Wireless World

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Stabilized power supply unit
Digital remote control

Wireless World

Electronics, Television, Radio, Audio

Sixtieth year of publication **April 1970** **Volume 76 Number 1414**

This month's cover illustration shows an unusual view of a watchmaker's wheel adopted by Pye to aid the handling of components in the production of small receivers (see p.158).

Contents

IN OUR NEXT ISSUE

Simple high-quality pre-amplifier, having a high input impedance, suitable for radio and ceramic gramophone pickups.

Low-cost horn loudspeaker system

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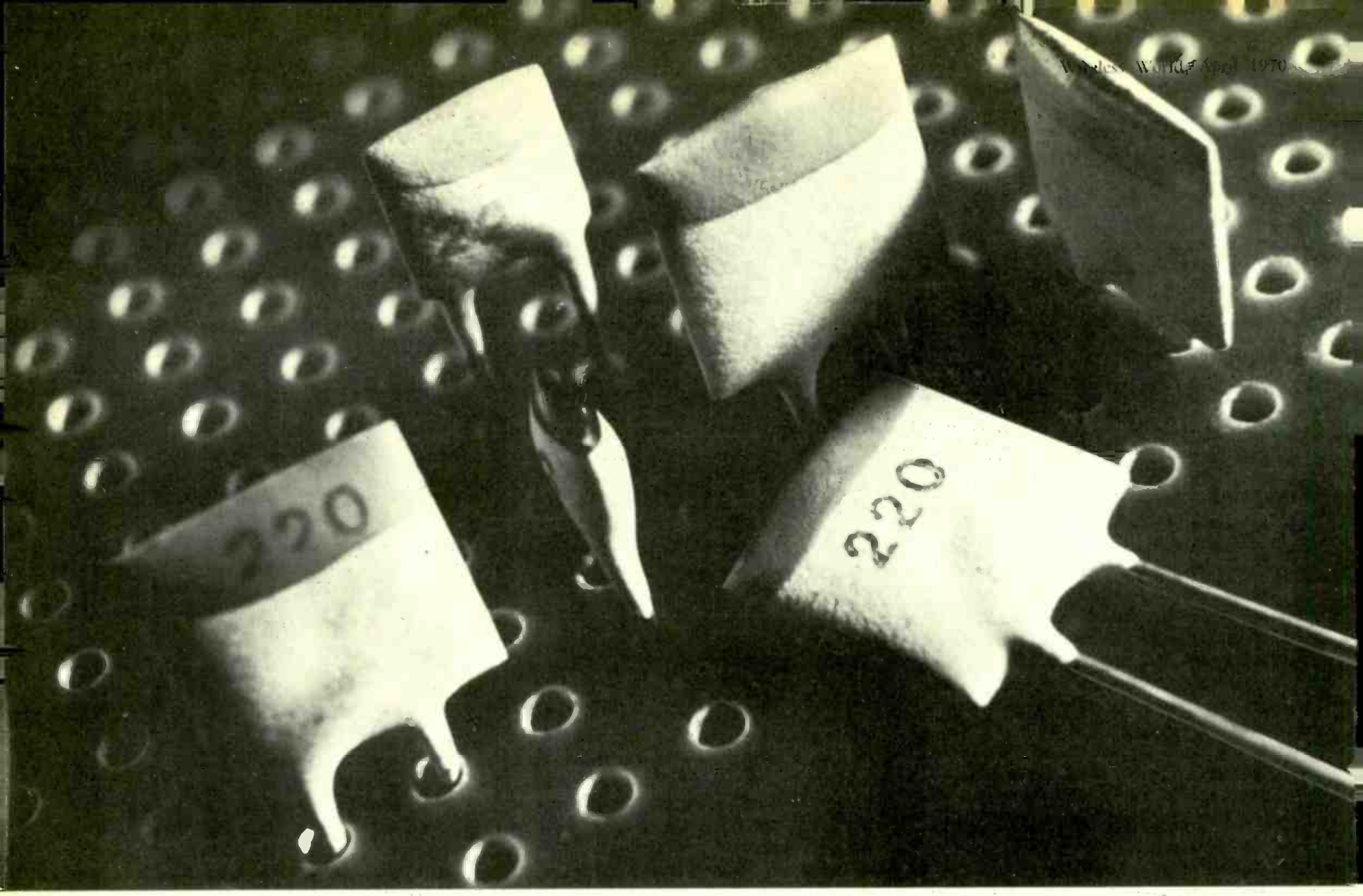

Why we are excited about the C333 range

In these fast-moving days you might wonder why we're excited about a new capacitor range. Well, sales figures tell us that a lot of circuit designers are also enthusiastic about this—the latest Mullard range of miniature plate ceramic capacitors. Setmakers have already ordered them by the million. And, as for us, we were excited about this new range long before we even sold the first one. In case you are not already using these plate ceramic miniature capacitors, let us tell you (enthusiastically) something about them.

They're small. Well, of course. This is the mini age. Naturally, we designed them to fit a 2.45 mm. grid printed circuit board. But we also made them rectangular and thin (2.1 mm. max.). In fact they are no bigger than the winder on your wrist-watch, so that they can pack very closely.

Wide range. This is something to be enthusiastic about. For the first time, circuit designers have available a wide range of low-cost, high stability, close tolerance miniatures to choose from —at low prices. The full range (at present) has 28 values in five sizes from 1.8pF to 330pF (the E6 range). With temperature coefficients between NP0 and N750 the stability of tuned circuits can be maintained over a wide temperature range—this is the C333 series.

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Stability. This is essential for the applications for which these capacitors are intended. We developed materials which would not oxidise or peel in arduous conditions. And a special lacquer coating to protect them in conditions of high humidity. In brief, we designed in high stability and long life.

Tight tolerance. Again, the use of very stable materials and highly automated manufacturing and quality control equipment ensures that every capacitor is held within very close limits—essential for the components used in oscillator and filter stages. The tolerance on every capacitor is within 0.25pF or ±2% —whichever is the greater.

Worth it? Our rising production figures indicate that a good many people think so.

Set designers appreciate that, at Mullard we continue to apply enthusiasm and care to the manufacture of all our devices—discrete components, valves and tubes, and semiconductors. And we continue to produce exciting results.

Materials research, applications research, automated quality production and control—all backed by experience in component manufacture stretching over the history of the electronics industry. All contributed to the quality and performance of this our latest range of capacitors.

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Wireless World

Technology versus Education

Technology is a means towards a better material standard of living. Education is a means towards a better quality of life. The two activities have quite different purposes. Yet they do overlap slightly at the edges, particularly in the field of vocational training. Technology needs and draws upon the resources of educated people: education depends to some extent on technology to provide subjects and stimuli for stretching the human mind.

Perhaps because of this overlap we seem to be getting into a muddle, with passions raised on all sides, about the function of some of our newer universities. The rumpus at Warwick University a few weeks ago, when students uncovered documents revealing an intimate liaison between university authorities and big business, is a case in point. The basis of the trouble seems to be that some students feel the universities are being exploited as outside R & D establishments by "the industrial-military complex". They say that the university authorities have abandoned their independence in return for "industrial-military" gold (or even silver). The rejection of technology (more so than science) by boys at school may stem from some knowledge of this situation, coupled with an association of technology with destruction, and a consequent reluctance to be treated by "them" as "technology fodder".

In electronics, of course, we know that there has long been a close collaboration between industrial firms and certain university departments. At Warwick itself, for example, the School of Engineering Science does research in microwave integrated circuits partly supported by G.E.C.-A.E.I. and Racal (and employees of these firms work in the School). The Wayne Kerr Company has endowed a chair of measurement science at Surrey University. For some years the computer department of Ferranti was almost indistinguishable (in staff and activities) from a section of Manchester University's department of electrical engineering. Mullard Southampton run an M.Sc. "bridging" course in partnership with Southampton University. Brookdeal Electronics sponsor work in the physics department of Reading University and the company's research director is a senior lecturer at the university. . . . And so on. This is all quite openly done—in fact great pride is taken in it—and whether or not it is considered sinister depends on which side of the artificial Arts-Sciences barrier one has been forced to stand. (A barrier, incidentally, which the Open University has knocked down.)

There is perhaps one small thing we can do about the emotional muddle. We may not be able to get rid of hypocrisy, snobbery and prejudices about education but we *can* decide to be honest about the verbal descriptions applied to things. *If* some of the newer establishments are not real universities (note, we are not making assertions about this) then nobody is going to be hoodwinked by the mere fact that they have been called universities. If they are really institutes of higher technology with a few Arts courses tacked on to keep the critics quiet, let them be honest in the way they describe themselves. (The Massachusetts Institute of Technology and, more recently, the Cranfield Institute of Technology are, presumably, proud of their titles.)

Ultimately, education, including *all* universities, must get its money from industry. But, for the good of the spiritual side of us, it is questionable whether this money should be transferred so directly that the philistines—and there are plenty—can insist "he who pays the piper can call the tune". Lord Radcliffe, the chancellor of Warwick University, has said as much himself.

Stabilized Power Supply

A versatile unit which will provide a variable stabilized output voltage with adjustable current limiting or a variable constant current with adjustable voltage limiting

by A. J. Ewins

The stabilized power supply to be described provides not only a fully variable, stable voltage output from 0 to 30 V at a continuous current rating of 1 A, but also a fully variable range of constant currents from 1 mA to 1 A at a maximum voltage of 45 V. In the voltage stabilized mode the constant current network provides current limiting over the same range of currents. In the constant current mode the stabilized voltage network provides voltage limiting from 0 to 30 V.

The power supply departs from convention in that the entire electronic circuitry, except the series regulator transistor, is powered by a separate voltage supply. As a result of this, no transistor, except the series regulator, need have a maximum V_{ce} rating greater than 20 V or a maximum power dissipation greater than 180 mW. This enables the constructor to select the transistors needed for the electronic stabilizing circuitry from the ever growing range of cheap, plastic encapsulated, silicon planar devices.

Although the maximum stabilized voltage provided by the power supply is only 30 V, it can easily be modified to provide an output voltage greater than this; the maximum value being dependant mainly on the V_{ce} rating of the series regulator transistor used. (The 2N3055 has a V_{ce} of 100 V max.) However, it is likely that the maximum current drawn from the supply would have to be reduced since a power dissipation of 100 watts (within the capabilities of the 2N3055) would call for an excessively large heat sink.

Circuit Description

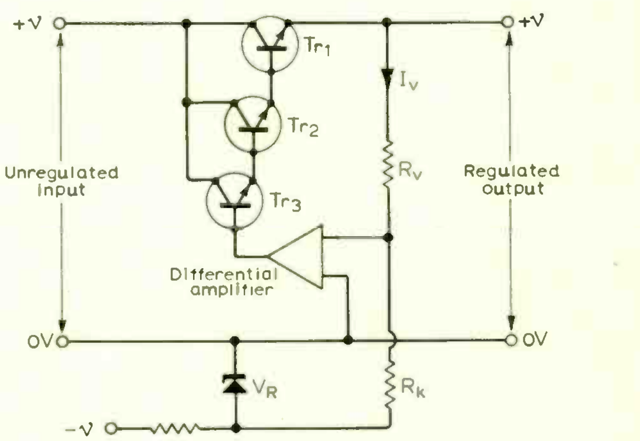
Before proceeding to a description of the circuit it will prove useful to show how the power supply departs from convention. Fig. 1 shows a fairly conventional stabilized power supply circuit. The output voltage, V_o is given by; $V_o = (R_v/R_k) \cdot V_r$ and is directly proportional to R_v if V_r and R_k are kept constant. Keeping R_k constant has the advantage that the sensing current, I_v, drawn by the potential divider, R_v and R_k, remains constant for all output voltages, thus the current through the zener reference diode remains constant also, helping greatly towards the stability of the reference voltage. Looking now at Fig. 2 it will be seen that the circuit is similar to that of Fig. 1 in principle, however, the difference amplifier and the first two transistors of the series regulator triplet, Tr_2 and Tr_3, are now powered by a separate voltage supply. The reference voltage is now a positive one since, due to the rearrangement of the circuit, a negative output voltage (with respect to the zero voltage line) is being regulated.

With this rearrangement of the circuit Tr_2 and Tr_3 do not have to withstand the full unregulated power supply voltage when supplying an output voltage of zero volts, with a consequent reduction in the maximum power dissipation required of Tr_2. If the series regulator, Tr_1, has a current gain of 30 at a collector current of 1 A, then Tr_2 must be capable of supplying 33 mA for a maximum output current of 1 A. In Fig. 1, Tr_2 would have had to have supplied this current at a maximum V_{ce} of about 35 V with a consequent maximum dissipation, when the output from the power supply is 0 V at 1 A, of $35 \times 33 = 1{\cdot}15$ W. In Fig. 2 the dissipation of Tr_2 under similar conditions is:

$$33(V_s - V_{eb1} - 33 \cdot R_s).$$

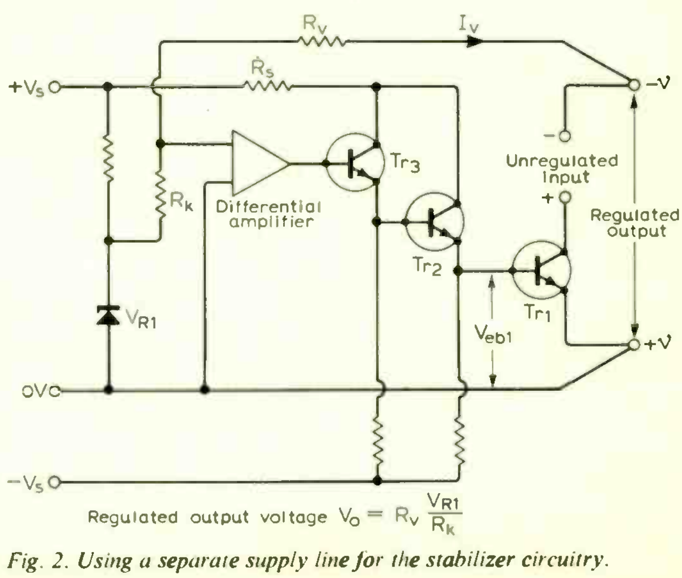
With $V_s = 13$ V (under load conditions), $R_s = 270\,\Omega$ and V_{eb1} of the order of 0·6 V the dissipation in Tr_2 is about 133 mW. However, in Fig. 2, the dissipation of Tr_2 is a maximum when its collector current equals $(V_s - V_{eb1})/2R_s$ which, in the above example, equals 23 mA. Thus maximum dissipation in Tr_2 is 142 mW.

The addition of a number of components in Fig. 3 limits the output current in the event of a short circuit or similar overload. When the output current is less than the value of the limiting current, the current flowing into the base of Tr_3 is controlled by the "voltage" difference amplifier, thus maintaining a stable output voltage. When the current flowing through R_c (which is equal to the output current, I_L, plus I_{b1} and I_v) is such that the voltage developed across R_c is equal to $V_{r1}[R_2/(R_1 + R_2)]$ the "current" difference amplifier takes



Regulated output voltage $V_O = R_V \dfrac{V_R}{R_k}$ $V_O \propto R_V$ if $\dfrac{V_R}{R_k}$ is constant

Fig. 1. A conventional stabilized power supply.



Regulated output voltage $V_O = R_V \dfrac{V_{R1}}{R_k}$

Fig. 2. Using a separate supply line for the stabilizer circuitry.

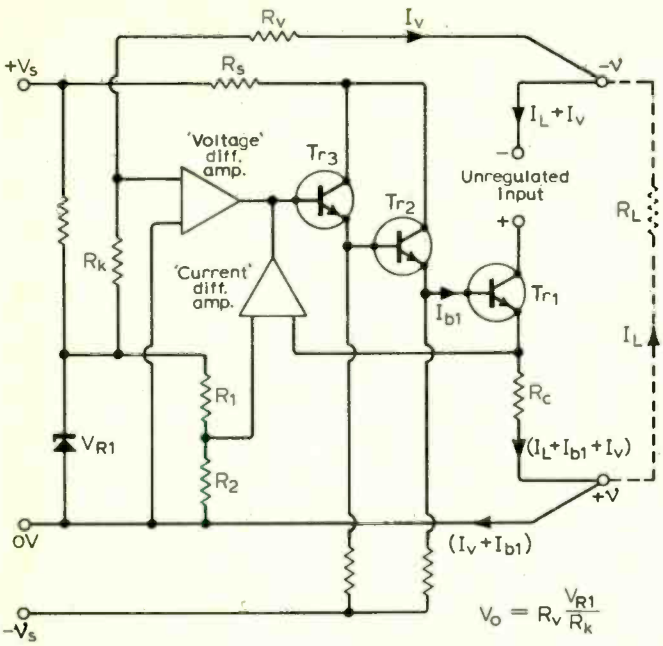


Fig. 3. Adding current limiting.

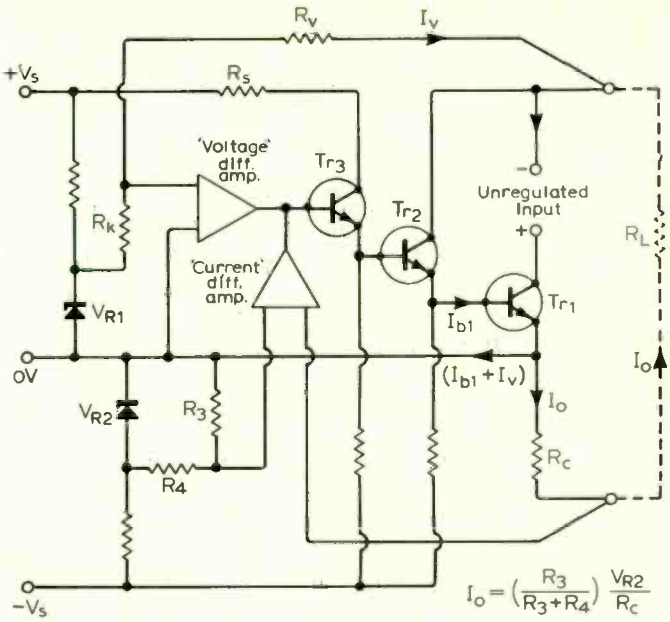


Fig. 4. Using the circuit to supply constant currents.

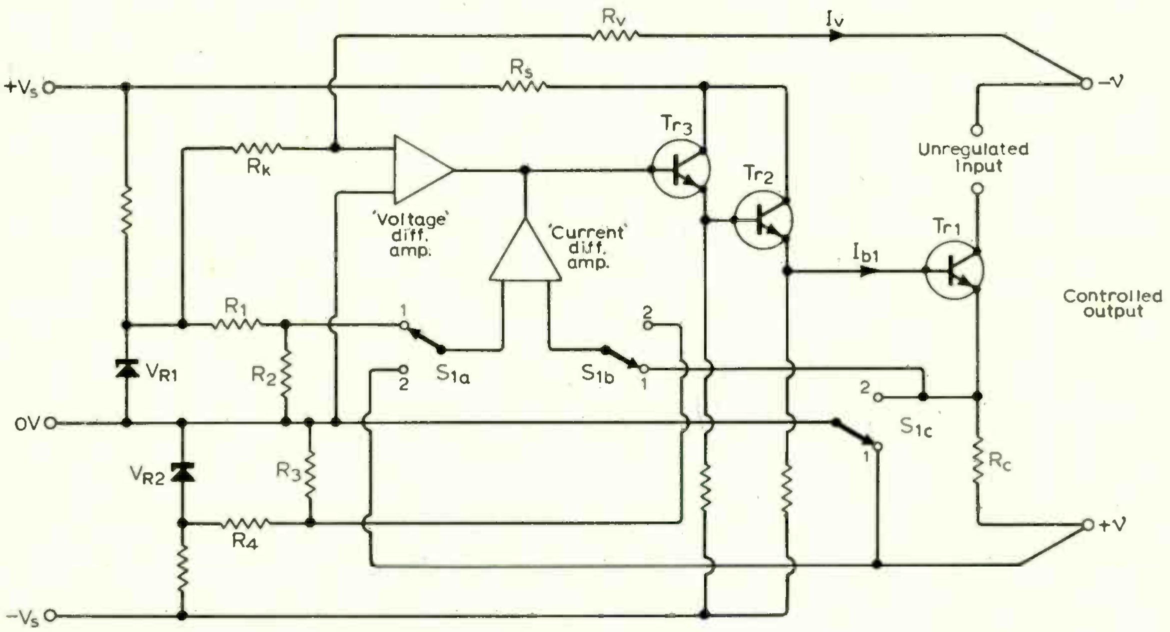


Fig. 5. Combining the circuits of Figs. 3 and 4 to provide a choice between a stabilized voltage output with current limiting or a constant current output with voltage limiting.

over control of the current flowing into the base of Tr_3 with the result that the output voltage is adjusted to maintain a constant current through R_c.

The output current is thus limited to a value given by:

$$[R_2/(R_1+R_2)]V_{r1}/R_c - I_{b1} - I_v$$

now $[R_2/(R_1+R_2)]V_{r1}/R_c$ is equal to the emitter current of $Tr_1(I_{e1})$ and

$$I_{e1} = (\beta_1+1)I_{b1}$$

where β_1 is the current gain of Tr_1. Therefore:

$$I_{b1} = I_{e1}/(\beta_1+1) \quad \text{and}$$
$$I_L = [\beta_1/(\beta_1+1)][R_2/(R_1+R_2)]V_{r1}/R_c - I_v$$

Thus, provided that β_1 is very much greater than 1 and does not vary greatly with the voltage drop across Tr_1, and I_v is very much less than I_L, then I_L is approximately limited to a value:

$$V_{r1}/R_c[R_2/(R_1+R_2)]$$

In order that a range of constant currents may be provided the circuit of Fig. 3 must be rearranged in such a way that the voltage developed across R_c is directly proportional to I_L. Fig. 4 shows such a rearrangement. Whereas, in Fig. 3, R_c was effectively in the emitter line of Tr_1, it is now effectively in the collector line of Tr_1. The currents I_{b1} and I_v do not now flow through R_c and the constant output current, I_o, is given exactly by the expression:

$$I_o = (V_{r2}/R_c)[R_3/(R_3+R_4)].$$

In this circuit, should the constant current fall below the value:

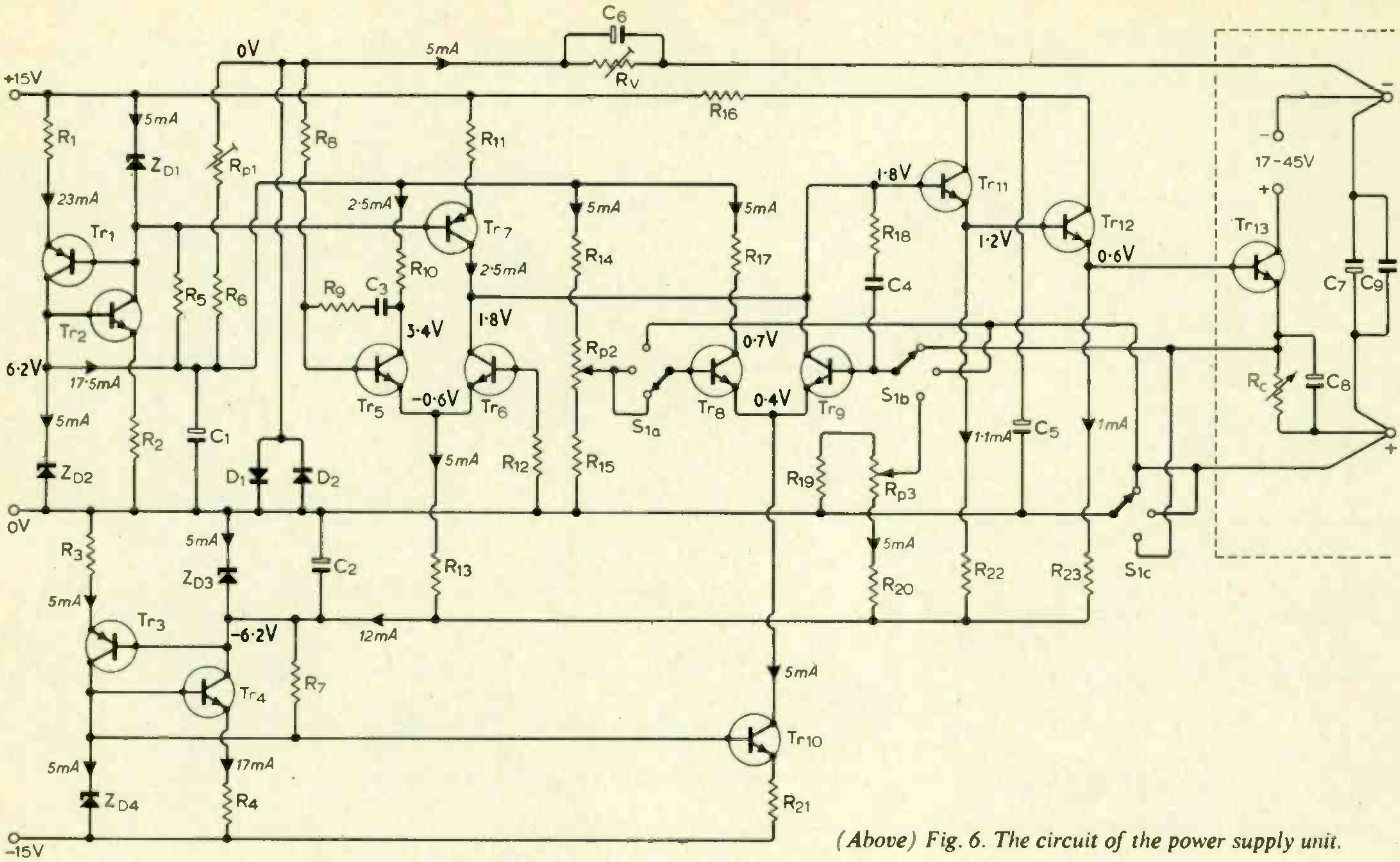
$$(V_{r2}/R_c)[R_3/(R_3+R_4)]$$

the "current" difference amplifier will lose control of Tr_3 base current to the "voltage" difference amplifier. In this event, the output voltage will be adjusted to a value equal to:

$$R_v \cdot (V_{r1}/R_k) - I_L R_c$$

and when the output is open circuited (I_L becoming zero) will be limited to a value $R_v \cdot (V_{r1}/R_k)$.

Fig. 5 is a combination of Figs 3 and 4 and includes the addition of switch S_1 called the "mode" switch. With the mode switch in



(Above) Fig. 6. The circuit of the power supply unit.

position 1 the output voltage is stabilized and the output current limited.

$$V_o = R_v \cdot (V_{r1}/R_k)$$

$$I_L = (V_{r1}/R_c)[R_2/(R_1+R_2)] \cdot (\beta/\beta_1+1) - I_v$$

where $I_v = (V'_o + V_{r1})/(R_v + R_k)$

and $V'_o = R_l \cdot I_L$ is less than V_o

With the mode switch in position 2 the output current is kept constant and the output voltage limited.

$$I_o = (V_{r2}/R_c)[R_4/(R_3+R_4)]$$

$$V_L = R_v(V_{r1}/R_k) - I'_o \cdot R_c$$

where $I'_o = V_L/R_L$, is less than I_o

Fig. 6 shows the electronic stabilizing circuitry of the power supply, as illustrated in simplified form in Fig. 5. The principle of operation is precisely as previously described, but with a considerable amount of circuit sophistication to improve the performance. The transistor pair, Tr_5 and Tr_6, is the voltage difference amplifier and the transistor pair Tr_8 and Tr_9 is the current difference amplifier. The common collector load of Tr_6 and Tr_9 is made to appear very high by employing a constant current source, provided by Tr_7, instead of the usual resistor. Similarly, the emitter load of the current difference amplifier is replaced by a constant current source, provided by Tr_{10}. When switching from the voltage stabilizing mode to the constant current mode the emitter voltages of Tr_8 and Tr_9 vary from +0·4 V to −1·6 V, a change of 2 V. As it is desirable to keep the emitter current at the same value in either mode (for balanced operation of Tr_8 and Tr_9), this could have been achieved by switching in alternate values of emitter resistor. However, providing a constant current source was considered the better (if not cheaper) solution.

The two major reference voltages, V_{r1} and V_{r2}, are provided by the zener diodes, ZD_2 and ZD_3. The currents through these two zener diodes are kept constant because the collector currents of Tr_1 and Tr_4 are constant by design as are the currents flowing away from the diodes. The additional zener diodes used in the reference voltage circuits, ZD_1 and ZD_4, provide stable voltages to the bases of the transistors Tr_7 and Tr_{10}, which, together with their respective emitter resistors, R_{11} and R_{17}, determine the values of the constant currents provided to the collectors of Tr_6 and Tr_9 and the emitters of Tr_8 and Tr_9, as previously described.

The preset resistors, Rp_1, Rp_2 and Rp_3, allow for accurate setting

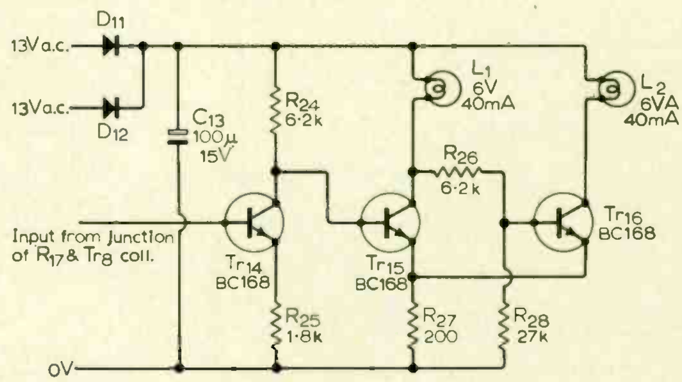


Fig. 7. Overload indicator circuit.

of the voltage, current limiting and constant current ranges.

The silicon diodes, D_1 and D_2, prevent the voltage on the base of Tr_5 from swinging beyond ±0·6 V safeguarding the transistor from possible surges in the output voltage. C_6 reduces the value of R_v to alternating signals increasing the loop gain of the amplifier and thus reducing the ripple content of the power supply. The capacitors, C_3 and C_4, reduce the loop gain of the amplifier at high frequencies, preventing instability. As a result the output impedance of the power supply rises from about 0·01 Ω at 1 kHz to 0·03 Ω at 20 kHz.

It was found necessary to include the resistors R_5 and R_7 because it was discovered that the two reference voltage circuits were not self-starting. Should trouble of this nature still be encountered, a more positive solution is to connect a resistor between the zero voltage line and the negative end of ZD_1 (or the zero voltage line and the positive end of ZD_4) dispensing with R_5 (or R_7). The value of the resistor should be such that the current flowing through it is of the order of 1 mA. This will, naturally, degrade the performance of the reference voltage circuit, but not very seriously.

An additional feature of the power supply is the provision of a current or voltage overload indicator. The circuit of the indicator is shown in Fig. 7. In the voltage stabilized mode, with no current limiting, the collector voltage of Tr_8 is a little above zero volts with the result that lamp L_1 will be normally lit. When current limiting takes place the collector voltage of Tr_8 rises to about 3 V, which is sufficient to turn lamp L_1 off and lamp L_2 on, indicating a current overload. In the constant current mode the operation of the indi-

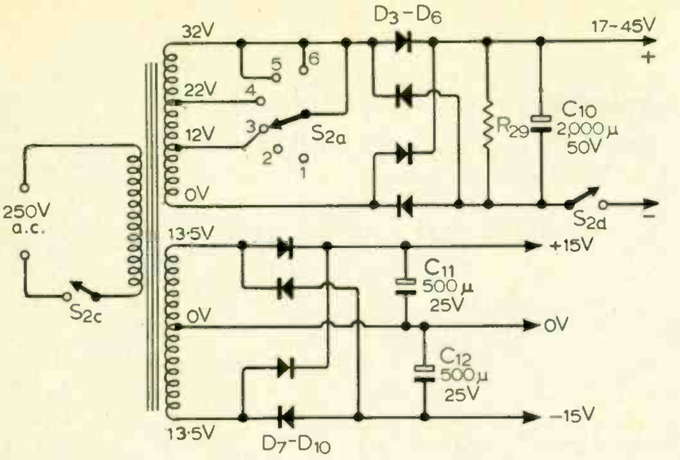
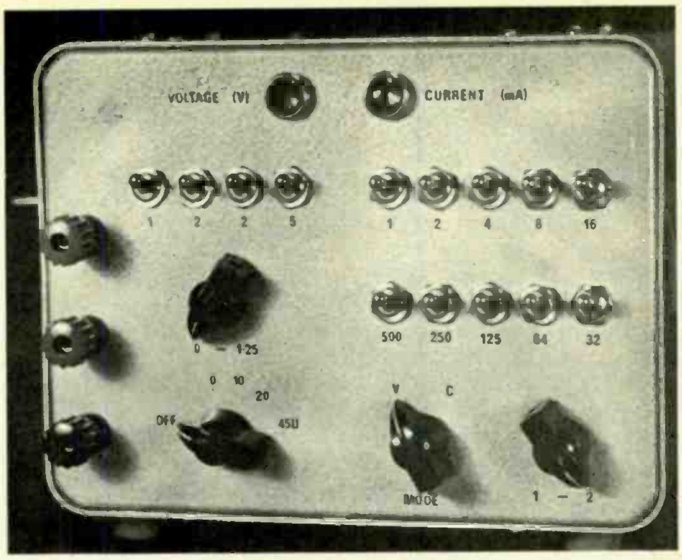


Fig. 8. The d.c. supply circuits.



Front panel of the completed prototype.

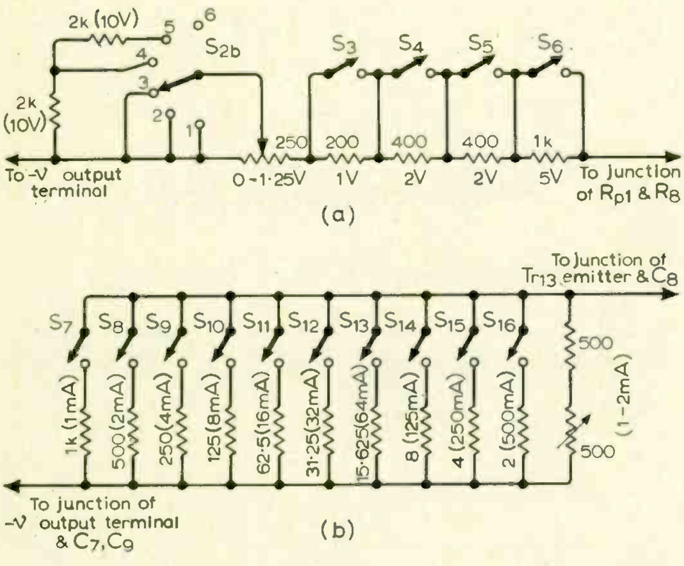


Fig. 9. (a) Construction of R_V; (b) Contruction of R_C.

Specification

Voltage ranges:	0 to 30 V in switched steps of 1 V, plus 0 to 1·25 V fully variable.
Current ranges:	1 mA to 1 A in switched steps of 1 mA, plus 1 to 2 mA fully variable.
Voltage limiting:	Operative on stabilized current output; limits voltage across the external load from 0 to 30 V.
Current limiting:	Operative on stabilized voltage output; limits output current from 1 mA to 1 A.
Setting accuracy:	1% on all switched voltage and current ranges.
Stability:	10% mains variation—less than 0·1% on all voltage and current ranges. Voltage output—no load to full load—less than 0·1%. Current output—0 to 30 V across load—less than 0·1%. Temperature variation—dependent upon temperature coefficient of zener diodes.
Output Impedance:	(Voltage stabilized mode—no current limiting) 0·01 Ω at 1 kHz to 0·03 Ω at 20 kHz.
Voltage ripple:	(Voltage stabilized mode) 2 mV peak-to-peak on full load.

cator circuit is reversed. L_2 is normally on, indicating a constant current output, and goes off, L_1 coming on, when the output current falls below the "constant" value, indicating voltage limiting. Thus, together with the position of the mode switch, the lamps L_1 and L_2 provide an indication of the operating conditions of the power supply. The voltage supply for the circuit of Fig. 7 is taken directly from the two 13·5 volt a.c. tappings on the mains transformer.

Fig. 8 shows the circuit diagram of the two voltage supplies. A word of explanation is necessary about the OFF/ON-Voltage Select switch, S_2. The two wafer banks, S_2(a) and S_2(b) (see Fig. 9(a) are self-explanatory, save the S_2(a) should be a break-before-make wafer and S_2(b) a make-before-break wafer. S_2(c) and S_2(d) are two halves of a mains ON/OFF switch operated by the 6-way rotary switch. The two halves are open in position 1 and closed in positions 2 to 6. The OFF/ON-Voltage Select switch provides the following functions:

(1) All supplies off. (2) Stabilizer circuitry on—unregulated voltage supply off. (3) All supplies on—unregulated voltage output 17 V max. —0 to 11·25 V stabilized output available. (4) Ditto Position 3 except that unregulated voltage output 31 V max.—stabilized voltage output 10 to 21·05 V. (5) Ditto Position 3 except that unregulated voltage output 45 V max. stabilized voltage output 20 to 31·25 V. (6) Unregulated output voltage of 45 V available at output terminals.

The inclusion of position 2 can be better understood by considering what happens when the power supply is switched off. If the power supply is operating with the OFF/ON-Voltage Select switch in position 3, the output voltage will be determined by the position of the four toggle switches and the variable control. On switching to position 2, the unregulated voltage supply is switched off and—depending on the stabilized output voltage set, the size of the external load and the reservoir capacitor, C_{10}—the voltage provided by the unregulated supply will stay above the value of the stabilized output voltage for a short time. However, the stabilizing circuitry is still on so that the stable output voltage, V_o, will be maintained until the voltage across C_{10} falls below a value a few volts greater than V_o. If the stabilizing circuitry was switched off at the same time as the unregulated supply, it would be quite possible for the voltage at the output terminals to rise, for a short time, above the value V_o. As an extra precaution, S_2(d) is included in the negative line of the unregulated supply making it impossible for an output voltage to appear at the terminals when the OFF/ON-Voltage Select switch is finally turned to position 1. Including position 2 also ensures that the stabilizing circuitry is operating before the unregulated supply is switched on, again preventing a possible surge in the output voltage should the stabilizing circuitry fail to control the output level immediately.

Fig. 9(a) shows the construction of R_v as used in the prototype power supply. The sensing current, I_v, flowing in the voltage feedback line was designed to be 5 mA. Thus the resistance of R_v is 200 Ω/V.

Fig. 9(b) shows the construction of R_c. For current limiting and the constant current supply, the voltage across R_c is stabilized at 1 V (it is, in fact, a little higher than this when current limiting because the current flowing through the external load is fractionally lower than that through R_c). The limiting and constant current values are thus determined by dividing 1 V by R_c. Thus I_L and I_o equal $1/R_c$. Switching the ten individual values of R_c in and out provides a range of currents from 1 mA to 1 A. An additional fully variable range from 1 mA to 2 mA is provided by a wire-wound variable resistor connected in series with a fixed one of the same value.

The methods of constructing R_v and R_c have already been discussed but a word about the components may prove useful. 1%, high-stability, carbon resistors of 1 watt rating were used for all the standard values of resistance. The "odd" valued resistors were 1%, wire-wound, 1 watt types, available, to order, from the Planet Instrument Co., 25(E) Dominion Avenue, Leeds, 7.

The mains transformer used was a Douglas, type MT.3AT with rewound secondaries. The original secondary, 0–30 V, multi-tapped and rated at 2 A was removed, carefully noting the number of turns per volt. One secondary, providing 0–12–22–32 V at 1 A, was wound using 19 s.w.g. enamelled copper wire; the other secondary was wound using 33 s.w.g. enamelled copper wire to provide 13·5–0–13·5 V at 50 mA.

The two transistor pairs, Tr_5 and Tr_6, and Tr_8 and Tr_9, of the "voltage" and "current" difference amplifiers were mounted in individual heat-sinks, constructed from $\frac{1}{2}$" × $\frac{1}{4}$" brass bar, to improve the long-term stability of the power supply.

The series regulator transistor, Tr_{13}, was mounted on a large, finned heat-sink attached, on the inside, to the back of the power supply cabinet.

Components List

Resistors

The prefix *R* and the suffix Ω has been omitted from components in the list below for clarity.

1—160	2—1·1 k	3—1·1 k	4—240
5—560	6—1·1 k	7—560 k	8—680
9—1·1 k	10—1·1 k	11—1·5 k	12—680
13—1·1 k	14—1 k	15—180	16—270
17—1·1 k	18—1·1 k	19—180	20—1 k
21—820	22—6·8 k	23—6·8 k	24—6·8 k
25—1·8 k	26—6·2 k	27—200	28—27 k

29—2·2 k, 1 W, 10%
all 0·25 W, 5%, carbon except where shown

p1—200 p2—50 p3—50
wirewound preset potentiometers

Capacitors

The prefix *C* has been omitted in the list below

1—25 μF, 12 V working electrolytic
2—25 μF, 12 V working electrolytic
3—0·001 μF disc ceramic
4—0·001 μF disc ceramic
5—8 μF, 25 V working electrolytic
6—8 μF, 25 V working electrolytic
7—50 μF, 50 V working electrolytic
8—25 μF, 12 V working electrolytic
9—0·1 μF, 250 V working polyester
10—2,000 μF, 50 V working electrolytic
11—500 μF, 25 V working electrolytic
12—500 μF, 25 V working electrolytic
13—100 μF, 25 V working electrolytic

Semiconductors

The prefix *Tr* has been omitted in the list below

1—2N4289	10—BC 168
2—BC 168	11—BC 168
3—2N4289	12—BC 168
4—BC 168	13—2N3055†
5, 6—BC 109*	14—BC 168
7—2N4289	15—BC 168
8, 9—BC 109*	16—BC 168

* matched pairs
† must have a minimum gain of 30 at 1A

The prefix *ZD* has been omitted in the list below

1—4·3 V, ZB4·3	3—6·2 V, ZB6·2
2—6·2 V, ZB6·2	4—4·7 V, ZB4·7

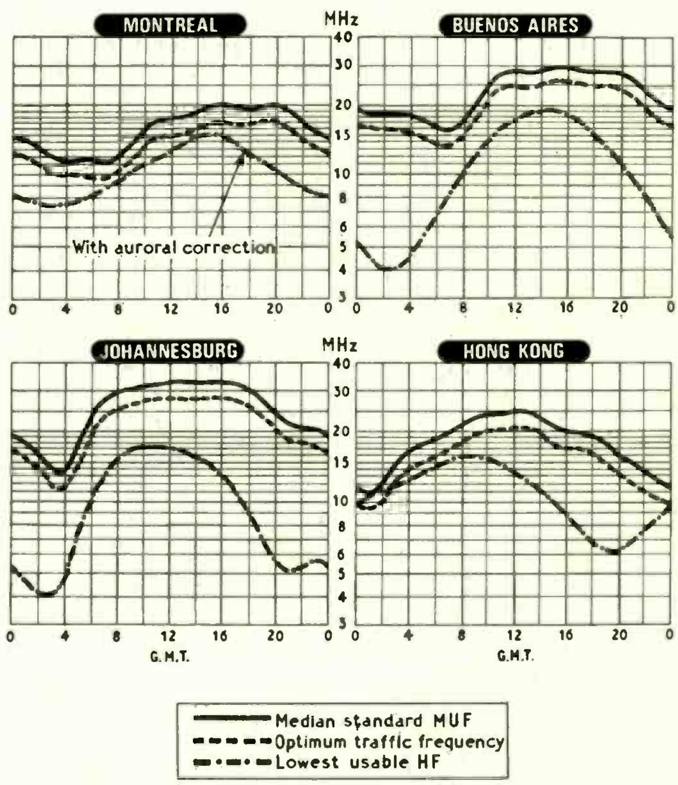
all 250 mW. S.T.C. type numbers shown

The prefix *D* has been omitted in the list below

1, 2—any silicon diode
3 to 6 any diode rated at 1 A, 100 p.i.v.
7 to 12—any diode rated at 100 mA, 40 p.i.v.

Mains Transformer: secondaries
0–12–22–32 V at 1 A
13·5–0–13·5 V at 50 mA
(see text)
6-pole, 6-way rotary switch plus mains ON/OFF switch (see text)
3-pole, 3-way rotary switch
Cabinet type-Y. G. W. Smith and Co. Ltd.
Resistors and toggle switches for constructing R_V and R_C (see text)
Two 6 V, 40 mA bulbs
Plugs, sockets, Veroboard, heatsink (4" × $4\frac{5}{16}$"), etc.

H.F. Predictions—April



The predictions are based on an ionospheric index of 96, the corresponding sunspot number being 83. These are slightly lower than the observed values for 1968 and 1969.

The trans-equatorial paths have their highest MUFs during equinox months and conditions should be good above 20MHz. Evening fading is relatively independent of season and cycle on the South African route but is worse during this period on others. The Far East will have weak unstable signals from midnight to 09.00 G.M.T. and North America will be liable to several days of weak signals from 06.00 to 16.00 G.M.T. The MUFs shown apply to both directions of the route while LUFs are for reception in the U.K. only.

Low-angle Radiation

Describing how long-distance propagation can be improved by exploiting the natural terrain

By L. A. Moxon, B.Sc., M.I.E.E.*

Since first hearing transatlantic morse signals in the early years of short-wave radio, the author has been fascinated by communication over long distances using low-power. This interest has been maintained by the frequent emergence of new and intriguing problems. In particular, by the discovery, when resuming amateur activities after the war from a new location, that communication was easy with Australia but almost impossible with anywhere else. Further, when Australian signals were at their best South Americans were usually weak or absent, clearly inconsistent with the usual theory of long-distance propagation by means of multiple earth-ionosphere reflections.

These mysteries were resolved by a process which stressed not only the importance of low-angle radiation, but also the need for more information on what constitutes a "low angle". A study of two medium-length east-west paths[1] has concluded that for these paths angles as low as 1 deg. are desirable, but for the most part quantitative data is in short supply.

Recent speculation[2] has suggested dramatic possibilities from the use of very low angles of radiation, perhaps even less than 1 deg., and it was with somewhat similar ideas in mind that a low-power (1W output), transistor s.s.b. transceiver was designed and built, light enough to be carried complete with aerial system up steep mountainsides.

*Amateur station G6XN

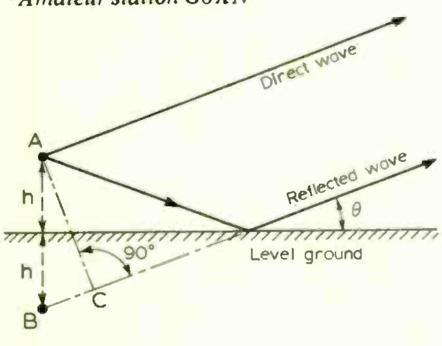


Fig. 1 When a horizontal aerial is erected at a height h over level ground, its image B is an antiphase. The direct and reflected waves are in phase at a distant point when BC = $\lambda/2$, i.e. when $2h \sin \theta = \lambda/2$ where θ is the angle of radiation.

It was hoped in this way to achieve efficient radiation at the desirable low angles whatever these might be, by exploiting natural ground features. An earlier exercise, complementary to this, was aimed at maximising the low angle radiation obtainable from a flat site with limited aerial heights, accepting the inevitable low efficiency and consequent need for relatively high power, to produce a given signal level.

On the basis of these experiments, and such information as can be found in the literature, solutions have been sought to the following problems:

(a) How to select the best site for an h.f. aerial, for communicating with low power over distances of 3,000 miles or more.

(b) How to make the best use of a given site.

The discussion which follows does not necessarily apply to commercial h.f. circuits for which 24-hour availability is likely to be more important than good results over shorter periods.

Avoidance of cancellation

The difficulty of achieving low angles of radiation arises from cancellation of the direct signals by the ground-reflected wave as shown by Fig. 1. This can, in principle, be prevented by one or more of the following procedures:

(a) Using a high mast so that the path difference for the two rays is $\lambda/2$, which then add in phase giving 6dB gain relative to free-space propagation. For 14 MHz and a radiation angle of 1 deg. this requires a mast height of 1,000ft, which is unlikely to be popular with the neighbours.

(b) Using a steep ground slope, as in Fig. 2. If the slope is 45 deg. a height of only 25ft is required at 14MHz to bring the direct and reflected waves into phase. This height is not critical and only 3dB is lost by dropping the height to 12ft 6in. or raising it to 3ft 6in. Moreover, there is the advantage of a single broad lobe in the vertical plane, whereas a large height as in Fig. 1 produces an interference-pattern with lobes and nulls alternating at 1 deg. intervals. The best angle of radiation is not necessarily always the lowest, and the optimum may well coincide with a null. So far all this is well known, but most references overlook the fact that the slope has to end somewhere. As first pointed out by Norton and Omberg[3] this has important consequences, of which more later.

(c) With vertical polarization and perfectly-conducting ground, the phase of the reflection coefficient is reversed and efficient low-angle propagation is achieved independently of aerial height. This can be approximated by laying down a conductive earth-mat of sufficient extent. A beam aerial designed on this principle[4] has been found to operate under radio conditions which render conventional equipment useless. The installation uses an earth mat 1,800ft long and 832ft wide, containing 25 miles of copper wire. Such a system is obviously beyond amateur resources, but sea-water is sometimes available and is a good-enough conductor to act as a useful (though not ideal) substitute.

(d) With vertical polarization and imperfect ground there is a "pseudo-Brewster angle", below which the phase of the reflection coefficient is reversed, so that for low angles and moderate or large aerial heights there is little to choose between vertical and horizontal polarization. In the vertical case, however, the reflection coefficient is less than unity so that cancellation is imperfect and some low angle radiation takes place, however, low the aerial. This principle has been exploited to produce a very effective, cheap and easily-erected beam for 7MHz, as described later.

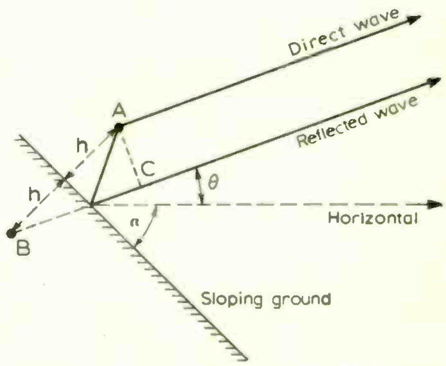


Fig. 2 With the aerial at a height h above ground sloping at an angle α, the direct and reflected waves are in phase when $2h \sin(\alpha + \theta) = \lambda/2$. For small values of θ this becomes $2h \sin \alpha \approx \lambda/2$. This diagram is identical with Fig. 1 except for rotation through the angle α, and the increased ground angle.

Fresnel zones

Figs. 1 and 2 are oversimplified to the extent that reflection takes place not from a point but from a Fresnel zone which is defined by the fact that reflections from all parts of it tend to add in-phase.

Formulae for the sizes and required degrees of flatness of these zones are to be found in the literature[3,5]. The size of the zone for the previous example based on Fig. 1 is very large, the near edge being at 2½ miles range, and the far edge (ignoring earth curvature) at 85 miles. As the height is reduced and the angle of maximum radiation relative to the ground increases, the corresponding Fresnel zone contracts with the far edge moving in roughly as the inverse square of the angle.

For the example based on Fig. 2 the "near edge" is 25ft behind the aerial and the far edge only 175ft down the slope. The shape is elliptical, its effective width being roughly 5 times the aerial height, and the ground need not be particularly flat. Obstacles with dimensions up to about a quarter of the aerial height are acceptable. Very long distances to the far edge (as in the first example) are reduced somewhat when due allowance is made for earth curvature[3].

Double reflections

Discussion so far has been concerned with situations which may seem ridiculous, since amateur resources have been implied and angles of 1 deg. assumed. Even if the angle is increased to 5 deg and a loss of 3dB accepted, the Fig. 1 situation would require a 100ft mast, and bottomless slopes exist only in mythology or mathematical fiction.

In practice, however, the steep slope is quite likely to sweep down like the Mountains of Mourne, or even Mull where the author conducted some experiments, to the sea, as illustrated by Fig. 3. A flat plain, however, is also a possibility and will serve equally well for the next part of this discussion.

It will be seen that there are now four waves to be considered, including two single and one double reflection, and if all these can be made to add up in phase there is a possibility of obtaining not 6 but 12dB gain compared with free-space propagation. This may appear complicated, but resolves quite simply into a practicable combination of the two situations which have just been criticised as absurd; 6dB gain being obtained from each of them.

For numerical consistency with the previous examples there is required only a sloping patch of mountainside extending for at least 25ft above and 175ft below the aerial. It should be centred on 1,000ft altitude with an unobstructed view of the sea, of which the nearest visible point should be not more than 2½ miles away.

Since the mountain is, in effect, being used as a "tall mast", however, this entails the penalty of a multiple-lobe radiation pattern in the vertical plane (as in the case of Fig. 1 with a tall mast). So that if the appropriate angle of radiation happens

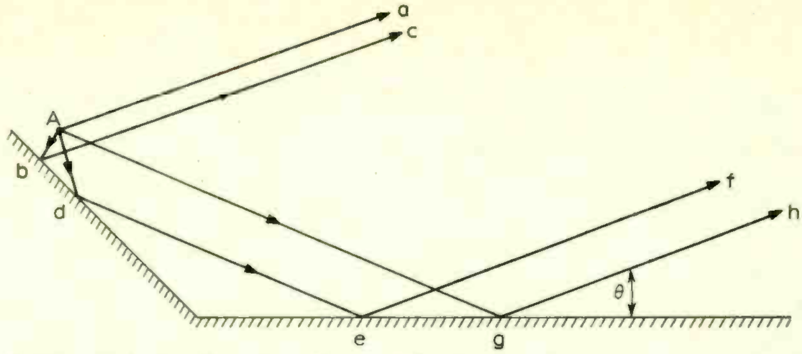


Fig. 3 Ground sloping down into the sea. The direct wave Aa, foreground reflection Abc, distant reflection Agh, and double reflection Adef add in phase if θ is small, $hg \approx \lambda/(4 \sin \theta)$, $h_s \approx \lambda/(4 \sin \theta)$, these being the heights of A above ground and sea respectively.

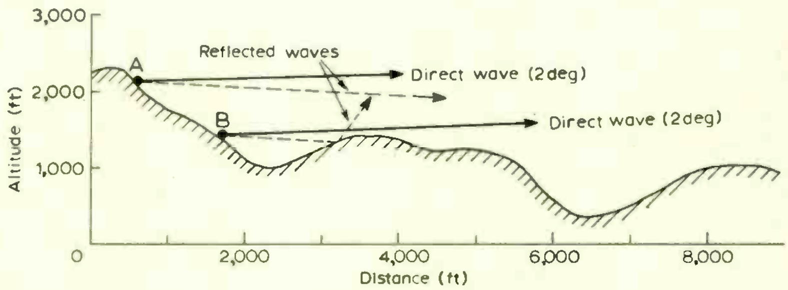


Fig. 4 Typical ground profile for mountainous country. Distant low-angle reflections are non-existent for transmitter at B, and probably unimportant (due to break up of Fresnel zones) for transmitter at A. In both cases low-angle reflections (not shown) are obtained from the foreground. (Isle of Mull, grid ref. NM 568332 bearing 104 deg.)

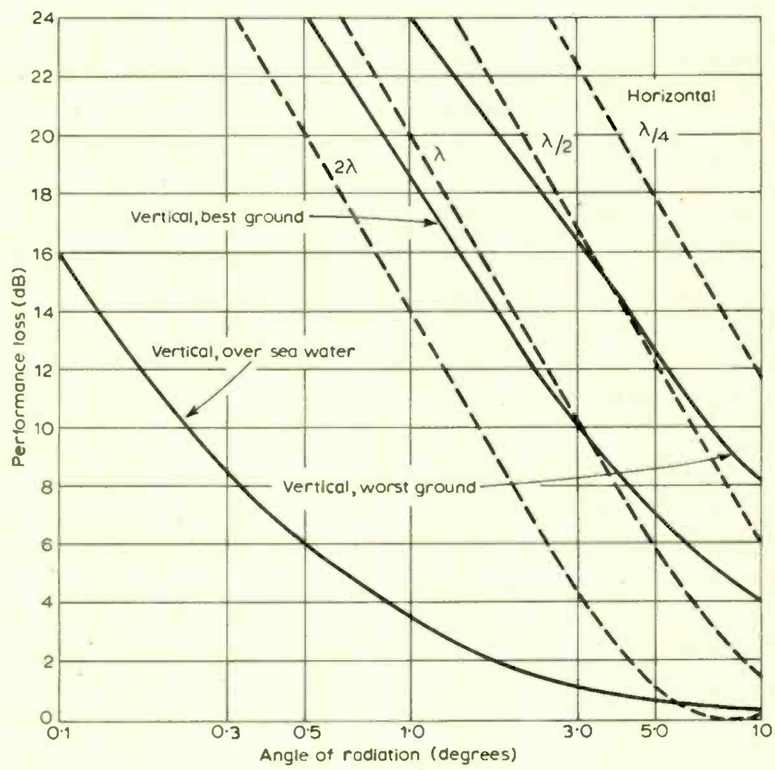


Fig. 5 Comparison of short horizontal and vertical radiators at h.f. assuming flat open country. "Zero loss" occurs with in-phase addition of the direct wave and a reflected wave of equal amplitude. Aerial heights are indicated in wavelengths for horizontal polarization (dotted curves). Vertical polarization curves are calculated for low height and a frequency of 7MHz; performance deteriorates slightly as frequency increases.

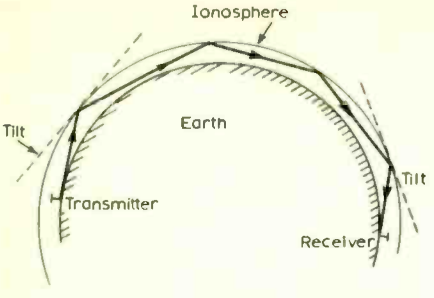


Fig. 6 Chordal hop. At the first and last reflection points, the ionosphere behaves as if tilted slightly towards the terminals. For tangential radiation (i.e. zero deg.), and tilt, however small, prevents a return to earth until a tilt of opposite sign occurs. (Ionosphere not to scale.)

to be not 1 deg. but 2 deg. signals will be almost completely cancelled and even if the operator were aware of this he would scarcely relish the idea of moving the aerial down 500ft to put the matter right. He might even prefer to sacrifice the 6dB gain obtainable from the sea reflection. But at this point it becomes appropriate to consider the situation sketched in Fig. 4.

Locations such as this are usually easier to find than those corresponding to Fig. 3 and it will be noticed that the distant reflecting areas are either blocked off by the foreground or badly broken up, thus failing to meet the required specification for the Fresnel zones. If the distant reflections are sufficiently reduced, Fig. 2 becomes after all a valid representation for the practical case and low-angle radiation should then be obtained with a gain of 6dB relative to free-space propagation.

Neglecting diffraction, this would be true for angles of elevation down to zero, assuming an aerial height of, say, 0.7 λ above any 45 deg slope 200ft in extent. For a 15 deg slope an aerial height of 2 λ and an extent of 1,800ft would be needed for the same result, but these dimensions are not critical and could probably be halved without serious loss of performance.

Polarization

With sloping ground horizontal polarization is preferable, because in the vertical case efficient use of the reflected wave is usually prevented by the Brewster-angle effect, tilting of the image, or both. In the case of flat ground, the best choice of polarization depends on the available aerial height, soil characteristics, and frequency.

Fig. 5 has been calculated from handbook data for vertical aerials above various types of ground[9] and on the basis of Fig. 1 for horizontal aerials at various heights. This provides a rough comparison between different aerials for given angles of radiation and soil conditions assuming, in the vertical case, heights low enough for the effect illustrated by Fig. 1 to be negligible.

In using these curves two points should be noted. Where horizontal polarization appears to be better, equally good results could usually be obtained with vertical aerials by raising them to the same height. The vertical aerial is then likely to be the more difficult of the two to support and feed. On the other hand height is usually the main problem in aerial construction. Horizontal supporting wires for vertical elements can be used to provide end-loading which allows considerable reduction of vertical length and, therefore, height.

Although the useful energy radiated per element is rather small, it is often easier at the lower frequencies to construct, say, a 5- or 10-element vertical array in this manner than to put up a horizontal dipole at a height which would give comparable performance.

Fig. 5 shows the possibility of radiation at 0.5 deg. elevation with a loss of only 6dB by using vertical aerials surrounded by sea water, which may appeal to amateur enthusiasts with portable transceivers and a preference for paddling rather than mountain climbing.

Experimental results

The good results at 14MHz in the direction of the long path to Australia mentioned earlier, were attributable to a steep ground slope (22 deg.) in that direction. Aerial height was only 23ft which was adequate for the down-slope direction, but resulted in poor propagation in the opposite direction even for short ranges.

The use of a full-wave dipole, later backed by reflectors, produced a narrow azimuthal pattern, thus discriminating against directions other than towards Australia. Comparative tests were carried out over several years with the cooperation of numerous Australian stations plus a local amateur (G3DVM), whose location was more conventional, his aerial being located at a height of λ/2 over flat ground.

Comparative reports, allowing for power differences and assuming 6dB per S-point, usually indicated an advantage of about 8dB in favour of the author's location and aerial system. Referring to Fig. 5, the loss for 6 deg. elevation at G3DVM would be 10dB, and a loss of 2dB would be applicable to G6XN for the same angle, which would, therefore, be the "most probable". It was noticed, however, that quite often the path remained open longer at G6XN with signal-strength differences reaching 20dB or more. This would be consistent with radiation angles in the region of 1-2 deg. On other occasions the advantage in favour of G6XN almost disappeared, suggesting angles in excess of 10 deg.

It is interesting to note that good conditions on the long path to Australia occur when the path is mainly in darkness, and complementary ionospheric tilts might be expected at each end of the circuit due to the darkness-daylight transition. This leads to the chordal hop mode of propagation first described by Albrecht[6,7] depicted in Fig. 6, in which waves travel by successive F-layer reflections without intermediate ground reflection.

Note that the lower the angle at which the ray strikes the ionosphere, the less likely it is to be reflected back to earth. Similar modes of propagation occur frequently on other long-distance paths especially north-south paths[8]. Because of reduced D-layer absorbtion and ground-reflection losses, these modes tend to produce very high signal levels over very long paths.

Tests with the portable s.s.b. transceiver have been carried out from steep ground slopes, using an inverted-V dipole having its centre propped up to a height of 20-25ft and about 1W of peak r.f. power. Attempts to communicate with Australia over the long path were made from six different locations having features typified by Figs. 3 or 4, with success in every case. The inverted-V dipole when erected over ground sloping at angles of 30-40 deg. appeared roughly equivalent to a Quad aerial at the home location erected at a height of 50ft, although direct comparison was not possible.

This result is consistent with the previous estimate of a 6-deg. angle of radiation since, from Fig. 5, a loss of 7½dB would be expected for the Quad despite its greater height, but this would be offset by an estimated 6dB or so of aerial gain. Insufficient results have so far been obtained to establish the practical advantage, if any, of using distant as well as foreground reflections on the lines of Fig. 3.

These tests were conducted in the 14MHz amateur band, but other contacts were made with Australia on 21MHz (short path), and with North America on 28, 21 and 14MHz. In these cases also, the combination of portable dipole plus steep ground slope appeared roughly comparable with the home "Quad". This was judged by the degree of difficulty in establishing contacts.

Fig. 7 shows one of the two "bays" of a

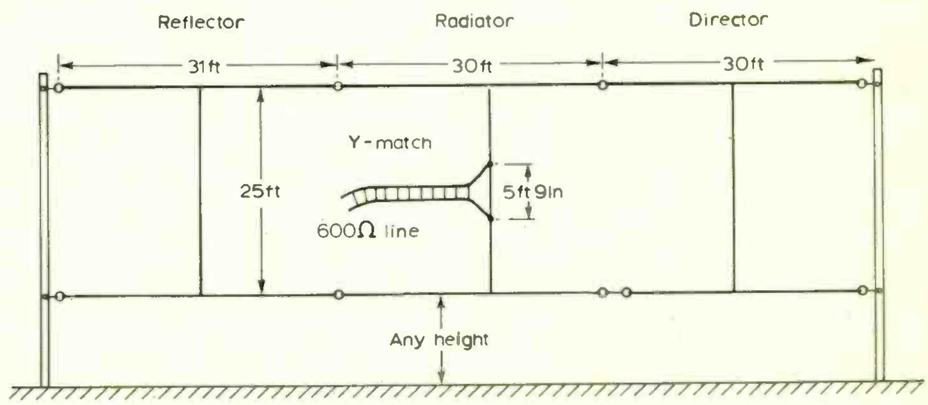


Fig. 7 Low-angle aerial for 7MHz. Height not critical. Reflector and director tunable, by adjusting length of verticals or of the lower horizontal wires. Dimensions approximate.

6-element 7MHz beam using short end-loaded vertical elements with the lower ends about 2ft from the ground. Results over the long path to Australia included good DX contest scores and, on one occasion resulting from failure of the main transmitter, two contacts with only 5 watts of peak r.f. power (s.s.b.). Fig. 5 suggests that for an angle of 6 deg., a vertical array having 6dB gain and located over average ground should be roughly equal in low-angle performance to a dipole at a height of $1\frac{1}{2}\lambda$ or a Quad at $\frac{3}{4}\lambda$.

Relative to typical aerials at a height of 50ft the vertical array would, therefore, be expected to do much better at 7MHz and be roughly equal at 14MHz; the latter estimate has proved to be over-optimistic since results, though good on 7MHz, averaged about 6dB down relative to the Quad at 14MHz.

Conclusion

From most locations it is difficult with simple aerials to achieve efficient radiation at angles below 5 or 10 deg. Attempts to reduce the angle lead to rapid escalation of cost and practical difficulties, and the difficulty of making cost-effective decisions is aggravated by lack of such information as how low an angle is desirable, and for what percentage of the time. On the other hand, given freedom in choice of location, a low angle of radiation is readily achievable by exploitation of natural ground features and is within the means of amateurs equipped with portable apparatus, and a set of Ordnance survey maps.

Much could also be learned from comparative tests from a number of fixed locations having different ground characteristics and various types of aerial.

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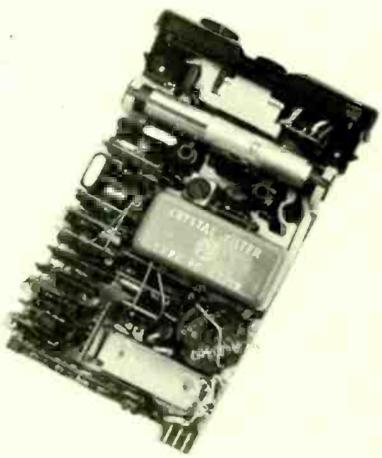
Radio Fire alarm

Personal call-out system for firemen

Production techniques are not in general the concern of *Wireless World* but this month one is featured on our front cover. It shows, albeit in an artistic setting, a watchmaker's wheel which has been adopted by Pye Telecommunications Ltd to facilitate the production of the "microboards" used in the pocket receivers for a fireman's call-out system. The system, which is being adopted by the fire brigades in several areas, operates in the 142-174 MHz band. The transmitter carrier of the 25-W base station is frequency modulated by two signalling tones—one as a test call and the other for a fire call.

The pocket receiver, which measures 12.7 × 6.3 × 2.5 cm and clips in a breast pocket, has a built-in aerial and is powered by a rechargeable 9-V nickel-cadmium battery giving 30 hours operation. The receiver incorporates a battery economizer circuit which switches it on for 0.5 sec and then off for 2.5 sec until the carrier is received and locks it on.

Studs fitted to the receiver enable it to be inserted in a bedside battery charger. It remains fully operative while in the charger.



(Right) Chassis of the fireman's pocket receiver which has an operating range of between 5 and 8 km from the base station according to terrain.

(Below) The watchmaker's wheel in use at Pye's Cambridge works.

Some improvements in the design of

Class-B Audio Amplifier Circuits

by K. C. Johnson

A bewildering number of articles have appeared both in this journal and elsewhere describing class-B audio amplifiers using transistors. The reader might well think that all the possibilities had been thoroughly explored already. When, however, I started to build a new system recently I was surprised to discover just how many small improvements can be made even to a well-tried design. It is true that none of them is either overwhelmingly important or even really original, but taken together they make an appreciably better circuit and so seem to justify yet another article on this subject.

The amplifier from which I started was the Fairchild AF11, which was offered as a kit of semiconductor devices and a tested circuit, though it is no longer in production. The arrangement had been clearly derived from the pioneer circuit of Tobey and Dinsdale, but was brought up to date and much improved by the use of diffused silicon transistors throughout. The first stage was changed so as to use a complementary type of device, since these are now scarcely more expensive in the small sizes and allow some advantage to be gained in the feedback arrangements, but the final power stage still employed two identical devices.

My final circuit is shown opposite, and the various ways in which it differs from the more conventional arrangement will be described in turn.

Earthing arrangements

Several writers have pointed out that it is an advantage to return the "dead" sides of the input, the feedback network, and the output all to the same power rail so as to avoid instability troubles. The first unusual feature of this circuit is that it is the *upper* rail which is chosen for this service rather than the lower one. One obvious advantage of this is that it allows the bootstrap line to be taken directly from the loudspeaker and so saves the need for a second electrolytic capacitor network. But there is a further advantage in that variations in the power supply voltage are much less important since there are no longer any large coupling capacitors bridging the supply rails. If the two rails are taken abruptly to the full working voltage, at switch-on for example, only the 40μF high-frequency bypass capacitor C_4 carries any large current and it is essentially just an extension of the power supply. The long time-constant at the base of Tr_1 controls the charging rate of all the other capacitors and the maximum current in the loudspeaker is no more than 30mA.

In the same way this use of a common return rail and the absence of any signal capacitors bridging the power rails allows a considerable amount of ripple to be tolerated on the power-supply voltage so that power-pack requirements are eased. There are just four places in the circuit where signals change their reference from one power rail to the other, and in every case the collector junction of a transistor is used so that only the current flow is of importance and the voltage is relatively immaterial.

To keep the loudspeaker current surge within similar limits at switch-off it is only necessary to ensure that at least 1000μF of charged capacitor are left connected across the power rails. This enables the currents in Tr_1 and Tr_2 to be kept flowing so that the circuit is able to shut itself down at the rate determined again by the long time-constant at the base of Tr_1. This requirement will normally present no problem, but even if it is not met the surge generated will certainly be no worse than in most other circuits of this type. R_{16} serves to keep the circuit biased properly if the loudspeaker is disconnected whilst the power remains switched on.

The pre-amplifier for this circuit must also be arranged so that the positive rail is the earth and so that the output voltage measured this way changes smoothly when the power is switched.

Middle rail voltage

In any circuit of this type the average voltage at the middle point between the output transistors must be set about half-way between the power rails so that equal output swings can be developed. The first-stage transistor is used at its full gain in this circuit for this purpose. The potentiometer formed by R_1 and R_2 sets a voltage on C_2 which is applied through R_3 to the base of Tr_1, while the actual average level is set on C_3 by R_6 and fed to the emitter. If these voltages do not correspond, the full power of the amplifier is available to correct the situation, with C_3 ensuring that the action is stable.

Thus if slow variations of the supply voltage occur, or if the amplifier is used on different supplies, the middle voltage is always automatically adjusted so as to be close to the actual half-way value rather than remaining at some pre-set level. As a refinement the precise value of R_2 can be set so that limiting of the output on overloading occurs symmetrically at the normal supply voltage, but if components of ordinary tolerance are used the loss of output swing if this is not done will be quite small.

Transistor currents

In contrast to the above it is desirable that the levels of average current at which the various transistor stages work should remain comparatively constant when the power supply is altered. There is no reason to drive a stage with less current just because less voltage is applied, although it is true that a lower impedance loudspeaker system must be used if advantage is to be taken of the current available.

In the conventional form of circuit these standing currents are in fact stabilized in every stage except the second. The third improvement in this circuit is that the diodes D_3 and D_4 are added so as to control this stage also.

With the circuit shown the supply voltage can be reduced from 60V to as little as 18V and the full output current of 2A remains available at almost the full swing the voltage allows, without any adjustment. To match this the loudspeaker impedance required must be reduced from 15Ω at the high voltage to about 4Ω at the lowest. If the loudspeaker is not matched then some output is lost, since either the voltage or the current reaches its limit whilst the other one is less than maximum, but there is no other serious penalty if the mis-match is not worse than a factor of two or so.

Cross-over current stabilization

Thermal runaway of the final transistors is not the problem with silicon devices that it was with germanium. Nevertheless the circuit has the resistor-diode networks R_{12} D_1 and R_{13} D_2 included between Tr_7 and Tr_8 to stabilize the cross-over current level more tightly. These resistors act to give a proportionate voltage for currents near the design value of 20mA, whilst the diodes take over for currents greater than about 50mA so that the peak output capability is scarcely reduced at all.

Now it might be thought that non-linear networks of this kind would cause serious distortion—and arguments to this effect have indeed appeared in print—but consider what is actually happening. The signal being amplified leaves Tr_2 as a collector *current*. Tr_4 is arranged to supply a constant *current* and thus the signal is still in the form of a *current* when it arrives at Tr_5 and Tr_6. It is amplified there and again at Tr_7 and Tr_8, but at no point in these stages is there any sort of a load resistance. Thus the voltages are irrelevant, except in so far as small amounts of current can be lost since no system is ever perfect.

There is, however, an improvement of the thermal stability of the cross-over current by a factor of about five over the customary arrangement of linear resistors of about 0.5Ω at these positions, and less output swing is lost. Thus these networks are well worth having even though silicon devices have so much less leakage and much better stability anyway. The diodes used for D_1 and D_2 should be of germanium, so that they take over at about 250mV, and they must be capable of carrying the full output safely. Their reverse characteristics and switching speeds are clearly of little importance and Mullard type OA10 is suitable. The resistors can be of the ordinary small composition type, as they never have to carry more than perhaps 50mW of power at the most, and there is then no worry about their being inductive.

Constant current transistor

The transistor Tr_4 has been added to serve as a constant current source, as has already been mentioned. It supplies the collector of Tr_2 with about 2mA and draws this current from the loudspeaker side of C_8 so as to obtain the customary bootstrap action. The resistor R_7 and capacitor C_6 help to keep the current constant, whilst D_3, D_4 and R_{15} stabilize the value against variations of the supply voltage. The transistor for this position must be capable of withstanding half the maximum supply voltage but need have no other special features. The Fairchild type BC116, as used already in the first stage, meets the requirements.

In conventional circuits a simple feed resistor carries the current to Tr_2 and the value used is usually no greater than 5kΩ. But the input impedance to Tr_5 and Tr_6 can easily rise to this same sort of value at the cross-over region, since the input impedances of the final transistors rise sharply at low currents and the value is directly multiplied by the current-gains of the driver stage devices. Away from cross-over these input impedances are very much lower, so that the effect is a fall in the value of the open-loop gain at cross-over. Put in figures we can say that the open-loop gain is multiplied by a factor of about 0.5 in this region.

Now the purpose of Tr_4 is to force as much as possible of the signal current from Tr_2 into the driver stage devices and so reduce this form of distortion. Since the effective resistance value obtained is in the region of 100kΩ the improvement is substantial despite the increase of the input impedance that results from the inclusion of R_{12} and R_{13}. The cost of the extra transistor required is comparatively small and in return we have obtained less distortion and better current stabilization in two stages of the amplifier.

Voltage reference transistor

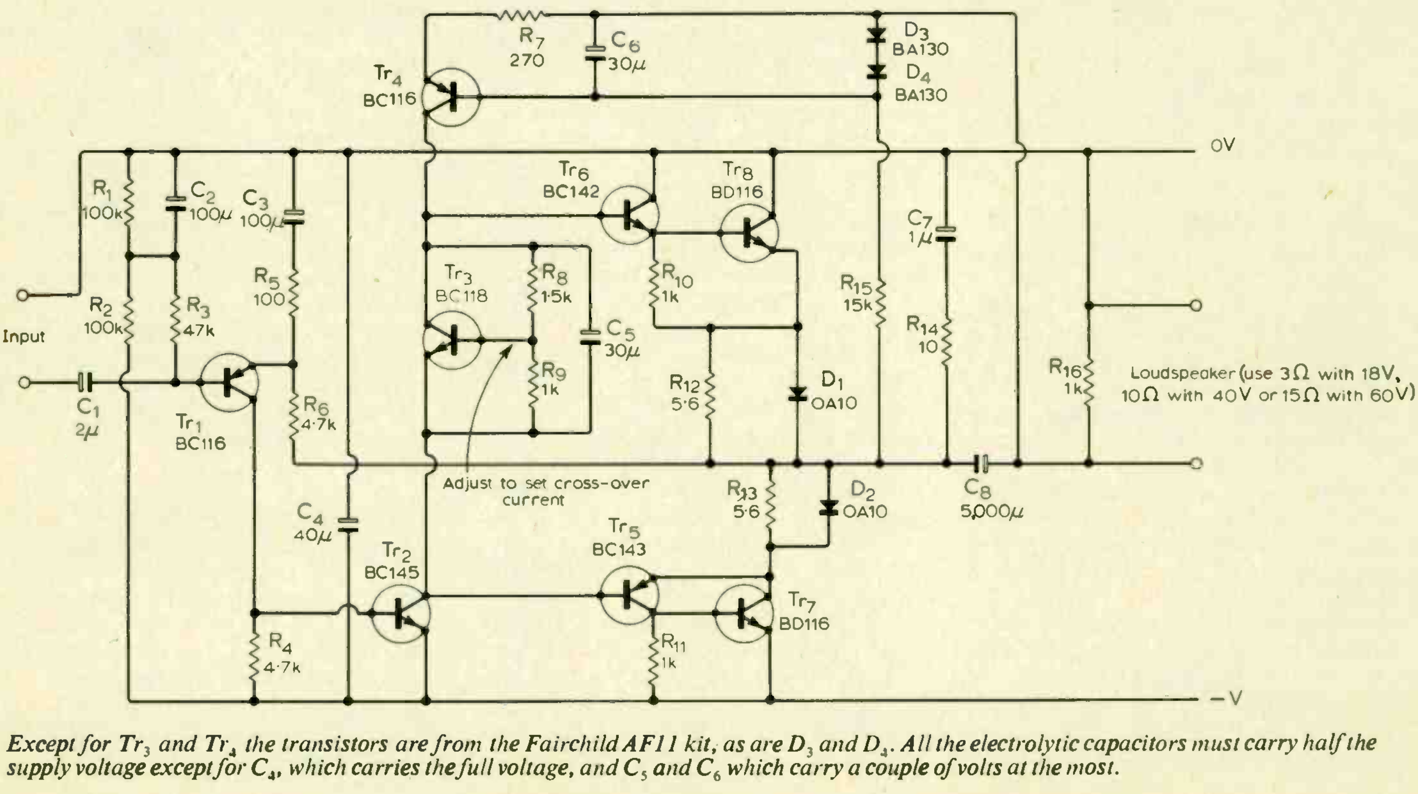
The transistor Tr_3 together with R_8, R_9 and C_5, determines the voltage used as a reference in the fixing of the value of the cross-over current. A transistor replaces the usual chain of diodes as it can provide a more satisfactory form of adjustment and may perhaps now even actually be cheaper. Almost any type of transistor will do provided that there is a gain of at least ten at a current of 1.5mA. Clearly a silicon device can be expected to be more stable and to provide a better tracking when the stages being stabilized all use this same material.

Resistor R_8 has to be reduced in value if the cross-over current is too large whilst R_9 must be reduced if it is too small. Make any adjustment carefully as this setting is fairly critical. Capacitor C_5 serves merely to provide an easy path for the signal current to reach Tr_6.

With silicon transistors of this kind the cross-over current is not at all critical. The value can rise to 50mA or more before the heating effect becomes significant whilst it can fall as low as 5mA before there is any appreciable increase in the distortion. The temperature differences would have to be in the region of 100°C before either of these limits could be approached, and temperatures of this order are certainly not developed in ordinary domestic usage even when no special heat-sink arrangements are made as is the case with my amplifiers.

Matching the transistor gains

The gain from the collector of Tr_2 to the output in a circuit of this type is determined primarily by the products of the current-gains of the driver and final transistor on the two sides. Thus in this circuit it is the product for Tr_5 and Tr_7 for negative swings and Tr_6 and Tr_8 for positive ones. It is these *products*, rather than the gains of the corresponding devices, that ought to be matched to reduce distortion. There is no great difficulty in doing this and indeed it offers the big advantage that relatively poor specimens of one device can be sold paired with star performers of the other



Except for Tr_3 and Tr_4 the transistors are from the Fairchild AF11 kit, as are D_3 and D_4. All the electrolytic capacitors must carry half the supply voltage except for C_4, which carries the full voltage, and C_5 and C_6 which carry a couple of volts at the most.

so as to give a standard product despite production spreads. So far as I know, though, no manufacturer has ever offered devices on this basis. When building an amplifier of this kind it is well worth taking the trouble to test the devices available and to select pairs for a constant value of this gain product.

An amplifier of this type has then, in principle, got a constant gain right through the cross-over region. The current from Tr_2 is indeed split into two pieces in some ratio determined by the relative impedances at the inputs of Tr_5 and Tr_6, and these are amplified separately. But they are simply added together again for the output, so that if the amplification factors are equal the exact manner of the splitting is of no importance. This situation is quite different from that in a valve class-B circuit where the signal is applied as a voltage to the two devices equally at all times, and their characteristics must be so shaped that the sum of their responses remains constant as the action transfers from one to the other. In this latter case a critical level of biasing, determined by the design of the valves, must be maintained so that the responses dove-tail together, but there is no corresponding requirement in the transistor circuit.

The only objection to an indefinite increase of the cross-over current here comes from excessive heating of the power stage and the need for a larger power-pack. There is no clear distinction with this type of circuit between class B with a large cross-over current and class A. The distortion decreases as the standing current is increased, and a compromise must be made between the distortion acceptable and the power level.

Choice of cross-over current

The value chosen for the cross-over current in my amplifiers is 20mA. This gives a standing power dissipation in the final transistors of 0.6W each at the full voltage. At this power level no heat-sinks are required in normal service, so that the devices can be mounted directly on the same small paxolin board as the other components. This in turn means that none of the wires concerned in the feedback loop need be more than 3in long and the stability problems are correspondingly reduced. There is no objection, however, to running at a higher level of standing current simply by reducing R_9, if a different compromise is required and heat-sinks and stabilization capacitors are provided.

But how serious is the distortion even at this level of 20mA? With modern diffused power devices, such as the Fairchild BD116, well over half the peak gain is still available at this sort of current. If we assume that the amount left is actually 75%, then this gain loss will cause a fall in the open-loop gain, due to the simple product of the betas, by a factor 0.75 at the cross-over point.

Further to this there is a loss of signal in the resistors R_{10} and R_{11} due to the rise of the input impedances of Tr_7 and Tr_8 at low currents. With typical silicon devices this is no worse than a factor of 0.95, and it is far less serious now than it was with germanium where the leak resistors had to be made much lower in value. It is tempting to omit these resistors altogether with silicon but, in fact, this is foolish as they are required to help the power devices turn off after fast transients.

Lastly there is the fact that Tr_2 is not really a perfect current source, but has a a finite output impedance. Even if the standing current in this stage is cut to the bare amount required for driving the full output together with a minimum safety margin (2mA in this circuit) the collector impedance will still be no higher than about 50kΩ, as the base is current fed. The input impedance to Tr_5 and Tr_6 is, however, 45kΩ or more, since the 15Ω of the loudspeaker is multiplied by at least 3000 due to the current-gains of the stages. Moreover, there is a further 10kΩ added to this, due again to the rise of transistor input impedances, at the cross-over point. Thus the loss of gain here is a factor 0.55 worsening to 0.45 at cross-over. The corresponding effect at Tr_4 is rather less than this as it is voltage fed and returned to the bootstrap line. Its inclusion does not make any serious difference to the general picture.

The combined effect of all these causes is then a loss of perhaps a factor 0.6 in the open-loop gain in the region of the cross-over. If the cross-over current value were made greater than 20mA this loss would certainly be reduced, but what other changes occur in this open-loop gain that would remain unaltered despite such an increase of this current?

The most serious effect here comes again from the collector impedance of Tr_2 and is due to the fact that this impedance is inversely proportional to the current in the device. Thus at the peak negative swing this impedance will fall as low as 30kΩ, while at the positive peak it will rise to perhaps 100kΩ. This causes a factor of loss of open-loop gain varying from 0.4 to 0.7. This effect is thus comparable with the factor 0.6 due to the effects at cross-over. The conclusion from this is that although a further increase of the cross-over current would indeed reduce the distortion the rate of reduction is becoming rapidly less so that, on balance, this value represents a reasonable compromise. If a more constant openloop gain is required then something must be done to increase the effective output impedance of Tr_2.

Stability of the feedback loop

The full product of the current-gains of the second, third and fourth stages of this circuit is in the region of 350,000, but, as we have seen, this is reduced by various factors so as to be perhaps 140,000 at the least and 250,000 at the most with variations over the signal swing. Now roughly 1/600 of the output current is fed back through R_6, R_5 and Tr_1, so that the effective gain round the feedback loop in the passband varies over the range from 230 to 420. This very large amount of feedback serves to make the overall incremental gain fall short of the value determined by the potentiometer formed by R_6 and R_5 by no more than 0.43% at the worst and 0.24% at the best.

This variation is less than $\pm 0.1\%$ from the mean and indicates that the performance of this type of amplifier is very good indeed. It is quite probable, in fact, that the linearity of the resistors used for R_6 and R_5 is not even as good as this and that they are, therefore, a major source of distortion. In any case there is little doubt that there are other components in any real audio system which are far worse than this circuit, so that there is little point in worrying about it overmuch.

However, this feedback will be quite useless unless the loop can be kept stable. The last feature in which my circuit is unconventional is in the fact that adequate stability is obtained without any extra capacitance having to be added between the collector and base of Tr_2. The network R_{14}, C_7 provides the usual dummy load to restrain the output voltage at the very high frequencies where the loudspeaker system is likely to be inductive and where oscillation is likely to occur, but the amplifiers as built have a response time to a sharp step input of about 1μs rise-time with an overshoot of no more than perhaps 10%. Notice that the sort of wiring commonly used to feed loudspeakers has a characteristic impedance substantially higher than the load resistance, so that a long lead will make the inductive effect greater rather than less.

As already mentioned, the layout used is very compact with no signal lead more than 3in long, but the rather unexpected stability seems to come from the very high impedance at the collector of Tr_2 due to the constant-current effect of Tr_4. This apparently makes the ordinary stray capacitances at this point have a time-constant which dominates the feedback action. At the same time the diffused power transistors used for Tr_7 and Tr_8 are so fast (they have $f_T = 40$MHz), that they no longer make a serious second time-constant. With germanium the final devices used were more than a hundred times slower than this and their response was an important factor in the stability considerations.

It follows from this step-input behaviour that the high-frequency cut-off of this circuit is at over 100kHz. If this is thought to be excessive it can be reduced as required by adding collector-base capacitance at Tr_2, and this will still further ensure stability. The low-frequency cutting action of the circuit comes directly from the increase of the feedback factor due to the time-constant of R_5 and C_3. The value of this is 10ms, so that the cut will come at about 16Hz. If this value is to be changed then C_1, C_2, C_3 and C_8 must all be multiplied by the required factor.

The result of all these modifications is an amplifier arrangement that works appreciably better than corresponding circuits of the same general type with only a marginal increase in the complexity. It is even possible that the total cost is no greater when the savings that can be made in the power pack are taken into account. Certainly there is no doubt that the component tolerances have been made substantially easier, and that these various features deserve consideration in the design of any future amplifier of this type.

Speakers in Corners

A disagreement with the widely held view that placing a loudspeaker in a corner of a room gives better sound quality

by H. D. Harwood, B.Sc.*

In his article "Loudspeaker Performance" in the February issue of *Wireless World*, P. W. Klipsch, states that "All speakers (I have found no exceptions) work better in a corner". This view, which seems to be very commonly held, does not agree with experience in the B.B.C.[1]. Historically it has been found that as the general sound quality of loudspeakers has improved, so the deleterious effects of mounting the loudspeaker in a corner have become more and more noticeable. The deterioration in quality has been found to be mainly in the middle and upper bass regions. It sounded as though the loudspeaker had a very irregular response/frequency characteristic and that the sound was apparently more reverberant and coloured. The effects in the lower frequency range were particularly noticeable on polyphonic organ music, the separate parts of which are changed in level according to their positions in the scale.

In the B.B.C. television sound control rooms have been chiefly affected, as the most convenient position for the monitoring loudspeaker has been above a group of picture monitors which are placed across a corner. This listening position is largely a forced choice because the listener's strong directional sense in the horizontal plane discourages the use of positions to one side of the monitors, while the space below is normally screened by the control desk and other obstacles. The monitoring loudspeaker is therefore normally placed near the ceiling in a corner, exactly the acoustic position favoured by Mr. Klipsch.

The hanging version of the LSU/10 studio monitoring loudspeaker (introduced in 1958) sounded satisfactory in such a position after a bass lift had been added. With the completion of Television Centre and the introduction in 1959 of the LS5/2A, it was found that these loudspeakers, which performed very well in most circumstances, gave inferior quality when hung in a corner, although it was often possible partially to overcome this by changes in the acoustics of the room. When the LS5/6[2] was introduced recently, the effect of mounting it in a corner was quite marked.

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Three hypotheses have been suggested to explain the effects:

1. The release of load on the base of the cabinet when the loudspeaker is removed from its plinth allows the cabinet to vibrate more freely, thus colouring the sound at a series of resonance frequencies.
2. The quality change is entirely due to interference effects between the direct sound from the loudspeaker units and that reflected from the walls and ceiling in the neighbourhood of the loudspeaker.
3. The effects are psychological in origin and associated with the unnatural or unaccustomed direction of the sound reaching the listener. This is very difficult to check and therefore the first two suggestions were examined first.

To check the first suggestion, listening tests were carried out, using both speech and music, when the loudspeaker was on its plinth near the middle of a wall and when it was raised just free of the plinth by means of a rope and pulley. No difference in sound quality could be detected at all and it was concluded that vibration of the base of the cabinet was not a cause.

If interference from reflections was the cause of the changes in quality, then past experience[3] would indicate that their amplitudes would be comparable with that of the direct sound, and the output of a microphone placed in the listening position would have a series of easily identified fluctuations.

Fig. 1 shows the arrangement used for experiments to test the hypothesis that the deterioration in quality was caused by reflections from the surfaces of the walls

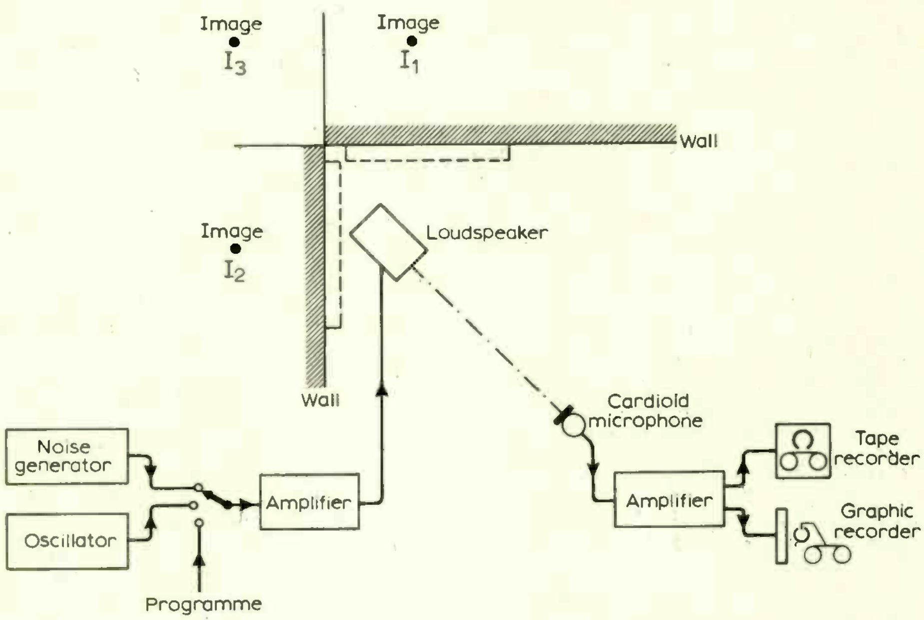

Fig. 1. Experimental set up used for investigating effects of corner placing.

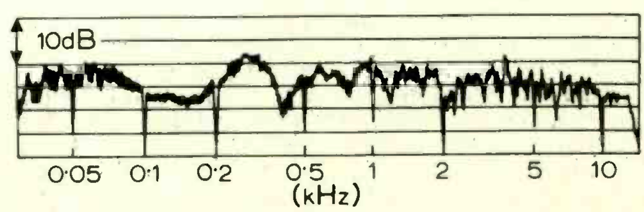

Fig. 2. Response/frequency characteristic with loudspeaker symmetrically placed in upper corner of room. The signal source was a warble tone.

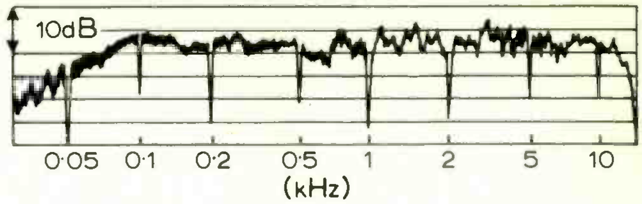

Fig. 3. Characteristic with loudspeaker in an asymmetrical position in a quality listening room (warble tone).

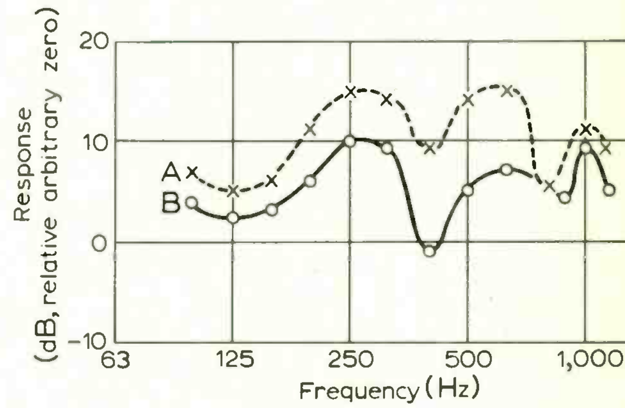

Fig. 4. Calculated response/frequency characteristics from loudspeaker in corner of room: curve A, calculated from direct and strongest three images; curve B, smoothed from measured characteristic in Fig. 2.

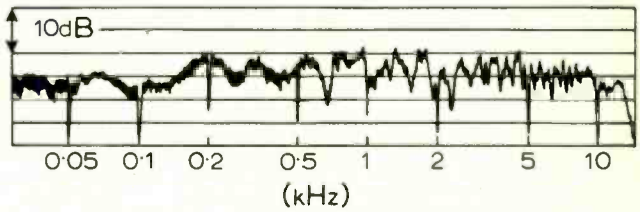

Fig. 5. Speaker moved to unsymmetrical position in room (warble tone).

and ceiling. For clarity it is shown in two dimensions only, but the extension to three dimensions is fairly obvious. For walls at right angles three images are formed, I_1, I_2, and I_3. If the walls are not at right angles then I_3 is split into two images, but for most rooms these two will coalesce at the wavelengths we are concerned with. Corresponding images will be formed in the ceiling.

In the tests the loudspeaker could be fed with pink noise, pure tone modulated over a range of $\pm$ 63 Hz at a rate of 10 times a second or with programme from recordings. A microphone with a cardioid directional pattern was used to reduce the effect of room reflections elsewhere and the output could be recorded on a graphic level recorder or on a magnetic tape recorder.

Fig. 2 shows the steady state characteristics with the loudspeaker in a symmetrical position in the corner of a room acoustically treated on surfaces other than that of the corner. The microphone was 1.3m above floor level on the loudspeaker axis. Fig. 3 shows the curve obtained in a listening room in an asymmetrical position with respect to the walls of the room. These curves of course represent the combined effect of room and loudspeaker and should in no way be confused with those of the loudspeaker alone.

Compared with Fig. 3, the curve in Fig. 2 shows a series of broad maxima and minima at low and middle frequencies, the maxima occurring at 50, 280, 630 and 950 Hz, the peak to trough variations reaching 11 dB; at high frequencies, too, there is a series of interferences. Listening tests on the loudspeaker using both pink noise and speech, in the condition corresponding to Fig. 2, showed a definite colouration just below 300 Hz, which agrees with the main peak in this region. There is a clear suggestion therefore that the colourations at low frequencies are associated with these peaks.

Fig. 4, curve A, shows the expected resultant of the sound pressure from the loudspeaker and its images calculated by ordinary vector summation from the following data:

1. Measured positions of loudspeaker and microphone.
2. Assumption of a value of 90% for the reflection coefficient at the walls with no significant phase change in reflection.
3. The assumption that the two images lying directly behind the loudspeaker could be neglected. One of these is formed by two successive reflections and the other by three, and both are formed by radiation inside a small solid angle at the back of the loudspeaker where the radiation is in any case low; otherwise the loudspeaker was assumed to be omnidirectional.

Curve B in Fig. 4 is a smoothed reproduction of a portion of Fig. 2 deliberately displaced from curve A. The similarity between the two curves is sufficiently close to confirm that interference by reflections from the surfaces surrounding the corner is an adequate explanation of the low frequency effects.

As the frequency is increased the fluctuations of Fig. 2 vary in depth owing to the varying directivity of the loudspeaker and the interaction of images at several different distances. From 3 kHz, however, the pattern becomes more regular, probably because the tweeter is in operation here and is more omnidirectional, giving stronger reflections from the nearby surfaces. The fluctuations still seem to be harmonically related to 270 Hz.

Fig. 5 is the steady state characteristic, for comparison with Fig. 2, obtained after moving the loudspeaker from its symmetrical position by 45 cm parallel to one wall. In this position the path lengths from two of the primary images are different and the fluctuations are therefore reduced at low frequencies.

A further response characteristic was taken at a symmetrical corner floor position, a carpet being on the floor. The low frequency fluctuations were similar to those in Fig. 2 but the high frequency ones were smaller, presumably due to the absorption of the carpet.

Fig. 6 shows the disastrous effect of placing the loudspeaker right in the corner so that it touches each of the walls.

The evidence given above shows that interference between reflections and the direct sound is sufficient to explain the measurable effects of the loudspeaker environment. It is also consistent with the subjective observations which were the starting point of the investigation. It may be a matter of some surprise that such large fluctuations as exist even in the best curves, i.e. Fig. 3, do not make the loudspeakers completely unacceptable in any other situation than that of a free field room, but it is a common observation that one does not normally notice the even larger fluctuations due to room modes which must equally affect live speech in a room. The faculties of binaural hearing and central nervous analysis give considerable weight to the direct sound.

Assuming that the effects are entirely due to interference, there are thus three alternative methods for improving reproduction from a corner placed loudspeaker.

1. To absorb sound falling on the neighbouring surfaces. This will require a highly efficient absorber working over the entire audio bandwidth to be applied to a suitable area around the loudspeaker position. A suitable type is a partitioned air space 15 cm deep closed by 5 cm of dense rockwool and a fabric or highly perforated cover.
2. To use unsymmetrical loudspeaker positions, preferably chosen to eliminate the major fluctuations.
3. To avoid the corner as far as possible, will give the best results.

An opportunity to test out these conclusions arose in the sound-control cubicle of Studio 1 in Television Centre. A loudspeaker, type LS5/2, which it was agreed gave a high quality of reproduction when near the floor, gave an objectionable quality described as "tunnelly" when hung above the television monitors in a corner of the room. The position of the loudspeaker is such that very little can be done in the way of adding absorbent at the sides of the loudspeaker without covering large areas of viewing window in the

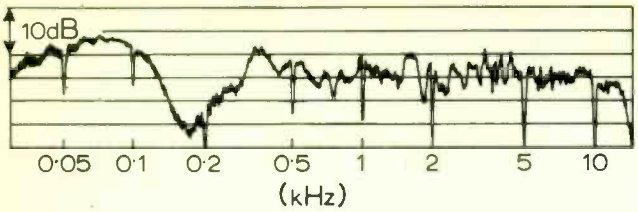

Fig. 6. Effect on characteristic of placing loudspeaker in corner touching walls and floor (warble tone).

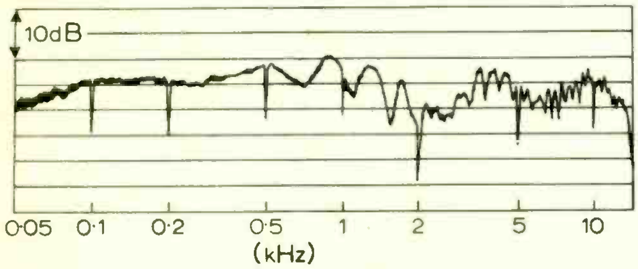

Fig. 7. High quality ***monitoring speaker placed in upper corner of television sound-control room (warble tone). The microphone had a cardioid characteristic.***

control room. The wall area available behind the loudspeaker was treated as described above, but the quantity of absorbent involved was so small that it was not surprising that very little benefit resulted.

A response/frequency curve was taken with a cardioid-type microphone at the edge of the control desk facing the axis of the loudspeaker and with warbled tone applied as in the earlier curves. The result is shown in Fig. 7 and the expected irregularities are evident in the 500 Hz to 2 kHz region. To check that the irregularities were not due to interference from a reflection off the desk the measurement was repeated, the microphone having a figure-of-eight polar characteristic, the null being directed towards the desk. Results were substantially the same.

It was noted that the sound quality varied rapidly with distance from the desk and indeed throughout the whole room, although the impression of "tunnelliness" persisted everywhere.

Since the first suggestion of improving the sound quality was inapplicable, the second was tried. The loudspeaker was lowered about 35 cm from the ceiling until it touched the monitors and the angle adjusted until it again faced the sound supervisor.

It was immediately obvious on listening that the sound quality had greatly improved in the normal monitoring position and furthermore that it did not vary substantially with position and was acceptable throughout the whole room.

A further response/frequency curve was taken at the monitoring position with the microphone in the cardioid condition. It was observed that the irregularities in the 500Hz to 2kHz region had almost disappeared, and that even those at high frequencies had been somewhat reduced. As a matter of interest, it was not possible even on careful listening to attribute any effect to these latter irregularities and it appears, therefore, that the ear is more tolerant in this frequency range.

Enough has been said to show that, far from all loudspeakers working better in a corner, this position is to be avoided for direct radiator loudspeakers whenever possible, if high quality sound is the criterion and not just a loud noise. If such a position is unavoidable, try first to make the distances to neighbouring surfaces appreciably different and if the floor is one surface use a thick carpet. If this measure is insufficient, acoustic absorbent material should be placed on the surfaces involved.

Acknowledgement. This article is published by permission of the Director of Engineering, B.B.C.

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3. "Recent work on the effect of reflectors in concert halls and music studios", by T. Somerville, C. L. S. Gilford, N. F. Spring and R. D. M. Negus. *J. Sound Vib.*, 1966, 3 (2), pp. 127–134.

Corrections & Amendments

We regret the need to draw readers' attention to the following amendments and corrections to recently published articles.

L. Ibbotson writes: My attention has been drawn to an error in question 15 of **"Test Your Knowledge"** No. 20 on Colour (January issue). The supposedly correct answer, (*b*), is wrong in the following particular. The three spectral wavelengths quoted were selected because the triangle on the chromaticity diagram with these as apices includes the largest possible range of real colours. It is clear from the chromaticity diagram that colour-mixing curves in terms of constant luminance would have maximum values around the three primary wavelengths quoted. However, to get the required filter (radiant flux) transmission characteristics, these curves require to be multiplied by the relative luminous efficiency curve: as a result the required radiant flux transmission peak for the red occurs at a wavelength of about 600mμ The other two transmission curves still peak at round about the primary wavelengths.

"Ceramic Pickups and Transistor Pre-amplifiers" (Feb. p. 56): Referring to Fig. 8(b) mechancial compensation can be allowed for by adjusting R_4, not R_1 as stated in the text. In the appendices (p.80) the diagram at the foot of the centre column should follow ". . . by thinking of the ceramic pickup capacitance as being a part of Z_1:", and the diagram in the right hand column should follow the text at the foot of the centre column.

"Digitally-controlled Tape-recorder Pre-amplifier" (March p.127): In Fig. 2 Tr_9 is n-p-n and should be drawn as is Tr_{11}. In Fig. 4(b) D_7 should be inverted and C_{15}, D_4, D_5 and D_6 should share a common connection. In the caption to Fig. 4(a) and in Fig. 5 it is suggested that diode 1N914 is a germanium type when it is actually a silicon planar device. Four such silicon diodes should be employed ($D_8 - D_{11}$) to give V_{ee}.

The following amendments should be made to the article **"80-metre S. S. B. Receiver"** by W. B. de Ruyter which appeared in the March issue: R_{12} should be connected to the a.g.c. line and not chassis as shown and the values of R_{28} and R_{21} should be interchanged.

Two corrections should be made to the article **"Pulse Generator using Integrated Circuits"** by C. Djokic (March p.130). The variable resistors in the output amplifiers (Fig.4) should be connected across the power supply as potential dividers with the wipers connected to the upper end of the 470Ω resistors, and gate C pin connections should be altered to 5 and 6 as per Fig. 6.

"Simple Linear A.C. Voltmeter": A printer's error in G. W. Short's letter (March, p.113) made nonsense of his correction. The oblique stroke was again omitted from the expression $R_2 = (V_{CC} - V_{CE})/I_C$.

"Pickup Characteristics" (December, p. 553): The stylus supplied with the Bang & Olufsen SP10 cartridge is spherical (0.6 thou) and not eliptical.

An Electronic Dice

Design for a digital novelty, the final details of which are left to the reader

*by Brian Crank**

A chance remark made at a game of snakes and ladders led to an interesting excursion into logic design. The dice had fallen off the table and as people searched the floor for it someone said "At least in this house you would think that there would be an electronic something to save all this trouble". Later the possibilities of making an electronic dice were investigated.

The circuit must have six stable conditions or states, each state corresponding to one of the sides of a dice as shown in Fig. 1 (a), and it must be capable of selecting anyone of these states at random. In practice the random element is provided by a high-speed multivibrator.

The groups of spots on the sides of the dice can be made up by using one, or by superimposing more than one, of the four patterns given in Fig. 1 (b). There are several ways in which these patterns can be displayed. One possibility is to use seven lamps, one lamp for each spot; in this case all the lamps to form a particular pattern in Fig. 1 (b) would be connected in parallel. Another solution would be to partially drill the spots in four sheets of Perspex, one sheet for each pattern, and to illuminate them using the edge lighting method employed in some numerical indicators. Finally, fibre optics could be tried. This would entail guiding the light from the lamps along fibre "light pipes" on to some form of translucent screen. (Fibre optic light guides which might be suitable can be obtained from Proops.)

The precise method of display is left to the ingenuity of the reader. However, it has been established that the logic circuit needed to drive the display must have four outputs, that is one output to illuminate each pattern.

*Assistant editor *Wireless World*

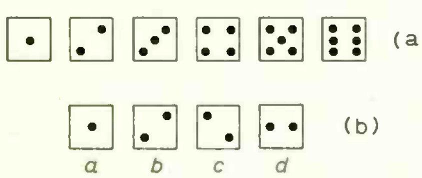


Fig. 1. (a) The arrangement of spots on a conventional dice; (b) the six scores of (a) can be formed with these four patterns

Several logic circuits were tried in the search for one using the minimum number of parts. The circuit finally chosen, although very simple, was arrived at after a good deal of effort had been expended.

The first stage in analysing the problem is to decide which of the four patterns are required to form the six sides of the dice and to present this information in a logical manner:

Dice score		Patterns required
1	=	a
2	=	b
3	=	ab
4	=	bc
5	=	abc
6	=	bcd

This states the facts but not in a way that is very meaningful. However, from these facts a table can be constructed. In this table a 1 is written when a particular pattern is required and a 0 is written when it is not.

Dice score	Patterns a	b	c	d
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	1	1	1

Do the first three columns of this table look familiar? If not some re-arrangement may help:

Dice score	Patterns a	b	c	d
1	1	0	0	0
3	1	1	0	0
5	1	1	1	0
4	0	1	1	0
2	0	1	0	0
6	0	1	1	1

The first three columns closely resemble

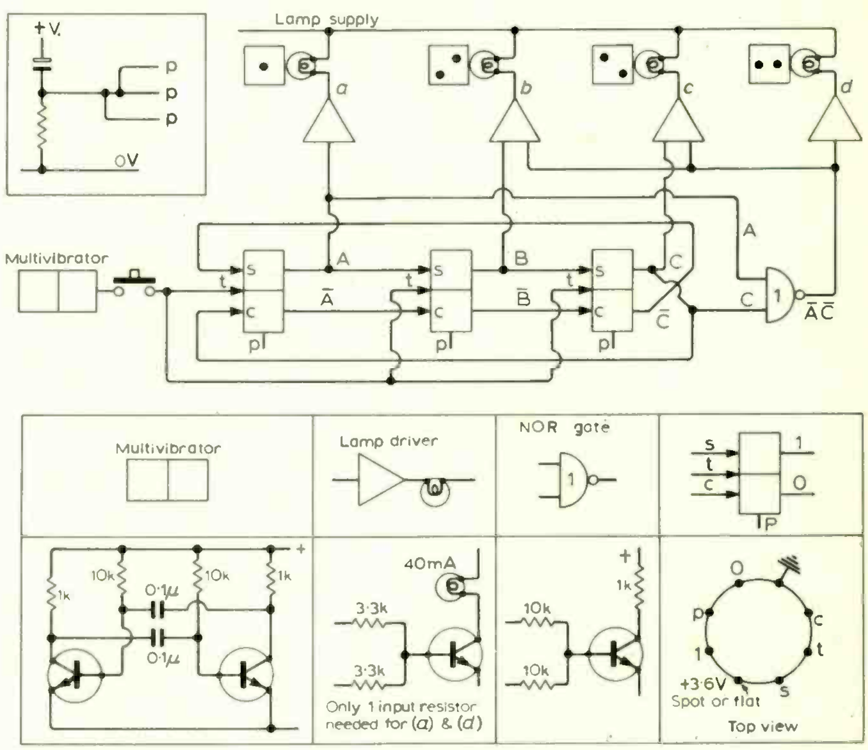


Fig. 2. The suggested circuit for a digital dice, the method of display is left to the reader, almost any general-purpose silicon transistors may be used.

the Johnson code. For readers who are not familiar with it the Johnson code is as follows:

0	0	0
1	0	0
1	1	0
1	1	1
0	1	1
0	0	1

This code is formed by a counter called a Johnson counter, sometimes known as a switch-tail ring counter. If the pattern requirements can be made to follow the Johnson code the lamps illuminating the patterns could be controlled directly by the counter and no gating at all would be required. Although we cannot reach this ideal solution we can come very close to it.

We will consider only the columns for patterns a, b and c at this stage; column d will be dealt with later.

The first line to depart from the Johnson code is the line for score two. This is 010 instead of the Johnson 001. This means that the Johnson code would have us illuminate pattern c instead of the required pattern b. Examining Fig. 1 (b) we find that patterns b and c both show a score of two so it does not matter which is used; 001 instead of 010 can be used, therefore, with no circuit changes.

The other line that needs modification is for score six. This should be 000 in Johnson code instead of 011. If the Johnson code is used no patterns would be shown at all for six, but we require patterns b, c and d to be illuminated. A gate must be employed to detect 000 and light the required patterns. A new table can now be drawn up:

Dice score	Patterns a	b	c	
6	0	0	0	– light b, c and d
1	1	0	0	
3	1	1	0	
5	1	1	1	
4	0	1	1	
2	0	0	1	

The gating requirements for the patterns can now be derived. It is assumed that a Johnson counter is employed in which the bistables are labelled A, B and C.

$a = A$
$b = B + \bar{A}\bar{C}$
$c = C + \bar{A}\bar{C}$
$d = \bar{A}\bar{C}$

The term $\bar{A}\bar{C}$ detects line 000 for score six and illuminates the lamps b, c and d.

A circuit based on the foregoing is given in Fig. 2. The Johnson counter is a standard shift register with the output crossed and fed back to the input. The term $\bar{A}\bar{C}$ is formed by a NOR gate fed with A and C. The $+\bar{A}\bar{C}$ function for lamps b and c is carried out using two resistors from the output of the NOR gate. Connection details for Fairchild μL 923 bistables are given although any similar device may be employed.

To "throw the dice" the push-button is pressed and released; during the time that the button is "made" the counter counts pulses from the multivibrator; the score is then displayed.

The Johnson counter has one serious drawback. Three bistables have eight possible states, only six of these being used in the Johnson counter. If on switch-on the counter goes into one of the two unused states it will switch between these states on each input pulse and will never get into the proper counting sequence. This is eliminated by the resistor and electrolytic capacitor shown in the inset of Fig. 2. These cause the preset inputs of the bistables to go positive for a short period after switch-on ensuring that the counter starts at 000. The value of this capacitor can be found by experiment and is not critical.

An experimental lash-up of this circuit was found to perform well. If required more push buttons can be connected in parallel with the one shown in the circuit so that each player may have one.

The logic side of the circuit has been reduced to three bistables, one gate and two resistors. This is thought by the author to be the minimal form of the circuit, but perhaps this is a "dicey" statement as *Wireless World* readers are almost certain to find a better solution?

Announcements

Revised dates have been announced for this year's London **Audio Festival and Fair** which will again be held at Olympia. The new dates are October 19th to 24th—the first day being reserved for the trade.

A summer school in applied optics for non-specialists is to be held from June 8th to 19th at Imperial College, London S.W.7. The course fee is £35 and further information and application forms may be obtained from the Registrar.

"Hybrid Computer Techniques" is the title of a course of six evening lectures to be held at Norwood Technical College, Knight's Hill, London S.E.27, commencing April 14th. Fee 15s.

Marconi Marine has received orders from three Japanese shipyards for the supply of **communications equipment, navigational aids** and dual radar installations for each of four new ore/oil carriers. The company is also supplying the communications and navigational equipment for *Esso Northumbria*, the largest ship ever to be built in the United Kingdom.

S.T.C. have been awarded a £350,000 contract by the Ministry of Technology for the development and construction of two functional models of a fully electronic access exchange for the Mallard project.

The Solartron Electronic Group Ltd, of Farnborough, Hants, has received an order from the Australian Government worth £2m to design, manufacture and install a combined action information and **tactical trainer** for the Royal Australian Navy.

An agreement has been signed between **Siemens** of West Germany and **Ferranti Ltd,** Edinburgh, according to which these two companies will collaborate on the design, development and production of laser systems for the Multi-role Combat Aircraft (M.R.C.A.) project.

The Channel Electronic Division of LRW Electronics Ltd, Cheltenham, has been awarded a £60,000 contract for the supply of 'Safetylink' **marine radio telephones** by Channel Marine Commercial Ltd.

Link Electronics Ltd, has received a contract from the Post Office, valued at just under £20,000, for the supply of 40 **portable waveform generators** to be used in conjunction with differential gain and phase testing equipment.

The Aeronautical Division of Marconi has received an order worth nearly £100,000 from Air New Zealand for additional **Marconi Doppler equipment** to be fitted to their DC8 fleet.

GEC-AEI (Electronics), Leicester, have been awarded a share of a **£10m contract** for work on the Singapore Government's 'Bloodhound' missile defence system.

GEC-AEI Telecommunications Ltd has received orders worth £750,000 from the Post Office for **microwave radio equipment** to expand three routes in the P.O. network of high-capacity-radio trunk transmission routes.

Microwave Associates Ltd, of Cradock Road, Luton, Beds, have received an order, valued in the region of £40,000, from Sveriges Radio of Stockholm, for mobile all solid-state **television relay systems** for outside broadcast use.

H. Tinsley & Company Ltd, Werndee Hall, South Norwood, London S.E.25, will in future manufacture and market the range of air-spaced variable capacitors and trimmers previously made under the **"Cyldon"** name by Sydney S. Bird & Sons Ltd.

Highgate Acoustics, 184 Great Portland Street, London W.1, have been appointed distributors in the United Kingdom and Eire for the **Pickering** range of cartridges previously handled by Auriema.

A new division of Amphenol has been set up to manufacture components under licence from **Entrelec**, of Villeurbonne, France.

Electroustic Ltd, of 73b North Street, Guildford, Surrey, have been appointed the sole U.K. agent for the **'Silec' range of semiconductors.**

Tranchant Electronics (U.K.) Ltd, 17 Charing Cross Road, London W.C.2, have been appointed exclusive agents in Great Britain for the **Intersil** semiconductor range.

Intertechnique Ltd, Victoria Road, Portslade, Sussex BN4 1XQ, have been appointed sole representatives for the U.K. and other territories for the complete range of equipment manufactured by IGAB of Sweden.

Cole Electronics Ltd, Lansdowne Road, Croydon CR9 2HB, have been appointed sole U.K. agents for the range of **contactless solid-state switches** manufactured by Rafi Electronic, of Ravensburg, W. Germany.

News of the Month

Parliamentary affairs committee

The Council of Engineering Institutions has formed a committee which will keep chartered engineers in Parliament informed of developments and opinion within the engineering profession. The committee is made up of representatives from the fourteen member institutions of the Council and members from both Houses of Parliament.

The parliamentary members are: Mr. E. Lubbock, Sir Ian Orr-Ewing, and Mr. A. Palmer. The chairman of the committee will be the present chairman of C.E.I., Sir Eric Mensforth, and the electrical, electronics and radio representative will be Sir Harold Bishop.

P.C.M. for B.B.C. stereo distribution?

It is now well known that the B.B.C. is experimenting with p.c.m. for distribution of high-quality sound—the advantages being, of course, the inherently stable characteristics of the system and immunity from noise and distortion in the sound transmission links. In fact, the Corporation has just finished a series of trials of the "sound-in-syncs" system using p.c.m. for television sound (*Wireless World* January 1969, page 38) between London and Kirk O'Shotts and this is expected to come into service within a year.

Writing in the first issue of *B.B.C. Engineering* (a journal replacing the Engineering Monographs), D.E.L. Shorter of the B.B.C. Research Department outlines what might be done in applying p.c.m. to monophonic and stereo sound signal distribution. If the stereo signal were applied to the p.c.m. system in the coded multiplex form in which it is required at the transmitter input, he says, it would be unnecessary to have a stereo coder at each transmitter. In the pilot-tone system used by the B.B.C., however, the spectrum of the multiplex stereophonic signals extends to 53 kHz and it would be a formidable task to design a system to accept the composite signal while meeting the requirements for signal-to-noise ratio. Even if this were done such an arrangement would not allow the information capacity of the channel to be fully utilised, if necessary, for other purposes. A more flexible arrangement could be achieved by transmitting the left- and right-hand signals over separate p.c.m. channels, each of which could then be used independently when required. This would also make more economical use of the capacity of the transmission circuit.

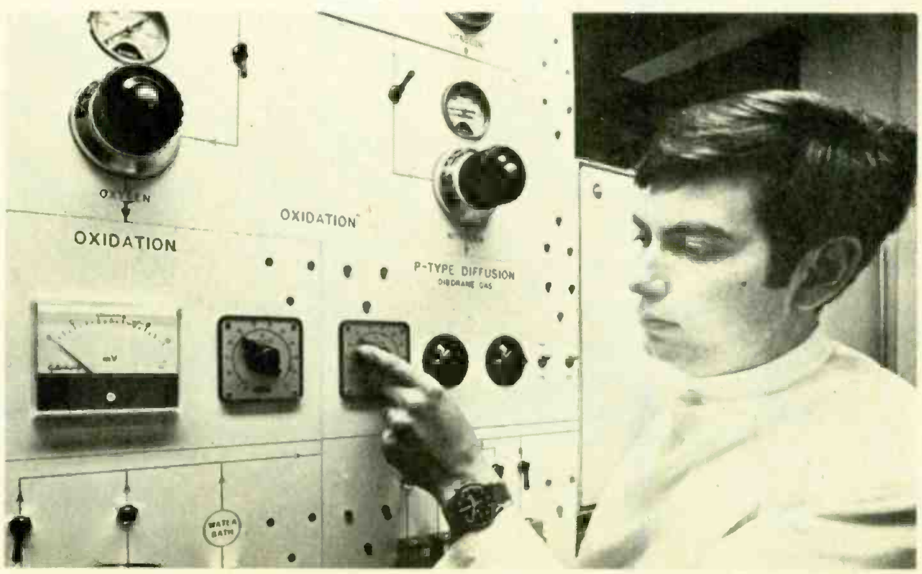
By using separate p.c.m. channels for the left- and right-hand signals, it would be possible to provide stereo coding in a rugged and simple way at the transmitter if the sampling frequency of the p.c.m. system were 38 kHz. The left-right switching, which is part of the stereo coding operation, could be done on the audio frequency signals appearing in sample-held form at the output of the digital-analogue converters. The signal resulting from this switching would then need only the addition of the 19-kHz pilot tone and filtration in a simple low-pass filter to remove components above 53 kHz in order to form the standard stereo signal. This artifice would avoid the need for a conventional analogue stereo coder at each transmitter and would be more economical in circuit capacity than digital distribution of the fully coded stereo signal. However, the use of a 38 kHz sampling frequency would still need some 12% greater capacity in the distribution system than the otherwise satisfactory sampling rate of 33.5 kHz. The higher sampling rate and novel stereo coder are thus of doubtful value.

In the same article, Mr. Shorter discusses the general problem of maintaining the high quality of sound (stereo or mono) in the coding and decoding processes involved in digital distribution. The main problems, it seems, are quantizing noise and distortion from the low level signals. Investigations have shown, however, that the required performance on both counts can be obtained from a 13-bit p.c.m. code using a process of interpolation between quantizing levels. Thus a p.c.m. system is in principle capable of satisfying all the requirements of a high-quality sound signal distribution network which would be able to cope with monophonic and stereophonic signals.

What, not who, is calling

For many people the telephone is the only means of directly communicating with someone else. At the present time a subscriber to the telephone system has at his disposal a vast switching network and he can set selectors clicking in this country, in Europe or in America merely by dialling; a direct pair of wires can be established between one telephone and any other—it does not matter if this

A fully equipped laboratory for the design and manufacture of bipolar micro-circuits has just been completed at Enfield College of Technology. The centre occupies only 750 square feet of floor space and cost about £40,000. The main idea seems to be to involve as many students as possible, in as many process steps as possible, and in projects of industrial value. Courses will be provided at all levels, from technician to post-graduate. Special courses can also be devised to meet particular needs, such as those of company managers and salesmen. Details of the three two-week practical courses to be held this year can be obtained from J. B. Butcher, Director, Microelectronics Centre, Enfield College of Technology, Queensway, Enfield, Middx.



connection be over land-lines, submarine cable, satellite or microwave link.

Computers now chatter to one another over the telephone and many firms send picture facsimiles to and from equipment associated with a telephone. However, for the majority of users the telephone is only a means of voice communication; a fact which means that the telephone system is largely being wasted at the present time.

Perhaps the most important additional use of a telephone would be as a computer terminal. This opens up a vast number of possibilities, too many to go into here, that could place at the disposal of subscribers huge amounts of information. Such a system could hit the printing industry hard, and who knows, in years to come you may receive your *Wireless World* on a c.r.t. display associated with a telephone—with optional line printer of course!

You may wish to switch on your central heating or cooker when you are away from home, this could easily be done by dialling a code on your telephone after connection has been established; and so on and so forth.

The present method of dialling, the Strowger system, does not lend itself to being used in any of the above ways. Before additional services could be provided it would be necessary to go over to the push button method of dialling using tones instead of pulses. The main advantage of the touch-tone system is not a question of novelty or aesthetics it lies in the fact that the push-buttons can be used to send codes after the appropriate number has been dialled.

Unfortunately push-button telephones require special exchange equipment. The Post Office say that this equipment will be installed over the next few years, in fact the Post Office already use push-button telephones in some of their buildings.

The telephone can be used as a means of sending huge amounts of information to a household, it can also be used as a means of extracting data from that household. In fact Bell Labs in America are running a pilot scheme at Holmdel, New Jersey, which reads domestic gas and electricity meters by computer over telephone lines. The computer "dials" the consumer's telephone number and is connected via special exchange equipment, which prevents the telephone bell from ringing, to transducers attached to the meters. The computer, on receiving the readings, carries out all the necessary accounting and recording. The process does not interfere with the normal operation of the telephone in any way.

Although all the above is technically feasible, and the main problem is one of economics, one is bound to ask if the meter reading system is socially acceptable. Apart from possible "big brother" implications many consumers rely on a chat with the "meter man" to gain some idea of what their bill is likely to be. In many areas, with modern high-speed computer processing, there is a gap of about a month between the meter being read and the bill arriving. This gives consumers time to prepare; with the proposed system there would be no early warning.

Tracking vehicle movements

An experimental computer control system designed to simplify and improve the operation of large vehicle fleets has just been demonstrated by Marconi to senior representatives of the London Transport Executive. Centred on a Myriad computer, the system is capable of continuously locating and identifying every vehicle throughout a network, presenting this information on a display screen, and immediately detecting any variations from schedule. This is done automatically without any involvement on the part of the vehicle driver. Additionally, it provides voice communication between the control centre and driver so that fresh instructions may be passed as and when necessary.

Each vehicle is fitted with a distance digitizer which counts the revolutions of its wheels, and therefore measures, digitally, the elapsed distance along a particular fixed route. Vehicles are also fitted with a radio telephone, adapted for two-channel operation, and a telemetry unit.

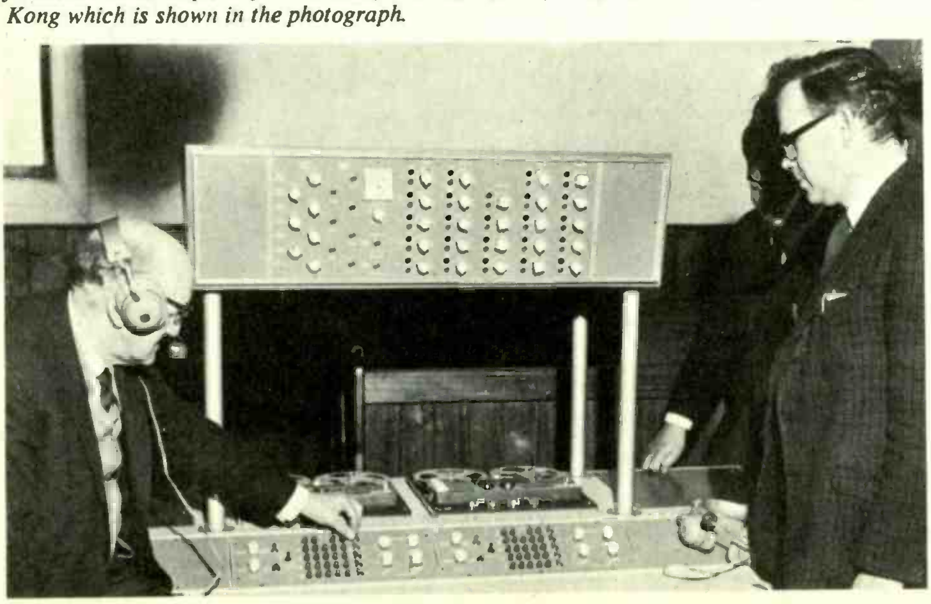
Digital information from each digitizer is passed into a register and is continuously updated at a prescribed rate—typically this might be every 25 feet of elapsed distance. The control room computer can interrogate any register, via the telemetry channel of the radio telephone, and the total elapsed distance count currently held in it will be passed over the link. This data is processed by the computer and displayed on the screen of a cathode-ray tube controlled by it. The display can take one of two basic forms. The route can be represented by a pair of straight lines, one for each direction, with prominent features such as fare stages identified. A vehicle is then continuously represented by a symbol at its current position on the route.

Alternatively, a second method of display allows all the vehicles in a particular area, a city centre for example, to be shown on a map electronically drawn on the screen.

The control room computer can be programmed to provide a number of other facilities. It can compare actual running times with those scheduled, and warn the operator if significant discrepancies are occurring. It can also generate a typewritten log of a day's operation, highlighting any 'out of schedule' running, and can provide this sort of 'history' for longer periods as well. Additional information such as crew meal break schedules may also be held on disc.

Finally, the radio telephone can easily be switched from the telemetry to a speech channel, to allow fresh instructions to be passed to drivers, or to allow emergency calls from them to base.

Sykes-Robertson (Electronics) Ltd. came into being in February 1968, mainly as a result of proposals made to Mr. J. Sykes, an electronics engineering consultant, who went to Sanday (Orkney) to escape the hurly-burly of the South of England. The idea was to find interesting work, mainly for youths and girls who otherwise would have to leave their homes and families to seek employment in the South. The scheme has been a success and the firm, working in a former school and school-house, is currently manufacturing and exporting electronic equipment mainly in the civil and military fields. A recent despatch from Sanday is a high-quality language laboratory for Hong Kong which is shown in the photograph.



University to industry, bridging the gap

A new four-phase sandwich course, lasting one year, is to be introduced by Birmingham University in October 1970. The first in a new series, this course has been developed on the principle that industrially related M.Sc. courses should be designed to bridge the gap between university and industry. It has been designed by several of the leading electronics companies in close collaboration with the University and is sponsored by the Conference of the Electronics Industry, with the support of the Ministry of Technology, the Engineering Industry Training Board, the Science Research Council and the Electronic Engineering Association.

The electronics industry has been concerned for some time over the difficulty of training high-grade systems engineers in the fields of radio communications and radar technology. Normally, each student will be sponsored by a firm in the electronics industry, which, with the assistance of the Science Research Council and the Engineering Industry Training Board will provide his salary and pay all his fees.

Features of the course are that a high proportion of the lectures will be given by people from industry and that the lecture periods have been designed in the form of "modules", each of about three to four weeks' duration which will be available to industry to use as short up-dating courses.

This presents a unique opportunity to graduates to enjoy an intensive course of study and training in industrial research and development while receiving the salary of a full-time staff member of the company by which they are sponsored. The two industry centres for the first year of the course are to be at the Marconi Company in Chelmsford and the Plessey Company at Ilford.

The normal entry qualifications are a first or second class honours degree in electronics, electrical engineering, physics or mathematics or an equivalent qualification "with experience". For further information contact the Post-Graduate Admission Tutor, Department of Electronic and Electrical Engineering, University of Birmingham, P.O. Box 363, Birmingham, 15.

NEW COMPUTER TYPEFACE

A new computer typeface, shown above, has been chosen as the in-house style of Marconi-Elliott Computer Systems Ltd. The typeface, which is based on a square and has no curves or diagonals, makes the design of automatic readers a simpler task; it can also be easily read, even by the untrained eye, and it is not difficult to print by hand.

Keeping passengers informed

Nelson Tansley, in co-operation with Southern Rail's signal and telecommunications engineers, have developed a public address system which has been installed along the fifty miles of line between Woking and Southampton airport. In this system there are three control points; taking the one at the signal box at Basingstoke as an example, the signalman can address any of the five Basingstoke platforms and/or the "up" or "down" platforms at any of the four other stations under his control (Hook, Winchfield, Fleet and Farnborough).

The system employs two pairs of audio cable that already existed along the line. A signalman presses a button corresponding to the particular platform, at the required station, he wishes to address. All four wires are used to send a parallel digital address code which selects the p.a. equipment at the required platform. If the p.a. equipment is not already in use a cable pair is released from the addressing task and is used to inform the control point that this is so. The signalman can then make his announcement. The communication system employs a 20kHz f.m. carrier which is amplified at each remote point and then passed on to the next point.

The circuit is arranged to automatically provide a warning should any part of the transmission path be interrupted.

Post-doctoral research fellowships

The Science Research Council has announced a new scheme of post-doctoral fellowships for outstanding young British research workers to enable them to devote the whole of their time to original and independent research. Under this scheme, starting in October, there will be about 25 awards of much higher value than the 40 awards made last year.

Selection will be based on ability and independent achievement. Graduates in the U.K. may, with the approval of their head of department, apply to S.R.C. for research grants. The new fellowships, which will normally be held for a period of two years and which will be worth between £1,450 and £1,800, will be tenable at institutions in the U.K. or abroad acceptable to the Council—these include universities, colleges and government or industrial laboratories—which can provide the facilities necessary for the proposed research.

Component distributors association formed

With the primary objective of "defining clearly the role that the distributor plays in the chain of events from the creation and production of a product to bringing it to the market place", nineteen companies have formed the Association of Franchised Distributors of Electronic Components (AFDEC). Prime mover was Waldo Thorn, of Celdis Ltd, who called a meeting in February attended by 48 representatives of electronic component distributors. Following the election of a preliminary council with Mr. Thorn as chairman, objectives of AFDEC were discussed including its relationship with the Ministry of Technology and other associations such as the Radio and Electronic Manufacturers' Federation.

Domestic receiver deliveries

The British Radio Equipment Manufacturers' Association has released details of the total disposals of receivers to the trade during 1969. In the list below the 1969 figure is followed by the 1968 figure in brackets and the percentage change. Totals given should be multiplied by 1,000.

Radio receivers 737 (1,025) −28%; car radios 340 (388) −12%; radiograms 201 (226) −11%; monochrome television receivers 1,673 (1,753) −5%; colour television receivers 154 (121) +27%.

The highlight during 1969 was, without a doubt, the colour television disposals which showed a large increase, particularly in the last four months of the year.

The Electronic Industries Association of America has also produced results for 1969; these are presented as above, however a multiplication factor of one million should be applied.

Radio receivers 9.7 (11.8) −17.7%; car radios 10.1 (10.7) −5.4%; monochrome television receivers 5 (5.55) −10.4%; colour television receivers 5.5 (5.8) −7.7%.

It is interesting to note that of the 39.4M radio receivers sold in America in 1969 only 4.7M were home produced.

Wildlife tape recording competition

The European Broadcasting Union felt that the European Conservation Year 1970 was an ideal time to recognize the importance of wildlife sound recording, so, at the suggestion of the B.B.C., it decided to sponsor a wildlife tape recording contest. The competition is open to all living in Europe and Iceland.

There will be four categories and the winner in each will receive a "silver nightingale trophy" and the runner up a "bronze nightingale trophy". An outright winner will be chosen from the category winners who will be presented with a "golden nightingale award". Enquiries for entry forms and rules should be addressed to the Wildlife Sound Librarian, B.B.C. Natural History Unit, Broadcasting House, Whiteladies Rd, Bristol BS8 2LR.

Travelling award

The Royal Television Society invites applications for the 1970 John Logie Baird Travelling Award which has been increased this year to £500.

What they say

"It wasn't until I joined the B.B.C. that I learned that the Heaviside layer was not the top brass at Broadcasting House!"—Lord Hill, chairman, B.B.C., speaking at the I.E.E. annual dinner.

Letter from America

Sales of recorded stereo tapes accounted for approximately 26% of all recorded music sold in America during 1969 and should increase to 35% in 1970, according to Donald Hall, vice-president of Ampex. He went on to forecast that tape sales would equal sales of discs by 1972 or 1973.

At the moment, 8-track cartridges are still more than holding their own with 74% of the sales, followed by 15% for cassettes. There is no doubt that cassettes will gain in popularity and eventually overtake the 8-track cartridges which are mainly used in car-players. North American Philips confirm the rapid increase in popularity of cassettes and a spokesman said "Cassette equipment represents the fastest growing segment of the home entertainment industry—and it will gain a further impetus when cassette players are fitted to the new 1971 cars". Incidentally, nearly 10 million car radios are sold in the U.S.A. every year—more than the sales of domestic radios!

Before leaving the subject of sales—a few words about television. Last year colour sets sold just over 5 million—about 10% more than black-and-white. RCA have just announced plans to build a 20,000-ft plant in Mexico for the manufacture of colour tubes, and a larger one in Puerto Rico which will concentrate on shadow masks. One of the new RCA portables features a remote control unit which "gives instant shut off without need to turn down the volume control first". This is accomplished with a "computer-tested integrated circuit amplifier". The automatic fine tuning is also "computer designed"!

Meanwhile, that flat television screen is still just around the corner and the latest contender in the race is International Devices Ltd., of Fort Erie in Canada, who say they will have a flat-screen receiver in production by the end of the year. An electro-luminescent coated screen is used with vertical and horizontal potentials applied by an XY grid. It is claimed that picture brightness has been achieved up to 25% better than on standard colour TV sets now on the market. According to the company president they are only working with colour because "black and white is more difficult" and he is reported as saying that screen sizes up to 36 by 50 inches would present no problems.

Much work is going on behind the scenes with video cassette recorders and Capitol announced recently that they had one on the drawing board awaiting the establishment of industry standards. They stated that "a cassette television programme of a half hour or full hour would probably sell for about \$30" (£12 10s.) and they also forecast a TV programme rental library system. The Capitol unit is simply wired to the aerial input of the home television set, and then all the user has to do is to insert a cassette and he can watch his favourite programme as many times as he likes.

Big news in the Hi-Fi world is the introduction of 4-channel stereo sound, or Quadrasonics. With present techniques this involves the use of two broadcasting stations but stations in Boston, New York and in other parts of the country have been pairing up to broadcast live concerts and tapes (made by Vanguard) and so have created considerable interest. True, there was some (predictable) criticism from a few sceptics who believe the whole idea is a gimmick thought up by speaker manufacturers or tape companies, but the majority of people who have heard 4-channel sound have been most impressed. How are the microphones placed? Well, for the initial Boston experiments (with the Boston Symphony Orchestra) two microphones were in the the usual stereo positions and two more were placed at the rear. One station carried the signals from the left front and left rear and the other from the right front and right rear. This unusual arrangement was in the interests of compatibility but recently the organizers had second thoughts and now one station transmits the signals from the front pair and the other station from the rear two. Not compatible at all; but I wonder how many complaints were received?

It is claimed that 4-channel stereo is much more *immediate*, more exciting than 2-channel (you could not use it as background music) and some enthusiasts are even saying "the difference between 4-channel and conventional stereo sound is greater than between 2-channel stereo and monophonic reproduction". It is certainly true that room acoustics become less important and there is a greater feeling of being at the actual performance. Some of the demonstrations feature large orchestral works where the rear channels supply most of the reverberation and this does help to give that 'you are there' feeling. However, I believe opera and drama will gain the most from the extra dimension. On the other hand, many contemporary composers are very enthusiastic about the possibilities and Henry Brant finds it ideal for his "space music". In a recent recording session at the large Eastman theatre, no less than five different groups of performers were used, on stage, in the balconies and in the aisles.

If Quadrasonics becomes popular, what are the record companies going to do about it? You may be sure they are not ignoring it and several companies are busily working on 4-channel discs using multiplex systems and it is rumoured that some will be demonstrated at a meeting of the Audio Engineering Society in New York very soon. It is obvious that it is not *really* feasible to use two separate broadcasting stations (except for experimental purposes) and so various schemes have been proposed that will allow 4-channel transmissions from one station. One of the most practical involves a multiplex arrangement and it is described by L. Feldman in *Audio* for January 1970. The only disadvantage is a slight loss in bandwidth of the rear channels but this may have to be accepted. Tapes, of course, present no problems and several recorders are now available with stacked heads. Scott brought out a Quadrasonic receiver in December but the majority of manufacturers are waiting to see what happens before they commit themselves. Among them curiously enough is Acoustic Research (AR) who have played a large part in organizing the Boston experiments. G. W. TILLET

Our contributor **George Tillett** *has been appointed editor of* "Audio". *Since going to the U.S.A. five years ago he has successively been director of engineering in the Pennsylvania plant of Fisher Radio Corp. and executive vice-president of Audio Dynamics Corp. Prior to leaving this country he had been with Daystrom, as chief engineer, and latterly with Wharfedale as technical director.*

SONEX 70

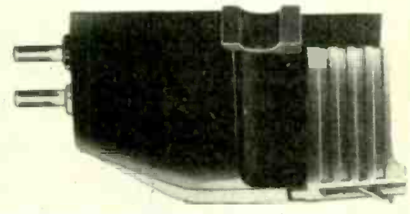
Exhibitors at the forthcoming London Hi-Fi Show

With the transfer of the annual London Audio Festival & Fair from a hotel setting to Olympia and from the spring to the autumn there has apparently been agitation by some manufacturers for a spring show similar to those run first at the Waldorf Hotel (under the auspices of the defunct British Sound Recording Association) and latterly at the Hotel Russell. As a result the Federation of British Audio formed a company—British Audio Promotions Ltd —to organize a specialist hi-fi exhibition. The first of what is planned as an annual event, is to be held for four days (April 23rd-26th) at the Skyway Hotel, near London Airport, Heathrow. Each of the 50 manufacturers taking space at 'Sonex 70', as the exhibition is called, will have an individual hotel room for demonstrations. One advantage of the Skyway Hotel is that, because of its proximity to the airport, all the rooms are sound proof. The list of manufacturers exhibiting is given below.

It is encouraging to note that although the show is sponsored by the Federation of *British* Audio, there are a number of overseas names among the exhibitors.

The show will be open from 11.00 to 21.00 on each of the first three days. On the last day (Sunday) it will open at 11.00 but close at 18.00. Admission on the first day is restricted to the trade. Tickets for the other days are obtainable free from exhibitors, audio dealers or the exhibition organizers British Audio Promotions Ltd., 49 Russell Square, London W.C.1.

In our June issue we plan to include a more detailed account of some of the new products, a few of which are illustrated here.



Goldring's G.850 stereo magnetic cartridge costs £6 10s and is designed to operate at a playing weight of between 2 and 3½ gm. The stylus has a 0.0007in diamond tip.

The XV-15 series of Pickering magnetic cartridges range in price from £15 15s (XV-15/100) to £39 (XV-15/750E). Some units have spherical and others eliptical styli. A groove-cleaning brush is fitted to each cartridge.

Manufacturers at the Show

Acoustic Research
Akai
Arena
Armstrong
Audiotechnica

BIB Multicore Solders
Brenell

Cambridge Audio
Cosmocord

Daystrom
Decca
Dynatron

Goldring
Goodmans
Grampian

I.M.F.

Jordan Watts

KEF

Leak
Lowther
Lugton
Lux

Metrosound
Modular Audio Components
Mullard

Ortofon

Peak Sound
Pickering
Pioneer

Quad

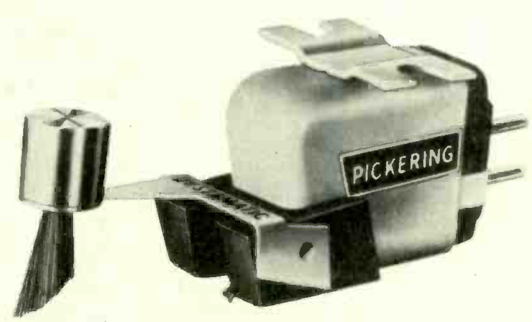
Radon
Rank Wharfedale
Revox
Richard Allan
Rogers
Rola-Celestion
Rotel

Sansui
Shure
Sinclair Radionics
Sugden, A. R.
Sugden, J. E.

Tape Recorder Spares
Teleton
Thorens
Toshiba

Vortexion

Williman Export



A reverberation amplifier, the SR202, from Pioneer enables controlled reverberation effects to be added to recordings that are judged to be too dry or dead. The system employs two time-delay circuits and the output is claimed to be free from peaks. The price is £45 9s 11d.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Measuring crossover distortion

Even by allowing Mr. J. F. Golding his margin of decibels by calculating-out the noise up to a level 3dB above that of the t.h.d. ("Letters" March 1970 issue), his 57dB s/n ratio amplifier turned down from maximum power to 10mW by means of the volume control would—based on 10W maximum power—permit easy measurement of little less than 0.5% t.h.d. Not easily down to 0.1% as stated by Mr. Golding in his letter. The reason for this, of course, is that the noise of the power amplifier although relatively small is significant. The full-power s/n ratio would not be retained at the low power, for this implies that the ratio of noise relative to full power is enhanced in exactly the same ratio as the power is diminished. In reality, while the output power is reduced from maximum by, say, 30dB by turning down the volume control, the noise yield at the output rarely falls by more than 10 to 15dB over the same volume control range. Obviously, the noise of the pre-amplifier section passed by the volume control adds to the noise of the power amplifier by a square law.

I initially test at maximum setting of the volume control because some pre-amplifiers tend to veer towards non-linearity more easily than may be appreciated. Moreover, the control might affect the frequency response either unintentionally or purposely (e.g., fixed 'loudness' action lifting treble and/or bass as the control is turned down), and the maximum setting ensures that an established test datum level can be quickly repeated, not always as simple as it may seem, by using the amplifier's volume control. Nevertheless, subsequent to exploratory tests there may be merit in rechecking at low volume-control settings and when so warranted I do this. It is also noteworthy that the noise decrease at the output, on turning the volume control right down to minimum from maximum, can be quite small, depending on the nature of the volume control circuit and the noise performance of the circuits either side.

Mr. Golding fails to specify the wave analyser which provides the 3,000:1 input noise bandwidth to filter bandwidth, but I am sure he will agree that the readout of such low-level distortion components as implied by his dB values relative to a low impedance output load is not exactly an 'easy' matter. I have found that an s/n ratio improvement of about 30dB based on a 10-W 8-ohm 80dB s/n ratio amplifier running at 0.1mW allows a threshold readout little better than 0.1% selected harmonic. For ultimate measurements deep into noise one has to adopt phase detection and correlation techniques, the latter allowing useful signal indication up to 60dB deep in noise.

T.H.D. is a popular way of amplifier distortion appraisal in spite of all the other more sophisticated methods. It is less costly and less time consuming than analysis of individual waves. It is ideal for speedy distortion comparisons, and with a 'scope attached to the readout the knowledgeable operator can quickly glean useful information about the nature of the distortion and observe crossover artifacts if they exist. Treble-end performance can also be highlighted and the presence of odd-numbered high-order harmonics is revealed to the owners of both sensitive and cloth ears.

GORDON J. KING,
Brixham,
Devon.

V.H.F. services

I was touched to notice in his March contribution that "Vector" has been studying the wisdom of the ages. Now that my friendly neighbourhood tower crane has moved away I think I was probably right in 1947 to urge a more detailed study of pulse modulation. But after all, was it in 1933 that the quite successful tests of single sideband and carrier were made from Daventry? And where did they lead us?

Two other articles of the period still have some interest. The f.m.-a.m. controversy was bedevilled by the statement in the House of Commons by the P.M.G. of the day that no discussion could fruitfully take place until he had considered an entirely new system of modulation. He did not tell the Post Office engineers what it was. He did not tell the BBC engineers what it was. But it was entirely new and there was a change of Government and when his party came back they didn't make him P.M.G. So we shall never know.

Another topical article followed, I think, my discovery that at Copenhagen the British contingent regarded engineers and foreign office staff as Falstaff saw bread and wine.

Without going into details we can split music into three classes: pop, palm court and proper. Land-lines need not be rationed, so that by using synchronized carrier only a small number of m.f. channels need be locked up to provide three European music programmes. The remaining channels are available for speech programmes, which are essentially national or local. Any country getting two or three national channels then would offer a choice of five or six programmes, even though its share of the production costs of the three common programmes would be small. The only trouble is that this solution provides the most listening, not the most jobs.

A final memory is of a letter, circa 1946, urging that television services should not be resumed. As an engineering problem the transmission of moving pictures was worth doing, because it was there. But there would never be the talent to produce 30 or 40 hours of programmes a week. How right I was.

THOMAS RODDAM

Theoretical and measured response

While musing on the operation of the tone circuitry in the pre-amplifier designed by Dr. Bailey, I did a few mental calculations, and was interested to note an apparently large discrepancy between the measured and theoretical treble response curve.

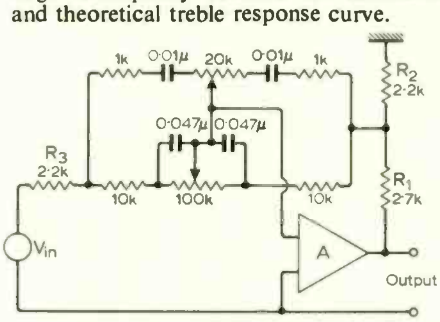


Fig. 1. Circuit of tone control.

Consider Fig. 1. At high frequencies all capacitors can be assumed low impedance, and in the limiting case, zero impedance. So for maximum treble-setting the high-frequency gain asymptote can be calculated if it is assumed that the two arms of the network are acting operationally. The limiting high-frequency equivalent circuit of Fig. 1 is shown in Fig. 2.

So the high-frequency gain asymptote is given as below:

$$G = \frac{1.2 + \dfrac{21 \times 10}{21 + 10}}{2.2 + \dfrac{1 \times 10}{1 + 10}}$$

$$= \frac{8}{3.1}$$

So $20 \log G = 8.2$ dB.

This value of G is about 10dB less than the apparent high-frequency asymptote given by Dr. Bailey. I would like, with respect, to suggest that perhaps the frequency response curves given were measured before the output attenuator R_1, R_2 and the input resistor R_3, were added. These are respectively included to increase the overall gain of the circuit to about 2, and as load impedance to match the treble filter which feeds directly into this stage.

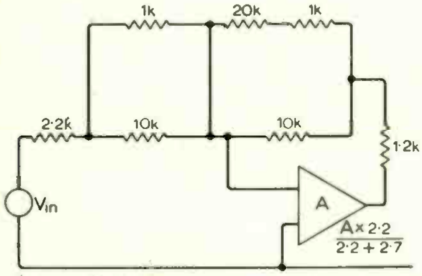


Fig. 2. High-frequency equivalent circuit.

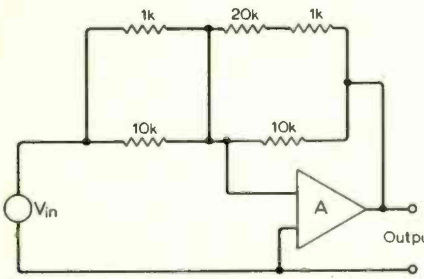


Fig. 3. Unity-gain version of Fig. 2 omitting R_1, R_2 and R_3.

The equivalent circuit at high frequencies for maximum treble lift can now be drawn as in Fig. 3 with R_1, R_2 and R_3 removed.

Now

$$G = \frac{21 \times 10}{21 + 10} \bigg/ \frac{1 \times 10}{1 + 10}$$

$$= \frac{6.8}{0.91}$$

So $20\log G = 17.5$ dB

This value agrees with Dr. Bailey's and is a reasonable figure.

It should be noted, therefore, that, so as not to restrict the range of the controls R_3 should be as small as possible.

It is also apparent that R_3 should equal the parallel combination of R_1 and R_2 otherwise the input and feedback portions of the network will not balance correctly with the controls centred.

P. M. QUILTER,
University of Sussex,
Brighton.

The author replies:
I was very interested in the letter from Mr. Quilter and his comments on the performance of the tone-control circuit. He is perfectly correct in his deductions and I must confess that the original curves were obtained with the treble filter circuit omitted. For this reason it is better to use the modified circuit where the filter components are bypassed with the filter out.

Personally, I have found that with speaker systems of low resonance (and similar performance pickups), treble filters are unnecessary unless a particularly dreadful recording is being played. 'Edginess' in reproduction is nearly always due to defects in speaker and/or pickup transient response—assuming that there is no crossover distortion trouble in the amplifier in use.

Similarly my treble controls are nearly always 'flat' and I use only a small amount of bass boost to make up for dynamic levels in playback. For my part I cannot see the need for ±20dB variation in controls, but I must agree that it looks better on a specification than say ±12dB.

Perhaps this is the reason why only one or two people have queried the performance (and then only h.f. boost). However it becomes obvious from Mr. Quilter's deductions that the two end-stop resistors of 1kΩ on the treble control are redundant. Also the 2.2kΩ resistor R_3 should be 1.2 kΩ for accurately balanced controls.

All this goes to show how simple modifications for one purpose can seriously modify the performance of a circuit in other directions. Many thanks Mr. Quilter, for a very useful lesson in the value of fully analysing the effects of modifications.

ARTHUR R. BAILEY

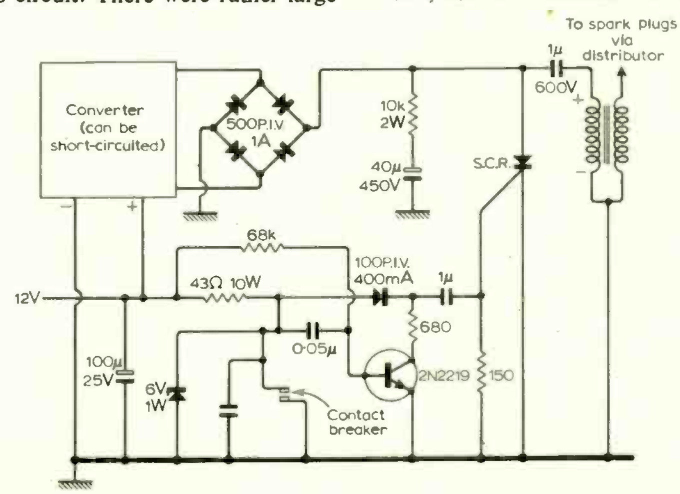
Capacitor-discharge ignition

During the last five years I have been interested in electronic ignition systems and after seeing Mr. Marston's article in the January issue of *Wireless World* I am prompted to write offering several comments on my own experiences.

In winter sub-zero conditions, the battery may drop to as low as 7V with a big engine and can rise to 15.5V under alternator charging. These limits are very severe on any ignition circuit, and accordingly in this continent [America] nearly standard ignition systems consist of a 1.5Ω ignition coil and a 1.5Ω series ballast resistor. While starting the ballast resistor is shorted out and the system gives fantastically good cold-weather starting. I doubted whether Mr. Marston's self-regulating converter would regulate well over a 2 to 1 voltage range, so I set about constructing his converter with a 17V 2A transformer that I happened to have brought back to Canada from a recent two-year stay in Cambridge. It has 210-, 220- and 240-volt primary taps. After rewinding two times 65 turns (the original had 136 turns) the converter put out about 500V in an ignition circuit with identical high-voltage components to Mr. Marston's circuit! There were rather large spikes at the transistor collectors and even at a very low sparking rate (induced manually) the voltage went down to 400V quickly. It seems the spikes do not have much energy to charge the 1μF discharge capacitor. At 10V d.c. input, the output was still 400V unloaded but this dropped to 300V at a low sparking rate. At 7V d.c. input the spark was inadequate. Mr. Marston's circuit may have regulated better (no two transformers are alike) but I feel such circuit action is not desirable where reliability is necessary. My friends and I have solved low starting voltage problems in several ways. One friend designed his system for 500V with 15V d.c. input, and this suffices until the battery falls below about 8V. Another friend uses a relay to switch in extra secondary turns on the converter transformer only during starting. My own solution is to add across the s.c.r. a large electrolytic capacitor in series with a 10-Ω 2-W resistor. The converter is a high-frequency unit (~1kHz) with no spikes, which supplies 400V with 15V input. When the ignition key is first turned on, the capacitor (~40μF) charges in a fraction of a second to ~400V, and the first 30 sparks are good and hot, no matter what the battery voltage.

Another serious problem is caused by the ballast resistor. After an ignition pulse, the converter again charges the discharge capacitor, causing typically several volts drop in the resistor. When charging ceases, the increasing voltage applied to the s.c.r. firing circuit could initiate a trigger. This has happened to some of my designs in the past and to combat any spurious triggering a 6-V 1-W zener diode was placed across the contact breaker. Any noise on the battery line produced by an erratic regulator will also be squelched by this zener. In Mr. Marston's circuit, transistor Tr_3 has an emitter-base breakdown voltage of about 7V, and the zener will also prevent very large base reverse currents which must flow when the contact breaker closes in the circuit as drawn. I do admire the trigger circuit for its positive ability to remove harmful effects of point bounce, and have already adopted it in my own unit.

The last point which I should mention as a purist is that a spark plug fires with lower voltage when the central electrode is negative, due to thermionic electron emission



Mr. Vanderkooy's circuit. The converter is an h.f. near-perfect square-wave unit using a nickel-tape-wound toroid.

from the hot electrode. All ignition systems, positive or negative earth, operate this way, and this feature should be preserved in an electronic system. A little analysis will show that in a standard ignition coil designed for a positive earth system (many British cars) the SW terminal should be grounded. (Fig. 6 in Mr. Marston's article.)

In conclusion perhaps readers would like to see my final circuit.

JOHN VANDERKOOY,
University of Waterloo,
Ontario.

The author replies:

From his letter, it seems that Mr. Vanderkooy has failed to grasp the operating principles of the converter circuitry, and does not appreciate the electrical requirements of an ignition system under cold start conditions.

I can assure Mr. Vanderkooy that the design of the converter section is such that it is virtually impossible for its output to exceed 414V ±5%. If higher voltages are obtained, it can only be because T_1 has been given a turns ratio greater than 15:1, or because ZD_1 and ZD_2 are not 27V ±5% types. If output voltages rise appreciably above the designed value, the s.c.r. (à 400V type) may be destroyed.

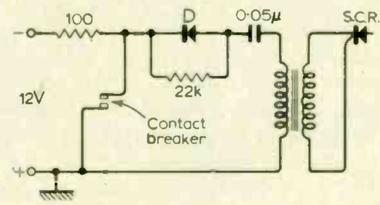
The ignition system has been specifically designed to give good cold-start characteristics; overshoot regulation is utilized to this end. While it is true that the overshoot (what Mr. Vanderkooy calls 'rather large spikes') contains very little energy, this energy is sufficient to meet cold start needs. Typically, a starter motor will turn an engine over at a 'brisk' rate of about 300 r.p.m. under 10-V cold start conditions, and at a 'sluggish' rate of only 150 r.p.m. at 8V. The table below shows the measured performance of the cireuit under these conditions, and also at 7V cold start; I consider the performance to be adequate under all conditions, and I feel sure that Mr. Vanderkooy will agree with me if he carries out a little practical research into the subject.

No. of cylinders	C_1 charge voltage		
	7V, 150 r.p.m.	8V, 150 r.p.m.	10V, 300 r.p.m.
4	260	290	325
6	250	280	322
8	240	270	310
12	237	265	300

Finally, I suggest that if Mr. Vanderkooy's battery potential does in fact fall as low as 7V under cold start conditions, there is something seriously wrong with either his battery, his starter motor, or his choice of lubricating oil; battery potential should in fact never fall below 8 volts, even under the most severe cold start conditions.

R. M. MARSTON

Having done some work on this system of ignition may I bring out a few points which may be of interest to readers? The converter transformer can conveniently be one of the centre tapped l.t. types which are on the market. Working backwards a 9–0–9 volt secondary is about right for square-wave working at 12V d.c. and gives a frequency of a few hundred Hz. The capacitor C_1 does need to be a low-loss type, a paper capacitor was found to become very warm at spark rates of 300 per second corresponding to 6000 revolutions per minute with a six-cylinder engine and 9000 with four cylinders. It is worthwhile to include a recovery diode across the s.c.r.: nearly 20% of the energy can be recovered from the leakage reactance on the backswing. Best results are usually obtained with a 6V 'sports' type coil which has a low primary inductance and resistance, the rated voltage of the coil does not matter much with this type of circuit. Putting a



'crowbar' across the inverter output at each spark seems rather brutal and I have always used choke charging with an inductance of 3 to 5 henries between the inverter and C_1. The circuit can be simplified by using a small differentiating transformer to produce the s.c.r. firing pulse.

Diode *D* and the 22kΩ resistor give a delayed recovery to avoid misfiring as a result of contact bounce. The normal ignition capacitor is removed when using this circuit.

I have had an ignition system of this type in use now for some 6 years and 70,000 miles with complete success.

H. HARPER,
Fleet,
Hants.

The author replies:

When designing the original circuit I tried to find a standard l.t. transformer that could be used in the system; I considered the possibility of using a 9–0–9 volt one, but found that they were generally available in 2- and 4-amp ratings only. Unfortunately the 4-amp type (which is essential for operation up to c.b. frequencies of 660Hz) was found to be physically too large to fit inside the standard chassis in which I built the unit. The 2-amp type was found to give a reasonable performance when used on a four-cylinder engine at speeds up to 6000 r.p.m., but to be inadequate when used on engines with six or more cylinders (the reasons for this should be self evident).

Regarding the use of a diode to give energy recovery on the backswing; D_3-D_6 already perform this function in the original circuit!

Regarding the use of a 6V 'sports' coil and the removal of the normal c.b. capacitor; the original system was designed to use the existing coil and c.b. components, thus keeping building cost to a minimum and enabling the ignition to be changed from C-D to normal, and vice versa, with great ease. Mr. Harper's mods nullify these features!

R. M. MARSTON

I have been developing a capacitor-discharge ignition system for some time and I think you may be interested to know how I have attempted to overcome some of the problems mentioned by correspondents.

I have positively prevented s.c.r. latching by doing two things. I have arranged a feedback system to provide the gate drive. This consists of a monostable with a feedback connection from the s.c.r. anode which causes the drive pulse to be switched off as the s.c.r. switches on. This prevents gate drive from latching the s.c.r. I have also used a driver h.t. converter. In this the pulses from the driver circuit are fed through a gating circuit before being fed to the output transistors, driving the transformer. So by using the gating circuit to switch the converter on and off, very fast and reliable turn on, and turn off may be obtained. This facility may also be used to regulate the voltage to which the capacitor is charged by using a comparator to measure this voltage and switch the converter off when the capacitor is suitably charged.

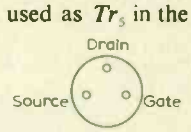
Finally I would like to make a few comments about the e.h.t. coil and the contact breaker points. Standard coils are not the best for use with capacitor-discharge systems. A far better coil would be a low-inductance primary, closed-iron type. These offer higher efficiency, higher operating speeds and less need for energy retrieval to recharge the capacitor (that is using the coil's back e.m.f. to charge the capacitor).

Also I believe it would be worthwhile for the more ambitious constructor to try to replace the points with a photo-electric magnetic or reed switch pick-up as points can be quite troublesome when lightly loaded.

D. J. WHITE,
Harborne,
Birmingham.

Modular pre-amplifier design

Some users of this design (*W. W.* July 1969) have found a somewhat higher level of background 'hiss' than had been expected at very low settings of the volume control. Where this has occurred it is usually due to the f.e.t. used as Tr_5 in the tone control circuit.



A much improved performance in this respect can be obtained by the use of an Amelco 2N4302 or 4303. In the former case it may be necessary to modify the biasing of the f.e.t. to ensure that the drain current is at a suitable level. (The voltage measured at the emitter of Tr_6, which is a convenient point, should be somewhere in the range 6-11 volts.)

The adjustment of the f.e.t. bias can be done either by alteration to the 33-kΩ source resistor, or by connecting a resistor of about 3.3MΩ between the emitter of Tr_4 and the gate of the f.e.t.

J. L. LINSLEY HOOD,
Taunton,
Som.

Digital Remote Control System

Up to fifteen circuits may be controlled from a remote point with this system

*by H. N. Griffiths**

Up to fifteen circuits can be remotely controlled using this system, the block diagram of which is given in Fig. 1. As can be seen the system consists of two units, a coder and a decoder, connected by some form of data link; this could be a pair of wires or a radio transmitter and receiver.

The coder is a pulse generator which can generate a train of between one and fifteen pulses under the control of the switches S_1 to S_{15}.

Initially the stop and set zero lines in the coder are UP (positive) so that the multivibrator is stopped and the counter is set to zero. Operation of any control switch (S_1 to S_{15}) earths the stop and set zero lines and the counter starts to count pulses from the multivibrator which will have started. When the counter reaches a preselected state, as determined by the logic network and the operated switch, the inhibit line goes UP and the multivibrator stops.

The decoder counter also counts the pulses from the multivibrator which are sent over the data link. When the multivibrator is inhibited the two counters will hold the same number. The logic network in the decoder now actuates the required control.

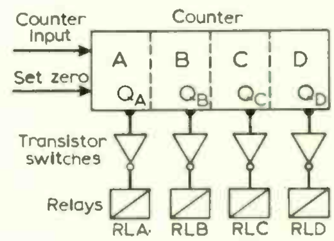
It is arranged that when the input to the decoder is UP (no signal) the decoder set zero line is also UP, resetting the counter. On receipt of the first negative edge the set zero line of the decoder goes down and is held down by capacitor C_S so that the counter can accept the incoming pulses.

On release of the control switch in the coder the stop and set zero lines in the coder go UP returning the coder to its initial state and the input to the decoder also goes UP (and stays there) so that the decoder counter also resets. The operated control is now released.

When fewer than fifteen controls are required, the decoder logic network can be simplified. Indeed, if relays are used to operate the controls it is possible to eliminate the logic network by using the relay contacts to perform the decoding logic functions. In such a system (Fig. 2) the relay coils are controlled directly by each stage of the binary counter via the transistor switches (see inset Fig. 3). Fewer relays are required to perform a given number of on-off control functions than is the case when a separate relay is used for each control. The overall reliability of the system is degraded, however, because each control is operated through a group of contacts in series and failure of any one of these will cause at least one control (and possibly half the total number of controls, depending on the position of the fault) to fail. However, the saving in circuitry and the increased simplicity of the system will, in many cases, offset the risk of simultaneous failure of more than one control.

Communication Channel

The simplest form of data link is two wires between coder and decoder. In



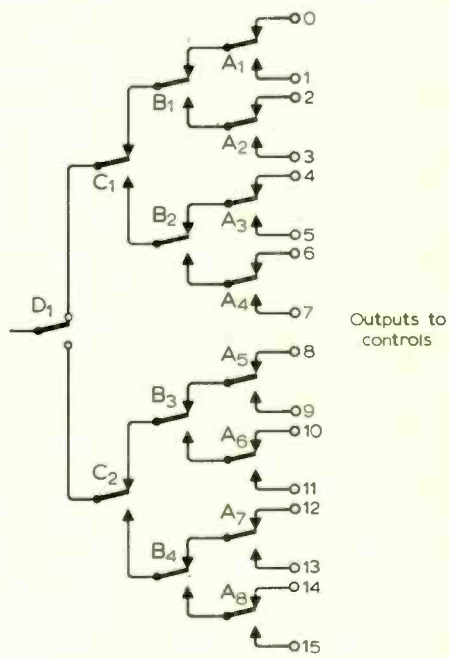


Fig. 2. (Above) Showing how the decoding can be performed with relays.

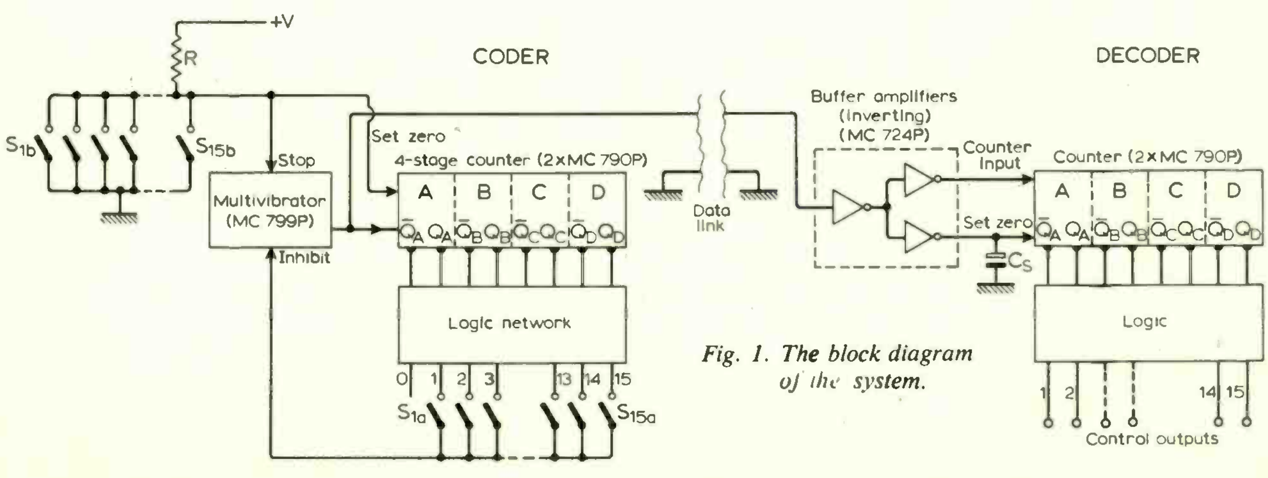


Fig. 1. The block diagram of the system.

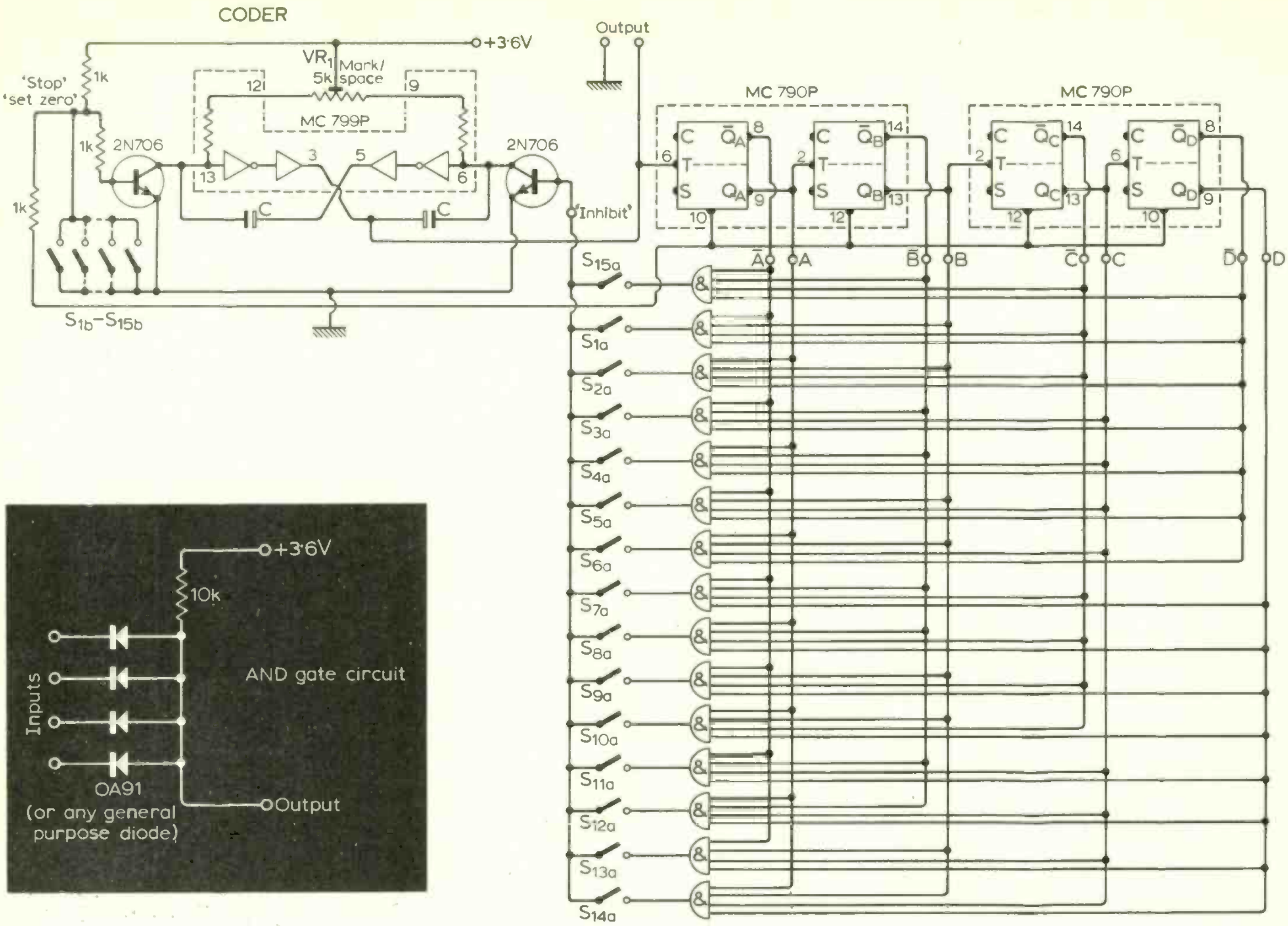
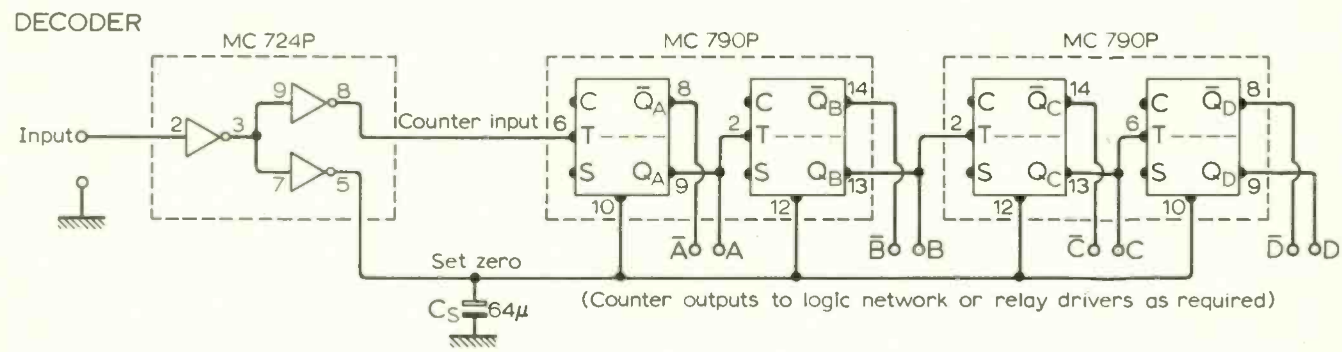
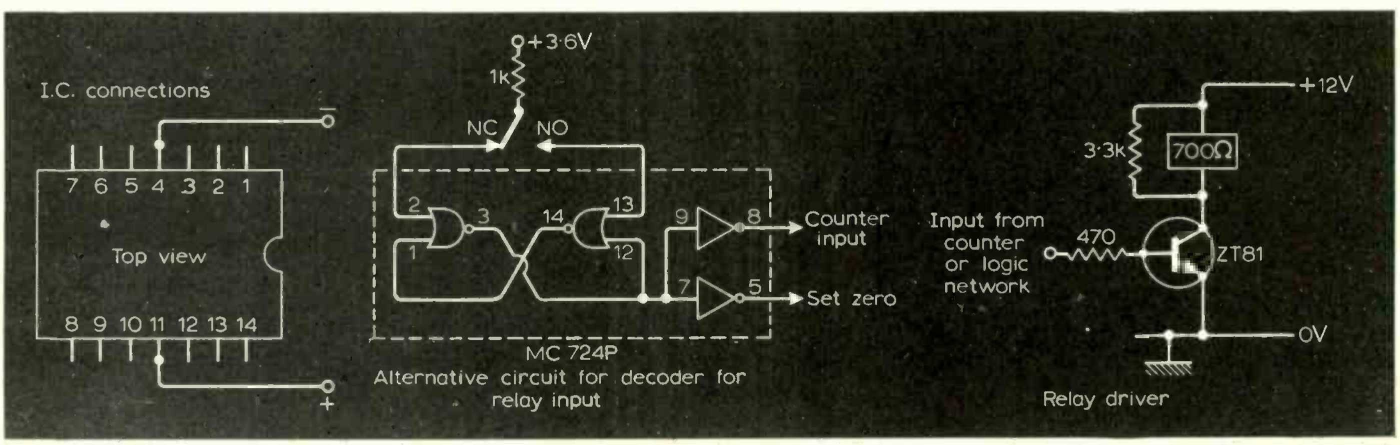


Fig. 3. The circuit of the coder (Above) and decoder (Below). If wished the decoder may be used with the relay decoding system of Fig. 2 or with the same AND gate networks as the coder. The inset above gives the circuit for the AND gates. A relay drive circuit for use with relay decoding and an alternative decoder input circuit for use with a relay input are given in the lower inset.





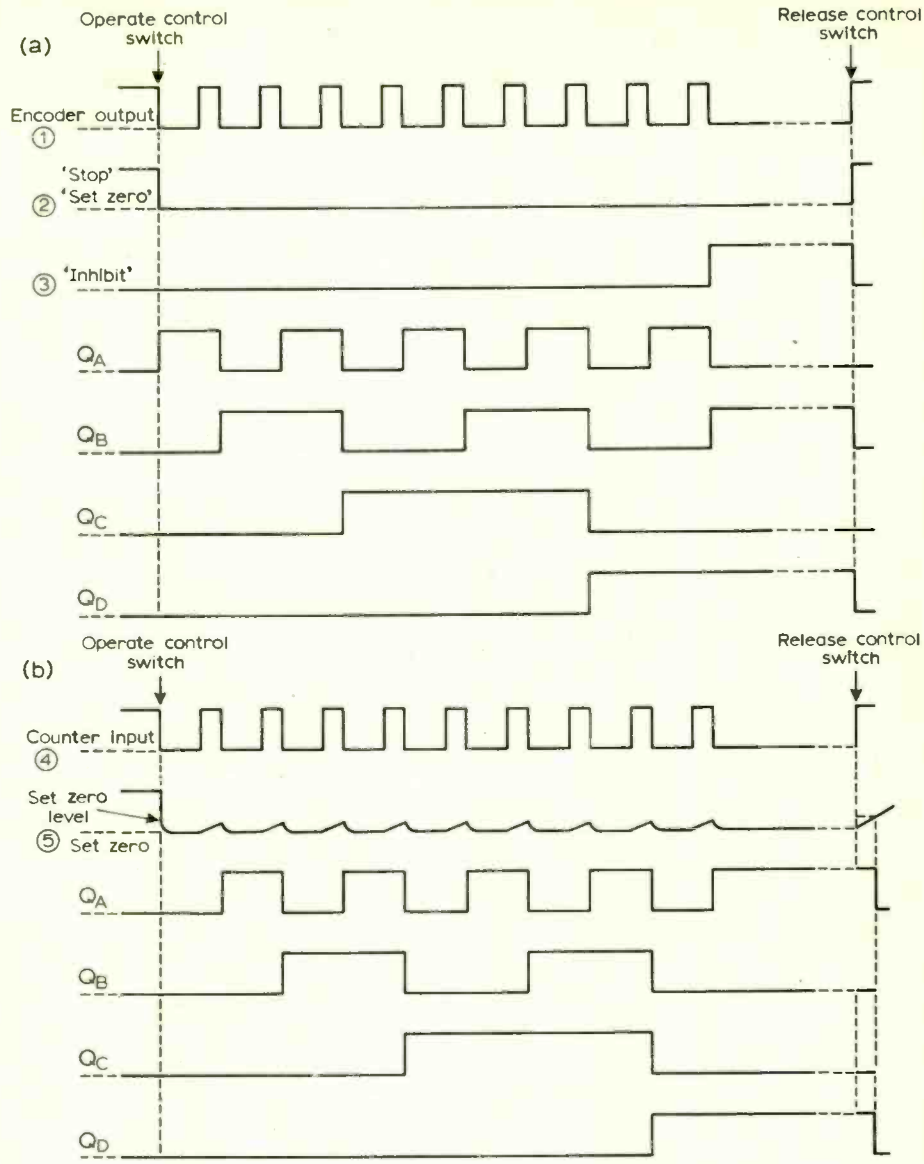


Fig. 4. (a) Coder and (b) decoder waveforms.

cases where complete freedom of movement of the remote unit is required a radio communication channel can be used to carry the control information. In fact, the original system was conceived as a means for the remote control of a model via a 27MHz radio link. Since amplitude modulation is used in the prototype, the system is susceptible to impulse interference which may be generated, for example, by the electric motors being controlled. It is therefore essential, in such a case, to incorporate a device which rejects impulsive spikes of short duration and allows the decoder to respond only to the relatively slow rate of the signal pulses.

Erratic operation may also occur if the supply voltages to the integrated circuits are allowed to drop too far below the nominal value of 3.6V. Since the decoder input is controlled by a relay in the radio control receiver, special precautions are taken to eliminate faulty triggering due to contact bounce. A 'set-reset' bistable is therefore interposed between the relay contacts and the counter input (see inset Fig. 3).

Transient operation of intermediate controls may occur when the counter in the decoder is stepping to its final state. One method of eliminating this is to connect a suitable capacitor in parallel with each relay.

The pulse rate in the prototype is chosen to be 20Hz. This is high enough to permit rapid selection of controls but sufficiently low to ensure reliable operation of the relay in the radio control receiver. This relay also provides a measure of impulse interference rejection since it responds to the signal pulses but rejects impulsive 'spikes' of short duration.

Circuitry

The circuit is given in Fig. 3. Simple diode AND gates are employed in the logic network. If used with a radio control receiver which employs a relay the alternative decoder input circuit should be used. The decoder may be built with the relay decoding circuit of Fig. 2 or with the same logic circuit as the coder, in this case the outputs of the AND gates are used to actuate the required controls.

Adjustment is confined to setting the pre-set potentiometer in the coder for satisfactory operation. It will be found that a mark-space ratio of 1:2 is about right.

In order to simplify the electronic design and improve reliability integrated circuits have been employed in both the coder and decoder. The coder uses three dual-in-line packages: a dual buffer (multivibrator) and two dual J-K flip-flops (counter). The decoder also uses three dual-in-line packages: a quad two-input gate and two dual J-K flip-flops (counter). The dual buffer (MC799P), quad two-input gate (MC724P) and dual J-K flip-flops (MC790P) are all from the Motorola range of r.t.l. circuits.

The prototype uses printed circuit construction but it is suggested that the first attempt at construction be made by mounting the packages on unclad 0.1-inch matrix Veroboard and interconnecting by direct wiring. Any mistakes are more easily rectified when the direct wiring technique is employed.

Transients

What happens to an LCR circuit when it's shocked

by Thomas Roddam

Two articles (*W.W.* February and March) have been devoted to considering the "natural" behaviour of simple circuits containing at most one inductance, one capacitance and one resistance. Even so, only one form of the *LCR* circuit has been considered, the form in which the same current appears at the terminals of each element. The same kind of result will be obtained for the other form, in which the same voltage appears at the terminals of each element. I do not propose to prove this: the actual solution can be obtained in an easier way and there is a limit to the amount of detailed examination which the editor, the reader and the author will stand.

Natural behaviour is the term used for the current which flows in a circuit when, having managed to get some energy in one of the energy stores, either as current in an inductance or charge in a capacitance, or both, the circuit is left isolated while the energy is being dissipated in the resistance element. We have seen that, as a general conclusion, we obtain a characteristic time for each storage type element in the circuit. If we have an *LR* or a *CR* circuit we get the current following the simple decay function

$$\exp(-t/\tau)$$

in which $\tau = CR$ or L/R, which we call the time constant. For the *LCR* circuit the general form depends on

$$\exp(-t\cdot R/2L)\exp jt\left(\frac{1}{LC}-\left(\frac{R}{2L}\right)^2\right)^{\frac{1}{2}}$$

in which we must take both positive and negative signs for the square root term. The interesting case at the moment is when $L/C > R^2/4$, which leads to the form

$$\exp(-tR/2L)\cos(\omega t)$$

It is usual to take, not $\tau = 2L/R$, but $\alpha = R/2L$, the damping constant. Then we have

$$\exp(-\alpha t)\cos(\omega t)$$

Fig. 1 shows the shape of this behaviour. As we increase R, keeping L and C constant, the decay envelope has a shorter time constant, a tighter time scale. In addition, ω, the square root term, becomes smaller, thus increasing the time scale of the oscillatory wave. If the decay envelope is falling faster than the oscillatory wave it will dominate the situation. This is rather dull, in waveform terms, and will not be discussed until we get to the complex plane. I had, indeed, intended to devote this article to the idea of complex frequency, but when I came to sort out the basic facts I found that transients must come first.

The great problem with the study of the transient behaviour of circuits is that it is complicated and tedious, rather than difficult. There are basically two kinds of transient behaviour. In one, the circuit is given an instantaneous shock, by closing a switch or some other equivalent means, but essentially just hit with a package of energy. We have already the sort of solution we shall expect, although whether it is to be $\cos\omega t$ or $\sin\omega t$ or $\cos(\omega t+\theta)$ depends on how the shock is delivered. The other kind of behaviour arises when we apply an energy source which can produce a continued action. The natural kind of source, which will go on indefinitely, is given by the function the circuit itself has defined, but with an infinite value for the decay time, $1/\alpha$. This means simply the common cosine wave, $\cos\omega t$. We set up the circuit of Fig. 2. After a good few times, the time $1/\alpha$ (for the *LCR* circuit), any energy involved in the starting process will have been dissipated and the system will have settled to the steady state.

The voltage across the capacitor will be given by the equation

$$V_C = \frac{1}{C}\int I\,dt = V_0\exp(j\omega t) - L\frac{dI}{dt} - RI$$

The point of writing $V_0\exp(j\omega t)$, with the implied operation of taking real parts later, is to make the mathematics have a simpler pattern. The equation is rearranged to the standard form

$$L\frac{dI}{dt} + RI + \frac{1}{C}\int I\,dt = V_0\exp(j\omega t)$$

We are going on for ever, so the current will have the same shape as the voltage, or so we guess.

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

If so:

$$\left(j\omega L + R + \frac{1}{j\omega C}\right)I_0\exp(j\omega t) = V_0\exp(j\omega t)$$

or $\quad I_0 = V_0/\left(R + j\omega L + \dfrac{1}{j\omega C}\right)$

$$\frac{V_0}{I_0} = R + j\left(\omega L - \frac{1}{\omega C}\right) = R + jX$$

This general form of Ohm's Law is one we use every day. X is the reactance and, if $\omega L > 1/\omega C$, X is of an inductive kind: if $\omega L < 1/\omega C$, X is of a capacitive kind.

Because $I = I_0\exp(j\omega t)$, we can write

$$I = V_0\cdot\left(\frac{\cos\omega t + j\sin\omega t}{R+jX}\right)$$

$$= \frac{V_0}{R^2+X^2}\cdot(R-jX)(\cos\omega t + j\sin\omega t)$$

$$= \frac{V_0}{R^2+X^2}\cdot(R\cos\omega t + X\sin\omega t) + \text{terms in } j$$

We take the real part of this, giving

$$I = \frac{V_0}{R^2+X^2}(R\cos\omega t + X\sin\omega t)$$

If $X/R = \tan\theta$

$$R/(R^2+X^2)^{\frac{1}{2}} = \cos\theta$$

$$X/(R^2+X^2)^{\frac{1}{2}} = \sin\theta$$

and then $\quad I = \left|\dfrac{V_0}{Z}\right|\cos(\omega t - \theta)$

in which $Z^2 = (R^2 + X^2)$

The voltage on the capacitance, V_C, is

$$V_C = \frac{1}{C}\int I\,dt = \left|\frac{V_0}{Z}\right|\cdot\frac{1}{\omega C}\cdot\sin(\omega t - \theta)$$

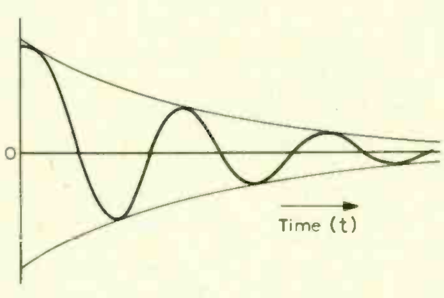


Fig. 1. The shape of exp $(-\alpha t)$ cos (ωt) enclosed in the decay curve exp $(-\alpha t)$.

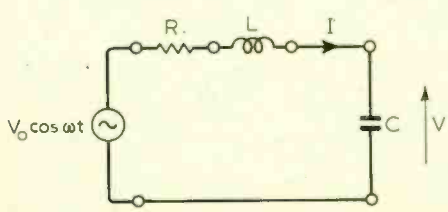


Fig. 2. The driven circuit.

The voltage across the inductance is

$$V_L = L\frac{dI}{dt} = -\left|\frac{V_0}{Z}\right|\cdot\omega L\cdot\sin(\omega t-\theta)$$

Notice how, if $\omega L = 1/\omega C$, V_C+V_L becomes zero. In a study of transient conditions we shall see that I_L and V_C are the terms we want.

The usual method of studying what happens when the oscillator signal is switched on is a straightforward affair of formal mathematics, followed by the consideration of a number of particular cases. The variety arises from the fact that we have the natural frequency of the circuit itself, $\omega_0 = 1/(LC)^{\frac{1}{2}}$ (leaving out the damping correction), the damping correction, the frequency of the supply. The drive may be at, $\omega = \omega_0$, near, or well above or below the natural frequency. The actual switching instant may be when the generator voltage is a maximum, or zero, or somewhere in between. There may even be some current flowing in the inductor, some charge in the capacitor. So, find the general solution and put in the boundary conditions.

When I came to do this I found it was totally incomprehensible. At the end of the process one emerges with an answer, for the specific conditions, but on the way one had no contact with any sort of physical reality. In more advanced circuit work this is normal, and the more advanced the theory the more likely you are to have a large amount of "reality" wrapped up in a single symbol. With tears pouring down my cheeks I scrapped the elegant analysis and began to look for a more direct way of determining the transient behaviour of the circuit. The approach I chose is not in any of the books I looked at, although that is probably my bad luck.

The key to all transient behaviour is the way the free circuit settles down to the rest stage. When we looked at its behaviour before we found that the current was of the form

$$I = \exp(-\alpha t)\cos(\omega t)$$

This form does not contain any constants of integration. The voltage on the capacitance is best worked out from scratch. If we start with the capacitor charged, to correspond with the way we started with current flowing in the inductor, we get again

$$V = \exp(-\alpha t)\cos\omega t$$

By working through the analysis for the two cases in which we consider either fixed current starting and capacitor voltage or fixed voltage starting and inductor current we get expressions of the form

$$\exp(-\alpha t)\sin\omega t$$

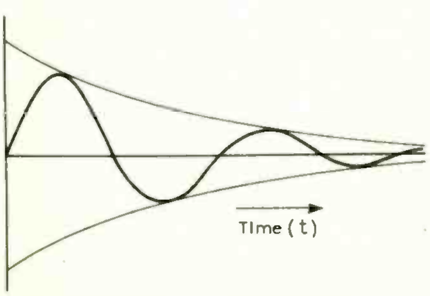


Fig. 3. The shape of exp (−αt) sin ωt.

In general, whatever the starting condition may be, we would expect the function to be of the form

$A\exp(-\alpha t)\cos(\omega t+\theta)$ [or $\sin(\omega t+\theta)$, whichever we choose, provided we adjust θ]. We have two constants of integration, which can be chosen to fit the initial current and voltage. Apart from the actual size of these functions, we can always write

$$\cos(\omega t+\theta) = \cos\omega t\cdot\cos\theta-\sin\omega t\sin\theta,$$

So that any value of θ can be realized if we take the right mix of the two curves, Fig. 1 and Fig. 3.

Let us adopt some low trickery. We set our circuit off with a current I_1 and a voltage V_1. I_1 is flowing into the capacitor, so that it will tend to increase V_1. Obviously V_1 is opposing the flow of I_1 and will tend to reduce it. We assume, since this is a fairly normal assumption among the more theoretical treatments, that α is small compared with ω. There is not much difference between successive cycles.

We began with a total energy of

$$\tfrac{1}{2}LI_1^2+\tfrac{1}{2}CV_1^2$$

After a short time, all the energy will be in the capacitance and the current will have fallen to zero. The capacitance voltage will then be V_{max}, given by

$$\tfrac{1}{2}CV_{max}^2 = \tfrac{1}{2}CV_1^2+\tfrac{1}{2}LI_1^2$$

Thus we can find V_{max}.

All this is on paper, so negative time is quite an acceptable thing. At a small value of t, with t negative, the curves show all the energy in the inductance, and $V = 0$. At this time

$$\tfrac{1}{2}LI_{max}^2 = \tfrac{1}{2}CV_1^2+\tfrac{1}{2}LI_1^2$$

As we have decided that we will take the case of $\alpha \ll \omega$, then two quantities, V_{max} and I_{max}, are very close to the correct values for the envelopes $(V, I)_{max}\exp(-\alpha t)$.

At this point I begin drawing Fig. 4. I mark in V_{max} and $-V_{max}$, I_{max} and $-I_{max}$, and then V_1 and I_1. I also draw the exponential envelopes.

Now if $V_1/V_{max} = \sin\omega t_0$, the voltage wave must have crossed the zero axis at $-t_0$. We can measure along from here in angle units of $\pi/2$, or time units of $\pi/2\omega$ ($= 1/4f$). Now we sketch in the waveform. The error in this is always less than

$$\exp(-\alpha\pi/2\omega)$$

Because α is small compared with ω it is tempting to take $\omega = \omega_0$, that is to use the frequency fixed by LC. Guillemin seems to do this, but it would appear to me that it leaves a nasty ambiguity in one of the cases we are now going to study.

The really tricky problem is that of switching on a sine-wave generator in the circuit. We are allowed to simplify it by assuming that the circuit had not recently been disturbed, so that it contains no stored energy. As it happens, the method we are now going to use makes it relatively easy to take account of any stored energy. The applied waveform is shown in Fig. 5, where the switch has been closed at a quite arbitrary point in the cycle. "Typical cases" in the textbooks usually amount to the choice of either switching at cross-over or switching at the peak. A typical case means one which is fairly easy to calculate, and I am not sure if these are, in fact, the easiest. Wait and see.

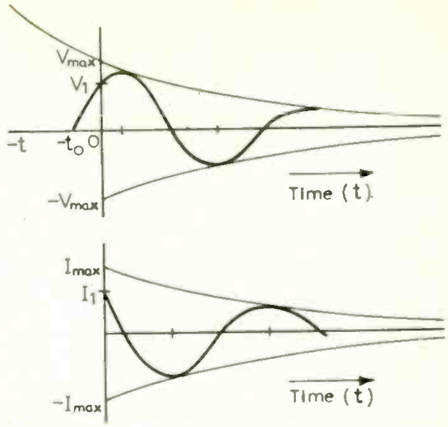


Fig. 4.

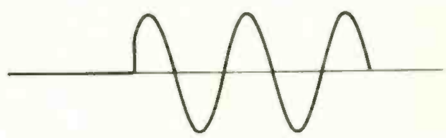


Fig. 5. Harmonic excitation applied at arbitrary phase.

I am determined to do no more thinking than I need. I know that if I look for the steady state, the current in an *RLC* circuit from a voltage $V_0\sin\omega t$ will be given by

$$V_0\sin\omega t = I(R+j\omega L+1/j\omega C)$$

To make the expressions look simpler we write

$$R+j\omega L+1/j\omega C = R+j(\omega L-1/\omega C)$$

$$= R+j\omega_0 L\left(\frac{\omega}{\omega_0}-\frac{1}{\omega\omega_0 LC}\right)$$

Now choose $\omega_0^2 = 1/LC$, giving

$$R+j\omega_0 L\left(\frac{\omega}{\omega_0}-\frac{\omega_0}{\omega}\right)$$

If we now write $\omega_0\left(\frac{\omega}{\omega_0}-\frac{\omega_0}{\omega}\right) = \Omega$, we have

$$I = V_0\sin\omega t/(R+j\Omega L)$$

or
$$I = \frac{V_0}{(R^2+\Omega^2L^2)^{\frac{1}{2}}}\cdot\sin(\omega t-\theta)$$

where $\tan\theta = \Omega L/R$. Although this looks like an *LR* circuit only, we can now have Ω negative for positive values of ω, whenever $\omega<\omega_0$ in fact. So that this way of writing the result involves a range

for ω =	0		ω_0		∞
Ω =	$-\infty$	−ve	0	+ve	∞

The voltage across the capacitor is given by

$$V_C = \frac{1}{C}\int I\,dt$$

$$= \frac{V_0}{(R^2+\Omega^2L^2)^{\frac{1}{2}}}\cdot\frac{1}{C}\int\sin(\omega t-\theta)dt$$

$$= -\frac{V_0}{(R^2+\Omega^2L^2)^{\frac{1}{2}}}\cdot\frac{1}{\omega C}\cos(\omega t-\theta)$$

Now we know the two important terms in the steady state solution. Let us adopt a simple trick. We use two voltage generators,

$$V_0 \sin \omega t \quad \text{and}$$
$$V_0 \sin (\omega t+\pi)$$

For one we get some current I_1, given by the equation above, and a capacitor voltage of V_{C1}. The other produces a current $I_2 = -I_1$, and a voltage $V_{C2} = -V_{C1}$. They might just as well not be there. Let us now, however, switch off the second generator. This is indicated in Fig. 6. The current produced by

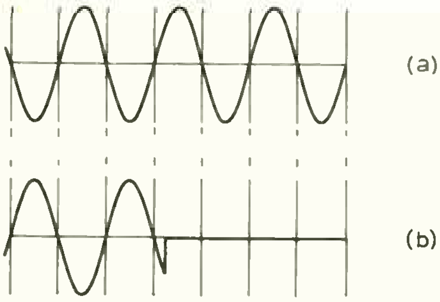


Fig. 6. Instead of switching on, *as shown in Fig. 5, one signal is switched* off.

the first generator continues to flow quite unperturbed. The stored energy associated with the second generator is the transient energy, and this sets up the decaying oscillation which we discussed earlier in the article. The formal justification for this method is that the equations are all linear.

If I were writing a rather grand textbook I should at this point begin to calculate a vast variety of examples. One simple way of doing this used to be to invite a selected group of students to lunch, flatter them by asking for unspecified help and then dole out the drudgery. Advances in modern technology make it possible to get one student to do it all on the department computer, and buy his own lunch into the bargain. But let us be realistic. In transient problems with a switched sine wave we normally have one of two situations. Either we don't know the switching phase, as in the ordinary switch-on situation, or the phase may vary systematically over a wide range, as in a phase-controlled rectifier circuit. We need a picture of the kind of behaviour we can expect. I am well aware that there are occasions when a detailed study of a special situation is required. Such problems can be solved by working out I_1 and V_{C1}, using the equations just given, and then using these in determining the ring shown in Fig. 4. This is just added to the steady state solution. What sort of an answer do we expect.

First of all, notice that we are concerned with two frequencies, for which I shall use the letter f. We have the generator frequency, f_g, and the frequency of the transient ring, f_r. With f_r goes the damping coefficient, which is $\alpha = R/2L$ and which modifies the undamped frequency slightly. For a lightly damped circuit we want $\alpha \ll 2\pi f_r$. This does not necessarily mean that $\alpha \ll 2\pi f_g$. A circuit with a very low Q, or very high damping, at the working frequency may ring vigorously at its natural frequency. Notice that this is likely when $f_r \gg f_g$.

Now we may proceed to pick out a few special situations. Suppose that f_r is very much less than f_g. When the circuit is being driven by the two opposing generators, the quantity Ω will be

$$2\pi f_r\left(\frac{f_g}{f_r}-\frac{f_r}{f_g}\right) = 2\pi\left(f_g-\frac{f_r^2}{f_g}\right)$$

This is very close to $2\pi f_g$, the value we should get if we made $f_r = 0$. The current is virtually that we should get in an RL circuit. It is quite easy to sketch out Fig. 7, which shows the current in the circuit. The switched-off generator leaves current flowing, and this decays exponentially. If we have a low value of α, i.e. $\alpha \ll 2\pi f_r$, this exponential would be replaced by a long, slow, oscillation. The two generator sine waves shown represent the currents, not the voltages: we can job back to the voltage from the $\tan \theta = \omega L/R$ equation. Obviously the most important case is when the current is a maximum. It should be noted that one very important feature of this circuit is that the current must follow a continuous curve. The inductance will always prevent a sharp step in current. Similarly the capacitance will always prevent a sharp step in voltage.

The second example is for the case when f_r and f_g are fairly close together. This is a rather tedious one to draw, because a good drawing needs about $5f_r/(f_g-f_r)$ cycles to show the pattern. We set about it as before, though now for $t>0$ we have an exponentially decaying sine wave which does not necessarily have its peak at $t = 0$. To draw it properly we must work out the peak from the total stored energy equation and for this we need to draw the capacitance voltage curve too. Physically what happens is this. When the transient situation occurs, the stored energy appears as a damped sine wave of frequency f_r. The generator produces an undamped sine wave of frequency f_g. The two current waves beat together at $|f_g-f_r|$ to produce the modulation effect shown more clearly in the sketch of Fig. 8(b). As the ring dies away the current settles to the steady state value. The detail at the beginning depends on the phase of the switch operation. It makes little difference to the kind of response whether $f_g>f_r$ or $f_g<f_r$. What is important is that the current may reach double its normal peak value. It is logical to guess that it is also possible for the capacitor voltage to reach double its normal peak value. Practical circuits in which this kind of transient condition can arise need tougher components than you thought.

At the desk one considers $f_r = f_g$. The analysis then finds that there are some small terms to throw away, and in the whole pro-

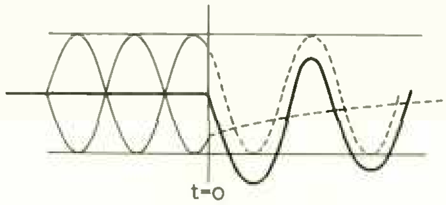


Fig. 7. Response of $f_r \ll f_g$. The decay curve at $t>0$ is the transient component, to which the steady state solution is added to give the overall behaviour.

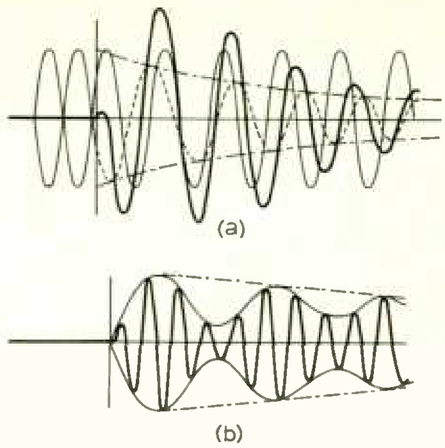


Fig. 8. Situation for $f_r<f_g$ but f_g-f_r small.

cess I rather lose track of whether f_g is the damped or undamped frequency. Anyway, I do not believe in this sort of equality. If we go back to the nearly equal frequency problem, and then say that the beats are so slow that they have died away before the first maximum is reached, we get a normal "soft-keying" growth in a straightforward sine wave. Rather roughly, this means that we consider the case where

$$\alpha > (f_g-f_r), \text{ even though}$$
$$\alpha \ll f_g$$

Since α will always exist, we never need to consider $f_g = f_r$: we just take them near enough together. In this way we avoid any awkward questions about roots of an equation coinciding.

Finally we come to the very interesting case when $f_g \ll f_r$: the ring frequency is high compared with the frequency of the drive. This is the kind of situation which is encountered when a mains transformer is switched on or off and the leakage inductance and stray capacitance form the ringing circuit. A feature of this situation is that if it is treated by purely analytical methods the result which emerges is totally unexpected in form. The conscientious student goes back over the analysis to find out just what went wrong. The method we adopt here gives us a direct feeling of the nature of the solution, with no surprises, or perhaps more appropriately, no unexpected shocks.

At the low drive frequency we can more or less ignore the circuit inductance. If the damping coefficient is low enough, we can even ignore the resistance. For this extreme case, the full generator voltage appears across the capacitance. If the resistance is not as low as all that, the voltage is split between capacitance and resistance and it is very easy to calculate the peak value of capacitance voltage. It is

$$V_C = V_0/[1+(\omega CR)^2]^{\frac{1}{2}}$$

Let us consider the extreme case. Let us also assume that the switching instant is when V_C is a maximum. The energy stored in the capacitance is $\frac{1}{2}(CV_C^2)$. For the transient waveform we have an exchange of energy between capacitance and inductance, and, as we have assumed that α is very small, the first current maximum, I_L, must satisfy the equation:

$$\tfrac{1}{2}I_L^2L = \tfrac{1}{2}CV_C^2$$

Thus $\quad I_L = V_C(C/L)^{\frac{1}{2}}$

But if $\omega_r = 2\pi f_r$, we know that $\omega_r^2LC = 1$

Then $\quad C/L = \omega_r^2C^2 \quad$ and so

$$I_L = V_C \cdot \omega_r C$$

The steady state current through the inductance is limited by the capacitance, and is $I_{L,s} = V_0 \cdot \omega_g C$. Taking $V_C = V_0$

$$I_{L,t} = \frac{f_r}{f_g} \cdot I_{L,s}$$

It will be seen that the transient current is very large indeed compared with the normal current (Fig. 9). We could have chosen a dif-

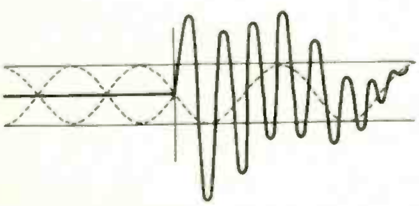


Fig. 9. For $f_r \gg f_g$ the current ring is very much larger than the steady state current.

ferent switching phase. Had we done so we should have found a smaller value of transient current, which we can work out for any phase by the energy equations. Worst case solutions are, however, the ones which normally interest us.

Very much the same pattern of results is obtained when we study the way a parallel tuned circuit behaves with the switching of a current source. The commonest form here, numerically, is the line transformer of a television set. Here, as indeed in all the variations, we would study the voltage across the capacitance and we know, in the similar but more general form of a transistor with an inductive load, it is energy associated with volts which we must watch. Energy associated with volts, because second breakdown is not a linear phenomenon.

More complex circuits can be handled on a piece by piece basis, but the labour involved is often prohibitive. Transients are not normally central to the main problem, and the main problem takes most of our effort. A knowledge of the sort of transient behaviour to expect, together with a quick calculation of the stored energy which has easy access to the danger points, will normally be sufficient. Then, if the situation is potentially dangerous, wheel out the oscilloscope.

Nowhere in this article is there any mention of musical transients in amplifiers. This is, of course, a topic of great importance. There are two aspects which make it unsuitable for treatment here and now. Musical transients are not produced by a click-on mechanism, but have finite rise and fall times; they pass through circuits, feedback amplifiers, with a much sharper phase shift characteristic than our single tuned circuit. Anyway, this article is quite long enough.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Apr. 8–15 Earls Court
Electrex '70
(Electrical Engineers A.S.E.E. Exhibition, Museum St., London W.C.1)

Apr. 13–16 University College
Atomic and Molecular Physics
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Apr. 23–26 Skyway Hotel
Sonex '70 HiFi Exhibition
(Federation of British Audio, 49 Russell Sq., London W.C.1)

Apr. 28 & 29 Royal Garden Hotel
Microelectronics Conference
(Business Conferences & Exhibitions, Mercury House, Waterloo Rd., London S.E.1)

BIRMINGHAM

Apr. 14–17 The University
Automatic Test Systems
(I.E.R.E., 8-9 Bedford Sq., London W.C.1)

HARWELL

Apr. 2–3 A.E.R.E.
High Voltage Electron Microscopy
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

OXFORD

Apr. 6–11 The University
Biological Engineering Conference
(J. Gasking, Dept. of Pharmacology, St. Bartholomew's Hospital Medical School, Charterhouse Sq., London E.C.1.)

READING

Apr. 6–8 The University
Thin Films Conference
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Apr. 15–17 The University
Defects in Semiconductors
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

UXBRIDGE

Apr. 14–16 Brunel University
Computer Graphics International Symposium
(R. Elliot Green, Brunel University, Uxbridge, Middx.)

OVERSEAS

Mar. 31–Apr. 2 New York
Submillimetre Waves
(Polytechnic Inst. of Brooklyn, 333 Jay St., Brooklyn, New York 11201)

Mar. 31–Apr. 3 Paris
Electrical-Electronic Engineering Seminar
(E.E.E. Seminar, 80 rue Jouffroy 75-Paris 17e)

Apr. 3–8 Paris
Electronic Components Show
(Fed. Nat. des Ind. Electroniques, 16 rue de Presles, Paris 15e

Apr. 5–9 Berlin
Cybernetics Congress
(Deutsche Gesellschaft für Kybernetik, 21 Stresemann Allee, 6 Frankfurt/Main 70)

Apr. 6–10 Paris
Advanced Microelectronics Conference
(Fed. Nat. des Ind. Electroniques, 16 rue de Presles, Paris 15e)

Apr. 7–9 Las Vegas
Reliability Physics Symposium
(K. H. Zaininger, RCA Labs, Princeton, N.J. 08540)

Apr. 10–20 Tokyo
Japan Electronics Show
(Japan Elec. Show Assoc., Tokyo Chamber of Commerce Bldg., 2-2 Marunouchi 3-chome, Chiyoda-ku, Tokyo)

Apr. 14–17 Washington
Geoscience Electronics Symposium
(I.E.E.E., 345 East 47th St., New York, N.Y. 10017)

Apr. 14–19 Frankfurt
Hi-Fi Show
(U.S. Trade Centre, Frankfurt/Main)

Apr. 21–24 Washington
International Magnetics Conference (INTERMAG)
(D. S. Shull, Bell Telephone Labs, 3300 Lexington Ave, Winston-Salem, N.C. 27102)

Apr. 21–24 Budapest
Microwave Communication Colloquium
(Microcoll—Technica Háza Budapest, V. Szabadsag tér 17, Hungary)

Apr. 22–24 Dallas
Southwestern I.E.E.E. Conference
(A. P. Sage, Inst. of Tech., S.M.U., Dallas, Texas 75222)

Apr. 27–29 Atlantic City
Frequency Control Symposium
(Electronic Components Lab., U.S. Army Electronics Command, Fort Monmouth, New Jersey 07703)

Apr. 27–30 Los Angeles
National Telemetering Conference
(A. V. Balakrishnan, UCLA, Rm. 3531, 405 Hilgard Ave, Los Angeles, Calif. 90024)

Circuit Ideas

H. F. Predictions—April

High-gain f.e.t. tuned amplifier

The reverse transfer capacitance of a field-effect transistor can be employed as a very stable Q multiplier with inherent automatic bandwidth control. Essentials are (Fig. 1) resistive drain and source loads and selection of C, which is smaller in value than a bypass capacitor. C determines the no-signal Q: decreasing the value moves the stage towards oscillation; increasing it has the reverse effect. This circuit, with no additional components, will replace two double-tuned 470-kHz i.f. stages. With a constant current supply it is reproduceable using wide-tolerance f.e.ts. The response of Fig. 2, after optimum adjustment of C, is a shallow curve, peaking reasonably close to oscillation over the middle third of each band. The detector stage assists in bandwidth control (varying the impedance of D_1), and even on weak signals accurate tuning is indicated by wideband quality. For operation at frequencies higher than 2MHz the drain load must be progressively reduced.

K. W. MAWSON,
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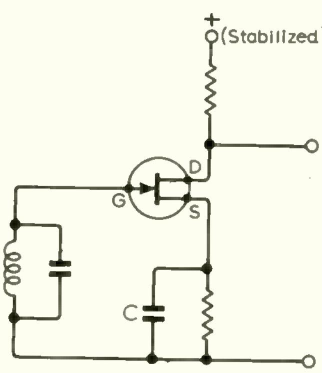


Fig. 1. F.E.T. as Q multiplier.

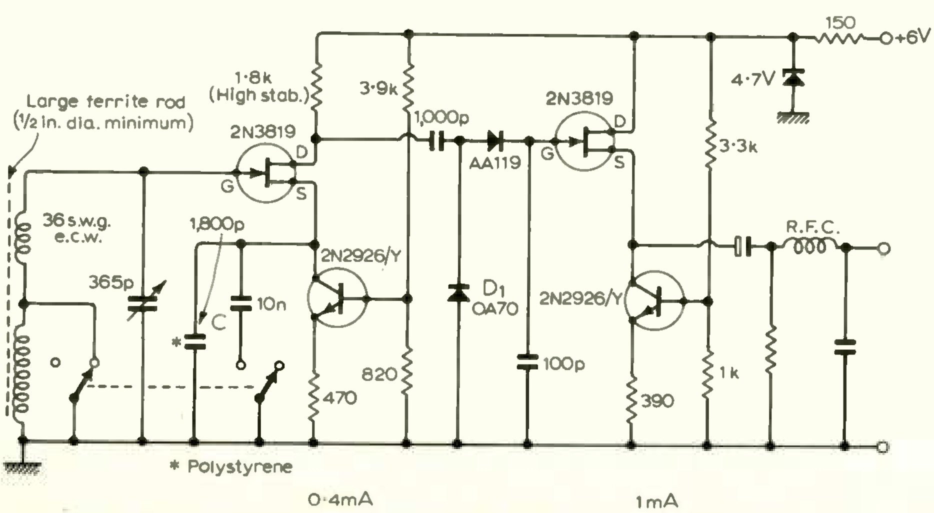
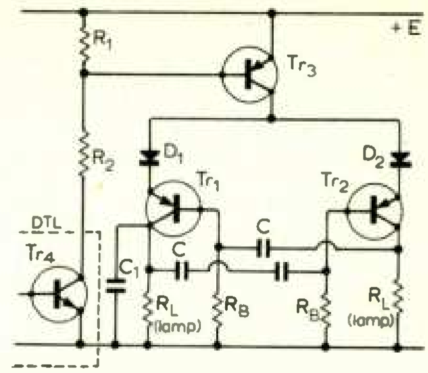


Fig. 2. M.W./L.W. tuner employing Q multiplier.

Logic circuit gates astable multibrator

When Tr_4—the output transistor of a d.t.l. logic stage—is switched off, the current in R_1 is very slight and Tr_3 is effectively off: R_2 is chosen so that when Tr_4 saturates, Tr_3 saturates thus permitting the multi to function. D_1 and D_2 are included to prevent base-emitter breadkown in Tr_1 and Tr_2 for a large voltage at the collector of Tr_3. C_1 is a small capacitor (100pF) included to make the collector circuits of Tr_1 and Tr_2 dissimilar: this ensures that the multi will not block. Conventional design theory governs the choice of C R_L, R_B. The circuit functions just as well if R_2 is omitted and the base of Tr_3 is driven from a high impedance source, e.g. the collector of a current-mode switch. For a 5V rail suitable values of R_1 and R_2 are R_1 = 1kΩ and R_2 = 2.2kΩ, for current in R_L up to 16mA. Typical low-cost devices which are



suitable are: diode IN4148 (G.E.); transistors (Ferranti plastic 'E' line) ZTX 500.

B. L. HART,
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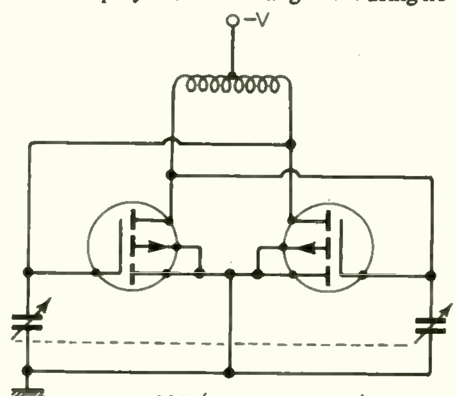
F.E.T. push-pull oscillator

Wide frequency range LC oscillators are usually Colpitts or Hartley configurations. Higher output can be obtained using a push-pull arrangement. Many thermionic valve circuits have been evolved and n-channel field-effect devices can be substituted without significant modifications. The use of p-channel enhancement devices can however simplify the bias arrangement using no



M206 (Marconi-Elliott)

Fig. 1. Oscillator operating up to 300MHz.

M206 (Marconi-Elliott)

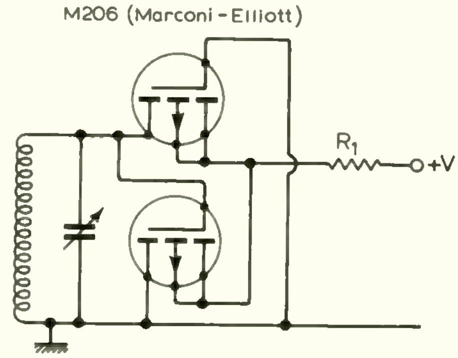


Fig. 2. Arrangement for operation between 50 kHz and 350MHz.

components other than the active devices and the tuning components is shown in Fig. 1. The tap on the coil can be omitted if a pair of chokes or resistors are used to feed f.e.t. drain connections.

The unusual re-arrangement shown in Fig. 2 allows the tuning components to be at ground potential. The circuit is no longer balanced and a resistor (R_1) or choke is required.

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Active Filters

9. Synthesis by factors

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

It is shown how a filter may be synthesized as a product of factors, and a number of numerical examples are given.

So far in this series we have dealt mainly with principles. In this article, although some important methods of realization still remain to be described, it is shown how some of the circuits already described can be put to use. The method is that of synthesizing the complete filter as a cascade of 1st- and 2nd-order sections, each with output impedance low enough for its response to be unaffected by the connection to it of the following section. Thus the response of the whole filter is the product of the responses of the individual sections. It is a practical method of design for specifications of moderate stringency, and also throws light on the nature of filters of higher order and their transfer functions.

It is not possible in this series to say very much about the design of filters as such, but an attempt is made in this Part to help the non-specialist reader—partly by calculation, and partly by the use of reference works—to make a start on the design of filters to a variety of specifications.

5th-order low-pass filter with Darlington response

In a conventional wave filter the important characteristic is the steady-state amplitude (or gain-versus-frequency) response. This can be specified, Fig. 1, by three parameters: A_p the maximum deviation from level response in the pass band; A_s the minimum attenuation in the stop band; $(\Omega_s - 1)$ the relative width of the transition band, Ω_s being the start of the stop band in the normalized characteristic ($\omega_p = 1$). And if any two are specified, the work of Darlington shows how to proportion the elements of a given structure to give the best value of the third. The nature of the relationship between the three is that, if for constant A_s a smaller value of Ω_s is required, then either a greater ripple in the pass band (A_p) must be accepted or a structure of greater complexity must be adopted. The steady-state amplitude response of a filter of Darlington design (sometimes called an elliptic-function filter) is of equal-ripple type in pass band and stop band, as indicated in Fig. 1.

* Royal Radar Establishment.

Thus we may quote from Reference 1 as a representative optimum set of values for the structure shown in Fig. 2: $A_p = 0{\cdot}1$ dB, $A_s = 40$ dB, $\Omega_s = 1{\cdot}44$; and the "ladder coefficients", i.e. the element values for the normalized filter, are given in Table 1, ω_p being used as the reference frequency, not ω_B as in the paper referred to

TABLE 1

Normalized component values for 5th-order Darlington filter. Fig. 2.

$A_p = 0{\cdot}1$ dB, $A_s = 40$ dB, $\Omega_s = 1{\cdot}44$
$\omega_p = 1$ radian/second, $R_S = R_L = 1$ ohm

C_1	1·016	C_2	0·175
L_2	1·197	C_4	0·521
C_3	1·596	T_2	0·4576
L_4	0·882	T_4	0·6780
C_5	0·773		

Although of symmetrical topology the filter is not symmetrical, since $C_1 \neq C_5$, $L_2 \neq L_4$, etc. This is always the case in an efficient filter of order higher than three; one reason is that the rejector circuits (L_2C_2 and L_4C_4) are tuned to different frequencies.

The five elements in the left-hand column of the table, by themselves, form a 5th-order simple ladder filter and give the transfer function a 5th-order denominator. The addition of the capacitances C_2 and C_4 does

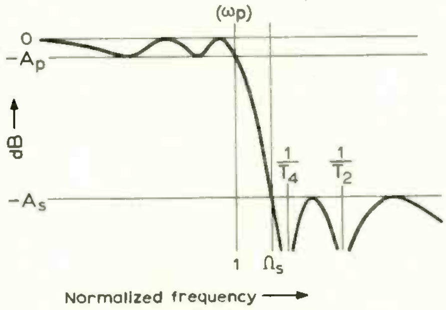

Fig. 1. Diagrammatic representation of 5th-order Darlington response.

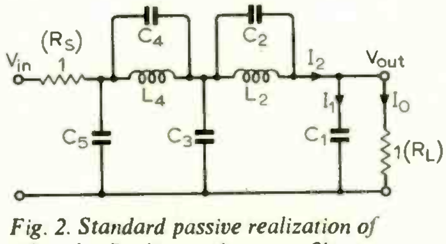

Fig. 2. Standard passive realization of 5th-order Darlington low-pass filter.

not change this order (although it does change the coefficients of the terms), but the numerator becomes 4th-order. Because $R_L = R_S$ and the reactances are assumed to be without loss, the voltage ratio at zero frequency is one half. Consequently the transfer function may be written

$$G(p) = \frac{V_{out}}{V_{in}} = \frac{1}{2}\cdot\frac{N(p)}{D(p)}$$

$$= \frac{1+ap+bp^2+cp^3+dp^4}{2(1+Ap+Bp^2+Cp^3+Dp^4+Ep^5)} \qquad (1)$$

The industrious may find the coefficients by analyzing the network:

$$I_0 = V_{out}/R_L$$
$$I_1 = V_{out}\,pC_1$$
$$I_2 = I_0 + I_1$$
$$V_2 = I_2Z_2 = \frac{(I_0+I_1)pL_2}{1+p^2L_2C_2}$$
$$V_3 = V_2 + V_0$$
$$I_3 = V_3pC_3$$

and so on. It is only fair to give warning, however, that over forty products have to be formed in working out the denominator. The numerator, however, is easily obtained. It is

$$1+p^2(L_2C_2+L_4C_4)+p^4L_2C_2L_4C_4$$

and so depends only on the components of the two infinite-rejection circuits. For the chosen example the numerical values of the denominator coefficients are: $A = 2{\cdot}73$, $B = 4{\cdot}19$, $C = 4{\cdot}68$, $D = 2{\cdot}85$, $E = 1{\cdot}38$.

For our present purpose the transfer function is required factorised. This may be regarded as the mathematical excercise of finding the roots of the equations $N(p) = 0$ and $D(p) = 0$. These roots are the z_1, z_2, etc., and p_1, p_2, etc. of the identities

$$N(p) \equiv d(p-z_1)(p-z_2)(p-z_3)(p-z_4), \qquad (2)$$

$$D(p) \equiv E(p-p_1)(p-p_2)(p-p_3)(p-p_4)(p-p_5), \qquad (3)$$

and are referred to as the zeroes and poles of $G(p)$, since if $p =$ any of z_1, etc. $G(p) = 0$, while if $p =$ any of p_1, etc. $G(p) = \infty$. The numerator of the chosen example can be treated generally as it factorizes into

$$N(p) = (1+p^2L_2C_2)(1+p^2L_4C_4); \qquad (4)$$

but p_1, p_2, etc. can be expressed only as particular numerical values:

$$p_1, p_2 = -0{\cdot}1080 \pm j1{\cdot}065$$
$$p_3, p_4 = -0{\cdot}413 \pm j0{\cdot}784$$
$$p_5 = -0{\cdot}667.$$

By multiplying together the denominator factors containing the complex conjugates p_1 and p_2 a 2nd-order factor with real coefficients is formed,

$$(p^2+\alpha_1\omega_1p+\omega_1^2);$$

and by writing $p_1, p_2 = -a \pm jb$, it is seen that

$$\omega_1^2 = a^2+b^2, \qquad (5)$$

$$\alpha_1\omega_1 = 2a, \qquad (6)$$

i.e. $$\alpha_1 = 2a/(a^2+b^2)^{\frac{1}{2}} \qquad (7)$$

If the factor is now divided by ω_1^2, which gives

$$\frac{p^2}{\omega_1^2}+\frac{\alpha_1 p}{\omega_1}+1,$$

it is easily compared with the preferred form

$$1+pT/q+p^2T^2,$$

whence $T = 1/\omega_1 = (a^2+b^2)^{-\frac{1}{2}}$ (8)

and $q = 1/\alpha_1 = (a^2+b^2)^{\frac{1}{2}}/2a$

$$= \left(1+\frac{b^2}{a^2}\right)^{\frac{1}{2}}\Big/2. \quad (9)$$

Or, by reference to Fig. 3,

$$T = \frac{1}{OP},\quad q = \frac{OP}{2OA}. \quad (10),(11)$$

For the example then

$$T_1 = 0{\cdot}9357,\quad q_1 = 4{\cdot}94$$
$$T_3 = 1{\cdot}129,\quad q_3 = 1{\cdot}073$$

and for the real 1st-order factor

$$T_5 = -1/p_5 = 1{\cdot}499.$$

Thus the transfer function has been obtained in the form $N(p)/D(p)$

$$= \frac{(1+p^2T_2^2)}{(1+pT_1/q_1+p^2T_1^2)}\times \frac{(1+p^2T_4^2)}{(1+pT_3/q_3+p^2T_3^2)(1+pT_5)} \quad (12)$$

with parameters as given above, and $T_2 = \sqrt{L_2C_2} = 0{\cdot}4576, T_4 = \sqrt{L_4C_4} = 0{\cdot}6780$.

The 2nd-order numerator and denominator factors may now be paired arbitrarily to give sections with unsymmetrical notch response, Part 2, Fig. 19. As the highest Q factor is not very high, both sections may conveniently be realized by the Sallen-and-Key type of circuit with added parallel path, Part 6, Fig. 11(b).

Consider the transfer function

$$G(p) = \frac{1+p^2T_4^2}{1+(1/q)pT_1+p^2T_1^2} \quad (13)$$

and let it be identically equal to the standard form

$$\frac{1+ap^2T_1^2}{1+(1/q)pT_1+p^2T_1^2} \quad (14)$$

Then $a_1 = T_4^2/T_1^2 = 0{\cdot}523$. Similarly for the other 2nd-order section, $a_3 = T_2^2/T_3^2 = 0{\cdot}164$. Hence the schematic for the whole filter may be as in Fig. 4. This gives the relative component values for the case of ideal amplifiers, $K = 1$, $A = \infty$.

Equation (8) of Part 6, which becomes when $b = \frac{1}{2}$

$$\frac{1}{q} = \frac{1}{q_i}+\frac{2q_i}{A+1}, \quad (15)$$

shows that for $q_i = 5$ and $A = 1000$ the

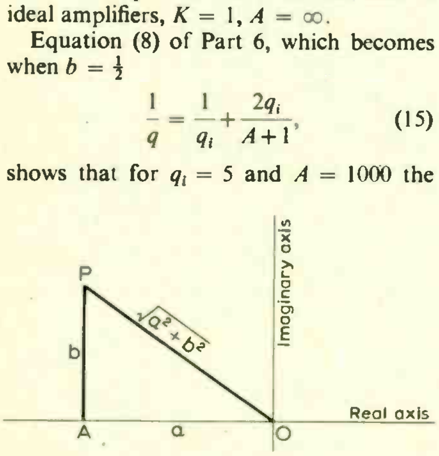

Fig. 3. P is the position of a pole, $p = -a+jb$.

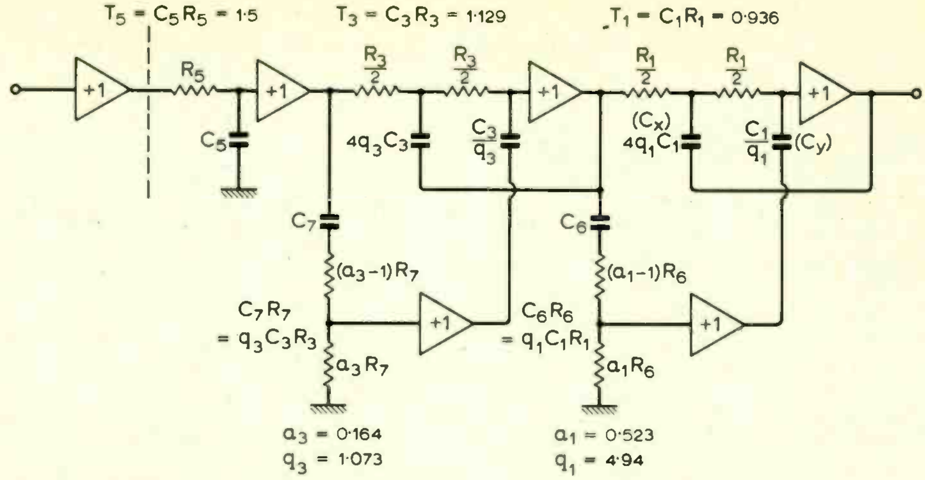

Fig. 4. Schematic for realization by factors of 5th-order Darlington response with 0·1 dB ripple in the pass band, 40 dB minimum attenuation in the stop band, and cut off at 1 radian/second.

ideal component values would give an actual q approximately 5% low, and that if compensation is made by increasing the ratio C_x/C_y, the appropriate value of q_i is 5·28. If this method is used it should be remembered that for a good zero the equality

$$C_6R_6 = C_xR_1/4 \quad (16)$$

must be maintained. Hence C_6 may have to be changed. A more convenient method of compensation would perhaps be to increase K slightly by using less than 100% feedback as shown in Fig. 5 of Part 6. The calculation really shows, however, that for accurate design A should be high, say 10,000 minimum, for q of this value. Alternatively a two-integrator loop may be used (Part 7), or a parallel-T system (to be described in a following Part). For the other 2nd-order section, $q = 1{\cdot}073$, a moderate value of A is sufficient, although for practical convenience the same type of amplifier is likely to be used.

Moving the cut-off frequency to the required value is a simple matter of scaling. So, to set the −3 dB frequency at 1000 radians/second (= 159 Hz) ω_p must be 923 radians/second and all time constants of the normalized filter must be divided by this figure. This gives (including small adjustments based on an accurate computation of the overall response) the values shown in Table 2 below.

TABLE 2

Component values for 5th-order Darlington filter, Fig. 4, scaled for −3 dB at 159 Hz.

Stage 1	Stage 2	Stage 3
T_5 = 1·623ms	q_3 = 1·073	q_1 = 5
R_5 = 16·2kΩ	T_3 = 1·222ms	T_1 = 1·018ms
C_5 = 0·1μF	T_7 = 1·313ms	T_6 = 5·09ms
	$R_3/2$ = 26·3kΩ	$R_1/2$ = 20·4kΩ
	$4q_3C_3$ = 0·1μF	$4q_1C_1$ = 0·5μF
	C_3/q_3 = 21,700pF	C_1/q_1 = 5000pF
	C_7 = 0·01pF	C_6 = 0·05μF
	$(a_3-1)R_7$ = 110kΩ	$(a_1-1)R_6$ = 48·6kΩ
	a_3R_7 = 21·5kΩ	a_1R_6 = 53·3kΩ

TABLE 3

Parameters for 5th-order Darlington response, normalized to cut-off frequency ω_p = 1 rad/s.

$$G(p) = \frac{(1+p^2T_2^2)(1+p^2T_4^2)}{(1+pT_1/q_1+p^2T_1^2)(1+pT_3/q_3+p^2T_3^2)(1+pT_5)}$$

A_s (dB)	$1/\Omega_s$	A_p (dB)	q_1	T_1	q_3	T_3	T_5	T_2	T_4
20	0·9	0·077	9·73	0·955	1·469	0·975	1·029	0·662	0·881
	0·95	0·38	17·38	0·988	2·017	1·065	1·380	0·746	0·937
30	0·7	0·009	4·262	0·850	0·962	0·871	0·900	0·456	0·676
	0·75	0·025	4·96	0·895	1·042	0·951	1·044	0·499	0·726
	0·8	0·071	5·724	0·935	1·167	1·033	1·238	0·546	0·776
	0·85	0·21	8·071	0·969	1·387	1·115	1·522	0·598	0·828
	0·9	0·72	12·60	0·994	1·857	1·187	2·02	0·663	0·881
	0·95	2·8							
40	0·6	0·012	3·554	0·842	0·885	0·927	1·043	0·378	0·576
	0·65	0·033	4·096	0·889	0·959	1·018	1·225	0·416	0·625
	0·70	0·09	4·902	0·932	1·070	1·108	1·460	0·456	0·675
	0·75	0·24	6·19	0·966	1·247	1·196	1·791	0·499	0·726
	0·80	0·66	8·489	0·992	1·560	1·270	2·295	0·546	0·777
	0·85	1·8	13·31	1·010	2·193	1·318	3·175	0·598	0·827
50	0·55	0·04	3·655	0·889	0·9188	1·073	1·364	0·342	0·527
	0·6	0·12	4·382	0·934	1·033	1·178	1·661	0·378	0·576
	0·65	0·32	5·405	0·971	1·213	1·274	2·078	0·416	0·626
	0·7	0·82	7·410	0·997	1·518	1·354	2·701	0·456	0·675
	0·75	2·0	10·886	1·015	2·076	1·407	3·710	0·499	0·726
	0·8	4·24							
60	0·45	0·039	3·331	0·881	0·884	1·096	1·424	0·274	0·430
	0·5	0·13	4·052	0·934	1·006	1·221	1·790	0·308	0·479
	0·55	0·38	5·162	0·975	1·203	1·334	2·311	0·342	0·527
	0·6	1·0	7·033	1·004	1·335	1·424	3·107	0·378	0·576
	0·65	2·4	10·367	1·022	2·145	1·479	4·397	0·416	0·626
	0·7	4·9							

In the pass band distortion from the theoretical curve is most likely to be caused by misalignment of the high-q section with respect to the other two. The greatest slope of the response of this section in the pass band is $\frac{1}{4}$ dB for a 1% change of frequency. For not more than $\frac{1}{10}$th dB error in the passband, therefore, an accuracy in the component values of $\pm 0{\cdot}4\%$ is indicated.

Points in favour of realization by factors are that requirements for amplifier gain and the effect of errors in component values are easily calculated, and hence amplifier gains and component tolerances are easily specified. A further convenience is that errors can be localized by measuring the responses of the individual section. These responses for the given example are shown in Fig. 5. The overall response was given in Part 1, Fig. 1.

An experimental filter of this design was shown by the Royal Radar Establishment on the Ministry of Aviation stand at the I.E.A. Exhibition, London, in 1964; and at the Physics Exhibition, London, in 1969 G.E.C., Ltd., (Hirst Research Centre, Wembley) showed some interesting developments of the same type of circuit.

The derivation of the factors of the transfer function from the element values of the passive filter serves to show the relationship between the several ways of specifying the filter and its responses. For accuracy, however, the qs and Ts of the factors are better computed directly from the Darlington theory as given in Ref. 1, Ref. 2, and elsewhere; and some sets of values so obtained are given in Table 3. The k of Ref. 1 $= 1/\Omega_s$. Tables of poles and zeroes for Darlington and some other types of filter are given in Ref. 3 and may be converted into real factors as shown above, Fig. 3 and equations (10) and (11).

3rd-order Darlington response

3rd-order Darlington is specified as in Fig. 1, though there is only one trough in the pass band, and one zero in the stop band. Such a specification is met by a structure as shown in Fig. 6. There is no longer any necessity to use an unsymmetrical structure, and in practice a symmetrical structure is used. This can be bisected into two equal halves, and hence a general expression for the transfer function found in factorized form,

$$G(p) = \frac{1+p^2T_2^2}{2(1+(1/q_1)pT_1+p^2T_1^2)(1+pT_3)} \quad (17)$$

The response may then be analyzed by simple algebraic methods. However, some ready-computed results are given here:

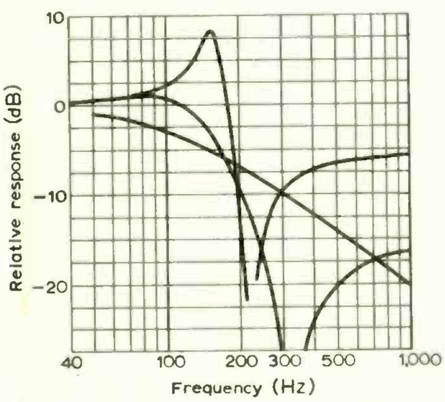

Fig. 5. Measured responses of the individual stages of a filter as Fig. 4, scaled to give −3 dB at 159 Hz.

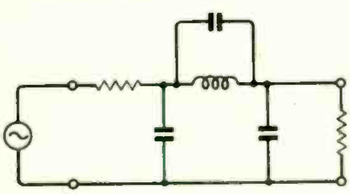

Fig. 6. Schematic for passive realization of 3rd-order Darlington response.

TABLE 4

Parameters for 3rd-order Darlington response, normalized to cut-off frequency $\omega_p = 1$ rad/s.

$$G(p) = \frac{1+p^2T_2^2}{(1+pT_1/q_1+p^2T_1^2)(1+pT_3)}$$

A_s (db)	$1/\Omega_s$	A_p	q_1	T_1	T_3	T_2
20	0·5	0·05	1·635	0·704	0·699	0·441
	0·6	0·15	1·929	0·826	0·928	0·533
	0·7	0·5	2·480	0·931	1·252	0·630
	0·8	1·5	3·731	1·007	1·778	0·731
30	0·4	0·1	1·515	0·766	0·919	0·351
	0·5	0·4	1·909	0·909	1·328	0·441
	0·6	1·3	2·685	1·010	1·959	0·533
	0·65	2·2	3·354	1·030	2·418	0·581
40	0·3	0·15	1·486	0·807	1·074	0·261
	0·4	0·8	2·080	0·978	1·778	0·350
	0·45	1·6	2·604	1·036	2·305	0·395
	0·5	2·9	3·373	1·074	3·012	0·441

Butterworth response

The occasional designer may like to have at command without resort to reference books a few design formulae suitable for meeting specifications of only moderate stringency such as might occur in the experimental laboratory in acoustical and vibrational work. In such applications the steep cut off given by a zero in the stop band may not be required, and the easily defined Butterworth (or maximally flat) response is often used:

$$|G(\omega)| = \frac{V_{out}}{V_{in}} = \frac{1}{(1+x^{2n})^{\frac{1}{2}}} \quad (18)$$

where $x = \omega/\omega_c$, ω_c is the -3 dB (or corner) frequency, n is the order of the response. The nature of this family of responses is shown in Fig. 7. Each for its own value of n is the best monotonic approximation to the two asymptotes, i.e. the closest-fitting curve with a slope continuously increasing in one direction, and all pass through -3 dB at $\omega = \omega_c$, i.e. at $x = 1$.

The first three we already know in factorized transfer-function form, Table 5.

TABLE 5

Amplitude and transfer functions for low-pass Butterworth filters, $n = 1$ to $n = 3$.

$\lvert G(\omega)\rvert$	$G(p)$
$\frac{1}{(1+x^2)^{1/2}}$	$\frac{1}{1+pT}$
$\frac{1}{(1+x^4)^{1/2}}$	$\frac{1}{1+\sqrt{2}pT+p^2T^2}$
$\frac{1}{(1+x^6)^{1/2}}$	$\frac{1}{(1+pT)(1+pT+p^2T^2)}$

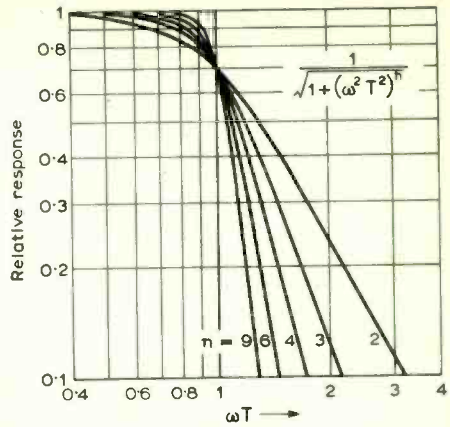

Fig. 7. Butterworth response, low-pass.

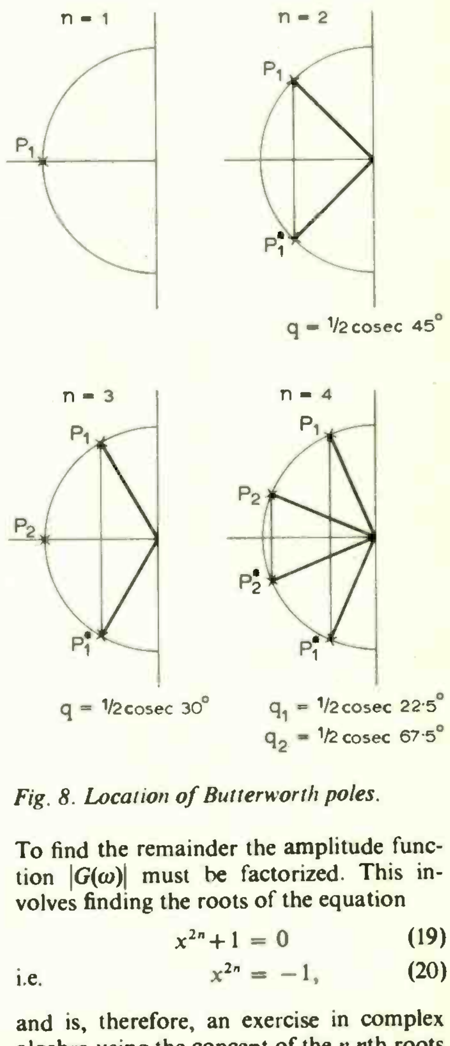

Fig. 8. Location of Butterworth poles.

To find the remainder the amplitude function $|G(\omega)|$ must be factorized. This involves finding the roots of the equation

$$x^{2n}+1 = 0 \quad (19)$$

i.e.

$$x^{2n} = -1, \quad (20)$$

and is, therefore, an exercise in complex algebra using the concept of the n nth roots of -1. (See, for example, Loney: Plane Trigonometry, Pt. 2, p. 141.) The complex conjugate factors so obtained are multiplied together, giving real 2nd-order factors in ω^2, with one real 1st-order factor when n is odd, and compared with the 2nd-order amplitude factor, equation (21) of Part 2, corresponding to the standard transfer-function factor

$$\frac{1}{1+(1/q)pT+p^2T^2}$$

The result is that the rth factor has

$$\frac{1}{q} = 2\sin\frac{(2r-1)\pi}{2n}, \quad (21)$$

and numerical results up to $n = 10$ are given in Table 6. For all odd values of n there is also a 1st-order (simple-lag) factor; hence for odd orders the products of the qs is 1, and for even orders $1/\sqrt{2}$.

TABLE 6

n	q_1	q_2	q_3	q_4	q_5
2	0·707				
3	1·000				
4	1·306	0·541			
5	1·618	0·618			
6	1·932	0·707	0·518		
7	2·247	0·802	0·555		
8	2·563	0·900	0·601	0·510	
9	2·880	1·000	0·653	0·532	
10	3·196	1·101	0·707	0·561	0·506

The results of the analysis can also be given in memorable form as the positions of the poles of $G(p)$ in the complex plane. As all Ts are equal the poles lie on a circle, and they are evenly spaced as shown in Fig. 8. It is clear that the highest Q factor increases with increasing n, and the curves, Fig. 9, give an idea of how the opposing curvatures of the high-Q and low-Q factors go towards giving an approximation to a level response in the pass band and to a constant rate of fall above cutoff.

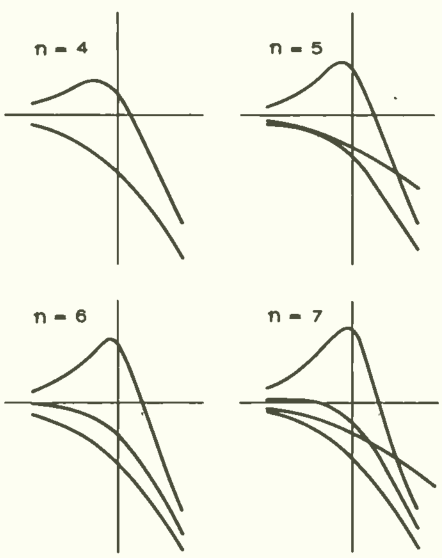

Fig. 9. Response of individual factors of Butterworth responses, n = 4 to n = 7.

It can also be seen that for n even and $\geqslant 4$ the lowest Q factor is little greater than $\frac{1}{2}$. If it is divided by a factor x so that it is made equal to $\frac{1}{2}$, the gain at ω_c can be returned to -3 dB by multiplying the highest Q factor by x. The overall response is hardly altered by the change, Fig. 10; and the Q factors for these approximate Butterworth filters are given in Table 7. The importance

TABLE 7

n	q_1	q_2	q_3
4	1·414	0·5	
6	2·0	0·707	0·5

of the modification is that the low-Q factor is now two buffered lags, and it may be possible to save an amplifier by incorporating them in some existing part of a system.

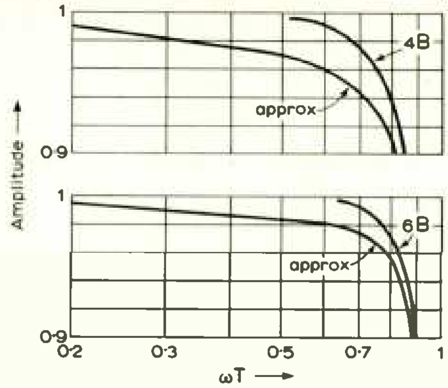

Fig. 10. Approximate Butterworth responses compared with exact responses.

3rd-order Chebyshev response

If some ripple is allowed in the pass band the corner can be sharper and the fall just beyond steeper. Consider the simple 3rd-order filter shown in Fig. 11. If it is equally terminated, $R_L = R_S = R$ (say), the network can be bisected into two halves, and the voltage transfer ratio easily found as

$$\frac{V_{out}}{V_{in}} = \frac{1}{2(1+pCR)(1+pL/R+p^2LC)} \qquad (22)$$

$$= \frac{1}{2(1+qpT)(1+(1/q)pT+p^2T^2)} \qquad (23)$$

where $\quad T = 1/\omega_c = \sqrt{(LC)}, \qquad (24)$

$$q = \frac{R}{\omega_c L} = \omega_c CR \qquad (25)$$

$$= R\sqrt{\frac{C}{L}} \qquad (26)$$

This confirms that high R gives light damping (high q), and also shows that as q increases the corner frequency of the 1st-order factor, $1/qT$, moves down the frequency scale, giving increased attenuation at high frequency. This "corrects" the increased gain in the vicinity of ω_c contributed by the 2nd-order factor, and so is consistent with the fact that when $R_L = R_S$ no peak in the response can rise higher than the zero-frequency level (-6 dB), since this is the optimum match between equal resistances.

Ignoring the factor $\frac{1}{2}$, the normalized ($T = 1$) amplitude response is given by $|G(j\omega)|$

$$= [(1+q^2\omega^2)\{(1-\omega^2)^2+\omega^2/q^2\}]^{-\frac{1}{2}} \qquad (27)$$

$$= [1+\omega^2\{(q-1/q)-q\omega^2\}^2]^{-\frac{1}{2}} \qquad (28)$$

Consider

$$y = \omega\{(q-1/q)-q\omega^2\}. \qquad (29)$$

If $q<1$, $(q-1/q)$ is negative and the slope $dy/d\omega$ is continuously negative; but if $q>1$, $(q-1/q)$ is positive and y is zero at a finite positive value of ω as well as at the origin, Fig. 12. Consequently when $q>1$, the normalized amplitude response, which is given by $(1+y^2)^{-\frac{1}{2}}$, has a trough and then returns to unity before descending towards zero. (See Fig. 13.) As Q increases the sharpness of the corner and the rate of attenuation just beyond the corner increase: so does the amplitude of ripple in the pass-band. This is a simple example of the general

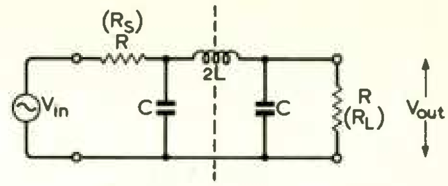

Fig. 11. Structure of simple (all-pole) passive 3rd-order low-pass filter.

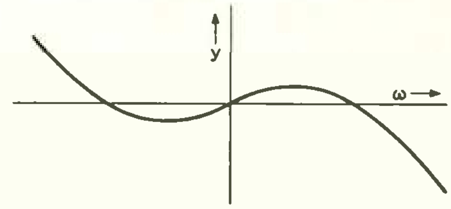

Fig. 12. Illustrating the mathematics of the production of a ripple.

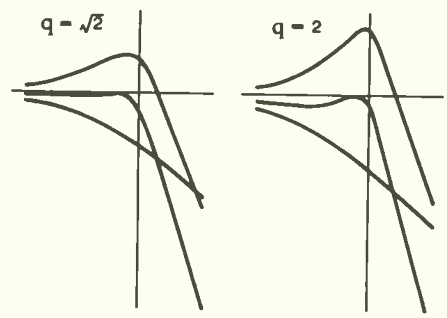

Fig. 13. Chebyshev responses, 3rd-order, and the responses of their factors.

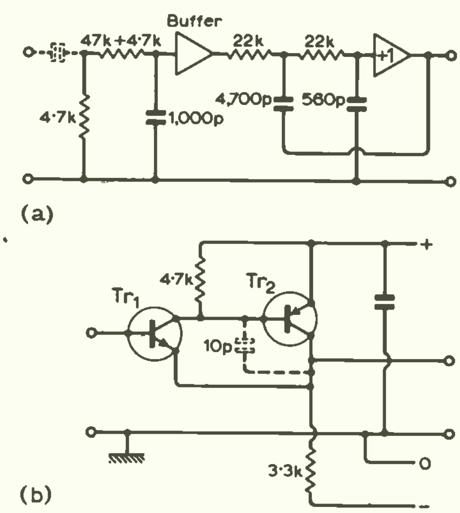

Fig. 14. (a) 3rd-order low-pass filter, -3 dB at 4·75 kHz. (b) Suggested amplifier. Tr_1: 2N3707, 2N3904, BC109C etc. Tr_2: 2N4058, 2N3906 etc.

nature of Chebyshev or equal-ripple response. The peak occurs where

$$\omega^2 = 1-\frac{1}{q^2}, \qquad (30)$$

So as $q \to \infty$ the peak approaches ω_c, while for $q = 1$ it is at $\omega = 0$ (i.e. the ripple disappears). As shown in Part 1 this is maximally-flat-amplitude (Butterworth) response, and here the corner frequency of the 1st-order factor is equal to that of the 2nd-order factor. For $q<1$ the corner frequency of the 1st-order factor is at a higher frequency than that of the 2nd-order factor, and this adds to the greater roundness of the corner compared with the Butterworth.

The trough occurs at

$$\omega^2 = \frac{1}{3}\left(1 - \frac{1}{q^2}\right), \qquad (31)$$

and the depth of the trough may be derived from the relationship

$$y_t^2 = \frac{4q^2}{27}\left(1 - \frac{1}{q^2}\right)^3 \qquad (32)$$

For 1 dB depth, maximum, q must be $\not> 2$ approx., Fig. 13.

As a compromise between low ripple and a sharper corner q may be chosen in the region 1·4 (0·15 dB ripple) to 1·5 (0·25 dB ripple); and Fig. 14(a) shows a schematic for an audio-frequency low-pass filter with $q = 1{\cdot}43$ approx. The ω_c of the 2nd-order factor is $10^6/36$ radians/second (= 4·4 kHz), and the −3 dB point for the whole filter is at 4·75 kHz approximately.

The amplifiers may be of a variety of types, and will probably be chosen for convenience and ready availability. The circuit shown in Fig. 14(b) is suitable, and although of only moderate internal gain (*c.* 500), gives enough loop gain to reduce distortion at (say) 1 V r.m.s. output to a very low level. An input buffer amplifier should be used if the output impedance of the previous stage is not negligible or cannot be incorporated into the first resistance of the filter. Provided Tr_1 maintains a high current gain at low I_C all impedances, and the two resistances in the amplifier, may be increased several times, giving economy in h.t. current and in the size of capacitors.

For higher-order Chebyshev filters the parameters must form a proper set, or the ripples will not be equal. Table 8 gives the Q factors and the relative magnitudes of the Ts for five 5th-order curves with depth of ripple from 0·02 dB to 0·8 dB. All these may be considered a better approximation to constant gain in the pass band, and the table shows that all but the first give more attentuation than 5th-order Butterworth, both at twice the cut-off frequency and at higher frequencies (Fig. 15).

Filters for pulse transmission

The high Q factor of at least one factor of a

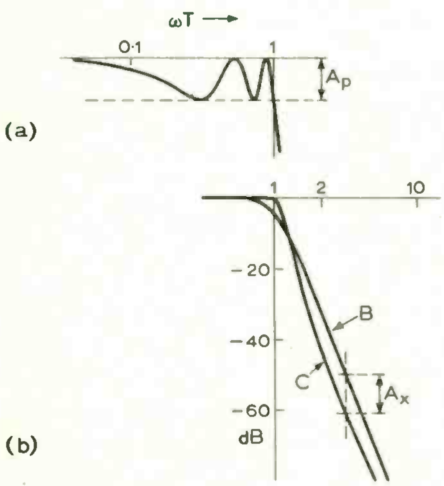

Fig. 15. Illustrating 5th-order Chebyshev response: (a) pass-band ripple, (b) increased attenuation compared with Butterworth 5th-order response, B.

TABLE 8

Parameters for 5th-order Chebyshev response $\dfrac{1}{(1+pT_0)(1+pT_1/q_1+p^2T_1^2)(1+pT_2/q_2+p^2T_2^2)}$

T_0/T	T_1/T	q_1	T_2/T	q_2	A_p	A_x $\omega T=2$	A_x $\omega T=\infty$
1·337	1·051	0·786	0·827	2·618	0·02	−3	0
1·642	1·181	0·859	0·885	3·000	0·06	2	5
2·164	1·337	1·000	0·946	3·702	0·2	7	10
2·377	1·383	1·062	0·962	4·000	0·3	9	12
3·236	1·506	1·328	1·000	5·236	0·8	14	17

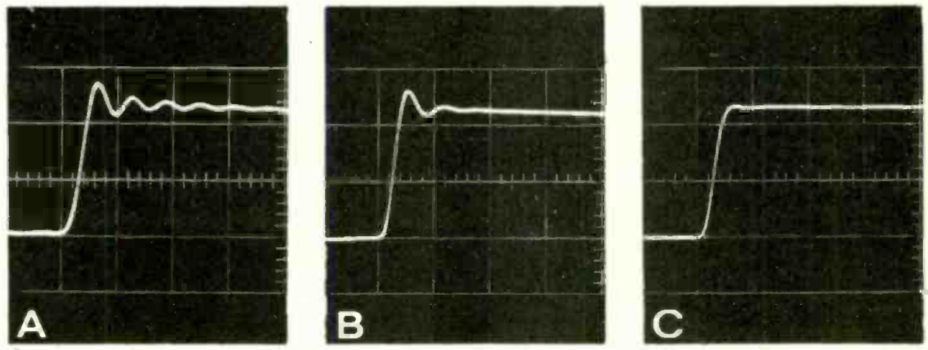

Fig. 16. Step responses of three filters: (a) a 5th-order Darlington, (b) a 5th-order Butterworth, (c) an approximate linear-phase filter.

filter with a sharp corner and rapid fall at the end of the pass band gives an oscillatory transient response. Thus for the Darlington filter described in the previous section the response to a step function, Fig. 16(a), shows an overshoot of about 15% and several subsequent oscillations of appreciable amplitude. To avoid such ringing it is not necessary for all factors to have $q \leqslant \frac{1}{2}$ ($q = \frac{1}{2}$ is critical damping), but it is necessary that all factors with corner frequencies falling within the passband should have low values of q. Thus the simple 5th-order filter with transfer function

$$G(p) = \frac{1}{(1+pT)^3(1+pT+p^2T^2)} \qquad (33)$$

has a step response, Fig. 16(c), quite suitable for pulse work; though the frequency response, Fig. 17(a), falls away considerably in the pass band and has a very rounded corner.

It is generally agreed that for good pulse response the phase lag should increase linearly with frequency through as much of the pass band as possible. If a high Q factor is present the slope of the phase curve is less near zero frequency but increases as the resonant frequency of the factor is approached. If the corner of the amplitude response curve is unnecessarily rounded, meaning that only very low Q factors are present, the slope of the phase curve is greater near zero frequency, but slowly decreases. The transient response then is not ringy, but the rise time is unnecessarily long. Note: a linear frequency scale is assumed.

The slope of the phase curve is associated with the idea of a group delay used in the wave theory of optics,

$$\tau_g = \frac{d\phi}{d\omega} \qquad (34)$$

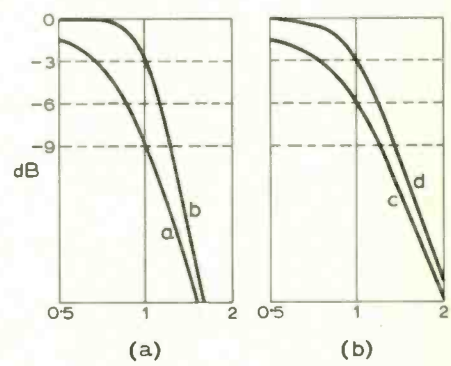

Fig. 17. Amplitude responses of Butterworth and approximately linear-phase filters.

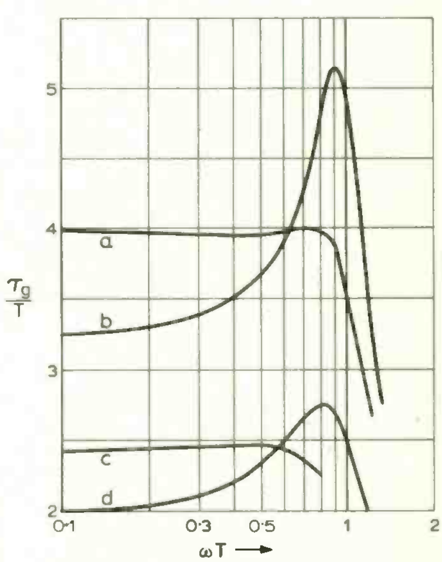

Fig. 18. Normalized group delay of Butterworth and approximately linear-phase filters.

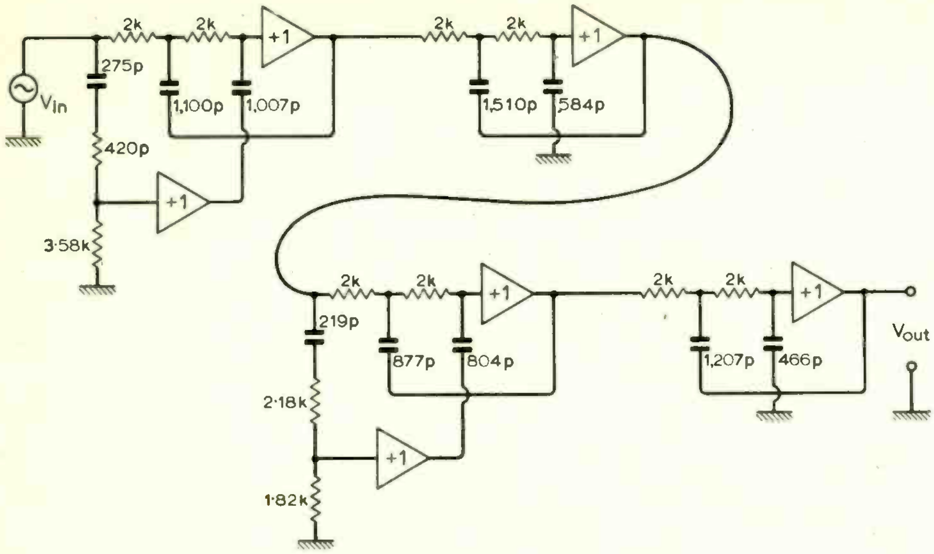

Fig. 19. Realization of the 8th-order Storey-and-Cullyer linear-phase characteristic. Resistors, Ω. Capacitors, pF.

This function for the filter just mentioned, equation (33), is shown in Fig. 18, curve *a* and for the 5th-order Butterworth filter in curve *b*. It can be seen that while the first is almost level up to 0·9 of the cut-off frequency, the second rises to a pronounced peak. Curves *c* and *d* give similar information for two 3rd-order filters: *d* Butterworth, *c* a similar filter with the *q* of the quadratic factor reduced to $1/\sqrt{2}$. The frequency responses are shown in Fig. 17(b).

An example of a linear-phase filter designed empirically is given in Ref. 4. It is an 8th-order filter with two frequencies of infinite attenuation, and the transfer function may therefore be resolved into two numerator factors,

$$(1+p^2T_a^2),\ (1+p^2T_b^2),$$

and four denominator factors,

$$(1+(1/q_1)pT_1+p^2T_1^2),\ \text{etc.}$$

The poles are given as

$$-4{\cdot}549\pm j1{\cdot}362,\ -3{\cdot}305\pm j4{\cdot}174,$$
$$-5{\cdot}687\pm j1{\cdot}703,\ -4{\cdot}131\pm j5{\cdot}218,$$

and the frequencies of inf. attenuation as

$$5{\cdot}027 \text{ and } 8{\cdot}796,$$

(all $\times 10^5$ radians/second). These give

$$\omega_1 = (4{\cdot}549^2+1{\cdot}362^2)^{\frac{1}{2}} = 4{\cdot}75\ (\times 10^5),$$

hence

$$T_1 = 1/0{\cdot}475 = 2{\cdot}105 \text{ microseconds},$$
$$q_1 = \tfrac{1}{2}(1+1{\cdot}362^2/4{\cdot}549^2)^{\frac{1}{2}} = 0{\cdot}5215,$$
$$T_a = 1/0{\cdot}5027 = 1{\cdot}991 \text{ microseconds},$$

and similarly for the other constants, giving Table 9.

If (a) is grouped with (1), and (b) with (3), two factors are obtained

$$\frac{1+a_1p^2T_1^2}{1+(1/q_1)pT_1+p^2T_1^2},\ \frac{1+a_3p^2T_3^2}{1+(1/q_3)pT_3+p^2T_3^2}$$

with

$$a_1 = T_a^2/T_1^2 = 1{\cdot}991^2/2{\cdot}105^2 = 0{\cdot}895,$$

and

$$a_3 = T_b^2/T_3^2 = 1{\cdot}137^2/1{\cdot}685^2 = 0{\cdot}455;$$

and (2) and (4) are left as simple 2nd-order low-pass factors. These add up to give the overall response, which has a well rounded corner much as curve *a* of Fig. 17(a), but, because of the zeroes a much steeper fall after the corner. The stop band, where the minimum attenuation is 30 dB, starts at 75 kHz. The end of the passband may be taken to be the −10 dB point, which is at 50 kHz (314×10^3 rad/s, $T = 3{\cdot}18\ \mu s$); and rectangular pulses down to a width of 20 μs are transmitted with full amplitude, though reduced to a shape similar to a single cycle of a cosine wave.

By following the procedure used before, the filter may be realized as a cascade of four Sallen-and-Key sections, two of simple low-pass type and two with a parallel path giving a zero, Fig. 19. As all *Q* factors are low, the amplifiers do not need very high internal gain. Provided the filter is not required to pass zero-frequency signals with a tight specification on zero drift, pairs of transistors connected in the enhanced-emitter-follower arrangement would be satisfactory. In general a tolerance of ±2% on component values will be quite adequate, as none of the factors show rapid changes of attenuation in or near the pass band. For good zeroes, however, a somewhat closer match between the time constant of the side-chain network and the short-circuited-output time constant of the network in the main path is advisable.

TABLE 9

Parameters of linear-phase filter, Fig. 19.

Subscript	(1)	(2)	(3)	(4)	(a)	(b)
T	2·105	1·88	1·685	1·50	1·991	1·137
q	0·522	0·805	0·522	0·805	—	—

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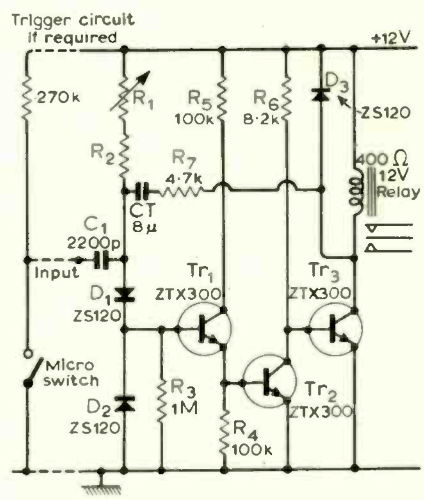
2. "Design Theory and Data for Electrical Filters", by J. K. Skwirzynski, Van Nostrand, London (1965).
3. "Filter Design Tables and Graphs", by E. Christian and E. Eisenmann, John Wiley & Sons, New York (1966).
4. "Active Low-pass Linear-phase Filters for Pulse Transmission", by D. J. Storey and W. J. Cullyer, Proc. I.E.E., April 1965, Vol. 112, No. 4, pp. 661–668.

Application Notes

Circuitry selected from device manufacturers' literature

Process Timer

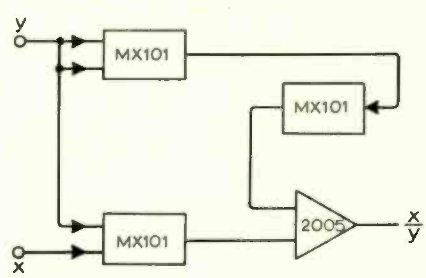
The circuit will hold the relay on for a period of between one and ten seconds (determined by R_1) when actuated by a negative input pulse. This pulse could



be provided by the switch and resistor shown. Extracted from the Ferranti "E-line Transistor Applications" handbook.

Four-Quadrant Division

The circuit produces X/Y using type MX101 multipliers from Fenlow electronics. The inputs X and Y can be of any sign. Use is made of the fact that $X \div Y = (XY)/Y^2$.



Dynamic Range versus Ambient Noise

A practical solution involving metal-cone loudspeakers and high-power amplifiers

by George Izzard O'Veering

The essential requirements for a high quality sound reproduction system are adequate power and adequate bandwidth. Since loudspeakers are inefficient, and the attainment of wide bandwidth systems is generally incompatible with high efficiency, the achievement of the desired acoustic spectrum from the subsonic to the ultrasonic makes heavy demands on amplifier output.

Moreover, it will be apparent on reflection that many of the musical and other instruments, the acoustic output of which it is desired to reproduce, are themselves both powerful and developed to a high degree of acoustic efficiency. It is clearly laughable to suppose that the majestic splendour of a full orchestral fortissimo or the lung power of a Wagnerian tenor in full cry can be represented adequately on an acoustic budget of a few hundred milliwatts. Inconvenient though it may be, there can be no doubt that to recreate the true dynamic range of much recorded sound over the required sonic spectrum makes demands on the output power of the audio amplifier/reproducer system which are well beyond the capabilities of most, if not all, of the equipment at present on the market.

Calculation of required power

The quietest sound which can be heard in a given environment depends entirely upon the background noise level of that environment. Unfortunately, most people live in close proximity to traffic, neighbours with television sets, dogs, and noisy children, and these things, together with the normal background sounds of the home, combine to give an ambient noise level of about 50dB. The minimum sound level which can be distinguished clearly above this background level is therefore 53dB. The dynamic range of orchestral music can be as much as 70dB, therefore in order to be able to hear the pianissimo as well as the fortissimo passages, a peak level of 123dB is required.

The acoustic power in watts required to produce a sound intensity level of 53dB is about 6μW for an average-size living room. Since a 10-dB increase in power output requires a tenfold increase in power, the 123-dB peak-power level will therefore require a maximum acoustic output of some 50W. If the loudspeaker efficiency is 5% (and this is significantly better than is obtained from most commercially available loudspeaker systems) a peak-power output of 1000W per stereo channel is obviously required if the total dynamic range of a symphony orchestra is to be heard in comfort.

It was clear from discussions both with manufacturers and distributors that no serious attempt had been made to meet the requirement for drive units capable of handling as little as 250W. Initial trials made with some of the more likely units, were generally unsatisfactory. In particular there was a tendency for the cone and speech coil to become detached, and for fraying of the surround. In addition, the failure was often made more serious by partial combustion of the inflammable materials within or in proximity to the speech-coil assembly.

When more substantial reproducer units had been evolved, this only brought to light the flimsy nature of the housings which had been supplied, and considerable annoyance was caused by a minor injury sustained when one of the cabinets burst during an orchestral transient and the room was filled with flying splinters. At this stage it was accepted that the cabinets used would require to be of comparable strength to the reproducers, and the assistance of the specialist who constructed the metal cone loudspeaker assemblies was sought to manufacture four sheet-steel column-loaded units, of a suitable type to take the 23in × 14in elliptical wide-band speakers. These are situated at the four corners of the listening room and the opposite units are connected in parallel but in antiphase. This has the effect of increasing the apparent dimensions of the listening room, in addition to reducing the I^2R losses in the speaker wires.

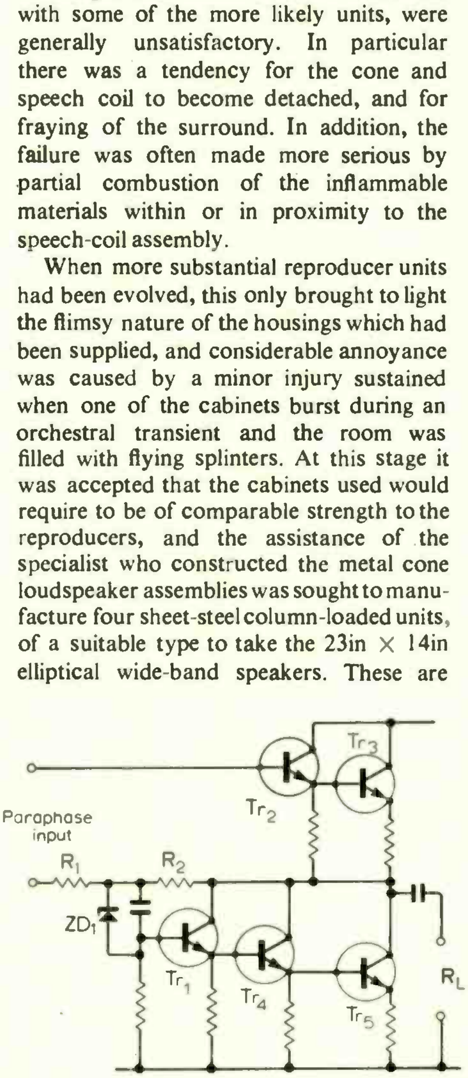


Fig. 1. Symmetrical output stage using only n-p-n transistors.

Each unit is rated at 500W, with a nominal 20Ω impedance. The required output from the amplifier is therefore 10A at 100V r.m.s. (282 volts pk-pk) per channel.

Power amplifier design

The use of a solid-state, transformerless amplifier to provide an output of 1kW into a 10-Ω load imposes certain limitations on the designer. In particular, the normal complementary or quasi-complementary output stage configurations are no longer practicable since the only useful and relatively cheap high-voltage transistors which are available are all of the n-p-n construction.

The basic output stage configuration employed, to provide a fully symmetrical push-pull class B output stage using only n-p-n transistors, is shown in Fig. 1. As shown, this would be satisfactory for power outputs up to about 50W.

In this circuit arrangement, Tr_2/Tr_3 and Tr_4/Tr_5 are Darlington pairs with Tr_2 and Tr_4 being normal small-power driver transistors. Tr_1, in combination with R_1 and R_2, provides the necessary signal level and amplitude transformation for the lower half of the output stage, and ZD_1 effectively stabilizes the voltage level at the power output point. This is chosen so that the largest symmetrical voltage swing is obtainable. The symmetry of this stage is maintained up to a frequency determined by the resistance of R_1 and R_2 and the input shunt capacitance of Tr_1. This will normally be well above the audible spectrum.

The final circuit employed is shown in Fig. 2. Although for simplicity only four parallel-connected output transistors are shown in each half of the output stage, this is only adequate for intermittent use at 1kW output. In practice six parallel connected transistors are required in each half of the output stage.

The paraphase input is obtained from two medium-power high-voltage transistors, Tr_3 and Tr_4, the h.t. supply for which is obtained from a separately smoothed 400-V line, because bootstrapping is not practicable with this type of driver stage.

The input is derived from a long-tailed pair of p-n-p transistors, of a type chosen for high voltage linearity, and freedom from avalanche or collector leakage (Early effect) distortion. Although 150V is applied to the end of the 'tail', the maximum collector-emitter voltage is limited to about 52V, because the base of Tr_2 is returned to the 50V tap on the zener diode chain. A variable resistor is included in the 'tail' to set the current through Tr_1 and Tr_2. This controls the current through Tr_3 and Tr_4, and, since the output d.c. level is determined by ZD_1, thereby controls the

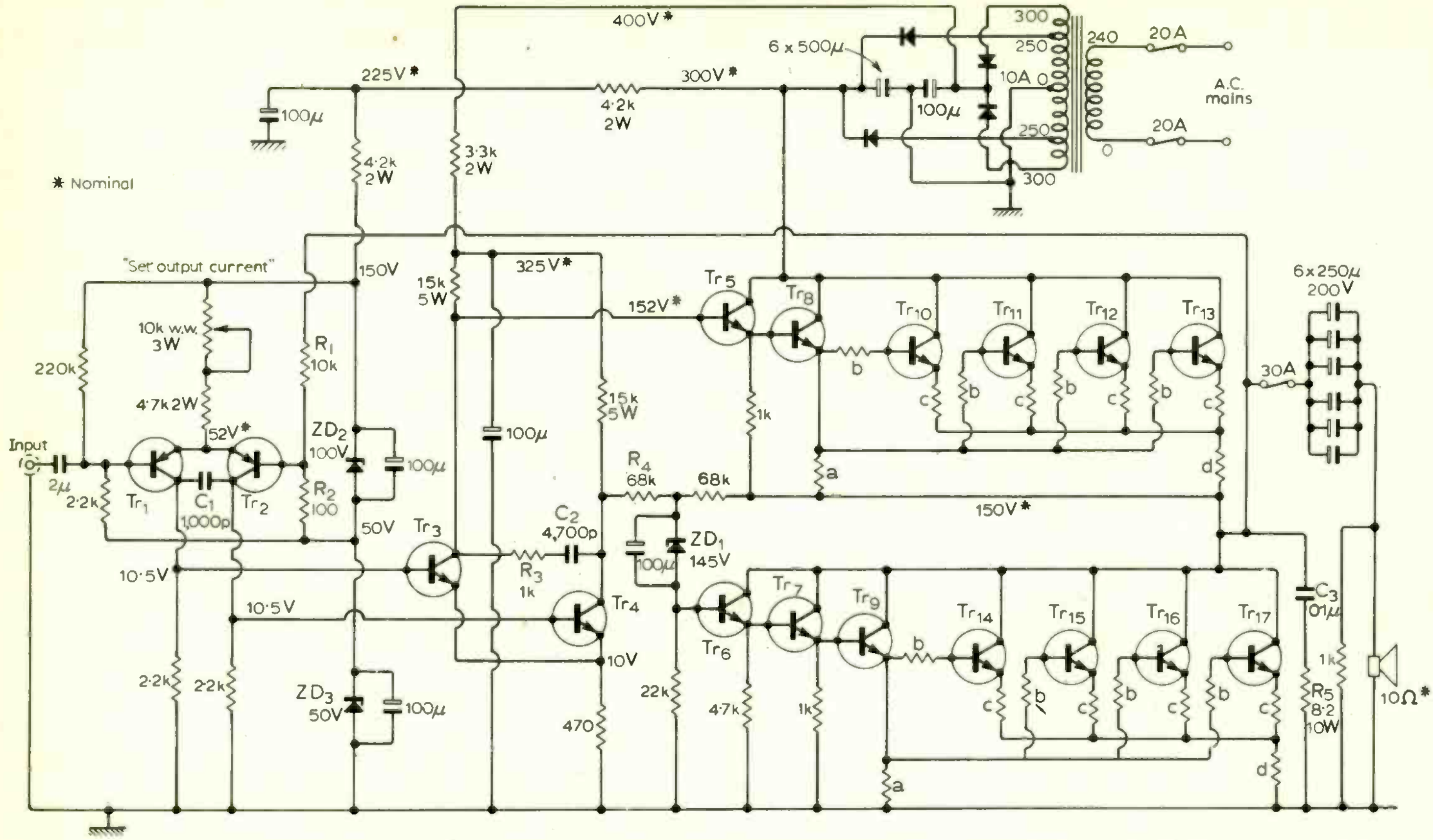


Fig. 2. Expanded version of Fig. 1 employing a Darlington triple as the output device. Tr_1, Tr_2—R.C.A. 38496; Tr_3 to Tr_7—MJE340; Tr_8 to Tr_{17}—MJ413. Lettered resistor values: a=22Ω, 2W; b=10Ω, 2W; c=0.5Ω, 5W; and d=0.1Ω, 5W.

quiescent current of the output stage. This should be set to about 200mA. Because of the absence of coupling or bootstrapping capacitors the gain of the circuit from the base of Tr_1 to the output of the power transistors is constant from the h.f. roll-off point down to d.c. The l.f. roll-off point is therefore determined solely by the 2-μF input capacitor and the output time constant.

The input impedance is 2kΩ in series with 2μF. The h.f. roll-off point and the phase stability margin is determined by C_1, (the input-lag capacitor) C_2 and R_3, and C_3 and R_5. The loop gain is determined by resistors R_1 and R_2 and is approximately 100. The full output is given by an input of 1V r.m.s., which can be obtained from any suitable high-quality pre-amplifier capable of operating into a 2-kΩ load.

Constructional details

The construction of the power amplifier unit follows conventional lines, and no unusual precautions are required apart from the need for generous heat sinks. Very satisfactory results were given in the prototype by the use of a pair of old cast-iron radiators, such as can be found second-hand for a few pounds in a builder's yard, to which the transistors can be individually attached by small bridges made from a suitably substantial gauge of copper sheet. The bottom and sides of an old copper preserving pan would be ideal. Care should, of course, be taken in drilling the attachment holes to make sure that the radiator shell is still capable of retaining water without leakage.

If such radiators cannot be found, a copper hot-water storage cylinder would serve admirably, but it would probably be more difficult to introduce such an item inconspicuously into the listening room. The siting of the output transistors should combine shortness of signal leads with the required thermal separation of the power transistors one from another. It should also be borne in mind that the circulating currents at full power are of the order of 30A. The leads to the loudspeaker terminal bosses—for which old car battery connectors are suggested—to the collector and emitter rails of the output transistors, and to the h.t. and earthy ends of the h.t. decoupling capacitor block must be substantial. A $\frac{3}{8}$in × $\frac{1}{4}$in bore copper pipe is preferable, but as an alternative, lengths of 12 s.w.g. copper wire may be plaited together.

After assembly, it is recommended that the amplifier units be bench-tested on a dummy load before attachment to the speaker units, since quite trifling faults can lead to a surprising amount of energy being released. For example, in preliminary listening trials with the prototype, an intermittent o/c in the earth braiding on an input to the pre-amp, led to the necessity for the listening room ceiling to be substantially restored and replastered.

Listening arrangements

Although the results obtained with good quality gramophone recordings have been most astonishing, and have brought home to the author in the most vivid way the qualities of stamina and emotional detachment required of an instrumental player situated, as the fortunate listener, in the midst of a large orchestra, it is clear that there are a large number of residual problems in the life-like reproduction of disc recordings, of which the major one is the avoidance of acoustic feedback. As with many other of these problems, it is suspected that the manufacturers of the equipment have not really got down to serious thought on this matter, and the solution which the author feels most people must adopt, that of housing the record player unit is some detached building, such as a small garden shed, is inconvenient and prevents the listener from hearing the beginning of the recorded piece. Moreover, if in one's hurry to return to the audition room, the pickup cartridge is let fall too rapidly upon the record, extensive damage can be caused to windows and other glazing.

Summing up

The performance of the equipment as installed is entirely satisfactory, and a wide variety of sound sources have been explored during the assessment of the scope of this system, and many sounds have been recaptured with a degree of realism not previously encountered. However, the development of this apparatus has not been without difficulty, scepticism and expense, and it has been suspected at times that unnecessary difficulties have been placed in the author's way. For these reasons, it is thought unlikely to appeal to those for whom high-fidelity reproduction is merely a passing interest. On the other hand, it has proved possible to purchase several of the adjoining properties at a very advantageous price, and this has undoubtedly offset a large part of the constructional costs.

World of Amateur Radio

Amateurs urged to tackle TV interference

As a result of renewed efforts by many British amateurs to overcome the problem of causing interference to local television receivers, the number of stations to be heard operating during television programme hours has risen appreciably during the past year. However, there are signs that the Ministry of Posts & Telecommunications is concerned at the number of requests being made to the Post Office by both amateurs and viewers for assistance in overcoming television interference (TVI). While the Ministry is responsible for all technical matters relating to the orderly use of the r.f. spectrum, interference investigation field work is now carried out by Post Office engineers under contract to the Ministry. Interference investigation costs the Ministry about £2 per hour.

Amateurs are being urged to acquaint themselves with the basic causes of TVI and to tackle interference problems without calling in the Post Office teams. Amateurs are also being encouraged to persuade manufacturers of commercially built amateur transmitters to pay more attention to design features likely to reduce the problem, including the choice of oscillator frequencies. It is being suggested that only when cases of TVI prove intractable or where the viewers concerned adopt an unco-operative attitude should the Post Office investigation officers be called in.

Australis Oscar 5 satellite

The Australian-built Oscar 5 satellite carrying 28- and 144-MHz beacon transmitters (see the March issue), launched on January 23rd, continued to function as planned until February 14th when, during the 273rd orbit, a commanding "on" of the h.f. beacon brought the battery voltage below that needed to operate the v.h.f. beacon. At the time of writing, the h.f. beacon continues in operation but is expected to have ceased by the time these notes appear.

Bill Browning, G2AOX, the European co-ordinator, has already received over 100 reports on the Oscar 5 telemetry signals, including many from Germany, Sweden and the U.K. The reports cover reception of the 144-MHz beacon since telemetry signals were not satisfactory on 28MHz, due to a modulator malfunction, although the carrier and "HI" identification signals were radiated. The simple stabilizing system also proved rather less satisfactory than had been expected resulting in deep fading of signals when the satellite was overhead. Many novel techniques were used by amateurs to read out the telemetry, including matching of incoming tones with a local generator by means of stereo headphones (giving accurate results at low signal/noise ratios). Almost all the reports showed close agreement in results.

Another highly satisfactory feature was the effective amateur communications links which brought masses of orbital predictions and other information to the London co-ordinator. These included radio-teleprinter links with Australia and the United States operated by Reg Wigg, G6JF in Devon and fed to London on 3.5MHz a.m. Direct London to U.S. links on s.s.b. were also used.

Many amateurs are hoping that the next Oscar will include (as in 1965) an active transposer, possibly 144MHz down and 432MHz up, to allow long-distance contacts to be made via the satellite. It is not known yet when the next amateur satellite is likely to be launched.

New group for the north east

A new North East England amateur radio group has been formed from within local clubs and societies to organize major amateur radio events, mainly evening "technical conventions". It is hoped that some five or six large meetings can be arranged each year to attract speakers from all over the country. Members of the group cover the whole of County Durham, Tyneside and Teesside as well as parts of Northumberland and the North Riding of Yorkshire. Members will be free from the commitments normally associated with regional and local radio clubs.

The first event takes place in Durham City on Friday, March 20th when F. J. U. Ritson, G5RI, of the University of Newcastle-upon-Tyne, is to give a lecture demonstration on aerials.

The secretary, J. Melvin, G3LIV, 5 Lancashire Drive, Belmont, Durham, will provide further details and a sample Newsletter to those interested. Peter Martin, G3PDM, is the interim chairman of what promises to be something new in the dissemination of technical information among amateurs.

Amateur microwave record?

An excellent contact was established during February between A. Wakeman, G3EEZ, operating portable on Clee Hill in the Midlands, and L. W. G. Sharrock, G3BNL, on Cleeve Common in the Cotswolds, on the 10-GHz (3-cm) band.

This is believed to be a new British record for amateur two-way operation on this band. A pulsed klystron transmitter was used at G3EEZ/P while frequency modulation was used at G3BNL/P.

A large number of v.h.f. and u.h.f. enthusiasts are expected to attend the 16th annual R.S.G.B. v.h.f./u.h.f. convention at the Winning Post hotel at Whitton on Saturday, April 25th. Technical lectures and an exhibition of equipment during the afternoon will be followed by a dinner. Tickets can be obtained from Frank Green, G3GMY, 48 Borough Way, Potters Bar, Hertfordshire.

In Brief: A change of address for the general secretary of the British Amateur Television Club: Ian Lever, G8CPJ, 65 Dynes Road, Kemsing, Sevenoaks, Kent, replaces the former Swanley address. . . . The first totally blind Irish amateur, Cathal O'Reilly, has recently been licensed as EI9CA. . . . Amateur licences in force at the end of October 1969 included 13,413 class A, 1,897 class B and 179 amateur television—class B licences are increasing much faster than class A. . . . The 28.185 MHz beacon station, GB3SX at Crowborough operates on a 24-hour basis with an output power of 20 watts to a three-element Yagi aerial usually, but not always, pointing East, or alternatively with an omni-directional aerial. . . . A German beacon station, DL0IGI operates on 28.20 MHz with a power of 200 watts to a vertical dipole. . . . The next U.K. Radio Amateurs Examination is being held on Monday, May 11th at 18.30 at many local venues. . . . A low-power 3.5-MHz contest is being held on April 5th. . . . W. E. Gardner, G3FYR, recently reported longish delay echoes during a contact with W2ELW on 28 MHz and received a letter from Professor O. G. Villard, Jr., W6QYT, acknowledging the usefulness of all such reports even though the present investigation (see December, 1969) is basically concerned with echoes of over one or two seconds and particularly those of five to ten seconds. These appear to be heard usually on only one station, and for time intervals of only a few minutes. . . . A printing error appeared in last month's note "50 years of callsigns"—line eight should refer to G4-*three*-letter callsigns.

PAT HAWKER, G3VA

Personalities

Several senior appointments in the Engineering Training Department have been announced by the B.B.C. **H. V. Sims,** M.I.E.E., F.I.E.R.E., previously head of training section (engineering) has been appointed to the new post of head of technical projects and services. He will be concerned with investigating new methods of presenting maintenance information and with the maintenance and installation of all the broadcasting training equipment at the Training Centre. **J. H. Brooks,** B.Sc.(Eng.), M.I.E.E., previously a senior lecturer, has become head of training section (engineering). He is responsible for the training of engineering and technical assistants in the Operating and Maintenance Departments of the Corporation. **D. G. Enoch,** M.I.E.R.E., previously a senior lecturer, has been appointed head of training section (technical operations) in succession to **G. W. MacKenzie** who was recently appointed head of engineering, Northern Ireland. Mr. Enoch is responsible for the technical training of the B.B.C's technical operators. **A. W. Harris,** B.Sc., A.C.G.I., M.I.E.E., is appointed assistant, overseas trainees, and is concerned with training courses and attachments for non-B.B.C. staff.

Among the 1970 recipients of awards by the Institute of Physics & Physical Society are: **Professor A. B. Pippard,** of Cambridge University, who receives the Guthrie Medal "for his contributions to low-temperature and solid-state physics"; **Dr. E. Eastwood,** director of research of the English Electric Company, who receives the Glazebrook Medal "for his work on radar and the application of physics in the electrical and electronics industry"; and **Dr. A. Hewish,** of Cambridge University, who receives the Charles Vernon Boys Prize "for his work in radio astronomy and particularly his discovery of the pulsar".

A. H. Ellson, M.B.E., B.Sc.(Eng.), M.I.E.E., has been appointed manager of the optical character reading group of the M.E.L. Equipment Company and **Th. P. Reede** will lead the company's technical marketing group, responsible for market research, business and product planning. Mr. Ellson was, until his new appointment, technical manager of the Microwave Division of M.E.L. and Mr. Reede joins M.E.L. from Philips Electrologica at Rijswijk in the Netherlands.

Norman Doyle, formerly marketing manager of Cossor Electronics' Communications Division, has been promoted divisional manager with overall responsibility for all aspects of the sales and marketing of Cossor's "Commando" range of radiotelephones and other u.h.f. and v.h.f. communications equipment. He is succeeded as marketing manager by **John Bonner** who recently joined the company. Mr. Bonner was previously sales promotion manager of Ultra Electronics for seven years.

Rank Precision Industries has announced the appointment of **James Warden** as chief engineer of the telecommunications product group of its Broadcast Division. Mr. Warden was formerly technical manager of the industrial products group of Cossor Electronics Ltd. He will be responsible for controlling the group's research and development programmes and will be based at Welwyn Garden City until June, when he will move to the new Rank Precision Industries factory at Ware.

Robert R. Heikes, B.Sc., Ph.D., director of engineering at Motorola's Semiconductor Products Division headquarters in Phoenix, Arizona, has been appointed as the company's managing director in Europe. Dr. Heikes will now be responsible for all Motorola activities in Europe. He will be based at the company's European Service Centre in Geneva and his responsibilities will cover the European sales offices and distributors and the manufacturing facilities in Toulouse, France, and East Kilbride, Scotland. Dr. Heikes received his degree in 1948 from the Massachusetts Institute of Technology and his doctorate in 1951 from the University of Chicago. Before joining Motorola he was associated with Westinghouse for 18 years.

Derek Ashby has joined Venner Electronics as their sales manager. Prior to joining Venner, Mr. Ashby, who is 34, was with Marconi Instruments for five years. He joined M.I. as a technical representative and was appointed manager of factored products in 1967. After National Service with the R.A.F. he joined Furzehill Laboratories as a development engineer.

Ferranti Ltd announces the appointment of **John Begbie** as general service manager with responsibility for all service policy in the Scottish Group and for co-ordinating activities with other departments in the Company. In addition, Mr. Begbie, who is 47, is appointed acting manager of the Ferranti factory at Dalkeith, Midlothian. Mr. Begbie studied at Edinburgh University, and after war-time radar experience joined Ferranti in Edinburgh in 1950 as a trials engineer. Following a spell in Australia as chief project engineer with a Vickers guided weapon team, he returned to Ferranti in 1957 to start the service department in Edinburgh. He is succeeded as service manager by **Eric Henney** who is 40. Mr. Henney was educated at the Royal College of Science and Technology, Glasgow, and after experience with I.B.M. and Barr & Stroud joined Ferranti in 1954.

Marconi-Elliott Computer Systems Ltd, Borehamwood, Herts, announces the appointment of **Iorwerth Evans,** B.Sc., as marketing director. He joins the company from Marconi Radar Systems Ltd in which he was general manager (Borehamwood) and a director. Born in 1932 Mr. Evans took a degree in mathematics at Imperial College, London. He joined the Guided Weapons Division of English Electric in 1953 where he stayed until 1959. After two years with Decca Radar Systems he joined Elliott Automation as chief systems analyst (defence systems), ultimately becoming general manager of Elliott Space and Weapons Automation Ltd. The 1968 merger between G.E.C. and English Electric resulted in the formation of Marconi-Elliott Computer Systems Ltd.

D. G. Smee, who joined Marconi in 1933, has been appointed an assistant managing director of both G.E.C.-Marconi Electronics and of the Marconi Company. He has held various senior management positions for the past 20 years (including manager of the Broadcasting Division) and has been Marconi's deputy managing director since 1968.

MCP Electronics Ltd (a subsidiary of Mining and Chemical Products Ltd) which acts both as a manufacturer and as a distributor for such companies as TRW Semiconductors Inc., will now operate with two principal divisions: intermetallics division, offering mainly semiconductor metals, under the management of **B. J. Wray,** a director of the company, and semiconductor division, with **David Cunningham** (newly appointed to the board) as general manager. Before joining MCP Electronics as sales manager, Mr. Cunningham was sales manager at SGS-Fairchild. Marketing in the semiconductor division has been divided into four groups, each with a product manager. **Terry Roeves** has been appointed product manager of the r.f. power devices group; **J. C. A. Chaimowicz,** of the optoelectronics group; and **W. E. B. Baldwin,** of the thick film integrated circuit group. A product manager for the industrial devices group has yet to be appointed.

OBITUARY

Lord Jackson of Burnley, F.R.S., D.Sc., F.I.E.E., professor of electrical engineering at Imperial College, London, from 1946-53 and 1961-67 died on February 17th aged 65. Willis Jackson graduated from the University of Manchester in 1925 and started on his academic career as a lecturer in electrical engineering at Bradford Technical College. In 1938 he became professor of electrotechnics at his old university, a post he held until his appointment to the chair at Imperial College. For the eight years between his incumbencies he was director of research and education with Associated Electrical Industries in Manchester. He was knighted in 1958 and created a life peer in 1967 for his services to education, science & technology. Lord Jackson served on many Government and scientific committees including the Television Advisory Committee of which he was appointed chairman in 1963.

Kenneth E. Harris, B.Sc., F.I.E.E., F.I.E.R.E., who died on January 27th aged 52, was in Sir Robert Watson-Watt's radar research team throughout the war and then for 14 years (1949-63) with Cossor latterly as technical director. His particular interest was secondary radar. In 1963 he joined Redifon as manager of the communications division and was appointed to the board in 1964. A year ago Mr. Harris left Redifon and has been associated with several other companies.

New Products

Two-hour Tape Cassette

The range of Scotch magnetic tape cassettes has been expanded to include a two-hour version. The new Philips-compatible cassette—the Scotch C-120—has an improved shim material which is reliable and eliminates tape binding and jamming. The shim material effectively reduces frictional drag and increases recorder battery life. The cassette uses Scotch Dynarange low-noise tape, giving good high-frequency response at slow ($1\frac{7}{8}$ i.p.s.) recording speed. The cassette is supplied in a durable hinged plastic case. Price 33s 6d. 3M Company, 3M House, Wigmore Street, London W.1.

WW 306 for further details

Coherent Filter

An active filter claimed to be capable of recovering signals which are more than 100dB below noise level has been introduced by Brookdeal Electronics (who tend to specialize in signal recovery instruments). Called the Type 467, it is a narrow-band coherent filter using a multi-path filter technique*, and is designed particularly for use in the signal channel of "lock-in amplifiers" (perhaps better

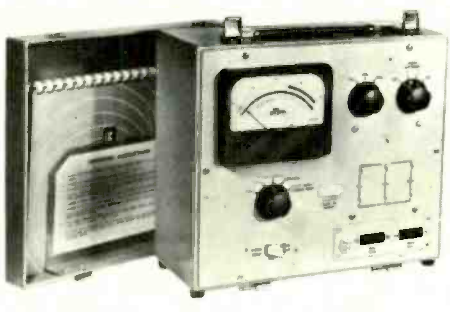
known to some readers as synchronous detectors). Its centre frequency is established by an external reference waveform, giving it the ability to follow a varying wanted signal, and normally it will use the same reference waveform as the synchronous detector. The bandwidth of the filter is 3Hz and the frequency range of operation is 10Hz to 100kHz. The output of the device is a square wave at the reference frequency with an amplitude 40dB greater than the in-phase component of that frequency at the input (max. output 3V pk-pk. from 600Ω). Input impedance of the filter to the signal is 100kΩ, 50pF, while the input impedance to the reference waveform is 10kΩ, 80pF. The design is such that the instrument requires no setting up or adjustment by the user. Brookdeal Electronics Ltd., 1 Market Street, Bracknell, Berks.

WW 301 for further details

*See, for example, *W.W.* March 1966, p.130.

Milliwatt Test Set

Hatfield Instruments, Type 747 universal milliwatt test set is a precision thermocouple meter for checking the standard 0dBm send level in 75Ω unbalanced, 140Ω balanced, and 600Ω balanced circuits. The 75Ω input covers frequencies up to 20MHz, whilst the 140 and 600Ω balanced inputs cover frequencies up to



1MHz. The instrument is protected against overloads of up to +25dBm on all inputs and the measurement range of −1 to +1dBm is displayed over the full 4-in scale of the meter. The accuracy of the standard version is ±0.05dB on all inputs. However, it is now available as option 1 with special calibration charts guaranteeing an accuracy of 0.02dB on all three inputs. Hatfield Instruments Ltd, Burrington Way, Plymouth PL5 3LZ, Devon.

WW 307 for further details

Memory Voltmeter with Chart Recorder

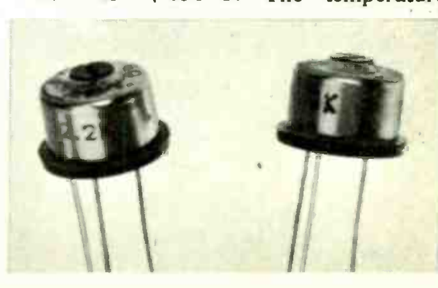
A dual-readout memory voltmeter with a built-in strip chart recorder, for use where a permanent record of transient or spike occurrences is desired, is available from Sintrom Electronics. This portable instrument, the 5201CR, has applications in monitoring power stations, power supplies, computer equipment and other similar installations. It employs amplitude memory to measure and hold 50 nanosecond or longer one-shot voltage peaks of single, transient, random or repetitive pulses permanently or until reset. A dual-shielded cabinet precludes common mode errors. The cabinet is isolated to 1000V. An optional gate circuit permits use as a sample-and-hold voltmeter. The recorder is a dry process, pressure-sensitive 63ft chart with a front access window. It will deliver 25 hours of continuous recording from a 30in/hr standard chart speed. A five position high response selector control is provided permitting the instrument bandwidth to be reduced in specific applications where the waveform to be measured is of

low frequency and where unwanted high-frequency noise is present. Voltage ranges are 0-3, 30, 100, 1000V to 30kV with optional probes. Input impedance is 10MΩ to 30kΩ depending on the range and accuracy ±3% of full scale. Sintrom Electronics Ltd, 2 Castle Hill Terrace, Maidenhead, Berks.

WW 316 for further details

Miniature Wire-wound Potentiometer

A miniature wire-wound trimmer potentiometer, the ADTO5, available from Guest International Ltd, is housed in a TO-5 type nickel-alloy case and may be mounted on a printed circuit board in exactly the same manner as a transistor. The terminal centres are spaced so as to enable flush fitting to a standard 2.54mm (0.1in) hole-pitch printed-circuit board. Rotation extends over 320° and mechanical overload protection is provided in the form of a slipping-clutch mechanism. Moulded-in terminations and a silicon rubber sealing ring help the device to withstand extremes of environmental conditions. The terminations are 0.28 to 0.36mm square copper/nickel alloy. The resistance range available covers from 15Ω to 15kΩ in preferred values. The power rating is 0.5W at 40°C and the temperature range is −55° to +150°C. The temperature



coefficient is not greater than 50 parts/10^6 per °C for the 15Ω to 47Ω values, 20 parts/10^6 per °C for the 100Ω to 200Ω values, and 120 parts/10^6 per °C for the 470Ω to 15kΩ values. Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey.
WW 302 for further details

Laboratory Power Supplies

Guest Electronics have modified their recently announced type 606 laboratory bench power supplies. These all-transistor units feature continuously variable ranges of 0-7.5, 15, 30 and 60V. Voltage output is controlled by a precision 10-turn helical potentiometer fitted with a vernier scale allowing the voltage to be set to a pre-determined value with guaranteed repeat-

ability. A built-in meter enables the output voltage or current to be monitored. Ripple noise is less than 0.5mV pk-pk and overload protection limits the output current to 110% of maximum. Reset is automatic. The model 606 is available in current ranges from 0–500mA up to 0–2.5A. Dimensions are 156 × 152 × 102mm and prices from £34 15s to £42 15s. Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey.
WW318 for further details.

Linear Power Controllers

A range of solid-state linear power controllers has been introduced by Eurotherm to provide efficient control of a.c. loads from 10 to 300A. Units supplying d.c. and three-phase loads are also available. Power is controlled by an inverse pair of thyristors in series with the load. R.F. suppression and protection against supply-voltage transients can be incorporated. An additional feature is a 'soft start' characteristic—the firing angle is gradually increased over the first few

cycles after switching on, thus preventing the sudden application of full power which may be harmful to certain loads. In addition, facilities exist for an over-ride control via external contacts. The control module is calibrated 0-100% power, with a linear scale owing to the "square law" feedback employed, and is fully compensated against supply voltage variations from +10% to −15% at 240V a.c. Units can also be supplied for operation from 415V a.c. Eurotherm Ltd, Broadwater Trading Estate, Worthing, Sussex.
WW 305 for further details

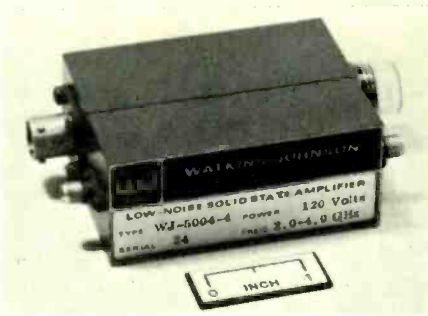
D.V.M. Multi-range Adaptor

Electrotech Instruments (of Coutant Electronics) have developed an adaptor unit that will convert any 1V full-scale digital voltmeter (input resistance $\gtrsim$ 10MΩ) to a multi-range digital meter for the measurement of a.c. and d.c. voltages, currents, and resistance. Known as the MMA 100 the adaptor is available either as a free-standing unit or built in to Electrotech's modular system cabinet which includes their new CDM 100 digital panel meter. The MMA 100 is built with push-button range selection and, when used in conjuction with a 1V full-scale digital meter, provides five voltage ranges and five current ranges for a.c. and d.c., and five resistance ranges. These are 0.1, 1, 10, 100 and 660V a.c.; 0.16, 1.6, 16, 160 and 1000V d.c.; 100μA, 1mA, 10mA, 100mA and 1A a.c.; 160μA, 1.6mA, 16mA, 160mA and 1A d.c.; and 160Ω,

1.6kΩ, 16kΩ, 160kΩ, and 1MΩ. According to the measurement function and range selected, the full-scale accuracy is between 0.1% and 0.5% and the sampling rate is between 2 and 3 per sec. Overvoltage protection is provided on a.c. and d.c. ranges—1000V on the three highest d.c. ranges and 250V on the two lowest; and 700V for the three highest a.c. ranges and 180V for the two lowest. On a.c. it will operate at frequencies from 40Hz to 10kHz. In the free-standing form the multimeter adaptor unit measures 147 × 60 × 180mm. The price is £70. Electrotech Instruments, Coutant Electronics Ltd, Instrument Division, 5 Loverock Road, Reading, Berks.
WW323 for further details.

S-band Low-noise Transistor Amplifier

Watkins-Johnson Co. has placed on the market a low-noise microwave transistor amplifier for operation in the S-band (2 to 4GHz). Designated the WJ-5004-4, this amplifier, with integral power supply has



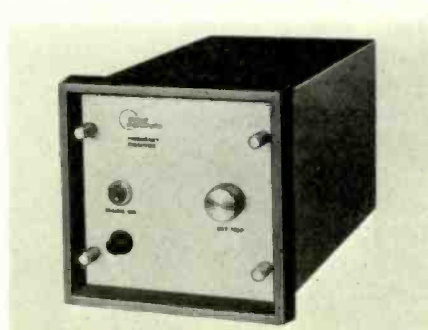
a guaranteed noise figure of 8.5dB maximum and power output of +7dBm (for 1dB gain compression). Overall design is consistent with the respective environmental requirements of MIL-E-16400F. Watkins-Johnson International, Shirley Avenue, Windsor, Berks.
WW 308 for further details

Oscilloscope for TV Servicing

Fully automatic television line and field triggering is featured in a new Philips oscilloscope, model PM3200X, specially designed for TV service and maintenance work. This ensures a completely stable display of all line- and field-signal waveforms. Other features are a 10MHz bandwidth, 2mV input sensitivity and the elimination of d.c. balance-correction by automatic drift compensation circuits in the vertical deflection pre-amplifier. The timebase circuit is triggered automatically but in the absence of a trigger it starts "free running". Sweep speeds cover the range 0.1μs/div to 0.5s/div. A separate triggering facility is provided for line/field triggering giving a stable display of both line and field information. The unit measures 175 × 210 × 330mm and weighs 5.3kg. Pye Unicam Ltd, York Street, Cambridge.
WW321 for further details.

Frequency monitor

Designed to provide an alarm or control signal when the input frequency deviates from a pre-determined figure, a new range of frequency monitors has been added to the Orbit 70 series of industrial control instruments. The principle of operation is based on the digital measurement of the period of the incoming signal giving a rapid single cycle response when the input frequency goes out of limits. Three versions, zero speed, underspeed and overspeed are available and combinations of under-



speed and overspeed modules can be housed in a single instrument to provide bandpass or high- and low-limit facilities. Thirteen overlapping ranges cover the frequency spectrum 1Hz to 30kHz. Alarm operation is within 0.1% of the set point and reset is automatically carried out without hunting. Output can be in the form of a relay changeover or of a logic level change. Construction is of i.cs mounted on plug-in p.c. modules. Orbit Controls Ltd, Alstone Lane Industrial Estate, Cheltenham, Glos.
WW 310 for further details

Field Intensity Receiver

A field intensity measuring receiver, designation number VSME1510, from Microwave International, covers the frequency band 30–300MHz in six ranges. The voltage measuring range covers 0-120dB (1μV to 1V). The unit employs transistors throughout and has an accuracy on its frequency calibration of 0.5% without a warm-up period. The frequency response is ±2.5dB on all ranges. The scale arrangement consists of a 340mm long cylindrical linear scale with continuously progressive frequency calibration. Total scale length is approximately 2 metres. The measuring accuracy when used on an accurate calibration source is better than ±1dB. By narrowing the bandwidth it is possible to measure sinusoidal voltages down to 0.1μV. The standard input impedance is 60Ω, and a 50-Ω unit is available on request. The bandwidth is 120–130kHz with 6dB drop. Microwave International (U.K.) Ltd, 33-37 Cowleaze Road, Kingston Upon Thames, Surrey.
WW 303 for further details

H.F. Receiver

Astro Communications have announced a new h.f. communications receiver, model S.R.502. This is a compact all-transistor modular unit suitable for table top or standard 19-in rack mounting. Only 3½in high, the main frame contains fully protected power supplies, audio, demodulator and i.f. circuits. Two cavities are provided which will accept a variety of plug-in modules. The right-hand cavity will accept either an h.f. tuning unit (0.5–30MHz in one band) or a v.l.f. tuning unit (10–500kHz in one band). The left-hand cavity can accept a battery pack which contains its own automatic charging circuit, a panoramic display, a digital frequency read-out unit with digital a.f.c. facilities or a digital frequency synthesizer with 100-Hz resolution. The receiver has been designed for a.m., s.s.b, c.w. and f.m. operation. The use of separate upper and lower sideband filters enables independent sideband operation with a simple adaptor. A high m.t.b.f. of 10,000 hours is claimed. Astro Communications Laboratory (U.K.), Coventry.
WW317 for further details.

Colour TV Pattern Generator

The Philips PM 5508 pattern generator, available from Pye Unicam, takes full advantage of the "self checking" properties of the PAL system which enables a receiver to be adjusted using the picture tube as the only indicator. This virtually eliminates the need for an oscilloscope, but, if one is used it can be synchronized by line and field sync pulses from the generator. The generator delivers ten signals which are selected by the push-buttons arranged across the front panel: (1) Black and white checkerboard of 6 squares by 8 squares for checking tuning, scanning, amplitude and linearity, (2) Blank raster with constant white content for purity check, (3) Blank raster with constant red content for purity check, (4) Eight-step staircase for grey scale tracking, (5) 11 dots by 15 dots for adjustment of static and dynamic convergence, on 625 lines only, (6) Cross hatch, 11 lines by 15 lines, for adjustment of static and dynamic convergence, on 625 lines only, (7) Four colour bars for delay line phase and amplitude adjustment, using tube as indicator, (8) Four colour bars for demodulator phase adjustment, using tube as indicator, (9) Four colour bars for matrix check, using an oscilloscope, (10) Eight colour bars similar to B.B.C. signal for general check. The lower half of the picture is white to serve as reference to enable the adjustment of the amplitude ratio of the colour-difference signals to the picture tube. Alternatively a simple modification enables colour bars to be produced over the whole screen if this is preferred. The ranges covered are bands I, III, IV and V, which are selected by push-buttons and continuous tuning is provided. Outputs are 15-20mV at r.f. (continuously variable) and 1V at video, both into 75Ω. Burst amplitude is variable for checking colour killer and a.g.c. The sound carrier can be modulated internally, unmodulated or switched off. The generator measures approximately 270 × 290 × 190mm and weighs approx. 5.6kg. Pye Unicam Ltd, York Street, Cambridge.
WW331 for further details

Transistors for switching 150W Pulses

Three new silicon planar transistors announced by Mullard have high switching rates and very low saturation voltages of not greater than 0.9V. Consequently, although the transistors, types BDY60, BDY61 and BDY62, have a continuous power rating of only 15W they can switch 150W pulses that have a duration not exceeding 50μs and a duty factor of 0.1. Earlier devices that switched 150W pulses had to have a higher continuous rating because they could not switch so rapidly. Although particularly suitable for use in high-frequency, silent, inverters and converters where efficiency is required, these types can also be used with advantage as pulse modulators in communications and radar systems. Typical transition frequency, f_T, (I_C = 0.5A, V_{CE} = 5V is 100MHz, and minimum h_{FE} (I_C=0.5A, V_{CE}= 10V) is 45. Mullard Ltd, Torrington Place, London W.C.1.
WW 313 for further details

Sine/Cosine Module

Burr-Brown have announced a sine/cosine function generator, model 4118/25, that may be used to produce various trigonometric gain responses. The module provides non-linear gain-shaping such that the output is −10 sin θ, where ±10V of input voltage represents a ±90° of angle θ. In addition, the unit may be connected to form cosine functions. By adding one or more external operational amplifiers, operation may be extended to include four-quadrant sine and cosine functions. Arc cosine and arc sine response functions may also be obtained. Accuracy is ±1% of full-scale for ± 10V input and

improves for small signals. Frequency response for accuracy of $\pm 1\%$ is d.c. to 1kHz—this accuracy includes both amplitude and phase shift errors. Temperature range is $-25°$ to $+85°$C. The module is self contained and requires no external components. Operation is from ± 15V supply. Fluke International Corporation, Garnett Close, Watford WD2 4TT.
WW330 for further details

New Audio Transformers

A new range of line-matching and microphone transformers for audio equipment is announced by Gardners Transformers. These complement the existing range introduced in 1961 and they come in two basic sizes using international octal, British 7-pin or flying screen lead connections. They are suitable for general purpose applications at high and low signal levels. Some of the new transformers, although similar in size and performance

to the existing types, now have a 20,000V capability to meet the Post Office requirement. They are protected mechanically by a new filling of closed-cell epoxide resin foam compound (the smaller types are vacuum-impregnated with a microcrystalline wax). Advanced technical data sheets AT15, AT16 and AT17 are available from the makers. Gardners Transformers Ltd, Christchurch, Hants., BH23 3PN.
WW 304 for further details

Precision R.F. Power Leveller

Weinschel Engineering introduces its model 1805 precision r.f. power leveller. This instrument is specifically designed to ensure precision and simplicity in systems used for transferring calibration factors of primary standards to bolometer mounts or secondary power standards (terminating or feedthrough type) and power meters. Model 1805 in conjunction with a d.c.-to-r.f. continuously variable attenuator, such as a p.i.n. modulator, establishes and maintains constant, precisely known reference values of r.f. power incident upon a terminating mount or emerging from a feedthrough mount into a Z_0 load. Minimum power level control range of 20dB is employed and only d.c.-substituted and bias power is used to maintain precise power levels, thus eliminating the a.c./d.c. error which is commonly found in some r.f. power bridge circuits. Selectable d.c.-

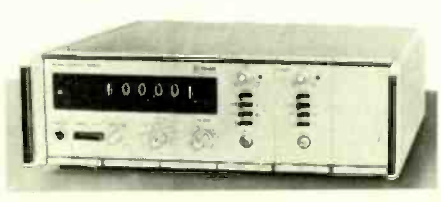
substituted power levels are 0.5, 1.0, 5.0 and 10mW; an external input capability is provided for establishing power levels between the fixed values. A selected level is maintained to within $\pm 0.1\% + 1\mu$W and is held constant for long periods of time over an ambient temperature range of 20°C and r.f. source level variations of ± 3dB. Once the desired power is selected with the range selector, the setting of a single toggle switch results in automatic control to maintain the selected value. If a deviation occurs, it is indicated on a meter having a 0.2μW resolution. Price $2,950. Weinschel Engineering Co, Inc., Gaithersburg, Maryland 20760, U.S.A.
WW324 for further details.

General Coverage Receiver Kit

The GR-78 general coverage receiver recently announced by Heath Company provides a.m., c.w. and s.s.b. coverage from 190 kHz to 30 MHz in six switch-selected bands. Solid-state circuit employs field-effect transistors in the r.f. section and four ceramic i.f. filters for improved sensitivity and selectivity and eliminating the need for alignment. Built-in bandspread tuning can be calibrated for either the shortwave broadcast or amateur bands, and a switchable 500-kHz crystal calibrator insures accurate dial calibration. This receiver comes complete with a rechargeable nickel-cadmium battery pack with a built-in charging circuit. Wiring options permit operation from either 120 or 240V a.c. and 12V d.c. Other features include switched a.g.c., an automatic noise limiter, receiver muting for use with a transmitter and a front panel relative signal strength meter. Price £68 18s. Daystrom Ltd, Heathkit Division, Gloucester.
WW 311 for further details

Time-interval Module

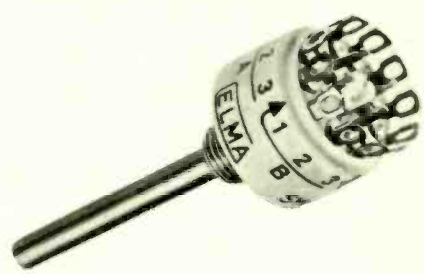
Time-interval measurements between pulses derived from two different lines can now be made with the addition of a time-interval unit, the PM6631, to the Philips PM6630 counter available from Pye Unicam. The unit can measure time



intervals between pulses with the same or opposite polarity, and also with amplitude differences as great as 20:1. With the addition of the PM6631, the counter can measure time intervals in the range 50ns to 10^6 seconds on pulses with widths down to 5ns. The triggering level for both pulses is individually adjustable in the range ± 1.5V (no attenuation) to ± 30V (20:1 attenuation), and trigger sensitivity is 150mV (pk-pk) for all pulses with widths greater than 5ns. Also provided is a separate d.c. output which indicates the trigger level used on the stop pulse and an oscilloscope output which can be used to display the exact position of the stop pulse in relation to the start one. Apart from this new measuring facility, the PM6630 combines a 160MHz frequency range with a 50mV r.m.s. input-signal sensitivity and an input impedance of either 1MΩ/15pF or 50Ω. A 100 MHz internal clock makes the instrument useful for signal-generator and communications equipment calibration, oscillator drift measurements and computer-clock frequency checks. Pulse width and delay measurement can also be obtained. Pye Unicam Ltd, York Street, Cambridge.
WW326 for further details

Rotary Stud Switch

The Elma sub-miniature rotary stud switch now features an improved case in glass-filled polycarbonate. This material is unaffected by most common solvents and is easily marked to aid wiring. Switches are available with tags for direct wiring to p.c. boards and may be supplied with screwdriver slots instead of shafts. Different torque settings are available. The



standard torque setting is 200 gm/cm; 400 and 600 gm/cm can be supplied to order. A ceramic wafer and gold-plated stud contacts are used. Contact resistance is better than 5mΩ and wafer insulation better than $10^{12}\Omega$. Switching capacity is up to 1A. Radiation Components Ltd, 76 Crown Road, Twickenham, Middlesex.
WW 309 for further details

Rotary Switch Kit

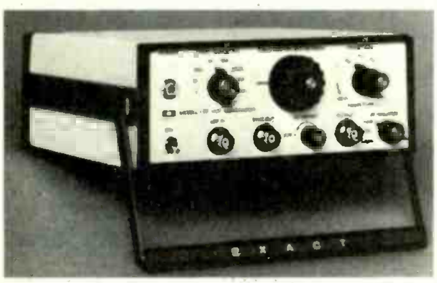
Switch kit series 44K30 by Highland Electronics enables designers to assemble their own prototype rotary switches. Over 400 switch combinations can be constructed with up to 12 poles and 12 switch positions. Assembled switches have an adjustable stop which can be changed without break-

continued on page 197

ing-down the switch. Components are re-usable and can be returned to the kit when the prototype is dismantled. Typical contact resistance is 10mΩ and contact rating is 0.5A at 230V a.c. resistive; 1A at 28V D.C. resistive. Highland Electronics Ltd, 33-41 Dallington Street, London E.C.1.
WW322 for further details.

Voltage-coupled Waveform Generator

A waveform generator with voltage-controlled frequency over a 1000:1 ratio, and a bandwidth from 0.1Hz to 3MHz, is being marketed by Environmental Equipments. The instrument, model 123, produces sine, square and triangular waveforms, as well as a sync pulse. Frequency is controlled to $\pm 2\%$ accuracy by a Kelvin-Varley divider in the form of a multiplier with both digital and vernier adjustments. External voltage control can



either be d.c. programming or a.c. frequency modulation. The output for all waveforms is at least 20V pk-pk into an open circuit, or 10V pk-pk into a 50Ω load. Attenuation of 60dB in steps of 20dB is provided, as well as variable ± 5V d.c. offset and floating output. A search mode is provided so the operator can use the vernier in the multiplier to sweep over a 1000:1 (three-decade) range within the frequency range selected. Both top and bottom panels of the instrument case are easily removable for calibration and maintenance. Environmental Equipments Ltd, Denton Rd., Wokingham, Berks.
WW328 for further details

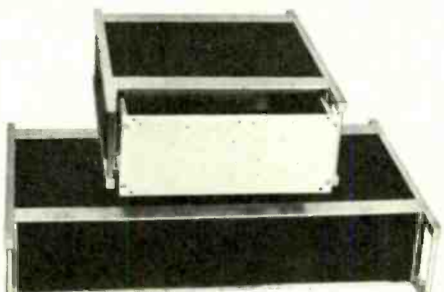
50-MHz Counter/Timer

Latest addition to the Marconi Instruments counter/timer range, TF2411, features a choice of plug-in frequency standards permitting the user to order an instrument with a performance and accuracy best suited to his applications. The TF2411 performs a wide range of functions including period and multi-period measurements, time interval, ratio and frequency measurements up to 50MHz. Using mainly integrated circuits and based on a system of plug-in printed circuit boards, the counter/timer has an f.e.t. input giving 10mV sensitivity and 1MΩ input impedance. Seven-digit readout is provided with a binary memory, and there is an optional b.c.d. printer-output. The cabinet measures 89 × 280 × 254 mm. The three plug-in

frequency standards at present available for TF2411 are: TM9933—a high-performance crystal and oven with an age rate of 1×10^{-7} per month and a warm-up time of 10 minutes to reach 1×10^{-7} operation; TM9888H—simple crystal oscillator which includes a 10-MHz external standard panel; and TM9890 which accepts external standard frequency signals between 1 and 10MHz. The choice of standard is made at the time of ordering. Marconi Instruments Ltd, Longacres, St. Albans, Herts.
WW 312 for further details

Equipment Cases

A range of modular instrument cases from Case Systems has been designed to give a flexible and compact method of housing electronic equipment. The cases are constructed from aluminium extrusions and plastic mouldings. Each case is mechanically stable when placed on any of its six sides, and the handles protect panel components, such as meters and switches, when the case is placed face



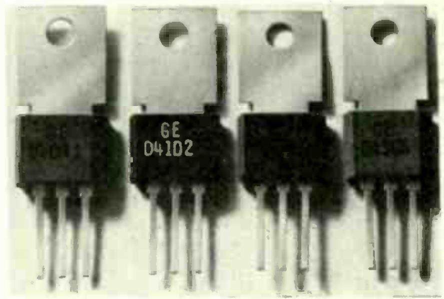
downwards or accidentally dropped. The protrusions at the rear which allow the case to stand face upwards, also protect rear connectors and components. The standard case, CS1 which is bench mounting can be converted to 19-in rack mounting simply by fitting brackets to each side. The CS1 will accept one module M1 or two modules M2. The CS2 or "half rack" case accepts one module M2 only. Case Systems, 20 Hunt Lane, Chadderton, Lancs.
WW329 for further details

High-Q Varactor Diodes for X-Band

Four gallium arsenide, Schottky barrier diodes announced by Mullard are intended for use as tuning elements in microwave circuits. Because the four devices, which form the 821CXY family, have resistances of not more than 3Ω, high Q-factors can be achieved. The diodes have zero-bias junction capacitances of 0.8 to 2.5pF, depending on the type. Breakdown voltage is not less than 12V, and the minimum ratio of junction capacitance at zero bias to capacitance at 12V reverse bias is 3. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW327 for further details

Colour-coded Audio Output Transistors

The full range of G.E. (U.S.A.) Power-Tab a.f. output transistors is now available from Jermyn Industries. Four main types, colour-coded for easy identification, make up two sets of complementary stereo



pairs: D40 brown, 1A 6W, n-p-n; D41 black, 1A 6W, p-n-p; D42 red, 3A 12W, n-p-n; D43 green, 3A 12W, p-n-p. Each type is available with 30, 45 or 60V continuous rating, with a wide range of gains up to 30. The flat pins are easily formed to TO5 or TO66 configurations. 100 up prices range from 7s 8d to 21s. Jermyn Industries, Vestry Estate, Sevenoaks, Kent.
WW325 for further details

Low-drift Op. Amps.

Advance Electronics announce three low-drift versions of their ZEL 1 series operational amplifiers. They are designated ZEL 1/02, /03 and /04 and have drift characteristics of 2.5, 5 and 10μV/°C respectively. Other main features of the ZEL 1 range are: d.c. gain 5×10^5 min; offset current 5nA max; slew rate 6V/μs min; c.m.r.r. 20,000 and input noise 2μV r.m.s. Prices £18 10s (/02), £11 (/03) and £8 10s (/04). Advance Industrial Electronics, Raynham Road, Bishops Stortford, Herts.
WW 314 for further details

Subminiature Relays

Two miniature relays measuring only 20.3mm long by 14.2mm wide by 6.35mm high have been introduced by Bourns. These are models 3120 s.p.d.t. and 3121 d.p.d.t. Both have a 1A rating at 26V d.c. and an operating temperature range of −65 to +125°C. Coil resistance and sensitivity ranges for the 3120 and 3121 respectively are 50–2,000Ω, 100mW nominal, and 65-2,000Ω, 160mW nominal. Contact material is gold-plated semi-precious metal and a life of 100,000 cycles is claimed. Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx.
WW319 for further details.

Literature Received

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

ACTIVE DEVICES

We have received the following literature from Marconi-Elliott Microelectronics Ltd, Witham, Essex.

t.t.l. 9000 series applications handbook .. price 30s
medium scale integrated circuits and memory elements product guide WW401
emitter coupled current steering logic data sheets:
MB501 dual four-input gate with bias driver WW402
MB502 dual four-input gate with bias driver and phantom NOR output WW403
MB503 eight-input logic gate with bias driver WW404

Microwave Associates, Ltd, Luton, Beds., have sent us a folder containing the following:

Micronotes WW405
high-power varactors (two) data sheet .. WW406
bulletin 4058 p.i.n. switching diodes (low-medium power) WW407
bulletin 4059 p.i.n. switching diodes (high-power) WW408
bulletin 4060 35V tuning varactors WW409
bulletin 4061A avalanche oscillator diodes WW410
bulletin 4063 varactors, high-power WW411
bulletin 4065A snap varactors WW412
bulletin 4067A varactors, high-power ... WW413
bulletin 4073 X-band Schottky diodes ... WW414
bulletin 4074/5/6/7/8/9, snap varactor diodes WW415
bulletin 4081 90V tuning varactors WW416

A number of additions for the Microspot cathode-ray tube manual and display equipment manual may be obtained from Ferranti Ltd, Gem Mill, Chadderton, Oldham, Lancs WW417

"What is Thick Film?", is the title of a leaflet which may be obtained from Reliance Controls Ltd, Drakes Way, Swindon, Wilts WW418

National Semiconductor Corporation, 2975 Ysidro Way, Santa Clara, California 95051, have published a data sheet on the LH101 operational amplifier, which is a variant of the LM101, and is now being manufactured in monolithic form WW419

Silicon General Inc., 7382 Bolsa Ave., Westminster, California 92683, U.S.A., have sent us data on the following products:

SG-1402, -2402, -3402 variable gain wideband amplifier/multiplier WW420
SG-710A, -710 differential voltage comparator WW421
SG-710B, -710C differential voltage comparator WW422
SG-711A, -711 voltage comparator WW423
SG-711B, -711C voltage comparator ... WW424
SG-105, -205, -305 voltage regulators .. WW425

Two more data sheets on d.t.l./t.t.l. compatible m.t.n.s. circuits from General Instrument Microelectronics, Stonefield Way, Ruislip, Middx, HA4 0JT, are available,

SS-6-2004 dual 4-bit parallel access, reversible static shift register WW426
SL-6-4025/32, quad 28/32-bit static shift register WW427

Leaflet No. 1, volume 1, of the Hivac Application Bulletin describes the use of glow diodes (cold-cathode glow-discharge tubes), in a number of circuits. Hivac Ltd, Stonefield Way, Ruislip, Middlesex WW428

A loose-leaf catalogue produced by Rastra Electronics Ltd, 275 King St, Hammersmith, London W.6, lists integrated circuits, transistors, diodes and many other items WW429

Quarndon Electronics (Semiconductors) Ltd, Slack Lane, Derby, DE3 3ED., who are distributors for Texas Instruments, S.G.S., Raytheon, Emihus and Sprague, have produced a comprehensive semiconductor catalogue, "Semicon 70", which is now available ....WW 462

The E.E.V. equivalents for nearly 2000 valves are listed in the "Equivalents Index—1970" which is published by the English Electric Valve Co. Ltd., Chelmsford, Essex ....WW 463

We have received a short-form catalogue from the Signetics Corporation, Trident House, Hayes, Middlesex, which lists linear and digital integrated circuits ....WW 464

PASSIVE COMPONENTS

The 5th edition of "Components Applications Data", may be obtained from Radiospares, P.O. Box 427, 13-17 Epworth St, London E.C.2 .... WW430

A leaflet, "Electrolube Contact Lubricant", is available from Electrolube Ltd, Oxford Avenue, Slough, Bucks WW431

Microwave waveguide filters manufactured by Ferranti Ltd, Components Division, Dunsinane Avenue, Dundee DD2 3PN, Scotland, are described in a leaflet WW432

"Military Specification Connector Manual", lists the products of Elco Pacific, 2200 Park Place, El Segundo, California 90245 .... WW433

Two additions have been received for the Erie Catalogue dealing with r.f.i. filter devices. Erie Electronics Ltd, South Denes, Great Yarmouth, Norfolk WW434

"Product Selector Guide", from the Dialight Corporation, 60 Stewart Avenue, Brooklyn, N.Y.11237 lists indicator lamps, digital readouts and illuminated push-button switches WW435

The new range of "Control-Line" Modules, which operate high-current loads from low-level control systems without mechanical contacts, are described in a catalogue from FR Electronics, Flight Refuelling Ltd, Wimborne, Dorset WW436

"Component Socket Guide", from the Elco Corporation, Willow Grove, Pennsylvania 19090, U.S.A., lists valve, crystal, relay, transistor and d.i.l. sockets WW437

Reed relays are the subject of a new catalogue from: Kempston Electrical Co. Ltd, Shirley Rd., Rushden, Northants WW438

A catalogue listing the products distributed by the D-T-V Group, 126 Hamilton Rd, London S.E.27, is available WW439

A range of contactless switches is described in a catalogue from Cole Electronics Ltd, Lansdowne Rd, Croydon CR9 2HB WW440

Miniature switches, microphones, headsets, leads, plugs and sockets are the subject of a catalogue from Danavox (Great Britain) Ltd, "Broadlands", Bagshot Rd, Sunninghill, Berks. ....WW 465

Two engineering bulletins received from Sprague (U.K.) Ltd., Sprague House, 159 High St., Yiewsley, West Drayton, Middlesex, describe capacitors.

2705A Metalized polycarbonate-film capacitors WW466
3456A Aluminium capacitors, non-aqueous electrolyte WW467

An eight-page potentiometer selection guide is available from Reliance Controls Ltd, Drakes Way, Swindon, Wilts. ....WW 468

Details of a seven-day prototype illuminated pushbutton switch service are given in literature from Forder Graham Ltd., Pinnacle Hill, Keslo, Roxburghshire. The service is based on a 4-pole change-over switch which can be supplied in banks with a variety of mechanical actions and contact configurations ....WW 469

HARDWARE, ETC.

A data sheet from Firth Cleveland Fastenings Ltd, Treforest, Pontypridd, Glamorgan, pictorially shows the uses of a range of Spire fasteners WW441

A copy of a paper "New Cleaning and Drying Techniques for Critical Electronic Assemblies", is available from: I.C.I. Ltd, Thames House North, Millbank, London S.W.1 .... WW442

A modular connecting system called Hypertac is described in a leaflet S/294C from Smiths Industries, Industrial Instrument Division, Kelvin House, Wembley Park, Middx WW443

Applications data and technical information on Loctite products for thread locking, retaining and sealing is given in a brochure from: Douglas Kane Group Ltd, Swallowfields, Welwyn Garden City, Herts.. WW444

EQUIPMENT

Over 200 power supply modules and about 50 measuring instruments are the subject of a leaflet from Lambda Electronics, 21 Aston Rd, Waterlooville, Portsmouth, Hants WW445

Performance details of the type TSA 6636/3 counter timer are in a data sheet. Venner Electronics Ltd, Kingston By-Pass, New Malden, Surrey. ... WW446

Helium-neon lasers are described in a leaflet from Ferranti Ltd, Dunsinane Avenue, Dundee DD2 3PN, Scotland WW447

A leaflet describing the digital voltmeter type LM 1867 may be obtained from the Solartron Electronic Group Ltd, Farnborough, Hants WW448

Lyons Instruments Ltd, Hoddesdon, Herts, have produced a leaflet which describes six pulse generators WW449

A Gunn-oscillator, type PM7015X is described in a leaflet from Sivers Lab, U.K. Office, Old Haverhill Rd, Little Wratting, Suffolk WW450

The following literature is available from Dana Electronics Ltd, Bilton Way, Dallow Rd, Luton, Beds:

Series 5740 digital voltmeters WW451
Series 5700 digital voltmeters WW452

We have received the following literature from

Marconi Instruments Ltd, Longacres, St. Albans, Herts.
Automatic testing—the way ahead WW453
TF 2210, 100MHz oscilloscope WW454

Lyons Instruments (Hoddesdon, Herts), newsletter for January 1970 discusses a programmed pulse system for dynamic testing WW455

Thyristor controllers for use between 100 and 300A are the subject of a data sheet published by AEI Semiconductors Ltd, Carholme Rd, Lincoln. WW456

"Servoscribe" flat-bed chart recorders are described in a leaflet from the Industrial Instrument Division, Smiths Industries Ltd, Wembley, Middx WW457

The diverse products of Hewlett Packard Ltd, 224 Bath Rd, Slough, Bucks, for measurement, analysis and computation are described in a handsome 647-page hard-bound volume WW458

The following two brochures are obtainable from Racal Group Services Ltd., 26 Broad St., Wokingham, Berks.
Solid state h.f. communications receivers .. WW 470
Radio telecommunications equipment and systems .... WW 471

V. N. Barrett & Co. Ltd., 1 Mayo Rd., Croydon, CRO 2QP, Surrey, have produced a new catalogue of used scientific and industrial equipment . WW 472

GENERAL INFORMATION

"Product Guide—1970", published by the Electronic Engineering Association, Berkeley Square House, Berkeley Square, London W.1, lists manufacturers of electronic capital equipment WW459

The Mullard Educational Service, Mullard House, Torrington Place, London W.C.1, have produced a leaflet listing all the publications available from them WW460

"Measuretest" instrument application notes (numbers 001 and 002), for colour television are available from Marconi Instruments Ltd, Longacres, St. Albans, Herts WW461

Tektronix U.K. Ltd, Beaverton House, P.O. Box 69, Harpenden, Herts, have three more books in their "Concept" series available; the price is 10s each including packing and postage. They are:
Horizontal Amplifier Circuits
Oscilloscope Probe Circuits
Probe Measurements

R.C.A. Great Britain Ltd, Lincoln Way, Windmill Rd, Sunbury-on-Thames, Middx, have available application note ICAN-4158 "Application of the CA 3059 zero-voltage switch in thyristor circuits"..... WW 462

The Scientific Instrument Manufacturers' Association of Great Britain, SIMA House, 20 Peel St, London W.8, have produced a booklet called "Metrication Guide" which is available from them price 50s.

Two new publications are available from the Mullard Educational Service, Mullard House, Torrington Place, London W.C.1
"A simple f.e.t. voltmeter" ....WW 473
"Introducing thyristors" ....WW 474

We have received two publications from the British Calibration Service, Millbank Tower, London S.W.1, which are listed below. The first of these explains what the British Calibration Service is and how a laboratory may apply for approval. The second publication lists all the laboratories that have obtained approval so far together with the type of measurements they can carry out and the degree of accuracy guaranteed.
About the British Calibration Service ... WW475
Directory of Approved Laboratories ... WW476

April Meetings

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

LONDON

1st. I.E.E.—Discussion on "Electrical measurement on acoustic surface wave devices" at 17.30 Savoy Pl, W.C.2.

1st. I.E.R.E.—Discussion on "Direct digital measurement of physical quantities" at 18.00 at 9 Bedford Sq., W.C.1.

3rd. I.E.E.—"Implementation of digital filters" by Prof. R. Boite at 17.30 at Savoy Pl., W.C.2.

3rd. I.E.E.—Discussion on "Aeronautical communication by satellite" at 17.30 at Savoy Pl., W.C.2.

6th. I.E.E.—Discussion on "Multi-element phased arrays" at 17.30 at Savoy Pl., W.C.2.

7th. I.E.E./R.Ae.S.—"Satellite communication" by J. K. S. Jowett at 18.00 at Savoy Pl., W.C.2.

8th. I.E.R.E.—Colloquium on "High resolution systems" at 14.30 at 9 Bedford Sq., W.C.1.

9th. R.T.S.—"Creating colour television titles" by M. H. Cox and R. Knight at 19.00 at I.T.A., 70 Brompton Road, S.W.3.

15th. I.E.E.—Discussion on "Photolithographic techniques in microelectronics" at 17.30 at Savoy Pl., W.C.2.

15th. B.K.S.T.S.—"The Minicam: the Pye/CBS miniature colour television camera" by Len Cosgrove at 19.30 at I.T.A., 70 Brompton Road, S.W.3.

20th. I.E.E./I.E.R.E.—Colloquium on "Skynet" at 10.00 at the I.E.E., Savoy Pl., W.C.2.

22nd. I.E.E.—"Telecommunications support for the Apollo programme" by Lorne M. Robinson (N.A.S.A.) at 17.30 at Savoy Pl., W.C.2.

22nd. I.E.R.E.—"Real-time computer model (business games)" by D. Simpson at 18.00 at 9 Bedford Sq., W.C.1.

23rd. I.E.E.—"Quasars and radiogalaxies" by Professor F. Hoyle at 17.30 at Savoy Pl., W.C.2.

23rd. Inst. Electronics—"Modern aspects of electronic instrument design" by G. F. Penner at 18.30 at West Ham College of Technology, Stratford, E.15.

23rd. R.T.S.—Fleming Memorial Lecture "The impact of automation on television transmission" by F. H. Steele, G. A. McKenzie and R. H. Vivian at 19.00 at the Royal Institution, Albermarle St., W.1.

28th. I.E.R.E.—Symposium on "Capacitors" at 10.00 at 9 Bedford Sq., W.C.1.

29th. I.E.E.—"Ionospheric research by means of oblique incidence sounders" by P. Bradley at 17.30 at Savoy Pl., W.C.2.

29th. I.E.R.E.—"Scanning circuits for 110° colour tubes" by K. E. Martin at 18.00 at 9 Bedford Sq., W.C.1.

30th. I.E.E./I.E.R.E.—"Microprogramming and processor design" by Prof. M. V. Wilkes at 17.30 at Savoy Pl., W.C.2.

30th. R.T.S.—"An image analyser for medicine using colour television techniques" by M. B. Coyne, F. Paice & Prof. E. D. Williams at 19.00 at the Wolfson Institute, Royal Postgraduate Medical School, Hammersmith Hospital, Ducane Road, W.12.

BARROW-IN-FURNESS

15th. I.E.E.—"Application of lasers" by Prof. E.D.R. Shearman at 19.30 at the Hotel Imperial, Cornwallis St.

BELFAST

10th. I.E.R.E.—"Aerials" by H. V. Sims at 18.30 at the Ashby Inst., the Queen's University, Stranmillis Road.

14th. I.E.E.T.E.—"Concorde—flight/auto controls and navigation" by H. Hill at 19.30 at the Ashby Institute, the University, Stranmillis Road.

17th. I.E.E.—Faraday Lecture—"People, communications & engineering" by J. H. H. Merriman at 20.00 at Sir Wm. Whitla Hall, Queen's University.

21st. I.E.E. Grads.—"Metal oxide silicon transistors" at 18.30 at the Main Lecture Theatre, Ashby Institute, Stranmillis Road.

BIRMINGHAM

8th. I.E.E. Grads.—"Thyristor drives" by M. F. Arnold at 19.00 at the Sumpner Bldg, the University of Aston, Gosta Green.

9th. I.E.R.E.—"Gramophone records—past and present" by G. M. Nathan at 19.30 at the University's Dept. of Electronic & Electrical Eng'g.

15th. R.T.S.—"University of Birmingham television service" by Dr. Peter Whitaker at 19.00 at the University.

BLETCHLEY

21st. I.E.E.—"Lasers and their applications" at 19.15 at Harwood House College.

BRIGHTON

14th. I.E.E.—"On the future of world communication" by Prof. E. C. Cherry at 18.30 at the College of Technology, Lewes Rd, Moulsecoumb.

CARDIFF

6th. I.E.E.—"Digital filters" by Dr. R.C.V. Macario at 18.00 at U.W.I.S.T.

23rd. R.T.S.—"The E.V.R. system" by Sir Francis McLean at 19.00 at the B.B.C. Llandaff.

CARLISLE

8th. I.E.E.T.E.—"Application of thyristors to industrial control systems" by S. Denyer at 19.30 at the Technical College, Victoria Place.

CHATHAM

23rd. I.E.R.E.—"Automatic trains on the Victoria Line" by R. I. M. Arthurton at 19.00 at the Medway College of Technology.

CHELMSFORD

15th. I.E.E.—"Radio-astronomy, thirty-five years progress" by F. W. Hyde at 18.30 at the King Edward Grammar School.

28th. I.E.R.E./I.E.E.—"24-channel p.c.m." by A. Stevens at 18.30 at the Civic Centre, Duke Street.

DUBLIN

15th. I.E.E.—Faraday Lecture—"People, communications & engineering" by J. H. H. Merriman at 20.00 at R.D.S. Hall.

DURHAM

22nd. I.E.E.T.E.—"Application of thyristors to industrial control systems" by S. Denyer at 19.30 at the University's Science Laboratories, South Road.

EVESHAM

20th. I.E.E./I.E.R.E.—"Large scale integration in microelectronics" by D. D. Jones at 19.30 at the B.B.C. Engineering Training Centre, Woodnorton.

LEEDS

16th. I.E.R.E.—"Thyristors into the home and industry" by R. Willis at 19.30 at the University's Dept. of Electronic and Electrical Eng'g.

28th. I.E.E.—"Electronic measurement as a guide to archeological research" by E. T. Hall at 18.30 at the University.

LIVERPOOL

1st. I.E.E. Grads.—"Laser holography" by Dr. J. M. Burch at 18.30 at the University.

6th. I.E.E.—"The pulsars" by Prof. F. Graham Smith at 18.30 at the University.

22nd. I.E.R.E.—"Schools project technology" at 19.30 at the University's Dept. of Electrical Eng'g.

MANCHESTER

8th. I.E.E. Grads.—"Communications bit by bit" by H. B. Law at 18.45 at U.M.I.S.T.

14th. I.E.E.—"History and development of time & frequency measurement" by C. R. Cordwell at 18.15 at U.M.I.S.T.

22nd. I.E.E.—"Radar data processing techniques with application to air traffic control" by Dr. P. J. C. Child at 18.15 at Renold Bldg, U.M.I.S.T.

NEWCASTLE-UPON-TYNE

8th. I.E.R.E.—"The symbolic integrated maintenance systems" by J. Hambleton at 18.00 at the Polytechnic (Rutherford College), Ellison Pl.

NORWICH

14th I.E.E.—"Electronic performance testing of motor vehicles" by E. Gamble at 19.30 at the Assembly Hall.

NOTTINGHAM

16th. R.T.S.—"Duplication of BBC-1 on u.h.f. & introduction of 3-channel colour" at 19.30 at the B.B.C. Studios, Wilson House, Derby Road.

PLYMOUTH

14th. I.E.E.T.E.—"Oceanographic instrumentation" by Lt. Cdr. T. J. Woodfin and Eng. Sub. Lt. M. Rushton at 19.30 at the Lecture Theatre, the College of Technology.

PORTSMOUTH

21st. I.E.E.—"Aids to all-weather landing of aircraft" by M. Catton at 18.30 at the Polytechnic, Anglesea Rd.

READING

16th. I.E.R.E.—"The design of solid-state audio amplifiers" by P. J. Baxandall at 19.30 at the J. J. Thomson Lab., the University, Whiteknights Pk.

RUGELEY

2nd. I.E.R.E.—"Engineer to manager—effecting the transition" by M. W. Lauerman at 19.00 at the Shrewsbury Arms Hotel, Market St.

SALFORD

13th. I.E.E.—"Electronics, man & aerospace" by R. E. Young at 19.30 at the University.

14th. I.E.E.—"Electronics, man & aerospace" by R. E. Young at 14.30 (students) and 19.30 at the University.

SALISBURY

13th. I.E.E.—"Colour television" by L. G. Dive at 19.00 at the Salisbury & Wilts College of Further Education, the Friary.

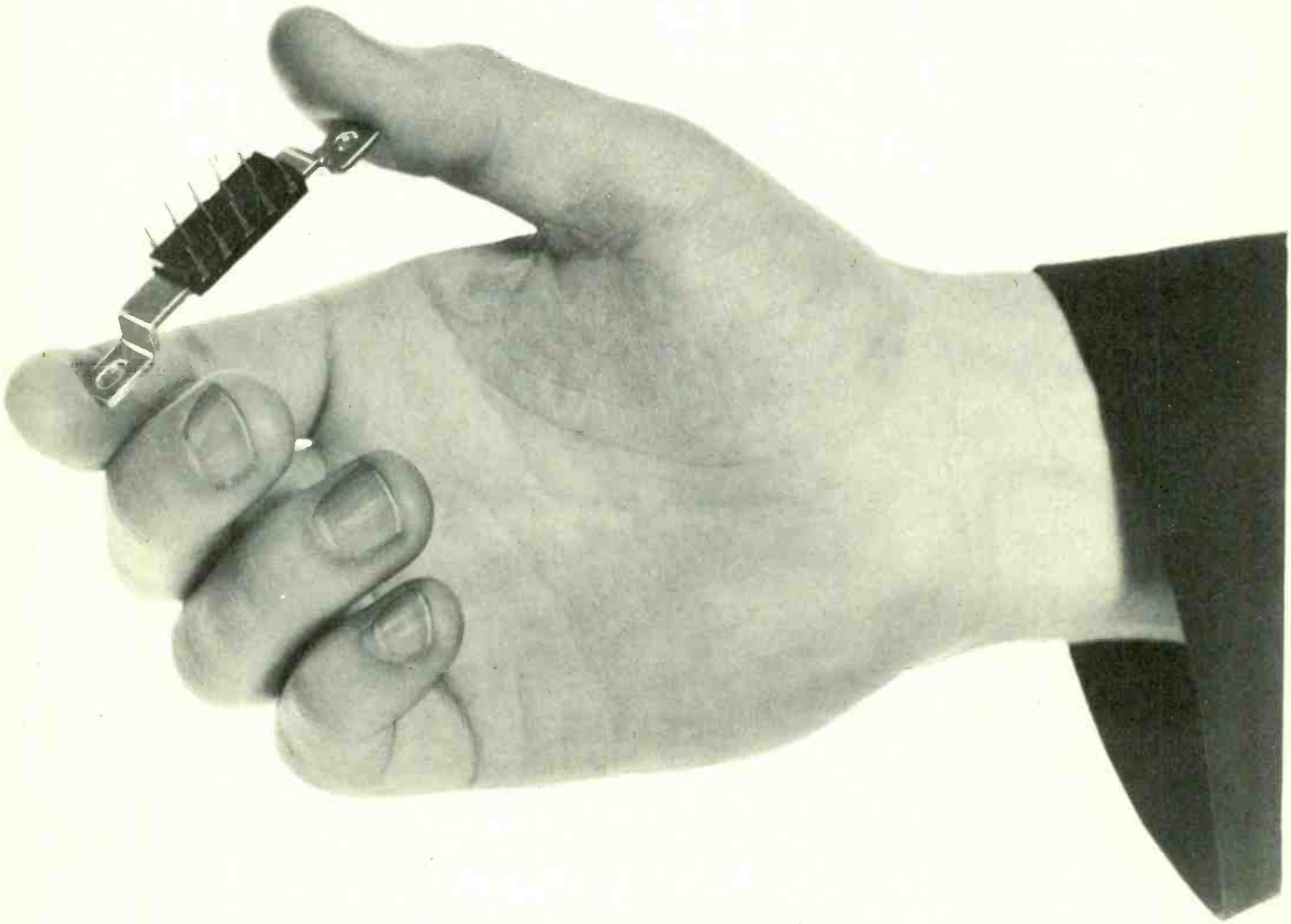
STOKE-ON-TRENT

9th. I.E.E. Grads.—"Voltage and its measurement from 'A' to about 'Q'" by F. W. Senior at 19.15 at the North Staffs College of Technology.

SWANSEA

9th. I.E.E.—"M.O.S. integrated logic" by J. A. Roberts at 18.15 at University College, Singleton Pk.

2 Watt and 3 Watt Professional IC Audio Amplifiers now available



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Preamplifier	0.1%	0.1%
Main amplifier	0.3%	0.3%
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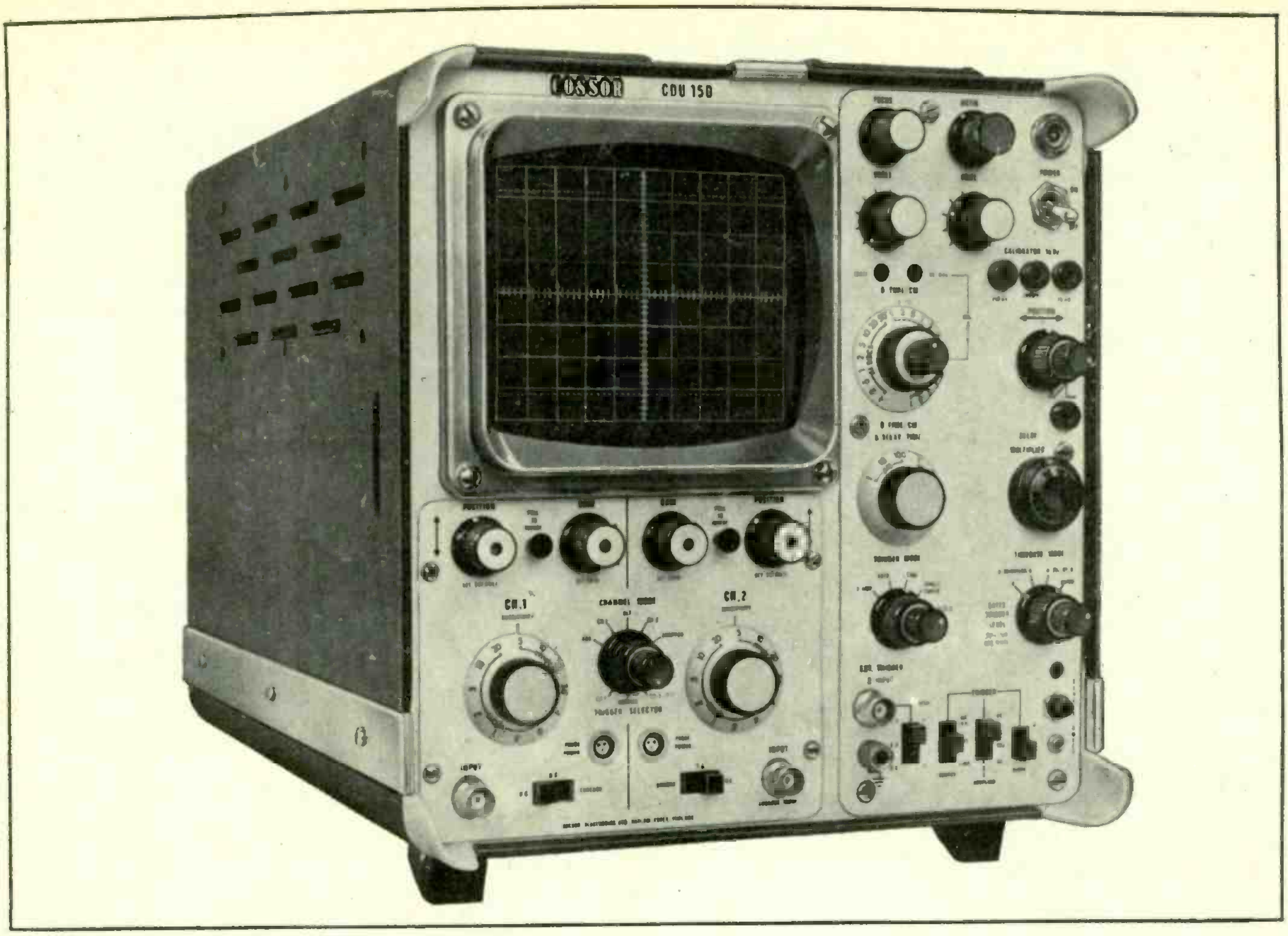
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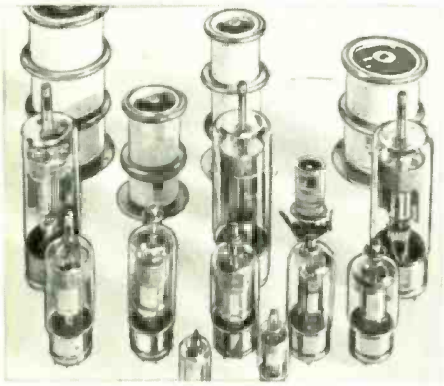

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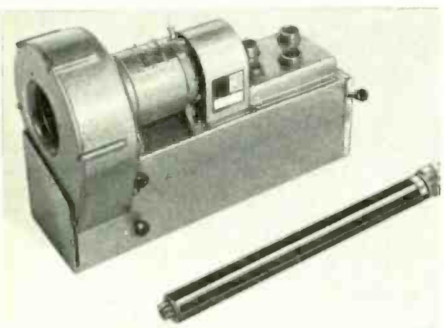
5. Pulse tetrodes



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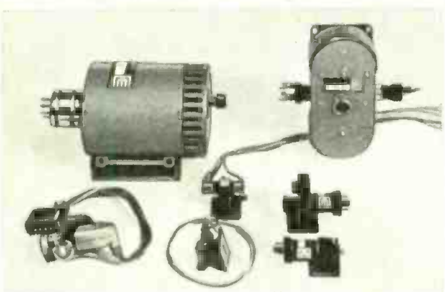
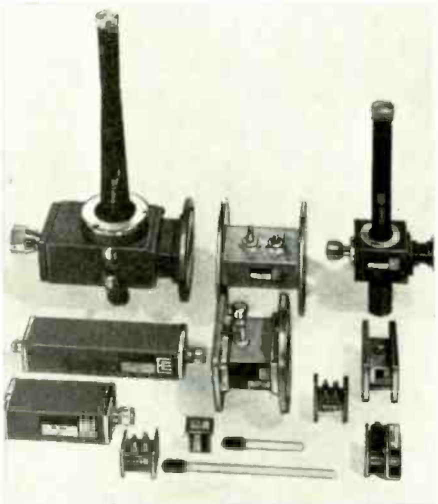


7. Low power klystrons and
backward wave oscillators



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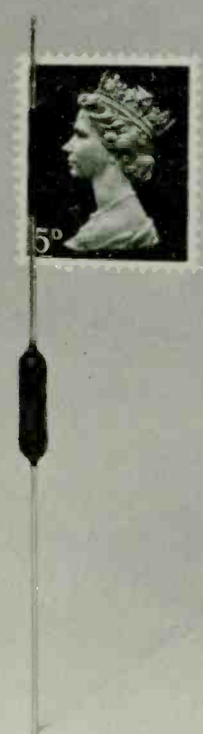

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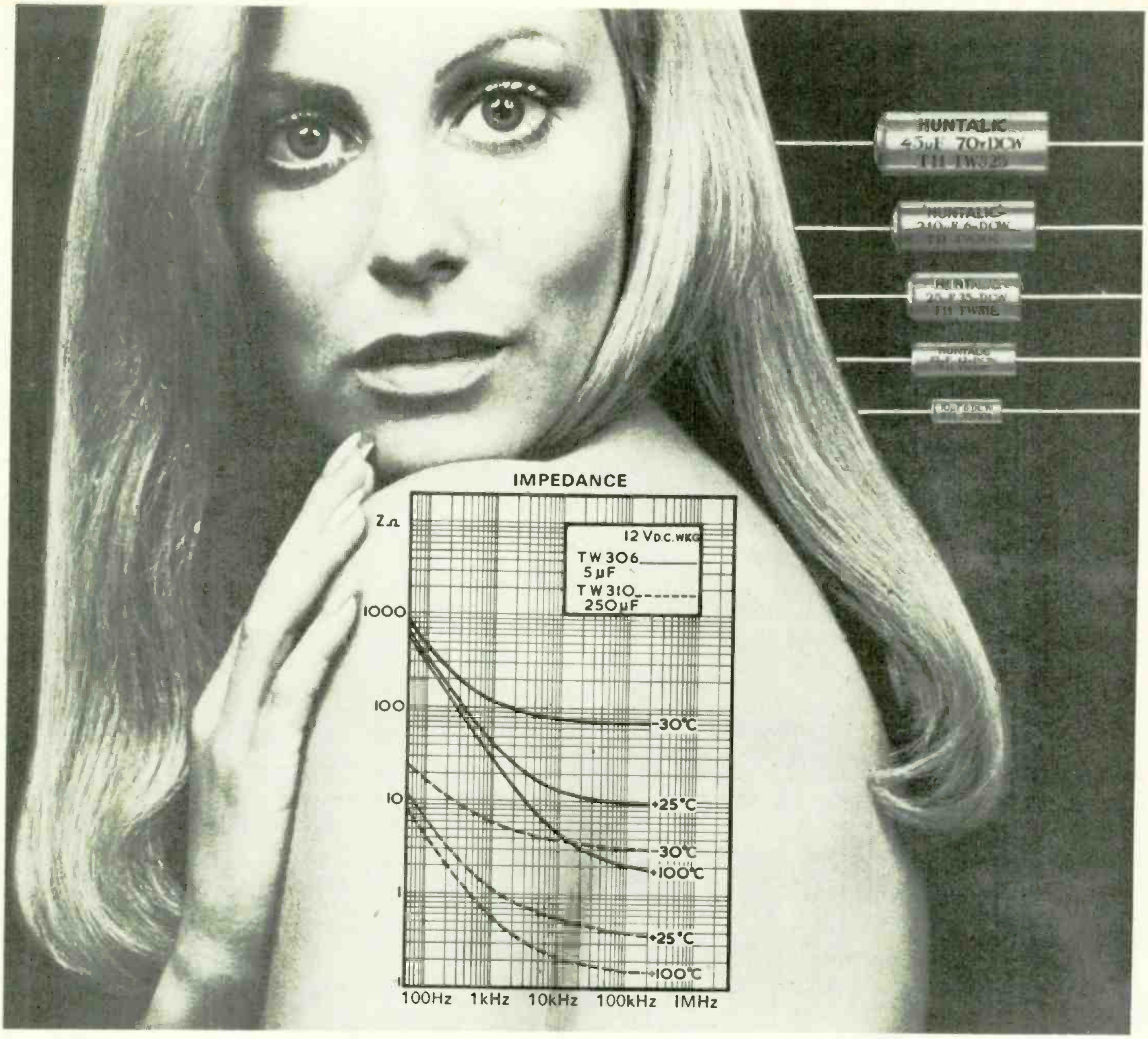

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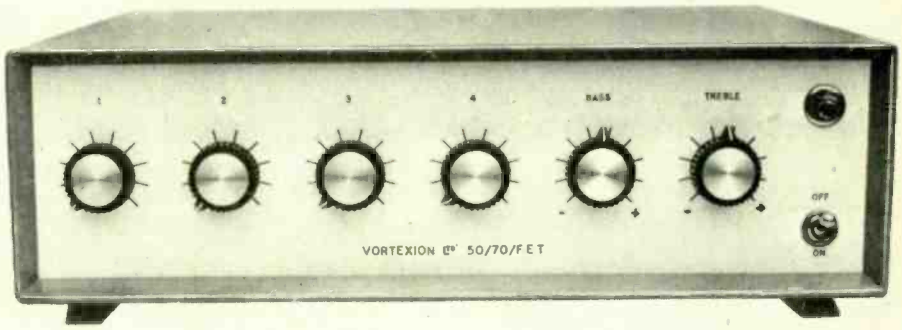
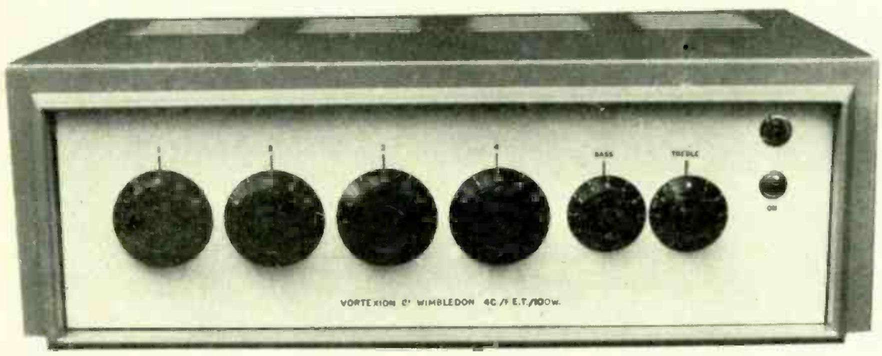


100 WATT ALL SILICON AMPLIFIER. A high quality amplifier with 8 ohms–15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Imput 0.4 V on 100K ohms.



THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4 channel F.E.T. mixer, 3 mic. 1 gram with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25% and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

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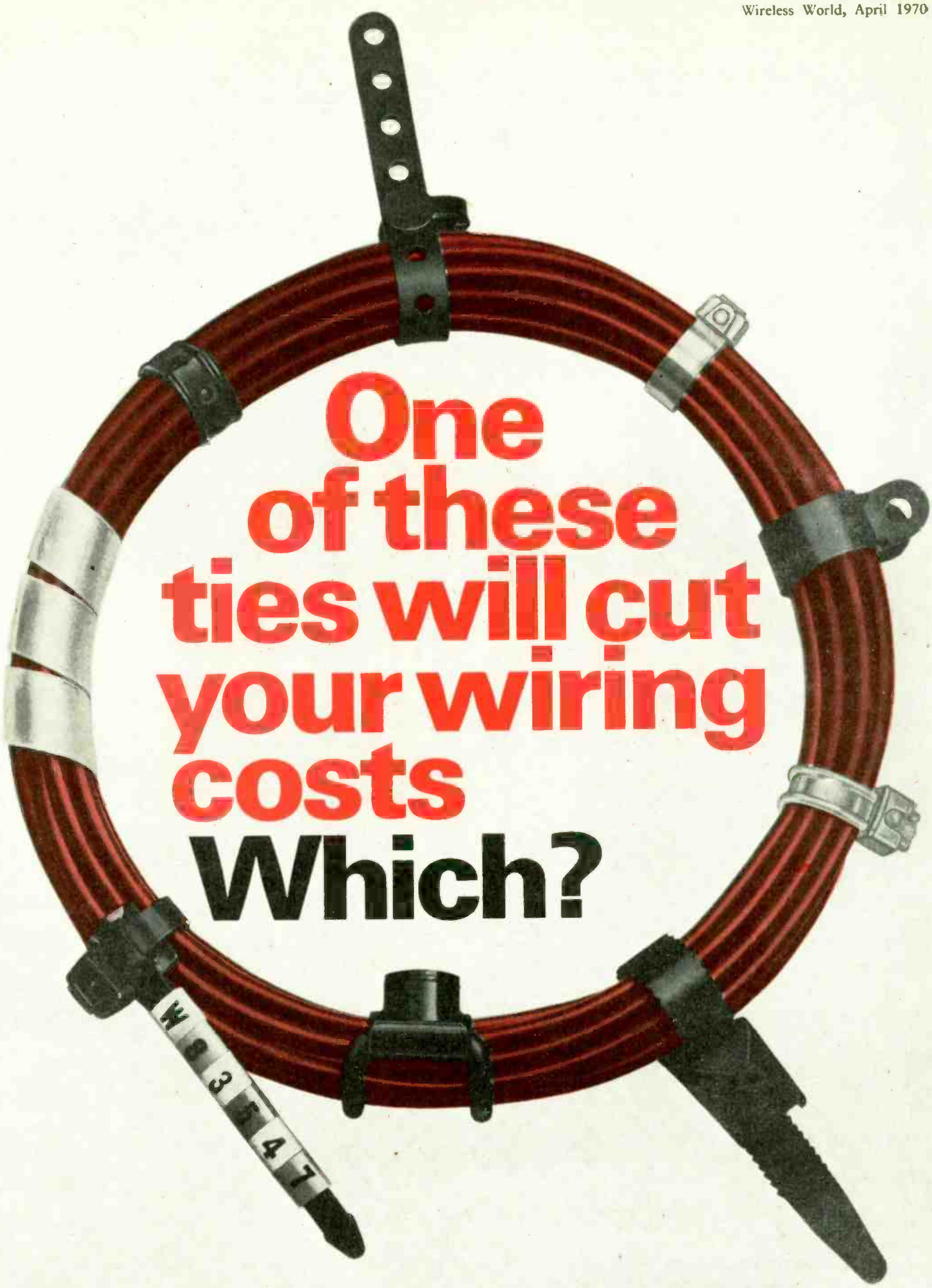
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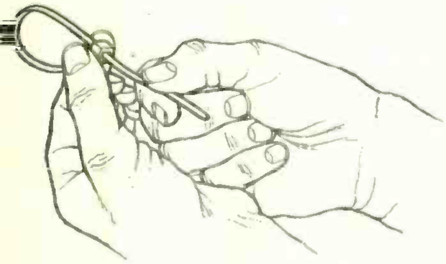
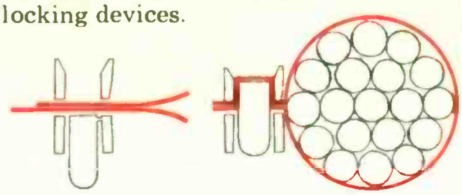
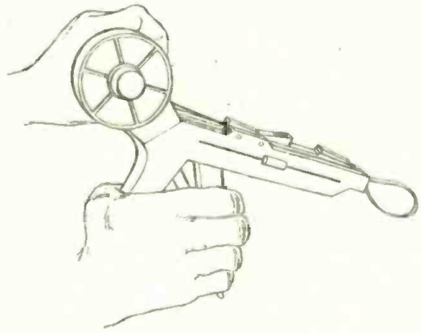


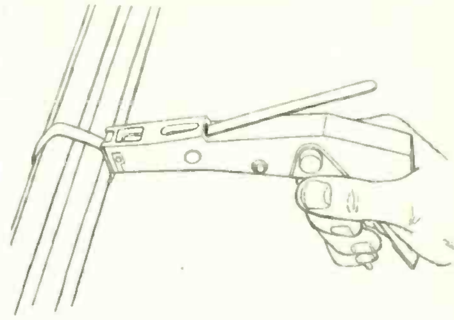
For example, there's Insulok MS – one piece cable ties for quick, simple, hand or tool fixing without pins or metal locking devices.



More Hellermann ingenuity . . . an exclusive extrusion system that prevents strapping pulling out even under extreme vibration. The principle is utilised in two Hellermann tying systems.



The first is called Tyton – an 'off-the-reel' system that binds 50% faster than any other comparable system. The second is Kabelrap – a heavy duty version using 'one-piece' ties.



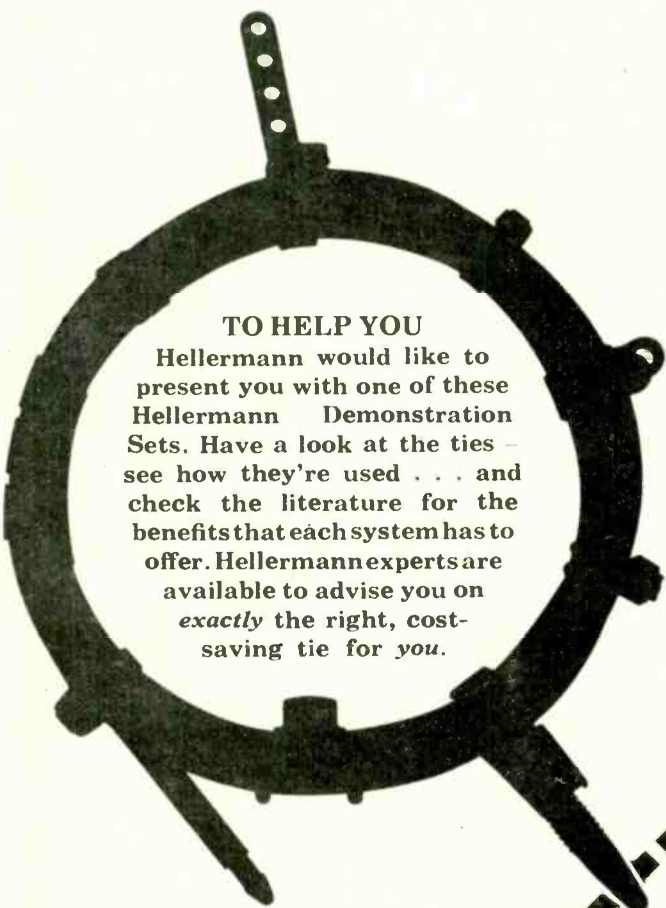
These are just three of more than a dozen Hellermann systems.

So you can see, Hellermann are deeply involved in all aspects of cable tying.

Job for job – pound for pound – Hellermann will give you increased output, simplified production, minimised tie wastage, quick and easy wiring amendment and, as an added bonus, better looking cable bundles.

The only problem: which Hellermann tie suits you best.

ask Hellermann



TO HELP YOU

Hellermann would like to present you with one of these Hellermann Demonstration Sets. Have a look at the ties – see how they're used . . . and check the literature for the benefits that each system has to offer. Hellermann experts are available to advise you on *exactly* the right, cost-saving tie for *you*.

Please send me a Hellermann Demonstration Set and a copy of your Ties Selection Guide.

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WW4/70

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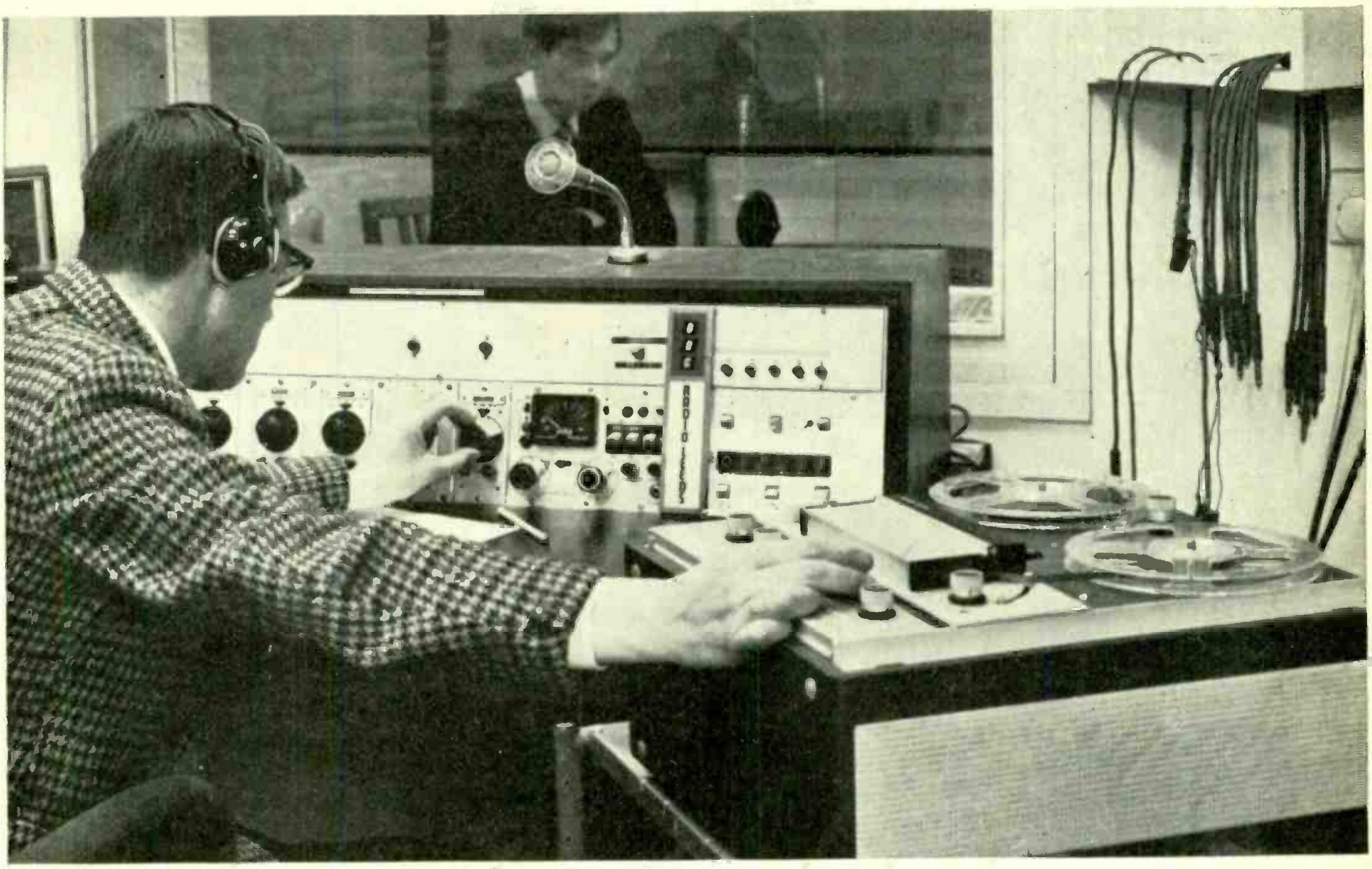

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WW

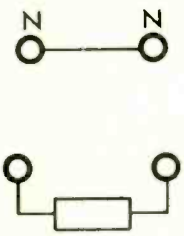
Some notes on Bridge Measurement by WAYNE KERR

Number 9
Four-Terminal Applications

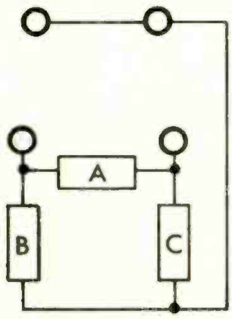
In this issue we are illustrating the principal applications of four-terminal technique made available by the Transformer Ratio Arm Bridge.

The diagrams show six different measurement arrangements using four connection points to the bridge. The two upper terminals marked 'N' in the first diagram are the neutral connections, the two lower terminals representing connections to the bridge voltage and current transformers.

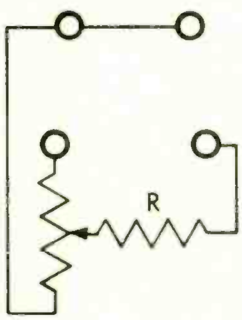
These diagrams are necessarily in summary form and, if further explanation is required, reference should be made to the first two issues of these notes.



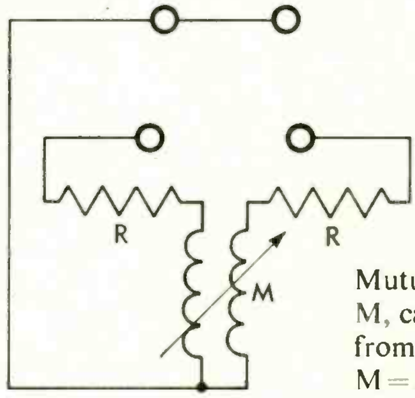
2-terminal connection for normal component measurements.



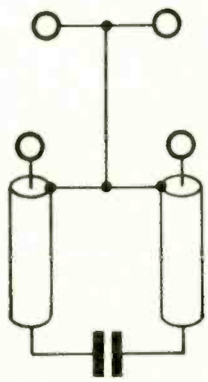
3-terminal connection. Bridge reads A, ignores B & C. Ideal for in-situ checks.



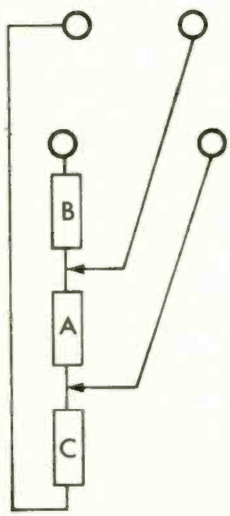
Potentiometer ratios can be related to angular rotation. Bridge reads R × (1/ratio).



Mutual Inductance, M, can be derived from bridge C reading: $M = R^2.C$.



Small capacitors (and all other types of component) can be measured at the end of long test leads. The effect of the neutral connections is to prevent the cable capacitances appearing in shunt with the component under test.



4-terminal connections minimise lead and contact resistance errors. Bridge measures A, ignoring B & C.

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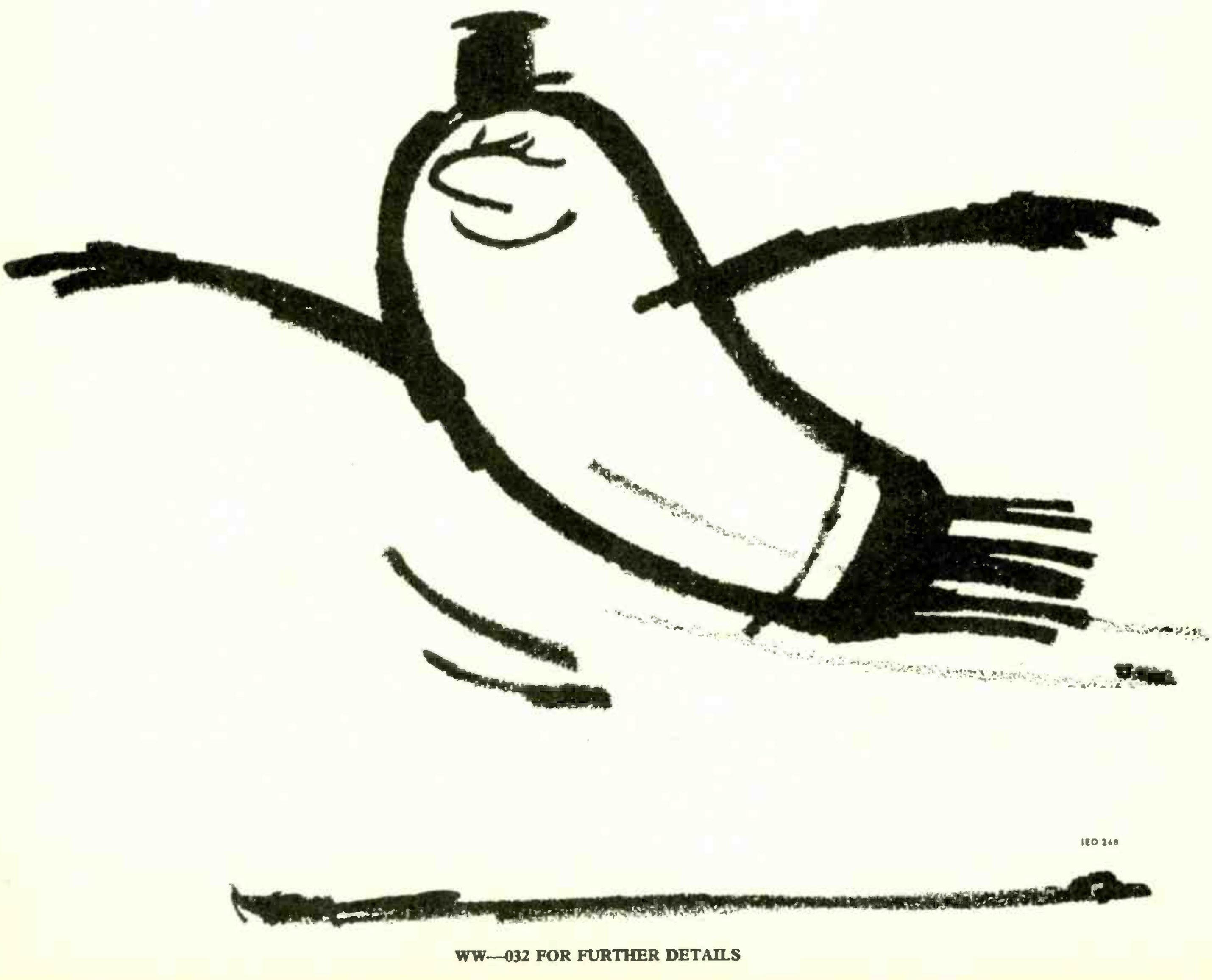

IED 268

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IED 268A

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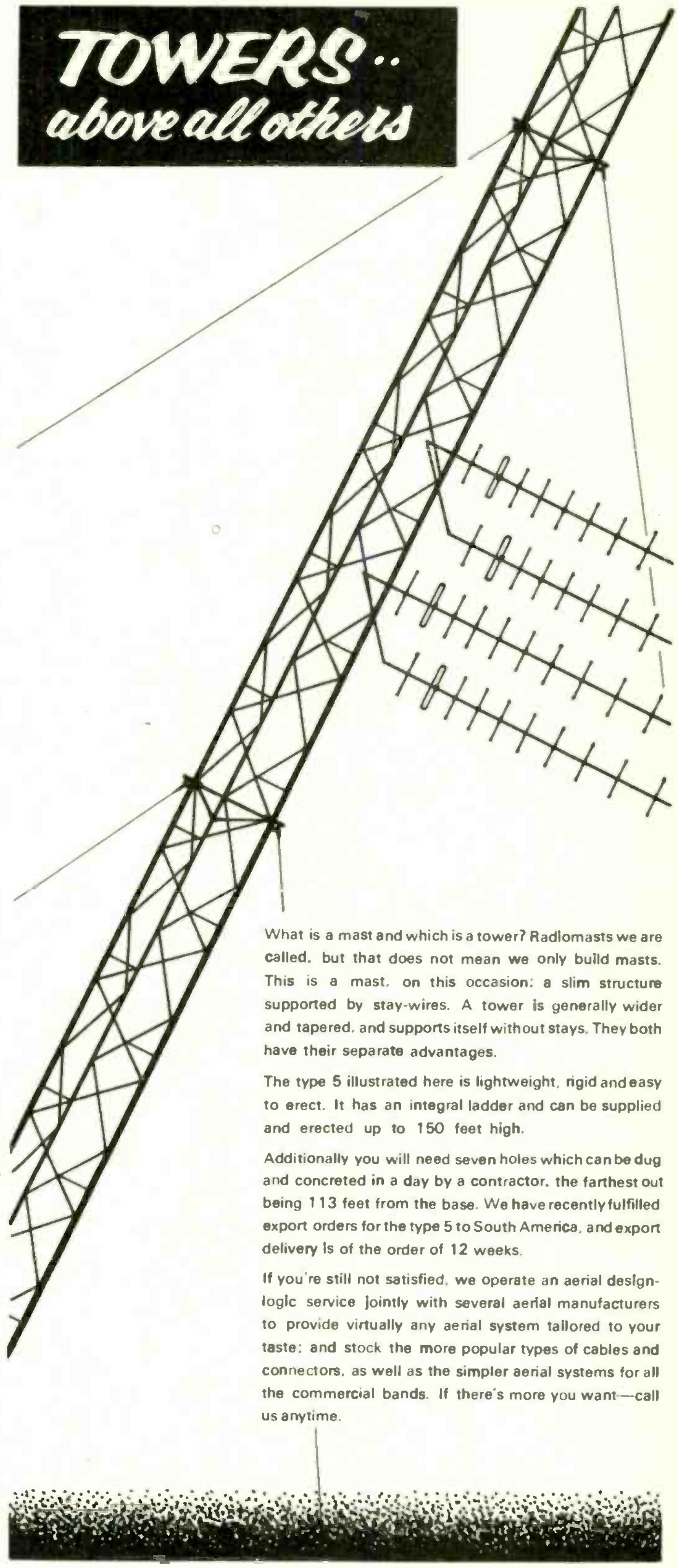

What is a mast and which is a tower? Radiomasts we are called, but that does not mean we only build masts. This is a mast, on this occasion: a slim structure supported by stay-wires. A tower is generally wider and tapered, and supports itself without stays. They both have their separate advantages.

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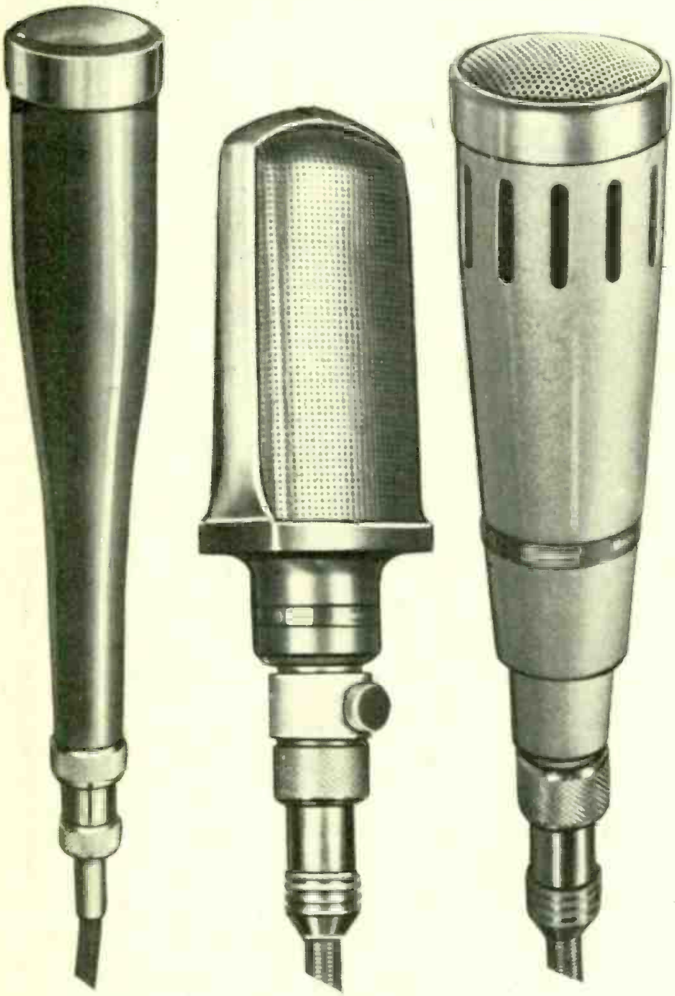

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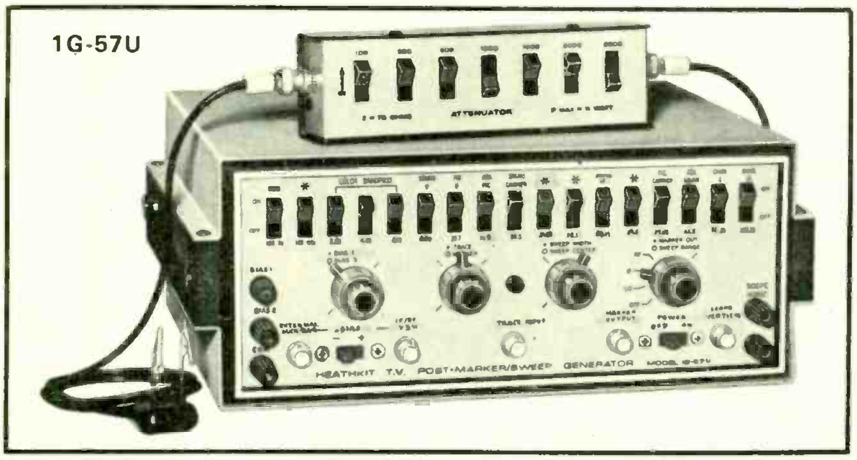
Heathkit for Instrumentation



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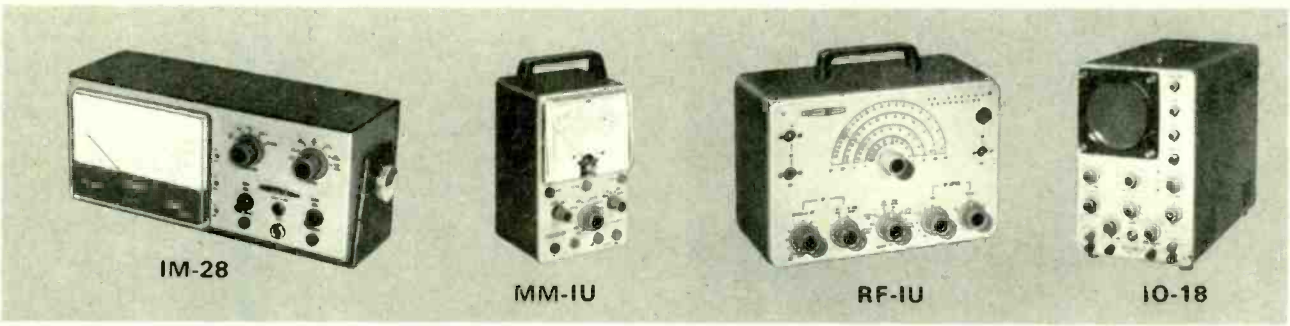

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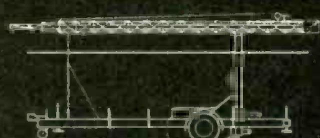

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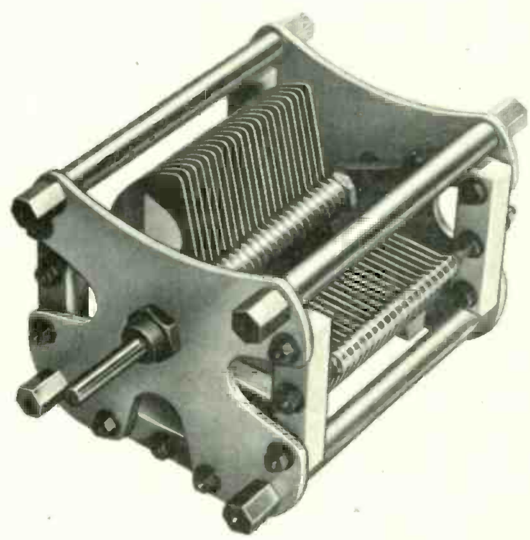

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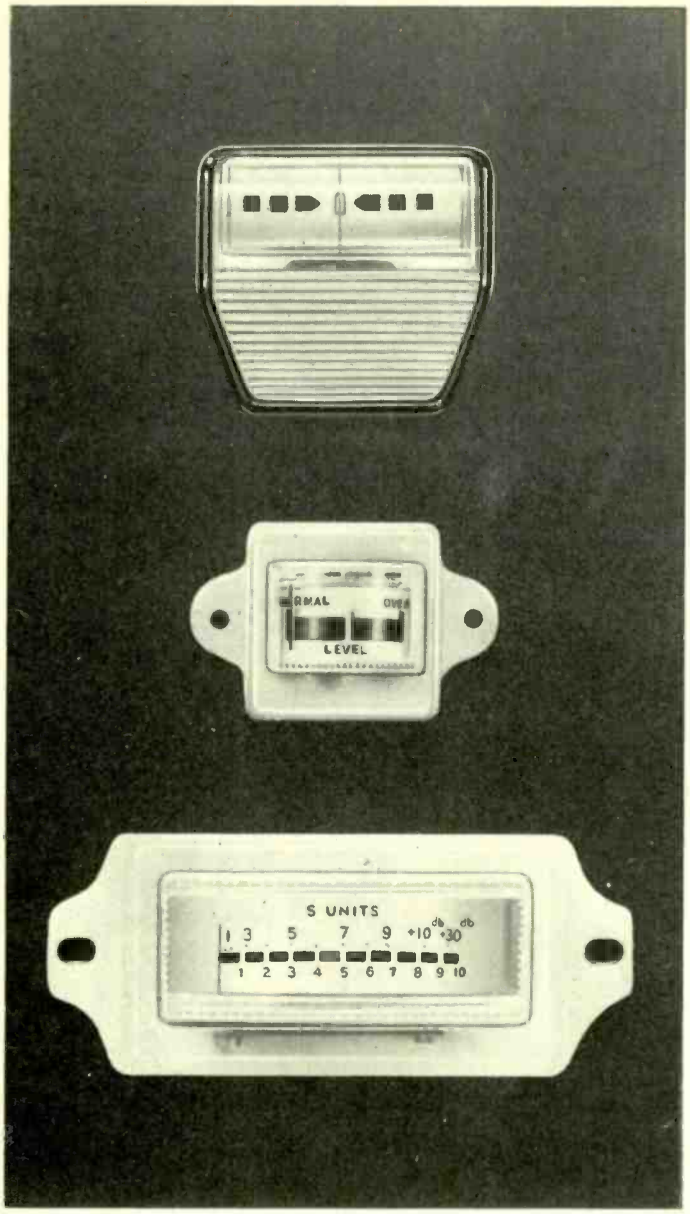

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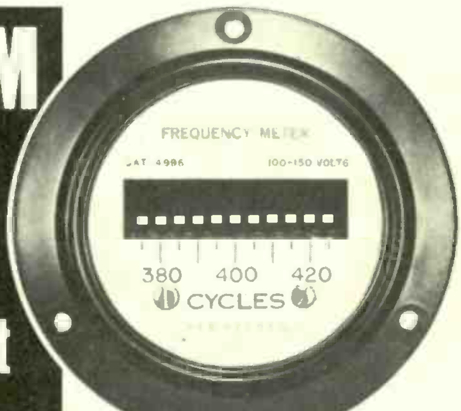

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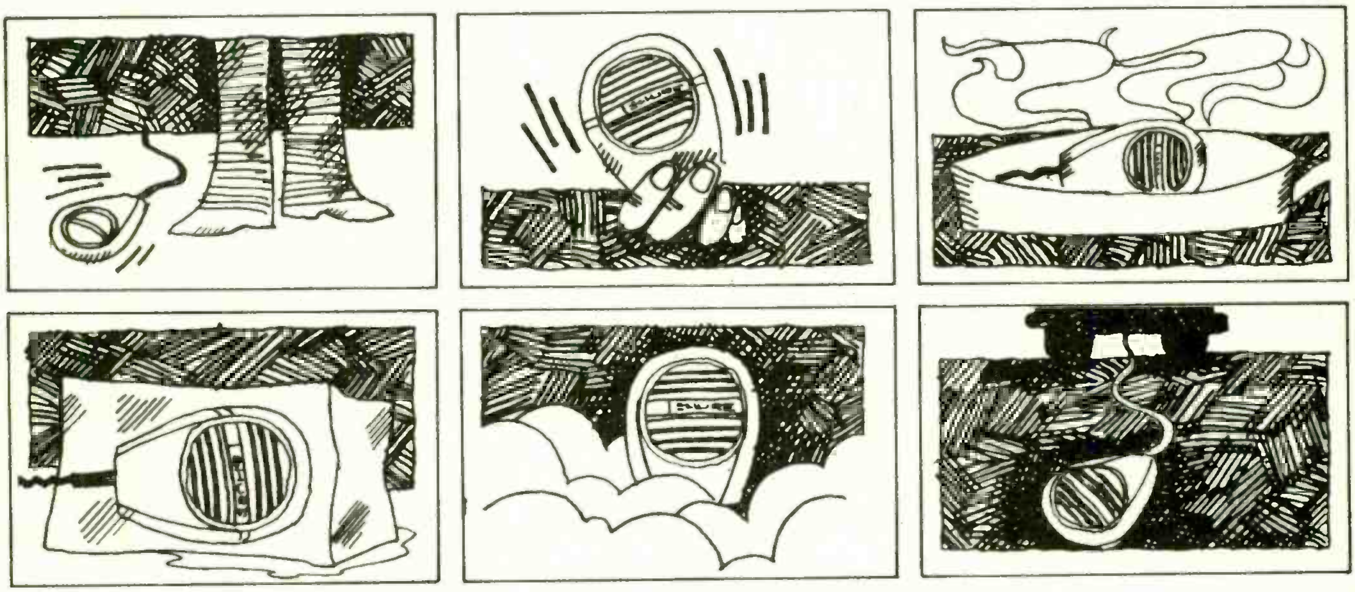

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WW4

WW—052 FOR FURTHER DETAILS

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SONEX 70
SKYWAY HOTEL
24th-26th APRIL

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.

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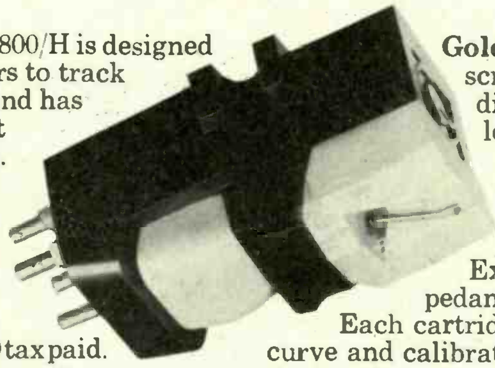

Goldring 800/H...the 800/H is designed for inexpensive changers to track between 2½—3½ grams and has a high output of at least 8mV. **£10.13.6** tax paid.

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...the 800 is designed for standard arms and changers where the requirements of high fidelity and robustness usually conflict. **£13.0.0** tax paid.

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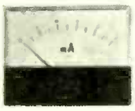


TYPE SW. 100
100 x 80 mm.

50µA	69/6	50V. D.C.	59/6
100µA	67/6	1 amp. D.C.	59/6
500µA	62/6	5 amp. D.C.	59/6
1mA	59/6	300V. A.C.	59/6
20V. D.C.	59/6		

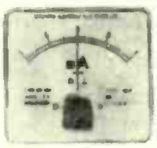
BAKELITE PANEL METERS

TYPE S-80
80 mm.
square fronts

50µA	62/6	50V. D.C.	49/6
100µA	59/6	1 amp. D.C.	49/6
500µA	52/6	5 amp. D.C.	49/6
1mA	49/6	300V. A.C.	52/6
20V. D.C.	49/6		

"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4¼in. × 4¼in. fronts.



50µA	72/-	10mA	52/-
50-0-50µA	62/-	50mA	52/-
100µA	62/-	100mA	52/-
100-0-100µA	62/-	500mA	52/-
200µA	57/6	1 amp.	52/-
500µA	55/-	5 amp.	52/-
500-0-500µA	52/-	15 amp.	52/-
1mA	52/-	30 amp.	52/-
1-0-1mA	52/-	20V. D.C.	52/-
5mA	52/-	50V. D.C.	52/-
		150V. D.C.	52/-
		300V. D.C.	52/-
		15V. A.C.	52/-
		300V. A.C.	52/-
		8 Meter 1mA	57/6
		VU meter	72/-
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50µA	62/-	10V. D.C.	40/-
50-0-50µA	52/-	20V. D.C.	40/-
100µA	52/-	50V. D.C.	40/-
100-0-100µA	47/6	300V. D.C.	40/-
500µA	45/-	15V. A.C.	40/-
1mA	40/-	300V. A.C.	40/-
5mA	40/-	8 Meter 1mA	42/-
10mA	40/-	VU Meter	62/-
50mA	40/-	1 amp. A.C.*	40/-
100mA	40/-	5 amp A.C.*	40/-
500mA	40/-	10 amp. A.C.*	40/-
1 amp.	40/-	20 amp. A.C.*	40/-
5 amp.	40/-	30 amp. A.C.*	40/-

Type MR.65P. 3½in. × 3½in. fronts.

50µA	67/6	20V. D.C.	42/-
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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
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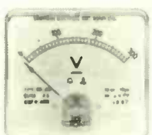
1 amp.	42/-	100mA A.C.*	42/-
5 amp.	42/-	200mA A.C.*	42/-
10 amp.	42/-	500mA A.C.*	42/-
15 amp.	42/-	1 amp. A.C.*	42/-
20 amp.	42/-	5 amp. A.C.*	42/-
30 amp.	42/-	10 amp. A.C.*	42/-
50 amp.	47/6	20 amp. A.C.*	42/-
10V. D.C.	42/-	30 amp. A.C.*	42/-

Type MR.38P. 1 21/32in. square fronts.



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50-0-50µA	37/6	200mA	27/6
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
		150V. A.C.	27/6
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200µA	37/6	300V. D.C.	30/-
500µA	32/-	15V. A.C.	30/-
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100µA	45/-	15 amp.	35/-
100-0-100µA	45/-	30 amp.	35/-
500µA	42/-	50 amp.	35/-
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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/-
100mA	35/-	300V. D.C.	35/-
		30V. A.C.*	35/-
		50V. A.C.*	35/-
		150V. A.C.*	35/-
		300V. A.C.*	35/-
		500mA A.C.*	35/-
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		10 amp. A.C.*	35/-
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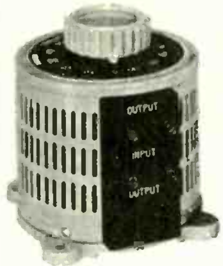

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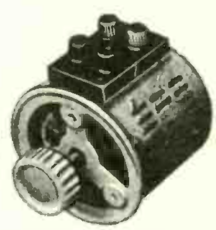

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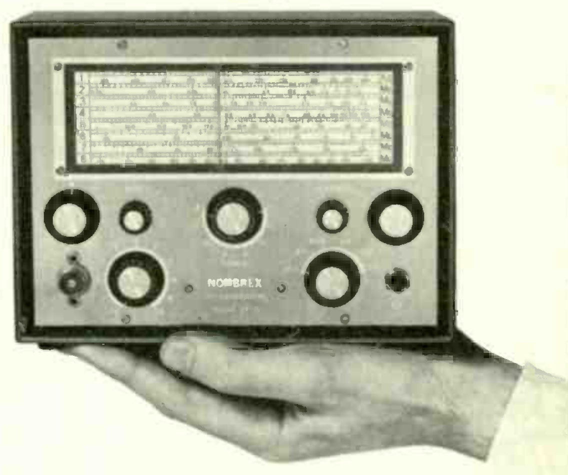

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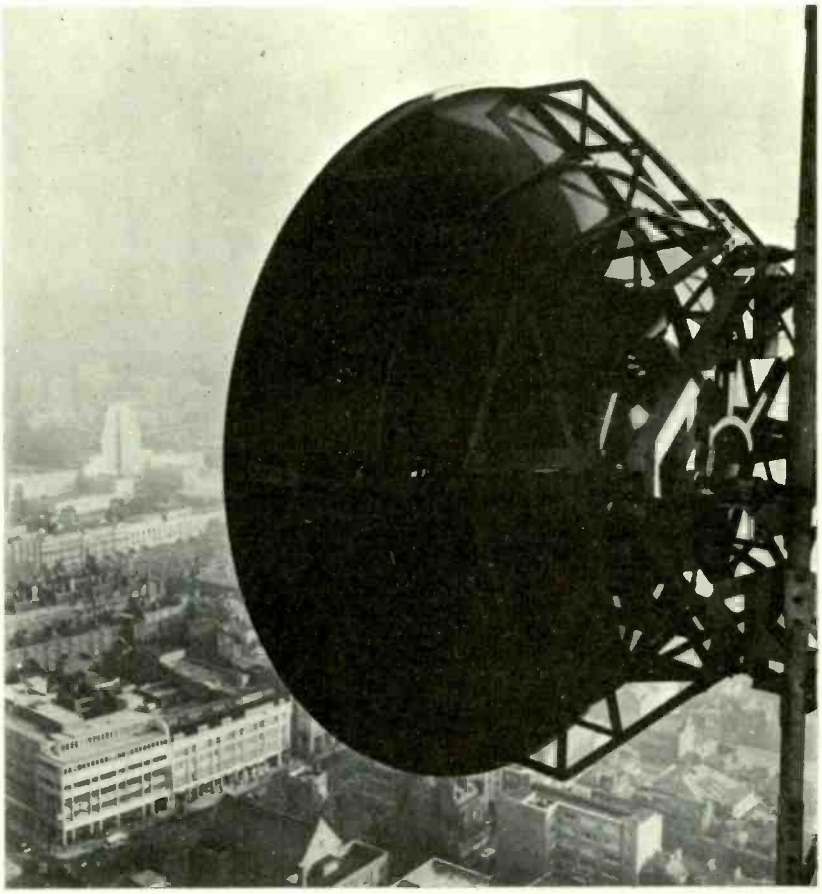

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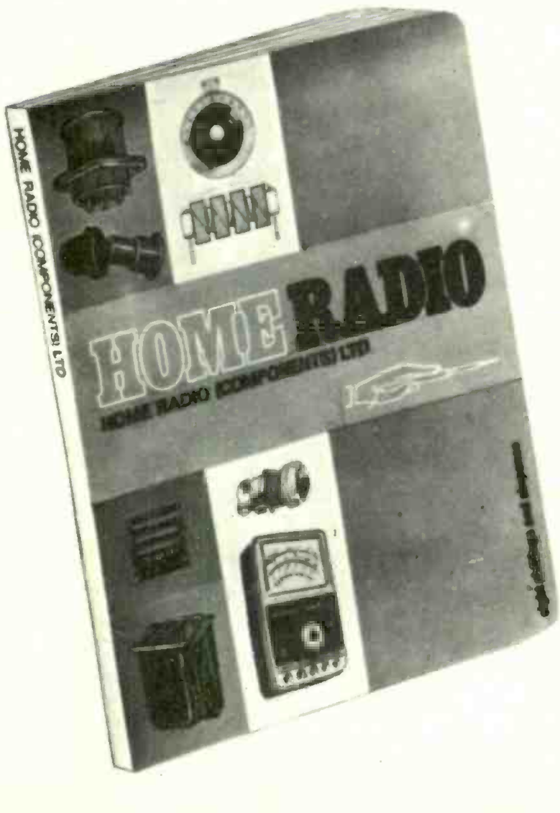

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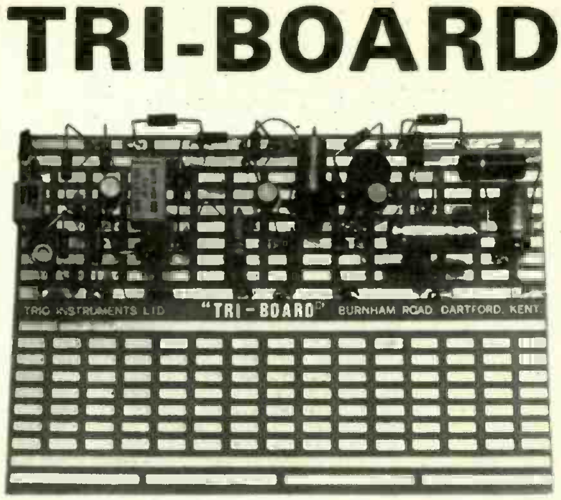
'TRI-BOARD'



The ideal "Breadboard" material for rapid construction of electronic circuits at the design and prototype stages of development programmes.

TRI-BOARD is supplied in Fibreglass which is suitable for cold punching or cutting. Board size is $7\frac{1}{2}'' \times 5\frac{3}{8}'' \times \frac{1}{16}''$ thick with 1 oz. copper
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PRICE 15/- net per board.
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(Established 1935)

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Long battery life and large overload ratings are leading features of these solid state instruments. Mains power supply units and leather carrying cases are optional extras.

Measure μV's from 1Hz to 3MHz

VOLTMETER RANGES
15μV, 50μV, 150μV . . . 500V f.s.d.
Acc. ± 1% ± 1% f.s.d. ± 1μV at 1kHz.

db RANGES
− 100dB, − 90dB, − 80dB . . . + 50dB.
Scale − 20dB/+ 6dB rel. to 1mW/600Ω.

FREQUENCY RESPONSE
Above 500μV: ± 3dB from 1Hz to 3MHz.
± 0·3dB from 4Hz to 1MHz.
Type TM3B can be set to a restricted B.W. of 10Hz to 10kHz or 100kHz.

INPUT IMPEDANCE
Above 50mV: > 4·3MΩ < 20pf.
On 50μV to50mV: >5MΩ <50pf.

AMPLIFIER OUTPUT
150mV at f.s.d. on all ranges into 200kΩ and 50pF without loss.

SIZES & WEIGHTS
TM3A: 5″ × 7″ × 5″. 5lb. 3½″ scale.
TM3B: 7″ × 10″ × 6″. 8lb. 5″ mirror scale.

type TM3A **£49** type TM3B **£63**

Measure μV's from 1Hz to 450MHz.

H.F. VOLTAGE RANGES
1mV, 3mV, 10mV . . . 3V f.s.d.
Square law scales. Acc. ± 4% of reading ± 1% of f.s.d. at 30MHz.

H.F. dB RANGES
− 50dB, − 40dB, − 30dB . . . + 20dB.
Scale − 10dB/+3dB rel. to 1mW/50Ω.

H.F. RESPONSE
± 0·7dB from 1MHz to 50MHz.
± 3dB from 300kHz to 400MHz.
± 6dB from 400MHz to 450MHz.

L.F. RANGES
As TM3 except for the omission of 15μV and 150μV ranges.

AMPLIFIER OUTPUT
As TM3 on L.F.
Square wave at 20Hz on H.F. with amplitude proportional to square of input.

SIZES & WEIGHTS
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TM6B: 7″ × 10″ × 6″. 9lb. 5″ mirror scale

type TM6A **£85** type TM6B **£99**

Measure D.C. μV's, pA's & Ω's

VOLTAGE RANGES
3μV, 10μV, 30μV . . . 1kV. Acc. ± 1% ± 1% f.s.d. ± 0·1μV. LZ & CZ scales.
Noise <0·5μV p-p on 3μV range.
Drift < 0·7μV/°C & <0·7μV/day.
Input res. > 1MΩ/μV up to 10mV, >10kMΩ on 30mV to 1V, 100MΩ above 1V.

CURRENT RANGES
3pA, 10pA, 30pA . . . 1mA (1A for TM9BP)
Acc. ± 2% ± 1% f.s.d. ± 0·3pA. LZ & CZ scales. Noise < 0·7pA p-p on 3pA. Drift <1pA/°C & < 1pA/day. Input res. 1MΩ up to 1nA, 100kΩ on 3nA to 1μA, 100Ω on 3μA to 1mA, 0·12Ω on 3mA to 1A.

RESISTANCE RANGES
3Ω, 10Ω, 30Ω . . . 1kMΩ linear. Acc. ± 1%, ± 1% f.s.d. up to 100MΩ. Test voltage 3mV at f.s.d. on Ω ranges. Test currents 1μA & 1nA on kΩ & MΩ.

RECORDER OUTPUT
1V at f.s.d. into >1kΩ on LZ ranges.

SIZES & WEIGHTS
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type TM9A **£75** type TM9B **£89** type TM9BP **£93**

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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.

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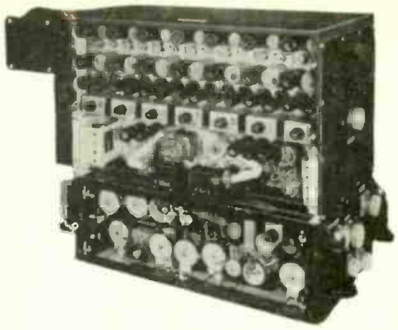
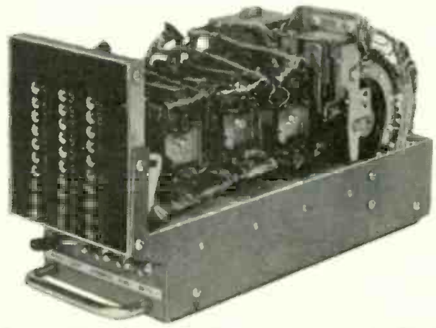


Ballistics Computers by Westinghouse. Nine servo amplifiers with associated motors and Power Packs. Brand new in sealed containers. Price on application.



Automatic Numbering Machine by Western Union. Four Uniselectors and 30 neons. Ideal basis for amateur computer. Application leaflet. £12.10s. post free.

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COMPUTER TRAINING PRODUCTS
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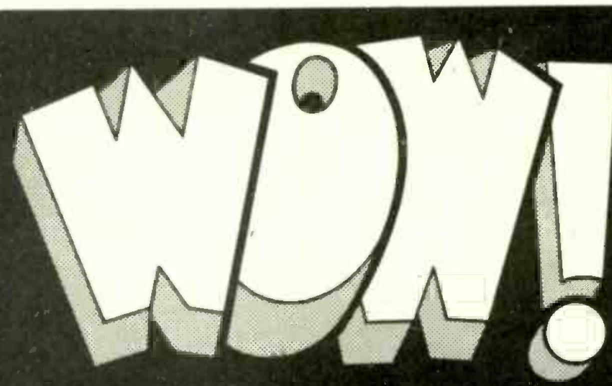

And how to stop it

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Frequency Response 30-20,000 cps—2dB.
Sensitivity 5 mv (max.)
Harmonic Distortion 0.5% at 1,000 cps.
Output for 3-8-15 ohm Loudspeakers.
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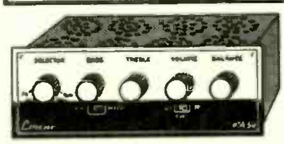
Recommended Retail price **£10**
Size 9¼ × 2¼ × 5¼ in.

If required an attractive wood cabinet with veneer finish can be supplied for any model. Prices from £3-10-0

LT66 12 WATT STEREO AMPLIFIER



A twin channel version of the LT55 providing up to 6 watts High Fidelity output on each channel.

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A-6010
Our finest 4-track stereo tape deck. Everything about it is professional.

Have you watched a TEAC demonstration yet? Have you seen (and heard) what can happen when a company of unusual capability in the magnetic tape industry decides to create some exciting new standards for the knowledgeable music lover?

The TEAC decks shown here are now available exclusively in select hi-fidelity shops throughout Europe. We think they're pretty incomparable.

Example: Model A-6010 has exclusive features like Phase Sensing automatic reverse which gives you up to four hours of uninterrupted music on a single tape. It has symmetrical soft-touch control operation for fast-winding in both tape directions, playback and stop. And it has outer-rotor motors for reel drive, four TEAC Techno-built tape heads, four solid-state amplifiers with silicon transistors, and much, much more.

The other models cost much less, but still give you TEAC's flawless performance.

In this age of tape recording ingenuity, it still might surprise you to see what TEAC is doing.

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A-1200
Medium priced tape deck with 3 heads, push-button operation, professional performance specifications. 2-track available as special order.

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4-head, 4-track stereo recorder with symmetrical control operation, 4 solid-state amplifiers, automatic reverse.

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Gramophone Record Maintenance and Stylus Cleaning Kit

Designed for use on NEW records or records in new condition which are to be played with pick-ups requiring very low tracking pressures. The 30,000 finely pointed tips of the Hi-Fi Parastat Brush positively explore every detail in the record groove to provide the high degree of record cleanliness necessary when using ultra lightweight pick-ups tracking at 2 grammes or less. The cover pad in the lid of the case is provided for the purpose of cleaning and activating the brush which when enclosed within the case is kept at the correct level of humidity required to control all static at the working surface. Perfectly clean records must be played with a perfectly clean stylus and an integral part of the kit is the new Watts Stylus Cleaner which provides a safe and efficient method of cleaning the stylus.

Supplied complete with instructions, 1 oz. New Formula dispenser, Distilled Water dispenser, spare pad cover and ribbons. Price 42/6 plus 1/3 P.T.

Replacements: 1 oz. New Formula dispenser 4/6 Distilled Water Dispenser 4/– Pad Cover and Ribbons 1/9.

STYLUS CLEANER

Available separately complete with instructions.

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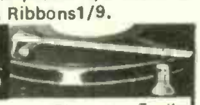
The original 'DUST BUG' Regd. (Patent No. 817598)



Automatic Record Cleaner. Easily fitted to any transcription type turntable. Provides a simple and effective method of removing static and dust while the record is being played. Surface noise and record and stylus wear is reduced, resulting in cleaner reproduction. Complete with ½ oz. New Formula Dispenser and instructions. **Price 18/9 plus 4/5 P.T.**

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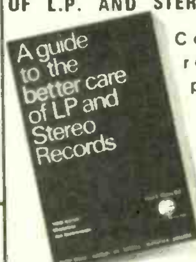
A GUIDE TO THE BETTER CARE OF L.P. AND STEREO RECORDS



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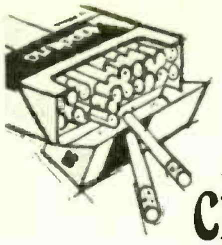
.........Manual Parastat/Humid Mop @ 52/6 ....
Spares as per attached list.
I enclose cheque/P.O. value £.............. *(Do not send postage stamps)*
Name ....
Address ....



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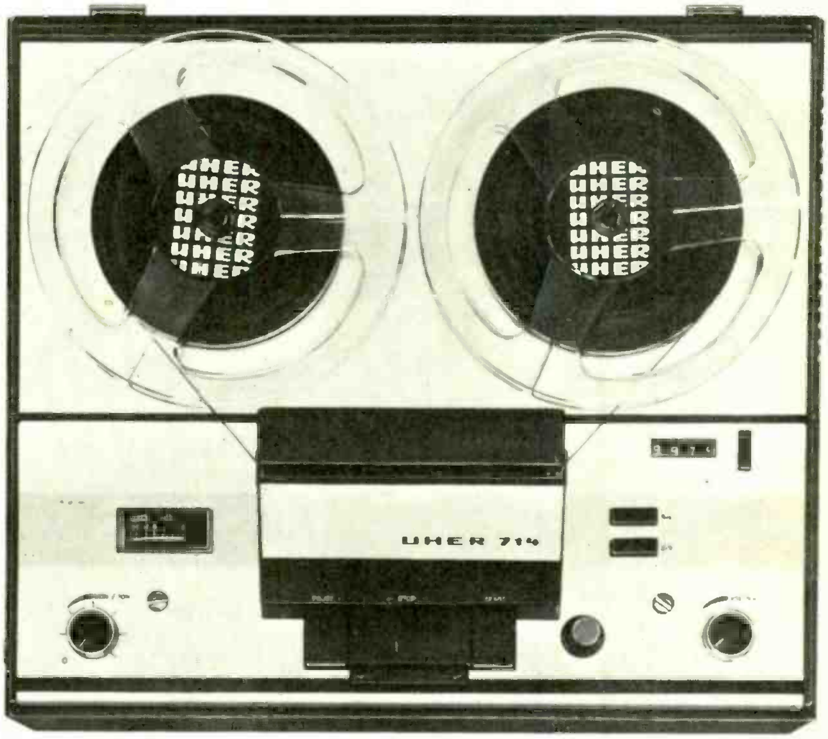
..the Uher 714 for less than £60



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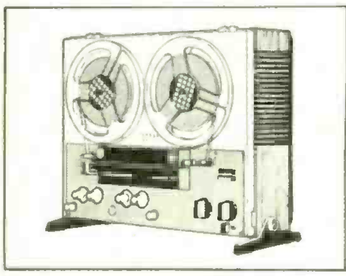
- Plays back stereo tapes
- Monitoring during recording
- Solid pressure-cast frame
- Silicon transistors
- Recording Level Instrument with dB scale
- Simple operation
- Light · Robust · Portable

The Uher 714 outclasses everything in its class.



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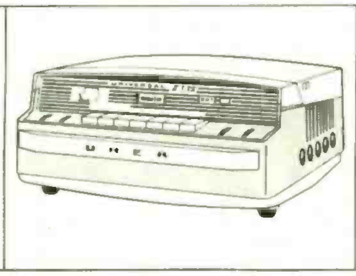

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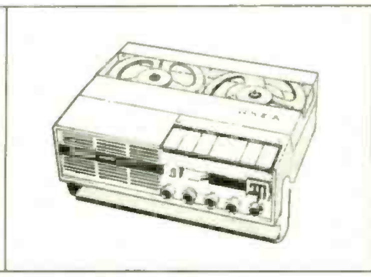

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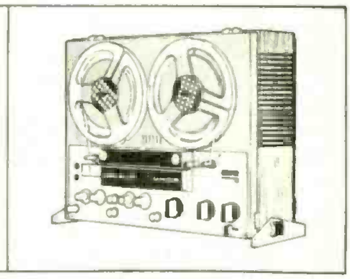

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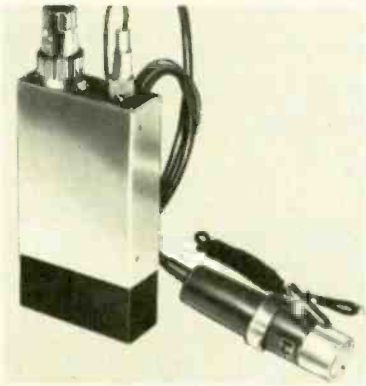
radio microphone systems

system R.M.S.5



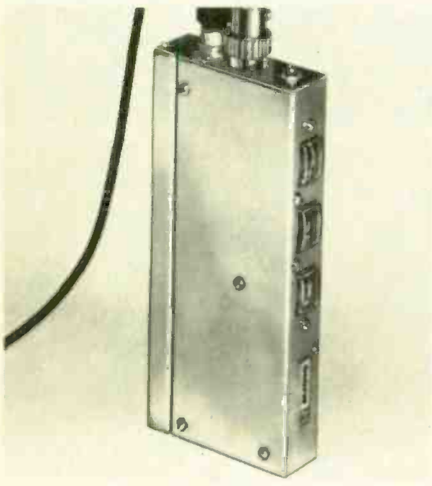
The **AUDIO** radio-microphone system R.M.S.5 meets the most stringent requirements for compactness, reliability and quality. It is extensively used in film, broadcast and television productions including those of the B.B.C and I.T.V companies. It is also the preferred choice in many fields of professional entertainment and has industrial and educational applications as well. As an alternative to the tiny transmitter, usually secreted about the person of the user, a complete hand-held microphone is now available with the transmitter contained within the tubular handle. Performance characteristics are the same for either version.

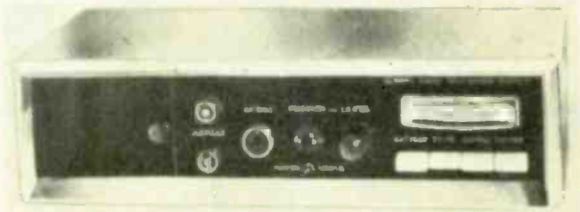
ABRIDGED SPECIFICATIONS

Frequency range from 50MHz to 175MHz, crystal controlled, with ±75KHz deviation. Power output from 1mW to 20mW. Stability ±10KHz at 175MHz from 0°C to 40°C, and correspondingly better at lower Hz. Hand-held model R.M.S.5H with microphone incorporates on/off switch and battery compartment.

NARROW BAND VERSION—The Post Office allows use of two wide band channels, or where speech quality is not important, five narrow band channels. A narrow band version of R.M.S.5 can be supplied accordingly.

RECEIVER. This is a crystal controlled superheterodyne with characteristics to suit the transmitter. A carrier/battery voltage indicator is incorporated.





system R.M.S.7

A fully professional assembly in which exceptionally high standards of quality are maintained within unusually small units of equipment. The receiver is not very much larger than the transmitter. The receiver, shown to the left, is fitted with a flexible plug-in "whip" aerial and includes separate battery, signal level and tuning indicators. The transmitter is as that for R.M.S.5 except that effective audio compression is incorporated. Audio response is ±2dB from 30-15,000Hz over the entire system. System R.M.S.9 uses the same transmitter as R.M.S.7 but has a larger receiver with push button controls and monitoring facilities for headphones.

In addition to the programme detailed above, AUDIO LIMITED have under development a 470MHz radio-microphone for TV use overseas, a half-watt radio-microphone for outside broadcasts, a 4 watt transmitter for radio-microphone links, and studio talk-back systems. Enquiries invited.

audio

AUDIO LIMITED, 46 PENTONVILLE ROAD, LONDON, N.1 **Telephone: 01-278 1020**

Wireless World

Electronics, Television, Radio, Audio

Sixtieth year of publication **April 1970** **Volume 76 Number 1414**

This month's cover illustration shows an unusual view of a watchmaker's wheel adopted by Pye to aid the handling of components in the production of small receivers (see p.158).

Contents

IN OUR NEXT ISSUE

Simple high-quality pre-amplifier, having a high input impedance, suitable for radio and ceramic gramophone pickups.

Low-cost horn loudspeaker system

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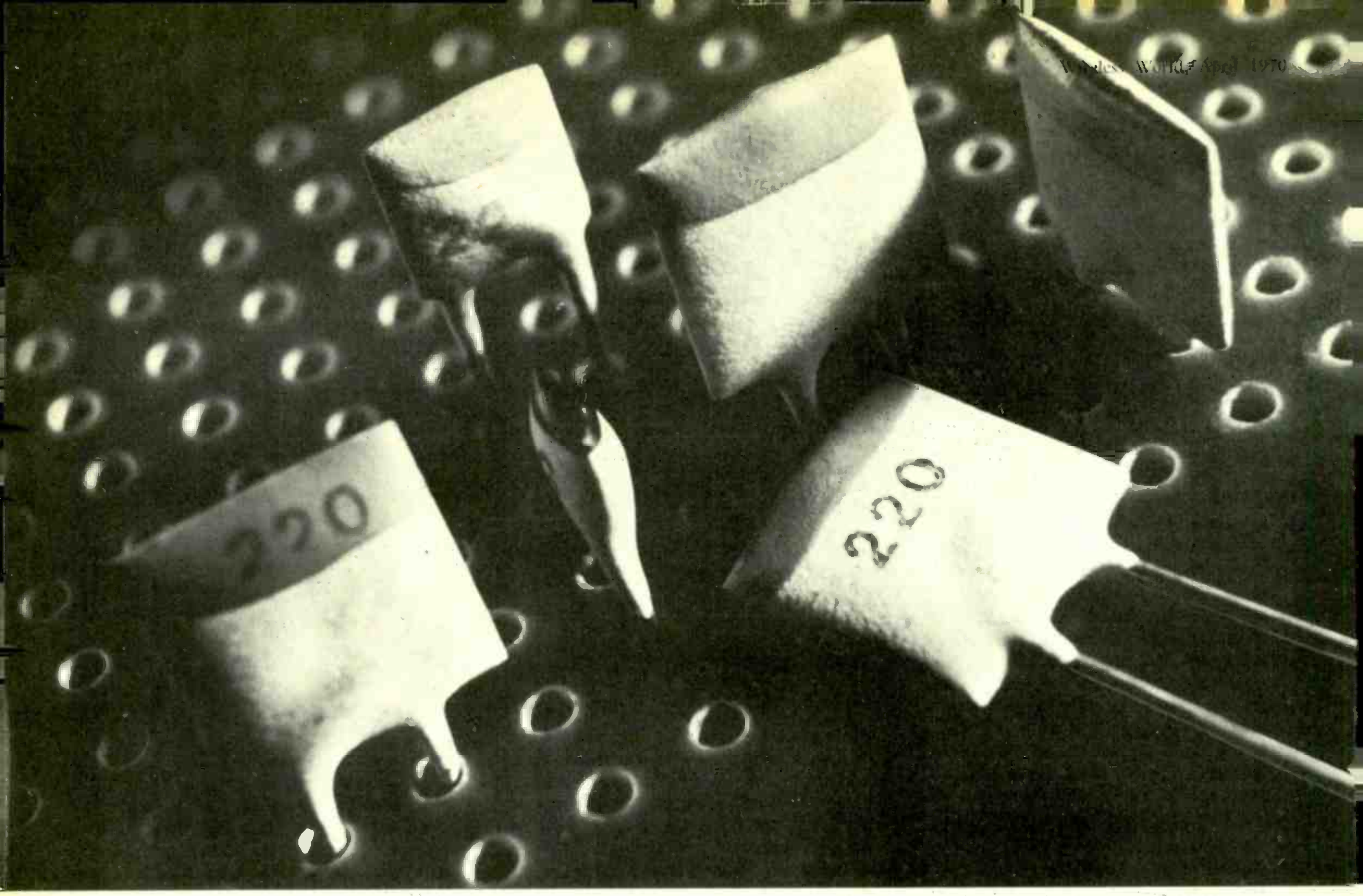

Why we are excited about the C333 range

In these fast-moving days you might wonder why we're excited about a new capacitor range. Well, sales figures tell us that a lot of circuit designers are also enthusiastic about this—the latest Mullard range of miniature plate ceramic capacitors. Setmakers have already ordered them by the million. And, as for us, we were excited about this new range long before we even sold the first one. In case you are not already using these plate ceramic miniature capacitors, let us tell you (enthusiastically) something about them.

They're small. Well, of course. This is the mini age. Naturally, we designed them to fit a 2.45 mm. grid printed circuit board. But we also made them rectangular and thin (2.1 mm. max.). In fact they are no bigger than the winder on your wrist-watch, so that they can pack very closely.

Wide range. This is something to be enthusiastic about. For the first time, circuit designers have available a wide range of low-cost, high stability, close tolerance miniatures to choose from—at low prices. The full range (at present) has 28 values in five sizes from 1.8pF to 330pF (the E6 range). With temperature coefficients between NP0 and N750 the stability of tuned circuits can be maintained over a wide temperature range—this is the C333 series.

High quality: low cost. These two conflicting objectives provided their own solution. In the first place we chose the most suitable materials for the performance and stability we required. Then we developed special, highly-automated processes to produce these tiny components within the rigid specifications we had laid down. These very efficient processes gave us the desired results; closely-controlled quality and low production costs.

Stability. This is essential for the applications for which these capacitors are intended. We developed materials which would not oxidise or peel in arduous conditions. And a special lacquer coating to protect them in conditions of high humidity. In brief, we designed in high stability and long life.

Tight tolerance. Again, the use of very stable materials and highly automated manufacturing and quality control equipment ensures that every capacitor is held within very close limits—essential for the components used in oscillator and filter stages. The tolerance on every capacitor is within 0.25pF or ±2%—whichever is the greater.

Worth it? Our rising production figures indicate that a good many people think so.

Set designers appreciate that, at Mullard we continue to apply enthusiasm and care to the manufacture of all our devices—discrete components, valves and tubes, and semiconductors. And we continue to produce exciting results.

Materials research, applications research, automated quality production and control—all backed by experience in component manufacture stretching over the history of the electronics industry. All contributed to the quality and performance of this our latest range of capacitors.

Mullard

components for consumer electronics

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Consumer Electronics Division,
Mullard House, Torrington Place,
London, WC1

CED98

The professional one

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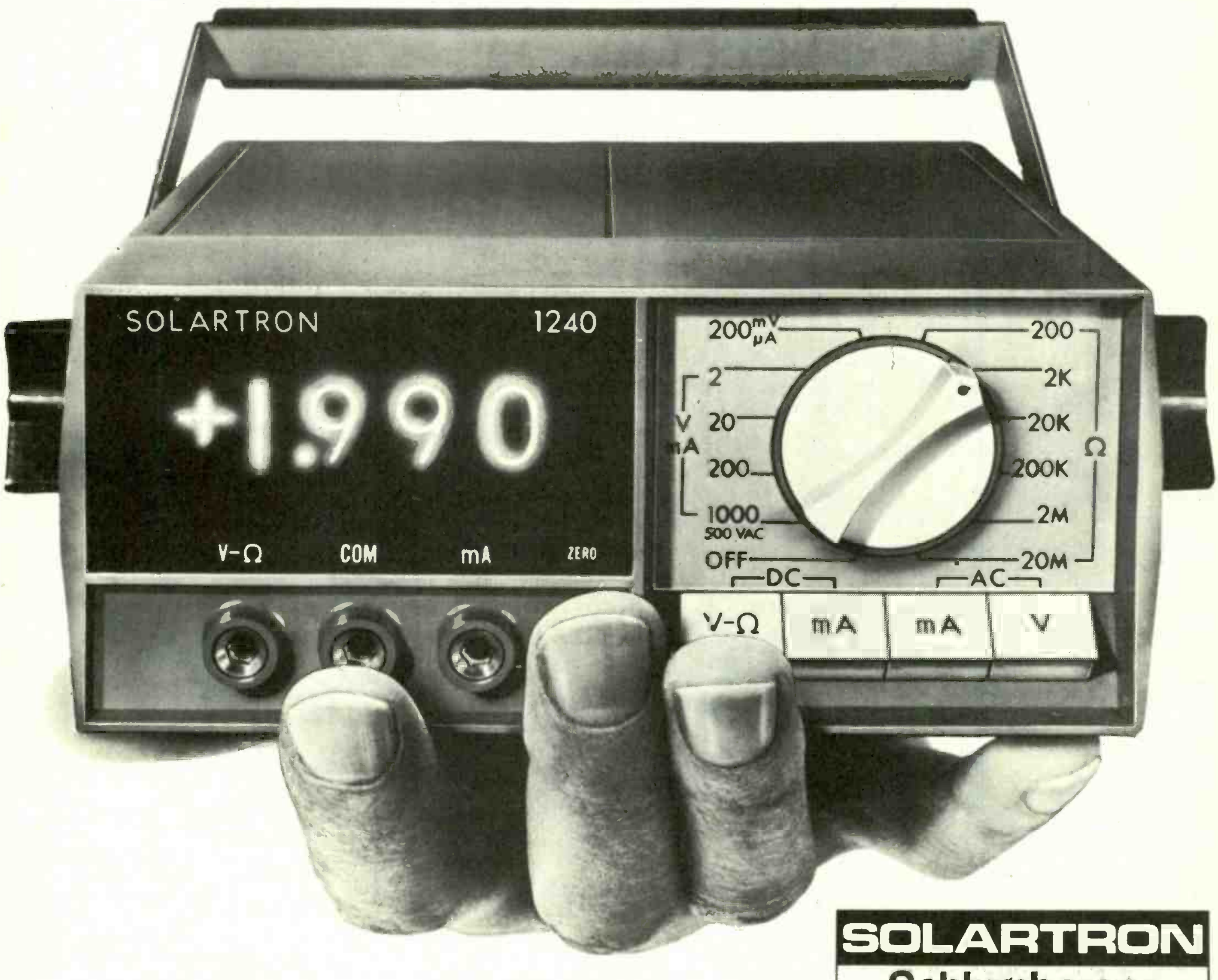
Technology apart, the 1240 has automatic polarity indication and a straightforward control layout including a single range selector and fingertip function switches. It's the easy-to-handle go-anywhere portable multimeter.

Go digital with the new 1240. From Solartron, European leaders in digital instrumentation.

Post the magazine's reply-paid card and we'll send you our data sheet of full details.



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WW—096 FOR FURTHER DETAILS

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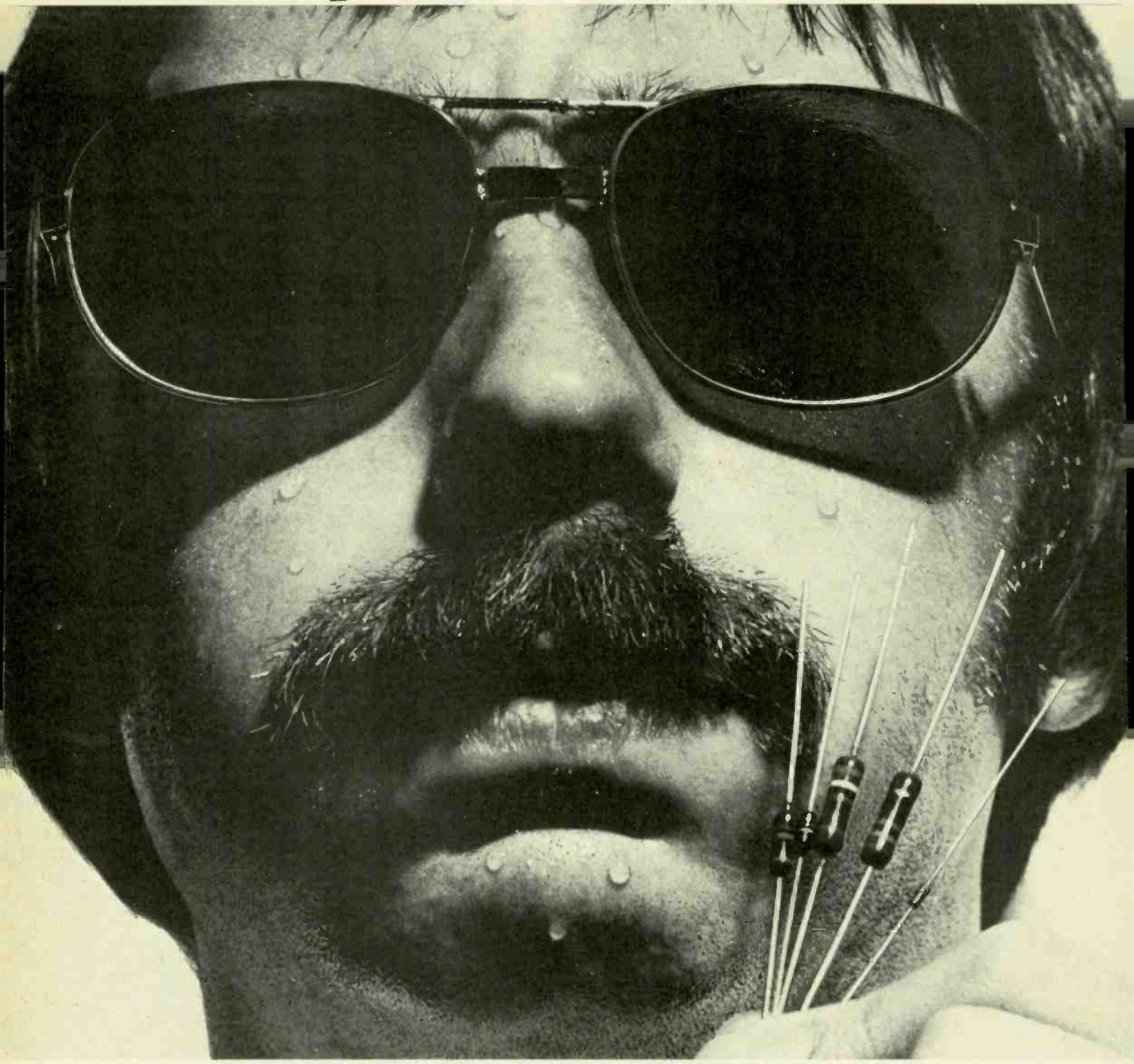

Just be faithful to Electrosil resistors and they'll be constant, too! Because we demand consistent performance from them before we'll let you have them. Maybe they're in aircraft flying at 50,000 ft. which later land in equatorial heat. Maybe they're in Antarctic equipment. They're indifferent. They've already had, from us, as savage thermal jolts as they're ever likely to get. They're glass-tin-oxide, of course, so you expect a much higher degree of stability and dependability.

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ELR13

Electrosil LIMITED have the experience

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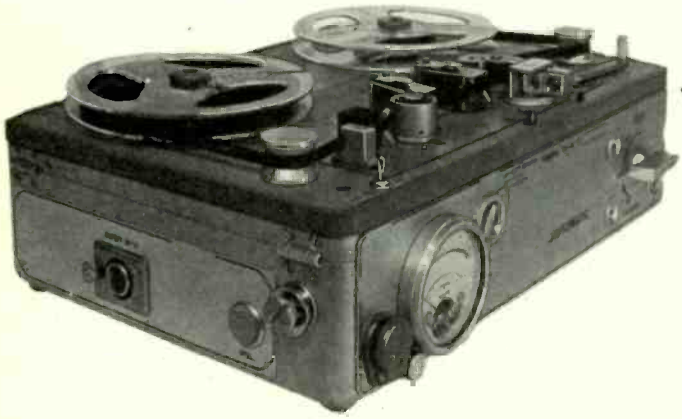
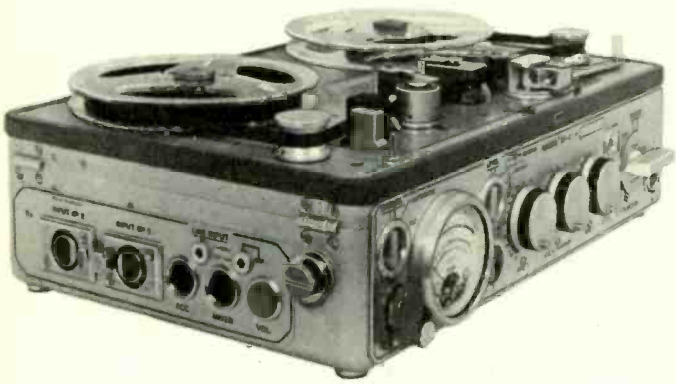
NAGRA IV

The world's best portable professional audio tape recorder



MODEL IVA Automatic, single speed

MODEL IVB Manual, single speed



MODEL IVD Automatic/Manual, three speeds

MODEL IVL Neopilot, three speeds, Automatic/Manual

* *Lids of transparent, shock resistant plastic, have been removed for clarity of illustration.*

These models plus eight variants give the professional user a choice of twelve basic Nagra IV tape recorders. Modular plug-in electronic circuit boards, available for each machine, allow unique flexibility in the choice of recording functions.

Study the Nagra IV brochure and see how you can select precisely the facilities you need, built in to one compact machine of outstanding performance and reliability.

Write or telephone for technical information.

HAYDEN LABORATORIES LIMITED,

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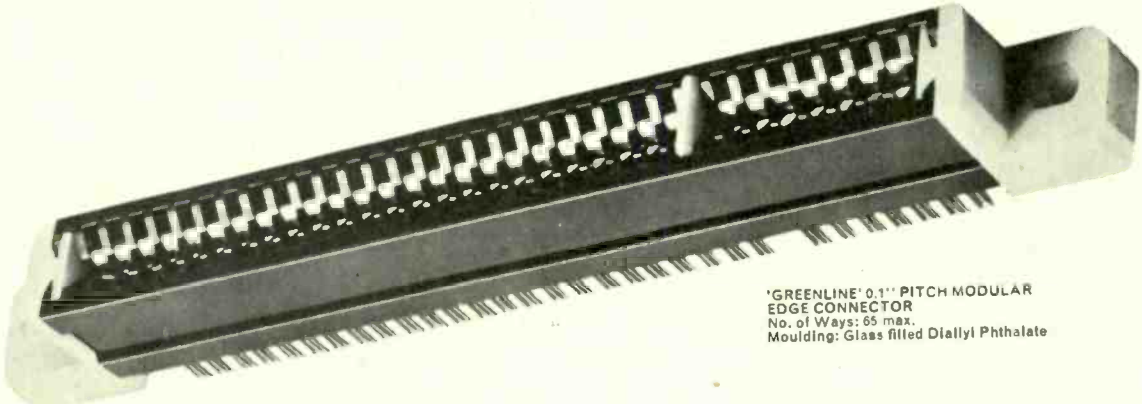
WW—099 FOR FURTHER DETAILS

the Pacemaker

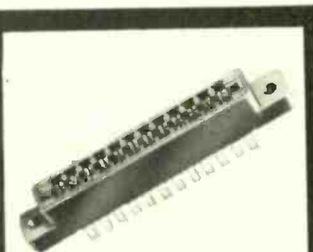


'GREENLINE' 0.1'' PITCH MODULAR EDGE CONNECTOR
No. of Ways: 65 max.
Moulding: Glass filled Diallyl Phthalate

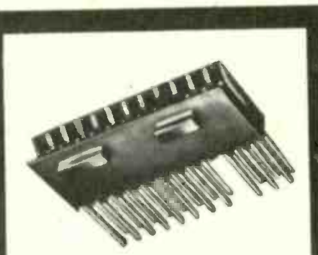
in optimum-reliability electronic components

In the continually-evolving technology of the electronics industry, Carr design and research keep pace with, and often ahead of, the ever-changing demands for increasingly sophisticated components.

But whilst designs may change from week to week, Carr quality and reliability remain constant, ensuring that complex high-precision specifications are met with absolute and consistent accuracy.

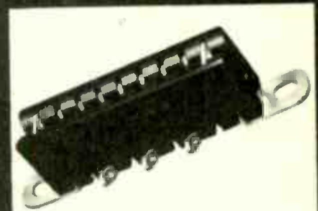


'GREENLINE' 0.150'' PITCH MOULDED EDGE CONNECTOR
No. of Ways: 4, 8, 12, 16, 24, 32 and 40.
Moulding: Glass filled Diallyl Phthalate

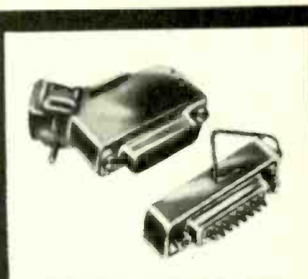


REED ELECTRONIC EXCHANGE CONNECTOR Mk.10 0.2'' PITCH
No. of Ways: 12+12 and 18+18
Moulding: Glass filled Polycarbonate

The connectors illustrated here are typical examples from our ranges. We have, of course, many other components of special interest to the computer and communications industries, with rapid, reliable deliveries in bulk quantities assured. Ask for data, or for a visit from one of our Technical Sales Staff. The application of his wide experience to your problems can help you towards easier, more advanced assembly techniques, with the collateral benefits of worthwhile savings on time and costs.



PERMACON MOULDED EDGE CONNECTOR. Maximum No. of Contact Positions and Pitches:
40 for 0.100'' Pitch 20 for 0.200'' Pitch
26 for 0.150'' Pitch
Moulding: Polypropylene



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No. of Ways: 9, 15, 25, 37 and 50
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And in addition to this, an unparalleled capability in chemistry, electron optics and vacuum physics enables Brimar 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.

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Want to know more about BRIMAR Industrial Cathode Ray Tubes? - ask to see our latest catalogue.

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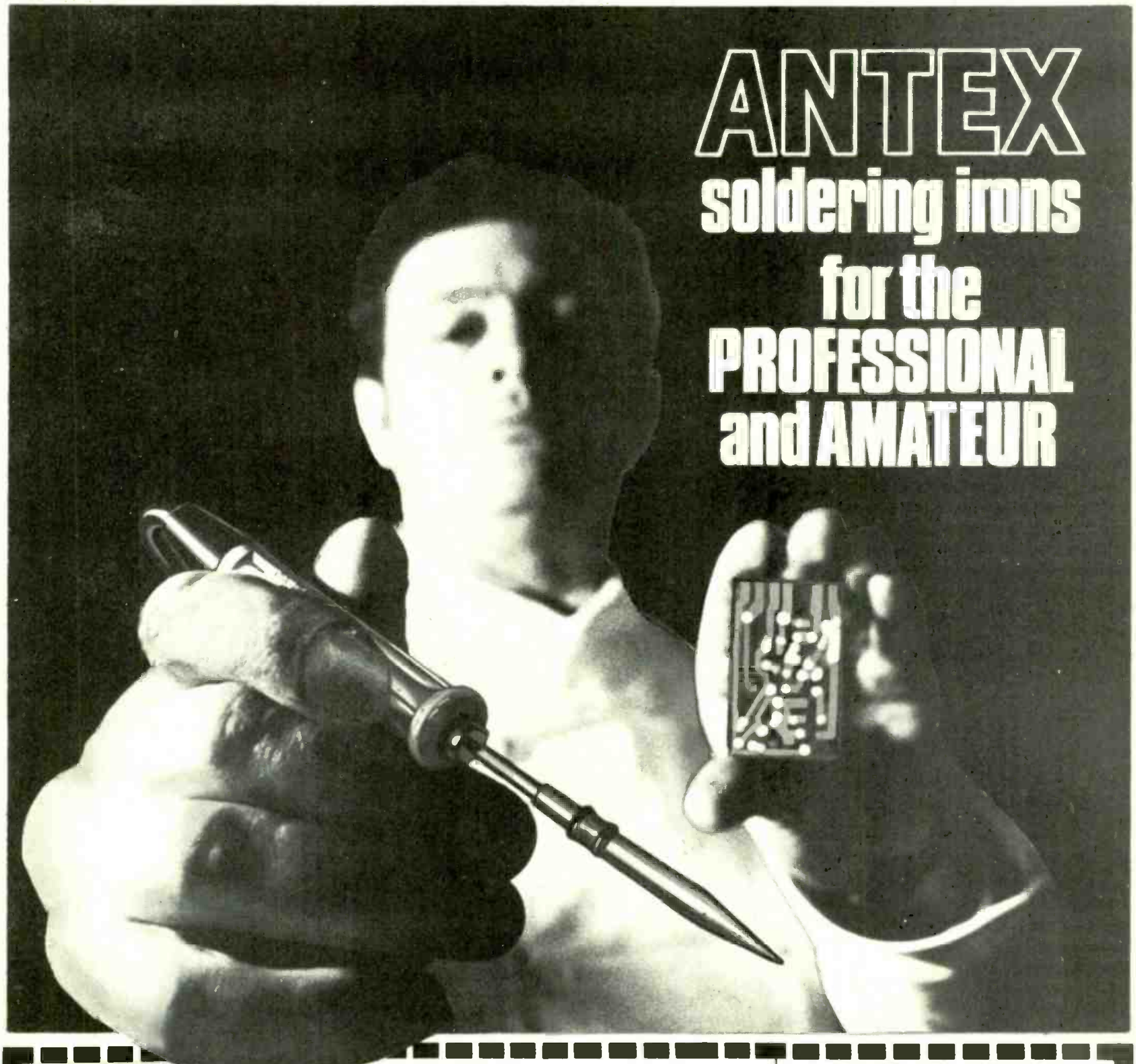
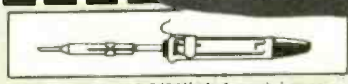
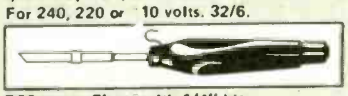




G 18 watts. Fitted 3/32" bit for miniature work on production lines. Interchangeable spare bits, 1/8", 3/16" and 1/4" available. For 240, 220 or 110 volts. 32/6.



E 20 watts. Fitted with 1/4" bit. Interchangeable spare bits 3/32", 1/8", 3/16" available. For 240, 220, 110 volts. From 35/-

ES 25 watts. Fitted with 1/8" bit. Interchangeable bits 3/32", 3/16" and 1/4" available. Ideal for high speed production lines. For 240, 220, 110, 24 or 12 volts. From 35/-

F 40 watts. Fitted 5/16" bit. Interchangeable bits 1/4", 3/16", 1/8", 3/32" available. Very high temperature iron. For 240, 220, 110, 24 or 20 volts. From 42/6

Spare bits and elements for all models and voltages immediately available from stock.

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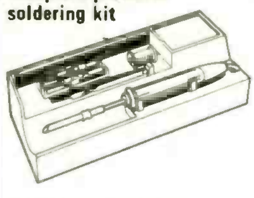

This kit—in a rigid plastic "tool-box" — contains

- Model CN 15 watts miniature iron, fitted [illegible] bit. Interchangeable spare bits [illegible].
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- Felt cleaning pad
- Stand for soldering iron

PLUS 36-page booklet on "How-to-Solder"—a mine of information for amateur and professional.

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15 watts - 240 volts

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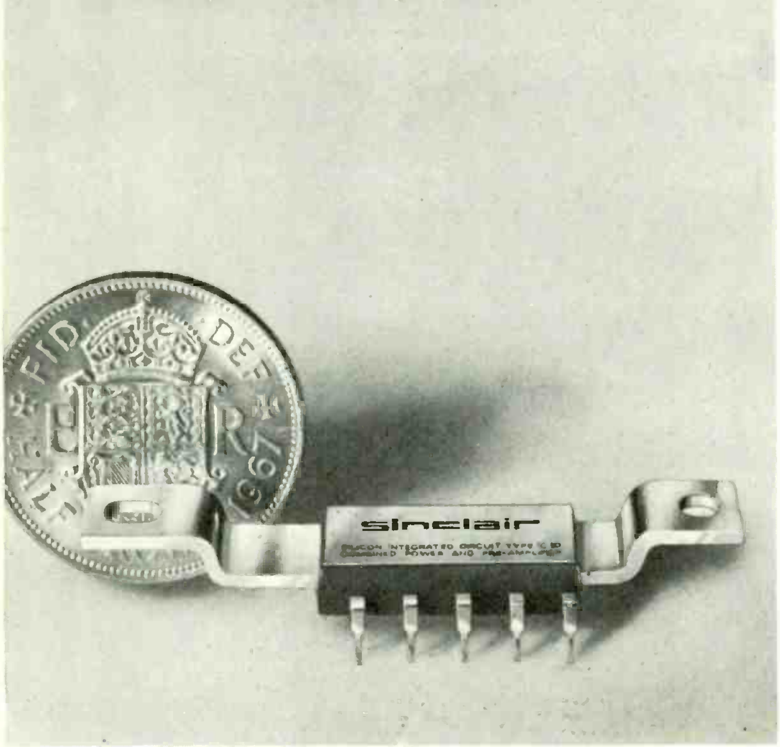
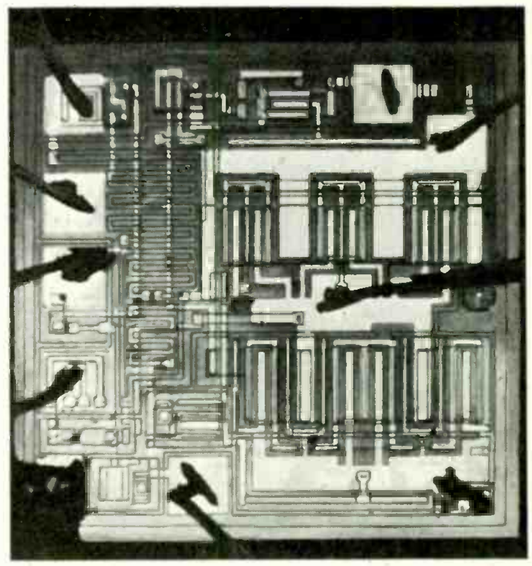
SINCLAIR IC-10



MONOLITHIC INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMP



A 13 transistor circuit measuring only one twentieth of an inch square by one hundredth of an inch thick!

the world's most advanced high fidelity amplifier

The Sinclair IC-10 is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself, a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, has 5 watts R.M.S. output (10w. peak). It contains 13 transistors (including two power types), 2 diodes, 1 zener diode and 18 resistors, formed simultaneously in the silicon by a series of diffusions. The chip is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is not only more rugged and reliable than any previous amplifier, it also has considerable performance advantages. The most important are complete freedom from thermal runaway due to the close thermal coupling between the output transistors and the bias diodes and very low level of distortion.

The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout), etc. Once proven, the circuits can be produced with complete uniformity which enables us to give a full guarantee on every IC-10, knowing that every unit will work as perfectly as the original and do so for a lifetime.

MORE SINCLAIR DESIGNS ON PAGES FOLLOWING

■ SPECIFICATIONS

Output:	10 Watts peak. 5 Watts R.M.S. continuous
Frequency response:	5 Hz to 100 KHz ± 1dB
Total harmonic distortion:	Less than 1% at full output.
Load impedance:	3 to 15 ohms.
Power gain:	110dB (100,000,000,000 times) total.
Supply voltage:	8 to 18 volts.
Size:	1 x 0.4 x 0.2 inches.
Sensitivity:	5mV.
Input impedance:	Adjustable externally up to 2.5 M ohms.

■ CIRCUIT DESCRIPTION

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from cross-over distortion at all supply voltages, making battery operation eminently satisfactory.

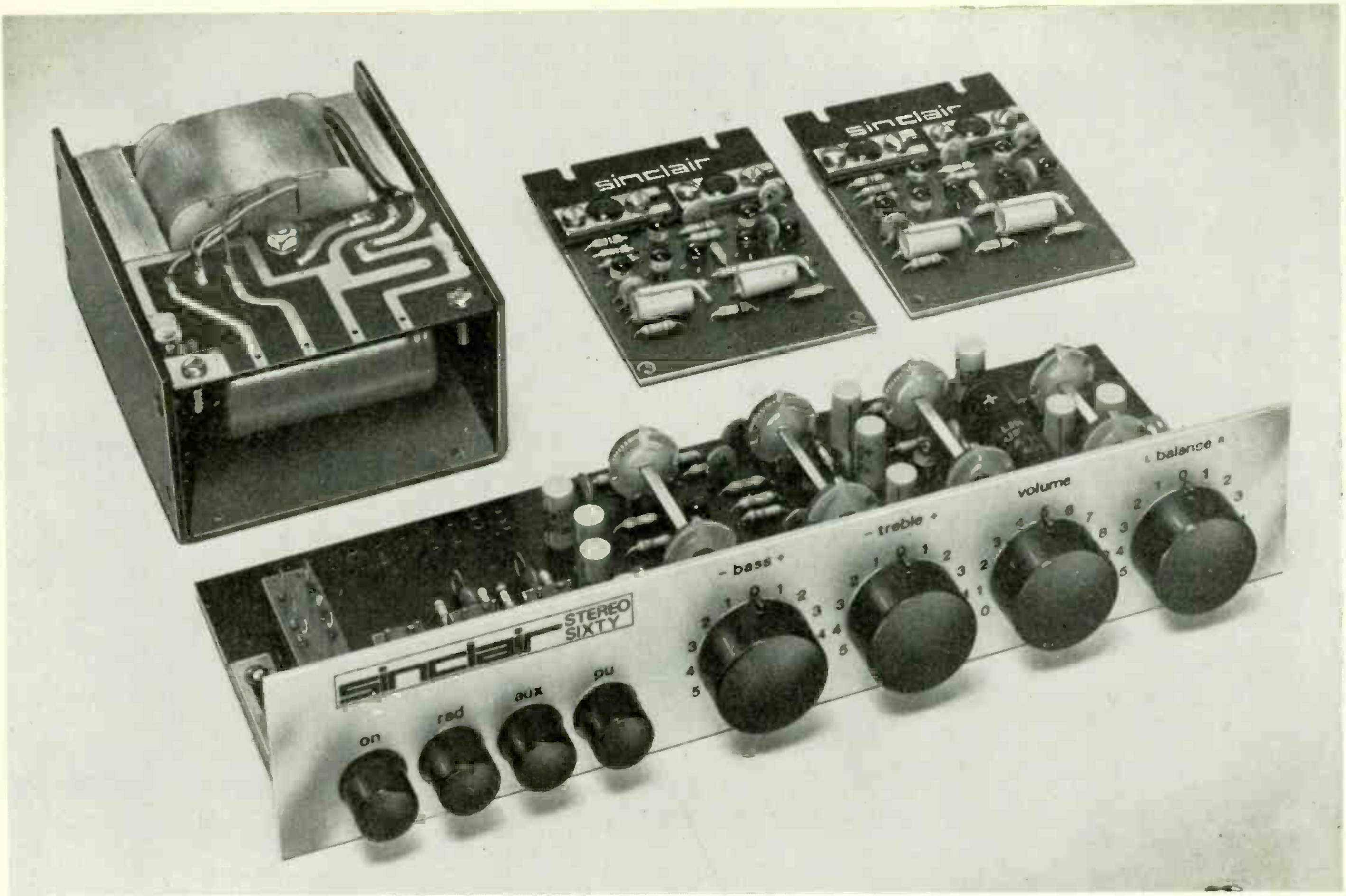
■ APPLICATIONS

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

SINCLAIR
IC-10 *with IC-10 manual Post free.* **59/6**

sinclair

SINCLAIR RADIONICS LTD. 22 NEWMARKET ROAD, CAMBRIDGE
Telephone: 0223 52731



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

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.

SPECIFICATIONS

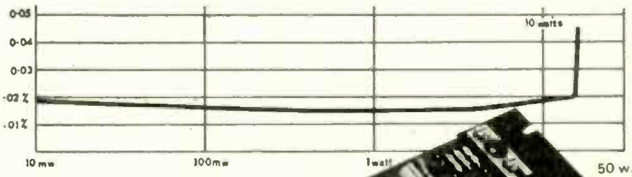
Power output—15 watts R.M.S. (30 watts peak) into 8 ohms using a 35 volt supply: 20 watts R.M.S. (40 watts peak) into 3 ohms using a 30 volt supply.

Output—Class AB.

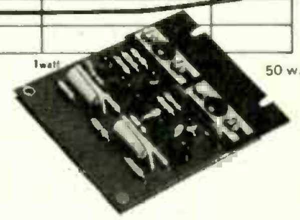
Frequency response: 30 to 300,000 Hz ± 1dB.
Signal to noise ratio: better than 70dB unweighted.
Distortion: 0.02% total harmonic distortion at full output into 8 ohms and at all lower output levels.
Size: 3½ x 2¼ x ½ inches.
Input sensitivity: 250mV into 100 Kohms.
Damping Factor: >500.
Loudspeaker impedances 3 to 15 ohms.
Power requirements: 8 to 35 V.d.c.

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.



Z.30

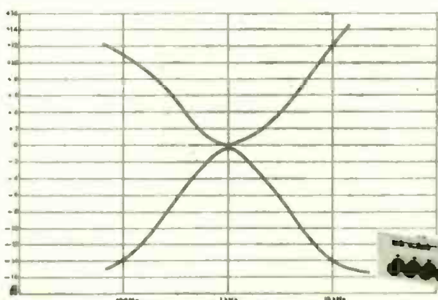
Ready built, tested and guaranteed, with Z.30 manual. **89/6**

STEREO SIXTY PREAMPLIFIER AND CONTROL UNIT

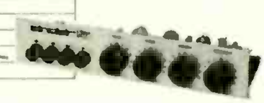
The Stereo 60 is a stereo preamplifier and control unit designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout and great attention has been paid to achieving a really high signal-to-noise ratio and excellent 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.

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—250 mV.
- 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.



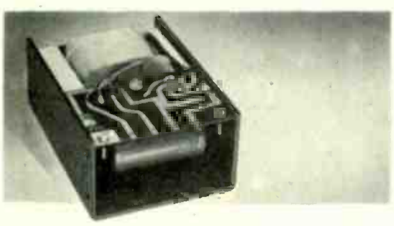
Treble and bass control curves



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.

SINCLAIR RADIONICS LIMITED
22 NEWMARKET ROAD, CAMBRIDGE
Telephone 0223 52731

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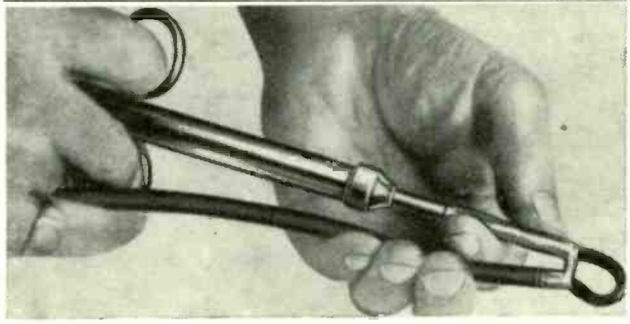

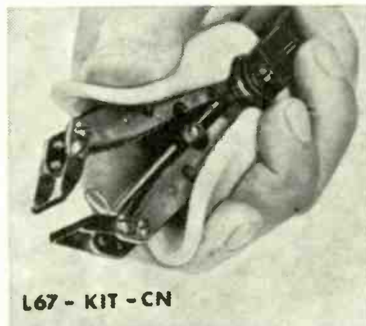

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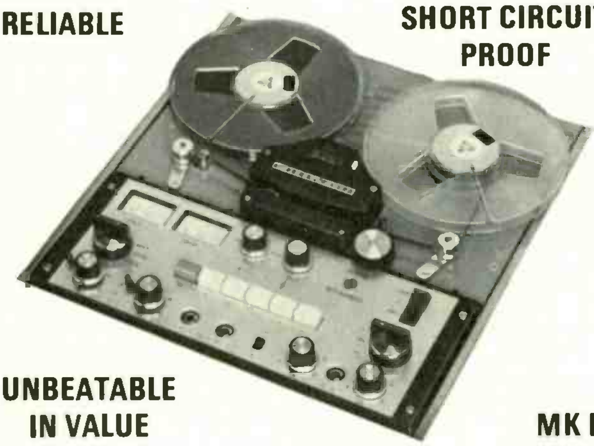

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S.T.C. sealed 2 pole c/o 48V. 2,500 ohm 48v. 3/6 ea. 12v 7/- ea.

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CHOKES. 5H; 10H; 15H; up to 120mA. 8/6 ea. Up to 250mA 12/6 ea.
Large quantity LT, HT, EHT transformers. Your requirements, please.
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PRECISION rotary stud switches 2 pole 12W size 2" sq., ¼" shaft. £2/10/0 ea.

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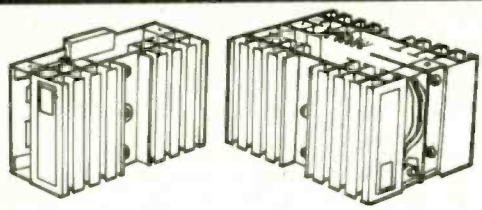

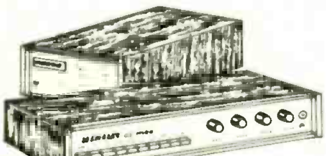

ON DEMONSTRATION

✲ HENELEC 'IC STEREO'

Three dual-channel integrated circuits are used in this new design by Henry's Radio, which has the unusual facility of doubling as a high quality headphone amplifier. Inputs are provided for magnetic, crystal and ceramic pickups and microphones, radio tuners, equalised tape signals, etc. Wide range tone controls and switched high and low pass filters are incorporated, and the unit has its own power supply. The silver and gold front panel, and slimline teak cabinet, give an impressive appearance to this fine amplifier. **PRICE £25.0.0**

✲ HENELEC STEREO 25-25

Comprises two PA25 amplifiers and MU442 in matching teak cabinet for direct use with above IC Stereo. **PRICE £23.0.0**

✲ HENELEC 'PA25' POWER AMPLIFIER

This silicon design uses complementary transistors in the symmetrical output stage, direct coupled to a loudspeaker of 8 ohms impedance or higher. Power output is 25 watts RMS with an 8 ohm load or 12 watts into 15 ohms, over a frequency range of 15Hz-25Hz 3db. Cool running is assured by the use of generously dimensioned black anodised heatsinks. Input 700mV 15Kcm. **PRICE £7.10.0**

✲ HENELEC 'PA50' POWER AMPLIFIER

Basically similar to the 'PA25', the 'PA50' will deliver 50 watts RMS to a 3-4 ohm load. Extra power is handled by complementary triplet circuits using the latest PNP and NPN silicon power transistors. As a result of extra heatsinking, the 'PA50' runs as cool as the 'PA25'. **PRICE £9.10.0**

✲ 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

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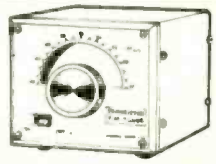
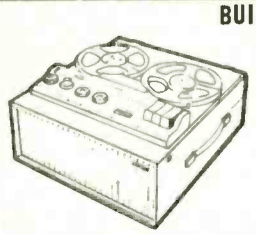
BUILD THIS VHF FM TUNER



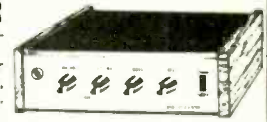
5 MULLARD TRANSISTORS. 300 kc/s BANDWIDTH. PRINTED CIRCUIT. HIGH FIDELITY REPRODUCTION MONO AND STEREO. A popular VHF FM Tuner for quality and reception of mono and stereo. There is no doubt about it—VHF FM gives the REAL sound. ALL PARTS SOLD SEPARATELY.
TOTAL COST £6.19.6 DECODER £5.19.6
ASK FOR BROCHURE No. 3 (FOR STEREO)

BUILD A QUALITY 4 TRACK TAPE RECORDER



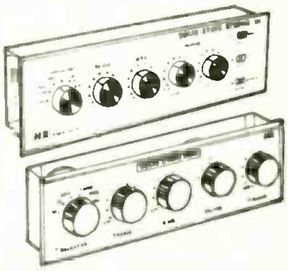
To get the best out of your MAGNAVOX DECK, you need a MARTIN RECORDAKIT. This comprises a special high quality 6 valve amplifier and pre-amplifier which comes to you assembled on its printed circuit board—in fact everything for making a superb Tape Recorder. You need no experience or technical skill 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-S.
Garrard 2025TC stereo, 5-S 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.

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).
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INTEGRATED MICRO CIRCUITS

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SL702C	Amplifier	29/6
μL90C	Buffer	10/-
TAD110	AM/FM Radio	59/6
CA3028	Osc/Mixer	24/6
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CA30 8	Array	22/6
CA30 4	FM	29/6

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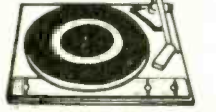

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2025GRS25		£5.19.6
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Cartridge Model	Less Cartridge	9TAHC Diam.	AT21 or M3DM	G850 AT21X*	AT33 Deram*	G800	J2203 800SE*	C591E Ceramic
	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d	£ s d
SP25 Mk II	11 9 6	13 12 6	19 0 0	16 15 0	16 10 0*	21 0 0	15 10 0	19 0 0
AP75	17 15 0	19 15 0	25 10 0	23 0 0	27 0 0	27 0 0	21 17 6	25 10 0
GL75P	46 0 0	—	53 10 0	60 0 0*	55 10 0	53 0 0	70 0 0*	53 10 0
GL69P	35 0 0	37 0 0	42 10 0	40 0 0	44 10 0	42 0 0	59 0 0*	42 0 0
MA70	12 10 0	14 10 0	20 0 0	17 12 6	—	—	16 10 0	20 0 0
AT60 Mk II	13 10 0	15 15 0	21 7 6	19 0 0	18 0 0*	—	17 12 6	21 10 0
GL75	33 0 0	35 0 0	40 10 0	47 0 0*	42 10 0	40 0 0	57 0 0*	40 10 0
SL72B	25 0 0	27 0 0	32 10 0	30 10 0	34 10 0	34 0 0	29 0 0	32 10 0
SL75B	31 0 0	33 0 0	33 10 0	36 10 0	40 10 0	40 0 0	35 0 0	38 10 0
SL95B	39 0 0	41 0 0	46 10 0	53 10 0*	48 10 0	48 0 0	43 0 0	46 10 0
SL65B	15 19 6	18 0 0	23 10 0	21 10 0	20 10 0*	25 0 0	19 15 0	23 10 0
GL69	23 0 0	25 0 0	30 10 0	28 0 0	32 10 0*	30 0 0	47 0 0*	30 10 0

PLINTHS/COVERS DE LUXE TYPE FOR GARRARD DECKS £8.10.0 (STATE MODEL) P.P. 6/-
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R.S.C. SENSATIONAL HIGH FIDELITY STEREO 'PACKAGE' OFFERS

Matching as recommended for optimum performance. Compare prices with equipment and cabinets purchased individually.

★ Super 30 Amplifier (30 Watt) in veneered housing.
★ Goldring Transcription Turntable on Plinth.
★ Shure or Goldring Magnetic Pick-up Cartridge.
★ Pair of Stanway II Loudspeaker Units.

Special total price. Four fully wired units ready to "plug-in". Really superb performance. Send S.A.E. for leaflet. **86 Gns.** Carr. 30/-

'Package' prices apply providing all individual units are purchased from any branch within 3 months (see leaflet).

★ Super30 Amplifier (30 Watt) in veneered housing.
★ Garrard SP25 Mk. II Turntable on Plinth.
★ Goldring CS90 Ceramic diamond tipped Cartridge.
★ Pair of Stanway II Loudspeaker Units.

Extremely Attractive Plinths finished in Teak or Afrormosia veneer. Tinted Transparent Plastic cover.

Special total price. Four fully wired units ready to "plug-in." **76 Gns.** Carr. 30/-

★ TA12 13 W Amplifier in veneered housing.
★ Pair of Dorchester Loudspeaker Units.
★ Garrard SP25 Mk II 4-speed Player on Plinth.
★ Goldring CS90 Ceramic P.U. Cartridge with diamond Stylus. Special total price. **53 Gns.** Carr. 25/-

Transparent Plastic cover 3 gns extra inc. carr. Terms Dep. £10.0.3 and 9 monthly payments £5.15.5 (Total 59 Gns.) Carr. 25/-

As above but with Garrard 3000 and Sonotone 9TA cartridge in lieu of SP25 and CS90. Special total price **47½ Gns.**
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Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround or "L" indicates Roll Rubber surround. "D" indicates Tweeter Cone providing extended frequency range up to 15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 15 ohms.

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HF 811D 8"	10W	£4/4	HF 120D	12" 15W	89/9
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Consisting of matched 12in. 11,000 line 15 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. **£5.15.0**
Or SENIOR 15 watt inc. HF 126 15,000 line Speaker £6/15. Carr. 6/6. Carr. 5/9

HI-FI LOUDSPEAKER ENCLOSURES

Teak or Afrormosia veneer finish. Modern design. Acoustically lined. All sizes approx. Prices inc. carr.
JE8 Size 16 × 11 × 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **£4.14.6**
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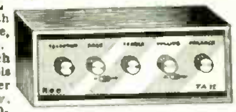
SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 × 16 × 10½in. Pressurised. **£6.19.9**

RSC TA12 Mk II 13 WATT STEREO AMPLIFIER

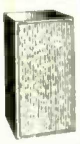
FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL



Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 30-20,000 c.p.s. —2dB ★ Harmonic Distortion 0.3% at 1000 c.p.s. Hum and Noise —70dB ★ Sensitivities (1) 300 mV (2) 50 mV (3) 100 mV (4) 2 mV ★ Handsome brushed silver finish Facia and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. 13½ GNS. Carr. 7/9. Factory built with 12 mth. gntee. 17 GNS. Or Dep. £5/2/6 and 9 mthly pymts. 34/- (Total £20/8/6). Or in Teak or Afrormosia veneer housing 20½ GNS. or Dep. £5/10/6 and 9 mthly. pymts. £2/1/7 (Total £24/4/9).

HIGH FIDELITY LOUDSPEAKER UNITS

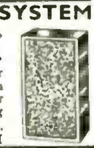
Cabinets of latest styling Satin Teak or Afrormosia veneer. Acoustically lined or filled with acoustic damping material. Ported where appropriate. Credit terms available.



DORCHESTER Size 16 × 11 × 9in. Appr. Range 45-15,000 c.p.s. Rating 8-10 watts. Fitted High flux 13 × 8in. Dual cone speaker. Impedance 3 or 15 ohms. **£8.19.9** Carr. 7/6

STANWAY II Size 20 × 10½ × 9½in. approx. Rating 10 watts. Inc. Fane 13 × 8in. speaker with highly flexible cone surround, long throw voice coil and 11,000 line magnet. High flux tweeter. Handsome Scandinavian design cabinet. Range 35-20,000 c.p.s. Impedance 15Ω. Gives smooth realistic sound output. Inc. carr. **16Gns.**

THE 'YORK' HIGH FIDELITY 3 'SPEAKER SYSTEM



•Moderate size approx. 25 × 14 × 10 in. •Range 30-20,000 c.p.s. Impedance 15 ohms. • Performance comparable with units costing considerably more. Consists of (1) 12 in. 15 watt Bass unit with cast chassis, Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker (4) High efficiency tweeter. (5) Appropriate quantity acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. Complete kit **20 Gns.**
REMARKABLE VALUE HEAR IT AT ANY BRANCH

R.S.C. BATTERY/MAINS CONVERSION UNITS

Type BM1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200/250 v. 50 c/s. is available. Complete kit with diagram 52/6 or, Ready for use, 3 GNS.

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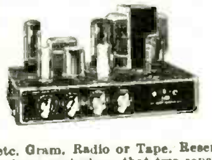
F.W. Bridged 6/12v. D.C. Output Input Max. 18v. A.C. 1a., 4/3; 2a., 6/11; 3a., 9/9; 4a., 12/9; 6a., 15/9.

F.A.L. "PHASE 100" AMPLIFIER

Fully Transistorised (Silicon) 100 watt Music Rating. 4 individually controlled Jack Inputs. For 3-30 ohm Speakers. S.a.e. for leaflet. Only **59 Gns.**

R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



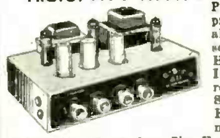
Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Performance figures: Hum level —70dB. Frequency response ±3dB 30-20,000 c/s. Sectionally wound output transformer. All high grade components. Valves EF86, EF86, ECC83, 807. 807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc. Gram. Radio or Tape. Reserve L.T. and H.T. for Radio Tuner. Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250 v., 50 c/s. A.C. mains. For 3 and 15 ohm speakers. Complete Kit parts wiring diags., instructions. Twin-handled perforated cover 27/6. Or factory built with EL34 output valves and 12 months' guarantee for 18 gns. Tech. figs. apply to factory built units. Carr. 12/6. **15 Gns.**
TERMS: Deposit £6.3.0 and 9 monthly payments of 34/- (Total £21/9/0.) Send S.A.E. for leaflet.

R.S.C. TA6 6 Watt HIGH FIDELITY SOLID STATE AMPLIFIER

200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram. Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case. approx. 9¼ × 2¾ × 5¼in. Attractive brushed silver finish facia plate 10¾ × 3¼in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Or factory built with 12 months' guarantee. £8.19.9. **7 Gns.** Carr. 7/6.

INTEREST CHARGES REFUNDED On Credit Sales settled in 3 months.

R.S.C. A11 HIGH FIDELITY 12-14 WATT AMPLIFIER



Push-pull ultra linear output "built-in" tone control pre-amp. Two input sockets with associated controls allowing mixing of "mike" and gram, etc. etc. High sensitivity. 5 valves—ECC83 (2), EL84 (2), EZ81. High quality sectionally wound output transformer. IND. BASS AND TREBLE CONTROLS. Frequency response ±3dB 30-20,000 c/s. Hum level—60dB. SENSITIVITY 40 millivolts. For Crystal or Ceramic PUs. High Impedance "mikes". For Musical Instruments such as String Bass, Electronic Guitars, etc. Size approx. 12 × 9 × 7in. For AC mains 200-250v. 50 cps. Output for 3 and 15 ohm spkrs. S.A.E. for leaflet. Complete kit **9½ Gns.** Full instructions and point-to-point wiring diagrams. Carr. 11/6 (or factory built 13½ Gns.) Twin handled metal cover 27/6. Terms on assembled units. Deposit 99/6 and 9 monthly payments of 26/-. (Total £16/13/6. RSC A11T transistorised version of above complete kit 9 Gns. (Assembled 13 gns.)

R.S.C. COLUMN SPEAKERS

Covered in two-tone Rexine/Vynair, ideal for vocalists and Public Address. 15 ohm matching.
TYPE C57 15 watts inc. five 7 × 4in. spkrs. £7/19/11.
TYPE C48S, 30 watts. Fitted four 8in. high flux 8 watt speakers. Overall size approx. 42 × 10 × 5in. 16 Gns. Or deposit 67/- and 9 mthly pmts. 34/9 (Total £18/19/9). Carr. 10/-.
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R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250v. 50c/s. Screened

MIDGET CLAMPED TYPE 2½ × 2½ × 2½in.
250 v., 60 mA, 6.3 v. 2 a. 17/11
250-0-250v., 60mA. 6.3v. 2a. 18/11

FULLY SHROUDED UPRIGHT MOUNTING
250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a. .. 24/9
250-0-250v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a. .. 39/9
300-0-300v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a. .. 39/9
300-0-300v. 130mA. 6.3v. 4a., c.t., 6.3v. 1a.
For Mullard 510 Amplifier .. 47/11
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a. .. 39/9
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a. .. 47/9
425-0-425v. 200mA. 6.3v. 4a. c.t., 5v. 3a .. 89/9
425-0-425v. 200mA, 6.3v. 4a., 6.3v. 3a, 5v. 3a .. 93/9
450-0-450v. 250mA. 6.3v. 4a., ct., 5v. 3a. .. 99/9

TOP SHROUDED DROP-THROUGH TYPE
250-0-250v. 70mA, 6.3v. 2a., 0-5-6.3v. 2a. .. 23/9
250-0-250v. 100mA. 6.3v. 3.5a. .. 27/9
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a. .. 28/9
350-0-350v, 80mA, 6.3v. 2a., 0-5-6.3v. 2a .. 29/11
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a. .. 39/9
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a. .. 39/9
300-0-300v. 130mA, 6.3v. 4a., 0-5-6.3v. 1a.
Suitable for Mullard 510 Amplifier .. 46/9
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a. .. 39/9
350-0-350v. 150mA., 6.3v. 4a., 0-5-6.3v. 3a. .. 46/11

FILAMENT or TRANSISTOR POWER PACK Types 6.3 v. 1.5a. 8/9; 6.3v. 2a. 9/9; 6.3v. 3a. 13/9; 6.3v 6a. 22/9; 12v. 1a. 9/11; 12v. 3a. or 24v. 1.5a. 23/9; 0-9-18v. 1½a. 19/11; 0-12-25-42v. 2a. 31/9.

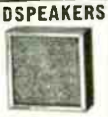
CHARGER TRANSFORMERS 0-9-15v. 1½a. 18/9; 2½a. 19/11; 3a. 21/11; 5a. 25/11; 6a. 29/9; 8a. 36/9.

AUTO (Step UP/Step DOWN) TRANSFORMERS 0-110/120v.-200-230-250v. 50-80 watts 19/9
150 watts 33/6; 250 watts 49/9; 500 watts 105/-

OUTPUT TRANSFORMERS
Standard Pentode 5,000Ω or 7,000Ω to 3Ω .. 8/9
Push-Pull 8 watts EL84 to 3Ω or 15Ω 14/9
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15Ω 24/9
Push-Pull EL84 to 3 or 15Ω 10-12 watts .. 23/9
Push-Pull Ultra Linear for Mullard 510, etc. 39/9
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15Ω .. 35/9
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15Ω 59/9

SMOOTHING CHOKES
150mA. 7-10H, 250Ω 12/9; 100mA, 10H, 200Ω 10/9; 80mA, 10H, 350Ω. 8/9; 60mA, 10H. 400Ω 4/11.

High Quality LOUDSPEAKERS



In teak or afrormosia veneered cabinets. L13 13" × 8" 10 Watt Model Gauss 10,000 lines, 3 or 15 ohms. Carr. 7/6. £4/19/9
L12 12" 20 Watt Model. 15 ohm. Size 18 × 18 × 10in. approx. Gauss 10,000 lines. Rexine covered 10/- extra. Carr. 8/9 £8/19/9

FANE ULTRA HIGH POWER L'SPEAKERS

High flux ceramic magnets. Imp. 8-15Ω. 2 yrs. guarantee.
12" 50w 10Gns.
15" 60w 12Gns.
18" 100w 21Gns.
All carr. free

W.B. 'STENTORIAN' HI-FI 10" SPEAKERS HF1012 £4.19.9

10w 3 or 15 ohms. Cambric Cone. Cast chassis. Mail Order only

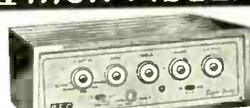
R.S.C. TFM1 SOLID STATE VHF/FM RADIO TUNER

★ High-sensitivity. ★ 200-250v. A.C. Mains operation. ★ Sharp A.M. Rejection. ★ Drift-free reception. ★ Output ample for any amplifier (approx. 500 m.v.). ★ Output for feeding Stereo Multiplexer. ★ Tuner head using silicon Planar Transistors. ★ Designed for standard 80 ohm co-axial input. Visually matching our Super 15 and 30 amplifiers. Printed circuitry. A quality product at considerably less than the cost of comparable units. Factory built 18 gns. Or in Teak finished cabinet as illustrated 21 gns. Terms: Deposit £6/1/- and 9 monthly payments £2/2/-. Total £24/19/-. STEREO VERSION 23½ gns. or in Cabinet 26½ gns. All prices include carriage.

R.S.C. SUPER 30 MkII HIGH FIDELITY STEREO AMPLIFIER

HIGH GRADE COMPONENTS. SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE

Employing Twin Printed Circuits 200/250v. A.C. mains operation.
TRANSISTORS: 9 high-quality types per channel.
OUTPUT: 10 Watts R.M.S. continuous into 15Ω (Per channel) 15 Watts R.M.S. continuous into 3Ω
INPUT SENSITIVITIES: Mag. P.U. 4 m.v. Ceramic P.U. 35 m.v. Tape Amp. 400 m.v. Aux. 100 m.v. Mic. 5 m.v. Tape Head 2.5 m.v.
FREQUENCY RESPONSE: ±2dB. 10-20,000 c.p.s.
TREBLE CONTROL: +17 dB to —14 dB at 10 Kc/s.
BASS CONTROL: +17 dB to —15 dB at 50 c/s.
HUM LEVEL: —80 dB.
HARMONIC DISTORTION: 0.1% at 10 Watts 1,000 c.p.s.
CROSS TALK: 52 dB at 1,000 c.p.s.



CONTROLS: 5-position Input Selector, Bass, Treble, Vol., Bal., Stereo/Mono Sw., Tape Monitor Sw., Mains Sw.
INPUT SOCKETS: (1) P.U. (2) Tape Amp. (3) Radio (4) Mic. or Tape Head. (Operation of Input Selector assures appropriate equalisation.)
CHASSIS: Strong Steel construction. Approx. 12 × 3 × 8 in.
FACIA PLATE: Attractive design in rigid Perspex. Spun silver matching control knobs as available.

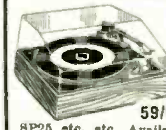
EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MIC. (Ceramic or Magnetic Moving Coil, Ribbon or Crystal.) CURRENTLY AVAILABLE. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USE WITH FIRST-RATE ANCILLARY EQUIPMENT.

COMPLETE KIT OF PARTS, point to point wiring diagrams & detailed instructions. **22Gns.** Carr. 15/-.
UNIT FACTORY BUILT 29 Gns. or Deposit £7/5/- and 9 mthly. payments 58/9 (Total £33/13/9) or in Teak or Afrormosia veneer housing 32 gns. Carr. 15/-. Terms: Deposit £7/3/6 and 9 mthly. payments 66/6 (Total £37/2/-.) Send S.A.E. for leaflet.

R.S.C. SUPER 15 HIGH FIDELITY AMPLIFIER

Solid state. Approx. as Super 30 but single channel. Complete kit with full constructional details and point to point wiring diagrams. **12½ Gns.** Carr. 12/6.
Or factory built: 15½ Gns., Carr. 12/6. Terms: Deposit 4 Gns. and 9 monthly payments 31/1 (Total £18/3/9); or in Teak or Afrormosia veneered housing 19 Gns.

R.S.C. PLINTHS for Record Playing units.



Cut for Garrard 1025, 2025, 3000, AT60, SP25 etc. etc. 59/9 Available with Transparent plastic cover. Prices inc. carr. **6 Gns.**

Record Playing Units

MONEY SAVING UNITS Ready to plug into Amplifier.
RP2C Consisting of Garrard SP25 Mk. II (with heavy turntable fitted Goldring CS90 high compliance ceramic Stereo/Mono cartridge with diamond stylus. Mounted on plinth. Transparent plastic cover included. Inc. carr. **23Gns.**
RP5C Garrard 2025 Auto Unit fitted GC823 Stereo Cartridge with diamond tip. Plinth and Cover as RP2C. Inc. Carr. **15Gns.**
Various other types with Magnetic P.U. Cartridges and 'Lift off' or 'Roll over' transparent covers at lowest prices.

FANE 'POP' 30C LOUDSPEAKER

12" 25 w 15Ω Dual cone
Post Free **£5.19.9**

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MAIL ORDERS to: 102-106 Henconner Lane, Leeds 13. No C.O.D. under £1. Terms C.W.O. or C.O.D. Postage 4/6 extra under £2. 5/9 extra under £5. Trade supplied. S.A.E. with enquiries. Branches open all day Sats. MAIL ORDERS MUST NOT BE SENT TO SHOPS.

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Amplifier Kits

Styled and kitted by T.R.S., using quality components, including valves or transistors and excellent instructions. Backed by T.R.S. service.

MULLARD 5-10. Mono. Basic kit (requires pre-amp as below or passive controls **£2 extra.**) Input Sensitivity—40 mV; Resoonse 20Hz-15KHz + 1dB: Output 10 watts R.M.S. at 3 or 15 ohms. **KIT £10.10.0; BUILT £13.0.0** (*Carr. either, 7/6*).

MULLARD 2-VALVE PRE-AMP with switching for 5 inputs; bass/treble/volume controls, etc. Sensitivity at Input—4mV max. to 330 mV into 80K-1 Megohm; Response 20-25,000 Hz +1dB. **KIT £6.19.6; BUILT £9.10.0** (*Carr. either, 5/6*).

MULLARD 10-10 STEREO AMPLIFIER. Input sensitivity—210 mV per ch.: Response 12 Hz—35KHz + 3dB: 10 watts R.M.S. output per channel into 3 or 15 ohms. **KIT £18.10.0; BUILT £22.10.0** (*Carr. either, 12/6.*)
As above, less controls and panel. Kit **£17.0.0**; Built **£21.0.0** (2+2 pre-amp. essential).

2+2 STEREO PRE-AMP similar to Mullard 2-valve pre-amp, but doubled with gang controls and balance. **BUILT £13.19.6** (*Carr. 7/6*).

T.R.S. 4+4 STEREO AMP
Low cost transistor amplifier based on Mullard modules. 4+4 watts output. For 8-15 ohms speakers. Input switching, etc. Bass and treble controls. Simple module assembly. Amp and pre-amp with front panel and knobs.
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THE NEW T.R.S. P.W. 12-12

T.R.S. have produced their own kit version of this outstandingly good combined stereo amp and pre-amp. It conforms closely to Practical Wireless's excellent circuit but is styled for a flatter, more conventional cabinet which will be shortly available. Kit includes two-tone front panel and control knobs.
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Complete Kit of parts less cabinet (carr. 7/6) **£24.10**

Power/Amp/Pre-amp Kits available separately.

VINAIR—Latest I.C.I. Cabinet and Speaker covering. Mottled Light-Grey, Off-White, Fawn, Black, etc., 2/6 per sq. ft. Multiples of 6 in. cut. **27/6** per yd. Maximum width 48 in.
Send 1/- for Samples—Refundable.

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ENAMELLED COPPER WIRE
New 2 oz. reel prices
14g–20g, 3/-; 22g–28g, 3/6; 30g–34g, 4/3; 36g–38g, 4/9; 39g–40g, 5/-.
Other gauges quoted for.

TINNED COPPER WIRE
16g–22g .. .. .. 4/6 per 2 oz.

EXCLUSIVE T.R. TAPE BARGAIN
Professional quality full frequency Mylar Tape by famous m/fr. Attractively presented in coloured simulated leather wallets with space for spare reel.
5 in. 900 ft. 12/6 5¾ in. 1200 ft. 17/6
7 in. 1200 ft. 17/6 7 in. 1800 ft. **22/6**
Post and packing 1/6 per reel, plus 6d. each for extra reels.

VEROBOARD—All standard sizes stocked.
2½×3¾, 3/-; 2½×5, 3/8; 3¾×3¾, 3/9; 3¾×5, 5/2; 17×2½, 12/6; 17×3¾, 15/-.
Accessories—Term Pins, 1/- doz., 3/- pkt. Face Cutter, 7/3. Pin inserting tool 9/6.

"CIR-KIT"—Adhesive copper strip 5 ft. by 1/16 in. spool 2/-

PLUGS AND SOCKETS
Phono plugs, 1/-; sockets, 1/-, twin. 1/6
DIN 5-pin plugs, 3/-; 5-pin sockets, 1/6; 3-pin plugs, 3/3; 3-pin sockets, 1/6.

VOLUME CONTROLS
1¼ in. dia. Long Spindles. Famous make. All values 5000 ohms–2 Megohms. Guaranteed 12 months.
Log or Linear tracks
Less Sw. 3/6; DP Sw. 5/-
ditto Centre Tapped ½ Megohm Log. 1 Megohm .. .. .. Less Sw. 5/-
Twin Ganged Stereo controls 1¼ in. dia. Long Spindles.
All values 5000 ohms to 2 Megohms.
Less Sw. Each 8/6
ditto 100K to 2 Megohms
With DP Sw. Each 10/6

STEREO BALANCE CONTROLS
Log/Anti-Log 5K, 10K, ½ Meg., 1 Meg., 2 Meg. .. .. .. Each 9/6

RESISTORS
Full Range 10 ohms–10 Megohms. (Midget type, modern ratings.)
10% ¼w, ½w, 4d.; 1w, 6d.
20% 1w, 8d.; 2w, 1/-.
5% Hi Stab (Cracked Carbon) all pref. values.
10 ohms–1 Meg. ¼w, 6d.; ½w, 6d.
ditto 1·2 Meg–10 Meg.
10% ¼w, 5d.; ½w, 6d.
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SKELETON PRE-SETS for P/circuit use. 100 ohms–2·5 Meg., 2/-.

GRAMO UNITS, PLINTHS, ETC.

GARRARD SP.25 Mk. II
10½ in. die-cast t/table, cueing device and counterbalance. Less cartridge. In maker's carton **£12.7.6** (*Carr. 7/6*)

GARRARD LM.2025
With latest stereo cartridge and lift control **£10.19.6** (*Carr. 7/6*)

PLINTHS
Garrard WB.1 **£3.15.0** (*Carr. 5/-*)

Garrard Clearview Cover SCP.1 **£3.10.0** (*Carr. 4/6*)
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CARTRIDGES
When bought together with playing units. Decca Deram, **£5.5.0**; BSR TC8/H (Stereo compatible), **25/-**; BSR Stereo TC.85, **28/6**; Sonotone 9TA/HC, with diamond **60/-**; Acos GP.93-1, **30/-**.

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Also T.R.S. 6-valve AM/FM Tuner Kit, **£12.10.0** (*Carr. 7/6.*) T.R.S. FM Transistor Tuner, parts **£15.15.0** (*Carr. 7/6.*)

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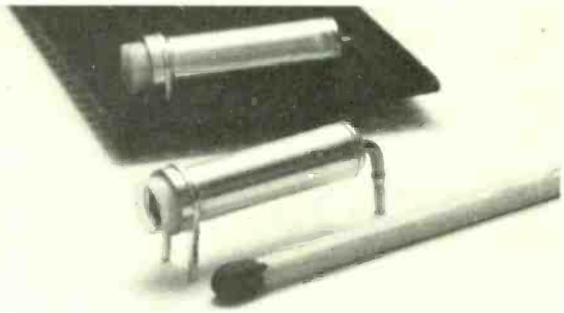
A NEW ADDITION TO THE RANGE



Miniature P.T.F.E. Tubular Capacitors

Oxley Developments Company Limited have introduced a new and improved range of miniature P.T.F.E. Tubular Trimmer Capacitors with capacitance swings from 5 to 30pF; TU/30/PC1, for horizontal mounting on printed circuit boards, as illustrated.

This range of components uses P.T.F.E. as the dielectric medium, resulting in a power factor of less than 5.10^4 at 10kHz, and the patented concentric design ensures uniformly smooth adjustment with linear, reveral-free tuning and temperature coefficient of 50 ppm/°C.

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OXLEY

WW—117 FOR FURTHER DETAILS

Kinver for Components

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This device is electrically similar to MIC709. MC709C. UA709C. N5709A. etc., supplied complete with specification sheet.

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Add 1/- to the above i.c.s. for data sheets if required (1/9 with SL403A. free with IC–10). Other data sheets (apart from IC–10) may be purchased separately at 1/6 per sheet, post free.

1 WATT AMPLIFIER MODULE TYPE PCM1

This amplifier unit is a printed circuit module incorporating the popular and well tried PA234 i.c. amplifier. The unit is a complete AUOIO AMPLIFIER and requires no external components. you simply connect an 18 volt power supply and a 15 or 16 ohm speaker or head phone. even the supply smoothing capacitor and the output capacitor are included! The overall dimensions. including capacitors. are 2½" x 3" x ⅞". The input for 1 watt output at 1 kHz is typicallv 300mV into 100 kohms.
This unit is available at only 36/- net. complete with descriptive leaflet or 70/- net per pair. Send for free leaflet.

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BC126	11/-
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NKT128	5/6
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NKT143	5/6
NKT144	8/-
NKT152	3/6
NKT161	6/-
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NKT163	5/6
NKT164	5/6
NKT165	6/-
NKT211	6/-
NKT212	6/-
NKT213	4/-
NKT214	4/-
NKT215	4/-
NKT216	10/-
NKT217	13/-
NKT218	5/3
NKT219	6/-
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	11/-
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NKT16229	
	11/-
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OC20	19/6
OC22	8/-
OC23	8/-
OC24	8/-
OC25	7/6
OC26	6/6
OC28	12/-
OC29	15/-
OC35	9/-
OC36	12/6
OC41	4/6
OC42	4/6
OC43	4/6
OC44	3/-
OC45	3/-
OC70	2/6
OC71	3/-

OC72	4/6
OC75	4/6
OC76	2/6
OC77	5/6
OC81	4/6
OC81D	3/-
OC82	5/-
OC82D	3/-
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OC203	7/6
OC204	8/-
OC205	9/-
OC206	10/6
OC207	7/6
OC309	12/-
OCP71	19/6
ORP12	9/6
ORP60	8/-
ORP61	8/-
ORP63	9/-
P346A	5/-
RAS310AF	
	6/-
RAS508AF	
	15/-
S1M	19/-
S4M	33/6
ST140	3/-
ST141	5/-
ST2	9/9
TI407	9/8
TIS34	17/6
TIS43	6/9
TIS44	1/9
TIS45	3/3
TIS46	3/3
TIS47	3/3
TIS48	3/3
TIS49	3/6
TIS50	5/6
TIS51	4/-
TIS52	4/-
TIS53	6/6
TIS60	6/6
TIS61	7/-
TIP31A	19/6
TIP32A	22/6
TSW30C	18/-
U23AAA	5/-
V205	20/-
V405A	9/3
XA102	6/-
XA702	15/-
ZE12V7	3/6
ZT22	19/-
ZT86	27/6
ZT2270	19/6
40250	12/6
40309	9/6
40310	13/-
40311	10/6
40312	13/6
40314	10/6
40315	10/6
40316	13/-
40317	11/-
40319	15/-
40320	10/6
40323	10/6
40324	12/6
40326	10/6
40329	7/6
40344	8/-
40347	9/6
40348	14/6
40360	11/6
40361	12/-
40362	14/-
40370	8/6
40406	16/-
40408	14/-
40467	16/6
40468A	16/6
40602	9/-
2G301	3/9
2G302	3/9

2G306	8/6
2G339A	5/-
2G371	3/-
2G371B	3/-
2G374	5/-
2G378	7/-
2G381	5/-
2N109	11/-
2N174	16/-
2N217	7/6
2N370	15/-
2N384	17/-
2N386	12/-
2N385A/	
2N388A	15/-
2N404	4/6
2N410	8/-
2N458A	25/-
2N511A	49/6
2N513A	122/6
2N599	10/-
2N601	25/-
2N657	20/-
2N696	4/-
2N697	4/-
2N698	6/-
2N706	2/6
2N706A	2/6
2N708	4/-
2N711	7/6
2N711A	7/6
2N715	7/6
2N716	7/6
2N743	4/6
2N744	6/-
2N753	5/6
2N914	4/6
2N918	7/6
2N929	5/6
2N930	7/6
2N1090	6/6
2N1091	6/6
2N1131	6/6
2N1132	8/-
2N1302	4/-
2N1303	4/-
2N1304	5/-
2N1305	5/-
2N1306	5/-
2N1307	5/-
2N1308	7/-
2N1309	7/-
2N1496	34/-
2N1507	4/8
2N1613	5/6
2N1671A	29/6
2N1711	6/6
2N1893	10/-
2N2147	17/-
2N2152	27/6
2N2148	12/6
2N2160	14/9
2N2243	26/-
2N2368	5/-
2N2369	5/-
2N2369A	5/6
SN2432	67/-
2N2484	8/-
2N2613	7/6
2N2614	4/-
2N2646	10/-
2N2711	6/-
2N2712	6/-
2N2713	5/6
2N2904	8/6
2N2904A	8/-
2N2905	10/-
2N2905A	8/-
2N2923	4/-
2N2924	4/-
2N2925	3/6
2N2926	
Green	2/-
2N2926	
Yellow	2/-
2N2926	
Orange	2/-
2N2926	
Brown	2/-
2N3011	12/6
2N3036	39/-
2N3053	5/-
2N3054	12/6
2N3055	15/-

2N3133	6/-
2N3135	6/-
2N3136	6/-
2N3235	28/6
2N3234	27/6
2N3391A	6/-
2N3392	5/-
2N3393	5/-
2N3394	4/9
2N3402	5/6
2N3403	5/6
2N3404	7/6
2N3414	5/6
2N3415	6/-
2N3416	7/6
2N3436	15/-
2N3525	21/9
2N3528	19/-
2N3606	5/6
2N3607	4/6
2N3702	3/3
2N3703	3/-
2N3704	3/3
2N3705	3/-
2N3706	2/9
2N3707	3/-
2N3708	2/-
2N3709	3/-
2N3710	3/-
2N3711	3/-
2N3819	8/-
2N3820	18/9
2N3826	6/-
2N3854	5/6
2N3854A	5/6
2N3855	5/6
2N3855A	6/-
2N3856	6/-
2N3856A	6/-
2N3858	5/-
2N3858A	6/-
2N3859	5/6
2N3859A	6/3
2N3860	6/-
2N3866	25/-
2N3877	9/-
2N3877A	9/6
2N3900	10/6
2N3900A	11/6
2N3903	7/-
2N3904	7/-
2N3905	7/6
2N3906	7/6
2N4037	15/-
2N4058	4/6
2N4059	5/-
2N4060	5/-
2N4061	4/-
2N4062	4/6
2N4284	3/-
2N4285	3/-
2N4286	3/-
2N4287	3/-
2N4288	3/-
2N4289	3/-
2N4290	3/-
2N4291	3/-
2N4292	3/-
2N4871	6/9
2N5027	10/6
2N5028	11/6
2N5029	9/6
2N5030	8/6
2N5172	3/-
2N5174	10/6
2N5175	10/6
2N5176	9/-
2N5232	5/6
2N5249	13/6
2N5249A	13/6
2N5305	7/6
2N5306	8/-
2N5309	12/6
2N5354	5/6
2N5355	5/6
2N5356	10/6
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3N128	18/6
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2S003	12/6
2S004	15/-
2S005	15/-
2S006	15/-
2S012	25/-
2S012A	22/6
2S017	15/-
2S018	17/6
2S019	19/6
2S104	12/6
2S301	8/6
2S302	7/6
2S303	10/-
2S304	12/6
2S306	15/-
2S320	9/-
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2S703	12/6
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AAZ13	2/6
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BA111	6/-
BA112	18/-
BA115	1/6
BA130	3/-
BAY31	2/6
BAY38	3/-
BY100	5/-
BY125	3/6
BY127	4/-
BY234	2/3
BYX10	3/-
BYX36	
150	2/6
BYX36	
300	2/10
BYX36	
600	3/9
BYY21	25/-
BYY23	26/3
BYY25	31/9
BYY142	3/9
BYZ10	9/-
BYZ12	6/-
BYZ13	5/-
CG6E	4/-
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OA47	1/6
OA70	1/6
OA73	1/6
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OA81	1/6
OA85	1/6
OA90	1/6
OA91	1/6
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IC10	59/6	Sinclair IC amp.
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PA424	43/-	Zero voltage switch
SL403A	49/6	3 watt Plessey amp.
TAA263	15/-	Mullard linear amp.
TAD100	45/-	IC receiver
TAA293	20/-	Mullard gen. purp. amp.
TAA310	30/-	Record/Playback preamp.
TAA320	13/-	MOS LF amplifier
UL702C	29/6	Plessey linear amplifier

Data sheets available on request 1/- per copy.

PLEASE NOTE: Only new—full specification integrated circuits, no below-specification types.

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	1–6	7–11	12+
ul 900	9/9	9/-	8/-
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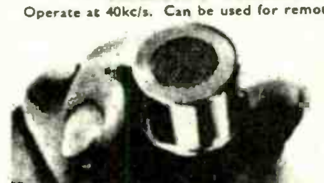
Prices for 100+ and 1,000+ on application. 5 page data and circuits article—2/6. Plastic spreaders—1/6 each.

ULTRASONIC TRANSDUCERS

Operate at 40kc/s. Can be used for remote control systems without cables or electronic links. Type 1404 trans-ducers can transmit and receive. **FREE:** With each pair our complete transmitter and receiver circuit. PRICE £5.18.0 Pair (Sold only in pairs)



SC41D GE triac 400 piv 6 amp **37/-**

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2N3055 15/- 115 watt silicon power transistor 25+13/- 100+11/-

IRC 20 8/6 Int. Rectifier thyristor 200 piv 1·2amp (similar C106B1) 25+7/9 100+7/-

BC107/8/9 2/9 NPN Planar transistors BC107 & 8 25+2/5 100+2/2 BC108 25+2/3 100+2/-

BY 127 4/- Mullard Plastic HV rectifier 800 piv 1 amp (similar BY100 etc.) 25+3/3 100+3/-

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56 CAY 29/6 Gallium arsenide emitter

MGA 100 35/- Gallium arsenide emitter

31F2 28/6 Infra-red detector diode

AD161/2 10/- Siemens/Telefunken NPN/PNP output pair 25+9/- 100+8/-

OCP 71 19/6 Mullard Phototransistor 25+17/3 100+14/9

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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.

VOLTMETER—Solartron VM 1484
Very suitable for the measurement of distorted or complex signals, noise or pulse voltages, employs thermocouples in a self-compensating bridge circuit. Reads true RMS values. Highcrest factors. Output up to 1 volt is available as a drive source for a DVM. Frequency range 10 Hz - 10 MHz. Accuracy 1% of FSD. Sensitivity 1 millivolt - 300 volts. Dimensions H. 8½ in., W. 5½ in., L. 13 in. £150. Carr. extra.

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. Power supply: 230V50 Hz. driving Synchronous Motor. Price: £52.10.0. Postage and packing £1 5s. 0d.

STRIP-CHART INDICATING RECORDER

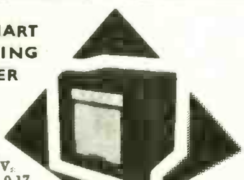


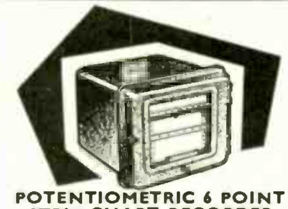
Chart width 9½ in. 10 mV. Sensitivity ± 0.17 of full scale. Source impedance 100 ohms. Speed of operation 33 sec. for full-scale travel. Chart speed ½ in., 3 in., 6 in. per hour. Single point. £49.10.0. P. & P. 30/-.

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

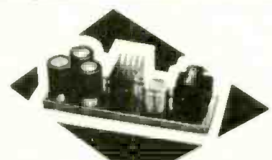
Portable 1, 2 and 4 channel pen recorders by Kelvin Hughes. General purpose recorders providing clear instantaneous and permanent records of phenomena with comparatively high rates of change. The torsion-strip suspension of the moving-coil renders the instrument immune to the effects of vibration and 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 thermocouples, 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

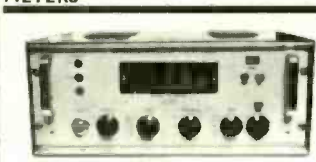
UNUSED MINIATURE ½ MILLION MAGNETIC STORAGE DRUM
Type N.S. 1389 16 write and 16 read heads 256 tracks magnetic storage drum. Each track at 600 r.p.m. Holds 1024 bits (32 words of 32 bits). Total storage 250,000 bits. Suitable for many data storage problems. 8" high, 10" dia., 21" base. £290. carr. extra.



ADVANCE TRANSISTORISED DC POWER UNITS

	Input 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%.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.
Type 2025. Scale 19,999. Accuracy .005%. Range 10 micro volts - 2 Kilo Volts. Input Z greater than 25,000 megohms. CMR 160 d.B. Price new £660. Our price £295. Carr. extra.

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 8.67 certificated. Accuracy to ½% up to 133 c/s. Range 250/450 V. and 0.5 to 1 A. £29.10.0. Carriage 30/-.

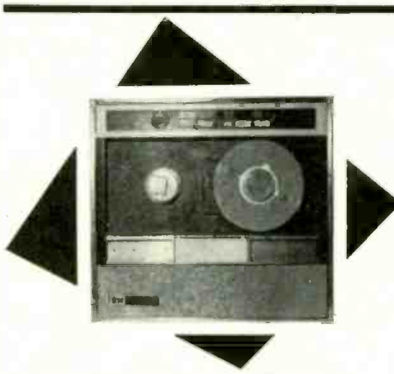
INDICATING MEASURING AMPLIFIER PR 7410
Suitable for vibration and frequency analysis. Frequency response 10-1,000 Hz. £45. Carr. 40/-.

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:
8E150, 8E50 of 8E165A.

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, aborting 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. 537 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

LINEAR THYRISTOR CONTROLLED LIGHT DIMMER
600w. module. Ideally suitable for photoflood or speed controller, etc. Will mount into standard socket boxes. Our price 49/6 + p. & p. 3/-.

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 BRPEII
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 } £325 Excellent condition.
80 column 1400/80 model verifier.

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/-.

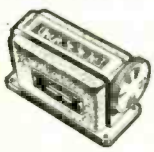
EICHNER 8 Hole Punch OR READERS
No motor drive required. Solenoid operated equipment using 48v. Reader £29.10 Punch £42.10 Carriage 25/-.

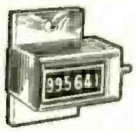
FLEXIWRITERS FPC8
Both Punch and Read Type Available. Any code can be made to suit customers requirements. Price on application.

LOW COST ELECTRONIC AND SCIENTIFIC EQUIPMENT AND COMPONENTS

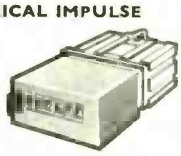
SOLARTRON MILLIVOLTMETER Type F252
1% accuracy on all ranges. 1.5 millivolts - 150 volts. FSD. Input resistance 30 Megohms. £35. Carr. extra.

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.

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/-.

HAND TACHOMETERS
By SMITHS within 2 p.c. accuracy. 4 ranges, 500, 1,000, 5,000 and 50,000

Price **£19.10.0** carr. extra

BERKELEY DECIMAL COUNTING UNIT 0-9
4 valves double triode type 5965 special quality Unit plugs into standard octal base. Modular construction with 10 miniature neon lamps on display panel. Power supplies 6.3v A.V. 150v D.C. Cut-on or Cut-off—15v. Size 5½ × 5½ in. xl. ¾ in. Price 65/- 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. ½ r.p.m., ¼ r.p.m., 120V 60 Hz, 1/10 r.p.m.. 30/- each. P. & P. 3/-.

HIGH TORQUE INDUCTION MOTOR.
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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 4 r.p.m., 2 r.p.m.. 1½ r.p.m., 1 r.p.m., ½ r.p.m., 1/3 r.p.m., 1/5 r.p.m., 1/10 r.p.m., 1/12 r.p.m., 1/20 r.p.m., 1/40 r.p.m., 1/60 r.p.m., 1/75 r.p.m., 1/120 r.p.m., 1/360 r.p.m., 1/720 r.p.m., ⅛. 1/20, 1/45 r.p.m; 120V 50 Hz 1/6 r.p.m., 1/15 r.p.m., 1/16 r.p.m., 1/20 r.p.m., 1/24 r.p.m., 1/30 r.p.m., 1/60 r.p.m., 1/120 r.p.m., 1/240 r.p.m., 1/300 r.p.m., 1/720 r.p.m., 1440 r.p.m. 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., ⅛, ½ 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/-.

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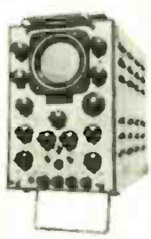
OSCILLOSCOPES


Solartron AD 513	£49/10
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Solartron AD 557	£55
Solartron CD 711	£65
Solartron CD 7118-2	£80
Solartron QD 910	£275
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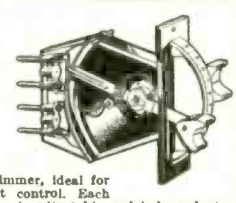
Cossor 1049 MkIII	£40
Cossor 1049	£35

DOUBLE FADERS 3W

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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Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
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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 1/16" 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 £80. 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.

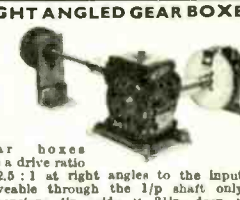
MARCONI T.F. 144G
Frequency Range 85 k.c/s. 25Mc/s. Output voltage 1 micro-volt to 1 volt. Output impedance 1 micro-volt. 100 milli-volt, 10 ohms. 100 milli-volts to 1 volt. 52.5 ohms. £55 + £2 carriage.

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 × 16½ × 9in.—15lb. £5/19/6.

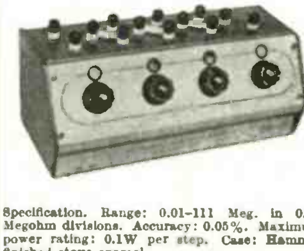
VOLSTAT
Advance
CV500/27. Input 95-130v. 50 Hz. Output 85v. R.M.S. Load 4 amps £8/10/0
CV25E. Input 190-260v. 50 Hz. Output 6v. 25 watts £9/10/0
CV50J. Input 190-260v. 50 Hz. Output 230v. 50 watts £12/10/0
Carriage extra 15/-.

RIGHT ANGLED GEAR BOXES

Gear boxes give a drive ratio of 2.5 : 1 at right angles to the input. Driveable through the 1/p shaft only. Dimensions 4in. wide × 3½in. deep × 4½in. high. Robust construction in cast iron. Price 74/-.
With pulley and ball race shaft mountings. Price 99/6. Carriage 15/-

OSCILLATORS

DAWE 443 B AUDIO SWEEP OSCILLATOR AND CONTROLLER
Brand new. 20 C/S—20 Kilocycles per sec. Accuracy. F 1%.
FM and adjustable frequency sweeps from 0 - 250 c/s. Sweep repetition rates 1 - 25 sweeps/sec. Price £89.10.0. Carr. 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 windings). 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/-.

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EF89	5/6
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EF92	2/6
EF98	15/0
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6AK5	5/-
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6AL5	3/-
6AM6	3/6
6AN8	10/-
6AQ4	4/-
6AQ5	6/3
6AS6	6/-
6AS7	15/-
6AT6	4/9
6AU5GT	20/-
6B4G	20/-
6BA6	5/-
6BE6	5/-
6BH6	9/-
6BJ6	9/-
6BK4	21/6
6BN6	7/6
6BQ7A	7/-
6BR7	17/-
6BR8	12/6
6BS7	25/-
6BW6	14/6
6BW7	13/-
6C4	5/-
6CB6	5/-
6CD6G	24/-
6CH6	7/6
6CL6	8/6
6CW4	13/6
6D4	15/-
6DK6	9/-
6F23	16/-
6F32	2/9
6F33	19/6
6J5G	4/-
6J6	3/6
6J7G	6/-
6K7	1/9
6K7G	2/-
6K8	2/9
6K8G	3/-
6L6G	7/9
6L6WGB	17/6
6Q7G	6/-
6SQ7M	7/6
6SG7	6/-
6SJ7M	7/-
6SL7GT	6/-
6SN7GT	5/6
6V6G	4/6
6X4	4/6
6X5G	4/6
7B7	7/6
7C5	22/6
7C6	15/-
7H7	6/6
7S7	45/-
7Y4	8/6
10F1	14/9
11E3	70/-
12AC6	10/-
12AD6	11/-
12AE6	9/6
12AT6	4/9
12AT7	6/-
12AU7	5/9
12AX7	6/3
12BA6	6/-
12BE6	6/3
12E1	20/-
12K7GT	7/-
12K8GT	8/-
12Q7GT	6/-
13E1	190/-
20P4	20/-
24B1	110/-
25Z4	6/3
25Z5GT	8/-
25Z6GT	8/6
27M1	72/6
30C15	15/-
30C17	16/-
30F5	17/-
30FL1	15/-
30L15	17/-
30L17	17/-
30P4	15/-
30P19	15/-
30PL1	16/-
30PL13	18/6
30PL14	15/-
35L6	9/-
35L6GT	9/-
35W4	4/6
35Z4GT	8/6
50C5	6/3
50CD6G	31/-
80	7/6
85A1	25/-
85A2	7/3
88L	160/-
90AG	45/-
90AV	45/-
90C1	12/-
90CG	25/-
90CV	25/-
150B2	11/6
150B3	8/6
705A	10/-
723A/B	120/-
725A	240/-
801	9/6
803	35/-
807	9/-
811	35/-
813	75/-
813USA	160/-
829B	60/-
833A	360/-
837	17/6
866A	15/-
872A	57/6
931A	72/6
954	5/3
955	3/-
2050	15/-
5644	40/-
5651	7/3
5654	8/-
5672	7/-
5687	10/-
5691	25/-
5694	30/-
5702	15/-
5749	10/-
5763	12/-
5784	35/-
5842	65/-
5876	60/-
5879	22/6
5893	150/-
5899	10/-
5902	17/-
5963	10/-
6057	10/-
6058	10/-
6059	18/-
6060	6/-
6061	12/-
6062	14/-
6063	7/-
6064	7/-
6065	9/-
6067	10/-
6072	12/-
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6146	27/6
7475	14/-
9003	9/-
9004	2/6
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2G402	6/-
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2G416	6/6
2G417	6/-
2N247	9/6
2N555	12/6
AC107	5/6
AC127	5/-
AC128	4/6
ACY19	5/-
ACY20	5/-
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GET571	5/-
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NKT211	6/6
NKT214	4/4
NKT216	6/4
NKT217	8/4
NKT218	22/6
NKT228	6/-
NKT404	12/6
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NKT713	7/6
OC16	15/-
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OC20	20/-
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OC25	7/6
OC26	6/-
OC28	12/6
OC29	14/6
OC35	6/3
OC44	4/-
OC45	3/3
OC71	3/-
OC72	4/-
OC74	4/6
OC75	4/6
OC76	3/-
OC77	8/-
OC78	3/-
OC81	4/-
OC81D	3/-
OC81M	5/-
OC81DM	3/-
OC82	3/-
OC82D	3/-
OC83	4/6
OC169	6/-
OC170	5/6
OC171	6/-
OC200	5/6
SX642	3/6
XA101	3/6
XA111	3/6
XA112	4/6
XA125	5/-
XA141	7/-
XA142	5/-
XA143	5/-
TUBES	
2AP1	80/-
3BP1	50/-
3DP1	40/-
3EG1	65/-
3FP7	29/-
3GP1	40/-
5BP1	80/-
5CP1	55/-
5FP7	35/-
88L	80/-
88D	200/-
ACR22	80/-
C27A	160/-
CV960	76/-
CV966	35/-
CV1526	65/-
CV1587	60/-
CV1588	35/-
E4504/B/16	76/-
ECR30	35/-
ECR35	50/-
MW-2	100/-
MW6-2	100/-
09D	80/-
09G	80/-
09L	80/-
VCR97	45/-
VCR138	60/-
VCR138A	60/-
VCR139A	45/-
VCR516	80/-
VCR517A	46/-
VCR517B	46/-
VCR517C	46/-

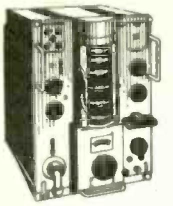
Valves tested and released to A.R.B. specification if required.

Express postage 9d. per valve.
Ordinary postage 6d. per valve.
Over £5 postage free.
Tel. 01-769 0199/1649

Monday to Saturday
9 a.m.—5.30 p.m.
Closed Sat 1-30—2-30 p.m.
Complete range of TV Tubes available from £4.5.0.

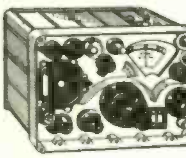
SEND S.A.E. FOR LIST of 6,000 TYPES VALVES, TUBES AND TRANSISTORS

ADMIRALTY B.40 RECEIVERS



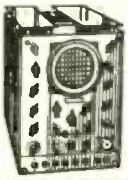
High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s-30 Mc/s. I.F. 500/Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 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

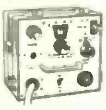


An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kc/s. Bandwidth 5.5 Mc/s Sensitivity 33 Mv/cm. Operating voltage 0/110/200/250 v. A.C. Supplied in excellent working condition, £22/10/-. Or complete with all accessories, probe, leads, lid, etc. £25. Carriage 30/-.

MARCONI CT44 TF956 AF ABSORPTION WATTMETER

1 μ/watt to 6 watts. £20. Carr. 20/-.

CLASS D. WAVEMETERS



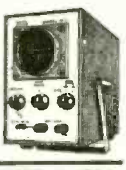
A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition £5.19.6 Carr. 7/6. Or brand new with accessories £7.19.6 Carr. 7/6.

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/-.

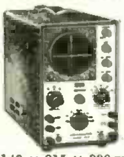
VOLTAGE STABILISER TRANSFORMERS. 180-260v. input. Output 230v. Available 150w or 225w. £12.10.0. Carr. 5/-.

TO-2 PORTABLE OSCILLOSCOPE



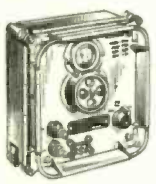
A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS—1 MHZ. Input imp. 2 meg Ω. 25 PF. Illuminated scale. 2" tube. 115 × 180 × 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. £22/10/-. Carr. 10/-.

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



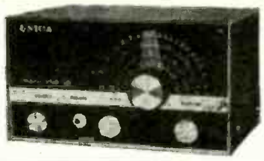
Small portable crystal controlled wavemeter. Size 7in. × 7½in. × 4in. Frequency range 500 Kc/s—10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. 89/6. Carr. 7/6.

MARCONI TF885 VIDEO OSCILLATORS
0-5 mc/s Sine Square Wave £45. Carr. 20/-.

MARCONI TF195M BEAT FREQUENCY OSCILLATORS
0-40 kc/s. £20. Carr. 30/-.

WS62 TRANCEIVERS
Large quantity available for EXPORT! Excellent condition. Enquiries invited.

UNR-30 4 BAND COMMUNICATION RECEIVER
Covering 550 Kc/s-30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/240 v. A.C. Supplied brand new, guaranteed with Instructions. 13gns. Carr. 7/6.

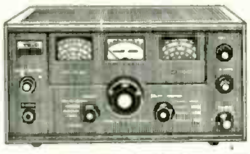


EDDYSTONE V.H.F. RECEIVERS
770R. 19-165 Mc/s. £150.
Both types in excellent condition.

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.

UR-1A SOLID STATE COMMUNICATION RECEIVER
4 bands covering 550 Kc/s-30 Mc/s continuous. Special features are use of FET transistors, S meter, built-in speaker and telescopic aerial, variable BFO for SSB reception, noise limiter, bandspread control, sensitivity control. Output for low impedance headphones. Operation 220/240 volt A.C. or 12 volt D.C. Size 12¾" × 4¾" × 7". Excellent value. Only £24. carr. 7/6.

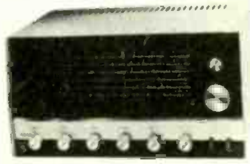
TRIO COMMUNICATION RECEIVER MODEL 9R-59DE



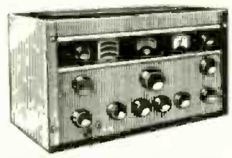
4 band receiver covering 500 Kc/s to 30 Mc/s, continuous and electrical bandspread on 10-15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter. ● Sep. Bandspread dial ● IF 455 Kc/s ● audio output 1.5 w. ● Variable RF and AF gains 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
TRIO JR 500SE 10-80 Metre Amateur Receiver	£65

LAFAYETTE HA.800 SOLID STATE AMATEUR COMMUNICATION RECEIVER SIX BANDS 3.5-4, 7-7.3, 14-14.35, 21-45, 28-29.7, 50-54 Mc/s.
Dual conversion on all bands. 2 × 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" × 9¼" × 8½". Complete with instruction manual. £57.10.0. Carr. Paid. (100 Kc/s Crystal 39/6 extra.)

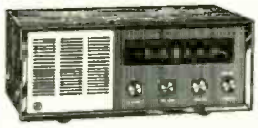


TRIO JR-310 NEW AMATEUR BAND 10-80 METER RECEIVER IN STOCK £77.10.0

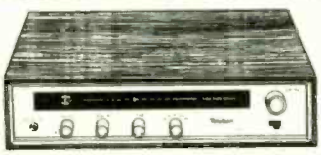


RCA COMMUNICATIONS RECEIVERS AR88D
Latest release by ministry BRAND NEW in original cases. 110-250v. A.C. operation. Frequency in 6 Bands. 535 Kc/s—32 Mc/s continuous. Output impedance 2.5-600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price £87.10.0. 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. 75Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. £37/10/-. Carr. 10/-.



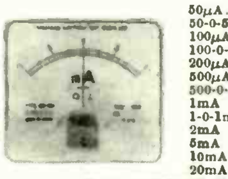
TELETON MODEL CR-10T AM/FM STEREO TUNER AMPLIFIER



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 13½in. × 3½in. × 9½in. approx. Price £34/0/0. Carr. 7/6.

SEW PANEL METERS

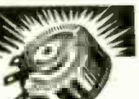
Type MR.38P. 1 21/32in. square fronts.



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		

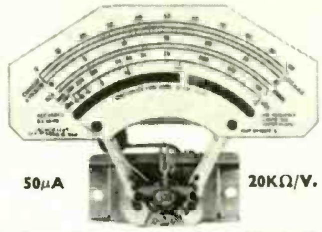
FULL RANGE OF OTHER SIZES IN STOCK—SEND SAE FOR LEAFLET

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

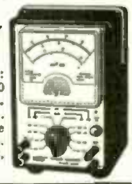


50μA 20KΩ/V.

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

MARCONI TF.142E DISTORTION FACTOR METERS
Excellent condition. Fully tested £20. Carr. 15/-.

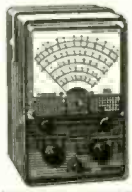
T.E.40 HIGH SENSITIVITY A.C. VOLTMETER



10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 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.

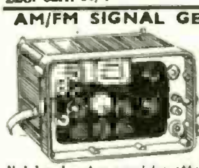
TE-65 VALVE VOLTMETER



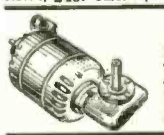
High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions £17/10/0. P. & P. 6/-. Additional Probes available; R.F. 35/- H.V. 42/6.

COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES
D.C. coupled. Band width 1 Kc/s. Perfect order. £25. Carr. 30/-.

AM/FM SIGNAL GENERATORS

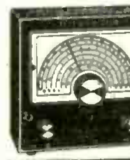


Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1μV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 8½ x 9in. Supplied in brand new condition complete with all connectors, fully tested, £45. Carr. 20/-.



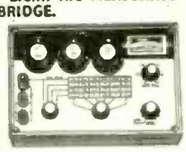
GEARED MAINS MOTOR
Parvalux type SD19 230/250 v. A.C. Reversible. 30 r.p.m. 40 lb. ins. Complete with capacitor. Excellent condition. 99/6. Carr. 10/-.

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. 5½" × 5½" × 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.
ALSO SEE OPPOSITE PAGE

FLUORESCENT CONTROL KITS

Each kit comprises seven items—Choke, 2 tube ends, starter, starter holder and 2 tube clips, with wiring instructions. Suitable for normal fluorescent tubes or the new "Grolux" tubes for fish tanks and indoor plants. Chokes are super-silent, mostly resin filled. Kit A—15-20 w. **19/6**. Kit B—30-40 w. **19/6**. Kit C—80 w. **23/6**. Kit E—65 w. **19/6**. Kit MF1 is for 6in., 9in. and 12in. miniature tubes, **19/6**. Postage on Kits A and B 4/6 for one or two kits then 4/6 for each two kits ordered. Kits C, D and E 4/6 on first kit then 3/6 for each kit ordered. Kit MF1 3/6 on first kit then 3/6 on each two kits ordered.

REED SWITCHES

Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types:
Miniature. 1in. long × approximately ⅛in. diameter. Will make and break up to ½A up to 300 volts. Price **2/6** each. **24/-** dozen.
Standard. 2in. long × 3/16in. diameter. This will break currents of up to 1A, voltages up to 250 volts. Price **2/-** each. **18/-** per dozen.
Flat. Flat type, 2in. long. Just over 1/16in. thick, approximately ¼in. wide. The Standard Type flattened out, so that it can be fitted into a smaller space or a larger quantity may be packed into a square solenoid. Rating 1 amp 200 volts. Price **6/-** each. **£3** per dozen.
Small ceramic magnets to operate these reed switches **1/9** each. **18/-** dozen.

TELESCOPIC AERIAL

For portable, car radio or transmitter. Chrome-plated—six sections extends from 7½ to 47in. Hole in bottom for 6BA screw. **7/6**.

TOGGLE SWITCH

3 amp 250v. with fixing ring. **1/6** each **15/-** doz.

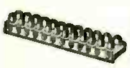
MINIATURE EAR PIECE

As used with imported pocket radios. **1/6** each **15/-** doz.

ISOLATION SWITCH

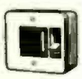
20 Amp D.P. 250 Volts. Ideal to control Water Heater or any other appliance. Neon indicator shows when current is on. **4/6** **48/-** per dozen.

15/20 AMP CONNECTORS



Polythene insulated 12-way strip. **2/6** each **24/-** doz.

13 AMP FUSED SWITCH



Made by G.E.C. For connecting water heater etc., into 13 amp ring main. Flush type **3/6** each **30/-** doz. Metal boxes for surface mounting **1/6** each **15/-** doz.

MICRO SWITCH

5 amp. changeover contacts. **1/9** each **18/-** doz. 15 amp model **2/-** ea. or **21/-** doz.

SUPPRESSOR CONDENSER TCC

.1 mfd. 250v. A.C. working metal cased with fixing lug. **1/9** each **18/-** doz.

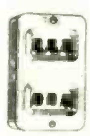
REED RELAY

Glass encapsulated reed switch in 24-volt solenoid, neatly enclosed in neat metal case, size 2⅛in. × ½in. × ½in. **3/6** each. Operates from 24 volts D.C. or from A.C. mains using rectifier, resistor and condenser (**3/6** extra).

SHEET PAXOLIN

Ideal for transistor projects, panels 12in. × 6in., **1/9** each. **15/-** per dozen.

G.E.C. MULTIPLE SWITCHES



Metal boxes (with cable knockouts) sprayed silver with cover and switch mounting grid. For 12 switches **6/-**, 6 switches **5/-**, 4 switches **4/-**, 2 switches **3/6**.

G.E.C. Clipper Switches

For the above boxes, 5 amp A.C. rating, one-way **1/6**, 2-way **2/-**, Bell push **2/-**, intermediate **2/6**, secret **2/6**, 15 amp one-way **2/6**.

THERMOSTAT

Continuously variable 30°-90°C. Has sensor bulb connected by 33in. of flexible tubing. On operation a 15 amp 250 volt switch is opened and in addition a plunger moves through approx. ⅛in. This could be used to open valve on ventilator etc. **29/6** plus 4/6 p. & ins.

HI FI BARGAIN

FULL FI 12-INCH LOUDSPEAKER. This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi load and Rhythm Guitar and public address.
Flux Density 11,000 gauss—Total Flux 44,000 Maxwells—Power Handling 15 watts R.M.S.—Cone moulded fibre—Freq. response 30-10,000 c.p.s.—specify 3 or 15 ohms—Main resonance 60 c.p.s.—Chassis Diam. 12in.—12⅜ over mounting lugs—Baffle hole 11in. Diam.—Mounting holes 4, holes—¼in. diam. on pitch circle, 11⅛in. diam.—Overall height 5⅛in. A £6 speaker offered for only **£3.19.6** plus 7/6 p. & p. Don't miss this offer. 15in. 25 watt **£7.19.6**. 18in. **100 watt £19.10.0**.

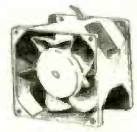
RING MAIN JUNCTION BOXES

Made by Rock. This won Designs Award for making quick and neat junctions in 9.029 twin and earthed cable as used for ring main circuits. Our price **1/6** each, **15/-** per dozen.

ERGOTROL UNITS

These units made by the Mullard Group are for operating and controlling d.c. Motors and equipment from A.C. mains.
Thyristors are used and these supply a variable d.c. resulting in motor speed control and operating efficiency far superior to most other methods.
The units are contained in wall mounting cabinets with front control panel on which are fuses—push buttons for on/off and the variable thyristor firing control.
4 models are available—all are brand new in makers cases:
Model 2410 for up to 5 amps **£17.10.0**
Model 2411 for up to 10 amps **£27.10.0**
Model 2413 for up to 45 amps **£47.10.0**
Model 2415 for up to 80 amps **£95. 0.0**
Note: 2415 is a floor mounting unit.

MINIATURE EXTRACTOR FAN

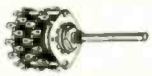


Beautifully made by famous German Company. PAPST System, 230/240 A.C. Mains operated, size 3½in. × 3½in. × 2in. Made for instrument cooling but ideal to incorporate in a cooker hood, etc. **65/-** P. & p. 2/9.

DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work **39/6** less plug. **45/-** with fitted 13 amp plug. **47/6** with fitted 15 amp plug, plus 4/6 P. & I.

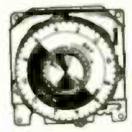
STANDARD WAFER SWITCHES



Standard size 1¼ wafer—silver-plated 5-amp contact, standard ¼" spindle 2" long—with locking washer and nut.

No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	10 way	12 way
1 pole	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6
2 poles	6/6	6/6	6/6	6/6	6/6	6/6	10/6	10/6
3 poles	6/6	6/6	6/6	6/6	10/6	10/6	14/6	14/6
4 poles	6/6	6/6	6/6	10/6	10/6	10/6	18/6	18/6
5 poles	6/6	6/6	10/6	10/6	14/6	14/6	22/6	22/6
6 poles	6/6	10/6	10/6	10/6	14/6	14/6	26/6	26/6
7 poles	6/6	10/6	10/6	14/6	18/6	18/6	30/6	30/6
8 poles	10/6	10/6	10/6	14/6	18/6	18/6	34/6	34/6
9 poles	10/6	10/6	14/6	14/6	22/6	22/6	38/6	38/6
10 poles	10/6	10/6	14/6	18/6	22/6	22/6	42/6	42/6
11 poles	10/6	14/6	14/6	18/6	26/6	26/6	46/6	46/6
12 poles	10/6	14/6	14/6	18/6	26/6	26/6	50/6	50/6

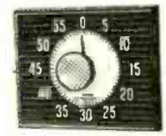
24 HOUR TIME SWITCH



Mains operated. Adjustable Contacts give on/off per 24 hours. Contacts rated 15 amps, repeating mechanism so ideal for shop window control, or to switch hall lights (anti-burglar precaution) while you are on holiday. Made by the famous Smiths Company. This month only **39/6** complete with perspex cover, new and unused, plus 3/6 postage and insurance, a real snip which should not be missed.

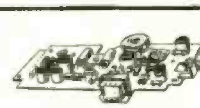
THIS MONTHS SNIP

1 HOUR MINUTE TIMER



Made by famous Smiths company, these have a large clear dial, size 4in. × 3in., which can be set in minutes up to 1 hour. After preset period the bell rings. Ideal for processing, a memory jogger or, by adding simple lever, would operate micro-switch. **22/6**.

1 WATT AMPLIFIER & PRE-AMP



5 transistors—highly efficient made for use with tapehead G4 but equally suitable for microphone or pick up. Limited quantity **29/6**. Full circuit diag. also shows tape controls 5/-.

VARIAC CONTROLLERS

With these you can vary the voltage applied to your circuit from zero to full mains without generating undue heat. One obvious application therefore is to dim lighting. We offer a range of these, ex-equipment but little used and in every way as good as new. Any not so, will be exchanged or cash refunded. 2 amp **£4.19.6**. 5 amp **£7.19.6**. 8 amp **£12.19.6**. 10 amp **£15.19.6**.

HOUR COUNTERS

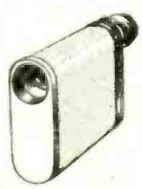
If you wish to know how long your equipment has been switched on then this is what you need. Counts running time up to 999 hours. 50 c/s mains operation. **49/6** plus 3/6 post and insurance. Resettable type **69/6** plus 3/6 post and insurance.

THE PECTRON HEATING/VENTILATING CONTROL

This neat unit contains all the controls needed for a gas-fired central heating system as follows:—
(a) A clock switch giving 2 on/off periods per 24 hours.
(b) A thermal delay switch to prevent cold air being blown while fire warms up.
(c) Auto transformer to vary voltage and thus control fan speed.
(d) A 24-volt transformer to provide the low voltage necessary to operate solenoid of gas valve.
(e) A changeover switch to bypass the clock.
(f) Changeover switch to cut off heat so allowing cold air to be blown for Summer ventilation.
(g) Neon indicator and fuses.
The unit has a circuit diagram and five leads labelled "Mains," "Fan," "Thermostat 1," "Thermostat 2," "Gas valve." **£5.19.6** plus 4/6 postage and insurance.

See in the dark

INFRA RED MONOSCOPE



This equipment is complete and portable. Basically it consists of an infra red image converter tube with optical lenses for focusing the image and a Zambini pile to provide the necessary E.H.T. The monoscope is housed in a hide case size 9 × 6 × 4in. approx.
Made originally for the army for night observations, sniping etc., this equipment has many scientific and practical applications; a limited quantity only is available in original sealed carton. Price **£9.19.6**.
NOTE. Although unused in fact still in original sealed cartons. The equipment is approx. 25 years old and consequently the Zambini pile may not now be operative. Drying out might help but a better idea might be to replace it with a battery operated power unit; there is plenty of room.

MINIATURE WAFER SWITCHES

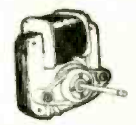
2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at **3/6** each, **36/-** dozen, your assortment.

WATERPROOF HEATING ELEMENT
26 yards length 70W. Self-regulating temperature control. **10/-** post free.

DRILL CONTROLLER

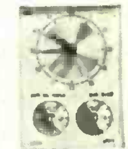
Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions **19/6**, plus 2/6 post and insurance. Made up model also available **37/6** plus 2/6 p. & p.

MAINS MOTOR



Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at **9/6**. Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

ELECTRIC CLOCK WITH 25 AMP SWITCH



Made by Smith's, these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only **39/6**, less than the value of the clock alone—post and insurance 2/9.

COOKER CLOCK
with temperature contoller

Cooker clock with temperature controller. This is as the clockswitch described above but with additional panel which incorporates oven thermometer and thermostatic switch. The thermostat switch may be set anywhere between 50°C. and 90°C. Made for high-class continental cooker, this is a very fine instrument. **£4.19.6**, plus **£1.10.0** for oven sensor unit.

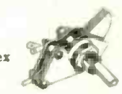
THERMAL CUTOUT

A miniature device ⅜in. dia. on one screw fixing mount—can be used for motor overload protection—fire alarm—soldering iron switch off, etc., etc.—15 amp contacts open with flame radiant or conducted heat. **1/6** each, **15/-** doz. **£5** 100.

COPPER CLAD ELEMENT

1250 watts—4ft. long but bent to U shape, ideal for overhead heater—just mount reflector above. **12/6** each, plus 4/6 post. **£6** doz. post paid.

0·0005mFd TUNING CONDENSER



Proved design, ideal for straight or reflex circuits **2/6** each. **24/-** doz.

SUB-MINIATURE MOVING COIL MICROPHONE
as used in behind the ear deaf aids

Acts also as earphone size only ½in. × ⅛in. × ⅛in. Regular price probably £3 or more. Our price **19/6**. Note these are ex-equipment but if not in perfect working order they will be exchanged.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **16/6**, plus 3/6 postage.

PP3 BATTERY ELIMINATOR

Run your small transistor radio from the mains—full wave circuit. Made up ready to wire into your set and adjustable high or low current. **8/6** each.

85 Watt Tubular Element. Very well made unit. The element is wound on a porcelain former then encased in a brass tube terminated with beaded leads 12in. long. Normal mains voltage. Price **5/-** each or **54/-** per doz.

250V AC working condensers for power factor correction, motor starting etc. 3.5 mfd. **6/6** ea., 6.5 mfd. **8/6** ea., 8 mfd. **9/6** ea.

3 amp battery charger kit comprises copper backed circuit board, 3 amp mains transformer, regulator resistors and smoothing condenser **29/6** inc. wiring diagram, post & ins, 4/6.

BALANCED ARMATURE

500 ohm, operates speaker or microphone, so useful in intercom or similar circuits. **6/6** ea., **£3.10.0** doz.

Acos crystal microphone. Adjustable stand converts this from hand mic. to desk mic. **19/6** ea.

HEAVY DUTY POWER PACK

40V 6 amps DC output—comprises 1st class mains transformer with normal primary, screen 20-0-20 6-amp output. Fully smoothed. Completely wired ready to work **£3.19.6** + 8/6 p. & i.

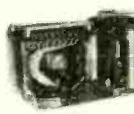
Where postage is not stated then orders over £3 are post free. Below £3 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

ELECTRONICS (CROYDON) LTD
Dept. WW, 266 London Road, Croydon CRO-2TH
Also 102/3 Tamworth Road, Croydon

ISOLATING/STEP DOWN TRANSFORMER
Primary 0, 240v., Sec. 0, 115, 240v. 10a. Ideal for workshop supply, only 6in. × 7in. × 7in. **£8**, carr. 20/-.

STEP DOWN TRANSFORMER
Primary 0, 240v., Secondary 0, 115v. 300 watts (conservatively rated). 4½in. × 4in. × 4in. **45/-**, p. & p. 8/-.

12v. 4a. POWER SUPPLY
Brand new, weighs 11 lb. Constant voltage transformer, input 0 – 112.5 – 123.5 – 195 – 220 – 235v., produces 12v. 4a. capacitor smoothed output. **£9.10.0** plus 10/– carr.



EX-COMPUTER POWER SUPPLIES
Reconditioned, fully tested and guaranteed. These very compact units are fully smoothed with a ripple better than 10mv. and regulation better than 1%. Over voltage protection on all except 24v. units. 120v. – 130v. a.c. 50c/s input. Mains transformer to suit **£3** extra if required.
We offer the following types:

6v. 8a. **£10**	20v. 15a. **£15**
6v. 15a. **£14**	30v. 7a. **£12**
12v. 20a. **£16**	24v. 4a. **£14**

Carriage 15/– per unit

DIODES EX EQUIP, SILICON

150 PIV 10 amp.	4 for **10/–**
150 PIV 20 amp.	4 for **20/–**
400 PIV 35 amp.	4 for **45/–**

p. & p. 1/–

LARGE CAPACITY ELECTROLYTICS
4½in., 2in. diam. Screw terminals. Top quality German manufacture. Will withstand short circuit discharge.
4,000μF 72v. d.c. wkg.
16,000μF 12v. d.c. wkg.
7/6 each, p. & p. 1/–
£3.10.0 doz., p. & p. 10/–.

PYE CAR RADIO
Push Button Tuning Heart

This PRESTOLOCK 5 station Push-Button Tuner Heart with Manual Over-ride is an ideal basis for a quality AM car radio. Size 6½in. × 4in. × 2in. **25/–**plus 3/– p. & p.

RELAY OFFER
Single pole changeover. 2in. × 0.6in. × 0.75in. 50v. 2.5KΩ coil, operates on 24v. 8 for **10/–**. 5,000 available, p. & p. 1/6.

MEMORY CORE STORE PLANES
160 BITS **£1.** P. & P. 2/–
4,000 BITS **£4.** P. & P. 4/–
1,000 BITS **£8.** P. & P. 8/–

EXTENSION TELEPHONES
Why get out of the bath when the phone rings. Install one in the bathroom.

19/6 each, p. & p. 5/–.
35/– for 2, p. & p. 8/–.
These are extension phones and do not have bells.

1,750 COMPONENTS FOR 65/– ? ?
YES, QUITE TRUE,
READ ON
BUMPER BARGAIN PARCEL
We guarantee that this parcel contains at least 1,750 components. Short-leaded on panels, including a minimum of 350 transistors (mainly NPN and PNP germanium, audio and switching types—data supplied). The rest of the parcel is made up with: Resistors 5% or better (including some 1%) mainly metal oxide, carbon film, and composition types. Mainly ⅛ and ¼ watt . . . diodes, miniature silicon types OA90, OA91, OA95, IS130, etc. . . . capacitors, including tantalum, electrolytics, ceramics and polyesters . . . inductors, a selection of valves . . . also the odd transformer, trimpot, etc., etc. . . . These are all miniature, up to date, professional, top quality components. Don't miss this, one of our best offers yet!! Price **65/–**, post and packing 6/6 U.K., New Zealand 20/–. Limited stocks only.

9 OA5, 3OA10, 3 Pot Cores, 26 Resistors, 14 Capacitors, 3 GET 872, 3 GET 872B, 1 GET 875. All long leaded on panels 13in. × 4in. 2 for **10/–**, p. & p. 3/6d. 4 for **20/–**, post free.

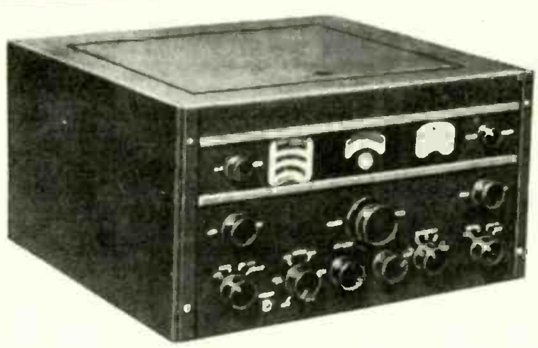
EX COMPUTER PRINTED CIRCUIT PANELS
2in. × 4in., packed with semi-conductors and top quality resistors, capacitors, diodes, etc. Our price, 10 boards **10/–**, p. & p. 2/–. With a guaranteed minimum of 35 transistors.
25 boards for **£1**, p. & p. 3/6. With a guaranteed minimum of 85 transistors. Transistor data included.

COMPONENT PACKS
200 capacitors, electrolytics, paper, silver mica, etc. **10/–**. Postage on this pak 2/6.
250 mixed resistors **10/–**, post & packing 2/–
40 wirewound resistors, mixed types and values. **10/–**, postage 1/6.

QUANTITIES AVAILABLE
EXTRACTOR/BLOWER FANS (Papst)
100 c.f.m. 4½ × 4½ × 2in. 2,800 r.p.m., 240v. A.C. Precision made in West Germany by Papst. These Fans are the best available. Genuine bargain at **50/-** each.

KEYTRONICS
52 Earls Court Road, London, W.8
Tel. 01-478 8499
MAIL ORDER ONLY. Retail and Trade supplied. Export enquiries particularly welcome. S.A.E. FOR LIST

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/-.

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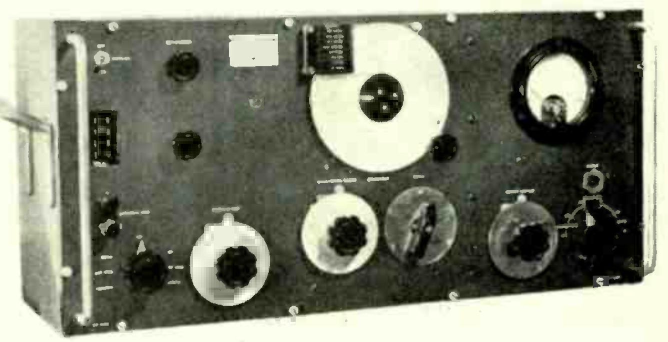

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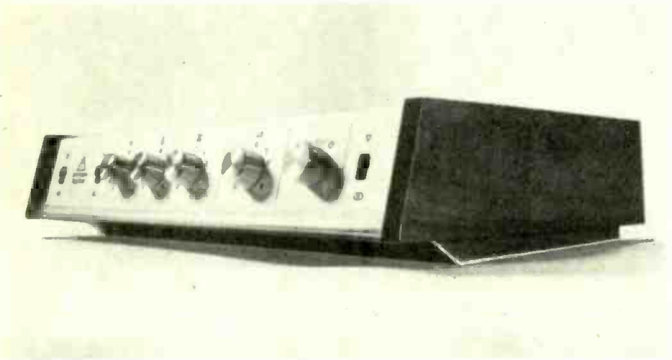

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NO INDIVIDUAL SELECTION.
POST & PACKING 5/-
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CURRENT RANGE OF BRAND NEW L.T. TRANSFORMERS. FULLY SHROUDED (*excepted) TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220/240v

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	6½ 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.

TRANSFORMERS, VARIABLE TRANSFORMERS, CHOKES, CAPACITORS, L.T. SUPPLY UNITS. Send 6d. stamp for latest 12-page Price List.

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PRI 220-240v. sec tapped 6–12 volts 2 amps fully shrouded terminal block connections. Tropicalised screen between PRI and sec. By famous manufacturers. Size H 3ins., D4 ins., inc. T.B.W. 2½ins. 15/-. P. & P. 3/6.

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600 r.p.m. Overall size 2 × 1½ × 1½ins. spindle length 1in. ½in. dia. 10/6. P. & P. 2/6.

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Very powerful. Overall size 2½ × 2 × 2ins. Pull 1½ins. 19/6. P. & P. 3/6.

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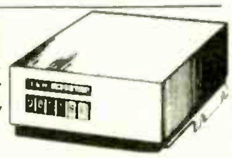
6 figs inc. 1/10ths, 1/100ths 40v. A.C. but complete with transformer for 240v. A.C. operation. All in plastic case. Size 6½ × 6½ × 3in. Condition as new 45/-. P. & P. 5/-.



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.

LONDEX 220-240v. A.C. RELAYS

Open frame type 12 heavy make contacts. 27/6. P. & P. 5/-.

VENNER SYNCHRONOUS BIO-DIRECTIONAL MOTORS

220-240v. 50 cycles 40 r.p.m. automatically reverses wherever spindle stop is placed overall size 2½ × 2 × 1ins. Spindle length ½in. dia. 1/16th. An ideal motor for display, giving a forward and reverse motion. 12/6. P. & P. 2/6.

CROUZET SHADED POLE MOTORS

A.C. 115/230v. 10 watts, 1 r.p.m. Overall size 2½in. dia. depth 2ins. Spindle ½in. dia. ½in.

INGRAM SYNCHRONOUS GEARED MOTORS

220-240v. 50 cycles, 3 watts, 6 rev. per hour. Overall size 2½ × 2 × 1½ins. Cog spindle length ½in. 8/6. P. & P. 2/-.

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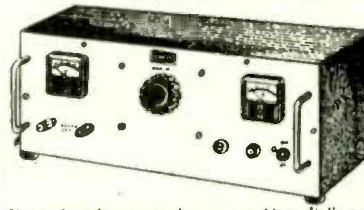
Built into metal case, size 8 × 7 × 7ins., with on/off switch, neon indicator. 13A 3-pin socket outlet. Pri. 220-240v. Sec. 220-240v. 1000 watts. £16.10.0. Carr. 15/-. 750 watts. £14.10.0. Carr. 12/6.

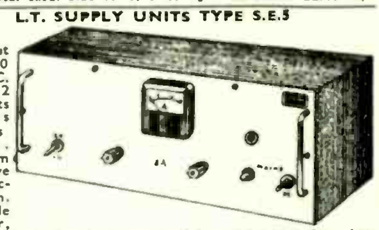
Open frame type. Terminal block connections. Pri. 240v. Sec tapped 110-240v. 2½kva. cont. rating. Size 9 × 8 × 8ins. Weight 65 lbs. £29.10.0. ex warehouse.

VARIABLE D.C. SUPPLY UNITS TYPE S.E.4



0-48 volt 10 amps, continuous from 240 volts A.C. Silicon full wave bridge rectification, isolated transformer with Variac controlled primary 3in. scale voltmeter and ammeter. Neon indicator. Housed in strong metal case. Size 17 × 7 × 6½in. £32.10.0. Carr. 15/-.

L.T. SUPPLY UNITS TYPE S.E.5



A.C. input 220-240 volts. D.C. output 12 or 24 volts 10 amps continuous rating. Selenium full wave bridge rectification. 3 in. scale ammeter, neon indicator. Housed in strong metal case. £17.10.0. Carr. 15/-.

HEINEMANN MAGNETIC CIRCUIT BREAKS

3 ph 440v. 3 pole 7·5 amps panel mounting. 25/-. P. & P. 5/-. Chilton circuit breakers 440v.-240v. 2 pole with solid neutral, 15 amps. 25/-. P. & P. 5/-. Single pole with solid neutral 20 amps. 15/-. P. & P. 3/6.

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COILS AND I.F. TRANSFORMERS IN LARGE-SCALE PRODUCTION FOR RECEIVER MANUFACTURERS

P.11 SERIES 10 mm. × 10 mm. × 14 mm. Ferrite cores 3 mm. 472 kc/s operation. Single-tuned I.F.s and Oscillator Coils.

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These ranges are available to manufacturers in versions suitable for most of the popular types of Transistors. The Oscillator coils can be modified to enable specific tuning capacitors to be used provided that bulk quantities are required.

OUR WINDING CAPACITY NOW EXCEEDS 50,000 ITEMS PER WEEK

On the most up-to-date and efficient machines backed by a skilled assembly labour force for all types of coils and assemblies.

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A WIDE SELECTION OF SERVOMOTORS NOW AVAILABLE INCLUDES THE FOLLOWING TYPES:

Mil size 11-400 Hz versions for 26 and 115v. operation with 10/20, 13/26 and 57.5/115v. control phase windings.

Mil size 08, 10, 11, 15 and 18 motor generators for 400 Hz operation with 26 and 115v. energised tacho generators.

Mil size 08, 10, 15 and 18 two phase servometers also available with 400 Hz windings and a limited range in 50 Hz types.

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Mil Size 11 **Servomotor gearheads** available in various ratios from 10:1 to 1000:1.

All items available ex stock and at extremely competitive prices.

Evershed and Vignoles' Servomotors and Servomotor-generators—we hold stocks of this well known manufacturer's items amounting to about 100 different types—an enquiry stating your broad design considerations will bring a reply by return indicating ex stock availability of the motor most nearly meeting your requirements.

Write for our Data Sheets A 131 onwards for details of available Servomotors.

MIL SYNCHROS available ex stock in sizes 08, 11, 15, 16, 18 and 23 for 50, 60 and 400 Hz operation.

Synchro Control Transformers
Synchro Control Transmitters
Synchro Control Differential Transmitters
Synchro Torque Transmitters and Receivers
Synchro Resolvers

Equivalent MAGSLIP ELEMENTS more suitable for educational use also in stock.

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400 Hz. MOTOR ALTERNATOR SETS Input 400/440v. 50 Hz 3 ph. output 115v. 400 Hz 150VA. (coml. rating) for external excitation £15.

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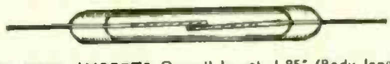
Numerous **instrument types, continuous rotation potentiometers** for control application and **HELIPOTS** in stock. List on application.

Gertsch **COMPLEX RATIO BRIDGE Model CRB2B.** Six digits in phase, four digits in quadrature. **Our Price £200.**



DRY REED INSERTS Overall length 1.85" (Body length 1.1") Diameter 0.14" to switch 500mA at up to 250v. D.C. Heavily gold clad contacts. **12/6d.** per doz., **75/-** per 100, **£27.10.0** per 1000 for quantities over 1000, **£25.0.0** per 1000 for quantities over 10,000. All carriage paid.

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TRANSISTORS Manufacturers' quantities of the following available: BSX76 (CV8615) fast switching silicon n-p-n. For q'ties 100-999 **2/-** ea., 1000-4999 **1/9d.**, over 5000 **1/7d.** ea. ACY20 medium power a.f. germanium. For q'ties 100-999 **1/10d.** ea., 1000-4999 **1/8d.** ea., over 5000 **1/6d.** ea. Both items in makers' packs.

CAMBRIDGE DYNAMOMETER VOLTMETERS in as new condition. 10 range up to 150v. In as new condition **£45.0.0** ea. plus carriage.

NOISE GENERATORS CT82 15KHz-160MHz into 43, 75 or 400 ohms **£22.10.0.**

OSCILLOSCOPES Solartron Type CD568 **£27.10.0.** Fully serviced.

EVERSHED 500v. WEE MEGGER in leather case. Fully checked **£14.0.0** (Carr. Pd.).

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Large stocks of PLESSEY Mk. IV or VI, 104; PAINTON ELECTROMETHODS; CANNON; BELLING LEE; AMPHENOL; TRANSRADIO items.

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Immediate delivery!

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A very wide range of these difficult-to-obtain items in stock. List available.

Carriage extra at cost on all items.

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THE AUDIO *Executive* SIXTY

A high output all-silicon AMPLIFIER of advanced design

We have incorporated into an amplifier all the desirable features that we would always have liked to offer during our several years experience of selling amplifiers—we now have a design incorporating the latest solid state all-silicon circuitry and the result is—

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This creation, while being reasonably priced, provides the following desirable features:—

1. A true 60 Watt R.M.S. continuous rating into 8 ohms.
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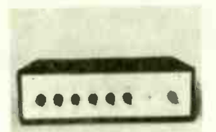
3. Built-in filters to protect speakers.
4. Three independently mixed inputs which can be high or low impedance microphone, crystal ceramic or magnetic cartridge from disc, or from tape, tuner or other auxiliary equipment.

The amplifier is built into a luxurious, supple black semi-quilted plastic covered timber cabinet; the chassis, backed by a massive heat sink carrying the output transistors, input jacks, output sockets, mains voltage adjuster, mains and output fuses, carries the driver transistors mounted on their own substantial heat sink, the input and output controls and the on/off switch. The power supply components are mounted direct on the sturdy chromatised cadmium plated chassis. The Audio Executive Sixty fully meets the requirements for

Discotheques
General Sound Reinforcement Systems.
High Power HiFi Systems.
Vocal and Guitar Amplification.



Price **£58.15.0**

Guaranteed for six months. **Individually packed in cartons. Trade Supplied**

SPECIFICATION

Power Output: 60 watts continuous sine wave into 8 ohms (resistive). 40 watts continuous sine wave into 15 ohms (resistive). 5A fuse incorporated in output circuit.
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.
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Input fused at 2A.

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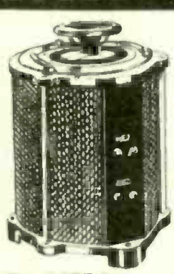
VARIABLE VOLTAGE TRANSFORMERS



50 AMPS

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
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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

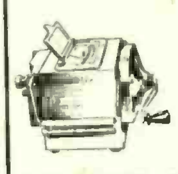
Fully isolated, low tension Secondary winding. Input 230 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.

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

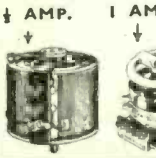
Designed for Panel Mounting. Input 230 v. A.C. 50/60 Output variable.

0-260 v.

½ amp	£3	10	0
1 amp.	£5	10	0
2½ amp.	£6	12	6

P. & P. 7/6

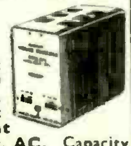
½ AMP. 1 AMP.



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 SOLIO STATE VARIABLE CONTROLLER

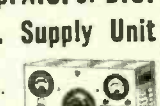
Ideal for lighting and heating circuits, compact panel mounting. Built in fuse protection. CONTINUOUSLY VARIABLE.
Input 230v AC output 25-230v AC
5 amp model **£8. 7. 6**
10 amp model **£13. 5. 0**

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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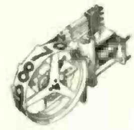
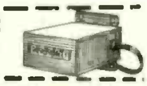
LARGE DIGIT 12-18 v. D.C. MAGNETIC COUNTER



4in. drum, calibrated 0-9. Figures 1¼in. high ¾in. wide. Set of 1m, 1b, 1c/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.

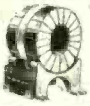
VEEDER ROOT COUNTER



230 v A.C. 50 cycle 5 figure counter (non resetable). 18/6, P. & P. 1/6.

RING TRANSFORMER

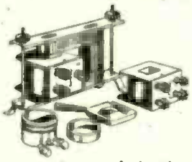
Functional Versatile Educational



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	12 v. at 5A	£1 17 6	5/6
2	30, 32, 34, 36 v. at 5 amps.	£4 13 6	6/-
3	30, 40, 50 v. at 5 amps.	£6 17 6	6/6
4	10, 17, 18 v. at 10 amps.	£4 19 0	4/6
5	6, 12 v. at 20 amps.	£6 8 6	6/6
6	17, 18, 20 v. at 20 amps.	£7 5 6	6/6
7	6, 12, 20 v. at 20 amps.	£6 17 6	7/6
8	24 v. at 10 amps.	£5 4 6	5/6
9	4, 6, 24, 32 v. at 12 amps.	£7 3 0	6/6

AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3/10/- 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.

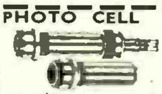
LIGHT SENSITIVE SWITCHES

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



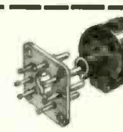
Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair £2/15/0 plus 3/6 P. & P.

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/-

BELLIN MULTI WAY PLUGS AND SOCKETS

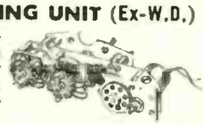


10 way plug and socket. (Socket chassis mounted.)
7 way reversed plug and socket. (Plug chassis mounted.)
Price: either type 3/6 pair. 9d. P. & P.

BURGESS MICRO SWITCH

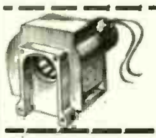
Lever operated c/o contacts. Price 4/- plus 9d. P. & P. 10 in maker's carton. 35/- post paid.

MOTORISED SWITCHING UNIT (Ex-W.D.)



Powerful, precision-made, ex-W.D., 12 v. D.C., reversible motor, drives multiple gear train with outputs approx. 4 r.p.m. and 5 r.p.m. Price 25/- P. & P. 4/6.

Ex. W.D. MINIATURE BLOWER UNIT



18-24 v. D.C. operation, overall length 3½ in. Blower 2¾ × 2½ in., 20/-. P. & P. 2/6.

POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 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 ¾in. dia. 5/16in., 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.

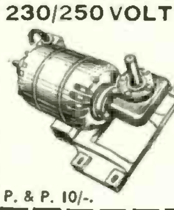
EXPERIMENTERS "ECONOMY" KIT
1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + instructions £5.5.0 plus 5/- P. & P.

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.

PARVALUX TYPE SD19 230/250 VOLT AC REVERSIBLE GEARED MOTORS

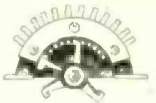


30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. Mounted on **substantial cast aluminium base**. Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. 6 gns. P. & P. 10/-.

DRY REED SWITCHES

2 × 1 amp Dry Reeds (make contacts) mounted in 870 ohm 9-18v coil. Size 3in. × 3½in. × ½in. 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. × 1½in. Mfg. by Elliott Bros. New 45/- each. Post Paid.

MINIATURE UNISELECTOR



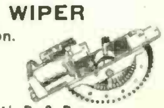
3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6, plus 2/6 P. & P.

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

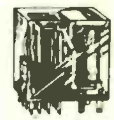


25 ohm coil, 24 v. D.C. operation.
£6.10.0, plus 2/6 P. & P.

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 × 9/16 × 13/16in. 8/6 post paid.

230 VOLT AC RELAY LONDEX four c/o 3 amp contacts. 18/6, incl. base. Post Paid.

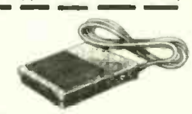
SANWA MULTI RANGE TESTERS

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: 5⅛ × 3½ × 1⅞ in. **Complete with batteries and test prods.** **£7.5.0** Post paid

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/–

FOOT SWITCH



Suitable for Motors, Drills, Sewing Machines, etc. 5 amp. 250 volts. Price 17/6 plus 2/6 P. & P.

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.

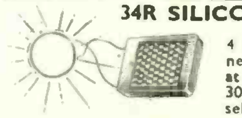
SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY

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 2½in. × 1 1/16in. 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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CA3005 RF Amplifier with 100mc/s bandwidth. Max. dissipation 26mW. For use as RF amplifier, balanced mixer, product detector or self-oscillating mixer. 27/-

CA3012 Wide Band Amplifier (up to 20mc/s), suitable as IF Amplifier for VHF/FM receivers. 22/-

CA3020 General Purpose Audio Amplifier of 550mW output. 30/-

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

PA237 2 watts Audio Amplifier. 40/-

The above three I.C's are in epoxy moulded double four-in-line package.

MC1709CG General Purpose operational amplifier in TO-99 case. 40/-

TAA263 3-stage direct coupled amplifier for use from DC to 600kc/s; 70mW dissipation. Output 10mW into 150 Ω load. 15/-

TAA293 3-stage amplifier with connection brought out to the individual leads. Bandwidth 600kc/s. 160mW dissipation. Output 10mW into 150 Ω load. 20/-

TAA320 MOST input stage followed by a bi-polar translator stage. 200mW dissipation. 13/-

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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The Company is engaged in the design and manufacture of a wide range of radio communications and allied equipment from military pack-set to broadcast transmitter, including communications receivers, M.F. beacons, teleprinter terminals, complete radio office installations for the Merchant Marine and mobile H.F. S.S.B. Stations.
Our Test Engineers have sound technical knowledge coupled with good practical experience in the alignment and test of H.F. and V.H.F. Communications equipment.
The work is varied and interesting and offers excellent opportunity to broaden experience in semiconductors, S.S.B. and Frequency synthesis.
Limited vacancies also exist for engineers experienced in Test gear maintenance.

Please write in the first instance to: The Personnel Officer
REDIFON LTD.,
Broomhill Road, Wandsworth, SW18.

REDIFON

A Member Company of the Rediffusion Organisation.

Suppliers of Radio Communications equipment to Home, Commonwealth, and foreign governments. Contractors to B.B.C., G.P.O., Crown Agents, Cable and Wireless, leading shipping companies of the world, etc.

403

Government of ZAMBIA

Police Department

requires

RADIO SPECIALIST

on contract for one tour of 36 months in the first instance. Salary according to experience in the Scale Kwacha 2460 to 3000 (Approx. £.Stg.1435–Stg.1750) plus an Inducement Allowance of £.Stg.684 a year which is payable direct to the Officer's bank in the U.K. Gratuity of 25% of total salary drawn. Both gratuity and Inducement Allowance are normally TAX FREE. Liberal leave on full salary or terminal payment in lieu. Free passage. Accommodation at moderate rental. Education Allowances. Outfit and plain clothes allowances. Contributory pension scheme available in certain circumstances.

Candidates, who will serve in the rank of Inspector of Police, must have completed a five year apprenticeship or hold a Service Trade Certificate or equivalent qualification and have had at least six years post-qualification experience in the Installation and maintenance of modern low and medium power H.F. equipment, S.S.B. and I.S.B. equipment, and of V.H.F. equipment including multiplex links. Knowledge of maintenance of teleprinters, diesel and petrol generators preferred.

The Officer will be required to maintain and install police radio equipment throughout Zambia, travelling by road and air, and to train Zambian Officers for City and Guilds examinations.

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/61274/WF.

404

Borough of Lowestoft Committee for Education

LOWESTOFT COLLEGE OF FURTHER EDUCATION

Engineering and Science Department

Principal: A. E. Boddy, B.Sc.(Econ.), F.R.G.S.

LECTURER

LECTURER GRADE I required for teaching radio, electronics and other subjects associated with the General Certificate for the Radio Officer (Merchant Navy) Course.

Salary in accordance with the Burnham Scale, at present £1,110 to £1,850, plus allowances for approved qualifications. Starting point within the scale determined by past teaching and/or appropriate industrial experience.

The post is vacant as from the 1st of May, 1970. Applicants preferably with teaching experience, suitable qualifications and industrial experience should apply to the Secretary, The Lowestoft College of Further Education, St. Peter's Street, Lowestoft, Suffolk, for further particulars and application form.

393

SKILLED MEN are required for the repair and overhaul of aircraft instruments and flight control units at BEA's Workshops at Heathrow Airport – London. Applicants should preferably be apprentice trained in one of the following trades–

- Electrical
- Instruments (Fine mechanical)
- Radio
- Electronics

and can expect a certain amount of 'on-the-job' training.

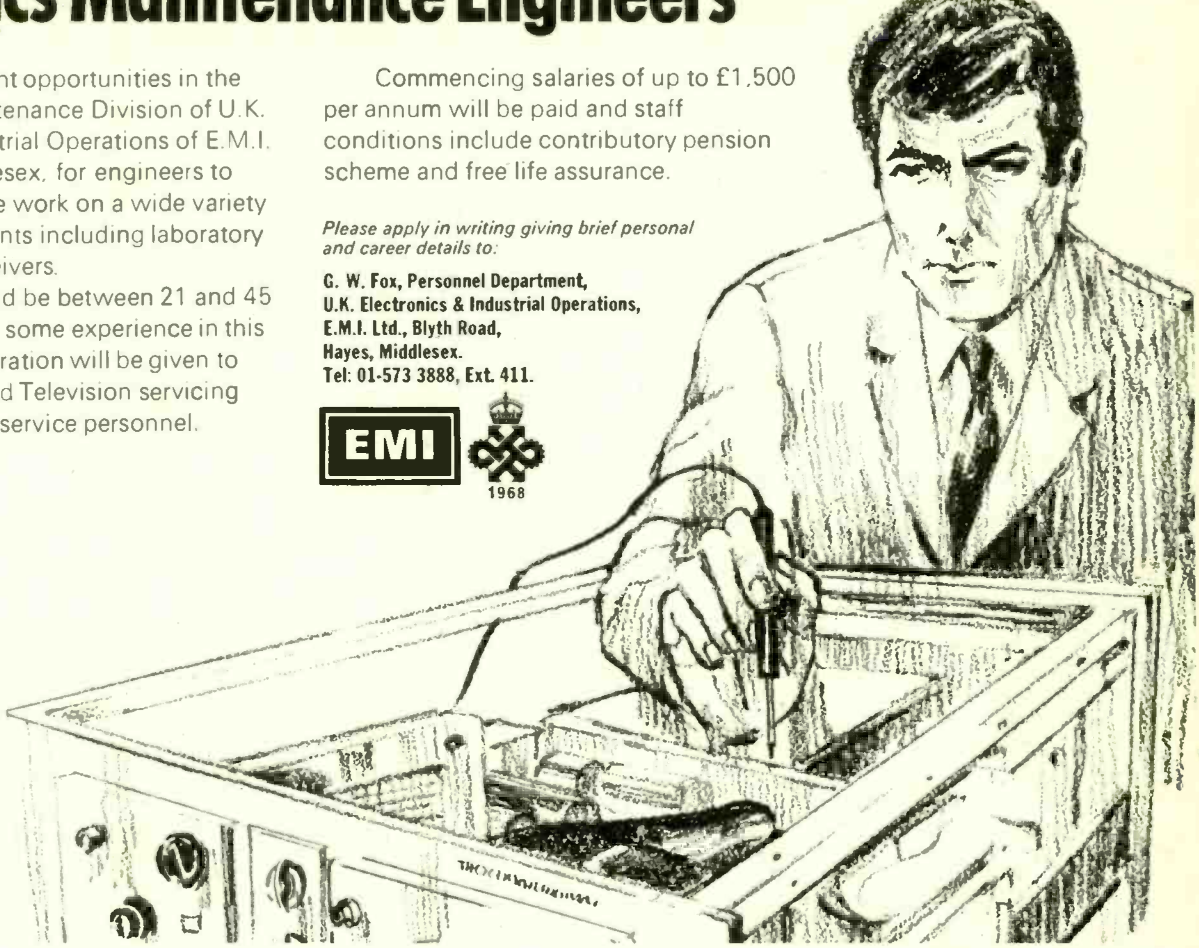
Commencing rate £27.4.6. rising within 6 months to £28.16.0. and ultimately to £32.16.6. according to qualifications and responsibility. Avionics supplement of £2.10.0. pw may later be earned by qualified staff.

* Good promotion prospects
* Generous shift payments when applicable
* Opportunities for holiday air travel.

Write or phone for an application form to
Personnel Officer Engineering (Employment) (WW)
BEA, Engineering Base,
Heathrow Airport – London,
Hounslow, Middlesex.
SKYport 3131 Exts. 4302, 4185 or 4692

BEA

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

309

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

SENIOR TELEVISION TECHNICIAN

is required to be responsible for facilities in a small wired TV Systems Laboratory. He should be conversant with Colour Television Receivers and will be responsible for the maintenance of specialised test equipment. Other duties will include maintenance of records and equipment movement control.

Qualifications in R.T.E.B. and Colour Endorsement or H.N.C. desirable.

Good prospects of promotion for a keen young man with initiative. Salary negotiable up to £1,500 p.a. depending on qualifications. Training can be given. Subsidised canteen.

Write, giving details of past experience to:

Head of Operational Services Dept.
Rediffusion Engineering Ltd.
187 Coombe Lane West
Kingston-upon-Thames, Surrey
Tel: 01-942 6641 390

COUNTY MEDICAL PHYSICS DEPARTMENT

ST. GEORGE'S HOSPITAL, LINCOLN

ELECTRONICS TECHNICIAN

(Medical Physics Technician Grade III)

Salary scale: £1,180—£1,500 p.a.

required to assist in the development and construction of electronics instruments used in Medical Physics. Applicants should possess O.N.C. or equivalent electro-technical qualifications and should be able to construct and test equipment from circuit diagrams. Applications, including age, details of qualifications and experience with the names of two referees to be sent to **The Hospital Secretary, St. George's Hospital, Lincoln.** 356

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.

405

METROSOUND GROUP OF COMPANIES

ELECTRO-MECHANICAL ENGINEER

A vacancy exists for a skilled Electro-mechanical Engineer who will be required to service and maintain a production unit of high speed tape duplicating equipments.

The applicants must be thoroughly conversant with the latest transistorised circuitry as applied to professional tape recorders and ideally should have had some experience with studio equipments.

The successful applicant who will be laboratory based will be paid a minimum salary of £1,600 p.a. which could be considerably increased in the case of an exceptionally experienced or qualified applicant.

Please write or telephone in the first instance to:

**Mr. R. Bishop,
Audio Works, Cartersfield Road,
Waltham Abbey, Essex.
Waltham Cross 31933.**

402

OMRON PRECISION CONTROLS

SUPPLIERS OF

**PROCESS TIMERS
MICRO & LIMIT SWITCHES**

are still expanding
and require experienced

FIELD SALES ENGINEERS

also

SALES OFFICE MANAGER

to co-ordinate operations
Apply: P. A. LEIGH.
Tel. 01-723 2231

349

RADIOLOGICAL PROTECTION SERVICE

(Department of Health and Social Security and Medical Research Council)
Clifton Avenue, Belmont, Sutton, Surrey

requires

Junior Technician and Technician

POST 1. **JUNIOR TECHNICIAN** required for duties in the Department of Electronics to assist in the construction of nucleonic instruments. Preference will be given to those candidates with aptitude and interest in electronic and mechanical practice. Salary according to experience at a point on the scale £467 (—922) plus London Weighting. M.R.C. conditions of employment.
Applications with the names and addresses of two referees to the Administrative Officer at the above address, quoting reference 70/3/4/17.

POST 2. **TECHNICIAN** required for duties in the Department of Electronics to maintain nucleonic instruments and systems. Previous experience of testing and 'fault-finding' on Electronic equipment is essential. Two 'A' level G.C.E's desirable but not essential.
Salary according to qualifications and experience at a point on the scale £982 (—1255) plus London Weighting. M.R.C. conditions of employment.
Applications with the names and addresses of two referees to the Administrative Officer at the above address, quoting reference 70/3/4/9.

Closing Date: 19.3.70

386

COMPUTER ENGINEERS

the big Burroughs challenge!

Burroughs large on-line systems dominate the U.K. market. A wide variety of concepts, a rapidly expanding market and a policy of promotion from within – all mean exciting opportunities for trained computer engineers to develop their skills in the large, on-line systems field or into the supervisory grades and beyond. Join the Burroughs boom – and grow with us.

We want experienced computer engineers to work on our B5500 and B6500 installations in the Greater London area With Burroughs, you can find the freedom to enlarge your talents, open fresh horizons, learn new skills – on the largest third generation systems in the world – these are the exciting prospects at Burroughs. In return we are offering you three weeks' paid holiday, free life assurance and a contributory pension scheme.

If you have an electronics qualification and experience with computer systems, then take a big step now into one of today's development industries – fill in the coupon and send off for one of our application forms. The address is:

The address is: **Geoff Lewis, Burroughs Machines Ltd. (Z), Heathrow House, Bath Road, Cranford, Hounslow, Middlesex.**

Computers | Visible Record Computers | Electronic Accounting Systems | Accounting & Adding Machines | Calculators | Cash Registers

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ADDRESS ....

.... WW/A

Vacancies exist in our AYLESBURY and CRAWLEY factories for:

SERVICE ENGINEERS

Our Product. Flight Simulators

Requirements. A complete theoretical knowledge coupled with at least 2 years practical experience in one or more of the following:—
Digital computing techniques, hardware, software & computer peripherals.
We are prepared to train suitable applicants who have considerable experience in transistorised and integrated circuits.
A knowledge of analogue computing techniques and principles of hydraulics systems would be advantageous. ONC or City & Guilds Electronics.

Travel. Must be prepared to travel anywhere in the U.K. and Overseas.

Salary. Negotiable but we are prepared to go as high as £1,800. for the right persons.

Applications to:

Personnel Manager, Redifon Air Trainers Limited, Bicester Road, Aylesbury, Bucks.

Personnel Manager, Redifon Limited, Flight Simulation Division, Gatwick Road, Crawley, Sussex.

413

BP

requires an

ASSISTANT TECHNICIAN

to undertake maintenance and development work in the Communications Division of their LONDON OFFICE. The maintenance element involves a sound knowledge of Teleprinters and associated telegraph equipment, and the development work requires a good working knowledge of Electronics and/or Audio systems.

Candidates, aged 25 to 30 years, should possess a minimum qualification of ONC and have at least 2 years' relevant practical experience. Preference will be given to applicants continuing their studies to HNC.

We offer three weeks' holiday, subsidised lunches, non-contributory pension and other benefits.

Please write giving brief details to **Mrs. M. G. Park, External Recruitment, The British Petroleum Company Limited, Britannic House, Moor Lane, London, E.C.2,** quoting reference R.11193/ZH.

407

ANTARCTIC EXPEDITION

require

Wireless Operator/Mechanics

With current morse speed of 20 w.p.m. PMG Certificate, teleprinter experience essential. Salary from £1,003 according to qualifications and experience with all living and messing free.

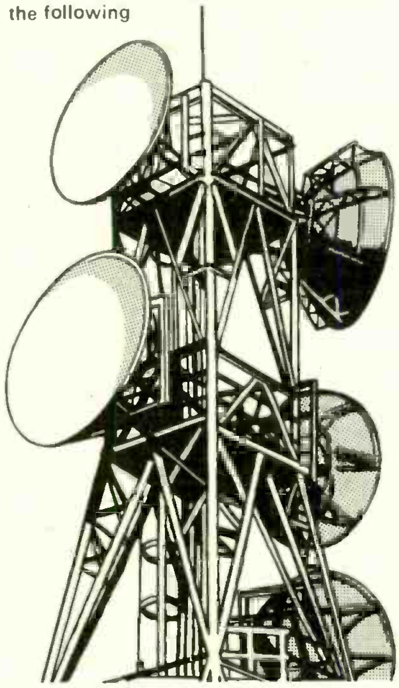
For further details apply to:

BRITISH ANTARCTIC SURVEY
30 Gillingham Street, London, S.W.1

406

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

UNIVERSITY OF LIVERPOOL
Institute of Child Health
Alder Hey Children's Hospital

Applications are invited for the post of

ELECTRONICS TECHNICIAN

to assist with research. Applicants should be suitably qualified and have experience in general instrumentation and pulse techniques. The successful applicant will be expected to be able to assist in the design and development of medical electronic Instruments. Initial salary, according to age, qualifications and experience. Application forms may be obtained from the Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote ref. RV/5643/W.W. 384

JUNIOR ELECTRONICS TECHNICIAN

required for construction and repair of electronic instruments and maintenance of a Linear Accelerator. G.C.E. "O" level in Physics and Maths required; "A" levels or O.N.C. an advantage. Day release for further study is possible. Salary according to age and experience.

Apply with full details to The Director, Medical Research Council Cyclotron Unit, Hammersmith Hospital, London, W.12.

360

MALE TECHNICIAN

BRISTOL POLICE require a Technician to service and maintain facsimile and dictation equipment.

38 hour week. Salary £965-£1,130 according to qualifications. The post is superannuable. Applications to:
The Chief Constable
Bristol Police Headquarters, Bristol 1 389

CRAFTSMEN and SEMI-SKILLED MEN

are required for interesting work in the Signal Engineering Department of London Transport at FULHAM

The workshop in which these vacancies exist undertakes a considerable variety of work which includes the manufacture of prototype mechanical and electronic equipment for Signalling, Automatic Trains and Automatic Fare Collection projects together with the overhaul of electro-pneumatic equipment, ticket machines, clocks, telephones and allied apparatus and fault finding on electronic components.

- **GOOD RATES OF PAY AND PROSPECTS OF PROMOTION**
- **ADDITIONAL PAYMENT FOR OVERTIME**
- **EXCELLENT WORKING CONDITIONS**
- **FREE TRAVEL ON AND OFF DUTY**
- **PENSION AND SICK SCHEMES**

This is an opportunity for a secure, absorbing and worthwhile occupation. Please apply to a London Transport Recruitment Centre:—

Griffith House,
280 Old Marylebone Road,
London, N.W.1

Chiswick Works,
566 High Road,
Chiswick,
London, W.4 359

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.

84

CAREERS IN RECORDING

PHILIPS PHONOGRAPHIC INDUSTRIES in Baarn, Holland, offer excellent career possibilities to young men between 22 and 30 years of age to join the Classical Recording Department as technicians.

Duties will include the installation and maintenance of equipment on major recording sessions in various parts of Europe.

Candidates must be prepared to reside in Holland and should have a thorough knowledge of at least one European language, ideally German or French.

Essential requirements are a good knowledge of music and the ability to follow a musical score; practical knowledge of basic electronics with experience in transistor circuitry and techniques; a general knowledge of recording and test equipment. ONC in telecommunications and audio experience would be an advantage.

Please apply in writing, giving details of age, education and experience, to:

The Personnel Officer,
Philips Records Limited,
Stanhope House,
Stanhope Place,
London, W.2.

Initial interviews will be held in London.

345

ELECTRONICS TECHNICIANS

As part of our rapid expansion in production requirements, we need a number of experienced men to trace and rectify faults in the complex equipment we use in the assembly and testing of semi-conductors. A sound knowledge of basic electronics is essential, and experience of working with advance equipment is highly desirable.

Good pay and conditions. Overtime work readily available.

Please write brief details or telephone for application form to:

ITT

Personnel Manager
STC Semiconductors Limited
Footscray, Sidcup, Kent
01 · 300 · 3333 Ext. 397

STC SEMICONDUCTORS

369

£2,200 — £2,600
ELECTRONIC ENGINEERS

are required for interesting contracts in the SOUTHERN HOME COUNTIES. Min. qualification H.N.C. and design experience in one of the following fields—wide band solid state feedback amplifiers, filters and networks or communication repeater amplifiers. Write to:

STRAND TECHNICAL CONTRACTORS LTD.
Norman House, 105-109 Strand, London, W.C.2; or Tel.: 01-836 6443

Quote Ref. B.37

346

Experienced Mftr./Working Jewellers have spare capacity to diversify with Electronics manufacturer. Five/soft soldering-Rhodium Plating of small component parts.

Strictest confidence. **Box No. WW392**

392

NOTTINGHAMSHIRE
BEESTON COLLEGE OF FURTHER EDUCATION

Radio, TV and Electronics Technicians, Part I
Course No. C & G 434

A one-year, full-time and/or block release course will commence in September, 1970. The course will be open to students already engaged in the Industry and to students leaving school this year who possess a good standard in mathematics and science. Minimum age of entry is 16 years.

Radio, TV and Electronics Mechanics, Part I & II
Course No. C & G 433

A two-year block release course will be offered in September, 1970. Part I of 13 weeks and Part II of 22 weeks. Minimum age of entry is 15 years.

Radio and Television Servicing, Part I
Course No. C & G 48

This one-year, full-time course will be offered next session for the last time after which it will be replaced by the Technicians and Mechanics courses. Students already in industry and those leaving school this year who possess a good standard in mathematics and science will be accepted on this course.

For further particulars and entry forms for the above courses write to: The Principal, Beeston College of Further Education, High Road, Beeston, Nottingham, NG9 4AH.

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

DEPARTMENT of Nuclear Physics, University of Oxford, has a vacancy in the experimental electronics group for a technician to work on the development, building and maintenance of modern nuclear electronic equipment. Salary within the range of £659-£1,316 depending on age, qualifications and experience. Five-day week working and good paid leave. Write to T. L. Green, Nuclear Physics Laboratory, Keble Road, Oxford, mentioning reference A123. [408

ELECTRONICS OFFICER required to run C.C.T.V. and Audio Section of the Department of Audio-Visual Communication, British Medical Association. He will be required to give information and advise on equipment to medical teachers. His responsibilities will include establishing contact with manufacturers, ordering equipment and materials, maintaining, modifying and operating equipment for demonstration and experimental purposes. Applicants should be able to present evidence of formal training and practical experience will be essential. The starting salary will be up to £1.550 p.a. according to qualifications and experience. Write briefly, in the first instance, stating age, education, qualifications and experience to the Director, Department of Audio Visual Communication, The British Medical Association, B.M.A. House, Tavistock Square, London, W.C.1. [347

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

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

SERVICE ENGINEER for repairing Audio Equipment required by Dixons Photographic Ltd., to be employed at North Acton. If interested, please contact P. Rowley for more details, either by telephone (01-965 0411) or by letter to Camera House, 95 Victoria Road, London, N.W.10. [362

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

TECHNICIAN

Applications are invited for the post of technician to maintain computer systems, to construct computer hardware, and to assist in the general running of a small electronics laboratory.

Suitable qualifications are experience in electronic equipment construction and maintenance of electro-mechanical devices and an interest in the subject generally.

Salary range £868–£1,486.
Pension plan.

Apply in first instance by letter stating briefly personal details and relevant experience to:

Mr. P. FENWICK, C.C.A.
R.S.M. Building, Imperial College,
Prince Consort Road, London, SW7

383

CRANFIELD INSTITUTE OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND CONTROL ENGINEERING

Applications are invited for appointment as

TECHNICAL OFFICER

in the High Frequency and Radar laboratories which are concerned with postgraduate teaching and research.
The duties, which are interesting and varied include the supervision of the day-to-day activities in the laboratories and responsibility for the development of specialised experimental equipment. Candidates should have appropriate experience and possess an H.N.C. or Graduateship of a professional institution as a minimum qualification. Salary within scale rising to £1,623 p.a. (under review). 37-hour week of five days, staff superannuation and sick pay schemes, generous holidays. Subsidised transport over a wide area.

Application form from Staff Records Officer, Cranfield Institute of Technology, Cranfield, Bedford.

373

RADIO TECHNICIAN

with initiative, responsibility, and ability to work unsupervised, is required by company operating construction barges and rigs in the North Sea.

The applicant should be capable of carrying out all repairs to VHF, SSB, Marine I.F. R-T, Radar, Sonar, and C.C.T.V.

Offshore and away from base duties may be frequent.

Salary will be negotiable.

Applicants should write giving brief details of experience and stating qualifications to:

Mr. Paul Nagelsmit
Brown & Root (U.K.) Limited
Casing Yard, Suffolk Road,
Great Yarmouth, Norfolk
Tel: Great Yarmouth 55371

352

SITUATIONS WANTED

ELECTRONIC ENGINEER, 22 years experience D.C. L.F., Audio, etc. Products and test gear. Presently £2,000 p.a., London, seeks responsible position West of line Salisbury/Worcester. Alternatively seeks others to start small Design/Manufacture Business same area. Box No. W.W. 396 Wireless World.

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 Minister of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic, the Post Office can offer you employment at a United Kingdom Coast Station, with a starting salary of £965—£1,215 (depending on 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 21 or over, please 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

93

Test Technicians

Our test department is expanding. It is responsible for the testing of magnetic storage devices, high-speed printers, punched-card and paper-tape equipment.

For people with experience in electronics, opportunities exist immediately. Further vacancies will arise over the next few months. Training will be given to those who do not have previous computer experience.

Applicants must have worked on the testing, maintenance or repair of electronic equipment, and preference will be given to those qualified to ONC (Elect.) or C&G Final.

Locations: Kidsgrove and Winsford. Both are situated in rural surroundings bordering on the Cheshire Plain. Housing is available at attractive prices, and assistance with mortgage can be arranged.

Write giving details of age, qualifications, and experience, to:

Brian Buckley, Personnel Services Manager,
International Computers Ltd., Kidsgrove,
Stoke-on-Trent, quoting reference WW239M.

International Computers **ICL**

ELECTRONICS CIRCUIT DESIGN ENGINEER

for varied and interesting work on the application of I.C.'s and discrete component circuits to the control and regulation of electric power.

Minimum qualifications: O.N.C. (Electronics). Experience in closed loop system design would be valuable.

Housing and removal assistance available in some circumstances.

Write with full details to:

The Technical Director,
BRENTFORD ELECTRIC LIMITED,
Manor Royal, Crawley,
Sussex

358

LEEDS POLYTECHNIC
Calverley St., Leeds LS1 3HE

Full-time three-week courses:

The Principles of

COLOUR TELEVISION

4th-22nd May and 8th-26th June

For details, write to:
Department of Electrical Engineering

370

PERKIN-ELMER LIMITED OF BEACONSFIELD

is actively engaged in the development and manufacture of automatic analytical equipments using infra-red, ultra-violet, nuclear magnetic resonance and other techniques.

The Company is in the process of considerable expansion and requires:

ELECTRONIC TEST ENGINEERS

The job descriptions for these appointments call for a sound knowledge of modern electronic circuits and the ability to diagnose faults logically and systematically using standard test methods. O.N.C. (Elec); City and Guilds Technicians Certificate or equivalent is desirable, but applications will be considered from those who have good practical test experience.

Apply to:
P. L. Nielsen
Personnel Officer
PERKIN-ELMER LIMITED
Post Office Lane
Beaconsfield, Bucks.

ARTICLES FOR SALE

AMAZING VALUE

Plessey SL402A Preamp and 2W Amp 42/-
GE PA234 1W Audio Amplifier 17/6
RCA 40669 8A 400V Triac 24/-

Notes supplied FREE with each order.
New Full Specification Devices, by Return.
P & P 1/-. Cash With Order. Mail Order Only.
Unbeatable rates for medium quantities.
JEF ELECTRONICS (W.W.), York House, 12 York Drive, Grappenhall, Warrington, Lancs. 394

CAPACITOR DISCHARGE IGNITION SYSTEM *(W.W. JANUARY 1970)*

Invertor transformer 30VA Ratio 15 : 1

CWO **32/-** + 5/- p. & p.

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Output Matching Impedance	4-16 ohms (100 V line extra).
Output Power	50 Volt-amperes nominal. (Watts into an 8 ohm resistive load).
Distortion	0·025% at clipping onset. 0·01% at −3 dB ref: clip level.
Input Facilities	High impedance 22K ohms. Low impedance, optional 200/600 ohms balanced/unbalanced.
Input Sensitivity	High impedance. 1 Volt r.m.s. Low impedance. 0·5 Volt r.m.s.
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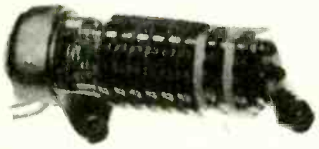

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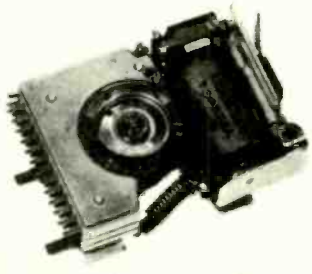

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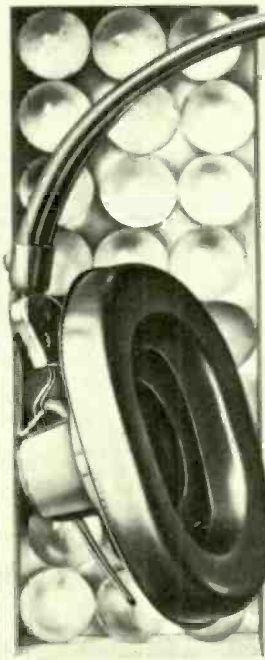

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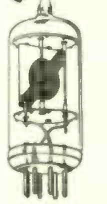

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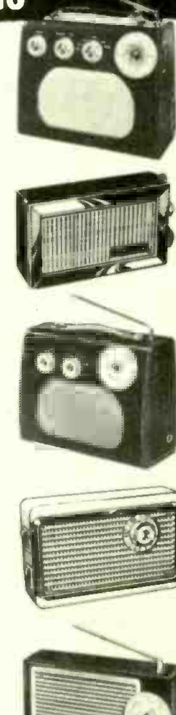

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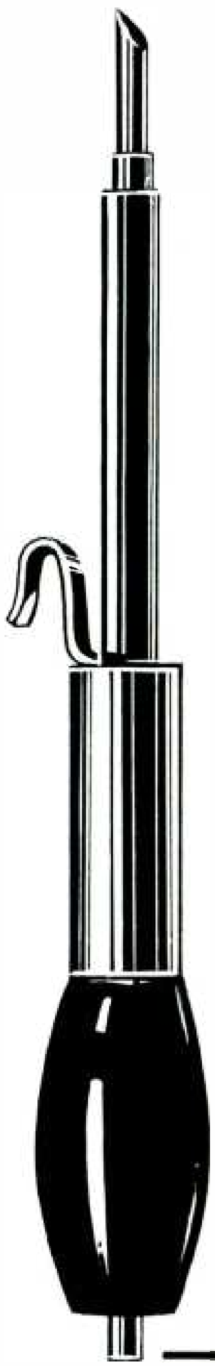

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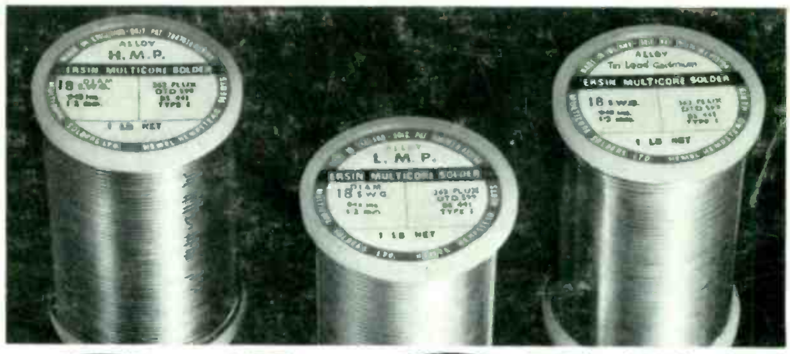

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H.M.P.

HIGH MELTING POINT

For service at high temperature, or service at very low temperatures. Outstanding creep strength. Melting range 296°C – 301°C (565°F – 574°F).

Applications

A useful application of H.M.P. is the soldering of joints close to each other in such a way that the connections made first are not re-melted while later joints are made, with for example, a standard 60/40 alloy, melting point 188°C. Essential for use where high operating temperatures are experienced, for instance, electrical motors, car radiators, high temperature lamps. H.M.P. is also ideal for equipment, which is being operated in low temperatures, as it reduces the chance of the joint becoming brittle.

Specification

Multicore H.M.P. alloy complies with BS.219 Grade 5S. Supplied in a form of Ersin Multicore 5 core solder wire on 1lb. or 7lb. reels, incorporating Ersin 362 rosin based flux. This non-corrosive flux-cored solder wire complies with BS.441 and is available from 10 to 26 s.w.g., and in Multicore Solder Preforms. Ask for Technical Bulletin No. 1369.

L.M.P.

LOW MELTING POINT

A low melting point solder for soldering silver plated and gold plated surfaces. Melting point 179°C (354°F).

Applications

L.M.P. reduces the absorption of silver or gold into the solder alloy whilst soldering, and therefore, preserving the silver or gold plated surfaces. Also reduces the chance of a brittle joint being made.

NOTE

a) The solution of gold into tin rises rapidly with temperature and so the use of L.M.P. Low Melting Point Solder is preferable.
b) The solution rate of gold into tin is also reduced because L.M.P. is a ternary alloy comprising tin, lead and silver.

Specifications

L.M.P. is normally supplied in the form of Ersin Multicore 5 core solder wire, incorporating Ersin 362 rosin based flux, which complies with Min. Tech. specification D.T.D. 599A. It is available from 10 to 34 s.w.g. in 1lb. or 7lb. reels and Multicore Solder Preforms. Ask for Technical Bulletin 1469.

T.L.C.

EXTRA LOW MELTING POINT

Extra low melting point solder. Melting point 145°C (293°F).

Applications

T.L.C. alloy can be used whenever a soldered joint should be made with the minimum heat input. This would include heat sensitive transistors, flexible printed circuits and gold plated surfaces. The melting point of T.L.C. alloy is 38°C lower than any tin/lead alloy. Because of its low temperature application it is considered completely non-toxic in use unlike the high temperature cadmium-bearing brazing alloys.

Specification

T.L.C. alloy is normally supplied in the form of Ersin Multicore 5 core solder wire, incorporating Ersin 362 rosin based flux, which complies with Min. Tech. Specification D.T.D.599A. T.L.C. alloy can also be supplied in the form of Multicore precision made solid solder wire, Extrusol extruded solid solder bars for solderbaths and Multicore Solder Preforms. Available from 10 to 34 s.w.g. on 1lb. or 7lb. reels. Ask for Technical Bulletin No. 1569.

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