ms, 10ms, 100ms and 1s



are selectable by push-buttons, as are the mode of operation, check position and power on-off switch. The U.K. price is £135. Racal Instruments Ltd, Duke Street, Windsor, Berks.
WW 318 for further details

Data Amplifiers

Two new data amplifiers have been introduced by Data Device Corporation—the model VA-21 video amplifier and the fast settling model FS-21. The VA-21 provides a slewing rate of 750V/μs, with a 12MHz frequency for full output. Its stable 6dB/octave roll-off characteristic gives a useful gain-bandwidth product of 80MHz minimum. Developed specifically for high frequency inverting applications, the VA-21 can be employed in video summing and deflection control amplifiers, and in high-speed data processing. Model FS-21 is a member of the same family, but optimized for fast settling. It is said to be suitable for digital to analogue conversion systems, sample-and-hold circuits, and pulse amplifiers. Both versions offer outputs of ±20mA at ±10V, 20μV/°C voltage drift and 0.5nA/°C current drift. The operating temperature range is 0 to 70°C with optimum performance from 10 to 50°C. V-F Instruments Ltd, Gloucester Trading Estate, Hucclecote, Glos. GL3 4AA.
WW 321 for further details

Laboratory D.C. Power Supply

New from Tranchant Electronics Ltd, is the TZ 45, an all-silicon solid-state d.c. power supply unit delivering up to 40V at 2A in both constant-voltage and constant-current modes, both modes having coarse

and fine adjustment controls. Unit measures 4×7×11½in. An over-voltage crowbar with operating time of less than 20μs, operating temperature range of 0-60°C, ripple 300μV r.m.s. and load and line regulation 1 part in 10,000 is available as an optional extra. Tranchant Electronics (U.K.) Ltd, 17 Charing Cross Road, London, W.C.2.
WW 312 for further details

T.T.L. Integrated Circuits

Monostable FJK101, high speed, full adder FJH191, 5-bit shift register FJJ241, single master-slave bistable element FJJ261 and two-bit adder FJH201 are five t.t.l. integrated circuits in dual-in-line encapsulations introduced by Mullard. The FJH191 has gated complementary inputs and is intended for use in parallel-add and serial-carry applications. The device provides a complementary sum output and an inverted carry output and it is claimed that one FJH191 needs less power than a selection of other t.t.l. circuits arranged to perform the same functions. Supply voltage required is 4.75 to 5.25V at 21mA. Fan-out from a carry output and sum outputs is 5 and 10, respectively. The FJJ241 has five R-S master-slave flip-flops connected to give parallel-to-serial or serial-to-parallel conversion of binary data. Access to the inputs and outputs of each flip-flop allows either parallel in and parallel out or serial in and serial out modes of operation. Supply voltage required is 4.75 to 5.25V at a typical supply current of 48mA. The width of clock and clear pulses is not less than 35ns and 30ns respectively. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW 331 for further details

Minimal Reactive Resistor

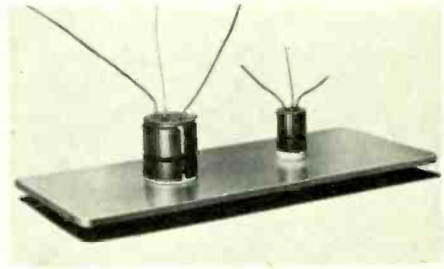
Although the claim for the FC100 by Reliance Controls is that it is believed to be the first non-reactive fixed Cermet resistor available with dual-in-line configuration, the Cermet element does have some minimal inductance. The dual-in-line package allows complementary mounting with silicon integrated circuits. The substrate is 96% alumina, the case diallyl phthalate, the terminals are plated beryllium copper. The FC100 is available with values from 100Ω to 1MΩ, and has a nominal weight of 1g. Reliance Controls Ltd, Drakes Way, Swindon, Wiltshire.
WW 330 for further details

Low-cost Thyristors

Two ranges of thyristors the TAG 3 and TAG 6 with 5.0 and 7.5A capacity rated up to 600V and 800V respectively are available from Jermyn. The maximum gate drive is 15mA at 2.0V and 25mA at 3.0V respectively. The TO-66 encapsulation employed ensures low thermal impedance between junction and heatsink. The 400V devices in each range are priced at 12s 8d and 16s 4d each respectively in quantities of 100-999. Jermyn Industries, Vestry Estate, Sevenoaks, Kent.
WW 337 for further details

Heat Sink Adaptors

The excellent thermal conducting and electrical insulating properties of aluminium oxide are used in the new A1004AX (TO5) and A1005AX (TO18) heat sink adaptors, manufactured by Jermyn. A body of anodized aluminium is seated on an aluminium oxide ceramic base, giving a total thermal impedance from transistor to base of approximately 13°C per watt. Electrical characteristics include 500V minimum breakdown



voltage (1000V typical) and 1pF (typical) capacitance from transistor to mounting surface. Jermyn Industries, Vestry Estate, Sevenoaks, Kent.
WW 315 for further details

Answers to "Test Your Knowledge"

Questions on page 141

1. *(c)* In the circuits of Figs 1 and 3 the capacitors charge up so that the potential across each diode only becomes positive for a small part of a cycle; the diode current only flows during this time. In the circuit of Fig. 2 the inductor keeps the current flowing; the diodes conduct for half-cycles in turn.

2. *(a)* The circuits of Figs 2 and 3 both have a fundamental ripple frequency of 100 Hz.

3. *(c)* The charge which flows out of the capacitor through the load while the diode is not conducting must be replaced while the diode conducts. As the ripple decreases the diode-conduction time is reduced so that the peak current during this time increases.

4. *(b)* The inductor resistance lowers the value of the output voltage since some of the steady component of the rectified voltage is developed across it.

5. *(d)* The inductor and second capacitor, acting as a filter, will very much reduce the ripple output compared to that of the other two circuits.

6. *(b)* The indicator smoothing of Fig. 2 produces a ripple which is more nearly sinusoidal. The filter circuit in Fig. 3 eliminates the higher frequencies in the ripple more efficiently than the fundamental, and thus leaves a residual ripple which is approximately sinusoidal.

7. *(c)* Figs 1 and 3 will give an output voltage which is not much less than the peak value of the supply.

8. *(d)* The steady output voltage for this circuit is the mean value of a full-wave rectified sine wave i.e. $2/\pi$ times the peak voltage.

9. *(d)* In the circuit of Fig. 3 the maximum reverse diode voltage is the peak value of the input voltage. In the circuit of Fig 2, and, approximately, in that of Fig. 1 it is twice this.

10. *(c)* Since the capacitor is charged to nearly peak positive input voltage, when the supply is peak negative the voltage across the diode is nearly twice the peak value.

11. *(d)* Inductor smoothing is only effective where flow of current through is continuous.

12. *(c)* Circuits in which an inductor is the first smoothing component have the better regulation.

13. *(c)* When the diode is conducting the capacitor is charging. When it is not conducting the capacitor is discharging through the load.

14. *(d)* In the circuit of Fig. 1 increasing *R* decreases the amount by which the capacitor discharges between charging pulses and thus reduces the ripple amplitude. In the circuit of Fig. 2 on the other hand, the smoothing effect of the inductor increases with increase of mean current (assuming that L does not change) and thus with decrease of *R*.

15. *(c)*. The inductor and second capacitor can be thought of as forming a potential divider for the ripple voltage which appears across the first capacitor. It is also necessary that the reactance of the capacitors should be much less than the load resistance value (but the first capacitor must not overload the diodes).

Real & Imaginary

by "Vector"

"Pipes and whistles in his sound"

"Local radio is likely to have audiences of millions instead of thousands as a result of a Government decision to allow the B.B.C. to use the medium wave as well as v.h.f. for local broadcasting." This newspaper summary caught my eye when speeding by British Rail towards London and Dorset House. On my arrival, and while waiting in the Editor's office, I began looking through the volumes of *W.W.* which grace the walls. These go back to 1911, almost to the dinosaurian era, but I had little difficulty in locating my immediate quarry, namely, the beginnings of v.h.f. (it was e.h.f. in those days) broadcasting in this country. Indeed, one could scarcely miss it, for the correspondence columns were so heated as to need asbestos paper. There were those who wanted v.h.f./f.m.; there were those who wanted v.h.f./a.m. and there were those who didn't want either at any price. Incidentally, among the last-mentioned I was intrigued to find our old friend Thomas Roddam putting in a plea for pulse modulation (p. 70, Feb. 1947). Given transistors and integrated circuits, how about it now, Mr. Roddam?

To press on, it seems that the end of World War II found the m.f. band in a chaotic state. Transmission technologies had improved tremendously and with them came increased output powers to blast propaganda across enemy frontiers. Nightfall brought a hideous cacophony, garnished with monkey-chatter and whistles; a situation which is still with us a quarter of a century later.

The B.B.C., with Government approval, decided to go to v.h.f. where sufficient channels to cover the British Isles were available. The vexed question of f.m. versus a.m. was settled by building a new station at Wrotham, Kent, to radiate both forms of modulation. After exhaustive tests, f.m. was chosen and stations were being built in quantity in 1954/55; all seemed set for the millenium.

For prospects were bright indeed. Here was a transmission system which provided speech and music of high quality, unimpaired by co-station interference or by natural or man-made static. With a network of f.m. stations covering the country, virtually everyone could have a choice of three programmes under almost flawless conditions. The m.f. stations would gradually become redundant and could then be phased out, except, of course, for external broadcasting.

The serpent in this Garden of Eden was not discovered for some little time. An integral part of the system was the home receiver. This was the one item over which the B.B.C. had no control; they could issue specifications for top-quality transmitters and aerial systems; they could badger the G.P.O. into providing landlines which would preserve the audio waveforms, but they could have no voice in the design of the home installation.

No one was alarmed when v.h.f. made a slow start, for that was John Citizen's conservative way. But as time went by it became very apparent that, in spite of all the seductive advertising, John had no intention of investing in the new system.

Various factors contributed to this; the times were uncertain; the new type of receiver was more expensive, and John's definition of high-quality reproduction was a big bad wolf in the bass register and a complete cut-off of the higher frequencies. But over and above these were two circumstances that both the B.B.C. and the domestic receiver manufacturers failed to recognize, although any dealer could have told them about it (and probably did!).

One was that before the war, John (and, more particularly, Mrs. John) had become accustomed to listening to foreign commercial stations, such as Fécamp and Luxembourg, which featured broadcasts in English. Naturally, then, when buying a new set, one of the first questions would be "Will it get foreign stations?" and if the answer was a hesitant, "No, not really" then this put the v.h.f. receiver out of court.

The second circumstance also showed the influence of the distaff side. Mrs. John has always had an aversion to trailing wires which interfere with the ritual of cleaning and dusting. A completely self-contained receiver which could be lifted and replaced was to her an ideal which had the added merit that it could be carried from room to room; this enabled her to perform the domestic rites without missing a single syllable concerning the vagaries of her favourite soap-opera tearjerker of the day. For this facility she was prepared to put up with any amount of interference.

When it dawned on the radio manufacturers that v.h.f. was an also-ran with the general public they panicked toward the wrong conclusion, deciding that cheaper receivers would put matters to rights. As a result, cheese-pared circuitry which cut down on such frivolities as an efficient a.f.c. system and cheap-and-nasty loudspeakers became the order of the day, the whole being accommodated in a two-by-nothing plastic box. Thus the poor old dealer was lumbered with a receiver which (a) would get only three B.B.C. stations, (b) was difficult to tune, (c) did not stay tuned because of frequency drift and (d) was of no better quality than the average m.f. set (and when mistuned was a darned sight worse).

With hindsight, it is easy to see that the cardinal mistake was that no finite date for the closure of B.B.C. internal m.f. stations was given. On the assumption that a receiver's life is five years, a deadline of, say, seven years from a given date would have been realistic. Henceforth, from the publication of that date, the industry would have been able to concentrate on two main types of receiver. One, for the quality-seeking minority, a v.h.f./f.m. receiver of unstinted design, and the other, for the mass market, an a.m./f.m. set covering the m.f. and v.h.f. bands as a minimum requirement. At the end of the seven years all B.B.C. domestic m.f. transmissions would have ceased; this would have sensibly reduced co-station interference on the band, thus adding to the enjoyment of the foreign station enthusiast.

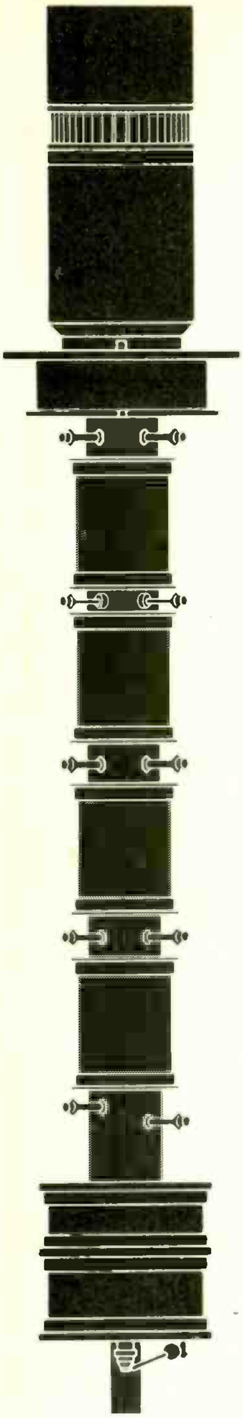
A friend of mine, who is a radio and television dealer, but is otherwise sound of mind, tells me that the trends of the 1950s are accentuated today. In the mass market the hefty mains receiver which requires an external aerial is virtually out, and very few are sold. The main sound radio market is the teenage group, the big sellers being the miniature cheap-and-nasty transistor portable (and its counterpart in record players), their main selling points being their undoubted ability to make a raucous noise. The larger mediocre-to-moderate quality portable is the main choice of the older age-groups.

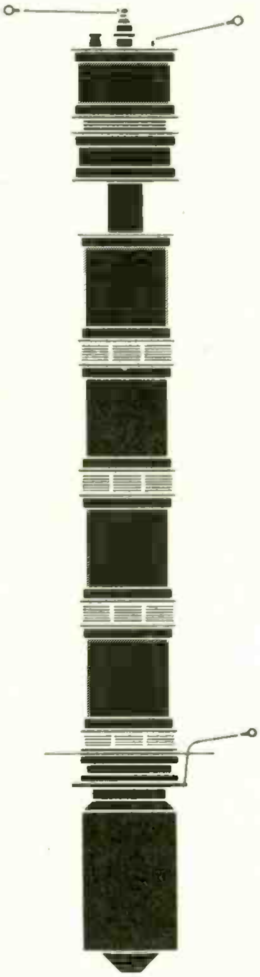
Sound radio today (says my dealer friend) is very much a subsidiary to television. In cases where married couples both go out to work the radio is used as an early-morning time check and is then off for the rest of the day. The housewife uses it as a background to those domestic chores which demand flitting from room to room.

In view of the secondary role of sound radio, cannot we learn the lesson of the past? Let's stop fiddling around with the m.f. band; instead, appoint a date (say 1976) when the B.B.C. Charter expires to end m.f. transmissions.

I realize that in saying this I am facing a formidable opposition which includes the B.B.C., the Post Office, Mr. Hughie Green and, possibly, the Editor (see his November '69 leader page). If B.B.C. m.f. transmissions continue but 'Vector' does not, you will know the reason why.

EEV klystrons – a wide and flexible range for UHF TV





5 7 10 25 40 kW

EEV make amplifier klystrons for UHF TV at power levels 5, 7, 10, 25 and 40kW into the aerial. Their reliability is established, their operating efficiency is good and their design provides a high degree of operational flexibility. A 40kW tube can, for example, be operated at the same efficiency at any power level between 20kW and 40kW. When operated at 40kW the tube needs only 135kW d.c. input.

Send for full details of the complete range of EEV amplifier klystrons.

English Electric Valve Co Ltd
Chelmsford Essex England Telephone: 61777
Telex: 99103 Grams: Enelectico Chelmsford

Please send me full details of your range of UHF TV amplifier klystrons.
I am interested in a klystron with the following parameters:

Frequency Range Bandwidth Power Level

NAME POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION WW40

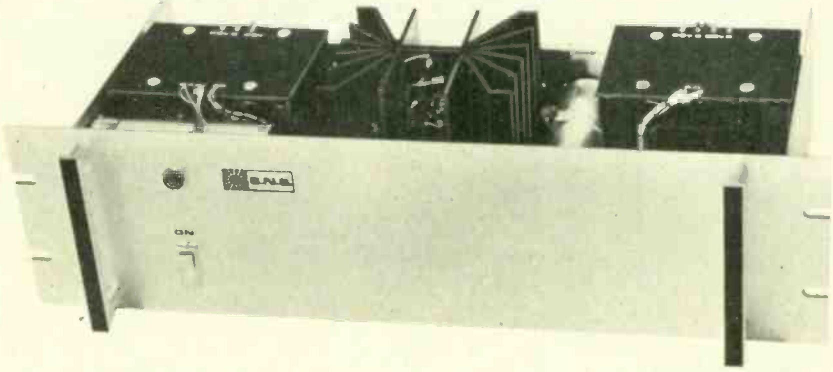
AP 354

PURE

100 WATT

POWER

TRY IT AND SEE!



None of this "see if you can squeeze it up to 100 watts". "Well it gets there at 2.875 KHz — anyway this is P.A., not HiFi — so who cares what the distortion is so long as it is not more than 6 or 7 per cent." **The S.N.S. CD.100 amplifier gives a pure, fully transistorised power output of 100 watts at 1 KHz with distortion less than 1 per cent.** You are probably saying "I've heard it all before". So have we! That is why we have built an amplifier which will set new standards in craftsmanship and performance. To prove it we will loan you one for a **seven day free trial.**

The CD.100 illustrated is a single input unit giving 100 watts RMS output for 25 mV input at 1 KHz so it can be driven by any tuner or tape machine or, of course, the output of a mixer. 50/100 volt line output (0-50-0-50) *Distortion less than 1 per cent at 1 KHz. *Full short circuit protection with the exclusive S.N.S. Current Lok circuit. *Ample thermal capacity to ensure the transistors run within their limits at 100 watts continuous Sine Wave. All these plus points, and many more, make the CD.100 yet another S.N.S. success.

S.N.S.

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WW—009 FOR FURTHER DETAILS

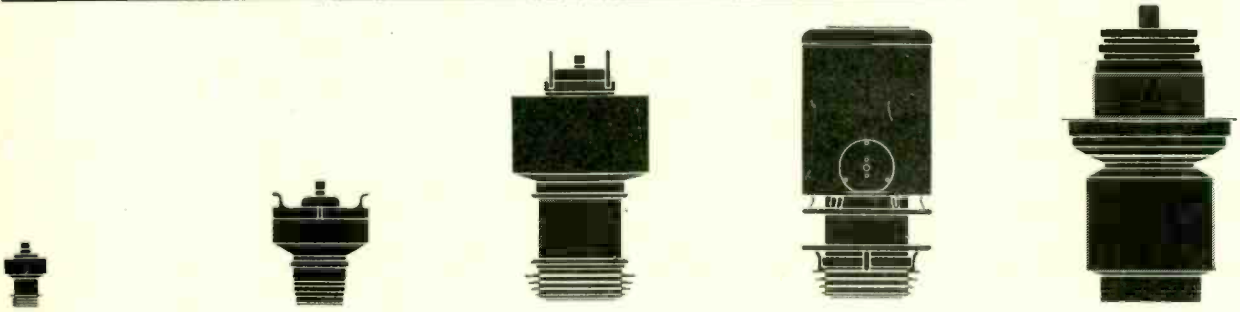
If you need power tetrodes at the right price look at this EEV range

Forced-air Cooled

Type	Service type	Anode dissipation max. (kW)	Output power (kW)	Anode voltage max. (kv)	Frequency (MHz)	Filament ratings (V)	Filament ratings (A)
4CX1000A 4CX1000K	—	1.0	3.2	3.0	110	6.0	9.0
4CX1500B	—	1.5	2.7	3.0	30	6.0	9.0
4CX5000A	CV8295	5.0	16.0	7.5	30/110	7.5	75
4CX10,000D	CV6184	10.0	16.0	7.5	30/110	7.5	75
4CX35,000C	—	35.0	82.0	20.0	30	10	300
CR192A (6166A)	CV8244	10.0	9.0	6.9	60/220	5.0	175

Vapour Cooled

Type	Anode dissipation max. (kW)	Output power (kW)	Anode voltage max. (kv)	Frequency (MHz)	Filament ratings (V)	Filament ratings (A)	Boiler unit
CY1170J	60	82	15	30	10	300	Integral
CY1172 (RS 2002V)	150	220	15	30	21	350	CY4120



4CX1000K
For audio or linear single sideband amplifiers. 4CX1000K has a solid disc screen contact to permit use up to 400MHz.

4CX10,000D
For audio, linear, single sideband or screen modulated r.f. amplifiers.

4CX35,000C
For audio amplifiers, r.f. linear amplifiers or Class C amplifiers or oscillators.

CY1170J **CY1172**
For audio amplifiers, r.f. linear amplifiers or Class C amplifiers or oscillators. Both types have a coaxial metal-ceramic envelope. A range of glass envelope types is also available.

English Electric Valve Co Ltd
Chelmsford Essex England Telephone: 61777
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Send for full details of EEV tetrodes

Please send me full data on your range of forced-air cooled and vapour cooled tetrodes.
I am also looking for a power tetrode with the following parameters.

Output power (kW) | Anode voltage max (kV) | Frequency (MHz)

NAME | POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER | EXTENSION | WW39

AP 358


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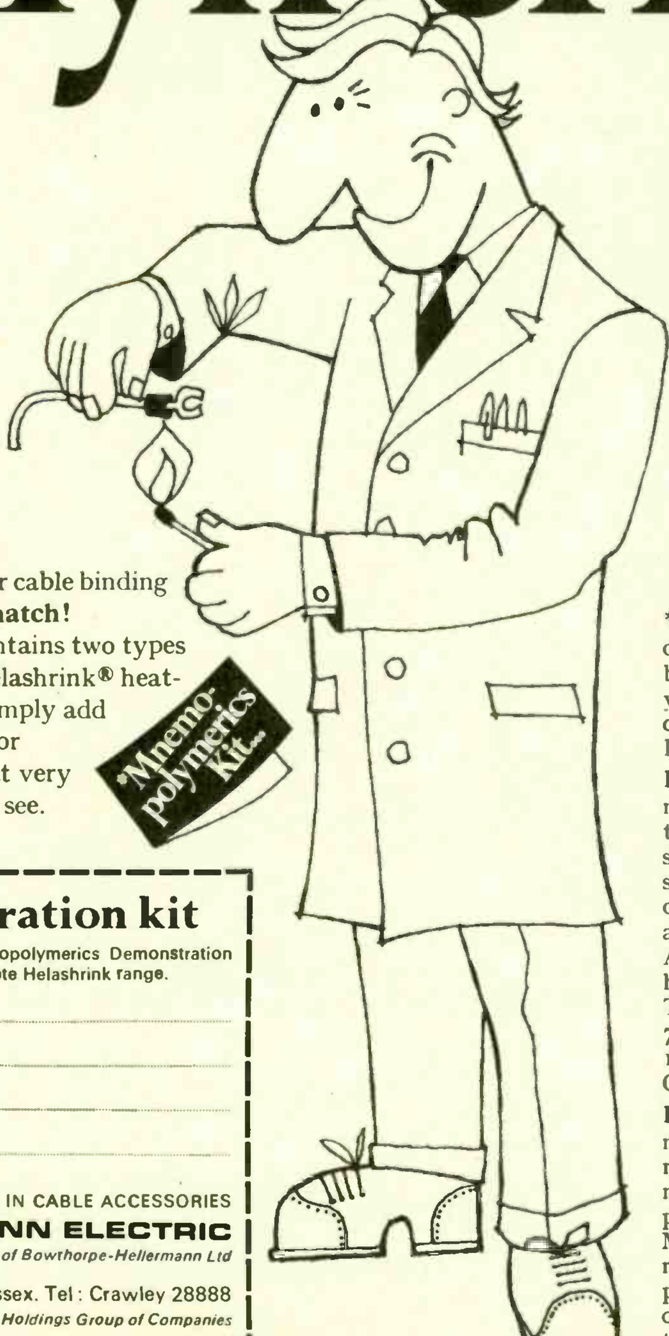

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Our demonstration kit contains two types of wired terminals and Helashrink® heat-shrinkable sleeves. You simply add heat for a tight shrink-fit or shroud. In seconds – and at very low cost. Post coupon and see.

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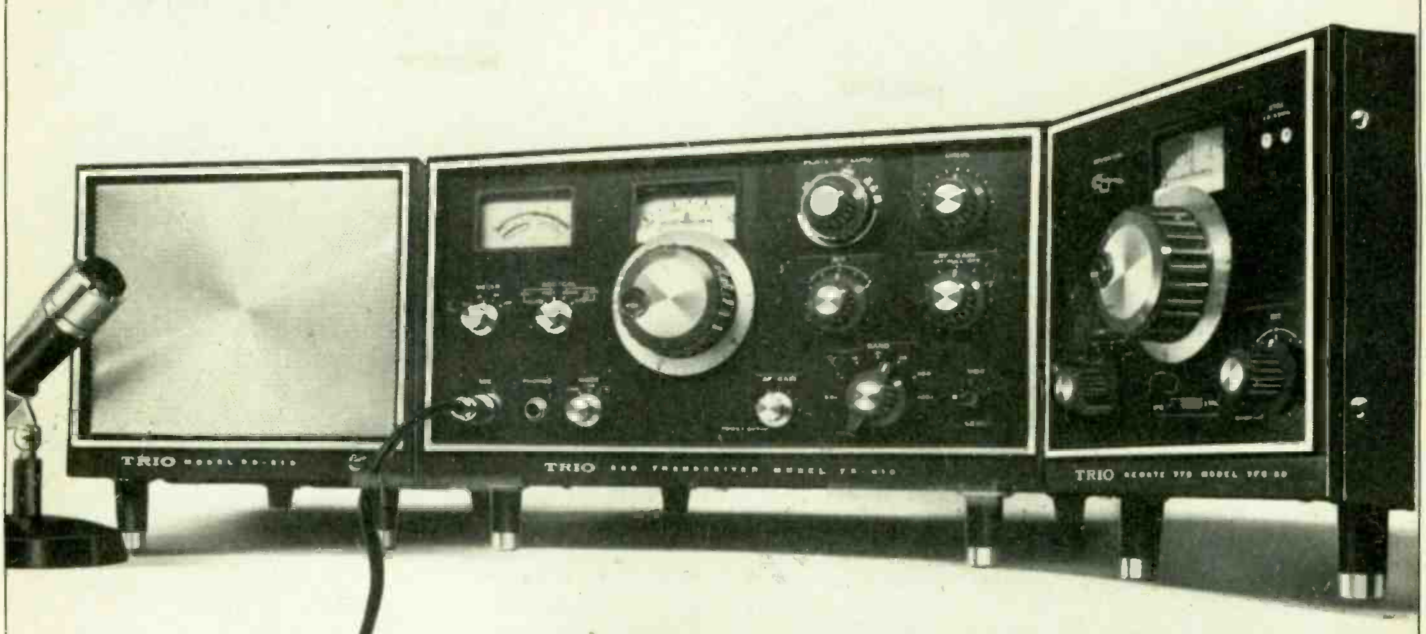
Helashrink Insultite® – sleeves, markers, tubing and end caps in a range of irradiated and non-irradiated materials designed to provide the right product for the job – at the right price. Materials can be selected for flexibility, rigidity, shock and vibration protection, resistance to contaminants over a range of operating temperatures from –55°C to 300°C.

WW—013 FOR FURTHER DETAILS

SSB

FOR SUPERIOR SSB TRIO'S TS-510 TRANSCEIVER



PS-510 TS-510 VFO-5D

TRIO's TS-510 is the definitive instrument especially engineered for complete "SSB ERA" function. It's a high power, high stability product of imaginative design that fully lives up to the renowned "TRIO" name. Extremely stable VFO, a new development that is built around 2 FET's and 13 transistors, guarantees stable QSO's during entire use, an accurate double-gear tuning mechanism and a linear tuning capacitor produce a 1 kHz direct reading on all bands. There's easy tuning in of SSB signals because the TS-510's frequency coverage has been compressed to 25 kHz for one complete rotation of the dial. Sharp cutoff for both reception and transmission is achieved by a sharp factor frequency filter built just for this 510 series model.

Combined with the TS-510's superb features are the distinctive, top quality **PS-510** (Power supply and speaker) and **VFO-5D** (Variable frequency oscillator). With an AC power supply that operates a built-in 16 cm speaker, the PS-510 has been created as an exclusive companion instrument for the TS-510. It can be installed at any location with the PS-510 because the power supply is regulated on or off at the TS-510.

The VFO-5D can match the TS-510 in performance and design. Its reading accuracy is unusually high since a double-gear dial covering 25 kHz per revolution is also used, as in the TS-510.

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WW—018 FOR FURTHER DETAILS

There are a couple of things you should know about the Welbrook All Silicon Stereo Amplifier

DISTORTION

0.1% at all output levels

PRICE

£42. 0. 0d.

A new and unique method of equalising impedances in the output stage enables only Welbrook to offer such true high fidelity reproduction at such low cost.

This technical breakthrough brings you the Welbrook W20 Stereo Amplifier, with no distortion rise at any level, for only £42. 0. 0d. This is a truly remarkable bargain among high quality stereo amplifiers, using Class B operation.

Performance:
Power Output:
24 watts R.M.S. (12 watts per channel) into 4 ohms load.
20 watts R.M.S. (10 watts per channel) into 8 ohms load.
14 watts R.M.S. (7 watts per channel) into 15 ohms load.
Total Harmonic Distortion:
Typically 0.1% for 10 watts per channel into 8 ohms load at 1 kHz with no increase at low levels.
Hum and Noise:
With volume control at minimum-80 dB. With volume control at maximum-55 dB.
Frequency Response:
-1 dB at 30 Hz and 15 kHz.
Inputs: Pickup:
R.I.A.A. characteristic, sensitivity adjustable up to 3 mV to suit crystal, ceramic or magnetic cartridges.
Tuner:
Flat characteristic-sensitivity 100 mV-input impedance 100 k ohms.
Tape:
Flat characteristic-sensitivity 100 mV-input impedance 100 k ohms.
Outputs:
Loudspeaker outputs to suit 4, 8 and 15 ohms. Tape output for recording-200 mV for rated input sensitivities-minimum external impedance 10 k ohms.
Tone Controls: Bass:
Ganged control giving ± 14 dB at 30 Hz
Treble:
Ganged control giving ± 14 dB at 15 kHz
Balance Control:
Facility to reduce output from either channel continuously from maximum output to zero.
Dimensions:
14¾" wide x 9" deep x 4" high (cabinet)
Price:
Recommended retail price; £42. 0. 0d. including cabinet.

For full details of the Welbrook Stereo Amplifier post the coupon to:

WELBROOK ENGINEERING & ELECTRONICS LIMITED,
BROOKS STREET, STOCKPORT, CHESHIRE, SK1 3HT

To: Welbrook Engineering & Electronics Limited;
Please send me full details of the Welbrook Stereo Amplifier.

NAME ....

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WW—019 FOR FURTHER DETAILS

QUAD 50 is a single channel 50 Watt amplifier designed for Broadcast, Recording and other applications in the Audio industry, completely proof against misuse and giving the highest quality of reproduction.

INPUTS – 0·5 Vrms unbalanced with provision for an optional plug-in transformer for bridging 600 ohms lines.
OUTPUTS – isolated providing 50 watts into almost any impedance from 4 to 200 ohms.
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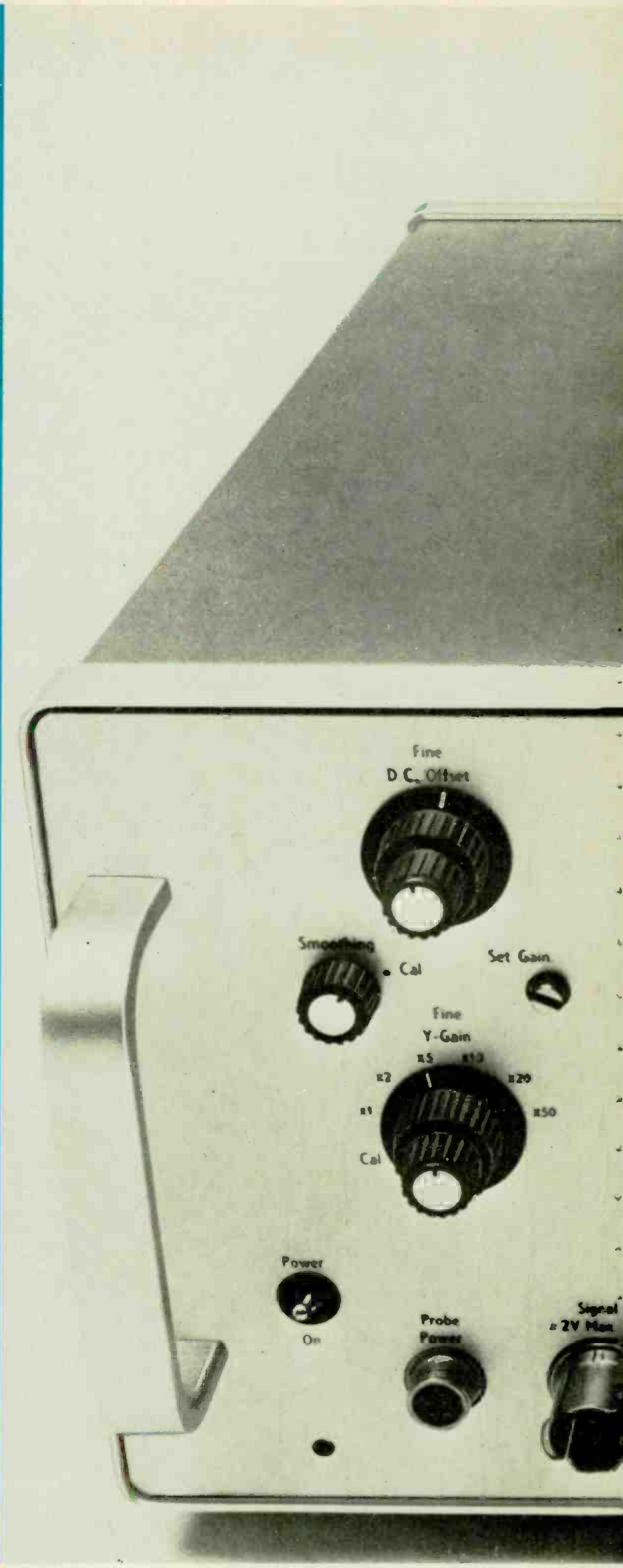

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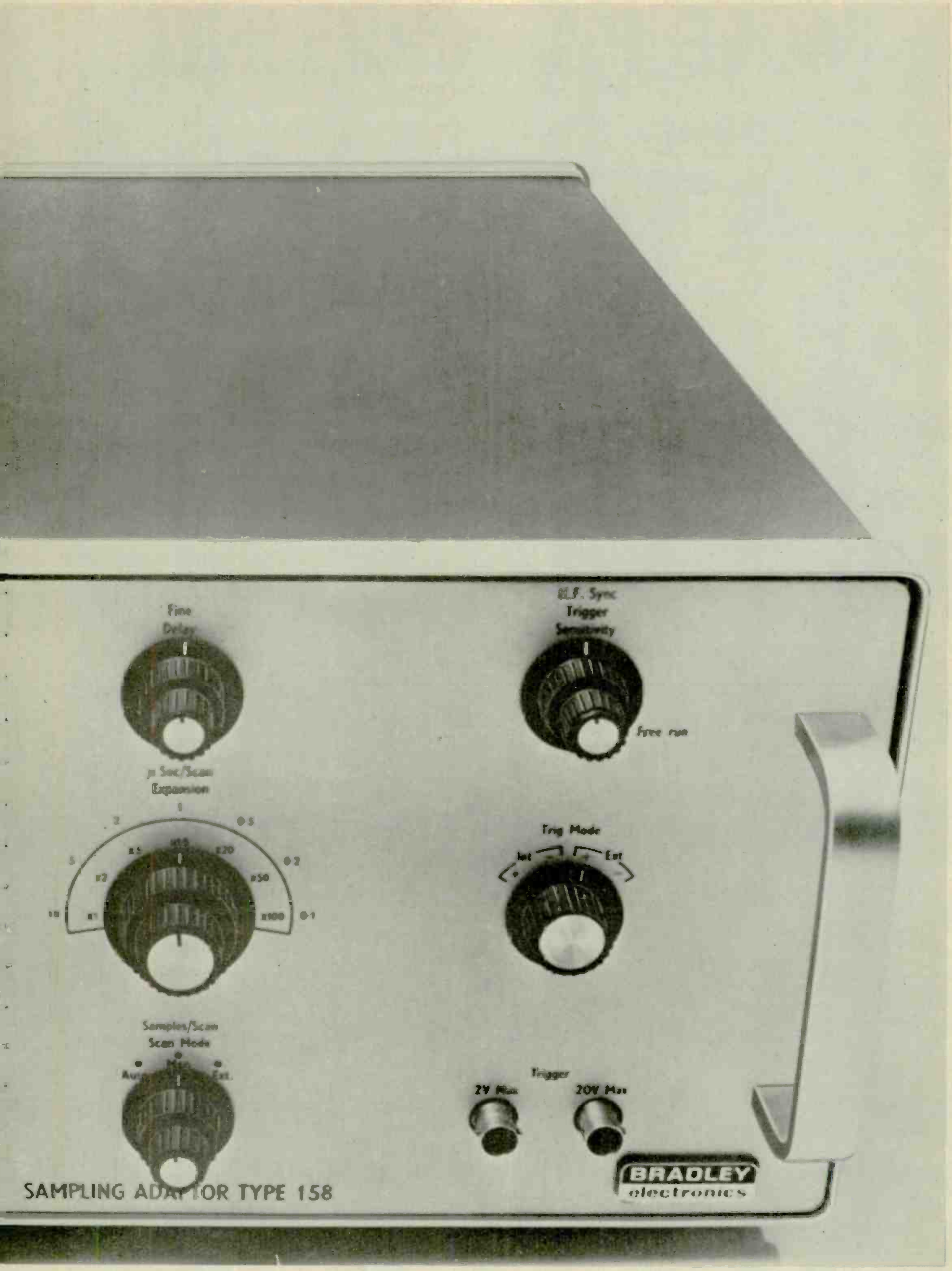
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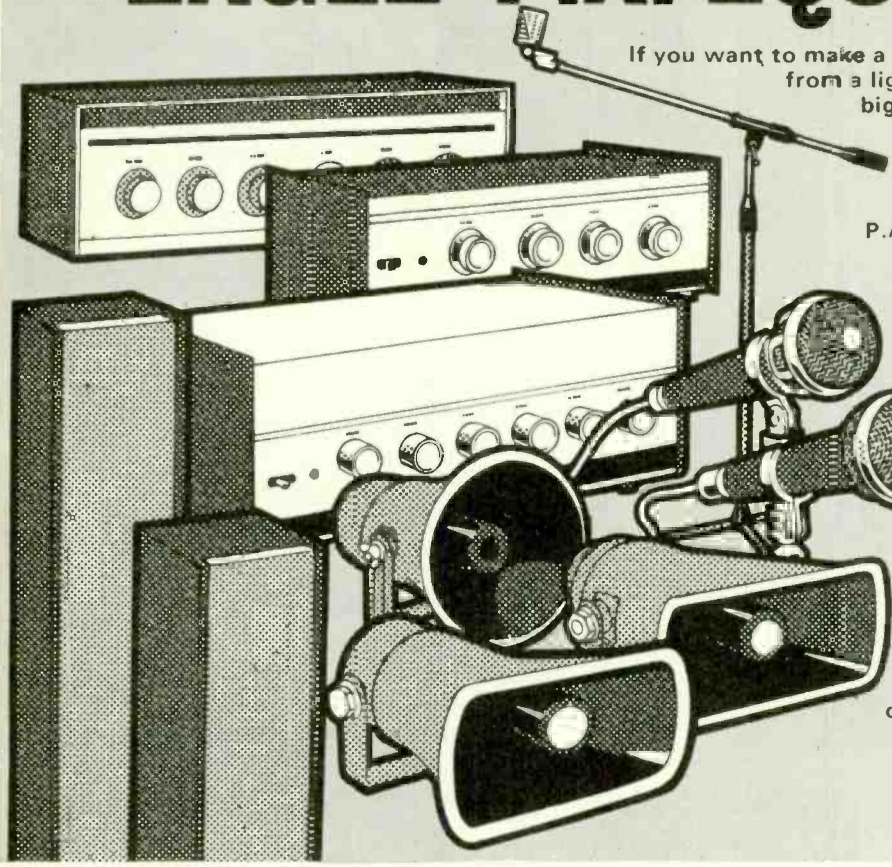

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WW—022 FOR FURTHER DETAILS

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ST400/200 recorders are designed to give you exactly what you expect from a Brenell today.

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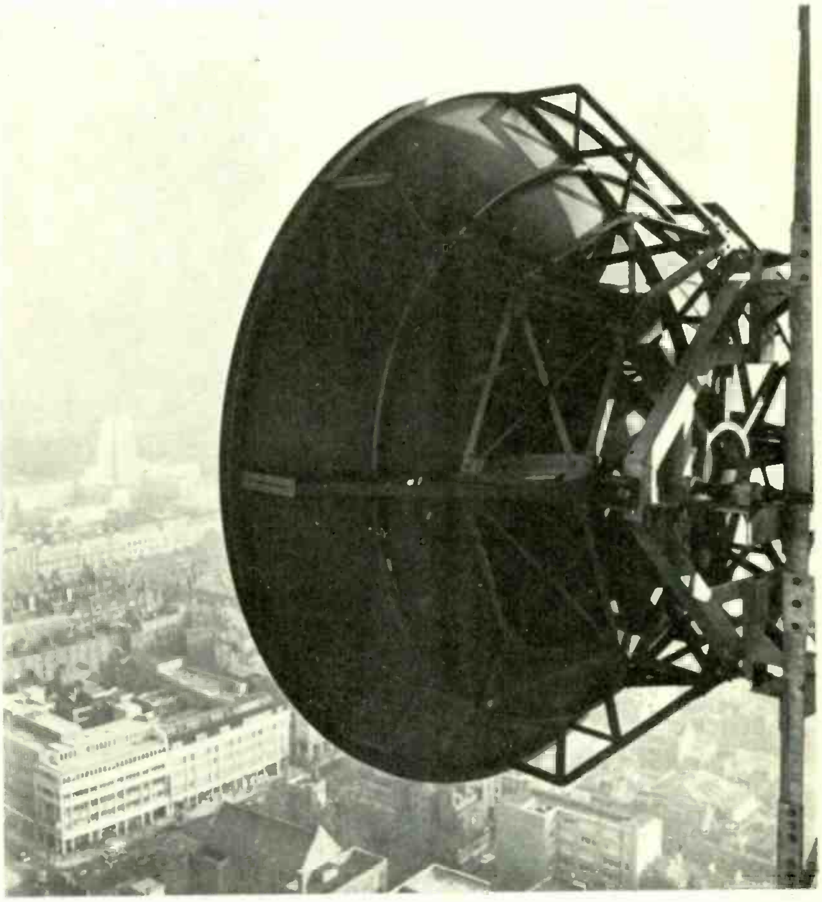
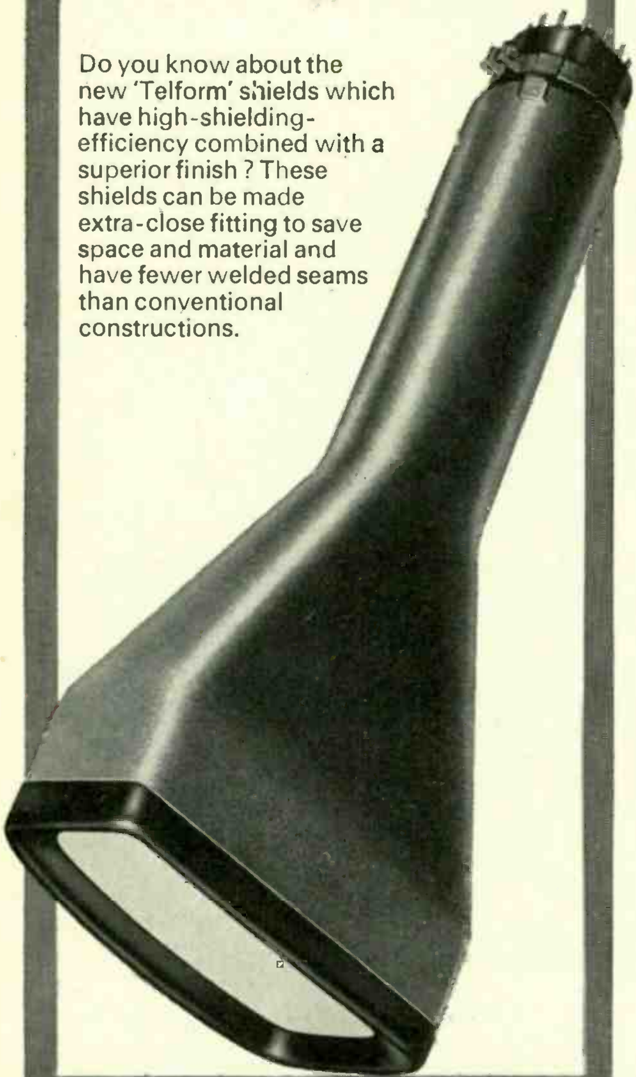


Telcon magnetic shields give today's circuits *tomorrow's* performance



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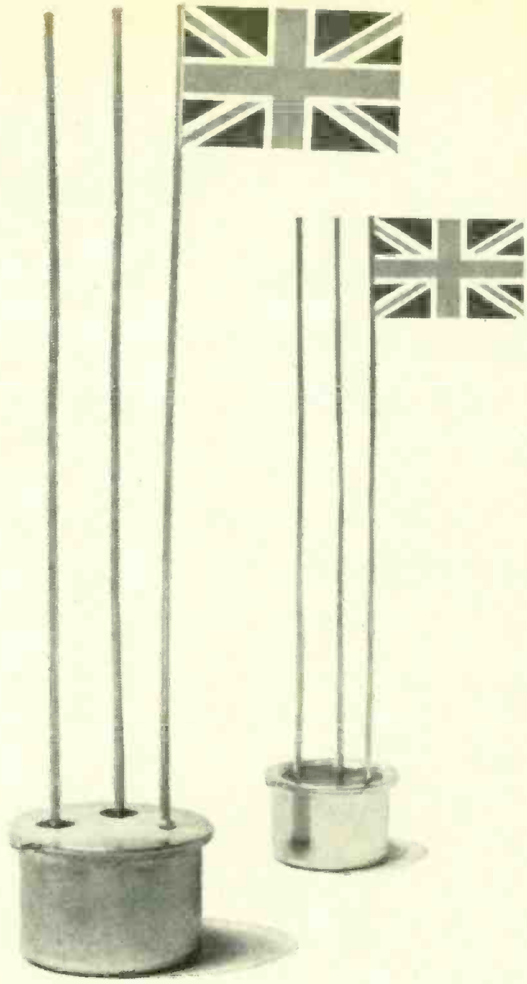

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WW—026 FOR FURTHER DETAILS

The international radio set

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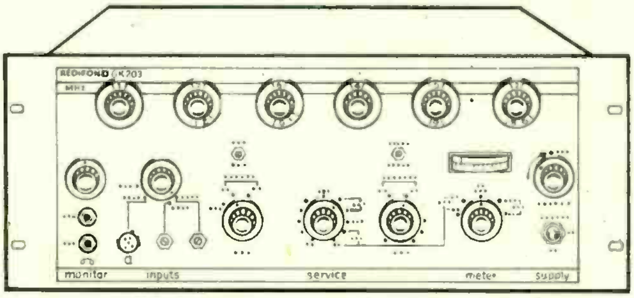
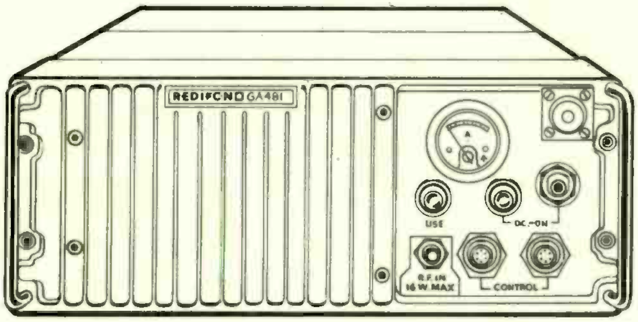
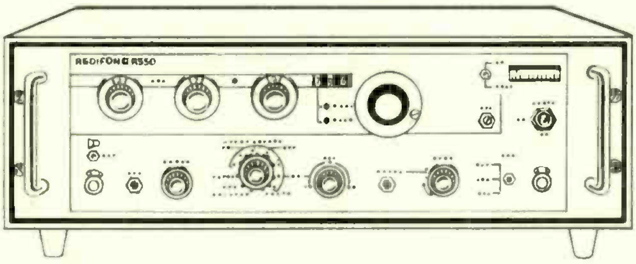
Redifon equipment has already proved itself in a wide variety of applications all round the globe. Such as diplomatic networks, police work, civil aviation services, maritime coast stations and, of course, for naval and military purposes too. The Redifon HF range could justly be called the International Set. Look at just a few of our products—all with unbeatable performance for price:



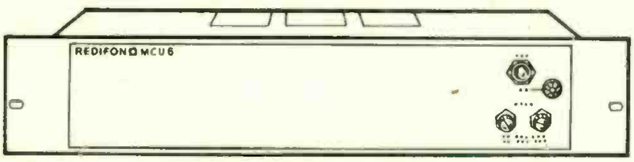
GK.203. Frequency synthesis drive unit. 1.5-30 MHz in 100 Hz increments. 17 modes of transmission, including ISB if specified.



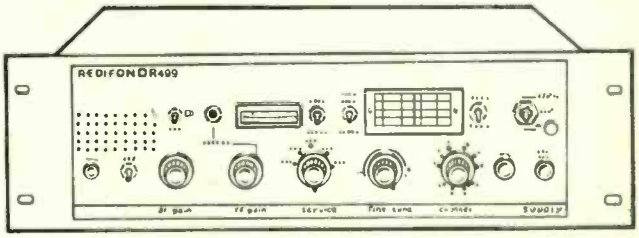
GA.481. 100-watt linear amplifier, broad-band 1.5-30 MHz. No tuning or loading. Automatic protection against any mismatch (from open- to short-circuit aerial) or excessive drive. Easily portable, will operate direct from vehicle supply.



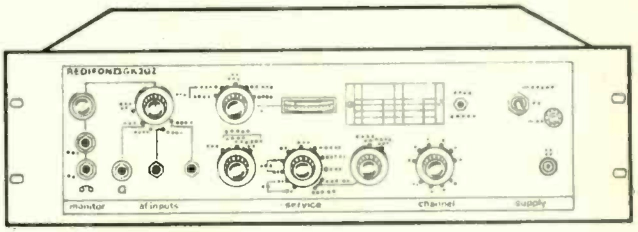
R.550. General-purpose MF/HF communications receiver. VFO tuning for search with a resolution of 10 Hz, and frequency synthesis with 100 Hz increments for accurate setting to known frequencies. Dynamic range exceeds 120 dB, with superb blocking and cross modulation characteristics. Stringent defence specification at realistic price for commercial users.



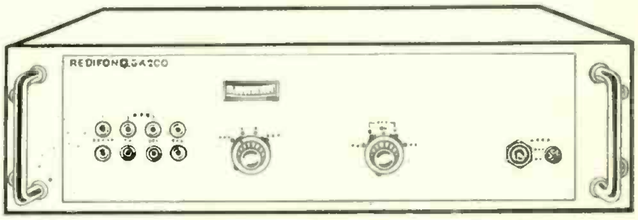
MCU.6. An aerial distribution amplifier that enables your receivers to go on doing their job long after other aerial amplifiers would have been blocked. 95 kHz-30 MHz. Several versions to meet your requirements.



R.499. Ideal for point-to-point, air-to-ground and coast station services. All the plus parameters of the R.550, but with 10 switched channels and automatic optimisation of reception for unattended operation.



GK.202. 10-channel drive unit for frequency and service generation, 1.5-30 MHz. 17 modes of transmission, including ISB if required.



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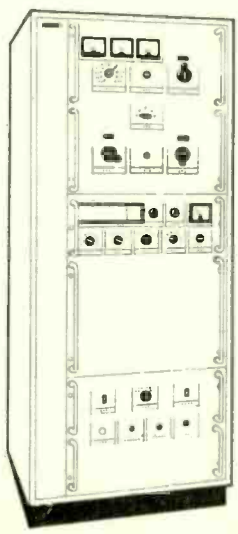

G.450 Series. General-purpose 1 kW HF transmitters for 10-channel or frequency synthesis operation, each completely self-contained with its own frequency and service generation, including ISB circuits if required. Simple to operate and maintain, with all unnecessary frills removed. Surprisingly low cost.

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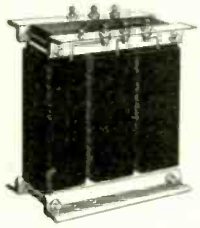

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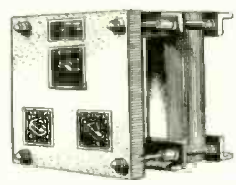

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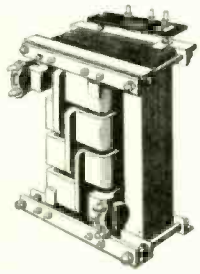

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20V. D.C.	59/6		

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20V. D.C.	49/6		

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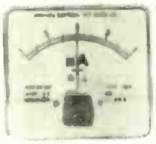

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100-0-100μA	62/-	500mA	52/-
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1mA	52/-	30 amp.	52/-
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50mA	40/-	1 amp. A.C.*	40/-
100mA	40/-	5 amp. A.C.*	40/-
500mA	40/-	10 amp. A.C.*	40/-
1 amp.	40/-	20 amp. A.C.*	40/-
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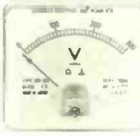
100μA	55/-	150V. D.C.	42/-
100-0-100μA	52/-	300V. D.C.	42/-
500μA	47/6	15V. A.C.	42/-
500-0-500μA	42/-	50V. A.C.	42/-
1mA	42/-	150V. A.C.	42/-
5mA	42/-	300V. A.C.	42/-
10mA	42/-	500V. A.C.	42/-
50mA	42/-	8 meter 1mA	47/6
100mA	42/-	VU meter	67/6
500mA	42/-	50mA A.C.*	42/-
1 amp.	42/-	100mA A.C.*	42/-
5 amp.	42/-	200mA A.C.*	42/-
10 amp.	42/-	500mA A.C.*	42/-
15 amp.	42/-	1 amp. A.C.*	42/-
20 amp.	42/-	5 amp. A.C.*	42/-
30 amp.	42/-	10 amp. A.C.*	42/-
50 amp.	47/6	20 amp. A.C.*	42/-
10V. D.C.	42/-	30 amp. A.C.*	42/-

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



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100μA	37/6	300mA	27/6
100-0-100μA	35/-	500mA	27/6
200μA	35/-	750mA	27/6
500μA	30/-	1 amp.	27/6
500-0-500μA	27/6	2 amp.	27/6
1mA	27/6	5 amp.	27/6
1-0-1mA	27/6	10 amp.	27/6
2mA	27/6	3V. D.C.	27/6
5mA	27/6	10V. D.C.	27/6
10mA	27/6	20V. D.C.	27/6
20mA	27/6	100V. D.C.	27/6
50mA	27/6	150V. D.C.	27/6
100mA	27/6	300V. D.C.	27/6
		500V. D.C.	27/6
		750V. D.C.	27/6
		15V. A.C.	27/6
		50V. A.C.	27/6
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50mA	30/-	5 amp. A.C.*	30/-
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500mA	30/-	20 amp. A.C.*	30/-
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100μA	45/-	15 amp.	35/-
100-0-100μA	45/-	30 amp.	35/-
500μA	42/-	50 amp.	35/-
1mA	35/-	5V. D.C.	35/-
1-0-1mA	35/-	10V. D.C.	35/-
5mA	35/-	20V. D.C.	35/-
10mA	35/-	50V. D.C.	35/-
50mA	35/-	150V. D.C.	35/-
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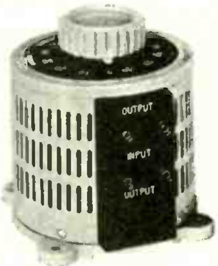

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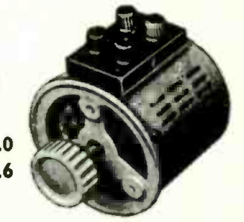

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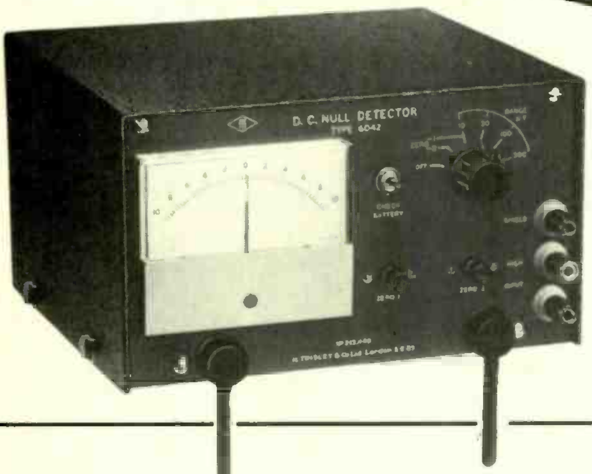

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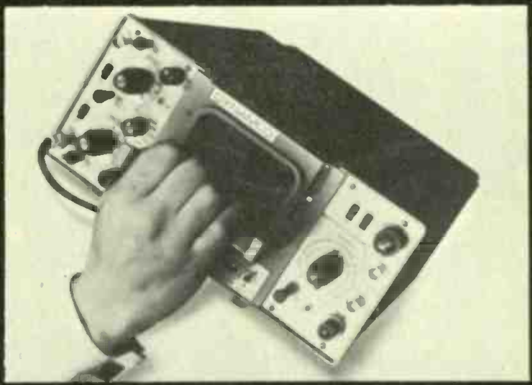

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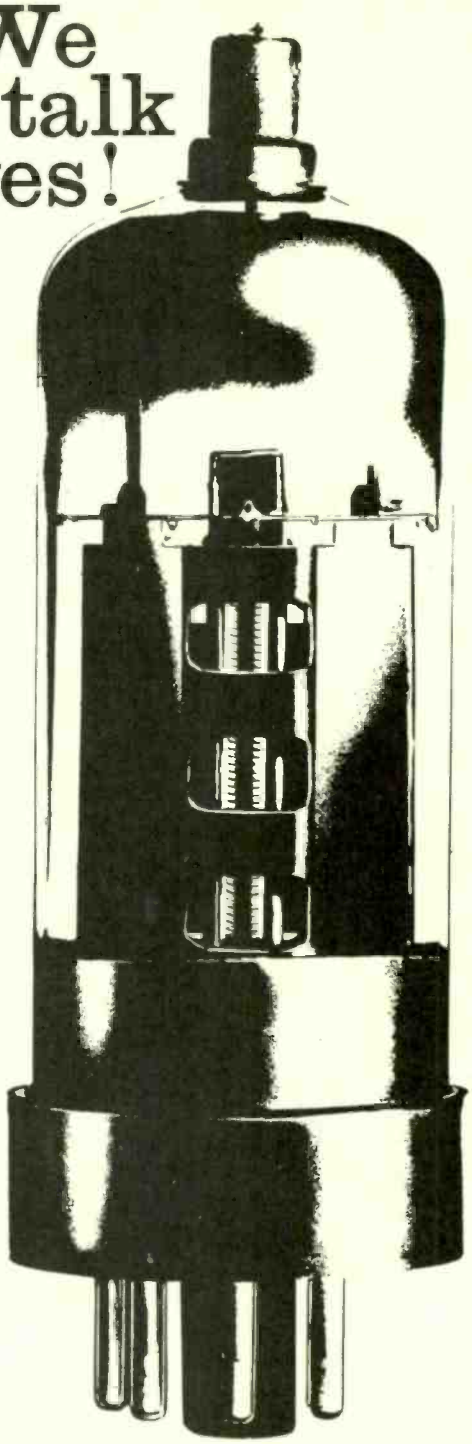

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IMMEDIATE DELIVERY of Stuart Centrifugal Pumps, including stainless steel (most models).

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trio LOW LEVEL INPUT TRANSFORMERS

This transformer has been designed specifically for use in low level input stages of D.C. "Chopper" amplifiers. It is currently used in applications requiring amplification of D.C. voltages of less than 1μV., in conjunction with a mechanical chopper.

Rejection of extraneous magnetic fields is obtained by winding both primary and secondary windings in a "hum bucking" configuration and by screening these in a nest of four magnetic screens of high purity nickel. Laminations are also nickel. Both windings are provided with electrostatic screens to obtain a high common mode rejection 100d.B. at 70Hz.

Primary and secondary are centre tapped and, when used in a "push-pull" input configuration, step-up ratios of 2:1 or 5:1 can be obtained according to type. Primary inductance exceeds 10 Henries at 70Hz. When the common mode rejection exceeds 100d.B.

TRIO INSTRUMENTS LTD., BURNHAM ROAD, DARTFORD, KENT. Telephone: Farningham 2082

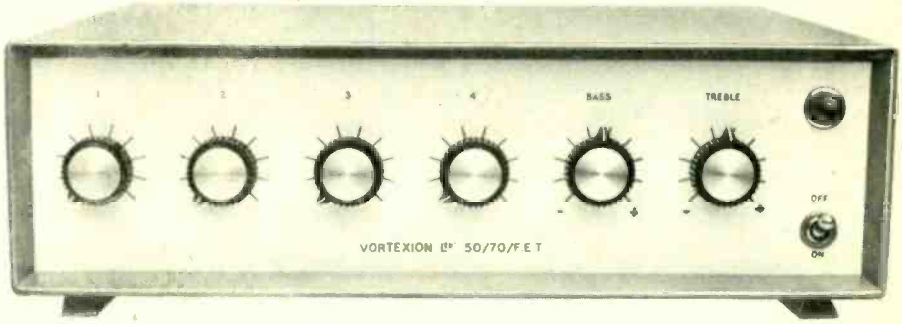
WW—034 FOR FURTHER DETAILS


81E

Vortexion

This is a high fidelity amplifier (.3% intermodulation distortion) using the circuit of our 100% reliable—100 Watt Amplifier (no failures to date) with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer amplifier, again fully protected against overload and completely free from radio breakthrough. The mixer is arranged for 3-30/60Ω balanced line microphones, and a high impedance line or gram. input followed by bass and treble controls. Since the unit is completely free from the input rectification distortion of ordinary transistors, this unit gives that clean high quality that has tended to be lost with most solid state amplifiers.

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



Size 14" × 11½" x 4½" Weight 20lb.
100μV on 30/60 ohm mic. input.
100mV to 100 volts on gram/auxiliary input 100KΩ.

ELECTRONIC MIXERS. Various types of mixers available. 3-channel with accuracy within 1db Peak Programme Meter. 4-6-8-10 and 12-way mixers. Twin 2,3,4 and 5 channel stereo. Tropicalised controls. Built-in screened supplies. Balanced line mic. input. Outputs: 0.5v at 20K or alternative 1mW at 600 ohms, balanced, unbalanced or floating.

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

30/50 WATT AMPLIFIER. With 4 mixed inputs, and bass and treble tone controls. Can deliver 50 watts of speech and music or over 30 watts on continuous sine wave. Main amplifier has a response of 30 c/s-20Kc/s ± 1db. 0.15% distortion. Outputs 4, 7.5, 15 ohms and 100 volt line. Models are available with two, three or four mixed inputs for low impedance balanced line microphones, pick-up or guitar.

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

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

20/30 WATT MIXER AMPLIFIER. High fidelity all silicon model with F.E.T. input stages to reduce intermodulation distortion to a fraction of normal transistor input circuits. The response is level 20 to 20,000 cps within 2 db and over 30 times damping factor. At 20 watts output there is less than 0.2% intermodulation even over the microphone stage at full gain with the treble and bass controls set level. Standard model 1-low mic. balanced input and Hi Z gram.

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

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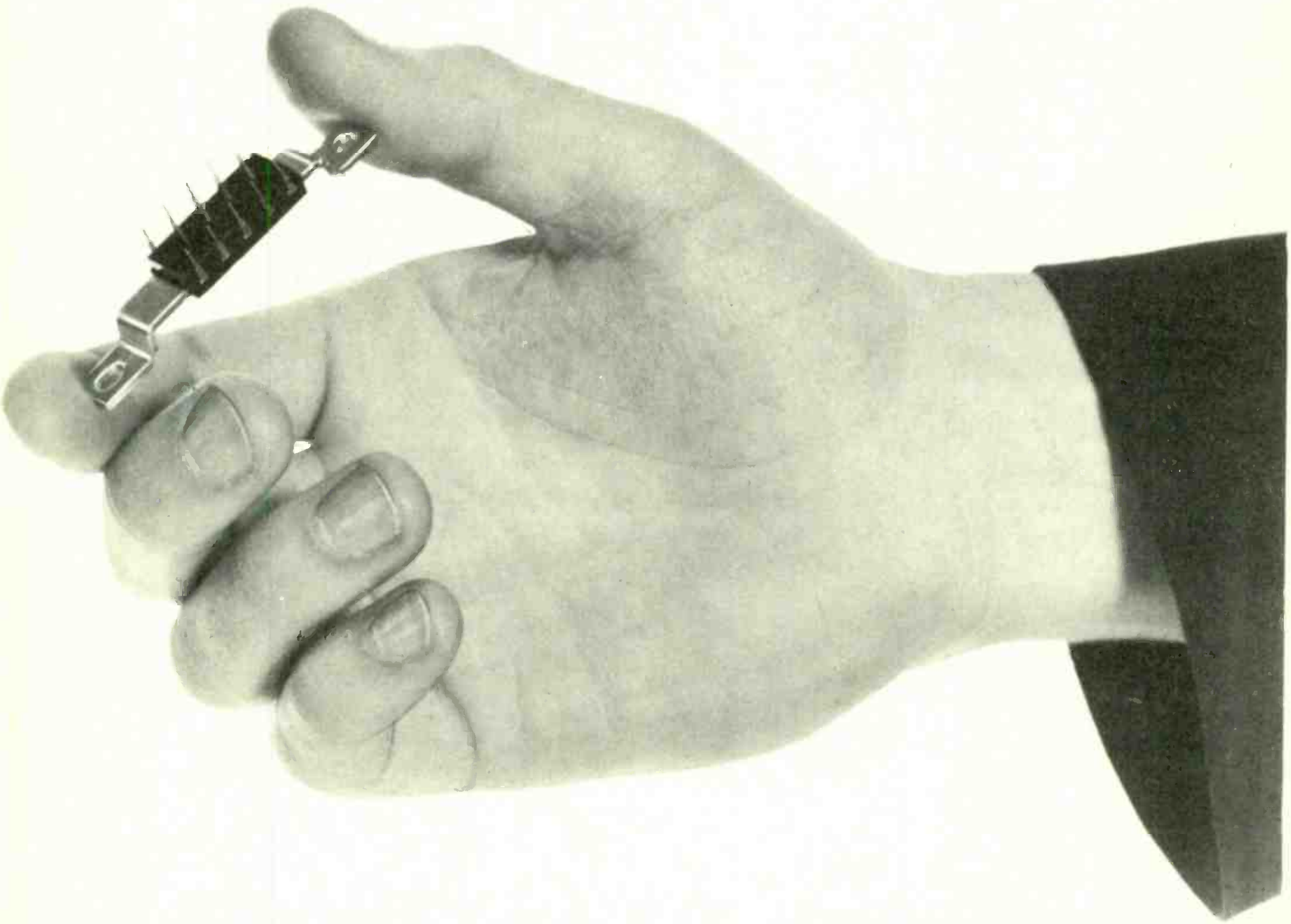
2 Watt and 3 Watt Professional IC Audio Amplifiers now available



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Characteristic	SL402A	SL403A
Output power r.m.s.	2W	3W
Input impedance		
Preamplifier	20 M Ω	20 M Ω
Main amplifier	100 M Ω	100 M Ω
Distortion		
Preamplifier	0.1%	0.1%
Main amplifier	0.3%	0.3%
Frequency response		
Lower—3dB point	20 Hz	20 Hz
Upper—3dB point	30 kHz	30 kHz
Operating voltage	+14 V	+18 V
Min. operating load	7.5 Ω	7.5 Ω

Farnell Electronic Components Ltd
Canal Rd, Leeds LS 12 2TU
Tel: Leeds 636311 Telex: 55147

SDS (Portsmouth) Ltd
Hillsea Industrial Estate, Hillsea, Portsmouth, Hants.
Tel: Portsmouth (0705) 62332 or 62180 Telex: 86114

PLESSEY microelectronics

Cheney Manor Swindon Wiltshire England Telephone: Swindon (0793) 6251. Telex: 44375

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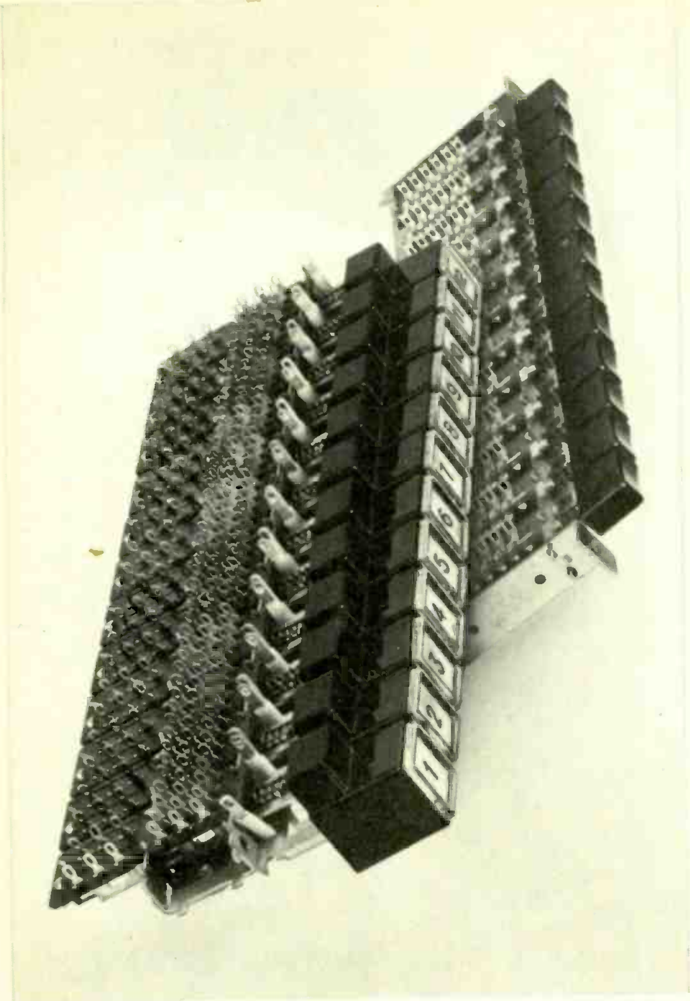

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Typical model B12/200S input 12V output 115-230V 200W.

Price £67-12-0

Type B12/200S

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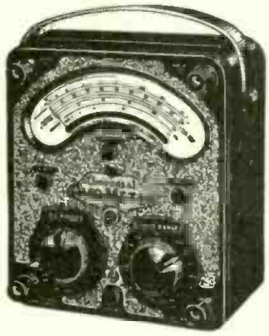
AVO

STOCKISTS

MULTIMINOR MK. IV



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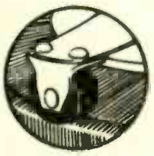

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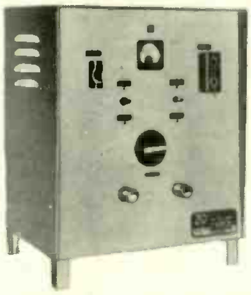

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  Output 20 amps at 24V and 12V fully adjustable
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40/- PACKING & CARRIAGE PER B.R.S.

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- ★ Input 240V 50 CPS
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- ★ Completely sealed

5 amp model **£8.7.6**

10 amp model **£13.15.0**

OMRON PROCESS TIMERS

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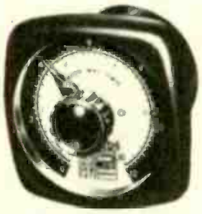
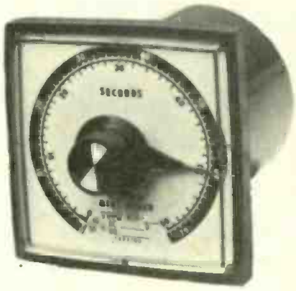


- ★ SYNCHRONOUS MOTOR & CLUTCH
- ★ 10 MILLION OPERATIONS
- ★ Instantaneous & Timed out 3 AMP contacts
- ★ Repeat Accuracy ± ½%
- ★ Dial ranges 0-10 secs up to 0-28 hrs. May also be used as impulse start

£11 dependent on quantity



NSY TIMER

- ★ 2 sets 5 amp changeover output contacts
- ★ 5 Million operations
- ★ Repeat accuracy ±½%
- ★ Set time can be altered whilst in operation

Dial ranges from seconds to hours

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160/- each dependent on quantity.

STP TIMER

SYNCHRONOUS MOTOR & CLUTCH
Matchbox size frontal area
Automatic re-set

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TEMPERATURE CONTROLLER TYPE THP

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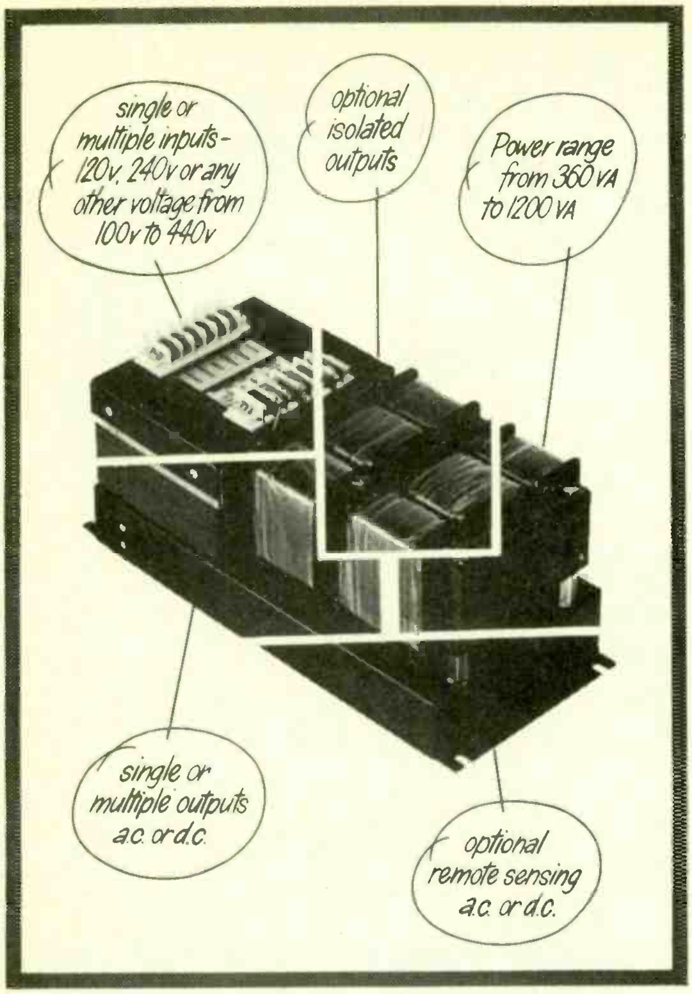

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We have a passion for cleanliness. A clean valve is a good valve, so in the factory meticulous chemical cleanliness is observed; every operator wears special protective clothing to prevent valve contamination; all components are covered prior to assembly; electrodes are cleaned by oxidising the metal surface, then reducing back to metal in an atmosphere of hydrogen.

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Mullard

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New Buyers Guide
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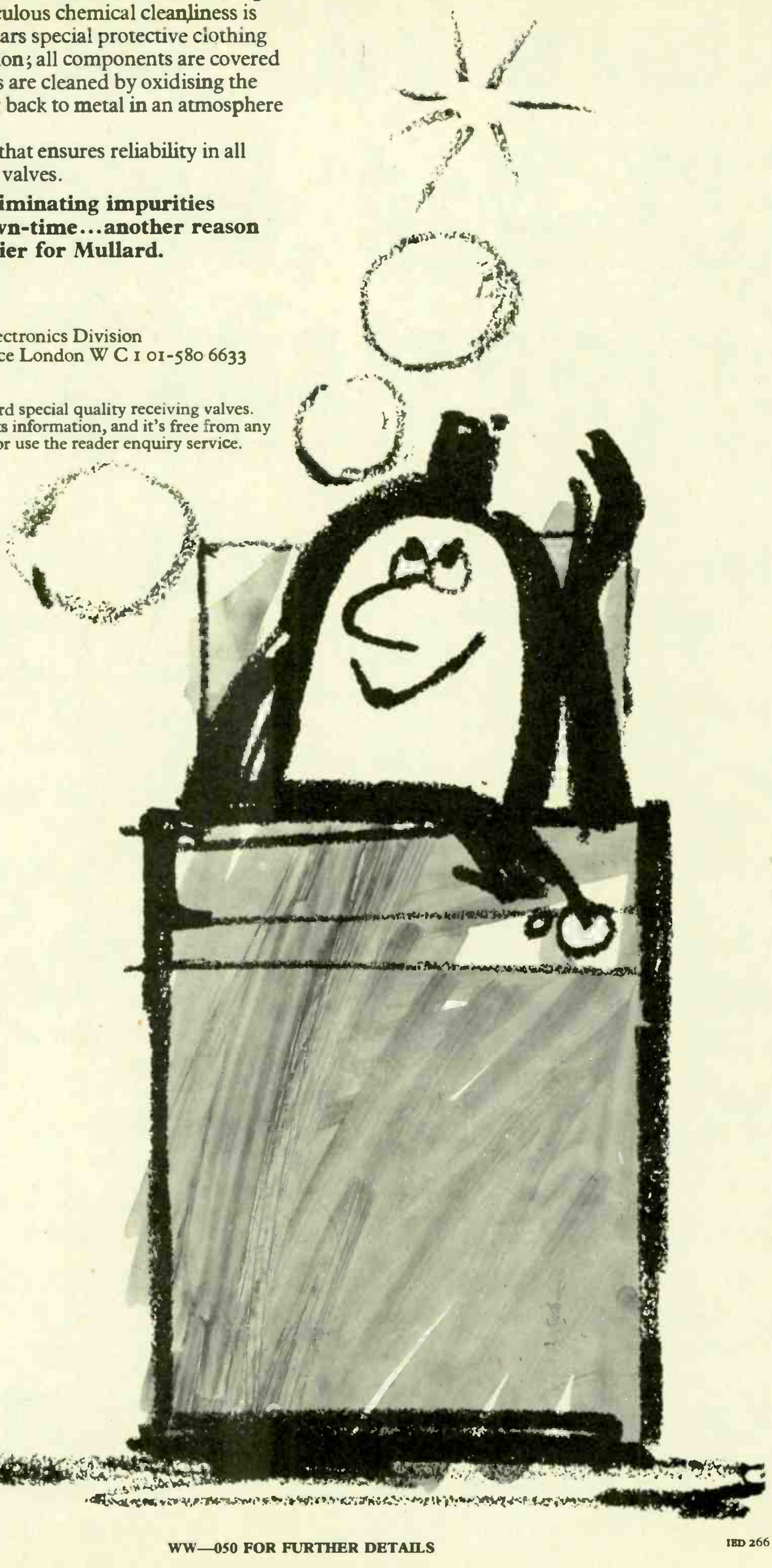

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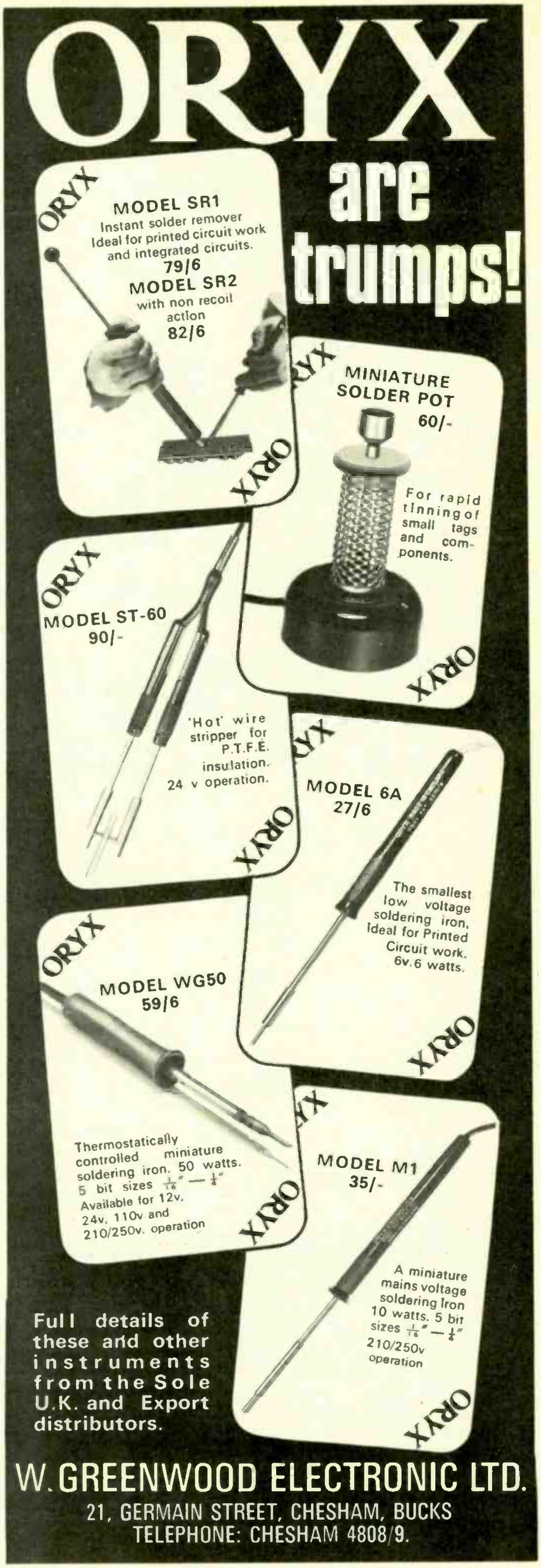

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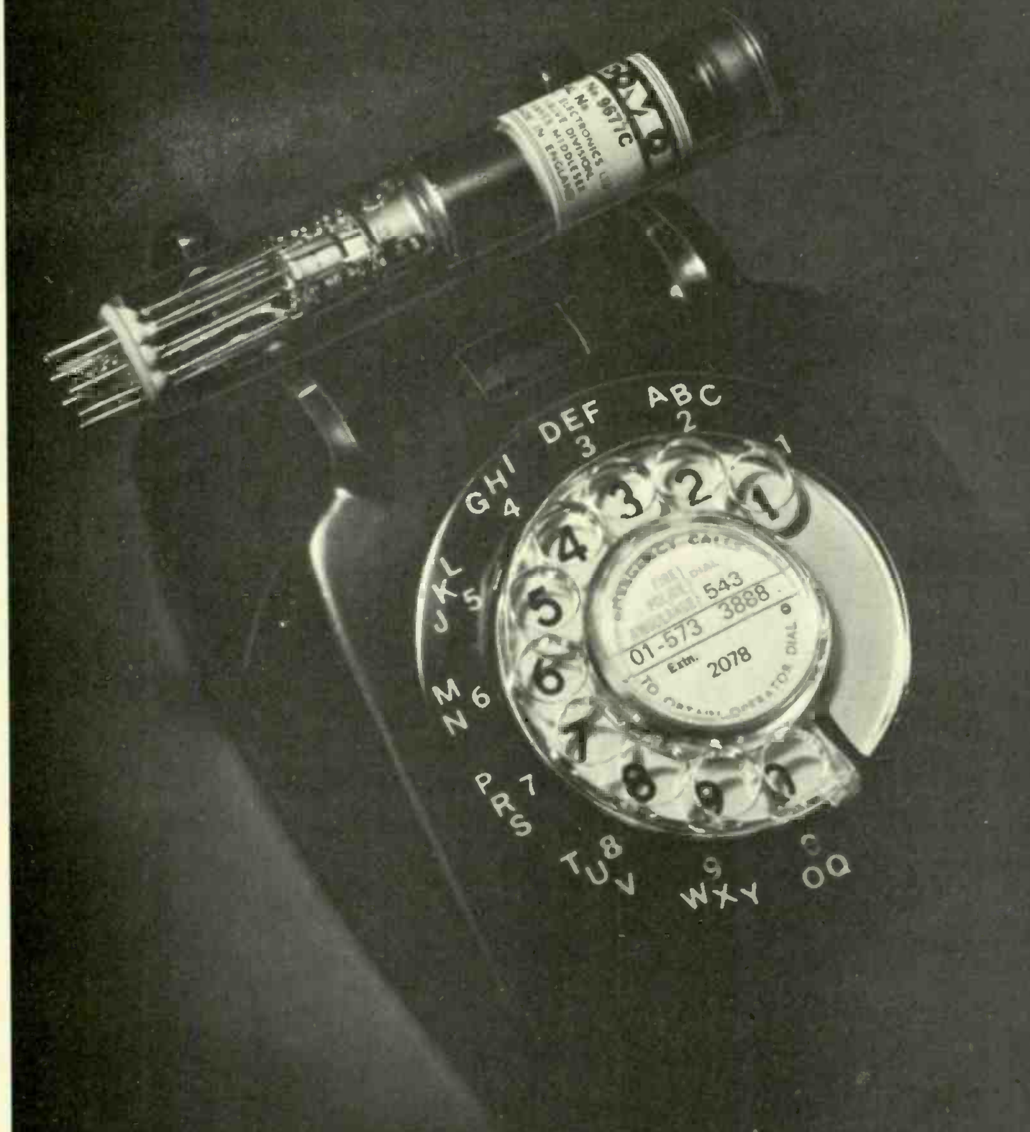

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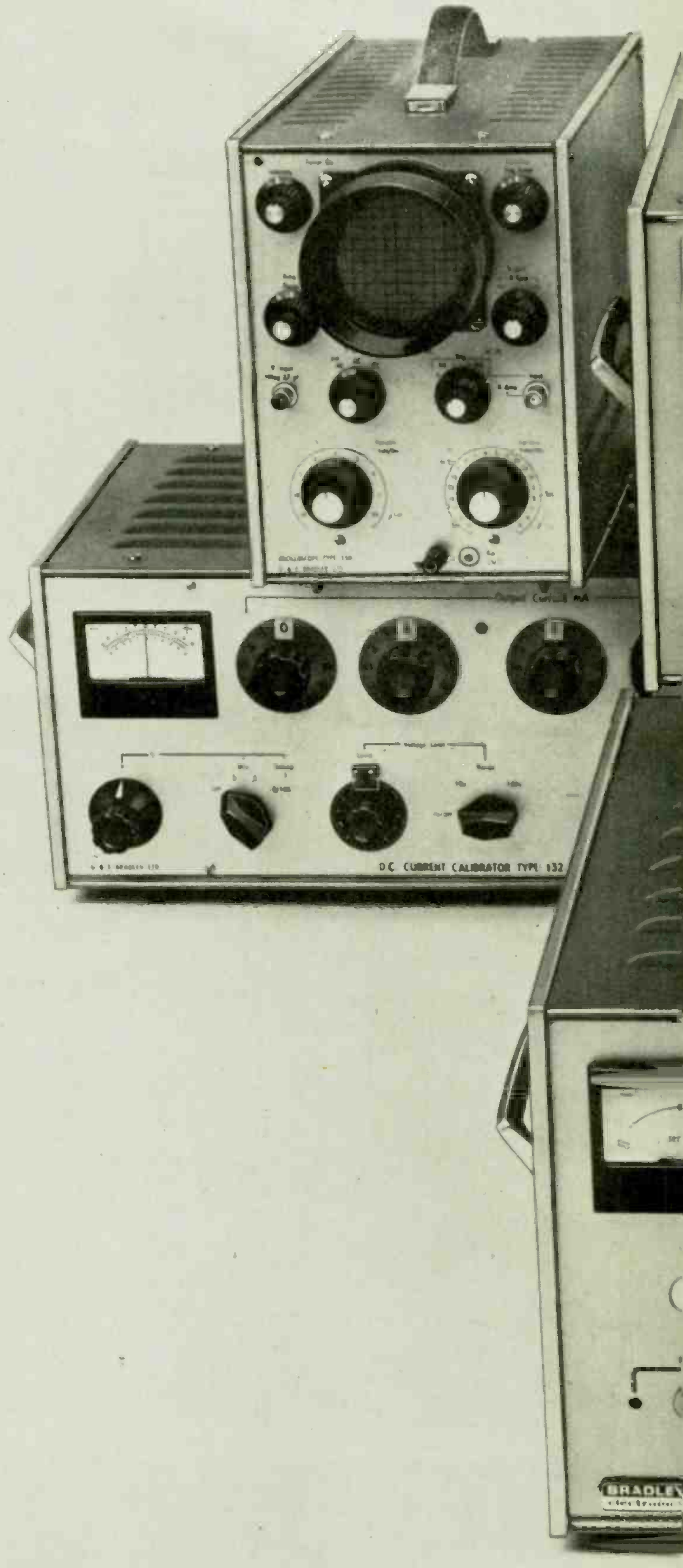

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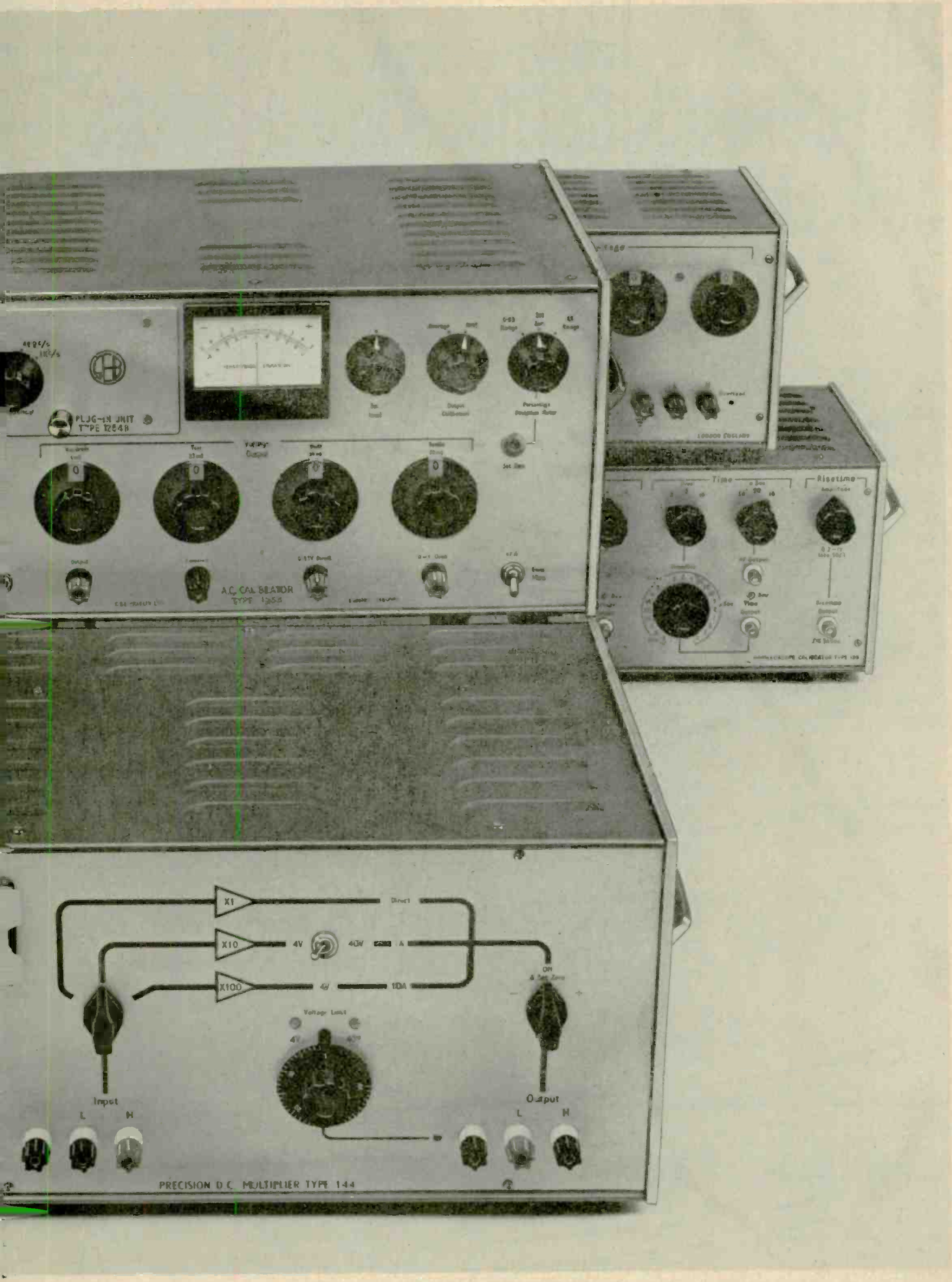
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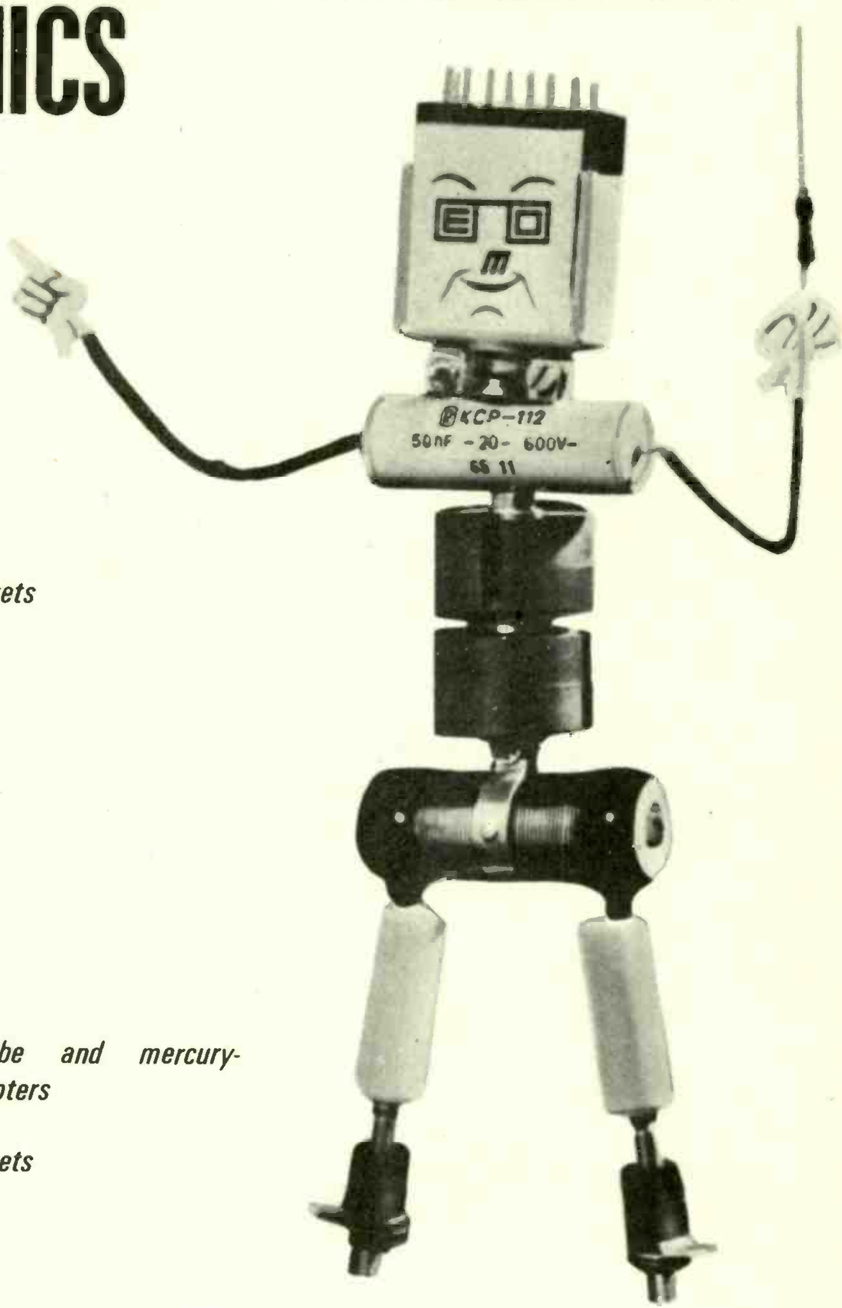

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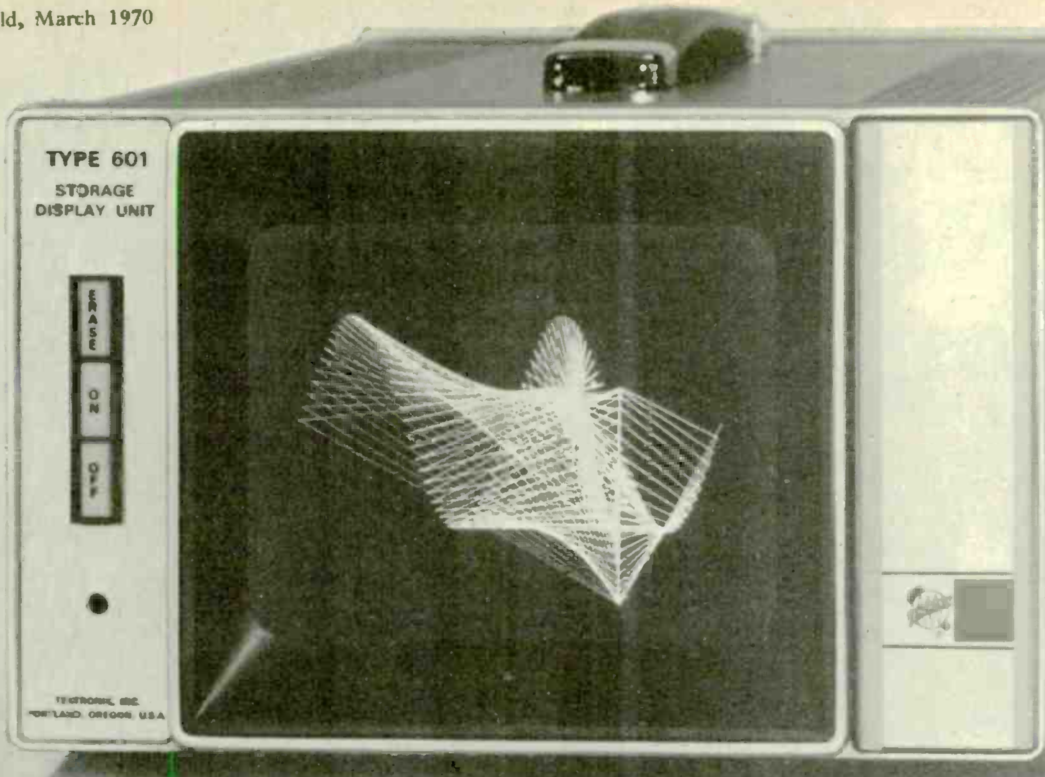

Type 601

The Type 601 Storage Display Unit permits stored, non-fading displays of combined alpha-numeric and graphic information from digital computers and other data transmission systems. The built-in vertical and horizontal amplifiers permit Y versus T plots up to 100kHz for remote storage monitor applications. All solid-state modular circuit design insures long-term stable performance.

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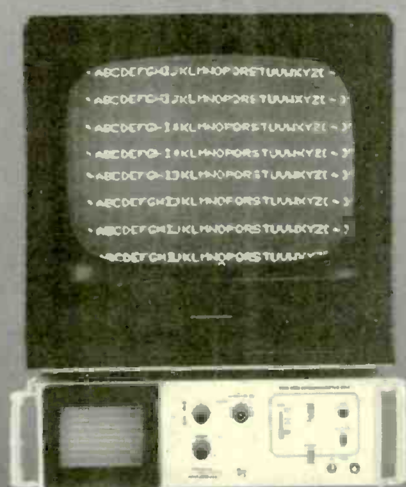

Type 4501 (not including monitor)

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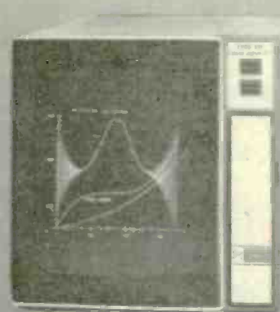

Type 611

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Accuracy ±1% or ±0.5% on all decades.

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Air Spaced ImH to IH ±5%.

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0.1 Ω to 1.1111 M Ω Average accuracy ±0.1% Resistance elements suitable for use up to 1MHz.

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All ranges available from stock. Write for descriptive leaflet or demonstration.

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High Input Impedance

rate of output	±10v 5mA
open loop gain	200,000
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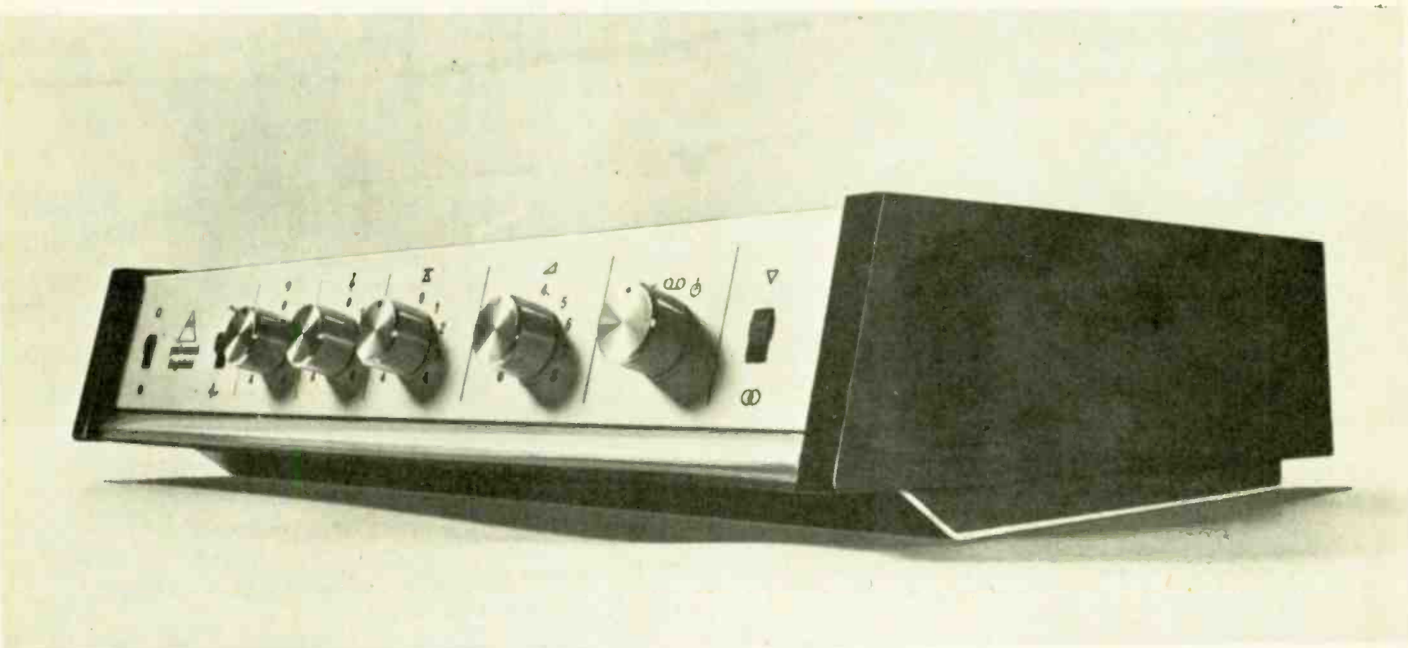
Write for design charts and prices or TELEPHONE—CHARD 3439

WW—062 FOR FURTHER DETAILS

peak sound englefield

peak sound



NEW DESIGN FROM PEAK SOUND

Proved-performance high fidelity with specification guarantee

The Peak Sound Englefield is a new system which assembles from laboratory designed modules to provide a cost-performance ratio which has never been bettered in high fidelity. Here is top-flight circuitry housed in a cabinet of elegantly original design which is both beautiful and completely practical back and front. By assembling these Peak Sound units, you can own one of the best high fidelity instruments you have ever heard or seen and all for a cost of about £38. The assembly is supplied complete down to the necessary connecting wires supplied colour coded, cut to length and stripped at the ends for soldering. You can use the Englefield Cabinet design to house either the 12 + 12 system as published in *Practical Wireless*, or the 25 + 25 watt system as approved for the *Hi-Fi News* Twin Twenty by Reg Williamson. Go to your stockist and ask to see and hear Peak Sound equipment now.

Matching F.M. Tuners will be available very shortly.

and this is the Peak Sound Specification Guarantee

Peak Sound guarantee that their equipment meets all specifications as published by them and that these are written in the same terms as are used in equipment reviews appearing in this and other leading high fidelity journals. Audio output powers are quoted at continuous sine wave power in terms of Root Mean Square values (R.M.S.) into stated loads at stated frequencies.

THE SPECIFICATION

Using two Peak Sound PA.12-15's, driven simultaneously at 1 KHz from 240 V. mains supply.

Output per channel: 11 watts into 15Ω: 14 watts into 8Ω. *(see spec. guarantee).*
Frequency bandwidth: 10Hz to 45 KHz for 1dB at 1 watt.
Total Harmonic Distortion at 1 KHz at 10 watt into 15Ω—0.1%.
Input sensitivities: Mag. PU.3.5 mV imp. R.I.A.A. equalized into 68 KΩ: Tape, 100 mV linear into 100 KΩ: Radio, 100 mV linear into 100 KΩ.
Overload factor: 29 dB on all input channels.
Signal/noise ratio: −65 dB on all inputs. Vol. control max.
Controls: Volume, Treble, Bass, Low-pass Filter, Mono/Stereo: On/off: Balance.
Using two PA.25-15 amplifiers, output is then 25 watts into 15Ω or 8Ω per channel at 1 KHz.
Power bandwidth for −1 dB at 20 watts R.M.S. into 15Ω at less than 0.25% distortion is 20 Hz to 20 KHz.

THE MODULES

Englefield Amplifier Cabinet with front panel, knobs, sockets, cut and stripped wire, fuses, edge connectors, etc.	£6 0 0
Two PA. 12-15 power amp. built modules	£11 19 0
SCU/400 Pre-amp/Control module, built	£15 15 0
PS/45 Power Supply kit	£4 10 0
	£38 4 0

Using two PA.25-15 modules at £11/15/- each and PS/68S Stabilized Power Supply Unit at £13/10/-, total price for complete system comes to **£58 15 0**

peak sound

Go to your Stockist. Peak Sound products are already available from dealers in many parts. If your own local stockist is not yet ready with the Peak Sound items you require, please send direct together with your supplier's name and address and your requirements will be dealt with without delay.

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Telephone: EGHAM 5316

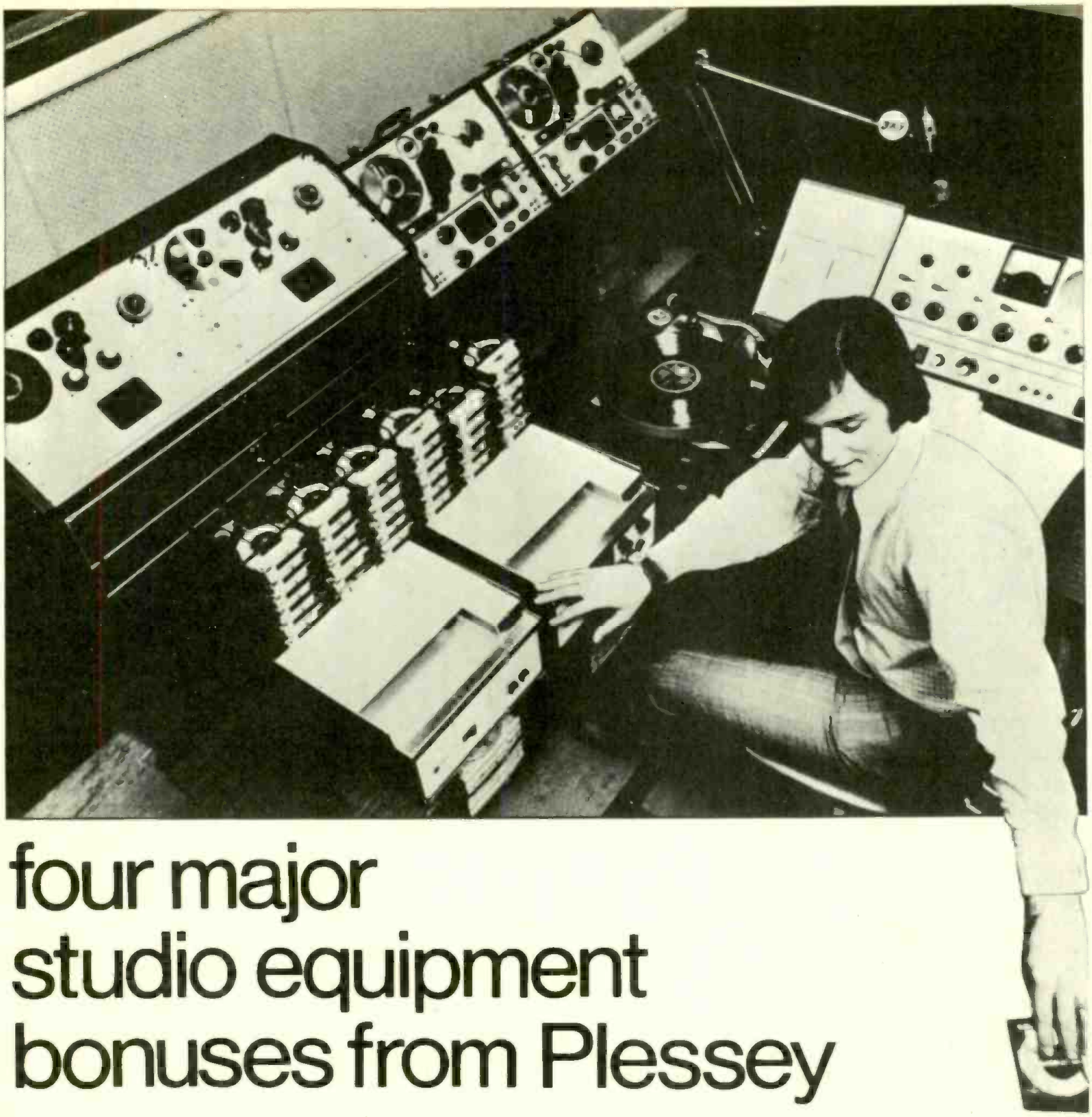
To Peak Sound, 32 St. Jude's Rd., Englefield Green, Egham, Surrey.
Details of Englefield systems, please and ....

Name ....
Address ....
.... WW 2

Write your stockists name and address in margin below and cut out with coupon if necessary

WW—063 FOR FURTHER DETAILS

HIGH FIDELITY MOVING COIL STEREO HEADPHONES (TYPE LS43) Now available from DAYSTROM LTD. GLOUCESTER



four major studio equipment bonuses from Plessey

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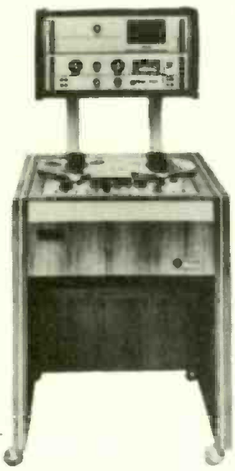
2 Widest range

3 Instant service

4 Total versatility



You gain these and many more bonuses using Plessey equipment. Arrange a demonstration now.

The range includes:

- 700 Series Solid State Studio Consoles
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- Rola 77 Mark III Recorder
- Rola Hi-Speed Copier
- Rola Auto Station
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AV21

WW—068 FOR FURTHER DETAILS

No other TRUE DUAL BEAM oscilloscope can compete in price

...except the D51,
by Telequipment of course

The D52 by Telequipment

The D52 is a tough little portable oscilloscope at the remarkably low price of £120.
Here are a few of its outstanding characteristics:

- ★ True Dual Beam
- ★ Large 5" flat faced PDA Tube
- ★ Matched Y Amplifiers—
  100mV/cm, DC—6MHz
  10 mV/cm, DC—1MHz
- ★ Calibrated Sweep Speeds—
  1B+ (+ variable)
- ★ Triggering Modes—full range including TV sync.
- ★ Weight 24 lb.

This is one of a range of fifteen oscilloscopes at prices from the Serviscope Minor at £25 to the sophisticated D53 Storage Oscilloscope for laboratory use at £513: Send for full details and short-form catalogue NOW!!!

TELEQUIPMENT

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WW—069 FOR FURTHER DETAIE

Wireless World

Electronics, Television, Radio, Audio

Fifty-ninth year of publication **March 1970** **Volume 77 Number 1413**

This month's cover illustrates a fish-eye view of the master control room at the new London headquarters of Thames Television; one of three new colour television centres in the capital (see p.104).

Contents

IN OUR NEXT ISSUE

Stabilized power supply. An unconventional design that will provide a constant-voltage, current-limited output or a constant-current, voltage-limited output.

Digital dice. Electronic novelty using the minimum of components.

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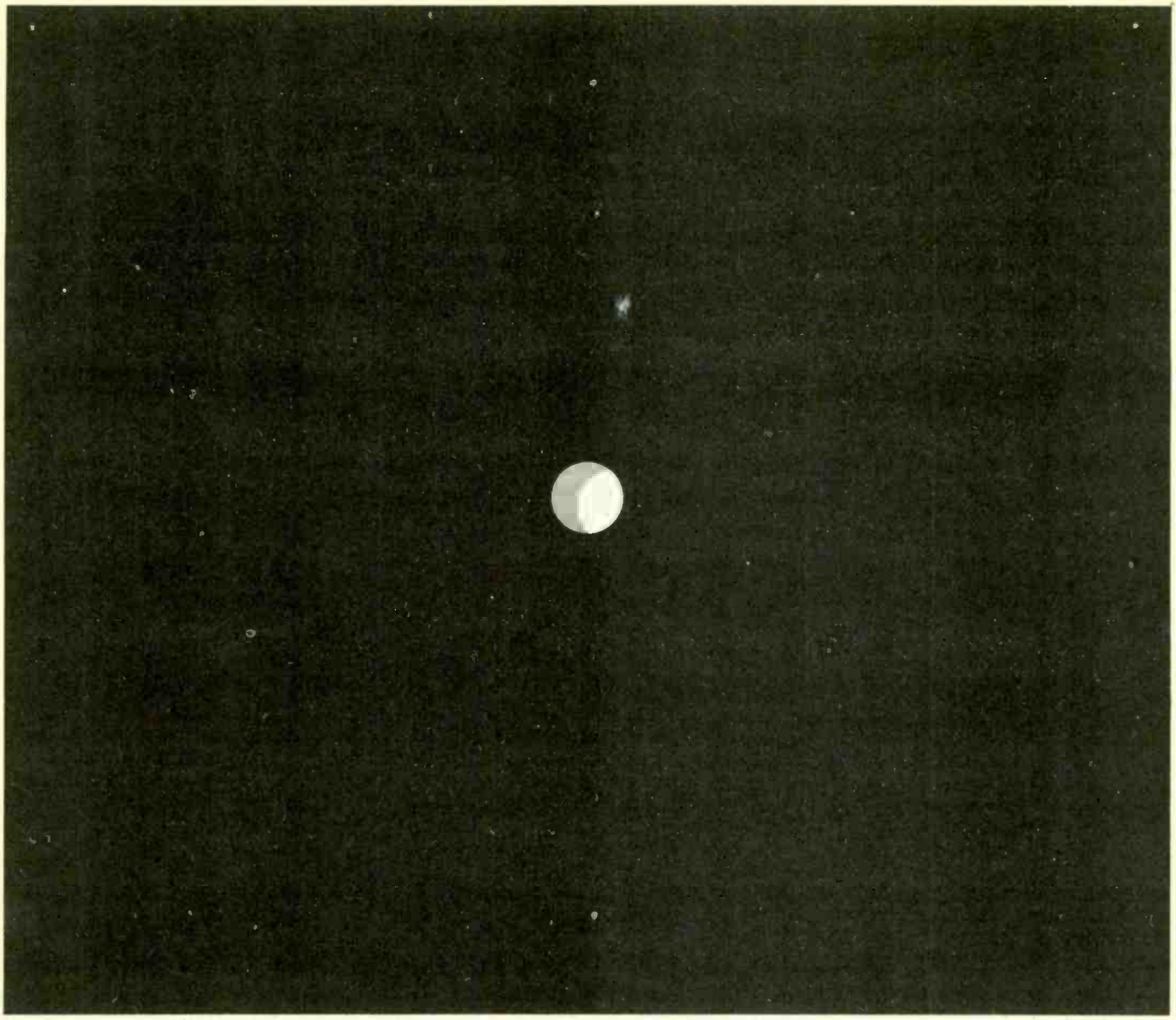

rare eclipse

The apertures in a cathode ray tube gun must be aligned precisely in spite of production tolerances in the six or more electrodes involved. Errors of the order of a tenth of a thou make all the difference if a round, crisp spot is to be maintained. The requirement is a dead fit for each component, no less. To this end, BRIMAR have developed their own methods for the production of assembly jigs to meet these exacting requirements.

Even after assembly in such accurate jigs as these, the guns are still subjected to rigorous 100% inspection; including a final optical test of alignment, where even fractional differences mean rejection.

And in addition to this, BRIMAR have an unparalleled capability in chemistry, electron optics and vacuum physics enabling them to offer the widest design diversity backed by a *personalised customer service*. This service, provided by engineers with extensive experience of the electronics industry, covers advice on tube characteristics, operating conditions and associated components.

Tailored packaging and reliable delivery to meet production schedules are also part of the BRIMAR Service.

Want to know more about BRIMAR Industrial Cathode Ray Tubes?—ask to see our latest catalogue.

BRIMAR

THORN **Thorn Radio Valves and Tubes Ltd.**
7 Soho Square, London, W1V 6DN Tel: 01-437 5233

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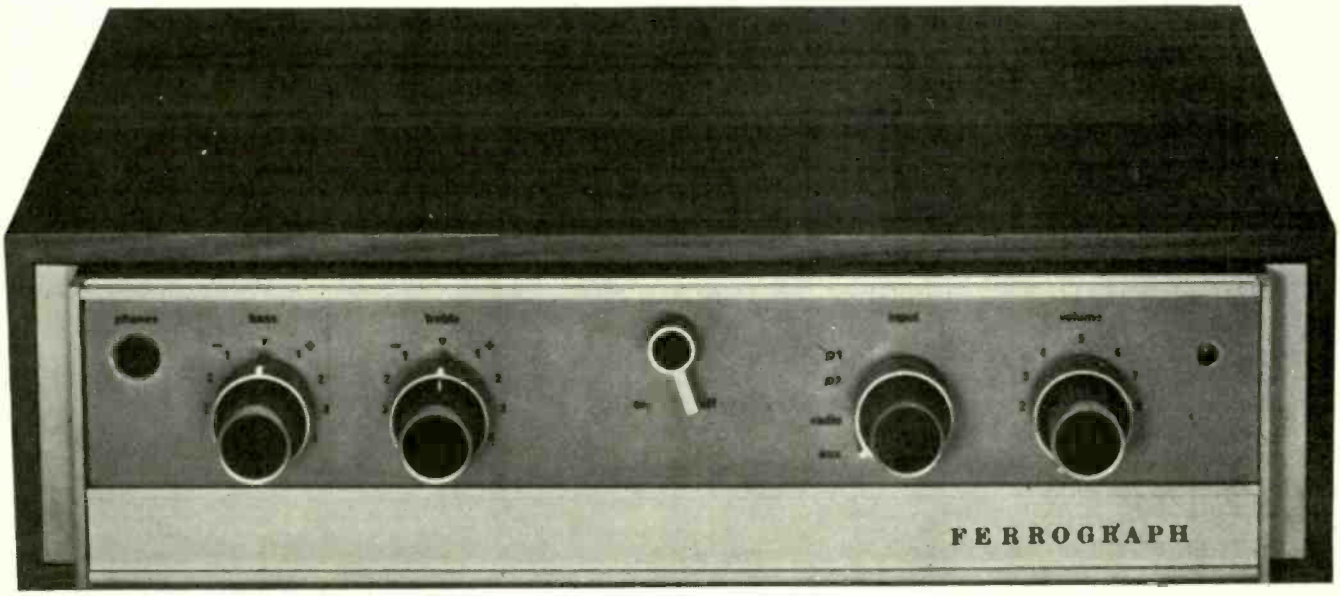

Ferrograph F307 stereo amplifier– the heart of great Hi-Fi

F307 is an integrated Stereo Amplifier, built in a tradition of excellence and extremely versatile in its capabilities.

It presents a clean uncluttered appearance, conforming very closely with the Series Seven Recorder in this regard. Only its main controls appear on the panel—all subsidiary controls being housed beneath a hinged extruded aluminium flap.

F307 delivers power output of 20 watts RMS per channel into a load of 8 ohms and has a total harmonic distortion of less than 0.25% at 1kHz at all levels up to its rated output.

Your Ferrograph dealer will be pleased to demonstrate F307 to you. When planning your Hi-Fi system, this is an Amplifier to which the most serious consideration must be given and its Manual makes informative and compelling reading.

FERROGRAPH

The Ferrograph Co. Ltd.
Mercury House, 195 Knightsbridge, London, S.W.7.
Telephone: 01-589 4485

To The Ferrograph Co. Ltd.
Mercury House, 195 Knightsbridge, London, S.W.7.
Please send me FREE details of the Ferrograph Stereo Amplifier F307 ☐
OR send me the F307 Manual for which I enclose 5s 6d post paid ☐
Name...
Address...
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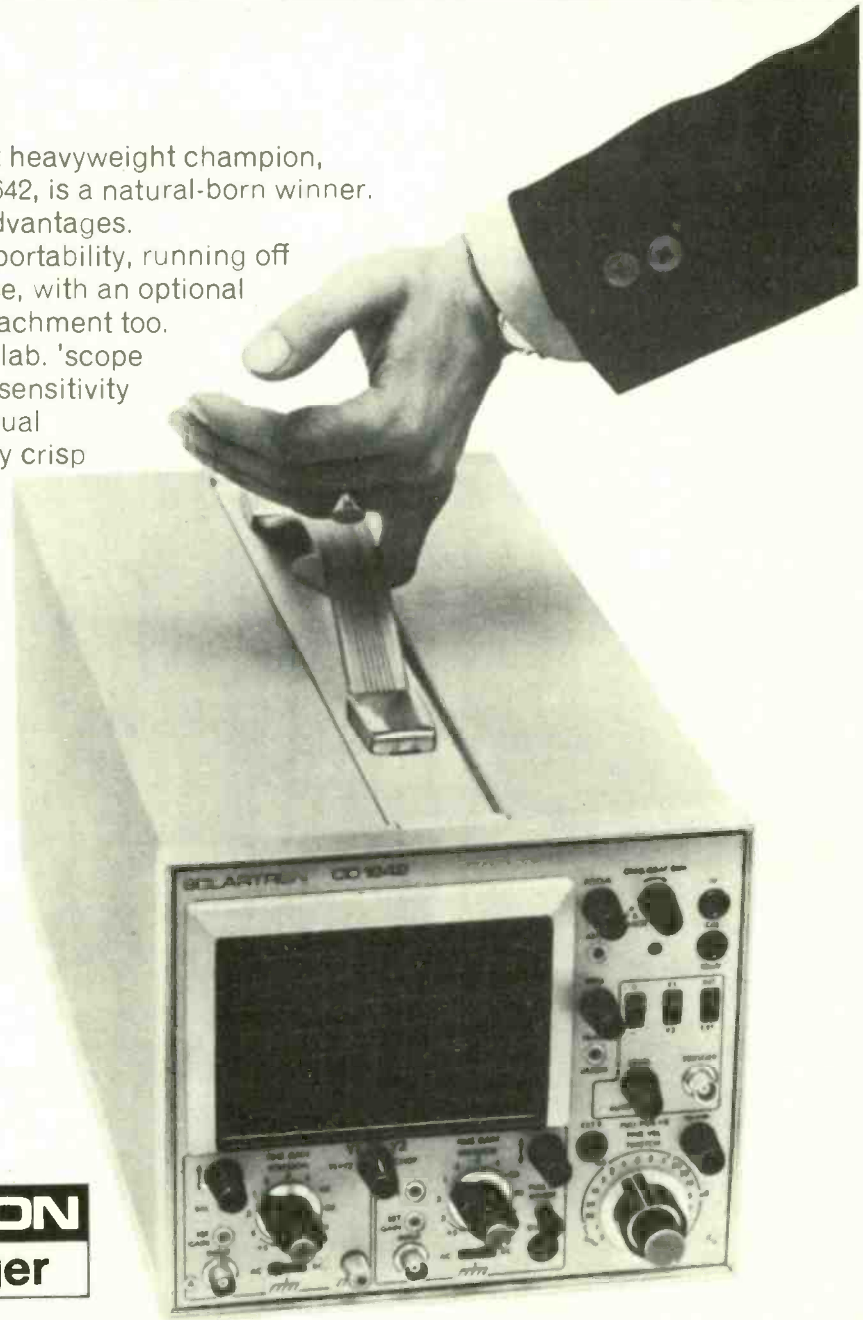
WW

WW—071 FOR FURTHER DETAILS

The light heavyweight champion wins on points



Solartron's light heavyweight champion, the CD1642, is a natural-born winner.
Look at its advantages.
Fully transistorised portability, running off every power source you use, with an optional rechargeable battery attachment too.
And you lose nothing in full-size lab. 'scope performance. It has 10 mV/cm sensitivity at 15 MHz, triggering to 25 MHz, dual trace, D.C.—15 MHz, brilliantly crisp displays and exceptional focus right to the edges.
And to top it off, we AGREE test every machine for a week in the toughest conditions to assure top performance.
So stop worrying about losing performance in the field.
The CD1642 gets a load off your mind as well as your arm.
Post the magazine's reply-paid card and we'll send you our data sheet of full details.

SOLARTRON
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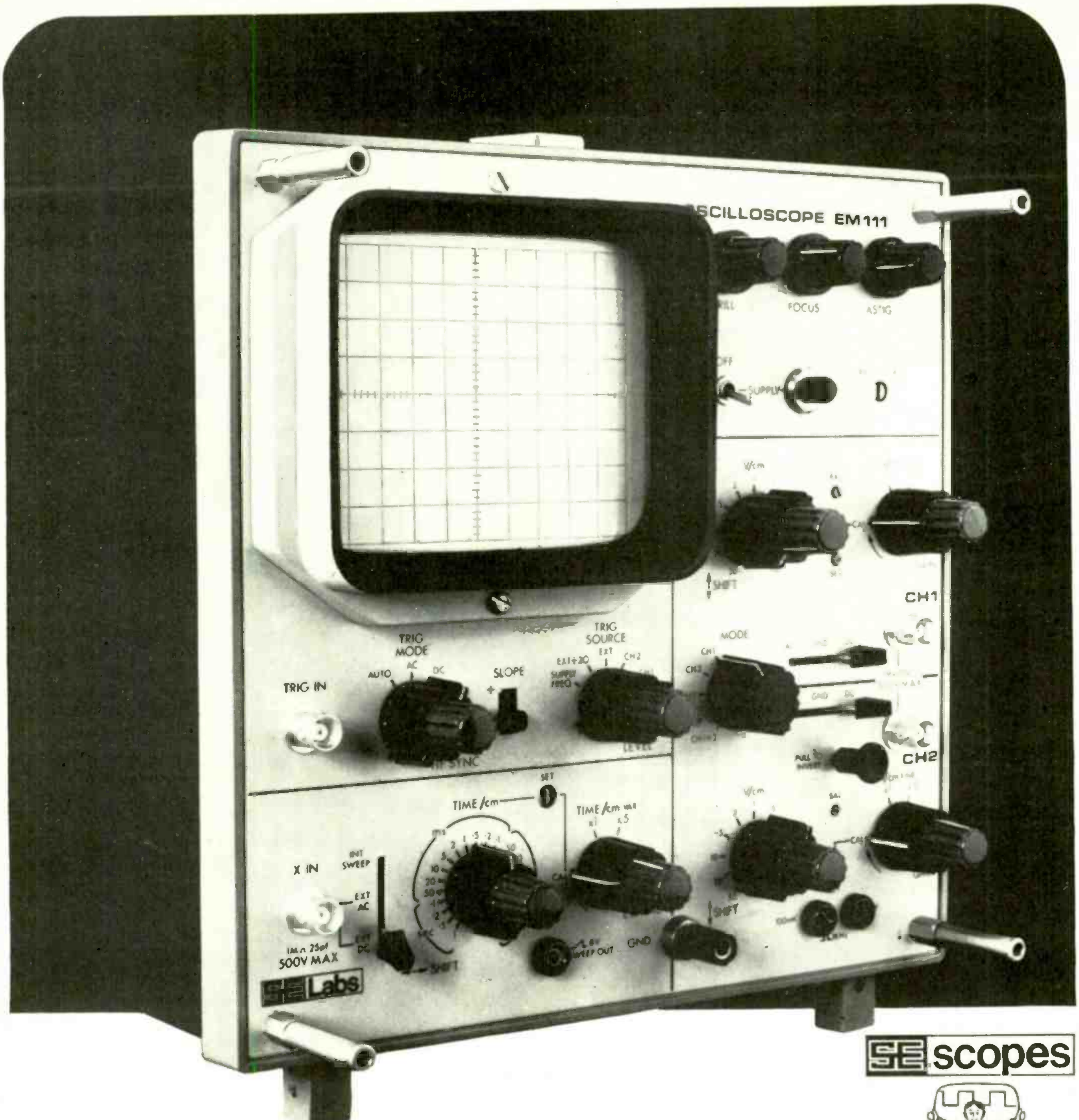

SE scopes

The Latest Big-Screen Attraction

The new SM111 dual-channel Oscilloscope. It's not the smallest scope sold, but, thanks to an SE breakthrough, gives you a full 10x8 cm. display, easily the highest screen-to-instrument ratio ever achieved in the world. The specification is of a good laboratory scope — 18MHz bandwidth, 20mV sensitivity - increased in X10 mode to 2mV on both channels, d.c. trigger facility and a dc coupled X-amplifier. It's portable, a.c. or d.c. powered, the rugged performance is guaranteed in all environments. It's a star-studded SE Production, on general release NOW. We bet it costs much less than you think. Write or ring today for full details or for an immediate demonstration.

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Northern Sales Office, Bessell Lane, Stapleford, Nottingham. Telephone: Sandiacre 3255.

WW—073 FOR FURTHER DETAILS

Some notes on Bridge Measurement by WAYNE KERR

Number 8
The Logarithmic Scale

This series of notes has described Transformer Ratio Arm networks which can be constructed to form manually operated or self-balancing bridges. In many cases, a linear relationship between the scale and the impedance or admittance parameter being evaluated is satisfactory, but when components are being selected to a specific tolerance, or a simple, wide range bridge is required, a logarithmic scale offers several advantages. Figure 1 shows a section of a scale obeying the logarithmic law of a slide rule.

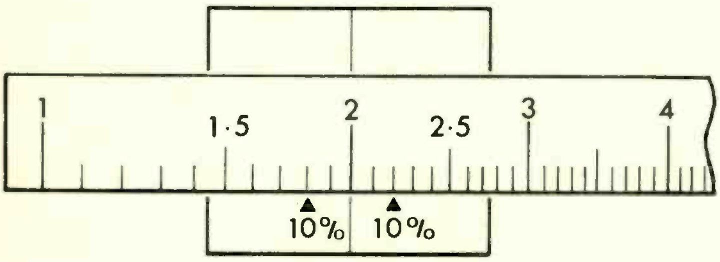


Figure 1

The spacing of the tolerance marks on the cursor is correct for any point on the scale and can be extended to include a range of tolerances in addition to the 10% marks illustrated.

A convenient logarithmic scale giving a reasonable overlap between decades can be achieved by using the arrangement shown in figure 2.

A linear wound variable resistor is connected across part of the winding of the left hand transformer. The sliding contact on the resistor covers a voltage range of 1:16 and as this voltage is applied to the standard impedance it varies the current flowing through the right hand transformer by an equivalent ratio. The resistor is connected by means of five equi-spaced taps to the transformer windings which supply voltages in the ratio 1, 2, 4, 8 and 16. Although this arrangement gives correct balance points on the logarithmic scale when the sliding contact lies precisely on a tap, the interpolation between these points is linear and errors arise of up to 6%. However, a resistor (R) connected in shunt to the voltage produced corrects the errors to less than 1% and a further slight correction to the scale calibration removes the errors completely. The advantages of the transformer ratio arm bridge described in earlier issues of this series can be obtained from this network. Two, three and four terminal measurements can be made and high impedance components can be connected to the bridge with long lengths of screened cable without the capacitance of these cables affecting the bridge balance point. A wide range of decade ratios between the standard and unknown impedances can be achieved by varying the tapping points on the right hand transformer. Furthermore, the unknown impedance can be connected to alternative voltage decade taps on the left hand transformer

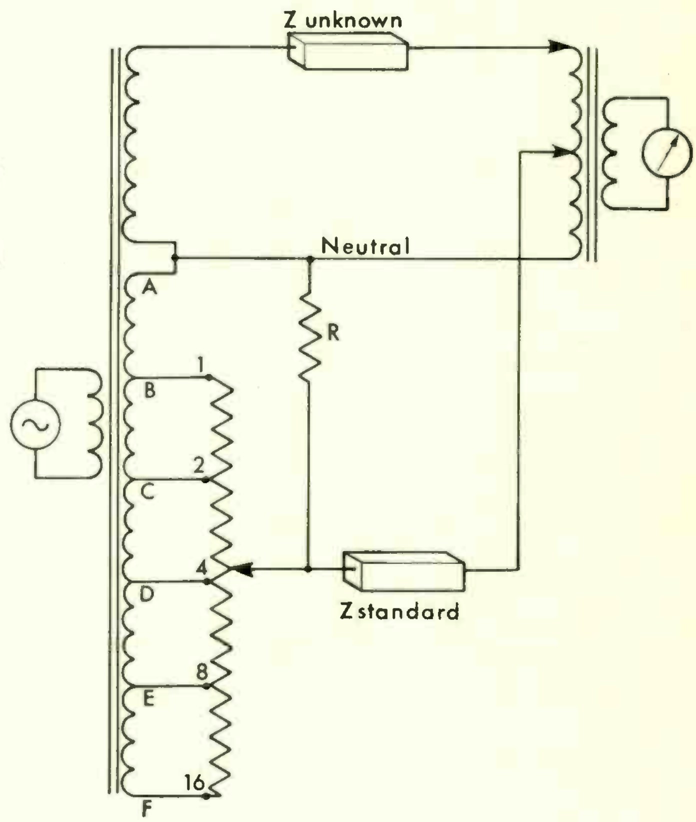
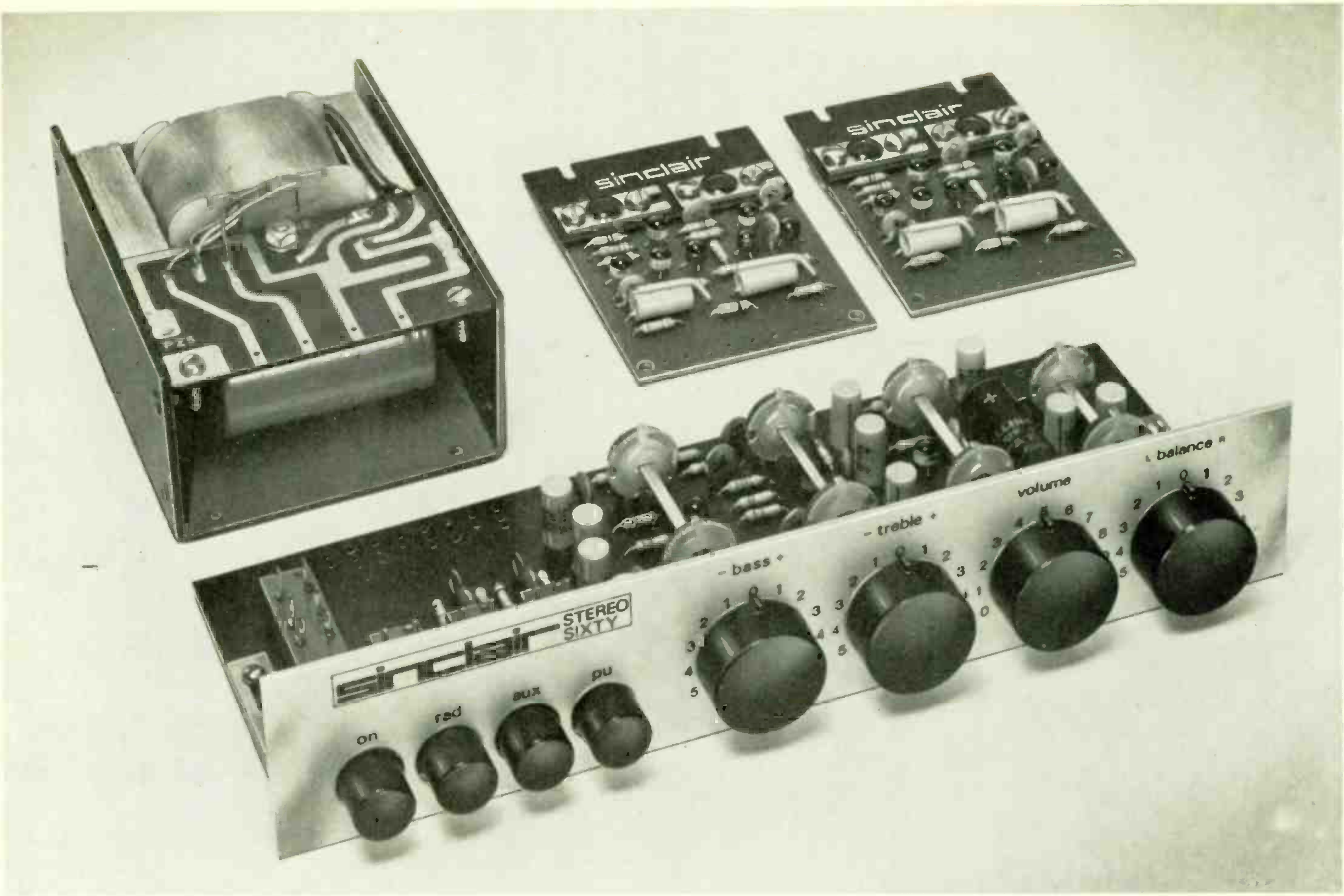


Figure 2

A further advantage of the bridge illustrated in figure 2 lies in the reciprocal nature of the standard logarithmic voltage and its relationship to the calibrated scale. The arrangement shown is correct for a capacitance or conductance scale with suitable standards but it can be easily adapted to inductance and resistance measurements by re-connecting the 1, 2, 4, 8 and 16 points to taps F, E, D, C and B, i.e.: reversing the order shown. Separate standards are necessary in this case and for component measurements a simple network must be added to balance the phase angle of the unknown impedance.



Project 60 an exciting alternative

The buyer of an amplifier today has a remarkably wide variety to choose from. It is unlikely that a purchaser would have real difficulty in finding a unit that met all his requirements, although the price might not be as low as could be wished. The only snags are that one's needs can change and that the technically correct amplifier may be physically inconvenient. If you are confident that there is an amplifier available, of the right size and price, which will meet all your needs for the forseeable future, then that is your best buy. If not, however, we can offer you another possibility which we believe to be an exciting alternative approach. That alternative is **Project 60**.

Project 60 is a range of modules which connect together simply to form a complete stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare with it in overall performance.

The modules are: **1**. The Z-30 high gain power amplifier, which is an immensely flexible unit in its own right. 2. The Stereo 60 preamplifier and control unit. **3**. The PZ.5 and PZ.6 power supplies. A complete system comprises two Z-30's, one Stereo-60 and a PZ-5 or PZ-6. The power supplies differ in that the PZ-6 is stabilised whilst the PZ-5 is not. This means that the former should be used where the highest possible continuous sine wave rating is required. In a normal domestic application there will not be a significant difference between using either power unit unless loudspeakers of very low efficiency are being used.

All you need to assemble your system is a screwdriver and a soldering iron. No technical skill or knowledge whatsoever is required and, in the unlikely event of you hitting a problem, our customer service and advice department will put the matter right promptly and willingly.

Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future. We shall shortly be introducing additional modules which will include a comprehensive filter unit, a stereo F.M. tuner and an even more powerful amplifier for very large systems. These and all other modules we introduce will be compatible with those shown here and may be added to your system at any time.

Project 60 modules have been carefully designed to fit into virtually every known type of plinth or cabinet. Only holes have to be drilled into the wood of the plinth or cabinet to mount the Stereo 60 and any slight slips here will be covered completely by the aluminium front panel of the control unit. The Project 60 manual gives all the instructions you can possibly want clearly and concisely.

sinclair

SINCLAIR RADIONICS LTD · 22 NEWMARKET ROAD · CAMBRIDGE
Telephone: 0223 52731

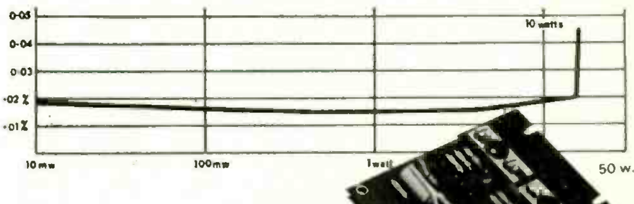
WW—077 FOR FURTHER DETAILS

Z-30 TWENTY WATT R.M.S. (40 WATT PEAK) POWER AMPLIFIER

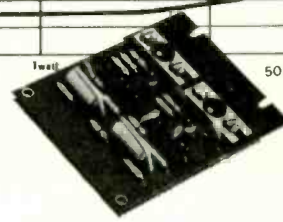
The Z-30 is a complete power amplifier of very advanced design employing 9 silicon epitaxial planar transistors. Total harmonic distortion is incredibly low being only 0.02% at full output and all lower outputs. As far as we know, no other high fidelity amplifier made can match this specification, no matter what the price. Thus you can be utterly certain that your Project 60 system will do full justice to your other equipment however good it may be. The Z-30 is unique in that it will operate perfectly, without adjustment, from any power supply from 8 to 35 volts. It also has sufficient gain to operate directly from a crystal pickup. So in addition to its use in a high fidelity system you can use a Z-30 to advantage in your car or a battery operated gramophone for your children, for example. These, and many other applications of the Z-30, are covered in the Project 60 manual.

APPLICATIONS

High fidelity amplifier; car radio amplifier; record player fed direct from pick-up; Intercom; electronic music and instruments; P.A., laboratory work, etc. Full details of these and many other applications are given in the manual supplied with your Z.30.



Power versus distortion curve of Sinclair Z.30.



SPECIFICATIONS

Power output—15 watts R.M.S. (30 watts peak) into 8 ohms using a 35 volt supply; 20 watts R.M.S. (40 watts peak) into 3 ohms using a 30 volt supply.

Output—Class AB.

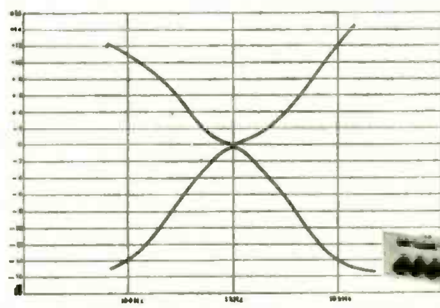
Frequency response: 30 to 300,000 Hz ± 1dB.
Signal to noise ratio: better than 70dB unweighted.
Distortion: 0.02% total harmonic distortion at full output into 8 ohms and at all lower output levels.
Size: 3½ x 2¼ x ½ inches.
Input sensitivity: 250mV into 100 Kohms.
Damping Factor: >500.
Loudspeaker impedances 3 to 15 ohms.
Power requirements: 8 to 35 V.d.c.

Z.30

Ready built, tested and guaranteed, with Z.30 manual. **89/6**

STEREO SIXTY PREAMPLIFIER AND CONTROL UNIT

The Stereo 60 is a stereo preamplifier and control unit designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout and great attention has been paid to achieving a really high signal-to-noise ratio and excellent tracking between the two channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs. The tone controls are also very carefully designed and tested.



Treble and bass control curves

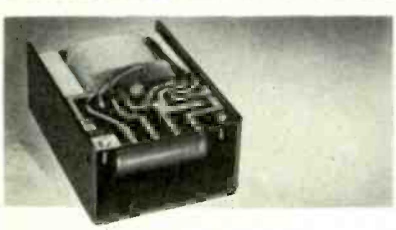
SPECIFICATIONS

- Input sensitivities—Radio—up to 3mV; Magnetic Pickup—3mV Correct within ± 1dB on R.I.A.A. curve. Ceramic Pickup—up to 3mV; Auxiliary—up to 3mV.
- Output—250mV.
- Signal-to-noise ratio—better than 70dB.
- Channel matching—within 1dB.
- Tone Controls—TREBLE + 15 to − 15dB at 10 KHz; BASS +15 to −15dB at 100 Hz.
- Power consumption 5mA.
- Power requirement—PZ.5 or PZ.6.
- Finish—brushed aluminium front panel with black knobs.
- Mounting—on cabinet front by spindle bushes and adjustable brackets.

STEREO SIXTY

Ready built, tested and guaranteed **£9.19s.6d.**

SINCLAIR POWER SUPPLY UNITS



PZ-5 30 volts unstabilised—sufficient to drive two Z-30's and a Stereo 60 for the majority of domestic applications.

Price: **£4. 19s. 6d.**

PZ-6 35 volts stabilised—ideal for driving two Z-30's and a Stereo 60 when very low efficiency speakers are employed.

Price: **£7. 19s. 6d.**

GUARANTEE

If at any time within 3 months of purchasing Project 60 modules from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter.

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22 NEWMARKET ROAD, CAMBRIDGE
Telephone 0223 52731

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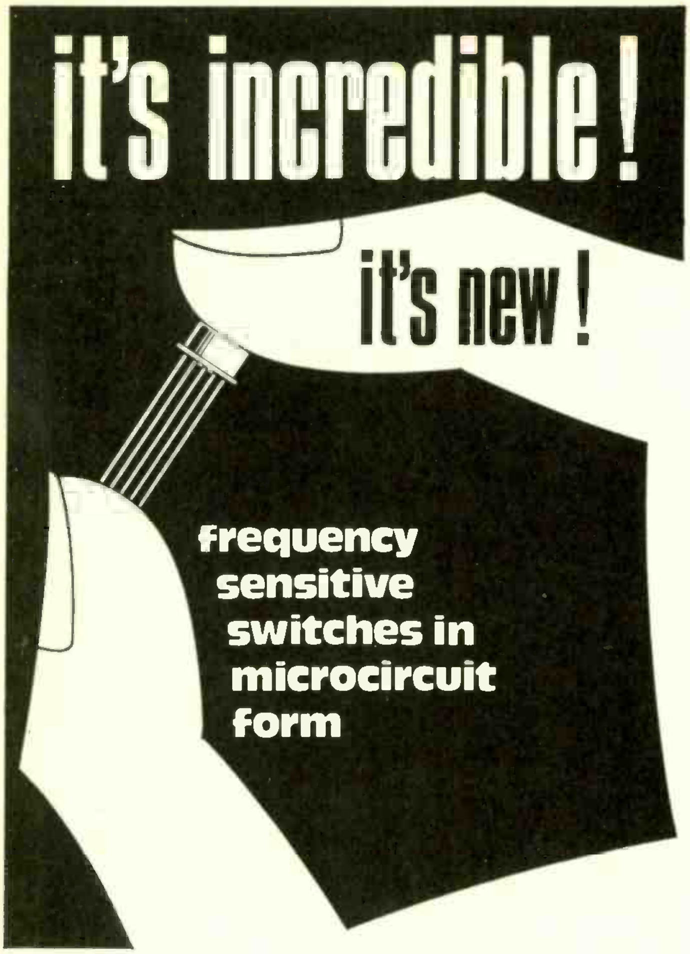
To: SINCLAIR RADIONICS LTD., 22 NEWMARKET RD., CAMBRIDGE
Please send ....
NAME ....
ADDRESS ....
for which I enclose cash/cheque money order
WW370

WW—078 FOR FURTHER DETAILS



breakthrough in size, cost, precision and versatility

Z TRIPS

This FX-201 'Z TRIP' is unique—it is the only frequency sensitive switch in microcircuit form. It incorporates over 200 transistors on a single monolithic silicon chip, and is housed in a TO-5 style can. This 'Z TRIP' consists of two independent 'band accept' frequency selective switches, incorporating an input amplifier, analogue/digital frequency discriminating circuits and buffered bistable output switches. It operates from a single d.c. supply and is rated for industrial environments.

The FX-201 accepts sinewave and pulse input signals: when the input signal frequency falls within either of the two predetermined acceptence bands the corresponding output is switched. Completely immune to random signal noise and harmonics.

- **Adjustable band frequencies** 10Hz to 30kHz
- **Adjustable band separation** 1% to 50%
- **Adjustable bandwidths** 1% to 50%
- **Band edge 'slope'** typically 0.1%
- **Response time** approx. 1.8 mSec @ 5kHz
- **Signal amplitude range** 20mV to 20V

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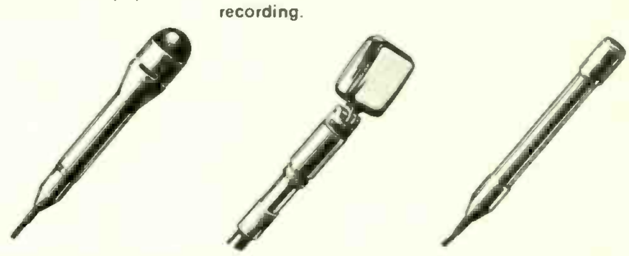

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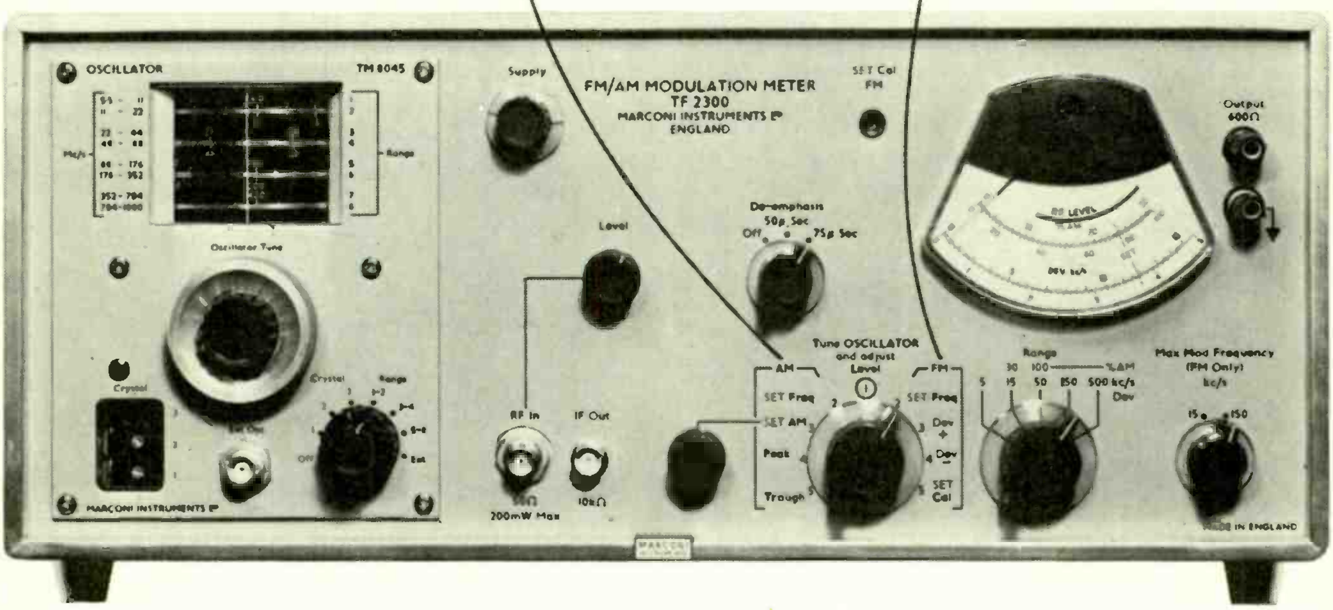

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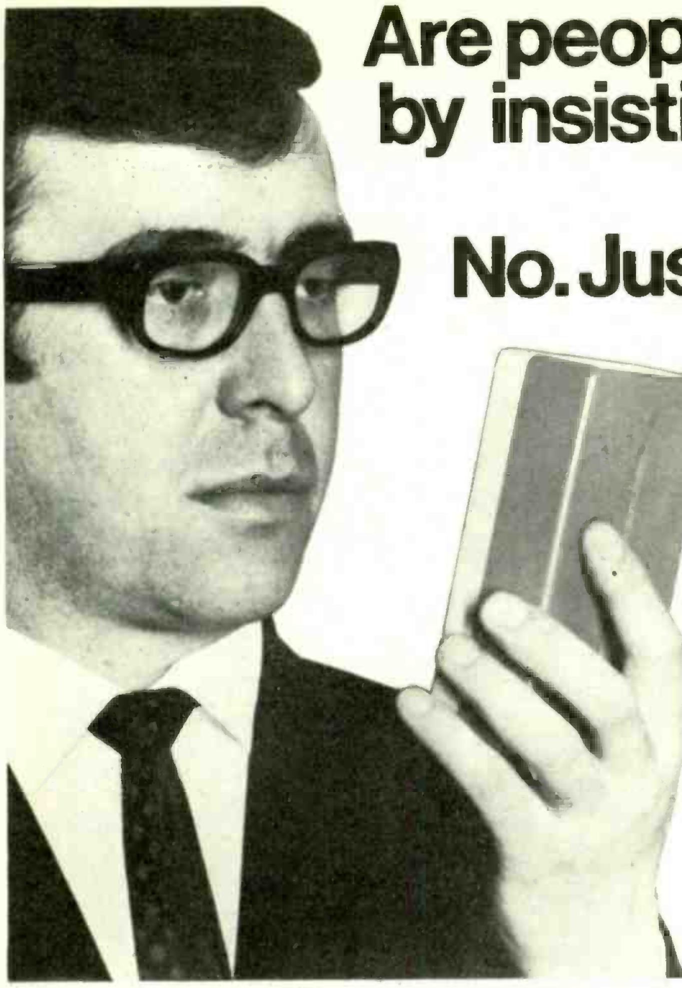

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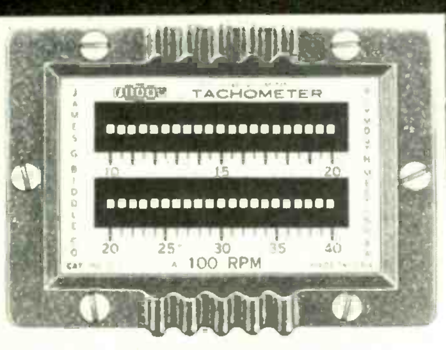

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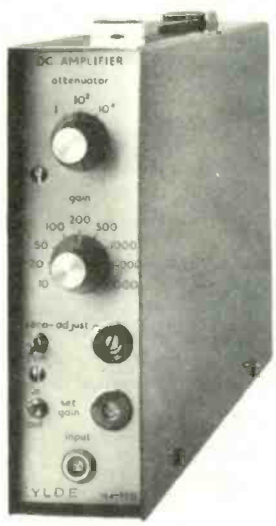

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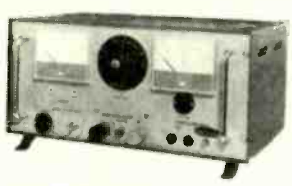

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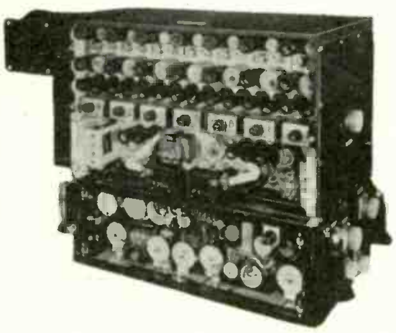

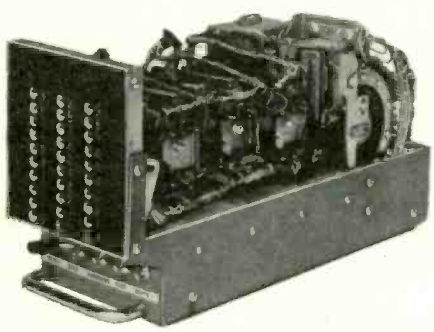


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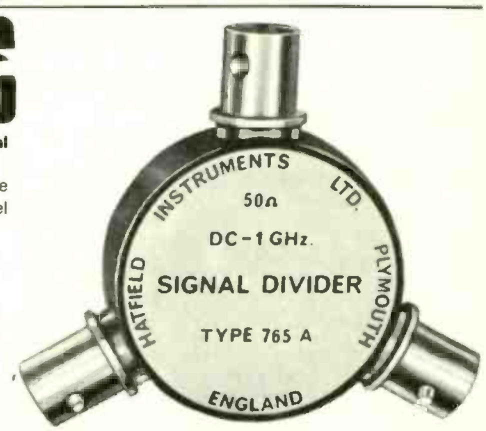
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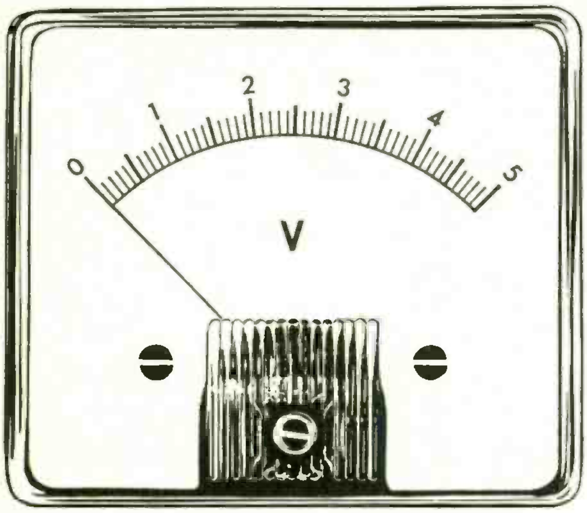

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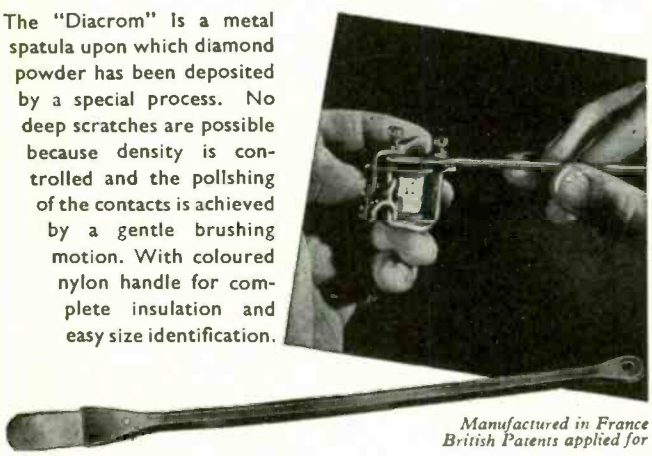

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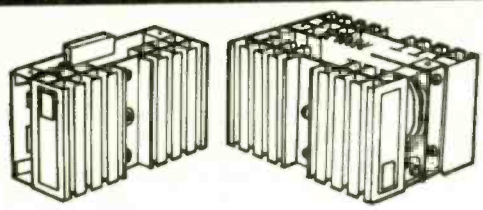

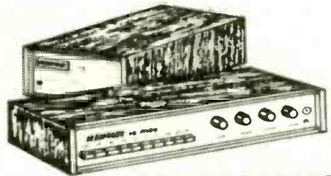

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✻ **HENELEC MU442 POWER SUPPLY**

Designed to run one or two 'PA25's' or one 'PA50' the MU442 connects to the amplifiers by means of plug-on harnesses. No soldering is required to connect up the system. Audio input plug and speaker plug go to the panel of the MU442. **PRICE £6.0.0**

✻ Mk.I 100 watts RMS with stabilised power supply overcurrent trip 100mV input sensitivity. Ideal for public address and discotheque equipment. **PRICE £49.10.0**

THE FINEST SOLID STATE UNITS ALL SILICON BRITISH EQUIPMENT

✻ *SEND FOR FREE BROCHURES* ✻

TO BUILD YOURSELF ALL TRANSISTOR DESIGNS

• PW Stereo Decoder (Reprint no.: 45A 1/6)	£5 15 0	p.p 3/6
or with optional power supply unit	£7 7 0	p.p. 6/-
• PE Spring Line Reverberation Unit (Reprint no.: 46A 1/6)	£11 5 0	p.p. 6/6
• Repanco 15 watt Invertor Kit	£3 7 6	p.p. 5/-
• Repanco 40 watt Invertor Kit	£4 17 6	p.p. 7/-
• Tiny Tone Radio Control Receiver (Reprint 18A 1/6)	£2 15 0	p.p. 3/-
• Henry's MW/LW Radio Tuner	£3 19 6	p.p. 3/6
• PW Switched FM Tuner (Reprint 1/-)	£3 17 6	p.p. 3/6

NOTE. FOR MANY OF THE INTEGRATED CIRCUITS LISTED APPLICATIONS AND CIRCUITS ARE AVAILABLE. COMPLETE LIST No. 36A WITH DETAILS ON REQUEST.

TRANSISTORS

FROM STOCK THE LARGEST RANGE AVAILABLE. COVERING ALL TYPES OF TRANSISTOR, INTEGRATED CIRCUITS, DIODES, RECTIFIERS, ZENERS, LIGHT DEVICES. FREE LIST No. 36 OF OVER 1,000 TYPES ON REQUEST.

TRADE AND INDUSTRIAL ENQUIRIES INVITED

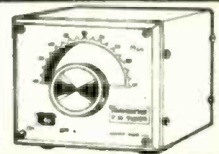
ALSO IN STOCK. TRANSDUCERS £5.18.0 PAIR WITH CIRCUITS. LARGE RANGE OF NUMICATOR TUBES AND INDICATORS, RELAYS AND COUNTERS, SOLENOIDS AND ACTUATORS—SEE CATALOGUE "A".

BUILD THIS VHF FM TUNER

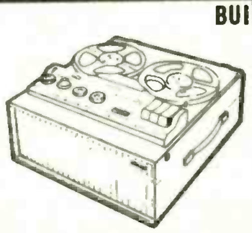
5 MULLARD TRANSISTORS. 300 kc/s BANDWIDTH. PRINTED CIRCUIT. HIGH FIDELITY REPRODUCTION MONO AND STEREO. A popular VHF FM Tuner for quality and reception of mono and stereo. There is no doubt about it—VHF FM gives the REAL sound. ALL PARTS SOLD SEPARATELY.

TOTAL COST £6.19.6 DECODER £5.19.6 (FOR STEREO)

ASK FOR BROCHURE No. 3



BUILD A QUALITY 4 TRACK TAPE RECORDER



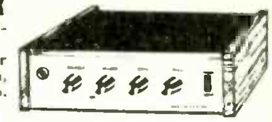
To get the best out of your MAGNAVOX DECK, you need a MARTIN RECORDAKIT. This comprises a special high quality 6 valve amplifier and pre-amplifier which comes to you assembled on its printed circuit board—in fact everything for making a superb Tape Recorder. You need no experience or technical skill to bring this about. THE INSTRUCTIONS MANUAL MAKES BUILDING EASY, AND SUCCESS IS ASSURED. Kit comprises Deck, Amplifier, Cabinet and speaker, with microphone, 7" 1,200 ft. tape, and spare spool.

ASK FOR BROCHURE 6 TODAY'S VALUE £60

PRICE 39 gns. p. & p. 22/6 NOTHING ELSE TO BUY

HENELEC 5-5 STEREO AMPLIFIER

Excellent low-priced British designed Stereo Amplifier for use with Record Decks, Tuners. 16 transistor mains operated. Output 5+5 watts for 8-15 ohm speakers. Black, silver and wood finish, size 13in. × 3in. × 6in. **PRICE £13.10.0.** p.p. 7/6. (Leaflet on request.)



Complete Stereo System 5-5.

Garrard 2025TC stereo, 5-5 Amplifier, Plinth/Cover. Two 10 watt speakers with tweeters in polished cabinets. size 18in. × 11in. × 7in. Usual price £49.10.0.

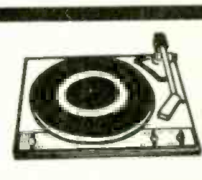
OUR PRICE £39.10.0. p.p. 20/-. ASK FOR BROCHURE 13.

OTHER SYSTEMS—ASK FOR BROCHURE 16/17. Over 40 specially designed systems, covering all price ranges.

RECORD DECKS GARRARD, BSR, GOLDING, THORENS. All at Special Prices!

•SP25 mk. II	Less cart.	£11 19 6
•SP25 mk. II	Mag. cart.	£16 0 0
•2025 TC	9TAHC Diam.	£8 19 6
•3000 LM	9TAHC Diam.	£9 19 6
A70 mk. II	L/C	£12 10 0
•AT60 mk. II	L/C	£13 10 0
•AT60 mk. II	9TAHC Diam.	£15 15 0
AP75	L/C	£17 17 0
AP75	with AT21	£25 12 6
•Plinth/Cover 95/- p.p 5/-. Delux £8.10.0. p.p. 5/-		
GL75P	L/C with P/C	£46 0 0
GL69P	L/C with P/C	£35 0 0

Carriage, etc. 7/6 any model.



•Complete List 16/17 on request with special prices with choices of cartridge.

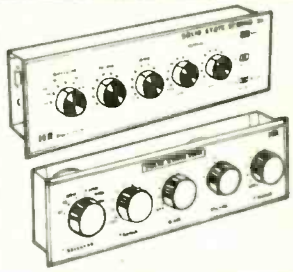
AUDIO EQUIPMENT

Mono or Stereo Audio equipment developed from Dinsdale Mk. II—each unit or system will compare favourably with other professional equipment selling at much higher prices. COMPLETE SYSTEMS AND MIXERS from £11.12.6 to £38.17.6 (all units available separately).

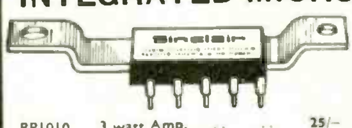
CHOOSE FROM 25 SYSTEMS

THE FINEST VALUE IN LOW-COST HIGH FIDELITY—CHOOSE A SYSTEM TO SUIT YOUR NEEDS AND SAVE YOURSELF POUNDS. Amplifiers 7, 12 and 25 watts, two types of Stereo Preamplifier, Mono Preamps and Mixer Modules.

*SEND FOR BROCHURES No. 12/14 and 21 TODAY!



INTEGRATED MICRO CIRCUITS



BP1010	3 watt Amp.	25/-
MC1304	Stereo Decoder	55/-
TAD100	AM Radio	47/6
PA237	2 watt Amp.	37/6
PA234	1 watt Amp.	20/-
PA230	Preamp.	22/6
MC1303	Stereo Preamp.	52/6
LA709C	Amp.	22/6
SL403	3 watt Amp.	49/6
TAA263	Amp.	15/-
SL702C	Amplifier	29/6
μL900	Buffer	10/-
TAD110	AM/FM Radio	59/6
CA3028	Osc/Mixer	24/6
CA3036	Dual Dar	18/6
CA3020	Amplifier	27/6
CA3018	Array	22/6
CA3014	FM	29/6

TRANSDUCERS. Type 1404 for LF communication with circuit £5.18.0 pair. Complete list and details of all integrated circuits No. 36A free on request.

9 AND 12 VOLT STABILISED SUPPLIES

Size approx. 3in. × 2in. × 1¼in. Output 100mA. Transistorised and Zener stabilised. Also unstab. output. UK made on PC with metal chassis.

PS 900 9 volt. 45/- p.p. 2/-
PS1200 12 volt. 47/6 p.p. 2/-

SINCLAIR EQUIPMENT IN STOCK

Z30 89/6, Stereo 60 £9.19.6, PZ5 99/6, Q16 £8.10.0, IC10 59/6, Micro 6 Kit 49/6. System 2000 in stock and on demonstration.

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Continually revised and enlarged. Over 300 pages of all types of components and equipment for every use. Complete with 5 2/- Discount Vouchers for purchases.

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BARGAINS IN NEW TRANSISTORS

ALL POWER TYPES SUPPLIED WITH FREE INSULATING SETS

2N696	5/6	2N3707	4/–	AF127	7/–
2N697	5/6	2N3708	3/–	BA102	9/–
2N706	2/9	2N3709	3/–	BC107	2/9
2N1132	9/9	2N3710	3/6	BC108	2/6
2N1302	4/–	2N3711	3/11	BC109	2/9
2N1303	4/–	2N3904	7/6	BC147	3/6
2N1304	4/6	2N3906	7/6	BC148	3/3
2N1305	4/6	2N3731	24/–	BC149	3/6
2N1306	6/9	2N4058	5/3	BC153	10/–
2N1307	6/9	2N3325	10/9	BC154	11/–
2N1308	8/9	2N3794	3/3	BC157	3/9
2N1309	8/9	2N4284	3/3	BC158	3/6
2N1613	6/–	2N4286	3/3	BC159	3/9
2N1711	7/–	2N4289	3/3	BC167	2/6
2N2218	9/3	2N4291	3/3	BC168	2/3
2N2147	18/9	2N4292	3/3	BC169	2/6
2N2369A	5/3	2N4410	4/9	BC177	6/3
2N2646	10/9	2N5192	25/–	BC178	5/8
2N2924	4/–	2N5195	28/3	BC179	6/–
2N2925	4/6	40361	12/6	BD121	18/–
2N2926R	2/3	40362	16/–	BD123	24/3
2N2926O	2/3	AC126	6/6	BF178	10/6
2N2926Y	2/3	AC127	6/–	BFX29	10/9
2N2926G	2/3	AC128	6/–	BFX85	8/3
2N3053	5/6	AC176	11/–	BFX88	6/9
2N3054	14/3	ACY22	3/9	BFY50	4/6
2N3055	16/–	ACY40	4/–	BFY51	4/3
2N3391A	6/3	AD140	19/–	BSX20	3/9
2N3702	3/6	AD149	17/6	MJ480	21/–
2N3703	3/3	AD161	16/- comp. pr.	MJ481	27/–
2N3704	3/9	AD162	16/- comp. pr.	MJ491	30/–
2N3705	3/5	AF118	16/6	IN4001	4/2
2N3706	3/3	AF124	7/6	IN4005	8/–

RESISTORS

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99 (see note below).	100 up
C	1/20W	5%	82Ω–220KΩ	E12	18	16	15
C	1/8W	5%	4·7Ω–330K	E24	2·5	2	1·75
C	1/4W	10%	4·7Ω10MΩ	E12	2·5	2	1·75
C	1/2W	5%	4·7Ω–10MΩ	E24	3	2·5	2·25
MO	1/2W	2%	10Ω–1MΩ	E24	9	8	7
C	1W	10%	4·7Ω–10MΩ	E12	6	5	4·5
WW	1W	10% ± 1/20Ω	0·22Ω–3·3Ω	E12		15d. all quantities	
WW	3W	5%	12Ω–10KΩ	E12		15d. all quantities	
WW	7W	5%	12Ω–10KΩ	E12		18d. all quantities	

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.

Prices are in pence each for quantities of one ohmic value and power rating. (Ignore fractions of one penny on total resistor order.)

Values:
E12 denotes series: 1, 1·2, 1·5, 1·8, 2·2, 2·7, 3·3, 3·9, 4·7, 5·6, 6·8, 8·2 and their decades.
E24 denotes series: as E12 plus 1·1, 1·3, 1·6, 2, 2 4, 3, 3·6, 4·3, 5·1, 6·2, 7·5, 9·1 and their decades.

NEW PLESSEY INTEGRATED CIRCUIT POWER AMPLIFIER TYPE SL403A. Only 48/6 NET. Operates with 18V power supply. Sensitivity 20mV into 20MΩ, 3 watts into 7·5Ω. Supplied complete with application Data on orders for 2 or more.

PE NOV. 69 STEREO AMPLIFIER KIT less metalwork .. **£11/18/– NET complete**

CARBON SKELETON PRE-SETS
Small high quality, type PR: Linear only: 100Ω, 220Ω, 470Ω, 1KΩ, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1MΩ, 2M2, 5M, 10MΩ vertical or horizontal mounting .. **1/– each**

S-DeCs PUT AN END TO "BIRDS-NESTING". Components just plug in.
Saves valuable time. Use components again and again.
5-DeC .. .. Only **30/6** post free

Compact T-DeC, increased capacity, may be temperature-cycled.
T-DeC .. .. .. only **50/–** post free

WAVECHANGE SWITCHES
1P 12W; 2P 6W; 3P 4W; 4P 3W—long spindles .. .. **4/9 each**

SLIDER SWITCHES
Double pole, double throw .. .. **3/– each**

MULLARD SUB-MIN ELECTROLYTICS C426 RANGE .. .. .. **Price 1/3 each**
Axial leads. Values (μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·5/64; 4/10; 4/40; 5/64; 6·4/6·4; 6·4/25; 8/4; 8/40; 10/2·5; 10/16; 10/64; 12·5/25; 16/40; 20/16; 20/64; 25/6·4; 25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2·5; 50/6·4; 50/25; 50/40; 64/4; 64/10; 80/2·5; 80/16; 80/25; 100/6·4; 125/4; 125/10; 125/16; 160/2·5; 200/6·4; 200/10; 250/4; 320/2·5; 320/6·4; 400/4; 500/2·5.

LARGE CAPACITORS. ALL NEW STOCK
High ripple current types: 2000μF 25V 7/4; 2000μF 50V 11/4; 5000μF 25V 12/6; 5000μF 50V 21/11; 1000μF 100V 16/3; 2000μF 100V 28/9; 5000μF 70V 36/–; 5000μF 100V 58/3; 1000μF 50V 8/2; 2500μF 64V 15/5; 2500μF 70V 19/6.

MEDIUM RANGE ELECTROLYTICS
Axial leads. Values (μF/V): 50/50 2/–; 100/25 2/–; 100/50 2/6; 250/25 2/6; 250/50 3/9; 500/25 3/9; 1000/10 3/–; 500/50 6/–; 1000/25 4/–; 1000/50 6/–; 2000/25 6/–.

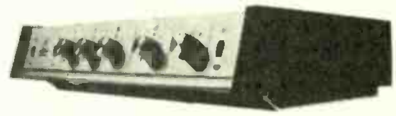
SMALL ELECTROLYTICS
Axial leads: 5/10, 10/10, 25/10, 50/10 **1/– each**
25/25, 47/25, 100/10, 220/10 .. .. **1/3 each**

COMPONENT DISCOUNTS
10% on orders for components for £5 or more.
15% on orders for components for £15 or more.
(No discount on net items)

POSTAGE AND PACKING
Free on orders over £2.
Please add 1/6 if order is under £2.
Overseas orders welcome: carriage charged at cost.

PEAK SOUND AMPLIFIER KITS

The new Englefield Kits



Build it 12+12 or 25+25

Brilliant new styling and available in two forms:

STEREO 15 WATTS PER CHANNEL
Supplied in kit form with complete amplifier and pre-amplifier modules and power supply components. Output per channel into 15Ω —13 watts R.M.S. **Price £38.9.0 Net**
In total kit form £32.13.0 net

STEREO 25 WATTS PER CHANNEL
Supplied in kit form with complete amplifier, pre-amplifier and regulated power supply modules. Output per channel into 15Ω —28 watts R.M.S. **Price £58.15.0 Net**
Specifications on these amplifiers in accordance with the Specifications in Guarantee published in Peak Sound advertisements.

Inputs:
Magnetic, RIAA 3·5mV
Ceramic 35mV
Tape 100mV
Radio 100mV
Signal to noise ratios: Better than 60dB all inputs.

ENGLEFIELD CABINET to house either above assemblies (as illustrated) **£6.0.0. Net**
Other Peak Sound Products as advertised.

COLVERN 3 WATT WIRE-WOUND POTENTIOMETERS: 10Ω, 15Ω, 25Ω, 50Ω, 100Ω, 150Ω, 250Ω, 500Ω, 1KΩ, 1·5KΩ, 2·5KΩ, 5KΩ, 10KΩ, 15KΩ, 25KΩ, 50KΩ.
Price .. .. **only 5/6 each**

CARBON TRACK POTENTIOMETERS
Double wiper ensures minimum noise level. Long plastic spindles.

Single gang linear	220Ω, 470Ω, 1K, etc. to 2·2MΩ	2/6
Single gang log.	4K7, 10K, 22K, etc. to 2·2MΩ	2/6
Dual gang linear	4K7, 10K, 22K, etc. to 1MΩ	8/6
Dual gang log.	4K7, 10K, 22K, etc. to 2M2Ω	8/6
Log/Anti-log.	10K, 47K, 1MΩ only	8/6
Dual anti-log	10K only	8/6
Any type with ½ amp double pole mains switch		extra 2/3

FETS n-channel
Low cost general purpose 2N5163, 25 volt .. only **5/– each**
Audio/r.f. Texas 2N3819 .. .. **8/6 each**
Motorola 2N5459 (MPF105) .. .. **9/9 each**

30 WATT BAILEY AMPLIFIER COMPONENTS:
Transistors for one channel £7/5/6 list, with 10% discount .. .. only **£6/11/–**
Transistors for two channels £14/11/– list, with 15% discount .. .. only **£12/7/5**
Capacitors and resistors for one channel, list £2.
Printed circuit board free with each transistor set.
Complete unregulated power supply kit **£4/17/6** mono or stereo, subject to discount.
Complete regulated power supply kit **£9/5/–** subject to discount.
Further details on application.

MAIN LINE AMPLIFIER KITS AS ADVERTISED. PRICES NET AUTHORISED DEALER

SINCLAIR IC.10 INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMPLIFIER
This remarkable monolithic integrated circuit amplifier and pre-amplifier is now available for despatch from stock. It is the equivalent of 13 transistor/18 resistor circuit plus 3 diodes and the first of its kind ever. It is d.c. coupled and applicable to an unusually wide range of uses all of which are detailed in the manual provided with it. **59/6 NET post free**
Sinclair products as advertised

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Hours: 9-5.30 daily; 1.0 p.m. Saturdays. ***Telephone: Egham 5533 (STD 0784-3)***

SUPER-BARGAIN STOCKTAKING SALE!!

**Use form below for your order. CONDENSERS MUST BE ORDERED BY STOCK NUMBER ONLY.
If any sale item is 'sold-out' when order received we shall substitute items of equal value.**

ELECTROLYTIC CAPACITORS

Stock No.	Capacity	Voltage	Price s.	Price d.	No. Required	£ s. d.
1	1 uf	6		4		
2	4 uf	25		4		
3	4 uf	4		4		
4	6 uf	6		4		
6	64 uf	9		4		
7	20 uf	6		4		
11	8 uf	6		4		
16	32	150		9		
17	64	2.5		3		
18	100/200/200/50	275	7	6		
19	50/80	300	3	0		
21	24	275	1	0		
22	10	25		3		
23	125	2.5		3		
25	16/32	350	2	6		
26	32	275	1	6		
28	75/75/75/75	150	2	6		
30	12.5	40		9		
32	3,000	35	7	6		
33	3,000	15	3	0		
34	3,000	30	7	0		
35	250	70	2	0		
36	2,500	9	2	0		
38	750	12	1	9		
39	100 uf	275	2	6		
40	30 uf	10		3		
42	16 uf	50 REV	2	0		
43	16/16	275	2	0		
44	16	275	1	0		

Stock No.	Capacity	Voltage	Price s.	Price d.	No. Required	£ s. d.
45	350	12		9		
46	20/4	275	1	0		
47	250	50	2	0		
48	500	25	1	6		
49	400	15	1	0		
50	400	2.5		3		
51	64	275	1	9		
52	32/32	350	2	6		
53	8/8/8	275	1	9		
54	500	6		6		
55	64	275	1	3		
56	25	6		3		
57	100	9		6		
58	400	50	2	0		
59	400	30	1	6		
60	500	4		3		
61	150	30	1	6		
62	64/32/8	275	2	6		
64	40	6.4		3		
67	30	6		3		
68	100/100/50	275	5	0		
69	50/50/50	350	4	0		
70	40/40/20	275	2	0		
71	400	6.4		3		
72	320	10		3		
73	32/32 + 25	275 / 25	2	6		

Total:

RESISTORS. EXCELLENT QUALITY. MAINLY 5%. 7/6d. per 100 of any one value. **2/-** per dozen of any one value. Smaller quantities **3d.** each.
Tick the values required:

13 ohms	560 ohms	3.3 k ohm	10 k ohm	39 k ohm	91 k ohm	1.2 meg ohm	8.2 meg ohm
22 ohms	750 ohms	3.6 k ohm	16 k ohm	43 k ohm	130 k ohm	1.5 meg ohm	9.1 meg ohm
36 ohms	1 k ohm	4.3 k ohm	18 k ohm	47 k ohm	360 k ohm	1.8 meg ohm	10 meg ohm
47 ohms	1.5 k ohm	4.7 k ohm	22 k ohm	51 k ohm	430 k ohm	3.6 meg ohm	
91 ohms	1.8 k ohm	5.6 k ohm	24 k ohm	62 k ohm	470 k ohm	5.1 meg ohm	
220 ohms	2.2 k ohm	6.8 k ohm	27 k ohm	75 k ohm	560 k ohm	6.2 meg ohm	
470 ohms	2.4 k ohm	7.5 k ohm	30 k ohm	82 k ohm	620 k ohm	7.5 meg ohm	

or our selection (mixed) **6/6d.** per 100.

Total:

SILVER MICA/CERAMIC/POLYSTYRENE CONDENSERS. 10/- per 100 of any one value. **3/-** per dozen of any one value. Smaller quantities **6d. each.** As available. In following values. Tick those required.

2 pf	5 pf	12 pf	25 pf	50 pf	80 pf	135 pf	180 pf	250 pf	680 pf	1,000 pf	2,500 pf
3.9 pf	6 pf	15 pf	27 pf	58 pf	82 pf	140 pf	190 pf	330 pf	800 pf	1,100 pf	2,700 pf
4 pf	8 pf	18 pf	30 pf	62 pf	100 pf	158 pf	200 pf	450 pf	820 pf	1,500 pf	3,000 pf
4.7 pf	10 pf	22 pf	39 pf	72 pf	125 pf	170 pf	240 pf	600 pf	900 pf	2,200 pf	6,200 pf

Total:

COMPARE THESE PRICES!!

MULLARD POLYESTER CONDENSERS

			No.	Price
1,000 pf	3d. each	400V		
1,500 pf	3d. each			
1,800 pf	3d. each			
2,200 pf	3d. each			
.15 uf	6d. each	160V		
.22 uf	6d. each	160V		
.27 uf	6d. each	160V		
1 uf	1/- each	125V		

Total:

25% discount lots of 100 per type.
50% discount lots of 1,000 per type.

TRANSISTOR BARGAIN! THEY CAN'T GET ANY CHEAPER! ! ! ! !
P.N.P. Audio. Untested, unmarked. MAINLY O.K. .. 10/- per 100
N.P.N. Silicon. R.F. types unmarked ALL USEABLE .. 10/- per 50
POWER OUTPUT (Similar OC35) ALL TESTED .. 4/- each £2 dozen

SILICON PLANAR TRANSISTORS. ALL TESTED. NO LEAKS OR SHORTS. Gain of 20/50 6d. each, 50/100 9d. each, 100/200 **1/-** each.

LIGHT SENSITIVE TRANSISTORS, 2/- each.

LIGHT SENSITIVE DIODES
Can be used to control any transistorised device, **1/-** each. **75/-** per 100. **£25** per 1,000.

THYRISTORS. 400 volt BTY 79 **7/6d.** each. SCR 51 (10 amp) **£1** each.

RECTIFIERS. Latest type. All marked. 800 volt peak, 1 amp mean current type 1N4006. 2/6 each, **24/-** dozen, **£7/10/-** 100. S.T.C. 3/4 (400 volt) 2/6 each, **24/-** dozen, **£7/10/-** 100. BYZ 13 or 19 (6 amp) 2/6 each, **24/-** dozen, **£7/10/-** 100.

BY 127 2/6d. each. **24/-** dozen. **£7/10/-** per 100. **£50** per 1,000.

RECORDING TAPE GIVE-AWAY! ALL BRITISH MADE, BEST QUALITY!
5" Standard .. .. 7/6d.
5¾" Standard .. .. .. 9/- 5¾" Long-play 12/-
7" Standard .. .. .. 12/- 7" Long-play 16/3
3" "Oddends" Minimum 150 2/3d.

MAINS DROPPER TYPE RESISTORS. Hundreds of types from .7 ohm upwards. 1 watt to 50 watts. A large percentage of these are Multi-tapped droppers for radio/television. Owing to the huge variety these can only be offered "assorted". **10/-** per dozen.

GIANT SELENIUM SOLAR CELLS. Last few to clear at half price! Circular, 67 mm. diameter 5/- each. 50 mm. × 37 mm. 3 for 10/-.

SKELETON PRESETS. Mixed. 6/- dozen.

VOLUME CONTROLS. ½ meg. 1 meg. with D.P. switch 5k. (No switch) all **2/-**

RECORD PLAYER AMPLIFIERS. All transistor. Complete with screened input lead, volume control and speaker leads. This excellent unit also has built-in rectifier and smoothing components enabling same to be used direct on 6 to 9 volt A.C. supply. Small number only! Cannot be repeated at this price! **30/-** ea.

TRANSISTOR RADIOS. Fantastic bargain! Tremendous value! Superb quality sound from large speaker! Excellent sensitivity! Complete with earpiece, battery and plastic carrying case, all packed in a colourful presentation box. You would expect to pay £5—but our price due to huge purchase is only **37/6d.!**

CO-AXIAL CABLE. Semi-air spaced. **8d.** yard. 60 yd. rolls **30/-** Postage **4/6d.**

CRYSTAL TAPE-RECORDER MIKES, 12/- each. **CRYSTAL EAR-PIECES WITH PLUG,** 5/- each. Magnetic earpieces. No plug. **1/6d.** each.

THIN CONNECTING WIRE. 10 yds **1/-**, 100 yds 7/6d., 1,000 yds. **50/-**.

RECORD PLAYER CARTRIDGES
ACOS GP67/2 15/- (Mono) GP94/1 **30/-** (Stereo, ceramic)
ACOS GP91/3 20/- (Compatible) ACOS GP93/1 with diamond needle **32/6d.**
ACOS GP93/1 25/- (Stereo) ACOS GP94/1 with diamond needle **37/6d.**

TRANSISTORISED FLUORESCENT LIGHTS. 12 VOLT
8 watt 12" tube, Reflector type 59/6 15 watt 18" tube, Batten type 79/6
Complete with tube. Postage 3/-

TRANSISTORISED SIGNAL INJECTOR KIT **10/-**
TRANSISTORISED SIGNAL TRACER KIT **10/-**
TRANSISTORISED REV. COUNTER KIT (CAR) **10/-**

VERO-BOARD

2½" × 1" × .15	1/3	17" × 3¾" × .15	14/8
3¾" × 2½" × .15	3/3	3¾" × 2½" × .1	4/2
3¾" × 3¾" × .15	3/11	3¾" × 3¾" × .1	4/9
5" × 2½" × .15	3/11	5" × 2½" × .1	4/7
5" × 3¾" × .15	5/6	5" × 3¾" × .1	5/6
17" × 2½" × .15	11/-		

Spot Face Cutter **7/6d.** Pin Insert Tool **9/6d.** Terminal Pins **3/6d.** for 36. Spot Face Cutter and 5 2½" × 1" boards **9/9d.**

**These prices cannot be repeated. Order now. Don't forget to add your name and address!
Please include suitable amount to cover post and packing. Minimum 2/-.**

G. F. MILWARD, DRAYTON BASSETT, near TAMWORTH, STAFFS. Phone: TAMWORTH 2321

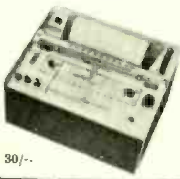
ELECTRONIC BROKERS

MEASURING INSTRUMENTS AND RECORDERS

NEW

6 Pen Event Recorder, 6 in. Chart width. Available in wide range of chart speeds. Rack mounted £79/10/0. Case to suit extra.

NEW AMERICAN 5" CHART RECORDER



Good general purpose potentiometric recorder. Suitable for research and laboratory work. Range 0-10 m.v. Variable zero set, Zenor divide reference. Input inpedance. Max 100 Kohms.
Price **£69.10.0.** P.&P. 30/-.

PORTABLE AC/DC PEN RECORDER

A most versatile pen recorder. Produces a trace on a curvilinear 3½ in. strip chart. Two speeds 1 in. and 6 in./hr. Limiting contacts to give alarm, and limits the current when it exceeds the high and/or low preset values. Range: 0 - 1MA D.C. Meter Resistance 400 ohms; 0 - 1MA A.C. Meter Resistance 1800 at 50 Hz; —10 to + 5 dB into 600 Ω Impedance Source. Chart speed: 1 in. and 6 in./hr. Chart width: 3½ in. curvi-linear. Power supply: 230V 50 Hz driving Synchronous Motor.
Price: **£52.10.0.** Postage and packing £1 5s. 0d.

STRIP-CHART INDICATING RECORDER

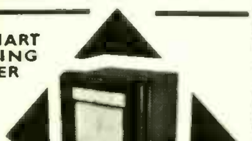


Chart width 9½ in. 10 mV. Sensitivity ± 0.17 of full scale. Source impedance 100 ohms. Speed of operation 33 sec. for full-scale travel. Chart speed ½ in., 3 in., 6 in. per hour. Single point. **£49.10.0.** P. & P. 30/-.

NEW PORTABLE RECORDING AMMETER

Specification. Type: Moving Coil, D.C. **Range:** 0-5 amp. **D.C. Chart Width:** 100 mm. **Scale Length:** 127 mm. **Chart Speeds:** 20, 60, 180, 600, 1800 and 5400 mm/hr. **Dimensions:** 180h × 163 w × 245mm. **Weight:** 5.5kg. List price £65. Our price **£35.**

PEN RECORDER

Portable 1, 2 and 4 channel pen recorders by Kelvin Hughes. General purpose recorders providing clear instantaneous and permanent records of phenomena with comparatively high rates of change. The torsion-strip suspension of the moving-coil renders the instrument immune to the effects of vibration and acceleration.
Six possible chart speeds, chart width 55 mm. length 150 ft., linearity 8 v. at 3 m.A. response D.C. to 100 c/s. Single pen with amplifier **£99**; 2 pen recorder **£85**, 4 pen with amplifier **£149**. Also 5 pen recorder complete with amplifiers, specification as above but housed in cabinet **£225**. P. & P. extra.

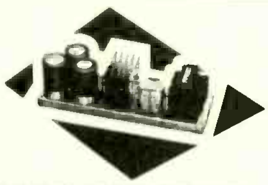
POTENTIOMETRIC 6 POINT STRIP CHART RECORDER BRAND NEW

For use with thermocouplers, pyrometers and other e.m.f. sources. 6 point. Range (—100) —0—(+100) mV; 0—1,600 deg. C. 6½ in. chart width; pen speed 8 secs. Accuracy ±0.5%; 10 chart speeds 20-720mm/hr. Tropicalised. Including tools and spares. Listed at over £200. Our price **£79.10.0.** Also available 0-100mW F.S.D. **£89.10.0.**

POWER SUPPLIES

UNUSED MINIATURE ¼ MILLION MAGNETIC STORAGE DRUM

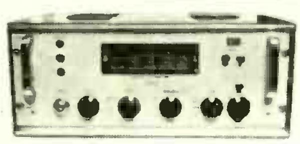
Type N.S. 1389 16 write and 16 read heads 256 tracks magnetic storage drum. Each track at 600 r.p.m. Holds 1024 bits (32 words of 32 bits). Total storage 250,000 bits. Suitable for many data storage problems. 8" high, 10" dia., 21" base. **£290.** carr. extra.



ADVANCE TRANSISTORISED DC POWER UNITS

	Imput Volts	Output Volts	Amps	Price
DC 4	200-245 ± 15%	12	4	£14.10.0
DC 6	230-245 ± 15%	24	5	£17.10.0
DC 8	230-245 ± 15%	48	4	£19.10.0

METERS



DIGITAL VOLTMETERS

DM.2022 digital voltmeter and ratiometer, accurate to 0.0025% offering exceptional linearity.
Reading rate of 50 per second. Outputs: Parallel B.C.D. Scale 39999. Inputs: 25000MΩ CMR 160dB on d.c. Range 10μV to 2KV. This is a rare opportunity to obtain such an instrument at such a low price of **£350.** Carriage free.
DM2006. An all solid state D.V.M. having a wide application. Scale 9999. D.C. accuracy 0.01% f.s.d. with a D.C. range of 10μV to 1KV. Input impedance 10000MΩ. C.M.R. 154dB. Outputs parallel B.C.D. **£245.** Carriage free.
DM2023. This D.V.M. is suitable for data-logging due to the high C.M.R. 175dB. It has six operating modes. Accurate to 0.001% and complete with plug in units to give either manual or automatic ranging from 10μV to 1KV with a 10MΩ input impedance. **£460.** Carriage free.
All the above units have been calibrated.
Digital Voltmeters 2003 A.C./D.C. D.C. range 1mV.-1KV. 4 Digits. **£135.**
2005 4 Digit range 10 microV. μ-2KV. Output BCD or decimal. **£260.**
2006 4 Digit D.C. range 10 microV.-1KV. Isolated output. Parallel BCD. **£285.**

2 in. dia. mounting A.C. voltmeter 0-300 V. A.C. **£1.15.0.** Carriage 6/-.
3½ in. dia. Electrostatic Kilo Voltmeter in wooden case. **£2.15.0.** Carriage 10/-.
Precision A.C. & D.C. Wattmeter. Model S.67 certificated. Accuracy to ½% up to 133 c/s. Range 250/450 V. and 0.5 to 1 A. **£29.10.0.** Carriage 30/-.

INDICATING MEASURING AMPLIFIER PR 7410

Suitable for vibration and frequency analysis. Frequency response 10-1,000 Hz. **£45.** Carr. 40/-.

BRAND NEW S.E. LABORATORIES TRANSDUCER complete with encapsulated

Amplifier/demodulator S.E. 441/2
Frequency D.C.—60 c.p.s.
Available in the following ranges:
SE150, SE50 or SE165A.

0 - 50 p.s.i.	0 - 500 p.s.i.	0 - 3000 p.s.i.
0 - 200 p.s.i.	0 - 750 p.s.i.	0 - 4000 p.s.i.
0 - 350 p.s.i.	0 - 2000 p.s.i	

Also available differential types ± 10 p.s.i.
Also available differential types, ± 10 p.s.i. List price £70+. Our price **£15**

COMPUTER AND PERIPHERAL EQUIPMENT

7 TRACK DIGITAL MAGNETIC TAPE STORAGE DECK

These machines originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay heads encased in one common unit. Low resistance heads. Frequency response approximately 0 Kc/s. to 50 Kc/s. Bit density 557 b.p.i. ½ in., 10½ in. spools 230 V. to 380 V. A.C. Capstan Motor speed 1,500 r.p.m. 48 V. D.C. Rewind motors complete with vacuum Assembly. Finished in brush aluminium and matt-black. Size 27 in. × 26 in. × 8 in. Weight 90 lb. Price **£72.10.0.** Carriage extra.

½" 7 TRACK

Ex-computer record/replay head complete with guides. Little used. Price **£12.10.0** Carriage 15/-.

BRAND NEW

Gresham Lion 1 in. 1 + 7 track record/replay heads. Of the highest professional quality. Cost £100 plus price **£12.10.0.** Carr. 15/-.

9 TRACK 1 in. Record/replay heads with sprocket drive, driven by synchronous motor. Mounted with integrated head assembly eliminating alignment problems. This can be fitted to any suitable type of transport system. Price **£8.10.0.** Carriage 15/-.

MODEL 72 MAGNETIC TAPE DATA STORAGE UNIT

This unit consists of ½ in. 8 channel read-write heads. Can be used to record any 6 bit code. Data can be read in either a forward or backward direction plus giving search facilities. The unit consists circuits for receiving and storing instruction signals. Recording density 250 characters per inch. Tape speed 100 in. per second, price **£190.** Excellent condition.

CANCELLED EXPORT ORDER

90 Column card sorter and punch type 425/0. Price on application.

PROGRAMME BOARDS BY SEALECTRO

These boards are basically a multi pole multi throw switch device consisting of a X-Y Matrix with two contact decks in the Z Plane running at 90 degrees to each other. Contact is made by either, shorting or plugging in pins. Ideal for prototype work, etc. Boards available in 24 × 60 2 plane **£12.10.0.** Pins available 1/3 each.

MEMORY PLANES

Ferrite core memory planes with wired Ferrite cores. Used for building your own computer or as an interesting exhibit in the demonstration of a computer. Mounted on plastic material, frame 5 × 8 in. Consisting of matrices 40 × 25 × 4 cores each one individually addressable and divided into 2 halves with independent sense and inhibit wires. **£8.10.0.** P. & P. 3/-.

MULLARD MATRIX CORE STORE STACKS

A.W. 510 5 planes 8 × 16 cores/per plane **£12/10**
A.W. 511 5 planes 18 × 32 cores/per plane **£25**
A.W. 534 20 planes 64 × 64 cores/per plane **£89/10**
A.W. 597 8 planes 32 × 32 cores/per plane **£55**
Single plane 40 × 25 × 4 **£8/10**
Flexi-writer 7 hole punch and keyboard **£199/10**

MEMORY STORE

M. M. 1044 complete with logic circuits mounted in Imhof cabinet

COMPUTERS Burroughs E 201

225 words store. **£450**
COMPUTER. 802B Hybrid computer with 1K store, in full working order. Complete with paper tape punches, and compatible for Holerith 80-Hole card-periphery. Numerous programmes available including test programmes. Full supporting literature. PRICE ON APPLICATION

DATA DISC HANDLER MK. IV

Self contained magnetic disc memory unit. Designed for integration with small computers and other digital systems. Suitable for Random Access. High density contact, recording, etc.

BRAND NEW COMPUTER TAPES AND EMPTY SPOOLS

Made by well known manufacturers
½ in. certified 2,400 ft. 800 b.p.i. £8.10.0
½ in. 2,400 ft. £6.10.0
½ in. Highest grade 2,400 ft. £3. 0.0
½ in. 10½ in. dia. spool and cassette £1.10.0
½ in. 8½ in. dia. spool and cassette £1.10.0
1 in. metal 10½ in. dia. spool and cassette £2.10.0
½ in. N.A.B. centres 10½ in. spool only £1. 0.0

TAPE PUNCH MODEL 25 7 HOLE

A multiwire tape punch designed for general application involving the conversion of parallel wire electrical impulses into punched papertape at 33 characters per second. Unit completely self-contained requiring only motor power and signal supplies.

7 HOLE NON PARITY TAPE PUNCH

New condition.

LOW SPEED 7 HOLE TAPE PUNCH

60 characters per second by well-known manufacturer.

TELETYPE 8 HOLE PAPER PUNCH MU27

Also available 5 hole punch BRPE2 as above. This model has interchangeable heads. Complete with spooler. Price **£35.**

HIGH SPEED 5/7 HOLE OPTICAL READER

20 characters per second.

CARD READERS

80 column 1500/80 model, punch
80 column 1400/80 model verifier. } **£325** Excellent condition.

HOLLERITH 80 COLUMN CARD PUNCH TYPE HO29 & VERIFIER AVAILABLE

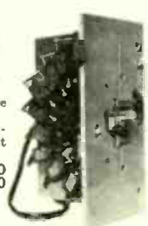
MULTI-RANGE TRANSISTORISED VOLTMETER 1063

Employing silicon planar F.E.T., this instrument gives long-term stability and negligible drift over a wide temperature range. Wide frequency band 0-300 MHz. using HPV 1063. Voltage range 0-30KV. Centre zero on DC ranges for differential circuit application. Input resistance 1 M.ohm/Volt on all DC ranges. Accuracy ± 3% F.S.D. Meter scale 5in. with IM different colour for different scales.
Special price **£42/10/0** each. Carriage £1/10/0.

TRANSFER CASE

For sending data by personal carrier, GPO post, passenger train, etc. Ideal. Suitable for despatching tape **20/-**. P. & P. 5/-.

EICHNER 8 Hole Punch OR READERS



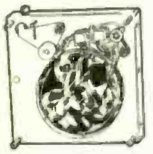
No motor drive required.
Solenoid operated equipment using 48v.
Reader **£29.10**
Punch **£42.10**
Carriage 25/-.

FLEXIWRITERS FPC8

Both Punch and Read Type Available. Any code can be made to suit customers requirements. Price on application.

LOW COST ELECTRONIC AND SCIENTIFIC EQUIPMENT AND COMPONENTS

CONTINUOUS TAPE CASSETTE

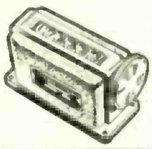


Suitable for sleep-learning, teaching programmes, programming machine tools, telephone answering etc. Complete with replay/record head and separate erase head. ¼" tape twin track. Speed 3¾" per sec. Length of tape 88 feet, but will hold three times this amount. 230V. 50 Hz supply. £3.9.6. p. & p. 10/-.

5 DIGIT COUNTER

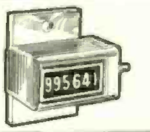
A very sturdy counter. Coil resistance 100 ohms. Minimum operational voltage 5v. Counting speed 13 counts per sec. Suitable for continuous counting with sine wave drive. Coincidence, recording and frequency meter 35/- p. & p. 5/-.

VEEDER ROOT 6 DIGIT COUNTER



Suitable for counting all kinds of production runs, business machine operation. Mechanically driven Type KA1337. Reset manual knob. Ex-equipment but new condition. Special price 25/- plus 5/- p. & p.

MINIATURE SQUARE COUNTER 6 DIGIT

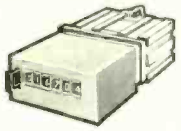


by Veeder Root. Rotary ratchet type, adds 1 count for each 36° movement of shaft 9/6 + 2/6 p. & p.

HI-SPEED QUICK RESET ELECTRO MAGNETIC COUNTERS

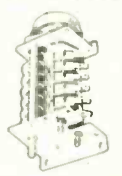
Push button reset 6 digits. 48 v. D.C. 3.5 watts. 20 counts per second. Size 3.875 × 2.625 in. Panel mounting. List £8. Our price 59/6.

6 DIGIT ELECTRICAL IMPULSE COUNTER



With electrical and mechanical reset. Counter driven by a 110v D.C. 4,400 ohms coil. Reset 110v D.C. 800 ohm coil. Housed in plastic-alloy case. The units can be interlocked with each other to give vertical or horizontal displays. Price 79/6 p. & p. 5/-.

REPEAT CYCLE TIMERS



These timers repeat a set cycle of switching operations via a cam and micro switch, for as long as the motor is energised. Single Cam RB 21 in 2 min., 4 min., 5 min., 6 min. cycles @ 45/-. Twin Cam RD 22 in., 4 min., cycles @ 55/-. 4 Cam RD 24 in 4 min., and 5 min. cycles @ 75/-. 6 cam RD 26 in., 3 min., 4 min., 5 min. cycles @ 95/-. 8 cam RD 28 in., 3 min., 4 min. cycles @ 115/-. All + p. & p. 5/-.

UNISELECTOR

8 and 4 Banks, 25 contact per bank, 2 sets of wipers 2 in. radius. Complete with surge capacitor. 25/- and 45/- respectively.

MINIATURE DIGITAL DISPLAY

Operates on a rear projection 6.3 pilot lamp. The lamp projects the corresponding digit on the condensing lens through a projector lens, on to the viewing screen at the front of the unit. 1 in. width. 3 1/16 in. deep. 1 1/16 in. high. Weight 3½ oz. Character size ⅝ in. high, 0.9 with 8 right hand decimal point and degree. Available to special order, words and other characters or colour, at cost of artwork or plates. List price 6 gns. Our price 49/6.

LOW OHM SAFETY METER

12 milli-amps 5 ohms. suitable for testing circuits where currents must be limited £12/10/- p. p. 17/6.

MOTORS

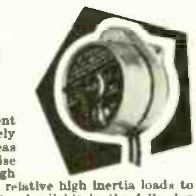
HYSTERESIS REVERSIBLE MOTOR

Incorporating two coils. Each coil when energised will produce opposite rotation of output shaft. 240V 50 Hz. ¼ r.p.m., ½ r.p.m., 1/6 r.p.m., 120V 60 Hz, 1/10 r.p.m., 30/- each. P. & P. 3/-.

HIGH TORQUE INDUCTION MOTOR

3-30 oz/inch. Available in the following speeds only 240V 50 Hz ½ r.p.m., 1 r.p.m., 2 r.p.m. 120 V 50 Hz 20 r.p.m. 30/- each. P. & P. 3/-.

LOW TORQUE HYSTERESIS MOTOR MA23



Ideal for instrument chart drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting torque enable relative high inertia loads to be driven up to 6-oz/in. Available in the following speeds and ranges: 240V 50 Hz 2 r.p.m., 1½ r.p.m., 1 r.p.m., ½ r.p.m., ¼ r.p.m., 1/3 r.p.m., 1/5 r.p.m., 1/6 r.p.m., 1/10 r.p.m., 1/12 r.p.m., 1/20 r.p.m., 1/40 r.p.m., 1/60 r.p.m., 1/75 r.p.m., 1/120 r.p.m., 1/360 r.p.m., 1/720 r.p.m., ⅛, 1/20, 1/45 r.p.m.; 120V 50 Hz 1/6 r.p.m., 1/5 r.p.m., 1/15 r.p.m., 1/16 r.p.m., 1/20 r.p.m., 1/30 r.p.m., 1/60 r.p.m., 1/120 r.p.m., 1/240 r.p.m., 1/300 r.p.m., 1/720 r.p.m., 1440 r.p.h. 25/- each. P. & P. 3/-.

HYSTERESIS CLUTCH MOTOR

with integral clutch allowing the motor to drop out of engagement with the gear train, thereby facilitating easy resetting when used in timers or in conjunction with a light spring. 6 oz. torque at 1 r.p.m. 240 v.. 50 c/s. L=left. R=right. 15 r.p.m. L. 4 r.p.m., ½, ¼ r.p.m. L, 1/5 r.p.m., 1/6 r.p.m., R & L, 1/10 r.p.m., 1/12, 1/15 r.p.m. L. Also 120 v. 50 c/s 2, 1/6, 1/12, 5/12, 4/11, 1/10 r.p.m. 25/-. P. & P. 3/-.

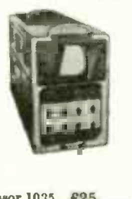
HIGH PRECISION MAINS MOTOR

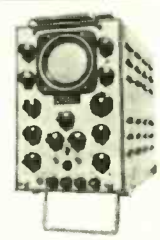
230V 50 Hz 1/8 h.p. continuously rated. 3000 r.p.m. Made by Croydon Engineering Model KA 60 JFB. Suitable for capstan motor. Size 8 in. long. 4½ in. diameter with 6 in. diameter flange and 4 fixing holes. £4.10.0 each. £1.5.0 postage and packing.

SYNCHRONOUS MOTORS

Model 8 71 r.p.h. and 1/60 r.p.h. Self starting complete with gearing shaft ⅛" dia. ½" long. 200/250 V 50 Hz. New Condition Ex. Equipment. 30/- p. & p. 3/.

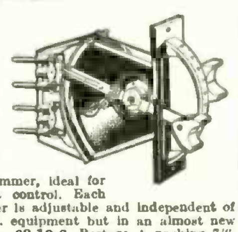
OSCILLOSCOPES





Cossor 1035. £25.
Cossor 1035 Mk. III. £35.
Cossor 1049 Mk. III. £40.
Solartron AD 513.2 L.F. & Servos & CD 5238.2 Long Persistent Tube. £49.10.
Furzehill 0.100. £25.
Airmec 249. £25.
Solartron AD 557 Pulse & Radar Field. £55.
Solartron Portable CD 1014 £80.
Philips 3230. £85.
Mullard L101 Double Beam £96.10.
Airmec 723. £19.10.

DOUBLE FADERS



1000 & 500 dimmer, ideal for light and heat control. Each resistive dimmer is adjustable and independent of each other. Ex. equipment but in an almost new condition. Price £3.19.6. Postage & packing 7/6.

PRECISION POTENTIOMETERS

TEN TURN 3600° ROTATION BRAND NEW

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
5	0.2	Colvern	2506	60/-
100/100/100		Beckman	A	160/-
100	0.5	Beckman	A.8	60/-
200	0.5	Beckman	A	60/-
500	0.1	Beckman	8	70/-
500		Colvern	2501	45/-
500		Foxes	PX4	40/-
500		Colvern	2610	50/-
2K	0.5	Beckman	8A1101	60/-
2K		Beckman	7216	60/-
2K		Reliance	GPM15	40/-
10K	0.5	Beckman	A	60/-
10K	0.1	Beckman X	A	70/-
15K		Foxes	GPM15	50/-
18K		Beckman	A	60/-
20K	0.5	Beckman	A	60/-
30K		Colvern	2402	30/-
30K		Beckman	8A95C	60/-
30K	0.1	Beckman	A.88	70/-
30K	0.5	Beckman	8A 1692	60/-
30K	0.25	Beckman	8A 1692	65/-
50K		Reliance	07.10	45/-
50K			07.5	45/-
50K		Colvern	2503	45/-
50K	X	Foxes	PX4	45/-
50K	0.5	Beckman	A	60/-
50K	0.1	Beckman	A	70/-
100K/100K		Ford	A	100/-
100K	0.1	Beckman	A	70/-
100K	0.5	Beckman	A	60/-
100K		Colvern	2501	45/-
100K		Colvern	2610	50/-
298K	0.1	Beckman	8A3902	70/-
300K	0.1	Beckman	A	70/-

THREE TURN 780° ROTATION

100/100	0.5	Beckman	A	60/-
300		Beckman	9303	45/-
10K	0.5	Beckman	C.88	45/-
20K/20K	0.1	Beckman	C.8	60/-
10K/10K	0.1	Beckman	C	60/-
50K	0.5	Beckman	C.8	35/-

FIFTEEN TURN 5400° ROTATION

25K/25K ... Beckman B ... 10 watts £6.10s
46/K/46K ... Beckman B ... 10 watts £6.10s

TWENTY TURN 7200° ROTATION

250 ohms .. General Controls .. PXM130 ... 80/-
1 Meg ..... General Controls .. PXM130 ... 80/-
50K Reliance ... 40/-

156 TURN 56, 160° ROTATION

460 ohms ..... Kelvin Hughes ..... KTP0701 ... £9.10s.

FIVE TURN 1800° ROTATION

500 ohms .... Colvern ... CLR 2505 ... 40/-
U1.5K ..... Colvern ... CLR 2605 ... 40/-

SINE COSINE

Kelvin & Hughes SCP5 .. 14-4K ... £17.10.0
Colvern 8601 ... 30K ... £17.10.0
CLR 9602—Cam Corrected 25K ... £17.10.0
SCP4 ... 32K ... £17.10.0
SCP1 ... 35K ... £17.10.0

PRECISION BECKMAN 40 TURN 14,400° ROTATION

Wirewound Precision Potentiometer. SE 107A 20 watts at 40°C. 3 3/16" Diameter. Servo Mounting. 200 K. Brand New £12.10s. List Price £30.

GENERATORS

SIGNAL GENERATOR

T.F. 801A Sine Wave, Square Wave Generator. Frequency Range: 10-310 M.c/s. Output Voltage (maximum) 200 milli-volts ± 2db. Output impedance 75 ohms. Mark/Space Ratio 50/50 on square wave. Price £120. Packing and carriage £2.

SIGNAL GENERATOR

T.F. 517F/1 Sine Wave, Square Wave Generator. Frequency Range: 120-300 M. C/s. Auxiliary 18-58 Meg. c/s. Output Voltage 0.2 Volts. Output impedance 75 ohms. £85.

MARCONI T.F. 144G

Frequency Range 85 k.c/s. 25Mc/s. Output voltage 1 micro-volt to 1 volt. Output impedance 1 micro-volt, 100 milli-volt, 10 ohms. 100 milli-volts to 1 volt. 52.5 ohms. £75 + £2 carriage.

PULSE GENERATORS

Model 101 Repetition rate 10 Hz-10MHz. Delay 30 n-10 m. secs. Output 10V. into 50 ohms. £95.

SQUARE WAVE GENERATOR

Frequencies: 1M. 100kc/s 10kc/s 50c/s
Load impedance 75 ohms.
Output Voltage 10V. 75 ohms.
0-18 volts into 2000 ohms.
Rise time from 30-50 Milli micro seconds at 1 meg. Cycle. £65.

MARCONI VALVE VOLTMETER TF 428B/1

Frequency response on probe 10Kc/s/3-100Mc/s. Five separate Voltage Ranges. Overload Protection 100-250 A.C.I.P. Input 1MΩ Acc. ±2 % or 00.2V. Size: 10 × 16¼ × 9in.—15lb. £5/19/6.

VOLSTAT

Advance

CV500/27. Input 95-130v. 60 Hz. Output 85v. R.M.S. Load 4 amps P.S.I. £8/10/0
CV25E. Input 190-260v. 50 Hz. Output 6v. 25 watts £9/10/0
CV50J. Input 190-260v. 50 Hz. Output 230v. 50 watts £12/10/0
Carriage extra 15/-.

RIGHT ANGLED GEAR BOXES

These gear boxes give a drive ratio of 2.5 : 1 at right angles to the input. Driveable through the I/p shaft only. Dimensions 4in. wide × 3½in. deep × 4½in. high. Price 74/-.
With pulley and ball race shaft mountings. Price 99/6. Carriage £1.

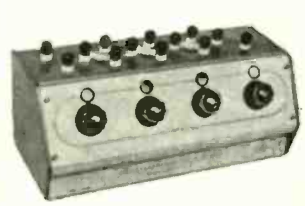
OSCILLATORS

DAWE 444C AUTOMATIC L.F. SWEEP OSCILLATOR (NEW)

Amplitude 0 - 10V. Frequency Range 5Hz-5 KHz ±2% ±0.5 Hz. 18 Sweep Rates of 10 octaves/min. Frequency Response 0.5 dB. £89.10.0. Carriage extra.

BRAND NEW LABORATORY TEST EQUIPMENT AT LESS THAN HALF PRICE

HIGH VALUE RESISTANCE BOX TYPE R.7003



Specification. Range: 0.01–111 Meg. in 0.01 Megohm divisions. Accuracy: 0.05%. Maximum power rating: 0.1W per step. Case: Hammer finished stove enamel.
List price £60. Our price £22/10/-.

PORTABLE WHEATSTONE BRIDGE

Specification. Type: Moving Coil Galvanometer. Ranges: 1. 0.05 to 5 ohms. 2. 0.5 to 50 ohms. 3. 5 to 500 ohms. 4. 50 to 5,000 ohms. 5. 500 to 50,000 ohms. Scales: Switched. Slidewire: 0.5 to 50. Galvanometer Scale: 10-0-10. Case: Moulded plastic. Internal Source: 4V. Dry battery. Dimensions: 200 × 110 × 65mm. Weight: 0.9 kg.
List price £25. Our price £9/19/6.

MUTUAL INDUCTANCE BOX TYPE R.7005

Specification Range: 0 - 11.100 mH in 0.002 mH divisions. Accuracy: $\pm(0.3 \times \frac{0.012}{M})\%$ where M = value of mutual inductance in mH set on the box. Frequency range: 0 - 2.5 K/cs for all decades except X1 = 0 - 15 K/cs. Maximum current: 0.5A for decades 1A for variometer (both primary and secondary dingings). Case: Polished teak. List price £65. Our price £26.10.

MUTUAL INDUCTANCE COIL TYPE R.7006

Specification. Value: 0.001 H. Accuracy: ±0.3%. Operating Frequency: 5 Kc/s, 10 Kc/s. Maximum current: 1A, 3A. Resistance of coils: 4 ohm, 1 ohm. Case: Moulded plastic. List price 8 gns. Our price 50/-

ALL ORDERS ACCEPTED SUBJECT TO OUR TRADING CONDITIONS A COPY OF WHICH MAY BE INSPECTED AT OUR PREMISES DURING TRADING HOURS OR WILL BE SENT ON APPLICATION THROUGH THE POST.

CARRIAGE EXTRA

ELECTRONIC BROKERS LTD., 49-53 PANCRAS ROAD, LONDON, N.W.1. Tel: 01-837 7781/2 Cables: SELELECTRO

CURRENT RANGE OF BRAND NEW L.T. TRANSFORMERS. FULLY SHROUDED (*excepted) **TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220/240v**

No.	Sec. Taps	Amps	Price	Carr.
1A	25–33–40–50	15	£10 10 0	12/6
1B	25–33–40–50	10	£7 12 6	9/6
1C	25–33–40–50	6	£6 15 0	9/6
1D	25–33–40–50	3	£4 0 0	7/6
2A	4–16–24–32	12	£7 2 6	8/6
2B	4–16–24–32	8	£5 7 6	8/6
2C	4–16–24–32	4	£3 12 6	7/6
2D	4–16–24–32	2	£2 7 6	5/–
3A*	25–30–35	40	£16 10 0	12/6
3B*	25–30–35	20	£10 5 0	10/6
3C	25–30–35	10	£7 5 0	8/6
3D	25–30–35	5	£4 2 6	7/6
3E	25–30–35	2	£3 2 6	7/6
4A*	12–20–24	30	£13 0 0	12/6
4B	12–20–24	20	£8 5 0	9/6
4C	12–20–24	10	£4 5 0	8/6
4D	12–20–24	5	£3 12 6	7/6
5A	3–12–18	30	£9 12 6	9/6
5B	3–12–18	20	£7 2 6	8/6
5C	3–12–18	10	£4 5 0	7/6
5D	3–12–18	5	£2 17 6	7/6
6A	48–56–60	2	£3 12 6	6/6
6B	48–56–60	1	£2 12 6	6/6
7A*	6–12	50	£10 7 6	10/6
7B	6–12	20	£6 2 6	8/6
7C	6–12	10	£3 17 6	7/6
7D	6–12	5	£2 15 0	6/6
8A	12–24	1	£1 12 6	6/6
9A	17–32	8	£6 5 0	8/6
10A*	9–15	2	£1 9 6	6/6
11A	6·3	15	£2 10 0	7/6
12A	30–25–0–25–30	2	£3 12 6	6/6

Note: By using the intermediate taps many other voltages can be obtained.

Example: No. 1 .. 7–8–10–15–17–25–33–40–50v.
No. 2 .. 4–8–12–16–20–24–32v.
No. 5 .. 3–6–9–12–15–18v.

AUTO TRANSFORMERS

240v.-110v. or 100v. Completely Shrouded fitted with Two-pin American Sockets or terminal blocks. Please state which type required.

Type	Watts	Approx. Weight	Price	Carr.
1	80	2½ lb	£1 19 6	5/6
2	150	4 lb	£2 12 6	6/6
3	300	6¾ lb	£3 12 6	6/6
4	500	8½ lb	£5 2 6	8/6
5	1000	15 lb	£7 2 6	9/6
6*	1500	25 lb	£9 15 0	10/6
7*	1750	28 lb	£14 15 0	12/6
8*	2250	30 lb	£17 17 6	15/–

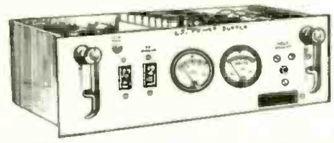
* Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

Samson's
(ELECTRONICS) LTD.

9 & 10 CHAPEL ST., LONDON, N.W.1

01-723-7851 01-262-5125

AMERICAN HIGHLY STABILISED POWER SUPPLY UNIT



Regulation between 7-15 volts D.C. at 20 amps. Fitted 0-30 D.C. ammeter, 0-15 D.C. voltmeter and overload protection switch. Built to a very high specification. Bench or rack mounting. Size 19 × 8 × 17 ins. A.C. input 110v. 50 cycles. Ex equipment but guaranteed in perfect condition. Maker's price in excess of £200. Our price **£29.10.0.** Carr. 30/-. 240/110 volt, 400 watts, Mains Transformer available if required. **£3** extra

ISOLATION TRANSFORMERS

Built into metal case, size 8×7×7ins., with on/off switch, neon indicator. 13A 3-pin socket outlet. Pri. 220–240v. Sec. 220–240v. 1000 watts **£16.10.0.** Carr. 15/–. 750 watts **£14.10.0.** Carr. 12/6.

OPEN-FRAME TYPE TERMINAL BLOCK CONNECTIONS

Pri 240v. Sec tapped 110, 240v. 2½kva. cont. rating. Size 9 × 8 × 8 ins. Weight 65 lbs. **£29.10.0** ex warehouse.

HEAVY DUTY AUTO TRANSFORMERS

240-110v., 5 kva. open-frame type terminal block connections. Size 9 × 8 × 8 ins. Weight 65 lbs. **£29.10.0** ex warehouse.

DUBILIER DUCONOL 40 MFD CAPACITORS

275v. wkg. A.C., **45/-**, P. & P. 8/6.

STC 7.19 mfd., 440v., 3PH. delta connection, 1.6 amps line current. **59/-**, P. & P. 8/6.

RADIO SPARES—H.T. TRANSFORMERS

Pri. 200–250v. Sec. 350–0–350v. 150M/A. 6·3v., 3A CT. 6·3v. 2·5A CT. 5v. 3·5A. Half shrouded. Flying leads. 59/6. Carr. 8/6.

PARMEKO POTTED TRANSFORMERS

Sec. 6·3v. Sec. 2–0–2v. 4A 5kv. Wkg. "C" core potted type. 17/6. P. & P. 3/6.

PARMEKO CHOKES—NEPTONE SERIES

10H. 180M/A., **25/-**, P. & P. 5/-. 10H. 120M/A., **12/6**, P. & P. 4/-. 10H. 75M/A., 15H. 75M/A., 15H. 50M/A., 5H 120M/A., 5H 60M/A., 50H. 25M/A., all types, **8/6** each, P. & P. 3/6. 0.7H. 450M/A., **12/6**, P. & P. 4/6. 1H. 300M/A., **10/6**, P. & P. 4/6. 5H 150M/A., **17/6**.

JUPITER SERIES SWINGING CHOKE

34H. 60M/A.-70H. 35M/A., 2.8kv., D.C. Wkg., **25/-** P. & P. 6/-.

PARTRIDGE TOTALLY ENCLOSED CHOKES

5H. 250M/A., 19/6, P. & P. 6/-. **GRESHAM SEALED OIL-FILLED CHOKES**: 12H. 200M/A., **29/6**, P. & P. 7/6. **HADDONS**: 12H. 60M/A., **10/6**, P. & P. 5/-. **L.T. SMOOTHING CHOKE**: 16M/H. 8 amps., 35/- P. & P. 5/-. **GRESHAM SWINGING CHOKE**: 20H. 100M/A. 10H. 450M/A. 49/6 P. & P. 7/6.

PARMEKO L.T. TRANSFORMERS

Neptune Series. Pri 230v. Sec tapped 1.8v., 2 amps, 3.6v. 3 amps, 4.1v. 3.2 amps, 4.9v. 3.6 amps., **17/6**, P. & P. 3/6.

GARDNERS H.T. TRANSFORMERS

C core Pri 200-240v. Sec 300-0-300v. 60M/A., 6.3v. 4 amps. Size 3½ × 3 × 3 ins. **17/6**, P. & P. 4/6.

DANFOSS PRESSOSTATS TYPE RT1

Range 25 ins., HG 40 p.s.i. Differential 8-42 p.s.i. Connection for ½ in. copper tubing. **37/6**, P. & P. 5/-.

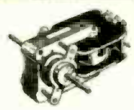
ZENITH DOUBLE-WOUND VARIABLE TRANSFORMERS

Input 240v., output 0-80v., 15 amps or 0-40v. 30 amps. Open-type slider control. Size: length 2 ft. 8 ins. × 8 ins. × 7 ins. **£27.10.0**, ex warehouse.

NEWMARK SYNCHRONOUS MOTORS

220-240v. 50 cycles, 3 watts 8 r.p.m. Overall size 2 × 2 × 2 ins. **10/6** P. & P. 1/6.

A.C. 220-240v. SHADED POLE MOTORS



1,500 r.p.m. Double spindle. Length 0.9 ins. and 0.6 ins. Overall size 3 × 3½ × 2 ins. New and Boxed. **12/6**. P. & P. 3/6.

LATEST RELEASE OF

RCA COMMUNICATION RECEIVERS AR88

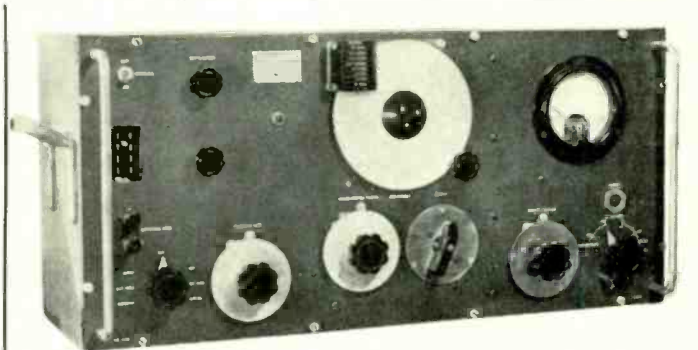
BRAND NEW and in original cases—A.C. mains input. 110V or 250V. Freq. in 6 bands 535 Kc/s-32 Mc/s. Output impedance 2.5-600 ohms. Complete with crystal filter, noise limiter, B.F.O., H.F. tone control, R.F. & A.F. variable controls. Price **£87/10/-** each, carr. £2.

Same model as above in secondhand cond. (guaranteed working order), from **£45** to **£60**, carr. £2.

***SET OF VALVES:** new, £3/10/- a set, post 7/6; **SPEAKERS:** new, £3 each, post 10/-. ***HEADPHONES:** new, **£1/5/-** a pair, 600 ohms impedance. Post 5/-.

AR88 SPARES. Antenna Coils L5 and 6 and L7 and 8. Oscillator coil L55. Price **10/-** each, post 2/6. RF Coils 13 & 14; 17 & 18; 23 & 24; and 27 and 28. Price **12/6** each. 2/6 post. By-pass Capacitor K.98034-1, 3×0.05 mfd. and M.980344, 3×0.01 mfd., 3 for **10/-**, post 2/6. Trimmers 95534-502, 2-20 p.f. Box of 3, **10/-**, post 2/6. Block Condenser, 3×4 mfd., 600 v., £2 each, 4/- post. Output transformers 901666-501 **27/6** each, 4/- post.

* *Available with Receiver only.*



MARCONI SIGNAL GENERATORS

TYPE TF-144G

Freq. 85Kc/s-25Mc/s in 8 ranges. Incremental: +/— 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV-1 volt-52.5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements: 19¾ × 12¼ × 10 in. The above come complete with Mains Leads, Dummy Aerial with screened lead, and plugs. As New, in Manufacturer's cases, £40 each. Carr. 30/-. DISCOUNT OF 10% FOR SCHOOLS, TECHNICAL COLLEGES, etc.

S.A.E. for all enquiries. If wishing to call at Stores, please telephone for appointment.

W. MILLS

3-B TRULOCK ROAD, TOTTENHAM, N.17

Phone: Tottenham 9213

HRO RECEIVER. Model 5T. This is a famous American High Frequency superhet, suitable for CW, and MCW, reception crystal filter, with phasing control. AVC and signal strength meter. Complete HRO 5T SET (Receiver, Set of 5 Coils & Power Unit) for **£27/10/-**, carr. 30/-.

COMMAND RECEIVERS; Model 6-9 Mc/s., as new, price £5/10/- each, post 5/-.

COMMAND TRANSMITTERS, BC-458: 5.3-7 Mc/s., approx. 25W output, directly calibrated. Valves 2 × 1625 PA; 1 × 1626 osc.; 1 × 1629 Tuning Indicator; Crystal 6,200 Kc/s. New condition—£3/10/- each, 10/- post.
(Conversion as per "Surplus Radio Conversion Manual, Vol. No. 2," by R. C. Evenson and O. R. Beach.)

AIRCRAFT RECEIVER ARR. 2: Valve line-up 7 × 9001; 3 × 6AK5; and 1 × 12A6. Switch tuned 234-258 Mc/s. Rec. only £3 each, 7/6 post; or Rec. with 24 v. power unit and mounting tray **£3/10/-** each, 10/- post.

RECEIVERS: Type BC-348, operates from 24 v D.C., freq. range 200-500 Kc/s, 1.5-18 Mc/s. (New) **£35.0.0** each; (second hand) **£20.0.0** each, good condition, carr. 15/- both types.

MARCONI RECEIVER 1475 type 88: 1.5-20 Mc/s, second-hand condition **£10.0.0** each. New condition **£25.0.0** each, carr. 15/-.

RACAL EQUIPMENT: Frequency Meter type SA20: **£35** each, carr. £1. Frequency Counter type SA21: **£65** each, carr. 30/-. Converter Frequency Electronic VHF Type S.A.80 (for use with the SA.20): 25 Mc/s-160 Mc/s, **£40** each, carr. £1.

ROTARY CONVERTERS: Type 8a, 24 v D.C., 115 v A.C. @ 1.8 amps, 400 c/s 3 phase, **£6/10/-** each, 8/- post. 24 v D.C. input, 175 v D.C. @ 40mA output, **25/-** each, post 2/-.

CONDENSERS: 150 mfd, 300 v A.C., **£7/10/-** each, carr. 15/-. 40 mfd, 440 v A.C. wkg., **£5** each, 10/- post. 30 mfd, 600 v wkg. D.C., **£3/10/-** each, post 10/-. 15 mfd, 330 v A.C. wkg., **15/-** each, post 5/-. 10 mfd, 1000 v, **12/6** each, post 2/6. 10 mfd, 600 v, **8/6** each, post 5/-. 8 mfd, 1200 v, **12/6** each, post 3/-. 8 mfd, 600 v, **8/6** each, post 2/6. 4 mfd, 3000 v wkg., **£3** each, post 7/6. 2 mfd, 3000 v wkg., **£2** each, post 7/6. 0.25 mfd, 2Kv, **4/-** each, 1/6 post. 0.01 mfd. MICA 2.5 Kv. Price **£1** for 5. Post 2/6. Capacitor: 0.125 mfd, 27,000v wkg. **£3.15.0** each, 10/- post.

OSCILLOSCOPE Type 13A, 100/250 v. A.C. Time base 2 c/s.-750 Kc/s. Bandwidth up to 5 Mc/s. Calibration markers 100 Kc/s. and 1 Mc/s. Double Beam tube. Reliable general purpose scope, £22/10/- each, 30/- carr.
COSSOR 1035 OSCILLOSCOPE, £30 each, 30/- carr.
COSSOR 1049 Mk. 111, £45 each, 30/- carr.

RELAYS: GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., **£2** each, 6/- post.
12 Small American Relays, mixed types £2, post 4/-.

Many types of American Relays available, i.e., Sigma; Allied Controls; Leach; etc. Prices and further details on request 6d.

GEARED MOTORS: 24 v. D.C., current 150 mA, output 1 r.p.m., **30/-** each, 4/- post. Assembly unit with Letcherbar Tuning Mechanism and potentiometer, 3 r.p.m., **£2** each, 5/- post.

SYNCHROS: and other special purpose motors available. British and American ex stock. List available 6d.

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price 25/-, post 5/-.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, **£2/10/-** each post 6/-.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps., **£2/10/-** each, carr. 12/6.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 2.6 ohms at 4 amps. Price (either type) **£2** each, 4/6 post each.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, £4/10/- each, 15/- carr.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 × 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19"Wx11"Hx14"D. (All connections at the rear). Excellent condition **£6.10.0.** each, Carr. £1.

AUTO TRANSFORMER: 230-115V, 50-60c/s, 1000 watts, mounted in a strong steel case 5" × 6½" × 7". Bitumin impregnated. **£5** each, Carr. 12/6. 230-115V, 50-60c/s, 500 watts. 7" × 5" × 5". Mounted in steel ventilated case. **£3** each, Carr. 10/-.

POWER UNIT: 110 v. or 230 v. input switched; 28 v. @ 45 amps. D.C. output. Wt. approx. 100 lbs., **£17/10/-** each, 30/- carr. SMOOTHING UNITS suitable for above **£7/10/-** each, 15/- carr.

DE-ICER CONTROLLER MK. III: 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 v., 12 r.p.m.; geared to two 30-way stud switches and two Ledex solenoids, 1 delay relay etc., sealed in steel case (4 × 5 × 7 ins.) **£3** each, post 7/6.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7/10/-** each, 15/- carr.

NIFE BATTERIES: 4 v. 160 amps, new, in cases, **£20** each, £1 10/- carr.

FUEL INDICATOR Type 113R: 24 v. complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in a 3in. diameter case. Price 30/- each, postage 5/-.

FREQUENCY METERS: BC-221, meter only £30 each, BC-221 complete with stabilised power supply **£35** each, carr. 15/-. LM13, 125-20,000 Kc/s., **£25** each, carr. 15/-. TS.175/U, **£75** each, carr. £1. FR-67/U: This instrument is direct reading and the results are presented directly in digital form. Counting rate: 20-100,000 events per sec. Time Base Crystal Freq.: 100 Kc/s. per sec. Power supply: 115 v., 50/60 c/s., **£100** each, carr. £1.

CT.49 ABSORPTION AUDIO FREQUENCY METER: freq. range 450 c/s-22 Kc/s., directly calibrated. Power supply 1.5 v.-22 v. D.C. £12/10/- each, carr. 15/-.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3/10/-** each, post 7/6.

APNI ALTIMETER TRANS./REC., suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. 3 relays, 11 valves, price **£3** each, carr. 10/-.

TEST EQUIPMENT

MARCONI	TF–1274	VHF Bridge Oscillator	**£75** each
	TF–1275	VHF Bridge Detector	**£75** each
	TF–1067/1	Heterodyne Frequency Meter	**£85** each
	TF–899	Valve Millivoltmeter	**£35** each
	TF–978	VHF Admittance Bridge	**£85** each
	TF–894A	Audio Tester	**£55** each
	TF–329G	Circuit Magnification Meter	**£45** each
	TF–428/2	Valve Voltmeter	**£12/10/-** each
	TF–428/1	Valve Voltmeter	**£8/10/-** each
	TF–726C	UHF Signal Generator	**£65** each
	TF–934	Deviation Test Meter	**£35** each
	6075A	Deviation Test Meter	**£65** each
	TF–987/1	Noise Generator	**£20** each
	TF–956	(CT.44) A.F. Absorption Wattmeter	**£20** each
FIRZ HILL	V.200	Sensitive Valve Voltmeter	**£35** each
	B.810	Incremental Inductance Bridge	**£75** each
SOLATRON	CD–513	Oscilloscope	**£45** each
	CD–513–2	Oscilloscope	**£47/10/-** each
	AW–553	Power Amplifier	**£30** each
AIRMEC	Type 701 Signal Generator		**£50** each
PHILLIPS	Type GM–6008 Valve Voltmeter		**£35** each
DAWE	Type 402C Megohm Meter		**£12** each

CANADIAN C52 TRANS/REC.: Freq. 1.75-16 Mc/s on 3 bands. R.T., M.C.W. and C.W. Crystal calibrator etc., power input 12V. D.C., new cond., complete set £50. Carr. £2/10/-. Power Unit for Rec., new **£3/5/-**. Carr. 10/-.

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each 0.9 ohms. Tolerance ±1% **£3** each, 5/- post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ±1% **£3/10/-** each, 5/- post.

TELESCOPIC ANTENNA: In 4 sections, adjustable to any height up to 20 ft. Closed measures 6 ft. Diameter 2 in. tapering to 1 in. **£5** each + 10/- carr. Or **£9** for two + £1 carr. (brand new condition).

COAXIAL TEST EQUIPMENT: COAXWITCH—Mnftrs. Bird Electronic Corp. Model 72RS; two-circuit reversing switch, 75 ohms, type "N" female connectors fitted to receive UG-21/U series plugs. New in ctns., **£6/10/-** each, post 7/6. CO-AXIAL SWITCH—Mnftrs. Transco Products Inc., Type M1460-22, 2 pole, 2 throw. (New) **£6/10/-** each, 4/6 post. 1 pole, 4 throw, Type M1460-4. (New) **£6/10/-** each, 4/6 post.

PRD Electronic Inc. Equipment: FREQUENCY METER: Type 587-A, 0.250-1.0 KMC/SEC. (New) **£75** each, post 12/6. FIXED ATTENUATOR: Type 130c, 2.0-10.0 KMC/SEC. (New) **£5** each, post 4/-. FIXED ATTENUATOR: Type 1157S-1, (new) £6 each, post 5/-.

FOR EXPORT ONLY
BRITISH & AMERICAN COMMUNICATION EQUIPMENT

Type B.44 Tx/Rx, Crystal controlled, 60-95 Mc/s, 12V. d.c. operation. W.S. Type 88, Crystal controlled, 40-48 Mc/s. W.S. Type HF-156, Mk. II, Crystal controlled, 2.5-7.5 Mc/s. W.S. Type 62, tunable, 1.5-12 Mc/s. C.44, Mk. II, Radio Telephone, Single Channel, 70-85 Mc/s, 50 watts, output, 230V. a.c. Input. G.E.C. Progress Line Tx Type DO36, 144-174 Mc/s, 50 watt, narrow band width. A.C. input 115V. BC-640 Tx, 100-156 Mc/s, 50 watt output, 110V or 230V input. STC Tx/Rx Type 9X, TR1985; RT1986; TR1987 and TR1998, 100-156 Mc/s. TRC-1 Tx/Rx, Types T.14 and R.19, FM 60-90 Mc/s. With associated equipment available. Redifon GR410 Tx/Rx, SSB, 1.5-20 Mc/s. Sun-Air Tx/Rx Type T-10-R. Collins Tx/Rx/Type 18S4A. Collins Tx/Rx Type ARC-27, 200-400 Mc/s, 28V d.c. With associated equipment available. ARC-5; ARC-3; and ARC-2 Tx/Rx. BC-375; 433G; 348; 718; 458; 455 Tx/Rx. Directional Finding Equipment CRD.6 and FRD.2 complete Sets available and spares. Telephone Installation type XY, (U.S.A.), 600 Line Automatic Telephone Exchange. Complete system with full set of Manuals. Mobile Communications Installation mounted in a trailer with 4 × pneumatic tyres. Consisting of 3xARC-27 Tx/Rx with all associated equipment (as new).

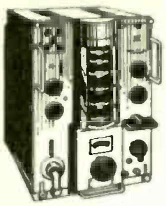
ALL GOODS OFFERED WHILST STOCKS LAST IN "AS IS" CONDITION UNLESS OTHERWISE STATED

CALLERS BY TELEPHONE APPOINTMENT ONLY

W. MILLS

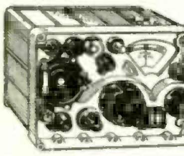
3-B TRULOCK ROAD, TOTTENHAM, N.17
Phone: Tottenham 9213

ADMIRALTY B.40 RECEIVERS



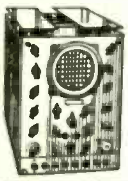
High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s-30 Mc/s. I.F. 500/Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½ × 13½ × 16in. Weight 114lb. Offered in good working condition. £22/10/0. carr. 30/-. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. £17/10/-. Carr. 30/-.

R209 Mk. II COMMUNICATION RECEIVER



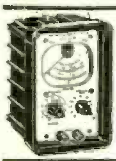
11 valve high grade communication receiver suitable for tropical use. 1-20 Mc/s. on 4 bands. AM/CW/FM operation. Incorporates precision vernier drive, B.F.O. Aerial trimmer. Internal speaker and 12v. D.C. internal power supply. Supplied in excellent condition. fully tested and checked. **£15.0.0** Carr. 20/-.

TYPE 13A DOUBLE BEAM OSCILLOSCOPES BARGAIN



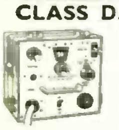
An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kc/s. Bandwidth 5.5 Mc/s Sensitivity 33 Mv/cm. Operating voltage 0/110/200/250 v. A.C. Supplied in excellent working condition, £22/10/-. Or complete with all accessories, probe, leads, lid, etc. £25. Carriage 30/-.

MARCONI CT44 TF956 AF ABSORPTION WATTMETER



1 µ/watt to 6 watts. £20. Carr. 20/-.

CLASS D. WAVEMETERS



A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition £5-19-6 Carr. 7/6. Or brand new with accessories £7.19.6 Carr. 7/6.

CLASS D WAVEMETERS No. 2

Crystal controlled. 1.2-19 Mc/s. Mains or 12v. D.C. operation. Complete with calibration charts. Excellent condition £12/10/0. Carr. 30/-.

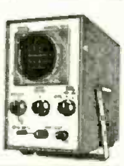
LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

0-20 Kc/s. Output 5K or 500 ohms. 200/250 v. A.C. Offered in excellent condition, £12/10/-. Carriage 10/-.

RACAL MA.168 TRANSISTORISED DIVERSITY SWITCH

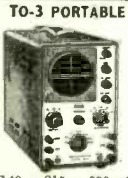
Brand new condition £15. Carriage 10/-.

TO-2 PORTABLE OSCILLOSCOPE



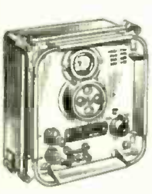
A general purpose low cost economy oscilloscope for every-day use. Y amp. Bandwidth 2 CPS—1 MHZ. Input imp. 2 meg Ω. 25 PF. illuminated scale. 2" tube. 115 × 180 × 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. £22/10/-. Carr. 10/-.

TO-3 PORTABLE OSCILLOSCOPE. 3" TUBE



Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps—1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook. £37·10.0 Carr. 10/-.

CRYSTAL CALIBRATORS NO. 10



Small portable crystal controlled wavemeter. Size 7in. × 7½in. × 4in. Frequency range 500 Kc/s—10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. 89/6. Carr. 7/6.

FIELD TELEPHONES TYPE L. Generator ringing, metal cases. Operate on 2 1.5 v. batteries (not supplied.) Excellent condition. £4.10.0 per pair. Carr. 10/-.

WS62 TRANCEIVERS

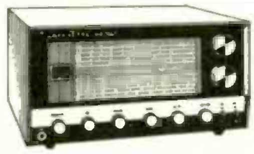
Large quantity available for EXPORT! Excellent condition. Enquiries invited.

UNR-30 4 BAND COMMUNICATION RECEIVER

Covering 550 Kc/s-30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/240 v. A.C. Supplied brand new, guaranteed with instructions. 13gns. Carr. 7/6.

EDDYSTONE V.H.F. RECEIVERS

770R. 19-165 Mc/s. £150.
Both types in excellent condition.

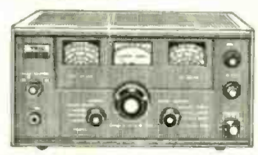


LAFAYETTE SOLID STATE HA600 RECEIVER

5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE. 150 kc/s-400 Kc/s AND 550 Kc/s-30 Mc/s. F.E.T. front end ● 2 mechanical filters ● Huge dial ● Product detector ● Variable BFO ● Noiselimiter ● S Meter ● 24½in. Bandspread ● 230 v. A.C./12 v. D.C. neg earth operation ● RF gain control. Size 15in. × 9½in. × 8½in. Wt. 18 lbs. EXCEPTIONAL VALUE £45. CARR. 10/-. S.A.E. FOR FULL DETAILS.

TRIO COMMUNICATION RECEIVER MODEL 9R-59DE

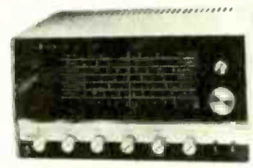
4 band receiver covering 500 Kc/s to 30 Mc/s, continuous and electrical bandspread on 10-15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter. ● Sep. Bandspread dial ● IF 455 Kc/s ● audio output 1.5 w. ● Variable RF and AF gains controls. 115/250 v. A.C. mains. Beautifully designed. Size 7 × 15 × 10in. With instruction manual and service data. £42. Carriage paid Trio Communication Type Headphones. Normally £5.19.6. Our price £3.15.0 if purchased with above receiver.



TRIO TS 510 Amateur Transceiver with speaker and mains P.S.U.	£212 0
TRIO JR 500SE 10-80 Metre Amateur Receiver	£69 10

LAFAYETTE HA.800 SOLID STATE AMATEUR COMMUNICATION RECEIVER SIX BANDS 3.5-4, 7-7.3, 14-14.35, 21-45, 28-29.7, 50-54 Mc/s.

Dual conversion on all bands. 2 × 455 Kc/s mechanical filters. Product detector. Variable B.F.O 100 Kc/s crystal calibrator. 'S' meter. Huge slide rule dial. Operation 230v AC or 12v DC. Size 15" × 9½" × 8½". Complete with instruction manual. £57·10.0. Carr. Paid. (100 Kc/s Crystal 39/6 extra.)



TRIO JR-310 NEW AMATEUR BAND 10-80 METER RECEIVER IN STOCK £77.10.0

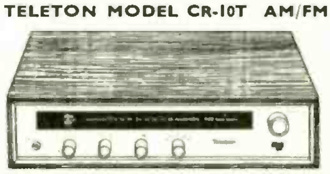
RCA COMMUNICATIONS RECEIVERS AR88D

Latest release by ministry BRAND NEW in original cases. 110-250v. A.C. operation. Frequency in 6 Bands. 535 Kc/s—32 Mc/s continuous. Output impedance 2.5-600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price £87.10.0. Carr. £2.

LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER

A completely new transistorised receiver covering 152-174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built-in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75 Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. £37/10/-. Carr. 10/-.

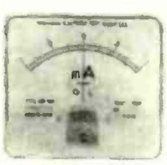
TELETON MODEL CR-10T AM/FM STEREO TUNER AMPLIFIER



A new model from Teleton. 31 solid state devices. 4+4 watt output. Inputs for ceramic/crystal cartridge. Frequency range AM 540-1600 KHz, FM 88-108 MHz. Automatic FM Stereo reception. Stereo Indicator. Controls: Tuning, function selector, Tone and R & L volume controls. AFC switch. Stereo headphone socket. Size 13¾in. × 3¾in. × 9¾in. approx. Price £34/0/0. Carr. 7/6.

SEW PANEL METERS

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



50µA	40/-	50mA	27/6	100V. D.C.	27/6
50-0-50µA	37/6	100mA	27/6	150V. D.C.	27/6
100µA	37/6	150mA	27/6	300V. D.C.	27/6
100-0-100µA	35/-	200mA	27/6	500V. D.C.	27/6
200µA	35/-	300mA	27/6	750V. D.C.	27/6
500µA	30/-	500mA	27/6	15V. A.C.	27/6
500-0-500µA	27/6	750mA	27/6	50V. A.C.	27/6
1mA	27/6	1 amp	27/6	150V. A.C.	27/6
1-0-1mA	27/6	2 amp	27/6	300V. A.C.	27/6
2mA	27/6	5 amp	27/6	500V. A.C.	27/6
5mA	27/6	3V. D.C.	27/6	S meter 1mA	32/-
10mA	27/6	10V. D.C.	27/6	VU meter	42/-
20mA	27/6	20V. D.C.	27/6		

FULL RANGE OF OTHER SIZES IN STOCK—SEND SAE FOR LEAFLET

LAFAYETTE STEREO AMPLIFIER MODEL STEREO 10

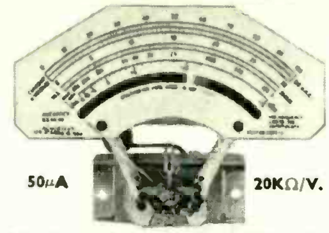
Completely transistorised 5 watts per channel I.H.F. music power. Inputs for gram and tuner. Separate volume controls and variable tone control for Bass and Treble. A compact size, big performance stereo amplifier ideal for limited space systems. Beautifully finished in grey and aluminium. Size 7½in. × 2 15/16 in. × 5¾in. AC. 220/240v.

Price **£11.19.6** Carr. 7/6.

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ¼in. dia. shafts. Bulk quantities available.
25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. 14/6. P. & P. 1/6.
50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. 21/-. P. & P. 1/6.
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. 27/6. P. & P. 1/6.

AVOMETER MOVEMENTS



50µA 20KΩ/V.

Spare movements for Model 8 or 9. (Fitted with Model 9 scale) or basis for any multimeter. Brand New and Boxed 69/6 P. & P. 3/6

AVO 48A

Perfect order with set of shunts and resistances £12.10.0. P. & P. 7/6.

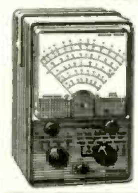
T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels −40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. £17/10/-. Carr. 5/-.

PLESSEY SL 403A

3-watt. integrated amplifier circuit. 49/6 post paid.

TE-65 VALVE VOLTMETER

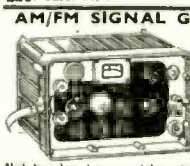


High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions £17/10/0. P. & P. 6/-. Additional Probes available; R.F. 35/- H.V. 42/6.

COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

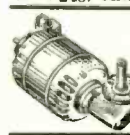
D.C. coupled. Band width 1 Kc/s. Perfect order. £25. Carr. 30/-.

AM/FM SIGNAL GENERATORS



Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1µV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 × 8½ × 9in. Supplied in brand new condition complete with all connectors, fully tested. £45. Carr. 20/-.

GEARED MAINS MOTOR

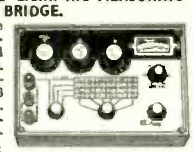


Parslux type SD19 230/250 v. A.C. Reversible. 30 r.p.m. 40 lb. ins. Complete with capacitor. Excellent condition. 99/6. Carr. 10/-.

TE-16A TRANSISTORISED SIGNAL GENERATOR

5 Ranges 400 KHZ-30 MHZ. An inexpensive instrument for the handyman. Operates on 9v. battery. Wide easy to read scale. 800 KHZ modulation. 5¼" × 5¼" × 3½". Complete with instructions and leads. £7/19/6. P/P 4/-.

TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.



A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1µH—111 HENRIES. 6 Ranges — 2%. C. 10PF ± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100µA. Meter indication. Attractive 2 tone metal case. Size 7¾" × 5" × 2". £20. P. & P. 5/-.

AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded
150 W. 42/6. P. & P. 3/6
300 W. 59/6. P. & P. 4/6
500 W. £4/10/0. P. & P. 6/6
1,000 W. £6/10/0. P. & P. 7/6
1,500 W. £7/19/6. P. & P. 8/6
7,500 W. £15/10/0. P. & P. 20/-.

G. W. SMITH & Co. (Radio) Ltd.

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OPTOELECTRONICS from PROOPS

New Science Projects combine fascination of Optics with Electronics.

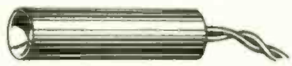
INFRA-RED TRANSMITTERS & RECEIVERS

Unique devices in a brand new electronic field that can be exploited in a wide range of applications. Miniaturized construction and solid state circuit design is combined with outstanding modulation and switching capabilities to provide infinite possibilities as short distance speech and data links, remote relay controls, safety devices, burglar alarms, batch counters, level detectors, etc., etc.

INFRA-RED PHOTO RECEIVER — MSP3

Ultra sensitive detector/amplifier for infra-red (Gallium Arsenide) or visible light optical links reception. Spectral response 9500 A. Robust, cylindrical package is coaxial with incident light to facilitate optical alignment and heat sinking.

85/- *post free*



MAX RATINGS

Total dissipation (in free air, T_{amb} = 25°C.).........100mW. Derating Factor.........2mW/°C. Output Current Intensity.........100mA. Voltage.........25V. Operating Temperature.........from —30° to +125°C.

Supplied complete with suitable lenses, full Technical Data and Application Sheets, including Line of Sight Speech Link.

GALLIUM ARSENIDE LIGHT SOURCE—MGA 100

Filamentless, infra-red emitter in a robust, sealed cylinder coaxial with beam to facilitate optical alignment and heat sinking.

35/- *post free*

MAX RATINGS

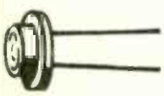
Forward current I_F max. D.C.........400mA. Forward peak current I_F max.* (pk).........6A*
Power dissipation.........600mW. Derating factor for T_{amb} greater than 25°C.........7.5mW/°C.*
Reverse voltage V_R max 1·0V.
**When mounted on an aluminium heat sink 1in. x ½in. x ½in.*

Supplied complete with suitable lenses, full Technical Data and Application Sheets, including Line of Sight Speech Link.

PHOTOCONDUCTIVE CELLS

CADMIUM SULPHIDE CELLS (Cds)

Inexpensive light sensitive resistors which require only simple circultry to work as light triggering units in a wide range of devices, such as: flashing or breakdown lights, exposure meters, brightness controls, automatic porch lights, etc. Not polarity conscious — use with A.C. or D.C. Spectral response covers whole visible light range.



MKY101-C

Epoxy sealed. ⅜ in. diam. x ⅛ in. thick. Resistance at 100 Lux – 500 to 2,000 ohms. Maximum voltage 150 A.C. or D.C. Maximum current 150 mW. **10/6** *post free*

MKY71

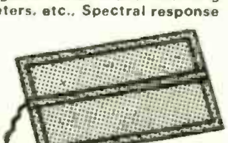
Glass sealed with M.E.S. base. Glass envelope $\frac{5}{16}$ in. diam., overall length 1 in. Resistance at 100 Lux – 50 Kohms to 150 Kohms. Maximum voltage 150 A.C. or D.C. Maximum current 75 mW. **8/6** *post free*

PHOTOGENERATIVE CELLS

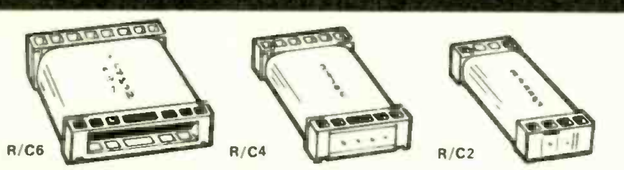
Selenium cells in which light energy is converted into electricity directly measurable on microammeter or used with amplifier as light trigger for alarm and counting devices, luminous fluxmeters, exposure meters, colorimeters, etc., Spectral response covers visible light range.

Type 1—1½ x 1$\frac{5}{16}$ in. Output 1 mA at 0.6 volts at 1,000 Lux **5/-** *post free*

Type 3—100 x 50 mm. Output 4 mA at 0.6 volt at 1,000 Lux **22/6** *post free*



REED SWITCH COILS & CAPSULES



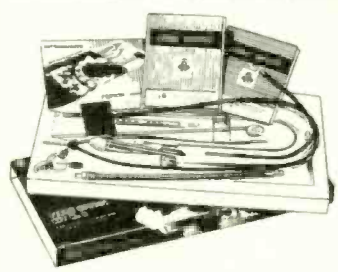
Compact assemblies of reed switches and operating coils that permit the design of an infinite variety of multiple switch circuits in an extremely small space. They eliminate the bulk and open contact disadvantage of electro-mechanical relays; hermetically sealed contact isolation ensures longlife reliability. Small enough to combine with solid-state components on printed circuit boards. Ideal for switching matrices, binary kits, control systems, etc. These were removed intact from highly expensive computer mechanisms and are guaranteed to be in perfect working order. Each capsule consists of a rare-metal screened, 24 volt DC operating coil on a nylon former with one detachable end for the removal and replacement of reed switches.

Types available:

- **R/C2** Two reed switches, contacts normally open. Size overall: 1⅛ x ⅜ x ⅜ in. **5/-** *post free*
- **R/C4** Four reed switches, contacts normally open. Size overall: 1⅛ x ⅝ x ⅜ in. **10/-** *post free*
- **R/C6** Six reed switches, 4 contacts normally open, 2 normally closed. Size overall: 1⅛ x 1⅛ x ⅜ in. **15/-** *post free*

FIBRE OPTICS

Highly flexible light guides that transmit light to inaccessible places as easily as electricity is conducted by copper wires. Fibre optics make it possible to control, miniaturize, split, reflect or transfer light from one source to many places at once and to operate photo devices, logic circuits, or illuminate in ways never before possible. Proops offer both glass fibre optics or inexpensive Crofon plastic fibres for hundreds of experiments or serious applications in a fascinating new science.



RANK TAYLOR-HOBSON ENGINEERS KITS

Basic fibre optic components that demonstrate new ways of employing light in serious applications. Two kits are available: each contains high-grade glass-fibre light guides consisting of thousands of fibres tightly bundled in flexible sheaths with ferruled, optically polished ends, together with connecting and light source components. Each is supplied complete with card wallets containing technical and application data.

KIT 1 £16 *Post free*
Contains: 1.5 mm. x 24 in., 3 mm. x 18 in., and 6 mm. x 12 in. light guides, plus 24 in. long x 2 exit component for punched card or coding applications. Also battery operated light source, 2-way 'Y' adaptor with non-random separation, and 3 mm./3 mm. and 3 mm./1.5 mm. connectors.

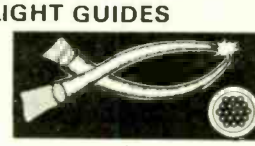
KIT 2 £28 *Post Free*
Contains: 3 mm. x 18 in., 6 mm. x 12 in. light guides; 1.5 mm. 'Y' guide with two 12 in. long tails; 24 in. long 12 exit component for coding or punched card applications, 24 in. lengths of Crofon 64 filament and monofilament plastic light guide. Also, coherent solids consisting of 25 mm. diam. field flattening lens, 6 mm. x 12 in. image conduit with polished ends, 4 mm. x 25 mm. image invertor. Complete with 2-way adaptor, fibre optic torch and batteries, 3 mm./3 mm. and 3 mm./1.5 mm. connectors.

● Special offer of IMAGE FIBRESCOPES £5 *Post Free* ●

Between 50,000 and 60,000 coherently arranged, 15 micron glass fibres that provide (with appropriate optics) perfect visual inspection into otherwise inaccessible areas. Originally made by Rank Taylor-Hobson for use in industrial and medical fibrescopes at £72 each, these have slight, superficially imperceptible faults and are assembled in transparent, lay-flat tubing instead of opaque, flexible conduit, as usual. Ends are ground, polished and metal capped. Absolutely ideal for demonstration in Schools and Technical Colleges and for many other applications that require highly sophisticated means of access to enclosed, difficult to get at places. Length overall: 3 ft. Cross sectional area: 3 x 3 mm. Resolution: 10 LP/mm. to 20 LP/mm.

LOW COST CROFON FLEXIBLE LIGHT GUIDES

Newly developed plastic light transmitting media by Dupont, which can be used for both serious projects and inexpensive prototype work. Ends can be ground flat, dyed or capped with epoxy resin. Temperature range: —40° to + 170°F. No loss of light through bending. **12 page Data and Applications booklet supplied free with each order. Types available:**



Multi-strand— 64 special plastic fibres, tightly bundled together in a tough, flexible conduit. **8/6 per foot. Minimum order two feet. 17/- p & p 1/6.**

Monofilament— single 0·040" plastic fibre which is specially useful for light indication in confined spaces. **4/- per foot. Minimum order three feet. 12/- p & p 1/-.**

RCA TRIAC — CA40432 *45/- post free*

Suitable for light dimming and motor control circuits

Gate-controlled, full-wave, A.C. silicon switch with integral trigger that blocks or conducts instantly by applying reverse polarity voltage. Suitable for A.C. operation up to 250 volts; controls currents up to 1440 watts. Size only ⅜ in. diam. x $\frac{5}{16}$ in. high. **Complete with heat sink, data and applications information.**

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AVO VALVE CHARACTERISTIC METER complete with manual, **£45** Carriage. 30/-.

SPECIAL OFFER
O9J TUBE 3/-

PHASE MONITOR ME-63/U. Manufactured recently by Control Electronics Inc. Measures directly and displays on a panel meter the phase angle between two applied audio frequency signals within the range from 20-20,000 c.p.s. to an accuracy of ± 1.0°. Input signals can be sinusoidal or non-sinusoidal between 2 and 30 v. peak. In excellent condition. **£75.** Carriage 30/-.

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AVO SIGNAL GENERATOR CT 378, 2-225MHz. **£38.10.0.** Carr. 18/-.

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To view **TEST EQUIPMENT** please phone for appointment

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and very many others, full list of meters upon request.

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RCA CA 3005 wide band RF Ampl 300mW diss	27/-
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PLEASE NOTE
Unless offered as "as seen" all equipment ordered from us is completely overhauled mechanically and electrically, thus ensuring that our equipment is in "connect and use" condition.

A.F. Amps with PRE-AMP 2.5W. **£2.2.6.** 3.5W. **£2.12.6.** Mono with tone controls **£6.2.6.** Stereo with tone controls **£12.19.6.**

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OAZ208 to OAZ213 6/6	OC82DM 3/-	IZT10 12/9	AC126 4/6	BU100 38/-	V405A 7/9
OAZ223 to OAZ225 10/-	OC83 4/6	2N1306 6/6	AC127 4/6	BYZ13 5/-	Z Range Zener diodes 3/6 ea.
OC16 15/-	OC83B 3/-	2N1307 6/6	AC128 4/-	BYZ16 15/-	Z2A range 7/6 ea.
OC22 8/6	OC84 5/-	2S303 10/-	AC176 7/6	CRS1/10 5/-	Z3B range 5/1 ea.
OC25 7/6	OC122 10/-	2N3053 6/6	ACY28 4/-	CRS1/20 9/6	ZL range 5/- ea.
OC26 5/-	OC139 6/6	2N3054 12/6	AD149 11/-	CRS1/30 10/-	Z8 range 7/6 ea.
OC28 8/-	OC140 8/-	2N3055 15/-	AD161 7/-	CRS1/35 11/6	
OC29 15/-	OC170 5/-	2N5109 41/-	AD162 7/-	CRS1/40 12/6	
	OC171 6/-	3F100 12/6	AF117 4/9		
	OC172 7/6		AF118 10/-		
	OC200 6/-		AF139 10/-		

MANY OTHERS IN STOCK include Cathode Ray Tubes and Special Valves. U.K. P. & P. up to 10/- 1/-; to £1 2/-; over £1 2/- in £, over £3 post free. C.O.D. 4/- extra.

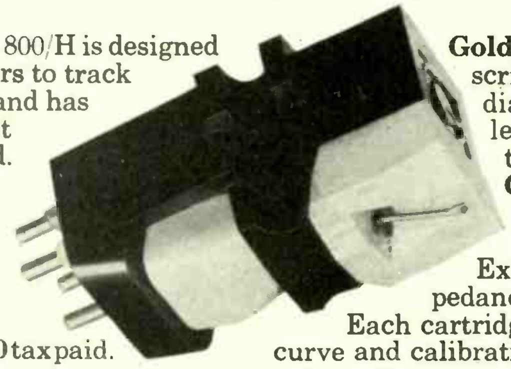
Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.

All overseas enquiries & orders please address to:
COLOMOR (ELECTRONICS LTD.)
170 Goldhawk Rd., London, W.12
Tel. 01 - 743 0899

You're on the right track–with Goldring 800 magnetic cartridges

Goldring 800 magnetic cartridges track unerringly. Because that's the way we make them. They're designed to translate even the most delicate information stored in the groove back into an identical electrical signal. We call it the sound of true transduction.

Hear it for yourself. You'll know you're on the right track.



Goldring 800/H... the 800/H is designed for inexpensive changers to track between 2½–3½ grams and has a high output of at least 8mV. **£10.13.6** tax paid.

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Goldring 800 E... is designed for transcription arms and a micro-elliptical diamond is fitted to a finer cantilever, end damped against natural tube resonance **£18.17.1** tax paid.

Goldring 800 Super E... the 800 Super E is for those to whom perfection is barely good enough. Extraordinarily low mechanical impedance for superb tracking capabilities. Each cartridge is supplied with its individual curve and calibration certificate. **£26.0.0** tax paid.

Send for details and complete range of Goldring Hi-Fi equipment
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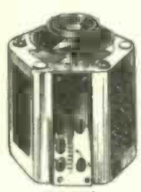
486-488 High Road, Leytonstone, London, E.11. Tel: 01-539 8343.

WW—108 FOR FURTHER DETAILS

NO EXCUSES! NO DELAYS! FROM STOCK!

VARIABLE VOLTAGE TRANSFORMERS



8 AMP

1 AMP

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.

BRAND NEW. Keenest prices in the country. All Types (and spares) from ½ to 50 amp. available from stock.

0–260 v. at 1 amp.	£5 10 0
0–260 v. at 2·5 amps.	£6 15 0
0–260 v. at 5 amps.	£9 15 0
0–260 v. at 8 amps.	£14 10 0
0–260 v. at 10 amps.	£18 10 0
0–260 v. at 12 amps.	£21 0 0
0–260 v. at 15 amps.	£25 0 0
0–260 v. at 20 amps.	£37 0 0
0–260 v. at 37·5 amps.	£72 0 0
0–260 v. at 50 amps.	£92 0 0

20 DIFFERENT TYPES AVAILABLE FOR IMMEDIATE DELIVERY.

Double Wound Variable Transformers

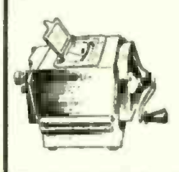
Fully isolated, low tension Secondary winding. Input 230 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.

0-36 v. at 5 amp. £9.12.6—p. & p. 8/6

0-36 v. at 20 amp. £21.0.0—15/- p. & c.

These fully shrouded Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.

INSULATION TESTERS (*NEW*)



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 VOLTS, 500 megohms. Price **£28** carriage paid.

1,000 VOLTS, 1,000 megohms, **£34** carriage paid.

5Amp. AC/DC VARIABLE VOLTAGE OUTPUT UNIT

Input 230 v. A.C. Output 0-260 v. A.C. Output 0-240 v. D.C. Fitted large scale ammeter and voltmeter. Neon indicator, fully fused. Strong attractive metal case 15in. × 8¾in. × 6in. Weight 24 lb. Infinitely variable, smooth stepless voltage variation over range. Price £38 plus 30/- p. & c. Similar in appearance to illustration below.

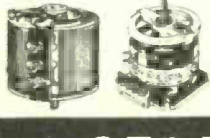
OPEN TYPES

Designed for Panel Mounting. Input 230 v. A.C. 50/60 Output variable. 0-260 v.

½ amp	£3 10 0
1 amp.	£5 10 0
2½ amp.	£6 12 6

P. & P. 7/6

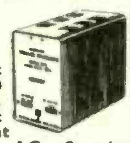
½ AMP. 1 AMP.



VAN DE GRAAF ELECTROSTATIC GENERATOR

fitted with motor drive for 230 v. A.C. giving a potential of approx. 50,000 volts. Supplied absolutely complete including accessories for carrying out a number of interesting experiments, and full instructions. This instrument is completely safe, and ideally suited for School demonstrations. Price **£7/7/-**, plus 4/- P. & P. L't. on req.

CONSTANT VOLTAGE TRANSFORMER



Input 185-250 v. A.C. Output constant at 230 v. AC. Capacity 250 watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17lbs. Price **£11/10/-**, P. & P. 10/-.

LATEST TYPE SOLID STATE VARIABLE CONTROLLER

Ideal for lighting and heating circuits, compact panel mounting. Built in fuse protection. CONTINUOUSLY VARIABLE.
Input 230v AC output 25-230v AC
5 amp model **£8. 7. 6**
10 amp model **£13. 5. 0**

SPEEDIVAC HIGH VOLTAGE HIGH FREQUENCY GENERATOR

Input 100/110 volts or 200/250 volts AC/DC Output 19KV variable. Ideal for testing insulation, vacuum, leakage path, gas discharge lamps, neon etc. A useful ozone and HF supply. Manufactured by Edwards High Vacuum Ltd. Brand new in maker's polished wooden carrying case. Offered at fraction of maker's price. £10.0.0 plus 7/6 p. & p.

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit

INPUT 220/240 v. A.C.
OUTPUT CONTINUOUSLY VARIABLE 0-36 v.

Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £55 plus 40/- p. & c.

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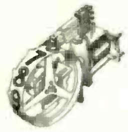
LARGE DIGIT 12-18 v. D.C. MAGNETIC COUNTER



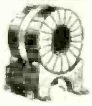
4in. drum, calibrated 0-9. Figures 1½in. high ⅞in. wide. Set of Im, Ib, Ic/o contacts operated by drum cam. The units which can be used in multiples are ideally suited for batch or lap recording or for the many purposes where large easily read numerals are required. Price 18/6, P. & P. 2/6.

VEEDER ROOT COUNTER

230 v. A.C. 50 cycle 5 figure counter (non resetable). 18/6, P. & P. 1/6.

RING TRANSFORMER

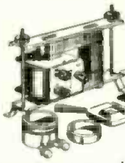
Functional Versatile Educational



This multi-purpose Auto Transformer, with large centre aperture, can be used as a Double wound current Transformer, Auto Transformer, H.T. or L.T. Transformer, by simply hand winding the required number of turns through the centre opening. E.g. Using the RT.100 V.A. Model the output could be wound to give 8V. @ 12½Amp., 4V. @ 25Amp. or 2V. @ 50Amp., etc.

Price: RT.100VA 3.18 turns per volt, £2 5 0+3/6 p. and p.
RT.300VA 2.27 turns per volt, £4 4 0+5/6 p. and p.
RT. 1KVA 1.82 turns per volt, £6 10 0+6/6 p. and p.

DEMONSTRATION TRANSFORMER (STENZYL TYPE)



Two removable coils are tapped at 0, 110, 220 volts, and 6, 12, 36 volts respectively. A composite apparatus designed for class demonstration. Electro magnetic induction, jumping ring, induction lamp, relationship between field intensity and ampere turns, induction melting, are just a few of the possible experiments. New modified model. £14/10/-. P. & P. 10/-.

L.T. TRANSFORMERS

All primaries 220-240 volts.

Type No.	Sec. Taps	Price	Carr.
1	30, 32, 34, 36 v. at 5 amps.	£4 13 6	6/-
2	30, 40, 50 v. at 5 amps.	£6 17 6	6/6
3	10, 17, 18 v. at 10 amps.	£4 19 0	4/6
4	6, 12 v. at 20 amps.	£6 8 6	6/6
5	17, 18, 20 v. at 20 amps.	£7 5 6	6/6
6	6, 12, 20 v. at 20 amps.	£6 17 6	7/6
7	24 v. at 10 amps.	£5 4 6	5/6
8	4, 6, 24, 32 v. at 12 amps.	£7 3 0	6/6

AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3/10/- each, P. & P. 4/6. 500 watt type £4/12/6 each, P. & P. 6/6. 1,000 watt type £5/15/- each, P. & P. 7/6.

LATEST TYPE SOLID STATE DEVICES

R.C.A. plastic Triac 400 PIV 8 amp. Price 25/6.
R.C.A. Diac for above, price 6/-. *Price includes data sheet and circuit.*

R.C.A. 40432 Triac and Diac in TO5 can 6 amp. 35/-.

G.E. P.U.T., D13, T1, 12/-. Texas F.E.T. 2N3819, 7/6.

All above prices plus 1/6 P. & P.

INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 2/- each.

A.C. CONTACTOR

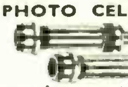
2 make and 2 break (or 2 c/o) 15 amp. contacts. 230/240 v. A.C. operation. Brand new. 22/6 plus 1/- P. & P.

LIGHT SENSITIVE SWITCHES

Kit of parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. Price 25/-, plus 2/6 P. & P. ORP. 12 and Circuit 12/6 post paid.

220/240 A.C. MAINS MODEL incorporates mains transformer rectifier and special relay with 2 × 5 amp. mains c/o contacts. Price Inc. circuit 47/6, plus 2/6 P. & P.

LIGHT SOURCE AND PHOTO CELL MOUNTING



Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair £2/15/0 plus 3/6 P. & P.

CONDENSERS

New at a fraction of maker's price.

2,500 mfd. 100 v...	12/6	4,000 mfd. 25 v...	10/-
10,000 mfd. 35 v...	15/-	4,000 mfd. 50 v...	15/-

POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES:** **100 WATT** 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm ·7a., 500 ohm ·45a., 1k ohm 280mA., 1·5k ohm 230mA., 2·5k ohm ·2a., 5k ohm 140mA., Diameter 3½in. Shaft length ⅜in. dia. ¼in., 27/6. P. & P. 1/6. **50 WATT** 1/5/10/25/50/100/250/500/1K/1·5K/2·5K/5K ohm. All at 21/-, P. & P. 1/6. **25 WATT** 10/25/50/100/250/500/1K/1·5K/2·5K ohm. All at 14/6, P. & P. 1/6.

Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia. brass bush. Ideal for above Rheostats, 3/6 each.

STROBE! STROBE! STROBE!

THREE EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES. SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION. The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.

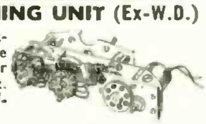
EXPERIMENTERS "ECONOMY" KIT 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + instructions £5.5.0 plus 5/- P. & P.

NEW INDUSTRIAL KIT Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor 1-80 f.p.s. Price 9 gns. 7/6 P. & P.

HY-LYGHT STROBE This strobe has been designed for use in large rooms, halls and the photographic field. It has 4 times the light output at 30 f.p.s. and utilizes a silica tube for longer life expectancy, printed circuit for easy assembly, also a special trigger coil and output capacitor. Light output approx 4 joules. Price £10.17.6. P. & P. 7/6.

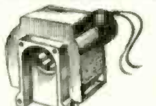
7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price 10/6 & 2/6 p. & p. or post paid with kits.

MOTORISED SWITCHING UNIT (Ex-W.D.)



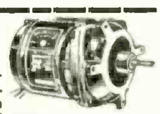
Powerful, precision-made, ex-W.D., 12 v. D.C., reversible motor, drives multiple gear train with outputs approx. 4 r.p.m. and 5 r.p.m. Price 25/-. P. & P. 4/6.

Ex. W.D. MINIATURE BLOWER UNIT



18-24 v. D.C. operation, overall length 3⅞ in. Blower 2⅜ × 2⅜ in., 20/-. P. & P. 2/6.

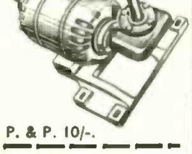
BODINE TYPE N.C.1 GEARED MOTOR



(Type 1) 71 r.p.m. torque 10 lb. in. Reversible 1/70th h.p. 50 cycle .38 amp. **(Type 2) 28 r.p.m.** torque 20 lb. in. reversible 1/80th h.p. 50 cycle .28 amp. The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for **230/240v A.C. input**

Price, either type £3.3.0 plus 6/6 P. & P. or less transformer £2.2.6 plus 4/6. P. & P. These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines etc. etc.

PARVALUX TYPE SD19 230/250 VOLT AC REVERSIBLE GEARED MOTORS



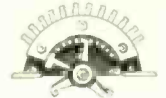
30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. Mounted on **substantial cast aluminium base.** Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. **6 gns.** P. & P. 10/-.

DRY REED SWITCHES

2 × 1 amp Dry Reeds (make contacts) mounted in 870 ohm 9-18v coil. Size 3in. × 3½in. × ⅛in. New. Price 8/6 per pair. Post Paid.

6 of the above mentioned units (12 Reeds, 6 coils) fitted in metal box. Size 4in. × 3½in. × 1⅝in. Mfg. by Elliott Bros. New 45/- each. Post Paid.

MINIATURE UNISELECTOR



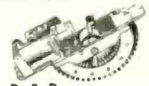
3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6. plus 2/6 P. & P.

UNISELECTOR SWITCHES *NEW*

4 BANK 25 WAY FULL WIPER

25 ohm coil, 24 v. D.C. operation. £5.17.6, plus 2/6 P. & P.

6 BANK 25 WAY FULL WIPER

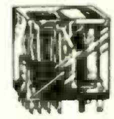


25 ohm coil, 24 v. D.C. operation. £6.10.0, plus 2/6 P. & P.

8-BANK 25-WAY FULL WIPER

24 v. D.C. operation, £7/12/6. plus 4/- P. & P.

RELAYS



NEW SIEMENS PLESSEY, etc. MINIATURE RELAYS AT A HIGHLY COMPETITIVE PRICE.

COIL Ω	WORKING D.C. VOLT	CONTACTS	PRICE
170	9—12	4 c/o H.D.	14/6
170	9—12	3 c/o + 1 H.D. c/o	12/6
230	6—12	2 c/o	12/6
280	6—12	2 c/o incl. base	14/6
700	12—24	2 c/o incl. base	12/6
700	16—24	4 c/o incl. base	15/6
700	16—24	4M 2B incl. base	12/6
2500	30—50	2 c/o H.D. incl. base	12/6
9000	40—70	2 c/o incl. base	10/-

H.D.=Heavy Duty. POST PAID

MINIATURE RELAYS

9—12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1in. × ⅞ × ½in. Price 11/6 Post paid.

30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3.200 ohm coil. Size only 1 × ⅝ × ⅝in. 8/6 post paid.

230 VOLT AC RELAY LONDEX four c/o 3 amp contacts. 18/6, incl. base. Post Paid.

SANWA MULTI RANGE TESTERS

NEW MODEL U-50D MULTI TESTER, 20,000 O.P.V. MIRROR SCALED WITH OVERLOAD PROTECTION. Ranges: D.C. volts: 100mV., 0.5 v., 5 v., 250 v., 1,000 v. A.C. volts. 2.5 v., 10 v., 50 v.. 250 v., 1,000 v. D.C. current: 5μA. 0.5 mA., 5 mA., 50 mA., 250 mA. Size: 5¼ × 3½ × 1⅞ in. **Complete with batteries and test prods. £7.5.0** Post paid

'AVO' MODEL 48A

Ex-Admiralty in good condition with instructions, leads, plus D.C. Shunts for 120 Amp and 480 Amp. A.C. Transformer for 60 Amp. and 240 Amp. Multiplier for 3600 volt. Complete outfit in fitted case. £15/0/0, P. & P. 10/-.

PANEL METERS AT BARGAIN PRICES

A.C. AMMETERS 0-1, 0-5, 0-10, 0-15, 0-20 amp. F.R. 2½in. dia. **ALL AT 21/- EACH.**
A.C. VOLTMETERS 0-25 v., 0-50 v., 0-150 v. M.I 2½in. Flush round **ALL AT 21/- EACH.** P. & P. extra.
0-300 v. A.C. Rect. M-Coil 2½in. 29/-
0-300 v. A.C. Rect. M-Coil 3½in. Type W23 ...... 45/-

230 v. A.C. SOLENOID. Heavy duty type. Approx. 3lb. pull. 17/6 plus 2/6 P. & P. **12 v. D.C. SOLENOID.** Approx. 1lb. pull. 10/6, P. & P.1/6. **50 v. D.C. SOLENOID.** Approx. 1lb. pull. 10/6, P. & P. 1/6. **50 v. D.C. SOLENOID.** Approx. 2lb. pull. 12/6, P. & P. 1/6.

NEW MODEL HIGH FREQUENCY TRANSISTORISED MORSE OSCILLATOR

Adjustable tone control. Fitted with moving coil speaker, also earpiece for personal monitoring. Complete with morse key. 45/- plus 3/6d. p. & p.

SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY

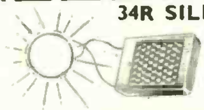
7 adjustments, precision tooled, speed adjustable 10 w.p.m. to as high as desired. Weight 2½lb. £4/12/6 post paid.

NICKEL CADMIUM BATTERY

1.2 v. 35 AH. Size 8¾ high × 3 × 1½. 30/- each, plus 4/- P. & P.

Sintered Cadmium Type 1.2 v. 7AH. Size: height 3½ in., width 2⅛in. × 1⁹⁄₁₆in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 12/6. P. & P. 2/6.

34R SILICON SOLAR CELL



4 × .5 volt unit series connected, output up to 2 v. at 20 mA. in sunlight, 30 times the efficiency of selenium. 45/-. P. & P. 1/6d.

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Lasky's

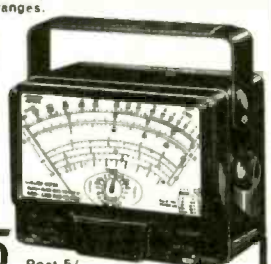
TMK METER KIT

ANOTHER LASKY'S EXCLUSIVE

This new meter kit by TMK offers the professional, electronics hobbyist and student the unique opportunity of building a really first class precision multimeter at a worthwhile saving in cost. The impact-resistant bakelite cabinet is supplied with the meter scale and movement mounted in position. The highest quality in components and 1% tolerance resistors are used throughout. Supplied complete in every detail with full constructional, circuit and operating instructions.

MODEL 5025 — 50,000 O.P.V. FEATURING 57 MEASUREMENT RANGES

A highly reliable instrument using an entirely new range selection mechanism which permits the use of a really large meter in a more compact cabinet. The range selected is clearly indicated on the actual meter face facilitating instant identification without taking your eyes from the meter. High speed rotary range selection knob; also features polarity reversal switch, shielded meter movement with overload protection circuit. Special A and mA measurement ranges.



SPECIFICATION:

- DCV: 0.0.25-2.5-10-50-250-1,000V at 25K/OPV 0-0.125-1.25-5.0-25-125-500V at 50K/OPV.
- ACV: 0-3-10-50-250-1,000V at 2.5K/OPV 0-1.5-5-25-125-500V at 5K/OPV.
- DCμA: 0-25μA at 125mA; 0-50μA at 250mA.
- DCmA: 0-2.5-25-250mA at 125mV; 0-5-50-500mA at 250mV.
- DC Amps: 0-5A at 125mV; 0-10A at 250 mV.
- Resistance: 0-10M/ohms (13, 85, 650.6.5K and 65K/ohms at centre scale).
- Output Capacitor (0.1μF, 400Vw) in series with ACV ranges
- Decibels: —20 to + 81.5dB in 10 ranges.

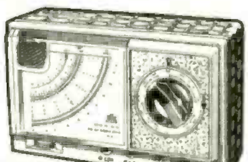
Operates on two 1.5V (U.7 type batteries). Black bakelite cabinet, size 5¼ x 6¾ x 2¾in. Strong resilient plastic handle. Complete with test leads.

KIT PRICE £10.10.0 Post 5/-

ALSO AVAILABLE READY-BUILT AND TESTED £12.10.0. Post 5/-

TTC Model C-1051 POCKET MULTIMETER

A completely new design 20,000 O.P.V. pocket multimeter with mirror scale and built-in thermal protection. Exceptionally large easy to read meter with D'Arsonval movement. Colour coded scales. Single positive click-in, recessed selection switch for all ranges. Ohms zero adjustment. Range spec. a.c. volts: 0-6-30-300-1,200V at 10K/ohms/V. DC volts 0-3-15-150-300-1.2KV at 20K/ohms/V. Resistance: 0-60K-6megs. DC current: 0-60 μA—300 mA. Decibels: —20dB to + 17 dB. Extremely high standard of accuracy on all ranges. Uses one 1½V penlight battery. Strong impact resistant plastic cabinet—size only 4¾ x 3¼ x 1⅛in. Two colour buff/green finish. Complete with test leads and battery.



LASKY'S PRICE 75/- Post 2/6

TRIO COMMUNICATIONS RECEIVERS

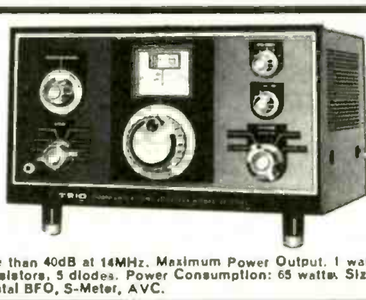
9R-59 DE

● 8 valve plus 7 diode circuit continuous coverage from 550kHz to 30MHz with Calibrated Bandspread on 10, 15, 20, 40 and 80 metre bands ● Clear SSB reception is achieved through the use of a product detector ● Beautifully designed control layout finished in light grey with dark grey case. Fully guaranteed, complete with instruction manual and service data.

SPECIFICATION: Frequency Ranges: 550-1600kHz; 1.6-4.8MHz; 4.8-14.5MHz; 10.5-30MHz. Bandspread: (Direct Reading on Ham Bands) 3.5MHz 80m; 7MHz 40m; 14MHz 20m; 21MHz 15m; 28MHz 10m. Sensitivity: A, B, C, Bands—Less than 6dB (for 10dB S/N ratio); D Band — 13MHz: Less than 18dB (for 10dB S/N ratio); 28MHz: Less than 10dB (for 10dB S/N ratio). Selectivity: ±5kHz at —50dB. Audio Output: 1.5 watts. Power Requirements: AC 115/230V, 50/60 Hz. Recommended Speaker Type: 4 or 8 ohm. Built-in Circuits: Bandspread; Automatic Noise Limiter (ANL); Automatic Volume Control (AVC); Headphone Jack. Dimensions: 7in. H, 15in.W, 10in. D.

LASKY'S PRICE £42.0.0 Carriage free

JR-500 SE



This is a high-performance Communications Receiver made specially to cover the amateur bands. It uses a crystal-controlled double super heterodyne circuit and provides high sensitivity and good stability. The JR500-SE covers all amateur bands between 3.5 and 29.7MHz and will also receive the 10MHz frequency standard signal.

SPECIFICATIONS: Frequency Range: Band coverage 3.5-29.7MHz in 7 bands. Reception: AM, SSB, CW. Selectivity. ±1.5kHz at —6dB, ±6kHz at —60dB. Sensitivity: 1.5uV for 10dB S/N ratio at (14MHz). Image ratio and if rejection: More than 40dB at 14MHz. Maximum Power Output. 1 watt. Valves and Transistors used: 7 valves, 2 transistors, 5 diodes. Power Consumption: 65 watts. Size: 13in. x 7in. x 10in. Special Circuits: ANL, Crystal BFO, S-Meter, AVC.

LASKY'S PRICE £65.0.0 Carriage free

TRIO PACKAGE DEAL

JR-500SE Receiver + **TRIO SP-5D** communications speaker + pair **TRIO HS-4** communications headphones. Total recommended retail price £75.7.0. **PACKAGE PRICE £69.10.0** Carriage 10/-

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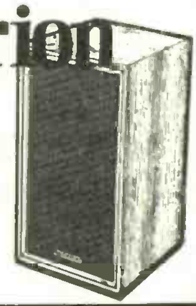
foster Criterion

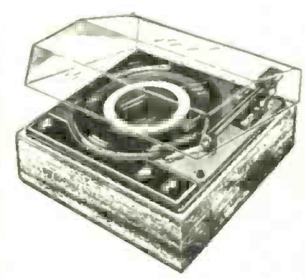
Mk II HIGH FIDELITY BOOKSHELF SPEAKER SYSTEM



Another high quality book-shelf system from Foster. The "Criterion" Mk. II is a sealed infinite baffle type enclosure using 5¼in. bass/mid-range woofer with rolled cloth edge and a 2½in. HF cone type tweeter. The compact cabinet is constructed of ½in. laminate with handsome oiled walnut veneer finish and black acoustic gauze front panel with satin chrome edge insert. SPEC: Frequency range 90-20,000Hz. Power handling 10 watts. Impedance 8 ohms. HF crossover. Screw tag connections at rear. Size 12½ x 7½ x 6½in. The performance of the "Criterion" is superior to many larger and more expensive units and at Lasky's exclusive price offers absolutely unbeatable value.

LASKY'S PRICE **£9.10.0** OR 2 FOR **£17.10.0** Post 1—7/6, 2—12/6.

Garrard RECORD PLAYERS



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SL72B	£25	0	0
AT 60 Mk II	£13	5	0
2025 TC complete with stereo cartridge	£8	17	6
3000 complete with 9TA HC stereo cartridge	£9	19	6
SL 65B	£5	19	6
1025 complete with stereo cartridge	£6	19	6
SL 95B	£40	0	0
SL 75B	£32	0	0

SINGLE PLAYERS

AP 75	£18	10	0
AP 75 with AD 76K magnetic cartridge	£21	10	0
SP 25 Mk II	£11	19	6
SP 25 Mk II with AD 76K magnetic cartridge	£15	10	0
401 Transcription Unit	£28	0	0

BASES AND COVERS FOR GARRARD UNITS:
Type WB1 and **WB5** for models AT60 Mk II, 2025TC, 3000, SL65B, SL55, 1025, SP25 Mk II. **Price WB1 £3 16 6. WB5 £5 12 6. Type WB4** for models SL72B, SL75B, SL95B **Price £5 12 6.** Perspex covers: **SPC1** for WB1 £3 14 1. **SPC4** for WB4 and WB5 (allows unit to be played with the cover in place—**Price** £4 8 0).

GARRARD PACKAGE DEALS

AP 75 complete with AD 76K Stereo magnetic cartridge teak plinth and perspex cover (illustrated) **£30.0.0** Post 10/-

SP 25 Mk II complete with AD 76K stereo magnetic cartridge, teak plinth and perspex cover **£19.0.0** Post 7/6

1025 complete with J2105 stereo ceramic cartridge, teak plinth and perspex cover **£11.19.6** Post 7/6

Post on Garrard units: 6/- extra—except AP 75, SL 75B, SL 95B and 401 7/6 extra. Post on bases and covers 5/- extra.

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These vacancies will be of particular interest to those who have served apprenticeships in radio or television, or to ex-service radar personnel.

The salary for these positions will depend on qualifications and experience but will be in the range of £1100–£1500. Assistance in finding accommodation will be given to single men.

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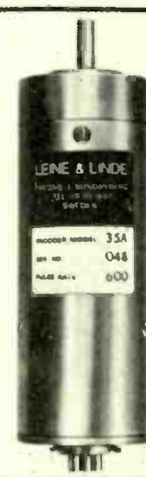

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CA3036 Buffer Amplifier consisting of two "super-alpha" pair of transistors suitable for stereo pick-up systems. 19/-

The above four I.C's are in TO5 encapsulation.

PA222 Audio Amplifier providing a max. output of 1.2 watts. 65/-

PA234 Audio Amplifier providing a max. output of 1 watt. 27/6

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The above three I.C's are in epoxy moulded double four-in-line package.

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TAA263 3-stage direct coupled amplifier for use from DC to 600kc/s; 70mW dissipation. Output 10mW into 150Ω load. 15/-

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TAD100 All active components required for an A.M. Receiver comprising mixer, oscillator, I.f. amplifier, a.g.c. and pre-amplifier stages. To build complete receiver only coils, capacitors and resistors are required and output stage for which one of the above described I.C.s can be used. Dual seven-in-line package. 45/-

Data sheet available for all the above I.C.s—free with I.C's or 1/- per data sheet if ordered separately.

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Wire ended, miniature, epoxy encapsulated.

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D815 series, from 4.7V to 18.0V ± 10% 8 Watts	7/6 each
D816 series, from 22V to 47V ± 10% 5 Watts	7/6 each
D817 series, from 56V to 100V ± 10% 5 Watts	7/6 each

Outlines: BZY series—miniature—wire ended
D814—'Top Hat' type
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Please state voltage required—nearest standard voltage will be supplied.

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Dual-in-line 10-lead flat package with heat sink strip. Maximum audio output 3 watts into 7.5Ω loudspeaker. Circuit consists of a pre-amplifier followed by a main amplifier. Distortion 0.3% at 1 watt increasing to 0.5% at full output. Frequency response 20 c/s to 20 mc/s. Operating voltage 18v. Built-in overvoltage cut-out. Price, complete with application sheet 49/6

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MULTIMETERS TYPE 108-IT

4-range precision portable meter. 5,000 o.p.v. D.C. Volt 2.5-10-50-250-500-2500V. A.C. Volts: 10-50-100-250-500-2500 V. D.C. current 0.5-5-50-500 mA. Resistance: 2,000-20,000 ohms-2-20 megohms. Power output calibration for 600 ohms line, £6/5/-. P.P. 7/6. Dimensions: 7⅛in. × 6in. × 3⅛in. Weight 3⅛lb.

TYPE MF16

D.C. Voltage range 0-0.5-10-50-250-500V.
A.C. Voltage range 0-10-50-250-500V.
D.C. current ranges: 500μA-10-100mA.
Resistance ranges: 100MΩ-1MΩ. The meter is also calibrated for capacity and output level measurements. Sensitivity 2000ΩV. Accuracy ±2.5% for D.C. and ±4% for A.C. measurements. Dimensions: 4⅛in. × 3⅛in. × 1⅛in. Price £4/5/-.

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6DS4	15/-
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6EH7	6/6
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6F6	14/-
6F6G	5/-
6F11	6/6
6F13	7/-
6F14	12/-
6F15	11/-
6F17	9/-
6F18	8/-
6F22	6/6
6F23	15/6
6F24	13/6
6F25	15/-
6F28	14/-
6GH8	11/-
6GK6	12/-
6J4	9/6
6J5GT	6/-
6J7	8/6
6K6GT	10/-
6K7	6/6
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6SH7	5/-
6SJ7	7/6
6SK7	6/6
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6SR7	7/6
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6U4GT	12/6
6U8	7/-
6V6GT	6/6
6X4	5/-
6X5GT	5/6
6X8	11/-
6Y6G	12/-
6Z4	5/6
7B5	12/-
7B6	12/6
7B7	7/6
7F8W	17/6
7Y4	12/-
7Z4	8/6
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9BW6	8/6
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10D1	8/-
10D2	8/-
10F1	18/-
10F9	10/-
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10P14	20/-
10Y	20/-
11D3	8/-
11D5	8/-
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12AV6	6/-
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12AX4GTB	9/-
12AX7	6/-
12AY7	13/6
12B4A	10/-
12BA6	6/6
12BA7	6/6
12BE6	6/6
12BH7	6/6
12BY7	10/-
12C8	6/-
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12E14	55/-
12J5GT	4/-
12J7GT	8/-
12K5	10/-
12K7GT	7/-
12K8	10/-
12Q7G	5/-
12SC7	5/-
12SG7	7/-
12SH7	5/-
12SJ7	5/-
12SK7	8/-
12SL7GT	8/-
12SN7GT	8/-
12SQ7	8/-
12SR7	6/6
1487	16/-
20CV	62/6
20D1	9/-
20L1	20/-
20P1	10/-
20P3	12/-
20P4	20/-
20P5	20/-
25C5	9/-
25L6GT	7/6
25Z4G	6/-
25Z6GT	12/-
30A5	8/-
30AE3	8/-
30C1	6/6
30C15	15/-
30C17	16/-
30C18	15/-
30F5	17/-
30FL1	15/-
30FL12	18/6
30FL13	18/6
30FL14	15/6
30L1	7/-
30L15	17/-
30L17	17/-
30P12	16/-
30P18	7/-
30P19	15/-
30PL1	15/6
30PL13	18/-
30PL14	17/-
35A3	10/-
35A5	11/-
35B5	13/-
35C5	7/-
35D5	13/-
35L6GT	9/6
35W4	5/-
35Z3	11/-
35Z4G	5/-
35Z5GT	7/-
42	8/-
50A5	13/-
50B5	7/-
50C5	7/-
50CD6G	35/-
50EH5	11/6
50L6GT	8/-
52KU	7/6
53KU	16/-
75B1	9/-
75C1	8/-
80	9/-
85A1	25/-
85A2	7/6
85A3	9/-
90AG	48/-
90AV	48/-
90C1	12/-
90CG	25/-
90CV	25/-
108C1	6/6
150B2	12/-
150B3	11/-
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310A	27/6
311A	37/6
328A	40/-
329	20/-
329A	35/-
715B	70/-
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807	9/6
807W	27/6
811A	30/-
813	75/-
829B	60/-
832A	57/6
833A	340/-
837	15/-
866A	14/-
872A	57/6
884	10/-
927	55/-
955	4/-
4378	25/-
5544	120/-
5545	150/-
5551A	320/-
5654	8/-
5670	10/-
5751	12/-
5796	280/-
5814A	12/-
5894	110/-
6080	27/6
6146	30/-
6146B	47/6
6267	6/6
6360	25/-
6550	33/-
6883	47/6
6922	12/6
6939	42/-
7199	15/-
7586	25/-
7591	20/-
7895	25/-
8005	135/-
9002	6/6
9003	10/-
A1834	16/-
A2293	23/-
AC/HL/DD	9/-
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BT19	80/-
C1A	90/-
C1K	80/-
CBL1	16/-
CBL31	17/-
CL4	12/-
CY31	7/-
DAF41	10/-
DAF91	5/6
DAF92	9/6
DAF96	7/9
DC90	9/-
DCC90	10/-
DF91	4/6
DF92	3/6
DF96	7/9
DH76	6/6
DH81	11/-
DH101	10/-
DK40	10/-
DK91	7/-
DK96	8/-
DL66	25/-
DL68	13/-
DL69	35/-
DL91	5/6
DL92	7/-
DL93	4/-
DL94	8/-
DL95	8/-
DL96	7/6
DM70	6/6
DM160	11/6
DY70	12/-
DY86	6/6
DY87	7/-
DY802	10/-
E55L	55/-
E80CC	21/-
E80CF	29/-
E80L	18/-
E81L	22/-
E83F	20/-
E84L	9/6
E88C	24/-
E88CC	12/6
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E188CC	16/6
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EA50	4/-
EAF42	10/-
EAF801	9/6
EB34	3/-
EB91	3/3
EBC33	9/-
EBC41	10/6
EBC81	6/6
EBC90	5/-
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EC53	10/-
EC86	12/-
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EC90	6/-
EC92	6/6
EC93	9/6
ECC33	11/-
ECC34	8/-
ECC35	17/-
ECC40	11/-
ECC70	17/-
ECC81	6/6
ECC82	6/-
ECC83	6/-
ECC84	6/-
ECC85	5/6
ECC86	9/6
ECC89	8/-
ECC91	4/-
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ECF82	7/-
ECF83	15/-
ECF86	12/6
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ECH83	8/6
ECH84	9/-
ECL80	9/-
ECL81	8/6
ECL82	6/6
ECL83	12/6
ECL84	11/-
ECL85	10/6
ECL86	8/6
EF9	9/-
EF39	9/-
EF40	10/-
EF41	12/6
EF42	14/-
EF55	13/-
EF80	5/-
EF83	10/-
EF85	7/-
EF86	6/6
EF89	5/6
EF91	4/6
EF92	7/6
EF93	4/6
EF94	5/-
EF95	5/-
EF96	4/-
EF97	10/-
EF183	6/6
EF184	7/-
EF800	20/-
EF804	20/-
EF811	15/-
EF812	15/6
EF814	13/6
EK2	15/-
EK90	5/-
EL5	11/-
EL34	10/6
EL36	9/6
EL38	27/6
EL41	11/-
EL42	11/6
EL81	10/-
EL83	7/6
EL84	5/-
EL85	8/6
EL86	8/6
EL90	6/-
EL91	5/-
EL95	7/-
EL360	23/-
EL803	17/-
EL821	11/-
EL822	18/-
ELL80	15/-
EM34	16/-
EM71	12/6
EM80	8/-
EM81	8/6
EM84	7/6
EM87	11/-
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EY51	8/-
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EY86	8/-
EY87	8/6
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HF94	5/6
HK90	6/6
HL23	7/6
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MSPEN/T	10/-
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PC86	11/6
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PCC89	10/6
PCC189	11/-
PCC805	17/-
PCC806	17/-
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PCF82	6/9
PCF84	9/-
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PCF87	16/-
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PCF806	13/-
PCF808	15/6
PCH200	14/-
PCL81	10/-
PCL82	7/9
PCL83	13/-
PCL84	8/9
PCL85	9/6
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PCL88	17/-
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PCL801	15/6
PD500	30/-
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PEN45DD	15/-
PEN46	7/6
PEN383	10/-
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PEN453DD	11/-
PF86	11/-
PF818	17/-
PFL200	14/-
PL33	7/-
PL36	11/-
PL81	9/6
PL82	9/-
PL83	8/-
PL84	7/-
PL302	15/-
PL504	16/-
PL508	17/6
PL509	30/-
PL801	16/-
PL802	14/-
PLL80	11/-
PM84	9/-
PX4	30/-
PX25	30/-
PY31	5/-
PY32	11/-
PY33	12/6
PY80	6/6
PY81	6/-
PY82	6/-
PY83	7/6
PY88	8/-
PY500	20/-
PY800	10/-
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PZ30	7/-
QQV02-6	42/-
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R10	20/-
R18	9/-
RG3-250A	14/-
RL18	10/-
S130	35/-
S130P	35/-
SP2	9/-
SP4	9/-
SP41	7/-
SP42	12/-
SP61	7/-
T41	17/-
TP22	11/-
TP25	6/-
TT21	48/-
TT22	50/-
U17	10/-
U18/20	13/6
U19	50/-
U20	13/6
U25	15/-
U26	15/-
U31	9/-
U33	30/-
U37	30/-
U50	6/-
U52	6/-
U76	5/-
U78	5/-
U81	13/-
U191	14/-
U201	7/-
U281	8/-
U282	8/-
U301	11/6
U403	10/-
U404	7/6
U801	20/-
UABC80	6/9
UAF41	10/-
UAF42	10/6
UB41	11/-
UBC41	9/6
UBC81	8/-
UBF80	7/3
UBF89	7/-
UBL1	10/-
UBL21	12/-
UC92	6/6
UCC85	8/-
UCF80	10/6
UCH21	11/-
UCH42	13/-
UCH43	12/-
UCH81	6/6
UCL81	11/-
UCL82	7/-
UCL83	12/-
UD143	15/-
UF9	11/-
UF11	10/-
UF41	10/-
UF42	12/-
UF43	11/-
UF80	7/6
UF85	8/-
UF89	7/-
UL41	12/-
UL84	6/6
UM4	5/6
UM84	4/-
UU5	10/-
UY1N	10/-
UY11	11/-
UY21	11/-
UY41	8/-
UY82	10/-
UY85	6/-
VLS631	38/-
VP23	6/6
VP41	7/-
VP133	15/-
VR75/30	9/-
VR105/30	7/-
VR150/30	6/6
VU33	10/-
VU39A	10/-
VU111	10/-
VU120	15/-
VU133	10/-
W76	8/-
W107	8/-
W729	12/-
X65	10/-
X66	10/-
X76M	9/-
XC11	15/-
XC12	6/6
XC12T	8/-
XC15	4/6
XC15T	7/-
XC23	17/-
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Z319	55/-
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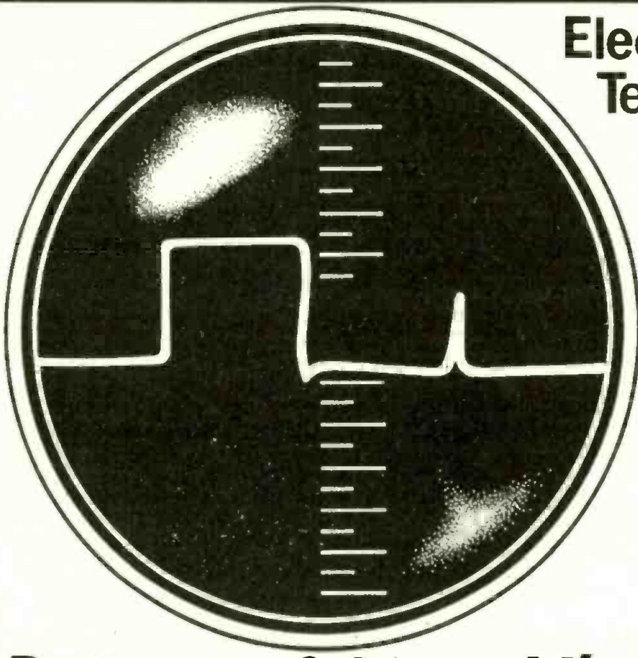
Electronic Test Technicians



Put some of the world's most sophisticated hardware to the test

What you will do

At IBM Greenock, you will be involved in the commissioning and testing of the latest IBM products which can include computers and sophisticated optical character recognition equipment. These products have to be tested thoroughly and all faults traced and rectified.

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You will have a strong electronic background, with experience in the testing of electronic products, maintenance of radio, radar or TV, or similar work in the armed forces.

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You will receive a mixture of formal and "on the job" instruction, and IBM will teach you all you need to know about their equipment.

Salary and Prospects

Starting salaries will be excellent. And the prospects are outstanding in this fast-growing company. Fringe benefits include a non-contributory pension scheme and free life assurance. IBM will also assist with removal expenses where applicable.

Write Today

Write with details of your age and experience to Mr. J. G. B. McKenzie, Manager, Personnel Selection, IBM United Kingdom Limited, P.O. Box 30, Spango Valley, Greenock, Scotland. Please quote reference ET2/WW/90062.

IBM

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ELECTRONIC ENGINEERS

Service Engineers required for Offices, throughout the United Kingdom, of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic Electronics with experience in Electronics, Radar, Radio and T.V. or similar field. Position is permanent and pensionable. Comprehensive training on full pay will be given to successful applicants. Please send full details of experience to the Service Manager, Sumlock Comptometer Ltd., 102/108 Clerkenwell Road, London, E.C.1. 82

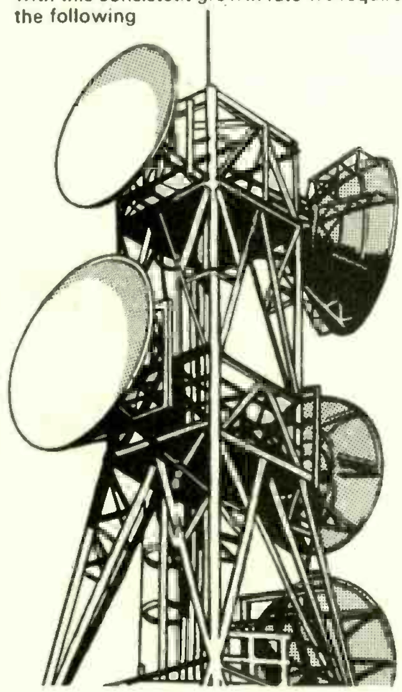
YOUNG ELECTRONICS ENGINEER

required for development work on digital equipment for Psychological Research. This post provides an excellent opportunity for an ambitious Junior, or Intermediate Engineer to join a small team whose talents are directed towards applying electronics technology to the most modern and exciting disciplines of Science. Good salary and prospects are offered by this rapidly expanding Company. Please write giving full details of qualifications and experience to:

Mr. K. J. Kapota, General Manager,
BEHAVIOURAL RESEARCH & DEVELOPMENT LTD.
124 Colne Road, Twickenham, Middx.
295

CONTINUOUS EXPANSION

Standard Telephones & Cables, Microwave and Line Division based at Basildon are growing fast. In order to keep pace with this consistent growth rate we require the following



Installation Engineers Technicians & Testers

Ref. 25720

To test and commission Multiplex, Co-axial Line and Microwave Radio Systems.

Ideal candidates will be less than 45 years of age with practical experience on some of the above equipment. These challenging posts call for drive, initiative and common sense. It is necessary for applicants to be prepared to work anywhere in the U.K.

Test Technicians

Ref. 27221

The diversity of products manufactured at the Basildon Plant demands experienced testing staff for work on complex transmission systems.

Candidates should hold an ONC in electrical engineering and be able to offer considerable practical experience in the field of testing and fault clearing all types of land-unit, pcm and microwave equipment.

Applications should be addressed to
The Personnel Officer,
STC Chester Hall Lane,
Basildon, Essex.

STC

91

BBC ENGINEER

EXTERNAL SERVICES SECTION OF
TRANSMITTER PLANNING & INSTALLATION DEPT.

The BBC have a vacancy for an Engineer in the External Services Section of Transmitter Planning and Installation Department. The department is responsible for the planning, installation and preparation of specifications for high power transmitters and for aerial and feeder systems at H.F. and M.F. transmitting stations in the United Kingdom and abroad.

Candidates should be qualified to degree or equivalent standard (Corporate membership of a relevant Chartered Institution would also be taken into consideration). In addition, applicants should have a general knowledge of modern transmitting stations and should have some experience of the installation and design of transmitters and aerial systems.

The post is based in London but candidates must be prepared to visit sites for short periods in the United Kingdom and abroad. A starting salary dependent on previous experience and qualifications of £2,030 to £2,238 p.a. would be paid rising to a maximum of £2,550 p.a.

1969

Requests for application forms to the Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA, quoting reference 70.E.2005.

279

computer engineering

NCR requires additional ELECTRONIC, ELECTRO MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.

Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.

Starting salary will be in the range of £900/£1,250 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.

Excellent holiday, pension and sick pay arrangements. Please write for Application Form to
Assistant Personnel Officer
NCR, 1,000 North Circular Road,
London, NW2
quoting publication and month of issue.

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Government of BOTSWANA
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to serve on contract for one tour of 24–36 months in the first instance. Salary according to experience in scale R.2340–3204 (approx. equiv. £Stg.1,365–1,869) a year basic plus an Inducement Allowance, normally tax free, of £Stg.360–518 a year paid direct into the officer's bank in the U.K. Gratuity 25% total basic salary drawn. Generous paid leave. Furnished accommodation. Education allowances. Free passages. Contributory pension scheme available in certain circumstances.

Candidates 30–45 years, must possess the City & Guilds Intermediate Cert. (Telecomms.) or equivalent *or* practical experience, preferably in the Police or Armed Forces, giving comparable ability. Several years' experience in the electronics or radio field, preferably in connection with H.F. S.S.B. and V.H.F./F.M. and ideally in police communications, is also essential.

The officer will undertake the installation, operation and maintenance of the police radio network comprising H.F., S.S.B. and V.H.F./F.M. stations to 500 watts throughout Botswana.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1, for application form and further particulars, stating name, age, brief details of qualifications and experience and quoting reference number M2K/691212/WF

Electronics Maintenance Engineers

There are excellent opportunities in the Installation and Maintenance Division of U.K. Electronics and Industrial Operations of E.M.I. Ltd., at Hayes, Middlesex, for engineers to carry out maintenance work on a wide variety of electronic equipments including laboratory test gear and trans-ceivers.

Candidates should be between 21 and 45 years of age and have some experience in this type of work. Consideration will be given to experienced Radio and Television servicing technicians and to ex service personnel.

Commencing salaries of up to £1,500 per annum will be paid and staff conditions include contributory pension scheme and free life assurance.

Please apply in writing giving brief personal and career details to:

**G. W. Fox, Personnel Department,
U.K. Electronics & Industrial Operations,
E.M.I. Ltd., Blyth Road,
Hayes, Middlesex.
Tel: 01-573 3888, Ext. 411.**

EMI 1968

Become a

RADIO TECHNICIAN

and work at the nerve centres of civil aviation

The National Air Traffic Control Service of the Board of Trade needs Radio Technicians to install and maintain the very latest electronic aids at Civil Airports, Air Traffic Control Centres, Radar Stations and specialist establishments. Vacancies exist in various parts of the United Kingdom.

This is responsible demanding work (for which you will get familiarisation training) involving communications, computers, radar and data extraction, automatic landing systems, and closed-circuit television. It offers excellent prospects with ample opportunities to study for higher qualifications in this fast-expanding field.

If you are 19 or over, with at least one year's practical experience in telecommunications, fill in the coupon now. Preference will be given to those having ONC or qualifications in Telecommunications.

Salary: £985 (at 19) to £1,295 (at 25 or over); scale maximum £1,500 (higher rates at Heathrow). Some posts attract shift-duty payments. The annual leave allowance is good and there is a non-contributory pension scheme for established staff.

Complete this coupon for full details and application form:
To: A. J. Edwards, C. Eng., M.I.E.E., M.I.E.R.E., Room 705, The Adelphi, John Adam Street, London WC2, marking your envelope 'Recruitment'.

Name..

Address..

.... WW/B4

Not applicable to residents outside the United Kingdom.

NATCS National Air Traffic Control Service

2841

Senior Posts for

DRAUGHTSMEN AND ENGINEERS

LABGEAR LTD. of CAMBRIDGE have vacancies in their engineering division for the following Staff:

1. **TWO SENIOR DESIGN DRAUGHTSMEN** with experience in light engineering, sheet metal design and layout of printed circuits.
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3. **A DEVELOPMENT ENGINEER** with experience in design of U.H.F. aerials and amplifiers.
4. **AN ELECTRONIC INSTRUMENT DEVELOPMENT ENGINEER** with broad general experience of both digital and linear techniques.

The above staff are urgently required to deal with a major expansion programme. Our own staff have been fully informed. Exceptionally good working conditions, first class pension and life assurance scheme.

Please apply to Personnel Manager,
LABGEAR LTD., CROMWELL ROAD, CAMBRIDGE
Telephone 47301

2832

Senior Development Engineer

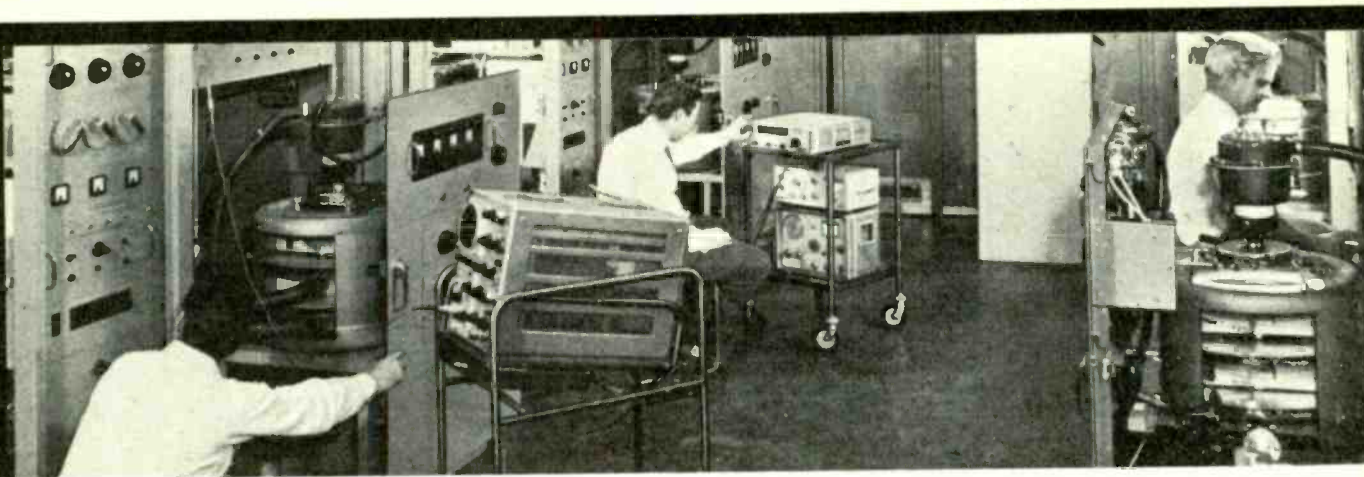
Radio and Audio Products

Kolster-Brandes Limited wish to strengthen the radio and audio section of their Engineering Department by the appointment of a Senior Engineer. He ought to be qualified to HNC or degree level—but experience and ability will impress us equally. Above all, we will be looking for evidence of real achievement, primarily in radio circuit design, and possibly also in the wider field of audio equipment.

Starting salary is likely to be in the range £1,600–£1,900, and conditions of employment are consistent with our standing as a major international company. Generous assistance will be given with re-location expenses.

Concise details of your qualifications and experience should be sent to Miss C. M. Arnold, Kolster-Brandes Ltd., Footscray, Sidcup, Kent.

ITT KB
television and radio



ELECTRONICS ENGINEERS

PYE TVT is a big company in broadcasting equipment and has large outstanding orders with both short- and long-term developments to complete. The continuing expansion has created a number of vacancies for the following competent Electronics Engineers to work on new projects in Cambridge:

Development Engineers, minimum qualification H.N.C. or equivalent, with five years' electronics experience in digital circuitry.

FM/RF Test Engineer with previous experience in FM systems and RF equipment. Applicants with experience of testing communications equipment would be most suitable.

Systems Test Engineers with proven ability in television studio equipment systems, including colour work. Applicants must be familiar with detailed performance measurements using complex and modern test equipment. Minimum requirements are H.N.C. plus five years' experience.

Test Engineers for sub unit testing. Applicants should have good general test experience of power supplies, video amplifiers, pulse circuits and semi-conductor circuits.

Salaries for these key positions in a fast-moving organisation will be above average, and other conditions of employment are excellent.

Apply:
Mr. A. Martin—Personnel Manager,

PYE TVT LIMITED

Coldhams Lane, Cambridge.
Telephone: Cambridge 45115

Government of UGANDA

REQUIRES

BROADCASTING ENGINEERS

To serve on contract for one tour of 21-27 months in the first instance. Salary according to experience in scale Uganda Shg. 21,120-27,780 (£Stg. 1,232-1,620) a year, plus an Inducement Allowance, normally tax free, of £Stg. 778-886 a year, paid direct into a Uganda bank account nominated by the officer. Gratuity 25% of total emoluments drawn. Liberal paid leave. Accommodation provided at reasonable rental. Outfit and education allowances. Free passages. Contributory pension scheme available in certain circumstances.

Candidates must possess the City and Guilds Final Certificate in Telecommunications (with Radio) or an equivalent qualification and have wide practical experience of technical broadcasting equipment including high power M.F. transmitting and studio control equipment. The officer will be required to undertake senior operational duties including the maintenance of broadcasting equipment in transmitting stations and studios; outside broadcasts and recordings in remote districts; and to give assistance with the training of junior engineering staff.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference M2K/690995/WF.

TEST

Right. We have your attention, so you can now forget about the girl.
We are looking for Electronic Testers to work on a wide variety of radio products ranging from the world's most advanced and compact mobile radio equipment to high-powered H.F. transmitters and complex navaids. Duties will include testing, fault-finding and alignment, and in the case of senior positions will include systems test and trouble-shooting work.

The people we are looking for must have previous experience either in industry or the forces and will preferably have passed City and Guilds in telecommunications. The posts will be based either at New Southgate, or at Rickmansworth from where, within the next twelve months, the company will be moving to a new site between Radlett and St. Albans.
Salaries and prospects are excellent.
Write or telephone NOW to:

Tom Anderson, Radio Products Group, Standard Telephones and Cables Ltd.,

STC

Oakleigh Road, New Southgate, N.11
01-368 1234
ext. 2578

RADIO OPERATORS

There will be a number of vacancies in the Composite Signals Organisation for experienced Radio Operators in 1970 and in subsequent years.

Specialist training courses lasting approximately nine months, according to the trainee's progress, are held at intervals. Applications are now invited for the course starting in September, 1970.

During training a salary will be paid on the following scale:

Age 21	£800 per annum
„ 22	£855 „
„ 23	£890 „
„ 24	£925 „
„ 25 and over	£965 „

Free accommodation will be provided at the Training School.

After successful completion of the course, operators will be paid on the Grade 1 scale:

Age 21	£965 per annum
„ 22	£1025 „
„ 23	£1085 „
„ 24	£1145 „
„ 25 (highest age point)	£1215 „

then by six annual increases to a maximum of £1650 per annum.

Excellent conditions and good prospects of promotion. Opportunities for service abroad.

Applicants must normally be under 35 years of age at start of training course and must have at least two years' operating experience. Preference given to those who also have GCE or PMG qualifications.

Interviews will be arranged throughout 1970.

Application forms and further particulars from:

Recruitment Officer, (R.O.3) Government Communications Headquarters, Oakley, Priors Road, CHELTENHAM, Glos., GL52 5AJ

Telephone No. Cheltenham 21491, Ext. 2270

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MINISTRY OF DEFENCE
(ARMY DEPARTMENT)

LECTURER GRADE II

Applications are invited for the post of Lecturer Grade II at the Army School of Signals, Blandford Camp, Dorset.
Candidates should have an honours degree in electrical engineering or physics with an interest in electronics. Candidates with a mathematical degree and interest in computers or the Cambridge Mechanical Sciences Tripos will also be considered. Experience in the use of modern military communications equipment and teaching experience are desirable but not essential.
Salary will be in accordance with the current scales of salary for Teachers in Establishments for Further Education. In addition to salary a special non-pensionable allowance of £365 per annum is payable for the slightly longer teaching year at the school. The appointment is pensionable under the Teachers' Superannuation Acts.

Requests for application form and further information should be made to:

Ministry of Defence (AD), CE3(b), Room 308, Northumberland House, Northumberland Avenue, London, W.C.2

Closing date for receipt of applications—10 days from date of publication

320

UNIVERSITY OF SURREY

Department of Biological Sciences

A SENIOR TECHNICIAN

is required in the HUMAN BIOLOGY section. The Department is about to move into a new building within the University campus at Guildford. This is a recently established section of the Department and offers good opportunities for a person with ability and enthusiasm, who is able to take responsibility in conjunction with the Chief Technician, for the design and development of new ELECTRONIC equipment for research and teaching, and the servicing and calibration of the Department's modern bio-medical electronics.

Staff are encouraged to engage in further studies relevant to the needs of the Department and day release is available for this.

Salary scale for Senior Technician: £1,056-£1,311.

Application forms are available from the Staff Officer, University of Surrey, Guildford, Surrey.

274

Government of MALAWI

requires

TELECOMMUNICATIONS OFFICER

[CIVIL AVIATION]

to serve on contract for one tour of 24–36 months in the first instance. Salary in scale rising to £1905 a year (inclusive of Overseas Addition), point of entry according to experience. In addition, a supplement of £196–224 a year is payable by the British Government direct into officer's bank in U.K. Gratuity 25% if officer completes 30 month tour. Generous paid leave. Furnished accommodation. Education and outfit allowances. Free passages. Contributory pension scheme available in certain circumstances.

Candidates, 25–45, should possess City and Guilds Telecommunication Technician's Certificate (Intermediate) plus at least two "B" year certificates and in addition not less than four years' experience in radio/radar maintenance after serving a recognised apprenticeship or similar training. Applicants lacking formal educational qualifications but with extensive experience can be considered.

The officer will be responsible for the installation and maintenance of telecommunications and radio navigational equipment at airports throughout Malawi.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating, name, age, brief details of qualifications and experience and quoting reference number M2K/681117/WF.

SOUTHEND-ON-SEA MUNICIPAL AIRPORT

RADAR/RADIO ENGINEER

Applications are invited for the above superannuated post from Technicians with experience in the maintenance of 3 c.m. and 10 c.m. Radar, VHF communications and recording equipment and navigational aids. Possession of appropriate City and Guilds or National Certificates desirable.

Salary according to Technical 4/5 Scales, £1,095-£1,540 (under review).

Applications, in writing, giving age, experience and qualifications, should be forwarded immediately to the Airport Commandant, Municipal Airport, Southend-on-Sea, Essex. 334

UNIVERSITY OF BELFAST
Department of Civil Engineering

EXPERIMENTAL OFFICER/ SENIOR EXPERIMENTAL OFFICER

Applications are invited for the post of Experimental Officer/Senior Experimental Officer. The Officer will be responsible for the electronic and electrical laboratory equipment in the Department of Civil Engineering and the design and development of specialised electronic devices for research work.

Applicants should hold a degree in engineering or qualification for corporate membership of a recognised engineering institution.

Appointment will be on the grade appropriate to the applicant's age and qualifications; the respective salary scales (which carry superannuation within the F.S.S.U.) are:

Experimental Officer—£1,120 × 60(6)—£1,480 × 70(1)—£1,550.

Senior Experimental Officer—£1,585 × 80(9)—£2,305 × 85(1)—£2,390 × 115(1)—£2,505 (Bar at £1,825).

Applications, giving full particulars of career to date and the names of two referees, should be sent to: **The Secretary to Academic Council, Queen's University, Belfast, BT7 1NN, by 14 March, 1970.** 316

GEC-Marconi Electronics

Technicians and Engineers for St. Albans and Luton

qualified or not!

Vacancies in all grades

- **VACANCIES** exist for work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.
- **APPLICATIONS** are invited from people of all ages with experience or formal training in electronics and from ex-Armed Services technicians.
- **SALARIES** up to £1,600 negotiable and backed by valuable fringe benefits.
- **RE-LOCATION** EXPENSES available in many instances.
- **CONDITIONS** excellent; free life assurance, pension schemes, canteen, social club.
- **37½-hour,** 5-day, office-hours week.
- **WRITE** or 'phone Personnel Department stating age, details of previous employment, training, qualifications, approximate salary required.

mi **Marconi Instruments Limited**

Longacres, St. Albans, Herts. Tel: St. Albans 59292

Luton Airport, Luton, Beds. Tel: Luton 31441

A GEC-Marconi Electronics Company

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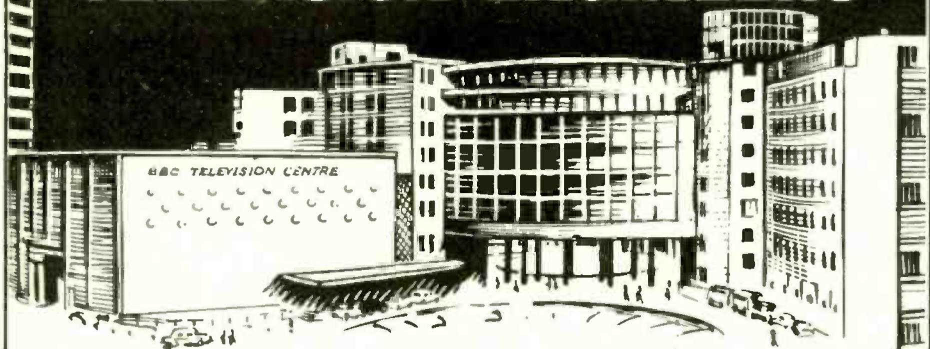
BBC
TELEVISION ENGINEERS



required for the expansion of the

COLOUR tv SERVICE

Do you have one of the following qualifications in electronics:

B.Sc. H.N.C. H.N.D. City & Guilds Full Tech. (Telecomms)?

If so you may be interested in the vacancies we have at our colour television studios at the Television Centre. We require qualified engineers to train in television techniques to work on our new colour studio equipment.

Applicants must have normal colour vision and be normally resident in this country.

Starting salaries in the range £1,175 to £1,609 depending upon experience on the basic grade of OP4. The salary scales are as follows:—

OP4 £1,453 to £1,843 by annual increments of £78
OP5 £1,700 to £2,140 by annual increments of £88
OP6 £1,921 to £2,446 by annual increments of £105

There are engineering grades above this commanding salaries of over £4,000 p.a. Those engineers who are required to work early morning or evening shifts and extra duty may earn from £200 to £300 above their basic salary. Promotion to grade OP5, OP6 and above is by internal competition on merit rather than seniority. There are therefore good opportunities for the progressive engineer to gain rapid promotion.

Write giving age and details of qualifications and experience to:—

The Engineering Recruitment Officer,
BBC Broadcasting House,
London W1A 1AA.

1969

Quoting Reference: 70.E.4004

UNIVERSITY OF CAMBRIDGE
Engineering Department
Electronics Technician

Applications are invited for vacancies in the Electronics Laboratory and Workshop of the Department, covering the manufacture and maintenance of a wide range of instrumentation and experimental equipment. Two posts are available, one on which experience in design and development is essential and the other requiring a skilled valve technician. The maximum salaries in the two posts are £1,548 per annum and £1,266 per annum respectively.

5-day week with $5\frac{1}{2}$ weeks' holiday per year.

Applicants should write in the first instance stating age and experience to the Superintendent of Workshops, Cambridge University Engineering Department, Trumpington Street, Cambridge, CB2 1PZ.

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MEDICAL RESEARCH COUNCIL
TECHNICAL OFFICER (Physics)

A research unit studying the medical effects of environmental pollution reouires a technician to assist in the development of physical and electronic instrumentation and the commissioning and running of a real-time computer system, soon to be installed. The successful candidate will be expected to learn digital computer programming.

Applicants preferably should have experience in electronics and if aged 22 or over H.N.C. or suitable University degree. Minimal qualifications "A" level mathematics and physics.

Salary according to age, qualifications and experience (Technical Officer or Junior Technical Officer grade).

Further details from and applications to: Professor P. J. Lawther, M.R.C. Air Pollution Unit, St. Bartholomew's Hospital Medical College, Charterhouse Square, London, E.C.1.

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ROYAL ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT
MINISTRY OF DEFENCE, Fort Halstead, Near Sevenoaks
ELECTRONICS

Two **ELECTRONIC ENGINEERS** (graded Experimental Officer/Assistant Experimental Officer) are required for work on advanced applications of electronics in the artillery field.

Qualifications and Experience: Degree HNC or equivalent, in appropriate subjects. Several years development experience is necessary in one or more of the following fields: VHF TV, Audio, Control and Digital Systems, including the use of I.C. techniques and other advanced methods. Age: AEO under 28, EO normally 26-30.

Prospects of permanent pensionable appointments. Promotion prospects.

Salary: AEO £940 (at 22)- £1,208 (at 26 or over)-£1,454; EO £1,590-£2,006.

APPLICATION FORMS from the Ministry of Defence (CE2(f)AD), Northumberland House, Northumberland Avenue, London, W.C.2. **Please quote 48/69/G in all correspondence.**

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UNIVERSITY OF ST. ANDREWS
Department of Chemistry

Applications are invited from candidates with an Ordinary Degree, H.N.C. or equivalent qualification in Electronics for a position in the Department of Chemistry. The successful applicant will be expected to assist in the servicing of spectrometers and in the development of electronic equipment. The new chemistry building is equipped with Mass Spectrometers (MS-902 and MS-10), N.M.R. Spectrometers (HA-100 and R-10) and a Decca E.S.R. Spectrometer in addition to I.R. and U.V. Spectrometers.

Salary in the range: £1,090 - £1,465 (Technical Officer); grant towards removal; pension scheme. Applications with the name of a referee should be sent before 15th February, 1970, to the Deputy Secretary, University of St. Andrews, College Gate, St. Andrews, from whom further particulars may be obtained.

288

Government of MALAWI

Posts & Telecommunications Department

requires

SECTIONAL ENGINEER

to serve on contract for one tour of 24-36 months in the first instance. Salary according to experience in scale rising to £1905 p.a. (inclusive of Overseas Addition) plus a Supplement rising to £244 p.a. paid by the British Government direct to officer's bank in the U.K. Gratuity 25% on completion of 30 month tour. Terminal payment in lieu of leave. Furnished accommodation. Free passages. Outfit and education allowances. Contributory pension scheme available in certain circumstances.

Candidates, between 25-45 years, must have specialised training and experience on the maintenance of microwave radio and associated equipment and hold passes in appropriate subjects in the City & Guilds of London Institute examinations or the equivalent.

The officer selected will be responsible for the maintenance of microwave radio route, carrier equipment and V.H.F. radio.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1, for application form and further particulars, stating name, age, brief details of qualifications and experience and quoting reference number M2K/690806/WF.

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UNIVERSITY COLLEGE CARDIFF
Department of Education
COMMUNICATIONS CENTRE
Electronics/Television Engineer

Applications are invited from suitably qualified and experienced persons for the above post. The successful applicant will be responsible for the maintenance of Television and other sound and electronic equipment in the mobile and C.C.T.V. units. He will also be associated with the planning within an expanding department, and with the preparation of teaching equipment in relevant science education courses. Qualifications should include H.N.C. or equivalent, in Electrical Engineering, and the applicant should have had not less than two years experience in sound and/or television engineering.

Salary in the Chief Technician (I) Grade £1,385-£1,578 p.a. Applications should be sent to:
The Registrar, University College, P.O. Box 78, Cardiff, CF1 1XL
by 1st March, 1970, quoting ADV 381/WW

331

UNIVERSITY OF LIVERPOOL

Department of Psychology

Applications are invited for the post of LECTURER in Psychology.

Preference will be given to candidates who have specialised in some aspect of experimental psychology and who have a good knowledge of instrumentation. The department will shortly be moving into a new building, which will provide up-to-date laboratory facilities. The initial salary will be within the range £1,240 - £1,365 per annum according to qualifications and experience.

Applications, stating age, qualifications and experience, together with the names of three referees, should be received not later than 2nd March, 1970, by the Registrar, The University, P.O. Box 147, Liverpool L69 3BX, from whom further particulars may be obtained.

Please Quote Ref.: RV/5658/WW

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GEC-Marconi Electronics

ELECTRONIC TECHNICIANS

Marconi can offer you

Attractive salary. Annual salary reviews
Good working conditions. 37-hour working week
Non-tied housing in a new town
in certain circumstances

At Basildon we have a number of vacancies for technical staff to work on the design and manufacture of specialised electronic test equipment and also on the repair and maintenance of general electronic test apparatus. Applicants should have a good basic knowledge of electronics and have some previous industrial or retail trade experience.

Marconi

THE QUEEN'S AWARD TO INDUSTRY 1966 1967 1968 1969

Please telephone or write for an application form to: Mr. R. McLachlan, Personnel Officer, The Personnel Dept, The Marconi Company Limited, Christopher Martin Road, Basildon, Essex. Phone: Basildon 22822.

A GEC–Marconi Electronics Company

2814

Radio Operators

Your chance of a shore job with good pay from the start!

If you hold a 1st Class Certificate of Competence in Radiotelegraphy issued by the Postmaster General or the Ministry of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic, the Post Office can now offer you a starting salary of £965—£1,215 (depending on your age). Annual rises will take you to £1,650 and there are good prospects of promotion to more responsible and better paid posts.
If you are over 21, write for more details to:

**The Inspector of Wireless Telegraphy,
External Telecommunications Services,
Wireless Telegraph Section (WW),
Union House, St. Martins-le-Grand,
LONDON E.C.1.**

REDIFFUSION

COLOUR TELEVISION FAULTFINDERS & TESTERS

We have a number of vacancies in our Production Test Departments for experienced faultfinders and testers.

Knowledge of transistor circuitry and experience with Colour Receivers together with R.T.E.B. Final Certificate or equivalent qualifications required.

These will be staff appointments with all the expected benefits.

Applications to:

**Works Manager,
Rediffusion Vision Service Ltd.,
Fullers Way South,
Chessington, Surrey (near Ace of Spades).
Phone: 01-397 5411**

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TECHNICAL OFFICER

HOME OFFICE POLICE SCIENTIFIC DEVELOPMENT GROUP

Unestablished vacancy for a TECHNICAL OFFICER GRADE III with knowledge and experience of workshop practice and electronic equipment. The successful candidate will work in the equipment section, which is concerned with assessment, trials and development of a wide range of equipment for police use, and will carry out construction, modification and test work in co-operation with police officers.

The post is based initially in Central London, but the section will move to Sandridge, near St. Albans, later in the year.

Qualifications: Ordinary National Certificate or evidence of an equivalent standard of technical education, together with a five year apprenticeship and at least three years' practical experience.

Salary: £1355 (age 25)—£1485 (age 28 or over on appointment)—£1675.

Applications should be made to the Principal Establishment Officer (T.O.) Room 324, Home Office, Whitehall, London, S.W.1 by 31st March, 1970

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BOROUGH POLYTECHNIC
BOROUGH ROAD, S.E.1

Department of Humanities and Social Studies

TECHNICIAN

required as soon as possible for this expanding department which provides a wide range of courses at undergraduate and professional level.

Duties will include the supervision, maintenance and preparation for use of audio-visual equipment. Some knowledge of such equipment is expected and there are opportunities for further training.

Salary scale: £745-£1,125 per annum, plus £125 per annum London Weighting. Minimum age 21.

Apply in writing to the Secretary, giving details of age, qualifications and experience, and quoting the reference H/T.

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67

ARE YOU INTERESTED IN HI FI? If so, and you have some experience of selling in the Retail Radio Trade, an excellent opportunity awaits you at Telesonic Ltd., 243 Euston Road, London, N.W.1. Tel. 01-387 7467. [21

ASSISTANT EXPERIMENTAL OFFICER required for Department of Chemistry. Salary in range £683-£1,454 per annum. An interest in electronics desirable; duties to be concerned mainly with the maintenance of instruments (such as pH meters, spectrometers, mass spectrometers, etc.) and possibly some design of electronic circuits. Apply in writing, quoting M.10, to Assistant Bursar (Personnel), University of Reading, Reading, Berks. [298

REDIFON LTD. require fully experienced TELECOMMUNICATIONS TEST ENGINEERS and ELECTRONICS INSPECTORS. Good commencing salaries. We would particularly welcome enquiries from ex-Service personnel or personnel about to leave the Services. Please write giving full details to—The Personnel Manager, Redifon Ltd., Broomhill Road, Wandsworth, S.W.18. [26

SENIOR TECHNICIAN/TECHNICIAN required for the construction, development and servicing of an interesting variety of electronic apparatus in modern chemistry teaching and research laboratories. Salary in ranges £1,026-£1,281 p.a. and £743-£1,047 p.a. according to age and experience, plus London Weighting £125 p.a. and possible £30 or £80 qualification allowance. Five day week. Four/five weeks annual leave. Pension scheme. Letters only to Registrar (C/T/ST), Queen Mary College, Mile End Road, E.1, stating which post applied for, age, past and present experience, any qualifications. [304

WE HAVE VACANCIES for Four Experienced Test Engineers in our Production Test Department. Applicants are preferred who have Experience of Fault Finding and Testing of Mobile VHF and UHF Mobile Equipment. Excellent Opportunities for promotion due to Expansion Programme. Please apply to Personnel Manager, Pye Telecommunications Ltd., Cambridge Works, Haig Road, Cambridge. Tel. Cambridge 51351, Extn. 327. [77

Government of ZAMBIA

DEPARTMENT OF CIVIL AVIATION

requires

RADIO ENGINEERS

Salary in scale up to £2590.
Low Taxation.
Tour of 36 months offered.
Generous leave on full salary.
25% End-of-Tour gratuity.

Commencing salary according to experience in scale Kwacha 2736 (£Stg.1596) rising to Kwacha 3216 (£Stg.1876) a year, plus an Inducement Allowance of £Stg.714 a year, payable direct to an officer's U.K. Bank account. Both gratuity and inducement allowance are normally TAX FREE. Free passages. Quarters at low rental. Children's education allowances. Generous leave on full salary or terminal payment in lieu. Pension scheme available under certain circumstances.

Candidates must be under 55 years of age and should possess 8 years' relevant experience following:—

(i) an apprenticeship of 5 years, or
(ii) possession of a Service Trade Certificate, or
(iii) possession of an I.C.A.O. certificate or
(iv) equivalent.

In addition, candidates should have a sound experience of the theoretical principles of and experience in the maintenance of the first two and at least one other of the following groups of communications and navigational aid systems:

1. Medium powered H.F. Transmitters and associated Receivers: Frequency Shift Keying; S.S.B. and D.S.B. Equipment; Medium Frequency Non-Directional Radio Beacons.
2. Low and High Powered V.H.F., A.M. Equipment.
3. V.H.F. Omni range; Automatic V.H.F. Direction Finders. Distance Measuring Equipment.
4. Instrument landing System.
5. Radar X Bank Terminal and P.P.I. Talk Down Equipment.
6. Audio and Remote Control Equipment; Public Address Equipment; Airport Magnetic Tape Recorders; Inter Office Communication; Underground Control Cables; Impulse and D.C. Switching System.
7. Teleprinter Telegraphy (torn tape) and associated Page Printers; Tape Recorders (autoheads); Semi-Automatic Message Switching System.

Duties include the maintenance, overhaul and installation of ground terminal radio communication equipment and navigational aids at Airports and Flight Information Centre.

Possession of a valid driving licence will be an advantage.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1, for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2Z/690315/WF.

327

AUDIO DESIGN ENGINEER

An outstanding opportunity with an attractive salary and the satisfaction of seeing complete equipments through design and production. Candidates should have H.N.C. or equivalent with several years experience in the audio industry.

Electrosonic Limited—Greenwich. 01-858 4784

333

LEC

RADIO & TELEVISION SERVICING RADAR THEORY & MAINTENANCE

This private College provides efficient theoretical and practical training in the above subjects. One-year day courses are available for beginners and shortened courses for men who have had previous training.

Write for details to: The Secretary, London Electronics College, 20 Penywern Road, Earls Court, London, S.W.5. Tel.: 01-373 8721.

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INDEPENDENT TELEVISION NEWS LIMITED

intends to appoint

TRAINEE TELEVISION ENGINEERS

Vacancies exist in the Vision and Sound Engineering Departments for Trainee Television Engineers. Applicants should have a keen interest in the technical problems of Television and have had some practical experience of electronics. They should possess either recognised Engineering Qualifications or "A" levels in science subjects. Training will be provided in the various engineering sections of ITN covering the field of television broadcasting. Where necessary attendance at evening classes will be arranged.

Trainees, who successfully complete their period of training, will be appointed to the permanent staff where benefits include a Pension Fund and Free Life Insurance. Opportunities for promotion to more senior grades will exist.

Salary during the nine months training period will be not less than £782 per annum whilst under supervision, rising substantially on appointment to permanent staff.

Candidates aged 18-25 should telephone or write for application forms:

The Personnel Manager, Independent Television News Limited, ITN House, 48 Wells Street, London, W.1
Telephone: 01 637 2424, Ext. 392

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OXLEY®

MIDLANDS/NORTHERN AREA TECHNICAL SALES REPRESENTATIVE

Company expansion has created a vacancy for a technical representative in the Midlands and part of the northern area of the United Kingdom. The successful applicant will be a person of proven ability with a wide degree of knowledge in the telecommunications and electronics field. Engineering qualifications to H.N.C. standard. Salary will be negotiated according to qualifications and experience. Company car provided; pension fund and life assurance scheme in operation.

Applications, giving details of education, experience, qualifications and salary, together with copies of two references or names and addresses of referees, to be forwarded to:

The Personnel Manager,
OXLEY DEVELOPMENTS COMPANY LIMITED,
PRIORY PARK, ULVERSTON, NORTH LANCASHIRE

287

hi-fi design and development

Rank Wharfedale and H. J. Leak, currently implementing plans which will double the present seven figure turnover within three years, are to expand the Acoustics Section of their Engineering Development Department, which also includes Research, Electronic and Mechanical Engineering Sections, a model shop and drawing office. Creative engineers are required to design and develop for manufacture new high quality loudspeakers and dependent systems, and work on improving the quality of moving coil designs such as the Wharfedale "Denton", "Dovedale III" and Leak "Sandwich" loudspeakers. Recent investigations have covered topics such as the increase of specific output, low colouration diaphragms and loudspeaker suspension terminations.

Candidates should be qualified to HND standard with relevant experience in the electro-acoustic field. A sound education and training in engineering, with a deep interest in hi-fi, is essential.

Salaries will be up to £3,000 per annum; contributory pension, free life assurance. Location – Idle, nr. Bradford. Assistance with removal expenses will be given where appropriate.

Please write, giving brief details and quoting Ref. MA.7519D, to:—

AUDIO VISUAL DIVISION

Deputy Executive Appointments Adviser,
The Rank Organisation Limited,
Millbank Tower, Millbank, London, S.W.1.

The Rank Organisation

The man with the gong – a man of many skills

ELECTRONIC TEST ENGINEERS

Salary up to £1,650 per annum

Test Engineers required for Production Testing of Numerically Controlled Machine Tools. Knowledge or experience of Logic Gating Systems or alternatively, Analogue Circuits and Systems desirable.

Minimum Age 24 years

AUTOLOGIC LTD.

James Estate · Western Road · Mitcham

648-0121

Write, telephone or call Mr. G. A. Boyd

329

ELECTRONICS TECHNICIAN required for new factory at Malvern, Worcs., to assist in the development and construction of electronic instruments and apparatus. Applicants should possess H.N.C. or equivalent and be able to design and construct equipment without supervision. Please apply stating age, full experience ond present salary to Box No. W.W. 322 Wireless World.

RADIO TEST ENGINEERS. Production testing and fault finding on transistorised Audio Amplifiers & FM Receivers. 5-day week. Apply, Chief Engineer, Rogers Developments (Electronics) Ltd., 4-14 Barmeston Road (off Bromley Road), Catford, S.E.6. Tel: 01-698 7424/4340. [22

UNIVERSITY OF SHEFFIELD. Chief Technician required in Department of Chemistry to take charge of Electronics Workshop, concerned with development and construction of new electronic equipment for research and teaching, and maintenance and repair of wide range of electronic equipment. Experience and qualifications. Salary £1,385—£1,578 per annum. Write, stating names and addresses of two referees, to the Bursar (Ref. B.467), The University, Sheffield, S10 2TN. [286

ARTICLES FOR SALE

BRAND NEW ELECTROLYTICS, 15/16 volt, 0·5, 1, 2, 5, 8, 10, 20, 30, 40, 50, 100, 200 mfds. 8d. Carbon Film Resistors ¼ watt 5% E12 Series 10 ohms to 1 Megohm 1/6 dozen, minimum order 7/6, postage 1/-. The C. R. Supply Co., 127 Chesterfield Rd., Sheffield S.8. [299

BUILD IT in a DEWBOX quality plastics cabinet. 2 in. × 2½ in. × any length. D.E.W. Ltd. (W), Ringwood Rd., FERNDOWN, Dorset. S.A.E. for leaflet. Write now—Right now. [76

HOW to Use Ex-Govt. Lenses and prisms. Booklets. Nos. 1 & 2, at 2/6 ea. List Free for S.A.E. H. W. ENGLISH, 469 RAYLEIGH RD., HUTTON, BRENTWOOD, ESSEX. [87

MARCONI Distortion Analyser Type 142E, complete with handbook. Tested and in working condition. Price £30 complete. Contact P. Brooke, Elcom (Northampton) Ltd., Weedon Road Industrial Estate, Northampton. Tel.: 51873. [278

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It may please be noted that offers should reach **Director, Signal and Telecom, Railway Board, Rail Bhavan, Raisina Road, New Delhi, India**, not later than 3 p.m. on 16th March 1970. The offers received will be opened on the same day at 3.30 p.m.

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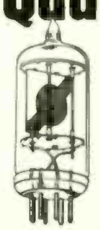

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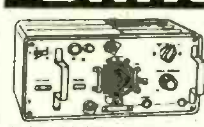

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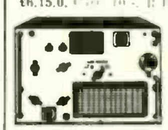

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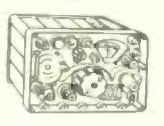

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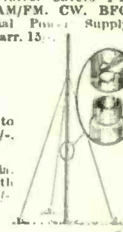

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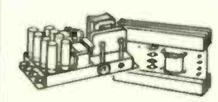

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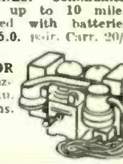

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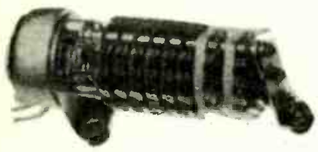

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Type: Moving Coil Galvanometer. Ranges: 1 0·05 to 5 ohms 20·5 to 50 ohms 35 to 500 ohms 450 to 5,000 ohms 5 500 to 50,000 ohms. Scales: switched. Slidewire: 0·5 to 50. Galvanometer Scale: 10-0-10. Case: Moulded plastic. Internal Source: 4 v., dry battery. Operating temperature: + 10 to + 35° C. Operating Humidity: Up to 80% R.H. Dimensions: 200 × 110 × 65mm. Weight: 0·9 kg. List price £25. OUR PRICE £9.19.6.

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Contains "Brown Convertor", for continuous balance system and associated circuit. Complete less valves (5) Brand new .... 50/- P.P. 4/6

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These P.S.U. are transistorised and stabilised, fused and protected output is at 400 mA., 240 v. A.C. Input size 4 × 3 × 2½ in. Ideal unit for building into equipment. Price 75/-. P. & P. 2/6.

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Frequency range 15 KHz to 30 MHz. Eleven bands. Output 0·4 microvolts to 4 volts. 75 ohms impedance. A high quality generator at a reasonable price. First-class condition. Recalibrated up to specification. **£200.**

LANGBOURNE DYNAMICS TYPE 4B

Low Voltage/Highly Stabilised POWER SUPPLY UNIT

Variable between 3-30 v. D.C. at 1 A. Fully transistorised and current limiting offered. BRAND NEW at only £13.10 inclusive of P. & P.

SPECIAL OFFER

"INSULATION TESTERS" TYPE No. 11 METROHM by famous British manufacturer. All solid state. No handles to crank. Runs off 9 volt transistor battery. Simply press button for function. Range 0·1 to 25M ohms for insulation testing. Also 0·1 to 100 ohms for resistance and continuity checking. Clear, concise scale. Small size modern instrument, complete with carrying strap and protecting cover. Offered in good used condition with battery ready to work. For 250 volt pressure only. List Price £19.10.0. Our price **£5.19.6** plus 4/6 post/packing.

AUDIO OSCILLATORS AMERICAN TS-382/U

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BUILD YOUR OWN LOW VOLTAGE PSU

We have a limited number of transformer and rectifier units consisting of good quality transformer with built-in mains selector plug from 110 to 250 v. input. Output 0-17-24-31-38 twice at 2.4 amp + associated control voltages. Complete with full wave bridge rectifiers (BYZ13) one set for each circuit and two TCC 5000 Mfd electrolytic condensers at 70 v. D.C. The components are mounted on two angle formed brackets ready drilled for easy fixing. Offered brand new at only **£4**. Post/packing 10/6. Also transformers only 45/-. Post/packing 7/6.

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HIGH VOLTAGE EHT INSULATION TESTERS. TELEMAX TYPE 115.

Variable EHT output from 1 to 15 Kv. Leakage current 0 to 100 microamps. For A.C. operation. 110 to 250 volts. Cost over £70. Our price, in good used condition, £35.

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40 ohms, 500 watts. Torodial wound on ceramic formers. BRAND NEW high quality units. Size 5 in. dia. Price 35/- each. P. & P. 5/-.

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Power range 0-60 watts in 2 ranges. Impedance 50 ohms. Frequency range to 500 MHz. Type of reception AM-CW-FM. Supplied with small transit case in first class condition.

WE HAVE FULL RANGE OF HIGH QUALITY OSCILLOSCOPES

Offered in FIRST CLASS condition

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Solartron CD513	£47
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Also Scopes by EMI, Marconi, Furzhill, Naggard, Telequipment. All instruments have been carefully overhauled, pre-calibrated and are offered guaranteed condition.

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R. & S. Signal Generator and Klystron P.S.U. Type SMPC. Range 1·7-5000 MHz.

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Digital voltmeters. Digital Frequency Meters to 220 MHz. Digital Wheatstone Bridges. A.C. and D.C. Millivolt meter. D.C. Voltage Calibrators. Precision Crystal Calibrators.

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NEW PRICES ON NEW COMPONENTS

RESISTORS
High stability, carbon film, low noise. Capless construction, molecular termination bonding.
Dimensions (mm.): Body: ¼W; 8×2·8
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Leads: 35
10% ranges; 10 Ohms to 10 Megohms (E12 Renard Series).
5% ranges; 4·7 Ohms to 1 Megohm (E24 Renard Series).
Prices—per Ohmic value.

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¼W	10%	2d.	1/6	3/3	10/4
¼W	5%	2½d.	1/9	3/8	11/8
½W	10%	2½d.	1/9	3/8	11/7
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CAPACITORS
Subminiature Polyester film. Modular for P.C. mounting. Hard epoxy resin encapsulation. Radial leads.
±10% tolerance. 100 Volt working.
Prices—per Capacitance value (µF)

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0·2	1/2	10/-	20/10	68/6

Polystyrene film. Tubular. Axial leads. Unencapsulated ±5% or ±1pf tolerance, 160 Volt Working.
Prices—per Capacitance value (µµF)

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POTENTIOMETERS (Carbon)
Superior grade enclosed controls. Low rotational noise. Body dia., 1in. Spindle, 2in.×¼in. Tolerance, 20%.
Linear: 1K to 2M. (¼W at 40°C).
Logarithmic: 5K to 2M. (¼W at 40°C).

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GANGED STEREO POTENTIOMETERS (Carbon)
¼W at 70°C. Long Spindle.
Logarithmic and Linear: 5k+5k to 1M+1M.

Prices per ohmic value	each	10 off	25 off	100 off
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High quality pre-sets suitable for printed circuit boards of 0·1in. P.C.M. 100 ohms to 5 Megohms (Linear only). Miniature: 0·3W at 70°C. ±20% below ½M, ±30% above ½M. Horizontal (0·7in.+0·4in. P.C.M.) or Vertical (0·4in.×0·2in. P.C.M.). Subminiature: 0·1W at 70°C. ±20% below 2·5M, ±30% above.

Prices—per ohmic value	each	10 off	25 off	100 off
Miniature (0·3W)	1/-	8/9	18/9	66/8
Subminiature (0·1W)	10d.	7/1	14/7	46/8

ELECTROLYTIC CAPACITORS (Mullard.) —10% to +50%.
Subminiature (all values in µF)

4V	8	32	64	125	250	400
6·4V	6·4	25	50	100	200	320
10V	4	16	32	64	125	200
16V	2·5	10	20	40	80	125
25V	1·6	6·4	12·5	25	50	80
40V	1	4	8	16	32	50
64V	0·64	2·5	5	10	20	32
Price	1/4	1/3	1/2	1/-	1/1	1/2

Small (all values in µF)

4V	800	1,250	2,000	3,200
6·4V	640	1,000	1,600	2,500
10V	400	640	1,000	1,600
16V	250	400	640	1,000
25V	160	250	400	640
40V	100	160	250	400
64V	64	100	160	250
Price	1/6	2/-	2/6	3/-

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Tubular 10%, 160V: 0·01, 0·015, 0·022µF, 7d. 0·033, 0·047 µF, 8d. 0·068, 0·1 µF, 9d. 0·15 µF, 11d. 0·22 µF, 1/-. 0·33 µF, 1/3. 0·47 µF, 1/6. 0·68 µF, 2/3. 1 µF, 2/8.
400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, 6d. 6,800pF, 0·01, 0·015, 0·022 µF, 7d. 0·033 µF, 8d. 0·047 µF, 9d. 0·068, 0·1 µF, 11d. 0·15 µF, 1/2. 0·22 µF, 1/6. 0·33 µF, 2/3. 0·47 µF, 2/8.

SEMICONDUCTORS: OA5, OA81, 1/9. OC44, OC45, OC71, OC81, OC81D, OC82D, 2/-. OC70, OC72, 2/3. AC107, OC75, OC170, OC171, 2/6. AF115, AF116, AF117, ACY19, ACY21, 3/3. OC140, 4/3. OC200, 5/-. OC139, 5/3. OC25, 7/-. OC35, 8/-. OC23, OC28, 8/3.

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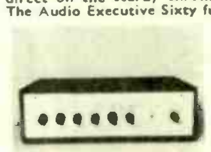

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Damping Factor: 30 (source impedance 0.5 ohm approx.).
Distortion: Total Harmonic Distortion at 1KHz at 60 watts into 8 ohms less than 1%, at 40 watts into 15 ohms less than 0.3%.
Frequency Response: ± 1db 40 Hz to 15 KHz.
Hum and Noise: —70 db.
Sensitivity: Input 1a 15mV Z=50K ohms flat.
1b 1.5mV Z=5K ohms flat.
Input 2a 4.5mV Z=50K ohms RIAA compensated.
2b 200mV Z=100K ohm. flat.
Input 3 200mV Z=100K ohm. flat.
Inputs 1 and 2 and 3 operate simultaneously offering full mixing facilities: choice of either a or b inputs, automatically disconnects the other. Alteration in level from any two inputs on altering the third from zero to maximum is typically —1 db.
Overload Capacity: Input 1 26 db. Input 2 26 db. Input 3 Infinity.
Power Bandwidth: —3 db. (8 ohms) 50Hz—18KHz.
Tone Control: Bass + 13 db to — 16 db at 50 Hz.
Treble + 16 db to — 13 db at 10 KHz.
Filters: —1 db points at 40 HZ and 15 KHz.
Mains Supply: 110, 120, 220, 240v 40-60 Hz.
Input fused at 2A.

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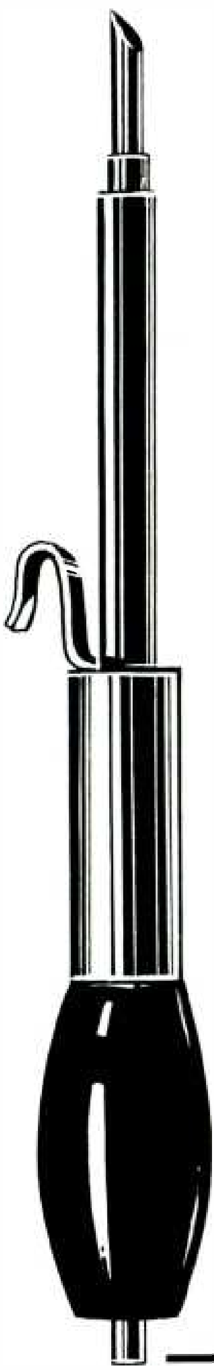

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S.W.G.	INS.	M.M.	FT. PER LB. 60/40	FT. PER LB. SAVBIT
10	.128	3.251	25.6	24
12	.104	2.642	38.8	36
14	.080	2.032	65.7	60.8
16	.064	1.626	102	96.2
18	.048	1.219	182	170
19	.040	1.016	262	244
20	.036	.914	324	307
22	.028	.711	536	508
24	.022	.558	865	856
26	.018	.46	1292	1279
28	.014	.375	1911	1892
30	.012	.314	2730	2695
32	.010	.274	3585	3552
34	.009	.233	4950	4895

STANDARD ALLOYS INCLUDE

TIN/LEAD	B.S. GRADE	LIQUIDUS MELTING TEMP °C.	°F.
60/40	K	188	370
Savbit No 1	—	215	419
50/50	F	212	414
45/55	R	224	435
40/60	G	234	453
30/70	J	255	491
20/80	V	275	527

HIGH AND LOW MELTING POINT ALLOYS

ALLOY	DESCRIPTION	MELTING TEMP. °C.	°F.
T.L.C.	Tin/Lead/Cadmium with very low melting point	145	293
L.M.P.	Contains 2% Silver for soldering silver coated surfaces	179	354
P.T.	Made from Pure Tin for use when a lead free solder is essential	232	450
H.M.P	High melting point solder to B.S. Grade 5S	296-301	565-574

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EXTRUSOL is a new concept in solder for solder machines, baths and pots used in the electronics industry.

EXTRUSOL is a very high purity solder which is also substantially free of oxides, sulphides and other undesirable elements.

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EXTRUSOL can be released under AID authority and conforms with USA QQ-S-571d

ADVANTAGES OF EXTRUSOL

1. Less dross on initial melting
2. More soldered joints per pound of solder purchased
3. Less reject joints
4. Improved wetting of electronic components and printed circuit boards
5. More uniform results

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A section of a typical cast solder bar. Note the surface dross and general contamination.

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