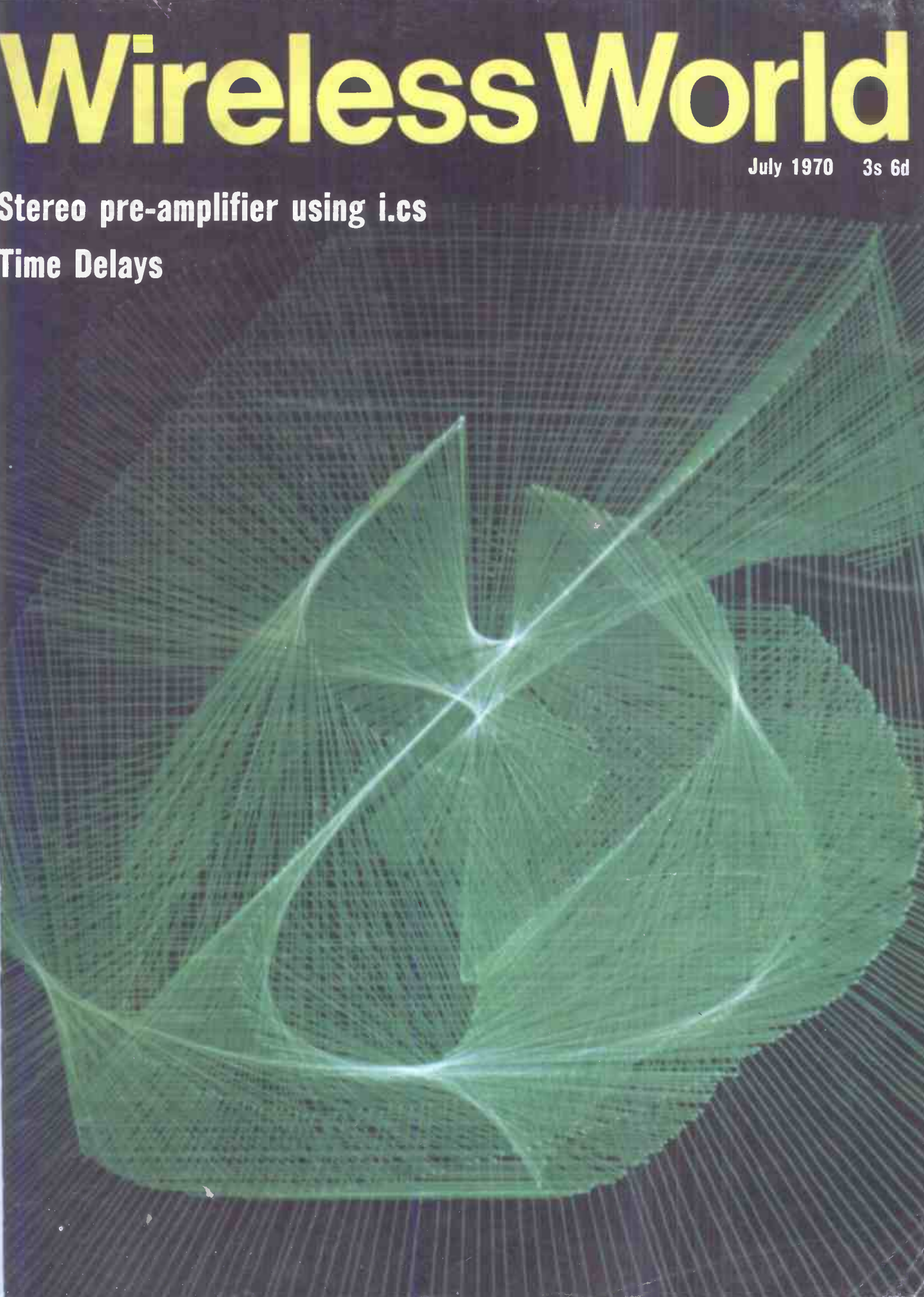
Wireless World

July 1970 3s 6d

Stereo pre-amplifier using i.cs

Time Delays



Wireless World

Electronics, Television, Radio, Audio

Sixtieth year of publication **July 1970** **Volume 76 Number 1417**

Our **cover picture** this month was selected on its artistic merits rather than to highlight any particular technical point. The design was produced by a Univac computer and graphic display unit as described on page 315.

IN OUR NEXT ISSUE

The first of a short series of articles on the design and construction of a **television wobbulator.**

Colour EVR. An outline of the system of colour electronic video recording developed by Dr. Goldmark of RCA.

Morse keyer using four m.o.s. logic circuits.

Contents

311 **"Together we stand. . . ."**

312 **Integrated Circuit Stereo Pre-amplifier** *by L. Nelson-Jones*

315 **Computer Graphics**

316 **Circuit Ideas**

317 **Time Delays** *by H. D. Harwood*

320 **Mechanical Filters for TV Receivers**

321 **15-20W Class AB Audio Amplifier** *by J. L. Linsley Hood*

325 **Electronic Building Bricks—2** *by James Franklin*

326 **News of the Month**

329 **Letters to the Editor**

332 **Sinusoidal Oscillator for use at High Temperatures** *by P. Williams*

333 **The Unijunction Transistor** *by O. Greiter*

336 **Crossword Puzzle**

337 **A Simple Op. Amp.** *by H. N. Griffiths*

338 **Conferences & Exhibitions**

339 **Noise in Transistors** *by F. N. H. Robinson*

340 **Domestic Video Records**

341 **Active-Filters—12** *by F. E. J. Girling & E. F. Good*

345 **H.F. Predictions**

346 **Coding Problems in Iterative Arrays** *by K. S. Hall*

349 **Roots and Responses** *by Thomas Roddam*

353 **Signal Monitoring Networks** *by A. E. Crump*

354 **Announcements**

355 **New Products at the I.E.A. Exhibition**

361 **World of Amateur Radio**

362 **Literature Received**

363 **Personalities**

364 **Real & Imaginary** *by "Vector"*

A89 **APPOINTMENTS VACANT**

A108 **INDEX TO ADVERTISERS**

ibpa
International Business Press Associates

I.P.C. Electrical-Electronic Press Ltd
Managing Director: Kenneth Tett
Editorial Director: George H. Mansell
Advertisement Director: George Fowkes
Dorset House, Stamford Street, London, SE1

PUBLISHED MONTHLY (3rd Monday of preceding month). *Telephone:* 01-928 3333 (70 lines). *Telegrams/Telex:* Wiworld Bisnespres 25137 London. *Cables:* "Ethaworld, London, S.E.1." *Annual Subscriptions: Home;* £3 0s 0d. *Overseas;* 1 year £3 0s 0d. (*Canada and U.S.A.;* $7.50). 3 years £7 13s 0d. (*Canada and U.S.A.;* $19.20). Second-Class mail privileges authorised at New York N.Y. Subscribers are requested to notify a change of address four weeks in advance and to return wrapper bearing previous address. BRANCH OFFICES: *BIRMINGHAM:* 202, Lynton House, Walsall Road, 22b. *Telephone:* 021-356 4838. *BRISTOL:* 11, Elmdale Road, Clifton, 8. *Telephone:* OBR2 21204/5. *GLASGOW:* 2-3 Clairmont Gardens, C.3. *Telephone:* 041-332 3792. *MANCHESTER:* Statham House, Talbot Road, Stretford, M32 OEP. *Telephone:* 061-872 4211. NEW YORK OFFICE U.S.A.: 205 East 42nd Street, New York 10017. *Telephone:* (212) 689-3250.

Wireless World

Editor-in-chief:
W. T. COCKING, F.I.E.E.

Editor:
H. W. BARNARD

Technical Editor:
T. E. IVALL

Assistant Editors:
B. S. CRANK
J. H. WEADEN

Editorial Assistant:
J. GREENBANK, B.A.

Drawing Office:
H. J. COOKE

Production:
D. R. BRAY

Advertisements:
G. BENTON ROWELL *(Manager)*
G. J. STICHBURY
R. PARSONS *(Classified Advertisement Manager)*
Telephone: 01-928 3333 Ext. 533 & 246.

"Together we stand . . . . . ."

We have on several occasions deprecated the proliferation of trade associations within the electronics industry. Our criticism has been mainly of the lack of overall co-ordination rather than of the number of organizations, all of which have performed a useful function, some within a limited and diminishing sphere—in fact in some cases there is no longer a *raison d'être*.

When the Conference of the Electronics Industry (abbreviated C.L.I. to avoid confusion with the Council of Engineering Institutions) was set up, with the top brass of the industry forming the council, it was hoped that here at last was the apex of the broad based triangle. The voice that could speak to governments, other associations and foreign organizations for the whole of the U.K. electronics industry; the industry's co-ordinating authority. As events have shown it was none of these, in fact, except for an annual dinner—at which a few pious platitudes were pronounced—little if anything was heard of its activities. It may, of course, have exerted a powerful influence without ostentation.

It is now announced that the C.L.I. is to be wound up. Will this mean a further fragmentation or will it open the way for another more effective body (the E.E.A.?) to take the helm?

There are certainly significant moves towards the unification of the various trade associations. First, the Electronic Engineering Association is to move later this year into the same building as the British Electrical and Allied Manufacturers' Association where they will share "service departments" and will liaise much more closely than in the past. The interests of the two associations certainly overlap in some areas. A joint "federation council" is to be set up. It is understood that other trade associations have been invited to come under the same roof (if not the same ceiling!) and thereby to save expense. The response however, has not been very heartening from some of them. One suggested that it could best serve the particular sector of the industry, by retaining its independence.

There has, of course, been a marked co-ordination of effort in the components sector of the industry since the formation of the Electronic Components Board. The question of proposed "federal structure" of the whole electronics industry is mentioned in the recent annual report of the Radio & Electronic Component Manufacturers' Federation. In view, however, of "the success of the E.C.B. in establishing an organisational identity for the components sector without prejudice to the internal autonomy of the three constituent associations (R.E.C.M.F., B.V.A. & V.A.S.C.A.) it would seem that the next logical stage in the evolution of an industry federation would be to co-ordinate the policies and activities of the Capital Equipment sector, in which five associations are involved to varying degrees".

This castigation of the "capital equipment sector" is not without justification. Not only would a federal structure bring added strength, avoiding the "you're treading on my territory" attitude which undoubtedly exists between secretariats, but the manufacturers would be saved the direct costs involved in multi-participation, and the indirect costs of representation on several associations in the capital goods sector.

At the annual meeting of the E.E.A. in March it was stated "We are trying to rationalize our trade associations . . . . . to have a more powerful voice". It is to be hoped that with the moves now going on we may see the dawn of a unifying electronic industries association in this country such as is operating in the U.S.A. and Japan. With the possibility of a closer link with Europe through the Common Market we will need such an organization to speak authoritatively to its opposite numbers in Germany and France.

Integrated Circuit Stereo Pre-amplifier

A simple low-noise design especially for use with the author's recently described 10-W class-A amplifier

by L. Nelson-Jones

The power amplifier[1] for which this pre-amplifier was designed has very low levels of noise and distortion, and in order not to impair the overall performance of the system the pre-amplifier had to have a similarly blameless performance.

A note[2] in the May 1969 issue of *Wireless World* particularly interested the author, as it described the use for a stereo pre-amplifier of the R.C.A. integrated circuit CA3048, which consists of four identical low-noise audio amplifiers in a 16-pin dual-in-line package.

The initial study of the integrated circuit centred round the circuit given in the original note in *Wireless World*[2]. This simple circuit (reproduced here as Fig. 1) was soon found to have a number of major shortcomings: the R.I.A.A. equalization network values given proved to be inaccurate at low frequencies; the noise performance was considerably impaired by the 20 dB loss of the passive tone control network; and the high frequency stability of the circuit was poor, as there was a tendency for the amplifier to oscillate at several megahertz producing noise and distortion, even with a carefully planned layout.

In the final circuit these problems were overcome by modifying circuit values, by adding separate tone control circuits of the active-feedback 'Baxandall' type, and by the addition of two capacitors to reduce the gain at radio frequencies thus curing the instability experienced in the original circuit.

Input stage and equalization

Due mainly to the built-in feedback elements of each section of the CA3048 amplifier circuit, there are limitations on the values which can be used in the equalization network, and also to the total range of gain available for equalization. In practice this means that one has to modify the values which would normally be used with such an amplifier to allow for the parallel internal feedback path. It appears to the author that this had not been done in the original published circuit in the region below about 1 kHz. The author's choice of values corrects the l.f. error at the expense of a slight lift at the h.f. end, due to the previously mentioned limitation of the total range of gain available for equalization. It was felt, however, that this set of values gave a much flatter overall result and that the h.f. error was in any case too small to be noticeable. In two pre-amplifiers constructed the resultant curves have been within a total spread of 1 dB (between 30 Hz and 20 kHz) of one another.

The stage giving equalization to R.I.A.A. characteristic is used for this purpose only, thus greatly simplifying the switching of the pre-amplifier from one source to another.

The second stage

The second stage, which has a flat frequency response, uses the remaining two sections of the CA3048 package. The gain of the CA3048 is controlled by the value of impedance seen at the right-hand side of the input long-tailed pair (Fig. 3), which will modify the amount of feedback applied via the internal feedback path. A d.c. blocking capacitor is used to ensure maximum d.c. feedback to maintain the correct operating point. A simple balance control is achieved, as in the original circuit, by the use of a potentiometer at this point so that the relative amounts of feedback to the right and left channels may be varied. The range of this control is deliberately restricted, since the unbalances it has to correct in the equipment should be small, those in normal discs are also small, and serious unbalance in any other stereo source should be put right at source. The range of the

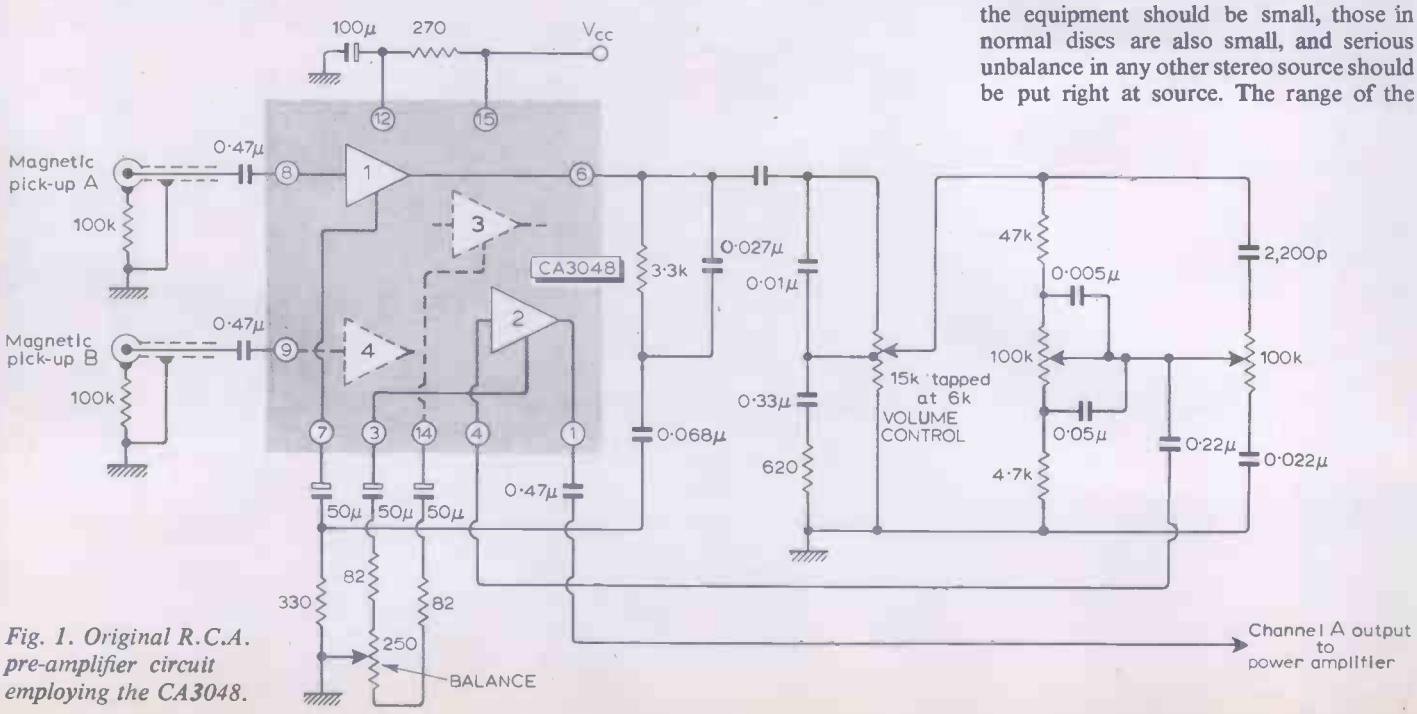


Fig. 1. Original R.C.A. pre-amplifier circuit employing the CA3048.

control as shown is a total of 6 dB on either channel.

This second stage is preceded by the selector switch, and the gain control. The positioning of the gain control at this point is dictated by the need to avoid overloading of the second stage, which would occur if the control were placed after the second stage.

The selector switch connects the auxiliary, and radio inputs direct to the gain control, with a resultant sensitivity of approximately 20 mV for full output (with the 8-Ω version of the power amplifier) of 560 mV r.m.s. Overload occurs at approximately 2 V r.m.s., taking the form of almost symmetrical clipping. Any attenuators used to match this sensitivity to that of the source should preferably not cause the gain control to be fed by a source of greater than 10 kΩ in order to preserve the very good noise level of the pre-amplifier.

The mono/stereo switch connects the inputs to the gain control in parallel when required.

The instability at first encountered with the CA3048, due to its very high gain-bandwidth product, was at first a problem in the second stage. A complete cure was found in connecting a 330-pF capacitor between slider and lower end of each gain control, together with the additional precaution of a screened lead at this point. The h.f. cut-off produced by this capacitor is well above the audio band, but is effective in reducing the gain at r.f., and also acts as one arm of a capacitive attenuator to any pick-up on this second stage input.

Tone controls

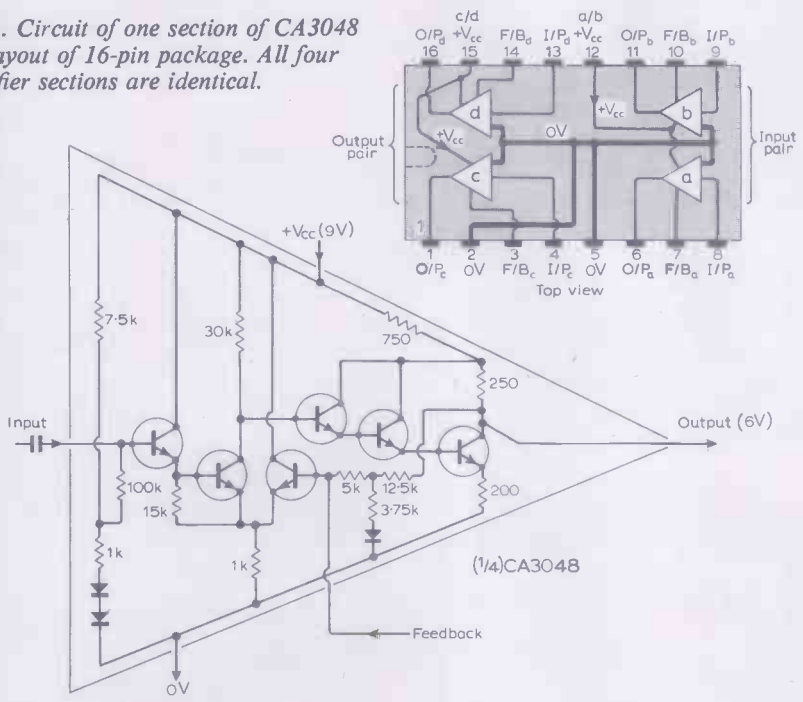
The passive tone control of the original circuit not only degraded the noise figure of the pre-amplifier by 20 dB but also proved to be a difficult one with which to obtain consistent results, there being a considerable tendency for the cut-off frequencies to change with control settings.

The active 'Baxandall' circuit adopted does not suffer from any of these side effects. The nominal 'flat' gain of the circuit is unity since there is no need of further gain, especially as the gain of the second stage has already had to be reduced to account for the removal of the 20-dB gain loss of the passive tone control network.

An additional capacitor of 470 pF is added directly between base and collector of the tone-control stage in order to limit the gain at frequencies above the audio band. The value chosen gives a cut of −0.6 dB at 10 kHz, and −2 dB at 20 kHz, in the flat position of the controls. The purpose of the cut at h.f. is to help to ensure that the power amplifier does not get any appreciable input at frequencies where its power handling is restricted. With an input from discs only, this is not a likely problem, but with tape and radio inputs there are possibilities of higher levels of input above the audio range. Some readers may think the cut is at too low a frequency, and may desire to reduce this capacitor; a value reduction to 220 pF is certainly in order, but it should not be eliminated as it assists in ensuring h.f. stability of the whole pre-amplifier.

Some readers may prefer the use of switched tone controls in which case each of the 2-gang 100-kΩ controls may be

Fig. 2. Circuit of one section of CA3048 and layout of 16-pin package. All four amplifier sections are identical.



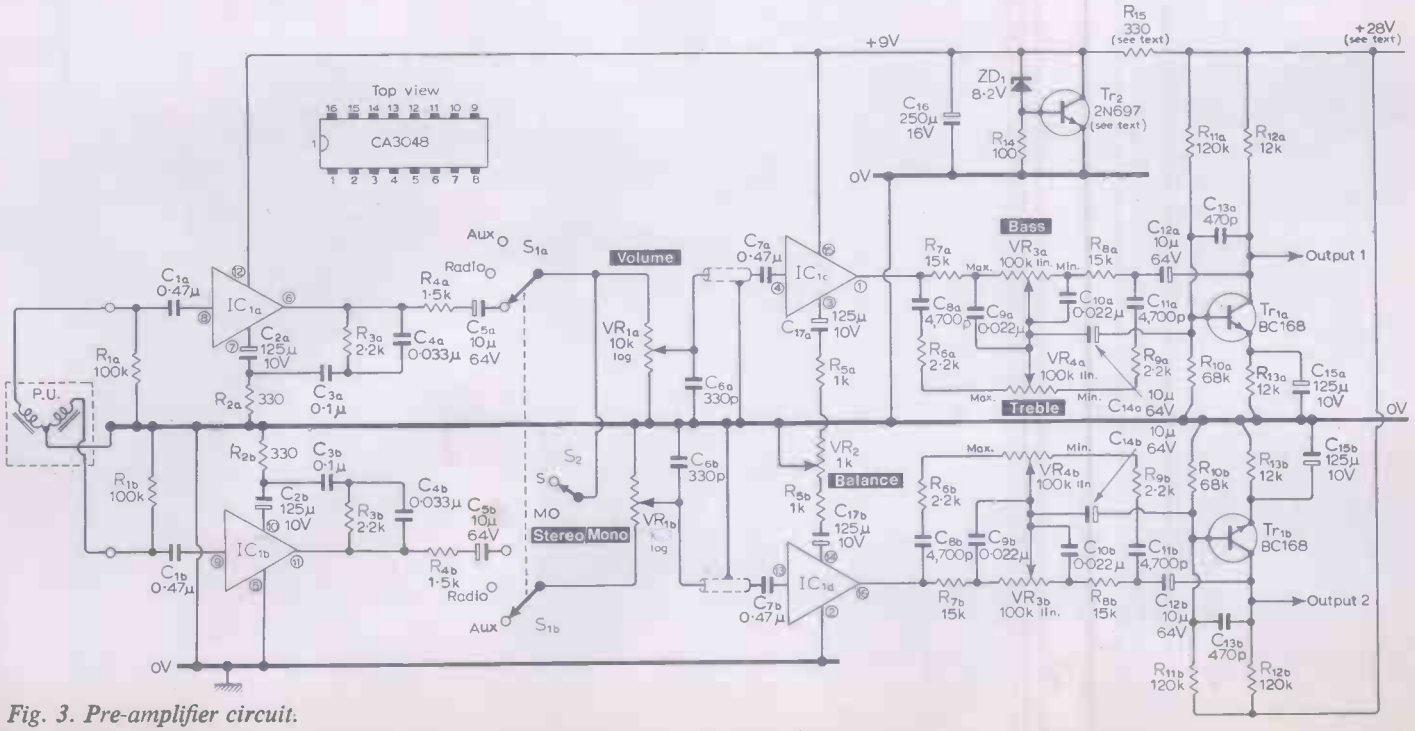


Fig. 3. Pre-amplifier circuit.

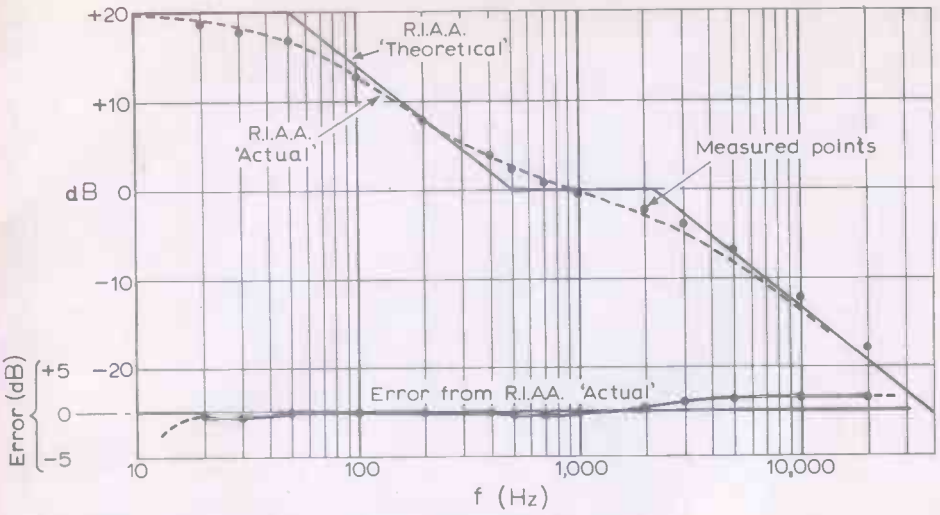


Fig. 4. Input stage R.I.A.A. equalization (tone controls flat).

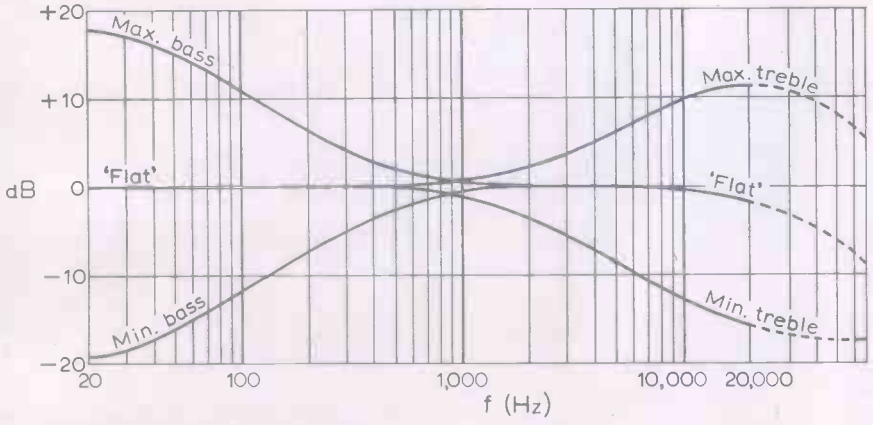


Fig. 5. Tone-control characteristics.

replaced by a 2-pole 7-way switch having six 16-kΩ resistors to each bank, or a 2-pole 9-way switch with eight 12-kΩ resistors.

Noise performance

The main source of wideband noise in the pre-amplifier is the second stage. The first stage contributes little as it has such a narrow bandwidth due to the R.I.A.A. equalization network. The contribution of the input stage is almost entirely $1/f$ noise which is at a commendably low level and is in any case not particularly audible in practice.

In practice the result is a unit producing no audible hum or noise at any normal setting of the gain control or tone controls. With the gain control set so that peak power reaches 10 watts on a loud recording (5 cm/s at 1 kHz on disc) and with bass and treble both at maximum (which is the worst case to be met in practice) there is still no audible noise 6 feet from both speakers (which are large units of good sensitivity), and only a very faint hum and hiss can be heard close to the speaker. These excellent results are confirmed by the measurements:

(a) Unweighted hum and noise with gain set for 10W into 8Ω (7 mV at 1 kHz from pickup) .... −63.5 dB, rel. 10W
(b) Wideband noise alone (less hum and $1/f$) ..... approx −80 dB, rel. 10W
(c) Unweighted hum and noise at normal listening level (approx. 50 mW average power, 1-2 W peak) ..... approx. −72.4 dB, rel. 10W

This last figure remains fairly constant for all lesser settings of the gain control, and represents the basic noise of the second stage and succeeding stages. The higher level of the first unweighted noise figure is largely due to hum from the windings of the pickup cartridge and $1/f$ noise from the first stage—both of which are of low audibility.

9-volt regulator

The integrated circuit requires a lower voltage supply than that available from the power amplifier. To protect the i.c. in the event of circuit failure, a simple shunt regulator was designed. This type of regulator also ensures freedom from voltage surges at switch-on, and switch-off. An incidental advantage of the use of such a regulator, together with its by-pass capacitor, is a very low cross talk figure for the pre-amplifier between channels. The original circuit[2] used decoupling for the supply to the first stage, but with the low level of ripple, and the low impedance of the supply from this regulator, a better performance is obtained without decoupling to this stage.

The TO-5 transistor of the regulator may be any type having a current gain of over 30 at 50mA, and it should be fitted with a heat-sink as the dissipation is approximately 500 mW.

Constructional details

The underside view of the prototype pre-amplifier is shown in Figs. 6 and 7. The CA3048 was mounted on a perforated bakelite 'pin-board' with fine tinned copper links soldered to 16 pins located in two rows on each side of the package. Layout should be kept simple, but is not critical provided reasonable precautions are taken to keep input and output leads separate. The whole assembly should be well screened, and mains leads, mains transformers, and the like kept as far away as possible, to minimize hum pick-up.

The two versions of the pre-amplifier built (one by the author, and one by one of his colleagues) have quite different layouts, yet give almost identical measured results.

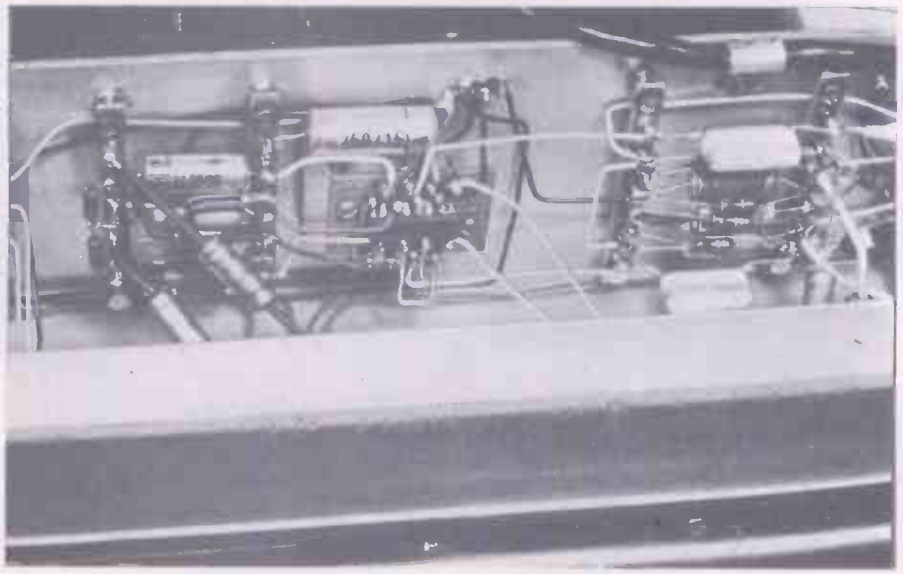


Fig. 6. Close view of the central region of the pre-amp showing the mounting of the i.c. The equalization network is to the left, the tone-control stage to the right, and the two transistors to the extreme right.

Components

$R_{1a,b}$–R_{14} are $\frac{1}{4}$W 10% carbon.
R_{15} is 330Ω 3W wirebound for 28V supply. (180Ω 1W for 19.5V and 470Ω 3W for 36V supply.)

Fig. 7. View from the rear towards the front of the prototype pre-amplifier. The supply regulator is at the far end adjacent to the volume control. The tone control circuit is next, adjacent to its controls. The i.c. is at the centre, with the input stage equalization network nearest the camera.

All other resistors are $\frac{1}{4}$W 5% 'Histab' carbon or 2% $\frac{1}{2}$W metal oxide, the latter being preferable.

$C_{1a,b}$, $C_{3a,b}$, $C_{4a,b}$, $C_{7a,b}$, $C_{9a,b}$, $C_{10a,b}$, are all polyester types such as Mullard C280AE or C296AA/A. Capacitor '*a*' should be matched to capacitor '*b*' within 5% in each case.

(Matching is essential for C_3, C_4, C_9 & C_{10}, but not absolutely essential for C_1 & C_7.)

$C_{8a,b}$, $C_{11a,b}$ & $C_{13a,b}$, are polystyrene $2\frac{1}{2}$% tolerance.

C_{16} is 250 μF 16V Mullard C437AR/E/250 or similar.

All the remainder may be Mullard C426 types or similar.

$VR_{1a,b}$, is 10 k + 10 k log stereo potentiometer (2 dB match).

$VR_{3a,b}$, $VR_{4a,b}$, are 100 k + 100 k in stereo pots (2 dB match). All these twin gang pots. are Radiospares 'Tandem' types.

VR_2 is 1 kΩ in carbon or wirewound.

$S_{1a,b}$ is 3-way 2-pole (prototype uses Radiospares midget wavechange switch 3-way 4-pole).

S_2 is miniature rotary type Radiospares 'Changeover SP'.

$I.C._1$ is R.C.A. CA3048 (CA3052 may also be used with a slightly worse noise figure, but is cheaper).

$Tr_{1a,b}$ are BC108, BC168, etc. (for the 36-volt version BC107B or 167B would be advisable).

Tr_2 any good TO-5 n-p-n transistor such as 2N697, 2N1613, 2N3053, etc.

Tr_2 is fitted with a heat radiator Redpoint 5F.

ZD_1 is 8.2V, 250mW, zener diode. Mullard BZY 88-C8V2, Texas 1S2082A, Radiospares MZ-E8.2V etc.

Mainline Electronics Ltd., Thames Avenue, Windsor Berks, are suppliers of the R.C.A. devices, and Electrovalue and Radiospares the majority of the other components.

Suitable Cartridges

The pre-amplifier has been designed with the use of a high compliance magnetic cartridge in mind. Most of the magnetic cartridges listed in the recent *Wireless World* summary[3] are suitable. The sensitivity of the pre-amp. is sufficient to allow for the use of the least sensitive, and the overload limit is high enough to allow for the most sensitive in this range.

I am grateful to my colleague Mr. A. Cullen for the use of the results from his version of this equipment which have been incorporated in this article, and for his co-operation throughout.

I am also grateful to R.C.A. (Gt. Britain) Ltd, for their help with the supply of very full data on the integrated circuit used.

REFERENCES

1. L. Nelson-Jones, "Ultra-low Distortion Class-A Amplifier", *Wireless World*, March 1970.

2. "Microelectronics at Paris Components Show", *Wireless World*, May 1969.

3. S. Kelly, "Stereo Gramophone Pickups", *Wireless World*, December 1969.

Computer Graphics

Recently the Univac Division of Sperry Rand Ltd produced several striking multicolour designs using their computers and graphic display consoles. Our front cover this month is an example of one of these. Shapes, which can be distinguished on the picture—squares, triangles, lines and points—were randomly programmed into the computer with no attempt to give them a definite pattern of movement. The tumbling shapes were shown on a graphic display and photographed through several different coloured filters—green and white in the case of our front cover.

A graphic display, one capable of showing engineering drawings, maps etc., is much more complex than the now familiar alphanumeric displays. According to Univac the development of graphic display terminals lags behind that of alphanumeric displays by between three to five years.

Cathode ray tubes are used for both types of display although these will probably be superseded by the laser, or one of the other competing devices, in about five years.

Drawings on graphic displays can be made by causing the c.r.t. electron beam to move between one previously defined point to another such point on the c.r.t. face in a straight line. Curves are simulated using a series of very short straight lines. A graphic display with a c.r.t. with a usable display area of 350 × 350mm (12 × 12 inches) may have a million precisely defined points on which the beam can be positioned. The million points would be determined by electronics which allow the beam to be positioned at any of 1000 positions in the X direction and at any one of a 1000 positions in the Y direction. The electronics would also allow the beam to move in a straight line between a point on the screen defined by a certain value of X and Y to another point specified by a different value of X and Y.

In normal practice the values of X and Y are fed to the display in binary form from a suitable digital processing equipment.

Often, also under digital control, the brightness of the display can be altered to one of a number of predetermined values. Shapes which are often used can be held in a memory, as subsequent values of X and Y, for use when required.

The computer and the display electronics have to work together to handle the formidable amount of data needed to produce even a simple drawing on the screen and must be flexible enough to allow the drawing to be altered at will.

The recent rapid advances in m.o.s. integrated circuitry is having a marked effect on display design as apart from the control logic and character generation circuits, m.o.s. shift registers are replacing other forms of storage in display equipments.

Circuit Ideas

Immersion heater indicator

Here is a circuit idea so simple that it does not require a drawing. If an indicator is required to show when a heavy a.c. current is flowing in a cable, for instance, to monitor thermostat and water heater combination, proceed as follows. Strip the secondary of an old bell-type transformer and wind the live wire of the pair to the heater twice round the transformer core (in the space previously occupied by the secondary) and connect a 47-kΩ resistor and wire ended neon lamp in series across the transformer primary. When the thermostat is closed sufficient voltage will be developed across the transformer primary (now acting as the secondary) to light the neon. The idea is useful when the supply cable passes near to the indication point and when long additional cables are to be avoided.

B. S. CRANK,
Wireless World.

Sensitive thermostat

The circuit uses a reverse biased germanium transistor sensing element in a bridge. The out-of-balance voltage from the bridge feeds a simple d.c. amplifier driving a relay via a bistable. The bridge components shown are suitable for a temperature range of 12-25°C. The operation is so sensitive that it was found necessary to use the 500 μF capacitor to smooth out short-term fluctuations which otherwise resulted in on-off operation of the bistable. The circuit has been used for over a year controlling a house central heating pump. The temperature control over the above range has been found to be better than $\pm$0.5°C. For applications with negligible thermal lag, the control is better than $\pm$0.1°C.

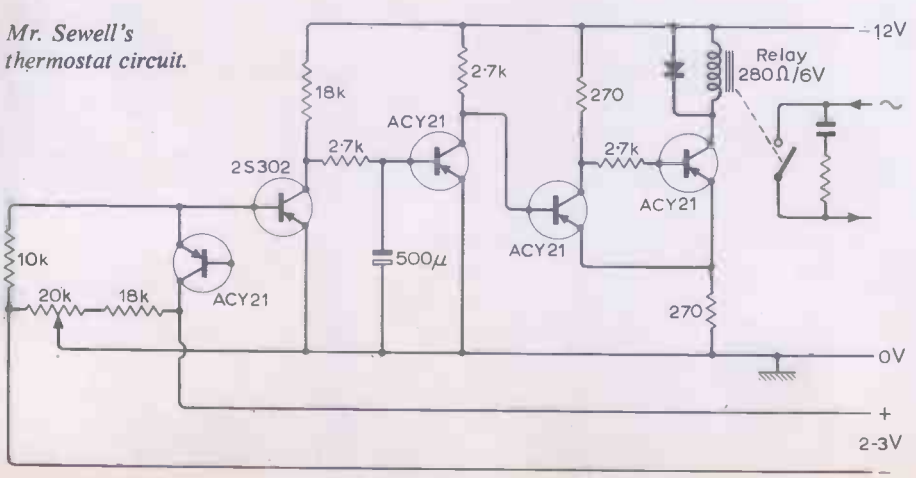
A. SEWELL,
Cheadle, Staffs.

Schmitt triggers

Simplified trigger: The potential divider chain R_1, R_2 and C for biasing Tr_2, in Fig. 1, can be eliminated by connecting a forward biased diode, D_1 in the emitter of Tr_2 (Fig. 2). The diode should be a silicon type of a current rating to suit the load current of Tr_2 but the voltage rating is not important since it is never reverse biased. Circuit design calculations are simplified and the loop gain is increased for low frequencies.

Trigger for variable loads: In Fig. 3 the common emitter resistor is replaced by a zener diode, D_1, the slope of the zener characteristic providing the feedback for the trigger action. For successful operation the current of Tr_1 must lie below the knee of the zener curve and that of Tr_2, above. To take an example. Suppose the trigger points are to be between 5 and 6V and the load of Tr_2 consists of 680Ω in parallel with a switchable 6-V 40-mA lamp. D_2 is used to provide the reverse bias for Tr_2—a conventional bias chain could have been used. On test, using GET111 transistors, an SX56 zener and a surplus silicon diode for D_2 the trigger points were 5.35V and 5.65V with the lamp and 5.35V and 5.5V without. Fig. 4 makes the operation clear. When Tr_1 is conducting the current is 2mA and the zener is at point P on the curve. When Tr_1 is turned off and Tr_2 conducts, the current without the lamp is about 8.5mA, point Q on the curve, and the voltage at the emitters rises by about 0.2V. Increasing the current to about 50mA, by connecting the lamp, produces only a further increase of 0.2V, point R, as the zener is now on the flat part of the curve.

P. GASCOYNE,
Wantage, Berks.



Mr. Sewell's thermostat circuit.

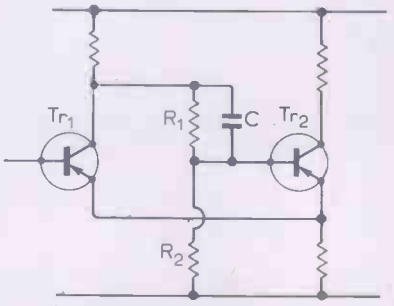


Fig. 1. Conventional trigger circuit.

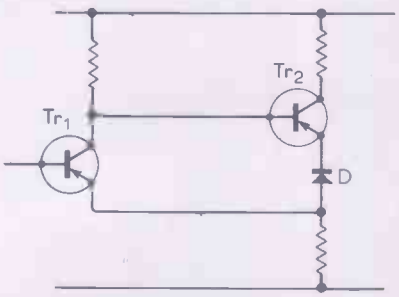


Fig. 2. Using diode to simplify trigger.

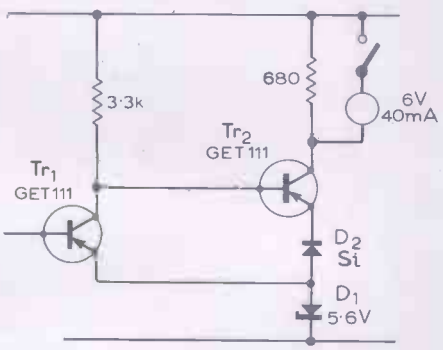


Fig. 3. Zener diode in place of common emitter resistor.

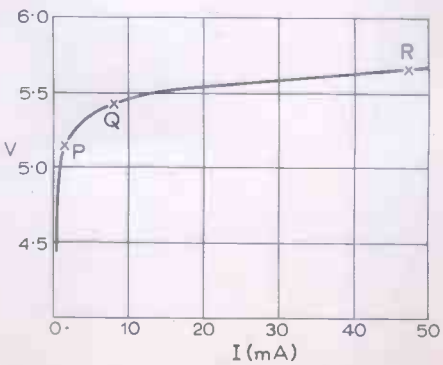


Fig. 4. Characteristic curve of the SX56.

Time Delays

A survey of the various methods of obtaining time delays, particularly for use in broadcasting

by H. D. Harwood, B.Sc.

Time delays used in the broadcasting service cover a very wide range from a few nanoseconds in television circuits to several hundred milliseconds in ambiophony† and the applications are correspondingly many and varied. For the purpose of clarity, therefore, delays are described in this article according to the method of obtaining them and the applications of each type are only briefly mentioned. In this connection it will be seen that for some applications more than one type of delay is required.

A description is also given of other types of delay which are not in use in the broadcasting service at the moment but which appear to offer potential advantages in one of the various fields of application.

All-pass electric circuits

Coaxial cable: This is the cheapest and easiest method of obtaining fixed delays of up to about 0·1 μs. The velocity of an electromagnetic wave in a coaxial cable is about 0·6 of the velocity of light and a signal made to traverse a length of cable will suffer a delay amounting to 1 μs per 180 m of cable. The lines can be accurately terminated and, as the cable can also be made with a high degree of uniformity, reflections can be kept to a low level. Beyond a delay of 0·1 μs the volume of cable becomes rather large unless a miniature form is used; but unfortunately, in practice, the miniature type is not so uniform along its length as the standard-size cable and therefore reflections will be more troublesome. The standard cable can be used up to 1 GHz and the cost is very low about £12 per μsec. Applications include equalization of delays for television timing pulses between programme points and central operations room.

Special delay cables: The velocity of propagation along a normal coaxial cable is substantially reduced if the inductance of one of the conductors is increased by winding it in the form of a tight helix. As a further measure, in one form of cable manufactured by the Hackethal Wire and Cable Co., the centre conductor is wound on a dust core of relatively high permeability[1] thus reducing the velocity still further.

In practice, it is difficult to make the inner conductor as uniform as that of ordinary cable and the variations give rise to reflections which in some cables may be only 20 dB below the main signal.

The impedance of the cable is of necessity high; values for cable made by the British Insulated Callender Cables Company with a polythene core vary from 130 to 1900 Ω, those for the Hackethal cable vary from 1500 to 3800 Ω; the higher values being associated with the greater delays per unit length. For very low velocity cables the delay is not quite constant with frequency but varies by about 10% in the 0 to 4 MHz band and also has a temperature coefficient of 0·08% per °C. The attenuation in the lowest velocity cables is about 3 dB/μs at 6 MHz compared with about 1 dB for the higher velocity cables.

One advantage of this form of delay is the lost cost, about 15s per μs; the chief difficulties are that the high impedance makes careful screening imperative to prevent cross talk between the ends; the high level of reflections can also be a nuisance with some cables.

Diameters vary from about 8 to 25·4 mm with delay and manufacturer. Applications include use in pulse generators and for equalizing delays in television programme circuits. A 5-μs line has been built[2] by the B.B.C. designs department for the latter purpose.

***LC* circuits:** As a further development, a delay line may consist of a single layer coil of insulated wire wound around a core of insulating material covering an earthed conductor; the delay depending on the storage of energy in the dielectric and magnetic fields. This type of line is dispersive in its simple form because the currents in different turns, whilst still magnetically linked, become increasingly out of phase as the frequency rises and changes in delay time of up to 25% may occur within the pass band.

The various means adopted to overcome this difficulty entail breaking the line up into segments. In one method due to Kallman[3] capacitive coupling between groups of turns is employed; the line being effectively divided up into as many as 48 segments. In this way, the delay was made constant for a 0·9-μs line to within 1% over the range 0 to 16 MHz. This rather empirical method was later treated more theoretically by Di Toro[4], who also gives design data.

Another technique due to Solov'yev[5] uses coaxial shorted turns to sectionalize the magnetic field in the line. In this way, the falling off of inductance with frequency is prevented but, once again, the design details have to be decided by cut and try methods.

The advantage of these forms of line is that they can easily be adjusted on test to give the precise time delay required and are very compact. They suffer, however, from the disadvantage of empirical design and high impedance, 400 to 4000 Ω, the latter condition necessitating the use of amplifiers and matching networks. Delays of up to 1 μs are practicable and are quite cheap to construct. The attentuation is fairly low ($\approx$10 dB at 6 MHz) and the reflections are more than 40 dB below the signal.

If the process of sectionalizing is taken further, we arrive at low-pass and all-pass networks. Many designs have been published using low-pass networks but the all-pass types have the following advantages over them.

(i) Their design does not have to take into account the varying frequency characteristic of the network near cut off.

(ii) The characteristic impedance is theoretically constant over an infinitely wide band and, although this cannot be achieved in practice, more sections can be employed before matching difficulties arise.

(iii) The design can be calculated with a high degree of accuracy.

Howorth[6] gives a good example of a 1-μs all-pass delay line using ten pairs of networks designed to give a fourth order maximally-flat group delay/frequency characteristic and a constant resistance network to equalize for unavoidable high frequency losses in the coils. Further details are given of staggered pairs of networks up to the tenth order for which a considerable improvement is claimed.

The pass band can be designed to cover any desired range of frequencies, there being no difficulty in achieving bandwidths of 6 MHz. The characteristic impedance is again a matter of design; a figure of 75 Ω

†Ambiophony: A term coined in 1959 by D. Kleis, of Philips, Eindhoven, to describe a system of acoustic feedback designed to modify the acoustics of a room. The sound is picked up by a central microphone, the output of which is delayed by various amounts and then fed back to numerous loudspeakers positioned around the walls and ceiling to modify the reverberation.

would normally be chosen for television purposes.

Delays of up to 10 μs can conveniently be made for the video bandwidth and the level of spurious reflections can be kept 40 dB below the signal if individual adjustment of the elements is used. The insertion loss in the line is low, e.g. 6 dB for a 3-μs line with a 6-MHz bandwidth.

The cost is higher than that of cable and amounts to about £100 for the example just quoted. The size of such a line would be about 700 × 76 × 76 mm.

Applications include a line of 330 μs for the audio band used in a limiter[7] to give the control chain time to operate before the programme reaches the main path.

The delays so far described are fixed in length, although a circular line of the Kallman type could perhaps be produced with a wiper contact. For purposes where a variable delay is essential one known as the Amtec has been produced by Ampex, in which the delay can be rapidly varied by means of an electrical control signal. The delay consists of a series of coils (wound on a common former so that they are mutually coupled) and shunt-connected varactor diodes. The delay is controlled by adjusting the bias on the diodes and a variation of ±20% is possible at rates of up to 15 kHz. To minimize the changes in delay caused by the signal itself (which appears across each diode), the diodes are connected so as to alternate in polarity along the delay line. The alteration in the characteristic impedance involved in changing the delay limits the usable variation to not more than about ±5% before excessive echoes and frequency response changes are produced.

Delays of up to about 5 μs are possible with this device. The bandwidth is adequate for television signals and when properly matched spurious echoes are 40 dB below the main signal. The impedance is of the order of 300 Ω and the line will only handle levels of up to 250 mV; amplifiers are therefor necessary before and after the line. The attenuation at 5 MHz is about 6 dB.

The main use is as a servo operated device to reduce the effect of quadrature errors in head alignment in video tape machines; it is also used in line store converters and vertical aperture correctors. The cost is approximately £500 and the size is 700 × 76 × 76 mm.

Ultrasonic delays

In the delays which have been considered so far the signal has been electrical and the velocity of propagation correspondingly high; this has meant that any delays of more than a few microseconds occupy a considerable path length. In the type of delay to be considered in this section, the signal is converted into a mechanical vibration with a much lower velocity of propagation, and correspondingly higher delays are therefore possible.

For example, the velocity of a shear wave in a quartz block is only 3760 metres per second and this is slower than the velocity of an electrical signal in a coaxial cable by a factor of about 10^5. Furthermore, it is possible to reflect the wave from a number of faces of the block thereby still further reducing the size necessary for a given delay.

A number of substances have been examined for possible use in delay lines; one example is a water line used by the Scophony television system in the early 1930s and again by the Telecommunications Research Establishment in the early days of radar. This was superseded by the use of mercury which gave a much better match to the quartz transducers and had lower attenuation. Solid materials which have been examined for this purpose include metals, plastics, rubber, glasses and gels[8]. Of these solids the lowest attenuation is obtained with glasses and fused quartz and only these are used today.

Similar low velocities of propagation can be obtained from torsional waves in wires and as these can be coiled to form a helix they can be made quite compact for delays up to 20 ms; they are also cheaper than quartz or glass blocks.

Solid ultrasonic delay lines: For an ultrasonic delay line fused quartz or glass has the advantage over crystalline materials such as metals in that, being amorphous, the scattering of the waves from crystal boundaries is avoided and hence the attenuation in the medium is less. The attenuation is in fact proportional to the square of the frequency instead of the fourth power as in a crystalline solid. For example, in the region of 10 MHz the mechanical Q factor of fused quartz is approximately 10^5. In a solid medium, waves can be propagated both in the shear and longitudinal modes. For very short delays, of the order of a few μs, longitudinal propagation is used as it has a higher velocity and thus increases the distance between the transducers for a given delay, so reducing the effects of capacitive coupling between the transducers and the disturbing effects of diffraction near them. For longer delays however the shear mode of propagation is preferable in order to reduce the path length required facilitating a more compact design; the ratio of the two velocities is approximately 1·6 to 1. One of the advantages of the shear mode is that waves are reflected from surfaces with no mode conversion provided the particle velocity is parallel to the surface. Furthermore, the wave may be guided by the top and bottom surfaces of the block without causing the spurious signals, due to mode conversion, which would occur with longitudinal waves. The major difficulty in using the shear mode of vibration is that of bonding the transducers to the delay medium but this has now been largely overcome by the use of indium cold welds[9].

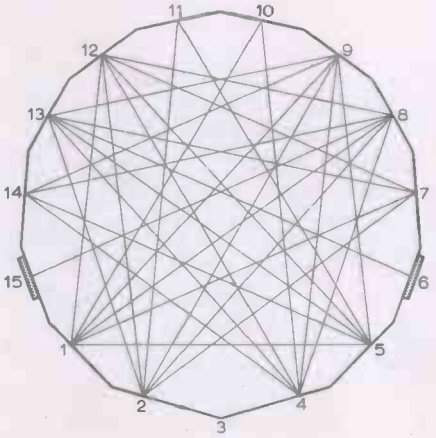


Fig. 1. Quartz block delay line.

For long delays extensive use is made of reflections to increase the path length in a given size block. A good example is shown in Fig. 1 where a 15-sided figure contains 31 legs in the acoustic path between receiving and transmitting transducers. A 1-ms delay line of this type would have a "diameter" of about 14 cm and delays of up to about 4 ms are feasible, with a bandwidth of about 15 MHz. For shorter delays the bandwidth is greater as the attenuation in the medium is less.

The electromechanical coupling of the receiving transducer is so low that very little of the energy in the incident beam is absorbed. The reflected energy returns to the transmitter where it is reflected again to the receiver, forming an echo which has three times the delay of the primary signal. Various means are adopted to reduce the amplitude of this echo. The first measure uses the directivity of the main beam. The transmitter usually consists of a rectangular piece of quartz whose length is long compared with a wavelength and whose directivity is given by:

$$P = \sin\left(\frac{\pi l}{\lambda}\sin\theta\right)\Big/\frac{\pi l}{\lambda}\sin\theta$$

where l is the length of the transducer, λ is the wavelength and θ the angle. This represents a main lobe flanked by a null and side lobes, the first of which is about 18 dB below the amplitude of the main beam. With a transmitter about 100 wavelengths long, the directivity is very high, the first null being about 40 minutes of arc and the first side lobe at about 55 minutes of arc away from the axis. In some designs advantage is taken of this null by tilting the axis of the transmitter so that for a "third time around" reflection already mentioned the null is incident on the receiver. The condition for this is given approximately by the relationship $\theta = 0{\cdot}4\lambda/l$ (since θ is small) and is equal to $(4 \times 10^8)/f$ minutes of arc for a source of length 1 cm. The reduction in pressure due to the axis of the main beam not being exactly on the receiver is small under these conditions and amounts to only 2 or 3 dB. As a further measure the two transducers are often backed by a wedge of lead; this absorbs a proportion of the energy incident on them, because of the attenuation in the lead.

Also, absorbent material is sometimes fixed to the area of the faces of the polygon which do not carry the main beam. As a result the spurious signals have been reduced in some cases to 60 dB below the level of the wanted signal, although 40 dB is a more usual figure.

The attenuation in the line is largely due to low electromechanical coupling in the transducers for short delays but attenuation in the medium is the limiting factor for long delays. Crystalline quartz is usually used for the transducers but various piezoelec-

tric ceramics[10] have been utilized as they have a coupling coefficient about six times higher than has quartz. They are much more fragile than quartz and there is some difficulty in bonding them to the quartz or glass block.

Fused quartz has a temperature coefficient of about -8 parts in 10^5/°C and for accurate work must therefore be temperature controlled. For this reason, glasses have been developed with a negligible temperature coefficient but as they have an appreciably higher attenuation they cannot be used for the longer delay lines. Quartz or glass lines have been used for linear field-period delays in television scanning systems as in PAL and SECAM receivers.

For the solid delay lines so far described, the time delay is fixed but there are some applications where it is desirable to be able to vary the time delay fairly slowly. For this purpose an optical scheme of pick off has been suggested by Arenberg [11] and others [12, 10]. When glass is stressed it becomes birefringent; light polarized parallel to and perpendicular to the direction of stress have different velocities. The magnitude of this effect varies with the stress and so can be made to vary the phase between the two mutually perpendicular components into which light can be resolved.

The arrangement used is shown in Fig. 2.

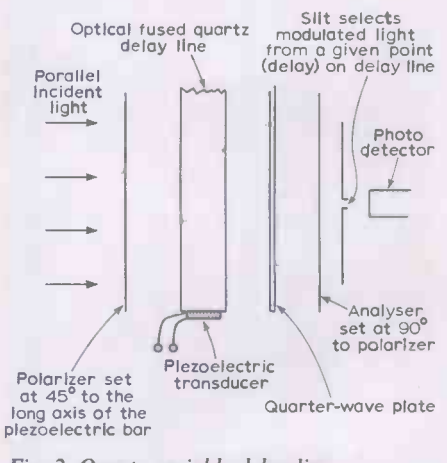


Fig. 2. Quartz variable delay line.

Light from a source is passed through a polarizing medium, a quarter wave plate, the optical delay medium, a defining slit and then through an analyser to a photocell. The analyser is so positioned that in the absence of a signal and the quarter wave plate no light would fall on the photo cell; the presence of a signal would therefore result in a rectified output from the cell. The quarter-wave plate biases the system so that a linear output is obtained from the cell in the presence of a signal. The slit can be moved along the line and continuous variation of the delay can thus be obtained.

One of the difficulties lies in obtaining a good signal to noise ratio, and to this end the stress in the glass is made as high as possible by the use of ceramic piezoelectric transducers which have the highest coupling coefficient.

Mercury delay lines: Mercury delay lines are not so cheap or convenient as quartz

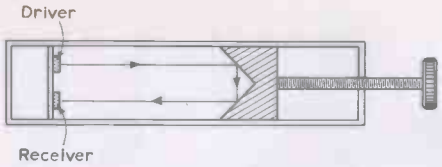


Fig. 3. Construction of a mercury variable delay line.

plates but have the advantage that they are easily adjustable in length, at any rate for delays up to about 350 μs. A typical construction is shown in Fig. 3. As in the case of quartz line a highly directional piezoelectric transmitter generates waves which travel along the mercury and are then reflected back from a corner reflector to the receiving transducer situated by the side of the transmitter.

The attenuation in the mercury is proportional to (frequency)^2 and is given by $\alpha/f^2 = 5\times10^{-15}\ l\ m^{-1}\ sec^2$. This is low for medium frequencies and amounts to about 15 dB at 15 MHz for a 1-ms line. It is obvious, however, that the attenuation increases rapidly as the frequency rises. In the low attenuation region, measures to reduce spurious reflections are essential, and the methods discussed in the previous section are applied. In addition, the transducers are sometimes terminated at the rear by a mercury filled cavity having a shape designed to trap and absorb the incident energy. By these means reflections can be reduced to about 40 dB below the main signal.

As the acoustic impedance of the mercury is a good match to that of the quartz transducers the bandwidth available is wide and the insertion loss due to mismatch is low. The main loss in the system is the poor electromechanical coupling in the transducers themselves, the total loss amounting to some 50 dB for a 1-ms line. The electrical load applied to the receiving transducer also obviously has a marked effect.

The temperature coefficient of delay of mercury in a steel container is $-0{\cdot}03\%$ per °C. The suggestion[13] has been made that where this is excessive a capillary should be attached to the bath which would thus act as its own thermometer operating a thermostat switch, and control could be exercised to within a few millidegrees.

Static delays of 1 ms and delays adjustable from 30 to 200 μs can be produced. In the latter case the corner reflector is mounted on a lead screw having a pitch such that one complete turn changes the delay by 10 μs. The bandwidth is about 8 MHz. The cost of the adjustable line is about £500 and the size $400\times100\times100$ mm. It has been used in a line store converter, a vertical aperture corrector[14] and a field store.

Ultrasonic wire delay lines: For these delay lines, waves are propagated along wires using either the longitudinal or shear modes. The expression

$$v = \sqrt{\frac{E}{\rho}}$$

for the velocity of low frequency longitudinal waves (E is Young's modulus, ρ is density) is found to be in error at ultrasonic frequencies where the wavelength becomes comparable with the diameter of the wire. Under these conditions Rayleigh gives the velocity as:

$$v_e = [1-\pi^2\sigma^2(a/\lambda)^2]\sqrt{E/P}$$

σ being Poisson's Ratio and a the radius of the wire, and this holds if $a/\lambda<0{\cdot}6$. At the highest frequencies the energy flows almost entirely in the surface layers. Because of the ensuing dispersion, lines using this mode of propagation are restricted to short lengths.

For torsional waves the velocity

$$v_s = \sqrt{\frac{\mu}{\rho}}$$

where μ is the modulus of rigidity and is thus free of dispersion provided the wire is straight. If however the wire is curved, as is desirable for long lines, a certain amount of dispersion takes place but this is very low provided the wire is naturally straight, i.e. there is no "set" in the line where it has been taken past the elastic limit.

The diameter of the wire is determined by the fact that only the zero order mode is wanted. Higher orders will exist above a lower cut-off frequency given by $f_c = (R_n V_s)/2\pi a$ where R_n is a constant dependent on the mode, and V_s is the sheer velocity. The value of R_n for the cut-off frequency (f_c) of the first order made is 5.136. Below their cut-off frequencies these modes are rapidly attenuated and it is safe to use frequencies up to $0{\cdot}75\,f_c$.

Another advantage in using the torsional mode rather than the longitudinal mode for long lines, is that the torsional velocity is only 0·6 of the longitudinal velocity with a corresponding gain in delay for a given length. Unlike the quartz and glass considered in the previous section, a wire is composed of a multi-crystalline material. Reflections at the crystal boundaries give rise to additional attenuation, proportional to f^4, which places an upper limit to the bandwidth.

Transducers: Wire lines can be driven by piezoelectric elements but in practice magnetostrictive devices are generally used. For longitudinal modes this takes the form shown in Fig. 4. A short coil surrounds the wire, which is biased magnetically by a permanent magnet as indicated. When a pulse of current is applied to the coil the wire changes dimensions (Joule effect)[15] and this disturbance is propagated in both directions with a velocity v_e. The wave arriving at the left hand termination block is absorbed

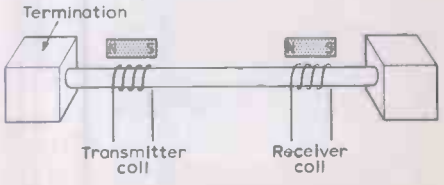


Fig. 4. Driving a longitudinal wire delay line.

and the other travels to the receiver coil, where it induces an electrical signal (Villari effect)[16] and thence to the right hand termination. The length of the coil determines the highest frequency of propagation, the efficiency rising to a maximum at a frequency where $f = v_e/2l$.

For torsional modes a converter due to Scarratt and Naylor may be used as shown in Fig. 5. In this case the longitudinal waves are generated in two strips as described above and excite the wire in the torsional mode. To avoid spurious reflections from the driver the termination must be very good. An alternative form due to Wiedemann[17] is shown in Fig. 6. In this case a biasing current flows in the solenoid and the signal current flows down the delay line. In either case the conversion efficiency is low the insertion loss of the two transducers amounting to roughly 40 dB.

The design of a typical long delay line is shown in Fig. 7. Delays of up to 10 ms are available but with these the bandwidth does not usually exceed 1 MHz; spurious echoes are often as high as −12 dB on these lines. For shorter delays bandwidths up to 5 MHz are feasible. The source impedance should be high and so should the load into which the output coil is connected; matching amplifiers are therefore required. The cost for a line of 3 ms is £70 and the size approximately 178 × 254 × 38 mm.

Because of the limited bandwidth, applications are few. Other ways of producing delays are discussed in the concluding part of this article next month.

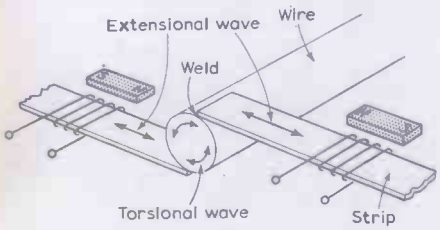


Fig. 5. Driving a torsional wire delay line (due to Scarratt and Naylor).

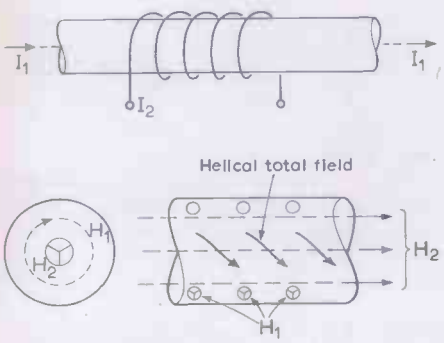


Fig. 6. Wiedemann transducer.

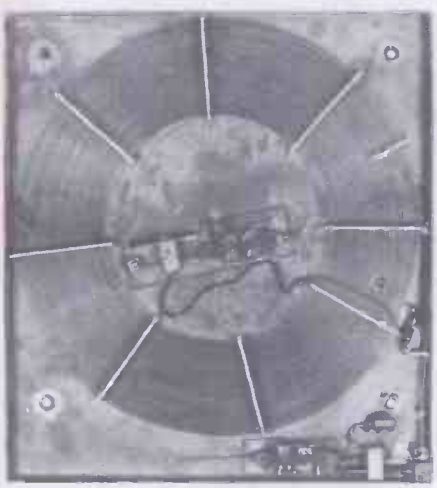


Fig. 7. A typical wire delay line with a long delay time.

REFERENCES

1. Stein Dimitri, R., "Magnetic Core Delay Cables", *I.R.E. National Convention Record*, 1954, Vol. II, Part 3, pp. 30–34.
2. "A 5 μs Delay Panel Type PA7/501". B.B.C. Designs Department *Technical Memorandum* No. 8.125, 1963.
3. Kallmann H. E., "Equalized Delay Lines", *Proc. I.R.E.*, Vol. 34, No. 9, pp. 646–657.
4. Di Toro, M. J., "General Transmission theory of Distributed Helical Delay Lines with Bridging Capacitance", *I.R.E. Convention Record*, Part 5 Circuit Theory, 1953, pp. 64–70.
5. Solov'yev, V. A., "Miniature Delay Line with High Resolution", *Elektrosvyuz*, 1961, No. 2, pp. 11–23.
6. Howorth, D., "Miniature Delay Lines for Television Equipment", B.B.C. *Technical Memorandum* No. T 1083.
7. Shorter, D. E. L., Manson, W. I. and Stebbings, D. W., "The Dynamic Characteristics of Limiters for Sound Programme Circuits", B.B.C. *Research Report* No. EL–5 1967/13.
8. "Preliminary Experiments on the use of Solid Materials as Supersonic Transmission Media for Delay Cells", Telecommunications Research Establishment 2940, 1941.
9. Brocklesby, C. F., Palfreeman, J. S. and Gibson, R. W. "Ultrasonic Delay Lines", Iliffe, London (1963).
10. Gibson, R. W., "Solid Ultrasonic Delay Lines", *Ultrasonics*, April/June 1965.
11. Arenberg, D. L., "Ultrasonic Solid Delay Lines", *J.A.S.A.*, Vol. 20, No. 1, Jan. 1948, pp. 1–26.
12. Brouneus, H. A. and Jenkins, W. H., "Continuously Variable Glass Delay Line", *Electronics*, Jan. 13th 1961, pp. 86–87.
13. Brocklesby, C. F., "Ultrasonic Mercury Delay Lines", *Electronic and Radio Engineer*, Dec. 1958, pp. 446–452.
14. Howorth, D. "Vertical Aperture Correction using Continuously Variable Ultrasonic Delay Lines, B.B.C. *Engineering Monograph* No. 47, May 1963.
15. Joule, J. P., "On the effects of magnetism upon the dimension of iron and steel bars", *Phil. Mag.* 111, 30, 1847.
16. Villari, F., "Change of Magnetization by Tension and Electric Current", *Annalen de physikalische Chemie* 126, 87, 1865.
17. Brocklesby, C. F. Palfreeman, J. S., and Gibson, R. W. G., "Ultrasonic Delay Lines", Iliffe, London (1963), p. 137.

Mechanical Filters for TV Receivers

Interest in mechanical filters continues to grow and modern microcircuit technology is helping us to obtain smaller and smaller devices working at higher and higher frequencies. Electrical filters depend for their frequency-sensitive effects on the natural behaviour of electrons oscillating between energy stores in the form of capacitors and inductors (or just capacitors in active filters). In mechanical filters the equivalent energy stores are the mass and compliance of lumps of solid material, say metal or crystal, which can be mechanically activated by suitable transducers, e.g. electromagnetic or piezoelectric. For example, some mechanical filters on the market, operating at centre frequencies up to about 20MHz, use thin plates of quartz with pairs of electrodes applied for activation and pick-up.

Recent work has been concerned with mechanical waves travelling on the surface of thin films of material. The latest example, from Zenith in the U.S.A., is an experimental device intended to provide a band-pass frequency response for use in the i.f. sections of television receivers. It uses lead zirconate, a piezoelectric ceramic, and the surface waves are launched and picked up by comb-shaped electrodes: the transmitting "comb" exerts mechanical stress on the material and this causes waves to travel across its surface and create a varying electric field which is detected by the receiving comb. In one example the transmitting transducer is a comb of about 20 teeth in the middle of the area of lead zirconate, while the receiving transducer consists of two combs, one on each side, which can be series or parallel connected. The spacing between the comb teeth is significant in determining the frequency response characteristic of the filter.

A complete i.f. section for a colour television set has been constructed, using four of these devices (known as Surface Wave Integrable Filters) with i.c. amplifiers to compensate for insertion losses, all mounted on a 2in × 1in thick-film circuit on a ceramic substrate. It is said to have given a good picture when substituted for a standard i.f. section in a colour receiver.

Zenith are also working on flat panel television picture displays.

15-20W Class AB Audio Amplifier

A design with class-A performance but reduced thermal dissipation

by J. L. Linsley Hood

Many class B designs can be operated in class A at low power levels if the quiescent current is increased. However, this often worsens the distortion characteristics of the output stage, particularly at intermediate (and audibly important) power levels, by displacing the crossover point to a region where the transfer slope is much steeper, and the crossover discontinuity therefore much more prominent. This effect is considerably accentuated by the fact that almost all modern transformerless power amplifier systems use either Darlington pair or augmented (p-n-p/n-p-n) emitter follower output pair configurations, and these have a very high mutual conductance.

The use of a complementary pair of emitter followers, driven from a voltage source having an output impedance which is very much lower than the normal input impedance of the output devices, appeared from this line of thought to offer the best way of minimizing the several problems mentioned above.

In practice, the necessary low impedance base-emitter paths can be arranged quite simply by driving the output transistors from a suitably tapped emitter load resistor in a conventional emitter-follower circuit, provided that the current flow in this load circuit is adequate to deliver the necessary output drive.

Moreover, this type of circuit arrangement will also operate, in class A, as a straightforward cascaded emitter follower, as can be seen from the circuit arrangements shown in Fig. 1. In (a), the transistors Tr_1 and Tr_2 act as a conventional Darlington pair, with a resistive emitter load to which the output load Z_L is coupled through C_1. In (b), essentially the same circuit is employed, but using a complementary type of transistor as the second stage emitter follower.

It is then possible to arrange the circuit as shown in (c), so that both of these configurations are employed simultaneously. Resistors of double the ohmic value can then be employed as R_1 and R_2, with half the emitter current in each transistor, to give an identical matching impedance to the output load. In practice, this circuit arrangement can be simplified into the form shown in Fig. 2, and the resistors R_1 and R_2 deleted since the load current for each transistor can flow through the other. This also improves the efficiency since the transistors have a very high dynamic impedance and form good emitter loads for each other. The two small value resistors R_x and R_y are included to assist in stabilizing the output transistor working points.

The actual value of the quiescent current in the output stage can be set by adjustment to VR_1. To avoid asymmetry, at low audio frequencies, the bypass capacitor should have as high a value as convenient.

This arrangement of the output transistors was of particular interest to the author, since the first three stages of such an amplifier could be substantially the same as those used in the previously described class A design, of which the performance was known. In fact, the system could be constructed on the basis of the class A design, with the quiescent current reduced to a much lower level, and a pair of suitably biased back-to-back emitter followers interposed between the output and the loudspeaker load. However, this would not have made the most of such a system. In particular, it will be noted that if the potential at the emitter (or base) of Tr_1 in Fig. 2 is held constant, the current through the resistor chain R_3, VR_1 will be constant for any particular value of

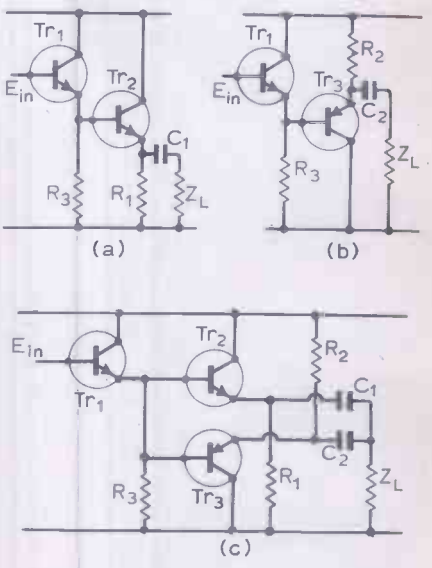


Fig. 1. Emitter follower configurations for class A operation.

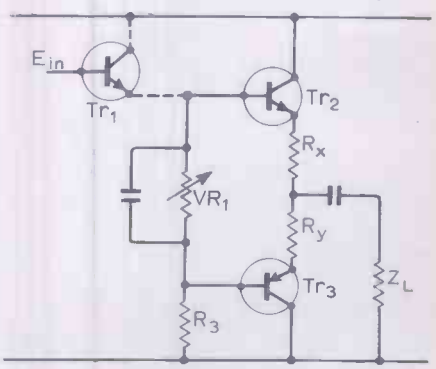


Fig. 2. Simplification of Fig. 1 (c).

VR_1 and therefore the turn-on potential applied between the bases of Tr_2 and Tr_3 will also remain constant (or virtually so). This allows the standing current of the output transistors to be defined precisely, since the d.c. output potential can be controlled by the use of unity gain d.c. negative feedback, and this effectively controls the emitter potential of Tr_3.

Also, since the last voltage amplifier stage is not required to deliver significant power, it can be optimized for voltage gain, with an increase in the available negative feedback. A practical amplifier circuit of this type is shown in Fig. 3.

The first two transistor voltage amplifier stages of this follow conventional design practice, with the collector load resistor of Tr_2 boot-strapped to obtain large voltage swing at the base of Tr_3 with as little second harmonic distortion as practicable. The collector of Tr_3 is also partially boot-strapped in order to reduce the peak voltage swing, and improve the symmetry of the output waveform prior to the application of the loop negative feedback. (Without overall n.f.b. the distortion at full output power is a little

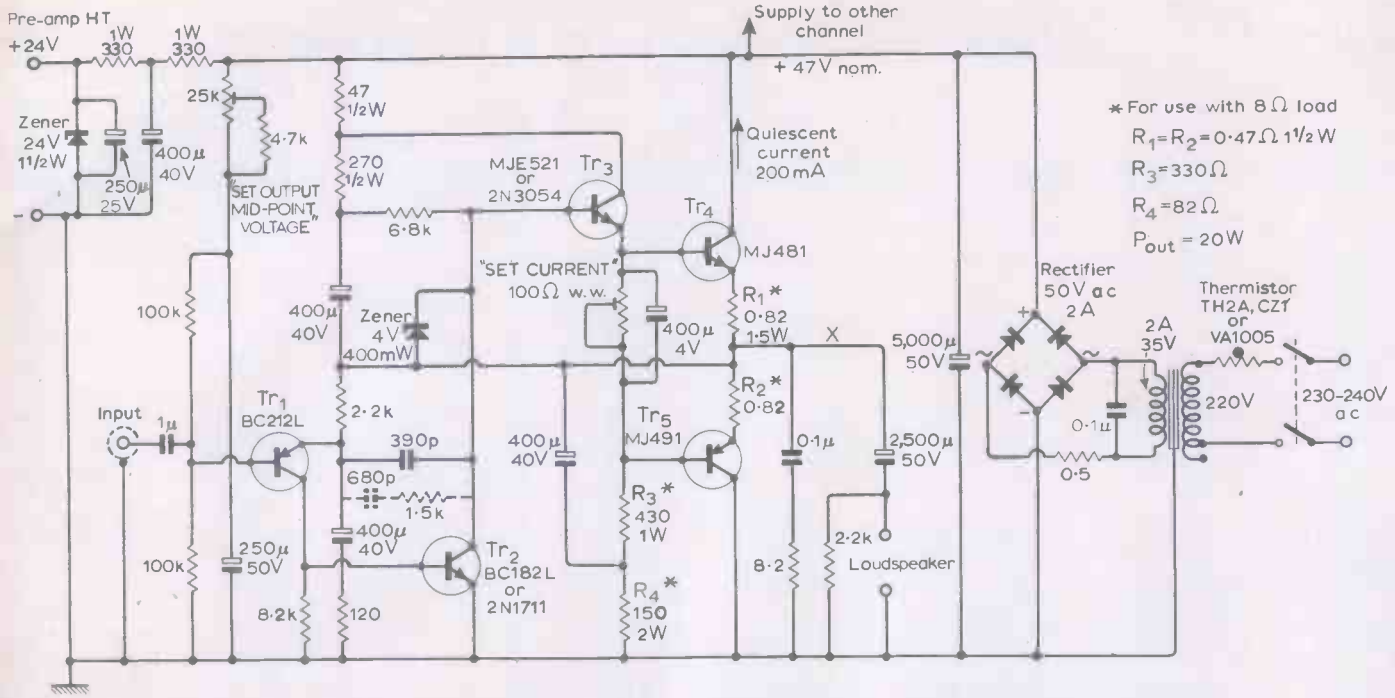


Fig. 3. Power amplifier circuit. The dotted components (680pF, 1.5kΩ) can be added if electrostatic speakers are used.

less than 4%, almost entirely second harmonic. This is similar to the performance of a good triode valve output stage prior to the application of n.f.b.) The lower end of R_3 is also fed with the output signal to improve the output voltage swing obtainable from Tr_5.

The 390-pF capacitor between the emitter of Tr_1 and the collector of Tr_2, and the 8.2-Ω resistor in series with the 0.1µF capacitor across the output, provide the necessary phase-angle correction and define the high-frequency gain of the feedback loop. With the values shown there is a 6 dB/octane roll off beyond 100 kHz, and the system is completely stable under all load conditions. However, with the use of a large value capacitive load there will be some overshoot on a rapid transient. The author believes that it is desirable, for tonal purity, for such overshoots to be eliminated, and it is recommended, therefore, that the 390-pF capacitor be shunted with a 680-pF 1.5-kΩ combination where it is intended to drive electrostatic speaker systems. However, on normal loads this merely reduces the h.f. roll-off point, and the power output available in the 30-50 kHz region, and can well be omitted.

The 100-Ω wire-wound potentiometer between the bases of Tr_4 and Tr_5 is used to set the quiescent current level to about 200 mA. The chosen current level determines the power level at which the system changes from class A to class B operation. With the suggested level of 200 mA, this transfer will occur at approximately 300 mW with a 15-Ω speaker (160 mW for 8Ω) although the measured current consumption will not appear to increase until a power output (into 15Ω) of about 1.2 W is reached because the h.t. line bypass capacitor is able to supply the peak current demands.

If the standing current through the output stage is increased, progressively larger output power levels can be obtained within the class A region, up to the level at which the amplifier acts as a pure class A system. The only observed penalty for this exercise is that the power supply demand and the thermal dissipation in the output transistors are both proportionately increased. However, if the output transistors are of dissimilar origin or are otherwise badly paired the operation of the circuit in class A will ensure that the distortion levels and other performance standards are attained in spite of this.

Performance characteristics

The specifications given below were obtained using the power supply system shown in Fig. 3. The amplifier was specifically designed to work from a poorly smoothed h.t. line, the values and positions of the h.t. decoupling and 'bootstrap' capacitors being chosen to avoid the intrusion of ripple into the signal circuits. The only significant difference observed in using a good quality stabilized and smoothed power supply is a small improvement in the already extremely good hum and noise levels.

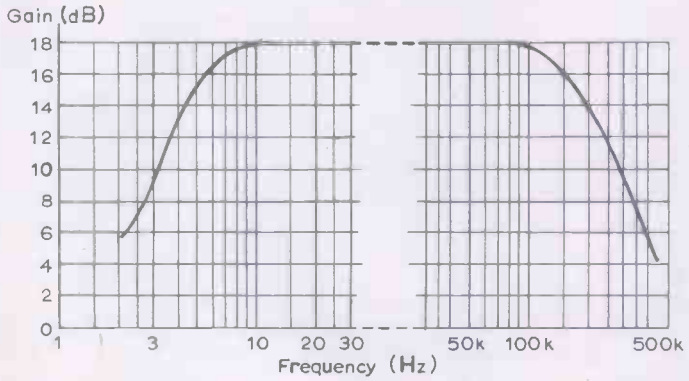


Fig. 4. Gain/frequency characteristics.

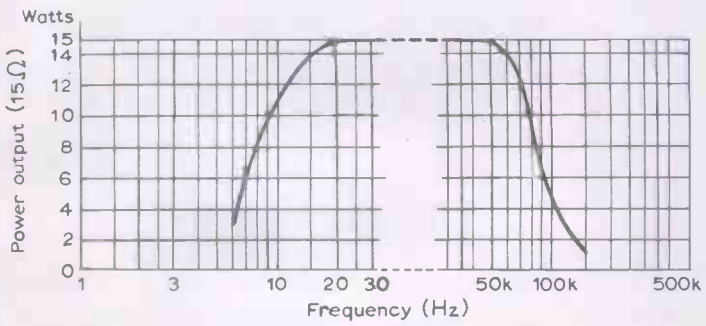


Fig. 5. Power output/frequency characteristics.

Power output. 15W into 15Ω, or 18W into 8Ω. (20W with modified output circuit components values).
Bandwidth. 10Hz—100kHz ±0.5dB at 2V output. 20Hz—50kHz ±0.5dB at maximum power output.
Output impedance. 0.03Ω (at 1kHz).
Total harmonic distortion. 0.02% at 15W/15Ω or 18W/8Ω; less than 0.02% at all power levels less than maximum output.
Intermodulation distortion. Less than 0.1%. 10W (12.3V r.m.s.) 15Ω, 70Hz. 1V r.m.s. 7kHz (or 10kHz).
Square-wave transfer distortion. Less than 0.2W at 10kHz.
Rise time. 3µs.
Input impedance. 20kΩ (approx.)
Gain. 18x.
Hum level. (Simple power supply) −70dB w.r.t. 1W

Noise level. (Simple power supply) –80dB w.r.t. 1W. (These figures are, respectively, better than –80dB, and –85dB with the regulated power supply.
Feedback factor. 46dB (typical).
Input voltage for max. output. 850mV r.m.s.
Load stability. Unconditional.

For the perfectionist, a suitable design for a regulated d.c. power supply, with re-entrant short-circuit and overload protection is shown in Fig. 10. This gives approximately 10dB improvement in the hum and (r.m.s.-weighted) very low frequency noise.

The gain/frequency, and power output/frequency graphs are shown in Figs. 4 and 5, and the relationship between output power and distortion, and signal frequency and distortion are shown in Figs. 6 and 7. The square wave performance into a 15-Ω resistive load, with any value of shunt capacitance up to 0.1μF, at 1kHz, 10 kHz, and 50 kHz are shown in Fig. 8. The sine wave output at 1 kHz, and 15W with a 15-Ω resistive load (42.5 V p-p) and the associated harmonic distortion (representing 0.02%) is shown in Fig. 9.

Listening trials

As described last month, a number of experiments were done during the development of this circuit to try to relate audible effects to the phenomena observable and measurable in the laboratory, and a transfer distortion analyser (British patent application No. 7925/1970) was made to judge the performance with non-sinusoidal waveforms. (A point was reached in the earlier stages of the design where the author's ear was no longer able to detect the subsequent improvements.)

The transient response of the 10-watt class A design (as originally published[1], without the modifications[2], suggested in October 1969 to reduce the h.f. bandwidth) is superior to that of the present circuit in the range 50kHz–2Mhz under load conditions of fairly low capacitive reactance. Under more adverse load conditions the present design will be (technically) better. However, the most careful comparative listening trials, with several of the author's long-suffering friends, have failed to uncover any audible difference between these two designs, both of which will almost certainly surpass in performance the best available valve-operated, transformer-coupled units.

Constructional points

The layout used in one of the prototypes of this design is shown in Fig. 11, using a 0.15-in matrix copper strip board. The layout should not be particularly critical provided that normal precautions are observed, such as keeping the output and input circuits reasonably well separated, and making sure that the power supply leads, and the loudspeaker return lead, connect to the board at a point close to that to which the collector leads of the output transistors are soldered.

Since the circuit has unity gain at d.c. the occurrence of a switch-on 'plop' in the loudspeaker can be avoided by the use of a suitably long time-constant in the decoupling circuit which provides the base bias for Tr_1. The voltage at 'X' (Fig. 3) will then follow the base potential of Tr_1 as it slowly rises following switch on. It is undesirable to have the full h.t. voltage applied during this period, and this is avoided by the incorporation of a thermistor (Radiospares TH2A or equivalent) in the mains transformer primary circuit. Since this will cause a drop of some 10-15V, this should be allowed for in the tapping point on the mains transformer. Also, since the thermistor becomes quite hot under operating conditions (this is necessary) it is important to mount it in such a way that this does not damage associated components or wiring.

The dissipation of the output transistors is normally about 8W, and the output pair can both be mounted on a single 3½in x 4in.

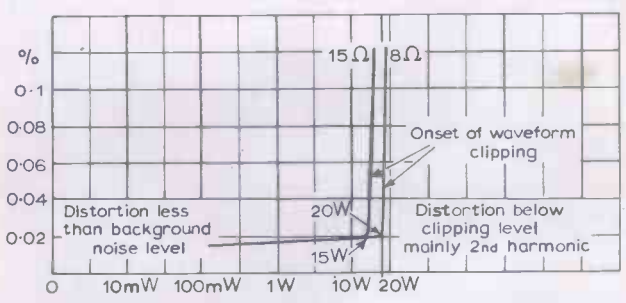


Fig. 6. Power output/distortion characteristics. The 8-Ω load characteristic was measured using the modified output-stage components.

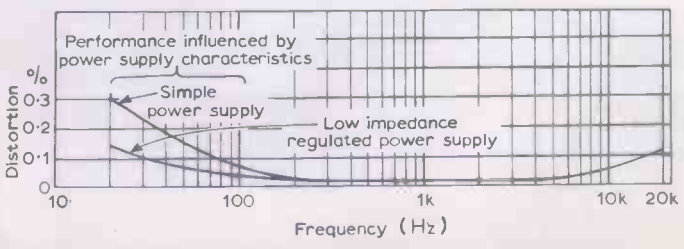


Fig. 7 Influence of signal frequency on distortion (1W into 15Ω)

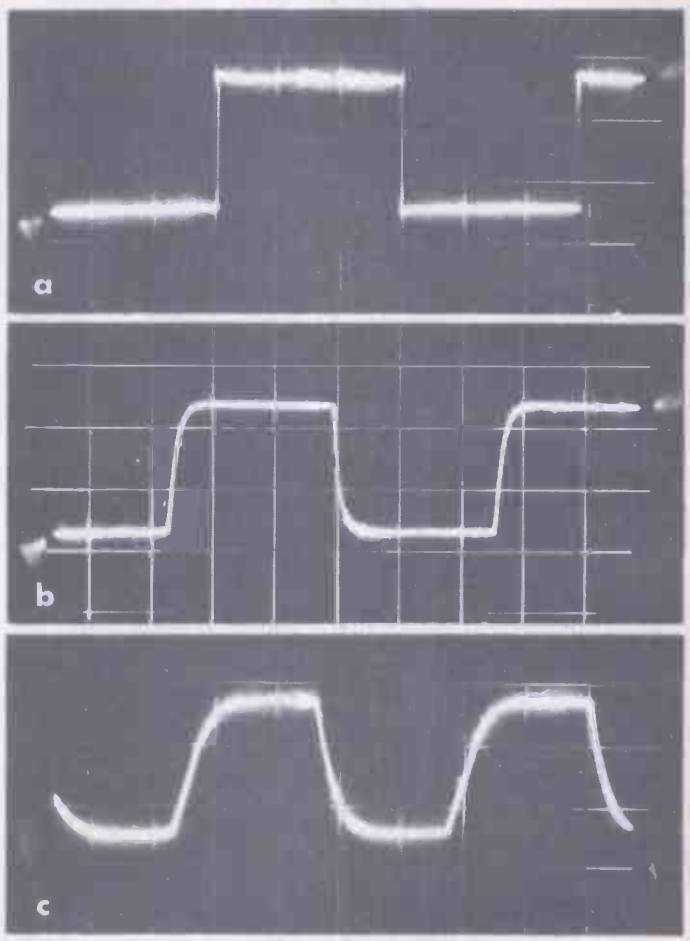


Fig. 8. Square-wave performance into 15Ω in parallel with 0–0.1μF. (Scale 2V/cm) (a) 1kHz, (b) 10kHz, (c) 50kHz.

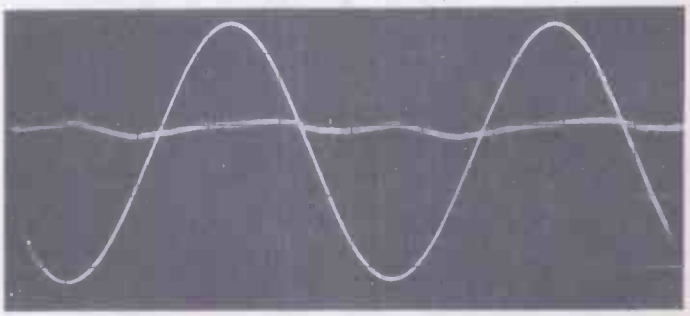


Fig. 9. 14-W 1-kHz sinewave into 15-Ω resistive load. Distortion 0.018% on scale 35mV/cm. Fundamental on scale 10V/cm.

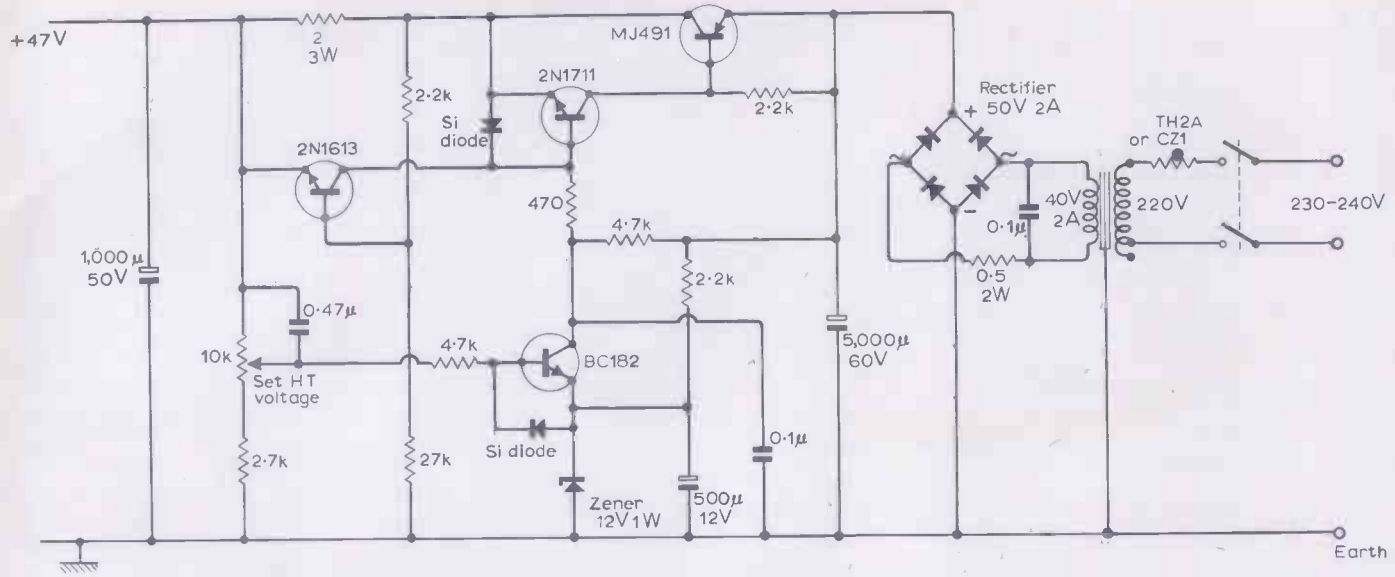


Fig. 10. Stabilized power supply with re-entrant short-circuit protection (12-49V).

black anodized, ribbed heat sink. The heat sink should be earthed —very simply by omitting the mica washer on the MJ491.

The driver-transistor dissipation is of the order of 2W in some circumstances, and this is somewhat in excess of the power which can be handled safely by the normal TO-5 cased device, such as the 2N1613, unless very careful heat sinking arrangements are employed. The use of such devices as the 2N3054 or the Motorola MJE521, mounted on a small piece of black-painted aluminium sheet, say 1in x 1½in, gives a very large safety margin in this stage. The performance of the Motorola MJE521 is slightly to be preferred, and was used in all the prototypes. This stage, however, is not a very critical one, and these transistor type variations are unlikely to make a significant difference to the system's overall performance.

The Texas BC212L and 182L are the preferred transistor types for Tr_1 and Tr_2, although the 2N1613 was also used in some development models as Tr_2 with identical results. The Motorola 2N-3906 and 3904 could also be used in the Tr_1, Tr_2 positions with almost equivalent performance, but this has not been tried. The use of ½-W carbon film 5% resistors is suggested except in the points where higher wattages are required. R_1 and R_2 should be of small diameter or low inductance. The various electrolytic capacitors can be of higher value or voltage working without ill effect.

A suitable printed circuit is obtainable from A1 Factors, of Nottingham, who can also supply the other components.

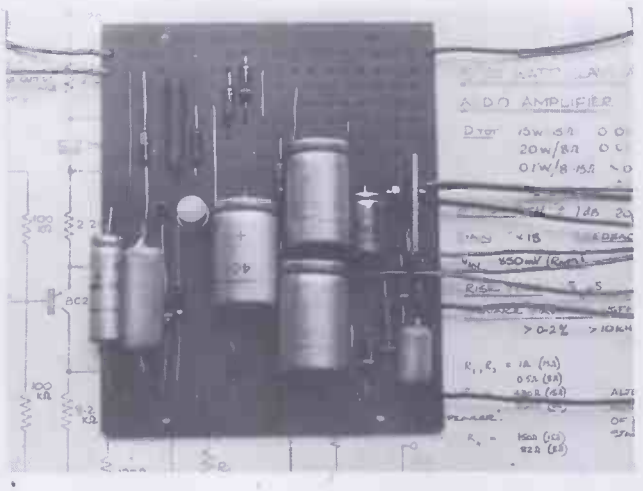


Fig. 11. Layout of components on 0.15-in matrix strip board. The 'set current' and 'set mid-point' potentiometer, and the power transistors, are off the board.

Appendix 1

Calculation of power output levels obtainable with given quiescent current in class A operation.

The maximum output power which can be obtained from a power output stage such as that in Fig. 3, in class A, is entirely determined by the quiescent current and the load impedance provided that adequate h.t. voltage is available. At frequencies which are low enough for the 'wattless" components of the load current to be ignored, the maximum current excursion which can be caused to flow through the load without taking one or other of the output transistors beyond cut-off is equal to twice the quiescent current (I_q) through the output stage. Since this is the 'peak' current through the load, if the waveform is sinusoidal, the r.m.s. equivalent current will be $2I_q/\sqrt{2}$, and at low frequencies, the power developed in the load will be $2I_q^2 . R_L$.

For example, if the stage is required to operate in class A up to one watt, with a 15-Ω load, the peak current swing through the load must be $1 = 2I_q^2 . 15$, or $I_q = 183$mA. Similarly, for an 8-Ω load, $I_q = 250$mA.

With the standing current suggested (200mA), 1.2 watts or 640mW will be given for 15-Ω and 8-Ω loads respectively. This should be adequate for most normal listening. For full class A operation up to 15W, quiescent currents of 710mA and 970mA respectively will be required.

Appendix 2

Output transistor protection

The use of class B output circuit configuration (and class AB comes within this category at the power levels concerned) in transistor power amplifiers of this general type leads to the possibility that very high instantaneous currents can flow, which will lead, regrettably, to the equally instantaneous destruction of the transistors involved, if the amplifier is operated at maximum drive into an effective short circuit, and this could be a load with a very high capacitive reactance, in some cases.

The classic system for output transistor protection, using two input bypass transistors, is that due to Bailey[3], and this is also applicable to the output circuit of this design. However, because of the d.c. asymmetry between the potential at the base of Tr_3 and the output point 'X', a much simpler arrangement can be used, consisting solely of a good quality (low leakage) zener diode between these two points, with the positive zener end connected to the base of Tr_3. Any 4·4.7V zener will do provided that the leakage current at 3V reverse, and 0.4V forward, is less than 10μA. The ITT 400-mW series ZF 4.7 is quite suitable. Again, for 20 W output into 8Ω, the resistors R_1 and R_2 must be reduced to 0.47Ω.

REFERENCES

1. J. L. Linsley Hood, "Simple Class-A Amplifier", *Wireless World*, April 1969.
2. "Letters to the Editor", *Wireless World*, October 1969.
3. A. R. Bailey, "Output Transistor Protection in A.F. Amplifiers", *Wireless World*, June 1968.

Electronic Building Bricks

2. Representing information by electrical variables

by James Franklin

Last month we defined electronics broadly as the use of electrons to represent and process information for human purposes. This is a rather grand phrase, and, like all generalizations, needs a down-to-earth example to give it real meaning. Let us, then, look at a simple electronic system.

Fig. 1 shows a system for counting objects moving along a conveyer in a factory. A lamp and lens produce a beam of light which passes across the conveyer belt at such a level that the moving objects interrupt the beam. The light falls on a photo-electric cell, which converts the light energy into electrical energy. The electrical energy from the cell is then conveyed to an electronic counter. This device counts *events*, not, as the name might suggest, numbers of electrons. In this case the events counted are the interruptions of the light beam, as detected by the photo-electric cell.

The graphs in Fig. 2 show in more detail how it works. At (a) is a graph of the light energy reaching the photo-electric cell over a period of time. It will be seen that this energy falls to a very low value, practically zero, when the beam is interrupted by an object (the small residual energy being the result of room light "leaking" into the cell). At (b) is a time graph of the electrical energy generated by the cell as a result of the incident light energy. One can see that it forms a sequence of falls of electrical energy, corresponding to the interruptions of the light beam. These events can be distinguished more clearly if we invert the vertical axis of the graph as at (c).

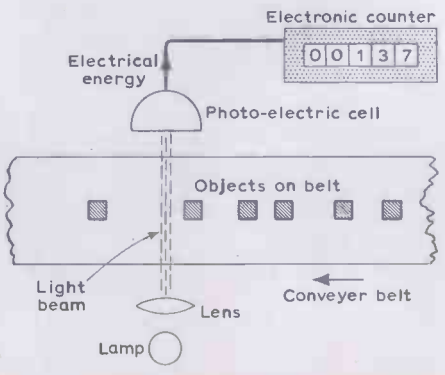


Fig. 1. A simple electronic system for counting objects moving on a conveyor

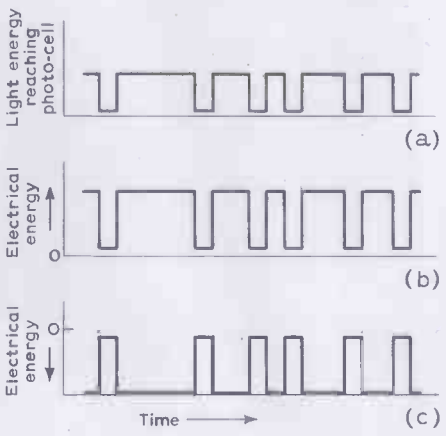


Fig. 2. How the required information in Fig. 1 is represented by an electrical variable: (a) light energy reaching the photo-electric cell; (b) resultant electrical energy; (c) the graph (b) inverted to show falls of energy as pulses.

Thus we end up with a sequence of *pulses* in the flow of electrical energy, representing the interruptions of the light beam and hence the passage of objects through the light beam. The electronic counter counts these pulses—the "events"—and thereby counts the number of objects travelling along the conveyer.

In this simple system the essential information is the number of objects that pass the detection station on the conveyor. Within the electronic system this information is represented by the variation of electrical energy shown in Fig. 2 (c)—a pulse (energy fall) for each object. This graph is one example of an electrical *signal*. In this form the electrical signal is similar to those produced by earlier methods—smoke, arm positions, flags, flashes of light etc.; it is a sequence of events representing and conveying information.

We have carefully said "representing and conveying" because a signal does both. We may, however, merely wish to represent information, without simultaneously conveying it, so that it may be sent later—this is called *storage*. The two functions are illustrated by analogy in Fig. 3. At (a) the quantity of material held in the container (which can be controlled by the inflow and outflow) may be used to represent some other variable, say air pressure. This is static information, and the process of holding it, storage. At (b) material is moving along a pipe—this could be the inflow or outflow pipe in (a). Here we could use the rate of flow of the material to represent the variable—and again this could be air pressure. So in both cases we have a mechanical variable made proportional to some other variable, but in one case the information is static (stored) while in the other case it is dynamic (conveyed).

In electronic systems we can use electrons as the "material" in Fig. 3—for example, quantity of electrons for static information, flow rate of electrons for conveying information. There are, in practice, several electrical variables which may be utilized—voltage, power, electric and magnetic fields, to name a few without explaining them here.

Another type of electrical signal is shown in Fig. 4. Although this time graph is a continuous variation of electrical energy in contrast to the pulses in Fig. 2 (c), it can still be regarded as a sequence of events because it consists of successive values of energy (though these successive values are infinitely close together). The electrical energy values here are actually proportional to sound energy values detected by a microphone, and they result from sound waves produced by a violin being bowed on its E string.

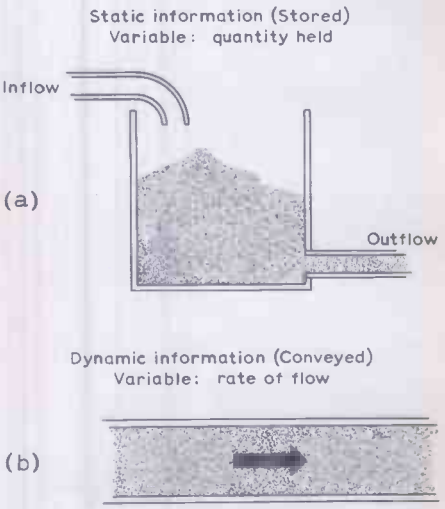


Fig. 3. Analogues illustrating how a material may be used to represent (a) static information and (b) dynamic information.

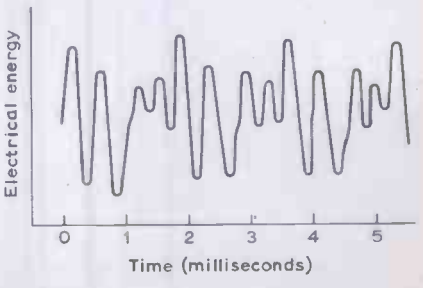


Fig. 4. Graph of electrical energy varying with time—a signal of a different type from that in Fig. 2 (c).

News of the Month

Where can you order a 1.35μF ± 0.5% capacitor?

You can now order a special capacitor of the above value and tolerance in one off quantity and expect a short delivery time. For your 38s 3d, and that is what it will cost you, you will get a high-quality polycarbonate capacitor with either axial or radial leads (your choice) in a rectangular package measuring 24 × 14 × 12mm; the working voltage will be 63 from −55 to +85°C. A temperature swing from 10°C to 60°C will change the capacitance by only 0.15%.

In fact the firm which offers this service manufactures 63V polycarbonate capacitors from 470nF to 22μF (any value) with tolerances of ±5, 2, 1 or 0.5%. A ±5% version of the capacitor mentioned above would cost 11s 4d.

The firm, which is British and is called MFD Capacitors Ltd, is offering a service which is unique, although their main business will be in standard value precision capacitors within the limits mentioned above.

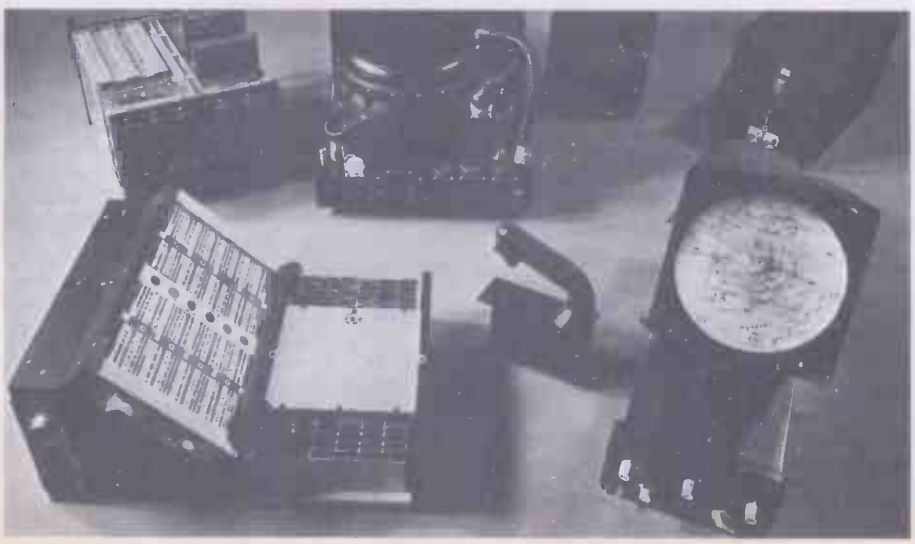
This service is made possible by a new manufacturing process and by a new approach to the problem of determining the capacitance of the final product. Once the metal-coated polycarbonate films have been wound they are measured and put in bins of a nominal standard value or in bins of a value representing given percentage increments above and below the nominal value. It is normal in film capacitor manufacture for the capacitors in this stage of manufacture to contain short-circuits which are later burnt away by the application of a high-voltage. MFD uses a winding technique that makes this process unnecessary. In fact the polycarbonate film used is so thin (0.002mm) it would be damaged by the process.

Subsequent stages of manufacture —coating the ends of the roll attaching the lead out wires and encapsulation— normally involve the application of heat and alter the value of the winding. The processes used at MFD do not alter the value making it possible to know the final value of the capacitor before manufacture is complete.

Because of this, and because two capacitor 'rolls' can be encapsulated together in the standard cases used, any desired value can be produced by connecting two selected rolls in parallel within the one encapsulation. In addition MFD will manufacture capacitors in various non-standard packages or with special characteristics.

MFD Capacitors Ltd have announced an agreement with Emihus Microcomponents Ltd under which Emihus will market the capacitors in the U.K.

Elliott Flight Automation have received a £5M order for digital inertial navigation and weapon aiming systems to be fitted to Jaguar aircraft for the R.A.F. The basic components of the system, which is built around the Elliott 920M miniature computer, are shown in the photograph. This system is much smaller and lighter than Elliott's first i.n. system which was designed for the Blue Steel stand-off bomb carried by V-bombers.



Microelectronics industry survey

The Ministry of Technology and the National Research Development Corporation have announced that they are to sponsor a comprehensive study of the microelectronics industry in Britain. It will cover the period 1970 to 1980. The survey will cover forecasts of markets, product costs and technological trends in microcircuits and will include a less detailed survey of the electronics industry as a whole and the ever-expanding list of other industries now making use of microelectronics.

The survey will be conducted by Mackintosh Component Consultants Ltd based in Glenrothes, Scotland, and will take about fourteen months to prepare.

New transmitter for Criggion

Early in the 1939-45 war it was decided to build a v.l.f. transmitting station that could take over from Rugby (GBR) should this station be put out of action. The shortage of steel for the aerial masts and the need for large amounts of cooling water led to the choice of a site at Criggion near the river Severn. The huge aerial was supported by three 600-ft towers (which had been built for a new radio station in Ceylon) and an anchorage on the top of Breidden Hill which rises steeply above the river Severn.

Hardly had the new transmitting station been completed when, in 1943, the Rugby station was severely damaged by fire. Criggion took over for the nine months it took to rebuild the Rugby station. Following this Criggion, with the call-sign GBZ, operated for 25 years.

In July 1969 a new, larger, aerial was completed on the Criggion site. Three new 700-ft masts were constructed, in addition to the original masts and the hill anchorage. The conductors used for the aerial represented a departure from normal systems for the Post Office in that steel cored, aluminium sheathed cable was employed offering a number of advantages; light weight, strength, high current carrying capacity, freedom from icing and corona, and high capacity to ground. In all fourteen miles of aerial cable, weighing about 40 tons, was used for the aerial.

The new aerial could handle four times the radiated power of the old one and now a new transmitter has been built to provide it. The new transmitter, built by Redifon, was officially inaugurated a few weeks ago. It consists of synthesizer type

frequency generating equipment driving three amplifiers.

Each of the amplifiers comprises a 5-kW wideband audio frequency amplifier, coupled to a single-stage tuned amplifier having an output of 150kW. Each or all of these three tuned amplifiers can be connected via heavy-duty r.f. switches to the common tuned tank and aerial circuit, and thence to the aerial system. The power fed to the aerial can, therefore, range from 150kW to 450kW, according to the number of amplifiers in use. The tuned output and aerial circuits are of orthodox design employing tuning capacitors of the type first used in the GBR transmitter forty five years ago. The anode tuning inductors are of the variometer type originally developed for a new transmitter built for the Rugby station. The aerial tuning inductor is a modified design of the one previously used at Criggion. The combination of the new aerial and amplifiers has raised the radiated power from approximately 7.5kW to 30kW at 19.6kHz, at which frequency GBZ normally operates.

Skynet-2

Hawker Siddeley Dynamics Ltd and GEC-AEI (Electronics) Ltd have each been given a contract by the Ministry of Technology to develop, in co-operation with American industry, proposals for higher powered Skynet communications satellites for defence purposes. A decision on which firm is to be the eventual prime contractor for two such satellites will be taken later this year. The craft are to be ready for launching in 1973 to replace the first two Skynet satellites which were built in America. The first of these was successfully launched last November. The replacement satellites will be more powerful and will be able to operate with small transportable ground stations.

U.K. exhibit at Mesucora

Under the sponsorship of the Electronic Engineering Association and with the support of the Board of Trade, under its joint venture scheme, a number of U.K. companies exhibited at the Mesucora exhibition held at the Palais de la Defense, Paris, from May 27th to June 4th. The companies who took advantage of the joint scheme are: Automatic Systems Laboratories, Ceta Electronics, Electronic Associates, the EMI group of companies (comprising EMI Systems and Weapons Division, S.E. Laboratories, Electron Tube & Microelectronics Division, EMI Tape and Meterflow), Ether, Eurotherm, J. J. Lloyd Instruments, Marconi Instruments, Metals Research, and the Ministry of Technology (comprising British Calibration Service, Scientific Instrument Research Association and Summerfield Research Station).

B.B.C. communications, reject/re-file position with the visual display unit in the centre

Computer controlled communications

The B.B.C's teleprinter network, which handles the transmission of news items, administrative messages and scripts to and from 60 outstations in London and the regions, has recently been equipped with an automatic switching system incorporating an STC6350 Automatic Data Exchange (ADX). The previous manual system handled more than 700,000 messages a year and was incapable of expansion. In this, incoming messages were perforated on paper tape and transferred to transmitting machines which were connected to the addressee outstations by an operator on a switchboard.

If expansion were possible it still would not have relieved the congestion which occurred at peak periods. Now installed in the Communications Centre at Broadcasting House, the store and forward 6350 ADX provides automatic routing and re-transmitting of messages with a transit time of only milli-seconds. This ensures that the circuits are always operating at their maximum carrying capacity. Stations originating a call do not have to wait until the called station is free before passing their message. Incoming messages are stored until destination lines become available. Designed around a Digital Equipment Corporation PDP-9 processor, the ADX system has a planned capacity for 125 inputs and 125 outputs. The processor is equipped with a fast ferrite core with a capacity of 16,384 18-bit words having a cycle time of 1μs. This is backed up by a Burroughs fixed head magnetic disc store with a capacity of 870,000 18-bit words and an average direct access time of 17ms. Control facilities refer abnormal conditions to one of five supervisory units for action and the system programmes ensure an extremely fast return to service in the event of failure, with full protection for all traffic. One of the supervisory units is a visual display where messages rejected by the ADX because of incorrect routing information in the header can be inspected. The unit has a keyboard through which the operator may correct the header information and automatically release the message for transmission.

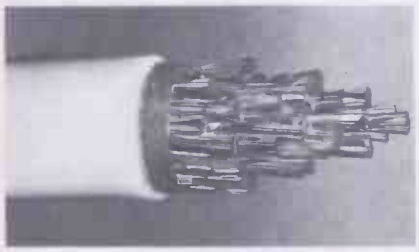
British exhibit at WESCON

The Electronic Engineering Association is sponsoring participation by 29 U.K. electronics companies at the 1970 Western Electronics Show and Convention (WESCON) which this year takes place in Los Angeles from 25th to 28th August. The British companies taking part are: Air Control Installations (Chard), AEI Semiconductors, Birch-Stolec, Bowthorpe-Hellermann, Ceta Electronics, Cossor Electronics, Culton Instruments, Electrolube, Elite Engineering, Ferranti, FieldTech, GEC-Elliot Process Instruments, Green Electronic & Communication Equipment, Industrial Control Systems, Jermyn Industries, Marconi Instruments, the M-O Valve Company, Mullard, Prosser Scientific Instruments, Racal Instruments, Rank Precision Industries, Research Instruments, Seer TV Surveys, SDC Electronics (Sales), Static Devices, Techne (Cambridge), Vero Electronics, Vision Engineering, and the Wayne Kerr Company.

Synchronous weather satellite

In response to a request from the American National Aeronautics and Space Administration Hughes Aircraft Company have submitted a design for a synchronous meteorological satellite capable of non-stop operation. The satellite, if accepted by N.A.S.A., will be cylindrical in shape measuring five-feet high by five feet in diameter. All-up weight will be around 450 kg.

The satellite after launch, using a Delta booster with six auxiliary strap-on rocket motors, would be under the control of the Environmental Science Services Administration (ESSA). From the height of 22,300 miles the satellite would take cloud cover



(Above) An 8,000-conductor telephone cable being manufactured at the works of British Insulated Callender's Cables and (left) the finished product. The cable employs "Hyperden" insulation, developed by B.I.C.C., made from cellular polythene 90μm thick giving an increase of 25-pairs-per-cable of a given diameter over earlier methods. The P.O. have successfully laid a length of the cable at Irlam, Lancs.

pictures at the rate of one every twenty minutes, receive information from up to 10,000 sensors (located on ocean buoys, in rivers, on merchant vessels and automatic weather stations), examine solar radiation for high-energy particles and solar X-rays and also measure the earth's magnetic field.

The information received by these means, in addition to photographs, would include temperature, humidity, pressure and water level measurements as well as data on the rate of flow of rivers and streams. All this information would then be transmitted to a ground station for analysis and distribution.

Hughes say that the satellite could be ready for launch eighteen months after the go-ahead was received from N.A.S.A.

The soldered joint

The International Tin Research Council mention, in their annual report for 1969, work being carried out in response to enquiries received from the electronics industry to assess the integrity of the soldered joint in the light of the demands made upon solder by modern automatic methods of soldering. It would appear that the quality of the solder, which must be very good for use in solder baths, deteriorates during mass soldering because of impurities which dissolve in the bath from the work.

The individual effects of small amounts of zinc, aluminium and phosphorus on the wetting behaviour of a 60/40 tin/lead solder have been studied in some detail. Using a plain resin soldering flux it was found that about 0.005% zinc in the solder began to cause the formation of a visible oxide film. This film could well result in the solder bridging the gaps between adjacent conductors on printed circuit boards, thus short-circuiting the electrical path. At a zinc content of about 0.01%, dewetting of the solder from a copper surface was manifest and at higher levels still the ability of the solder to spread on the copper was noticeably reduced.

Similar effects were observed when aluminium additions were made to a 60/40 tin/lead solder, but here visible surface oxidation began to occur at a very much lower level (0.0005 to 0.001% aluminium). The deleterious effects of traces of aluminium appear, however, to be eliminated by the presence of small amounts of antimony in the solder bath. Although phosphorus is less likely to be picked up in solder, it was found that, at phosphorus contents exceeding about 0.01%, the solidified solder deposit had a rough, "gritty" appearance and dewetting began to be apparent.

Naval battle simulator

A complex military tactical trainer which employs more than £0.5M worth of electronic data display equipment supplied by Marconi Radar Systems has been brought into service at the naval training establishment *H.M.S. Dryad* at Southwick. The trainer was designed by Ferranti working in co-operation with the Admiralty Surface Weapons Establishment and uses three Ferranti computers which drive more than one-hundred A.E.I. type 1400 displays of various sizes. During the course of a particular battle, at any one time, there may be upwards of 200,000 characters displayed on the various screens. The equipment will simulate ships, submarines, aircraft and other weapons, and it will realistically represent radar, sonar, data handling and communications equipments.

Students are accommodated in cubicles each containing at least two plan displays and a separate tabular display. Each cubicle represents a vehicle in the battle and responds realistically to the commands given by the students. Instructors have control of a large number of additional vehicles with which they can inject new circumstances.

A complete photographic record of each exercise is taken for later analysis.

The Harlech colour television outside broadcast vehicle (right) is equipped with four of the EMI colour television cameras type 2001 and is sub-divided to provide separate control areas for production, sound and vision. The sound facilities provide for 24 inputs into six groups. The vision system allows simultaneous mixing and special effects operation from up to ten inputs and a separate caption scanner.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

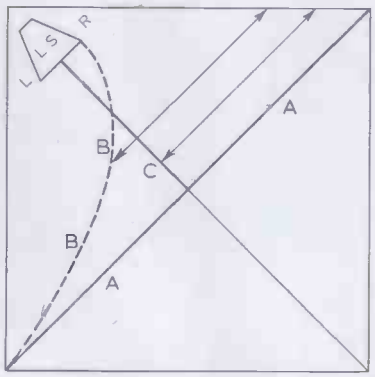
Low-cost horn

I am glad "Toneburst" has brought into the open in his article in the May issue of *W.W.* the apparent disparity between real and theoretical cut-off frequencies of corner horns. When, some years ago, a home-built horn of mine appeared to cheat by reproducing tones lower than expected, the thoughts indicated below seemed to reconcile fact with theory reasonably well. I offer them, without professional authority, in the hope that confirmation or rejection by those more knowledgeable will help to remedy the absence of any study of the function of the room as a component of the total horn system.

A horn cannot emit frequencies as low as 30Hz unless it has a mouth of about 38ft circumference or 10ft sides if square. If a corner horn reproduces 30Hz then there must exist a mouth very much larger than that which we see, well forward into the room and connected by some kind of flare extension. With a loudspeaker firing diagonally into a square room this mouth will be the rectangle formed on the other diagonal, with dimensions of room diagonal and room height. (In a rectangular room the effective diagonals would be of the square of the shortest wall.) The extension flare formed by floor, walls and ceiling is not ideal, particularly as the ceiling presents a large and abrupt step in one "contour".

This step is mentioned in a later paragraph. For now, note that the listener is either *in* this horn or in a position comparable, in terms of wavelength, with having his ear within a few inches of the mouth of a mid-frequency horn, where the losses and aberrations attributed to mouth and flare are less evident than at more ordinary distances.

Whereas sound from the mouth of an auditorium (e.g., cinema) bass horn is distributed widely, from the effective mouth of a corner horn it is confined, hence there should be some apparent gain which would off-set the shortcomings of the extension flare to some extent. The mouth radiates into an enclosed volume of air (half the room volume for a square room) that is much smaller, and therefore stiffer, than that encountered in any ordinary auditorium. Presented to the cone by horn transformer action this stiffness could be quite considerable and the necessity of some balancing stiffness behind the cone would help to explain the dramatic improvement in bass response noted by "Toneburst" when he fitted a rear pressure chamber. Cone excursion, and therefore distortion, could be expected to be less than in auditorium horns. Is this, I wonder, another reason why the Klipsch horn is so widely acclaimed?



A, plane of effective mouth; B, desirable, but unattainable lateral expansion (shown for the right hand only); and C, collision plane, virtual partition limiting lateral expansion of both wavefronts.

The rectangular wavefronts emerging from the so-called mouths formed between horn cabinet and corner walls are separated, initially, by the width of the cabinet. Lateral expansion brings the inner vertical edges into collision at a vertical plane on the centre-line shown in the sketch. As the colliding edges have equal and opposing energy the collision plane is a virtual partition which prevents further lateral expansion. It forms, with the floor and walls, two flare sections that would limit expansion to something seriously short of the exponential flare-rate (indicated in the sketch) if vertical expansion was also inhibited. However, the top flare "panel" is the ceiling and the required expansion is accommodated.

It is, of course, exceeded, but the ceiling step now seems lossy only to the extent by which its capacity exceeds the volume needed to fulfil the flare rate. Even the remaining capacity may be taken up by the presence (in the horn!) of large furnishings, such as armchairs, at floor level. Whatever its effective volume may be the ceiling step seems comparable with a leaky flare panel, but the leak is not into unlimited atmosphere. Even in open air an improvised conical megaphone of rolled, unjointed cardboard, or just a single cupped hand—both very leaky horns—are capable of some useful gain.

Despite my admiration of "Toneburst's" experimental effort and design ability, I feel obliged to suggest alternative methods of construction. End-grain butt joints are notoriously weak even with the finest glues, the simple halving joint is far more reliable.

Concrete does not bond with wood; it merely clings, aided in the present case with nail inserts. Effectively we have heavy concrete panels nailed together via sticks. Why, incidentally, if three flare panels must be concrete, should the fourth be wood?

I would use "multi-ply" or blockboard again on the grounds that what's good enough for Klipsch is good enough for me. The panels forming flares, pressure chamber and loudspeaker mounting constitute an array of stiffening webs that impart great rigidity and divide the large panels into smaller areas virtually incapable of flexing, provided a good resin or casein glue is used, with fillets to augment the glue areas.

These observations in no way detract from my admiration of the bold design and experimental effort, against the weight of existing theory, that has provided enthusiasts with a simplified small horn of good performance. My other comments are intended to arouse some responses that may help to explain why it works so well.

W. GROOME,
Halesowen,
Worcs.

The designer replies:—

Mr. Groome's letter is very interesting indeed. In the bass horn I described, the openings in the sides of the rectangular enclosure together provide a cross-sectional area of 260 sq in (130 sq in on each side). Simply placing the enclosure in a corner yields the remarkable results. The important point to note here is that the rate of expansion of the horn outside the enclosure (i.e., the flaring rate made in conjunction with the walls) is too rapid to be accommodated by horn theory for the results attained. Even for a 40-Hz cut-off the cross-sectional area should double in about 16in. An interesting question: when is a horn not a horn? Mr. West (in the June issue) suggests that the air chamber behind the cone turns the enclosure into an infinite baffle type below 100Hz in my design. Yet it is a characteristic of the Klipsch horn that the efficiency is well maintained down to about 40Hz.

Where do we go from here? Perhaps we ought to abandon horn theory as such and get some experimental results on a different track. There is a need for a medium-efficiency loudspeaker that will give corner-horn quality down to at least 20Hz—and that is a good design aim for anyone. The delay-line bass speaker (at present designated "transmission line" following Bailey's article[1]) is rather a non-starter because it offers synthetic bass. Synthetic bass? Synthetic because energy from the rear of the

bass speaker cone is delayed for half a cycle before it emerges to augment the signal from the front of the cone. The signal is thus a blend of the past and the present—but very good on sine waves.

Turning again to Mr. Groome's letter I quite agree with his remark about halving joints—that they are much more reliable than end-grain butt joints—but I have to report no breakages myself.

The use of concrete for the *large* panel areas and the sides gripping the speaker-mounting board, is to ensure rigidity and thus prevent even the suspicion of hangover. You will certainly get "horn quality" from a well-braced plywood structure but I believe that concrete gives audibly better results, even for the treble horn.

"TONEBURST"

[1] A. R. Bailey, "A Non-resonant Loudspeaker Enclosure Design", *Wireless World*, October 1965.

Further experience with C-D ignition

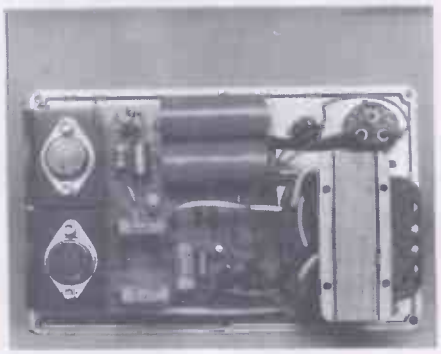
I trust that the following practical details of further experience with Mr. Marston's C-D ignition system (January 1970) since my letter in your March issue will be of interest.

Currently, I have the system fitted to two 6-cylinder cars, one having been recently transferred from a 4-cylinder model. Neither of these cars is in the high-revving class (very few 6-cylinder engines are) and I would say that the Repanco TT51a transformer that I used is quite capable of handling the power required under ordinary road-running conditions. Therefore, for anyone who wishes to build the system without having to reconstruct a transformer, I would unhesitatingly recommend the TT51a for ignition systems up to 6-cylinder capacity. Because of its reduced output, compared with that of Mr. Marston's "bespoke" transformer, I would also suggest that R_6 be dispensed with, also the zener regulating network. Neither of my two systems has these items and there have been no component failures to date. The only other change that I have made to the author's circuit is to make $R_1 = 100$ ohms instead of 50. The resulting c.b. points current is adequate for keeping the points free of oxide. Good sparking is obtained right down to 5V input from the battery.

The protective resistor in the base of Tr_3 was added to both systems immediately Mr. Marston suggested its inclusion (March letter). In consequence this probably forestalled premature failure of this transistor, as occurred with Mr. Burn's unit.

Needless to say, I am very pleased with the continuing excellent performance and reliability from the C-D system. It performed extremely well during most of the winter period and its cold-starting capability (notwithstanding the reduced h.t. from the TT51a) is outstanding. In this country, it is nowadays not possible for one to explore the undoubted high-performance potential on an ordinary road-going car (not legally, at any rate) but I have no doubt that for all practical purposes, this system is a very worthwhile addition to any passenger car. Constancy of ignition tune over very long periods is not the least attractive of its many advantages, to say nothing of the improvement in battery life that ought to follow from rapid cold-weather starting.

Perhaps some enterprising transformer manufacturer could be persuaded to offer a commercial version of Mr. Marston's re-wound transformer at a reasonable price.



Mr. Bolton's C-D ignition unit.

The accompanying photograph shows the simple construction of the two C-D ignition systems, on the lid of a lightweight alloy box. The small heat-sinks on the left would appear to refute the suggestion of Mr. J. F. Henderson (March "Letters") that "the power transistors will suffer from excessive heat-dissipation". The only components that run very hot are the bias resistors for the inverter, and R_1, as is to be expected.

D. E. BOLTON,
Seaford,
Sussex.

The author replies

Mr. Bolton's letter makes very pleasant reading. The only worth-while comment I have to make concerns his elimination of the zener regulating network in the converter circuitry. If these diodes are removed, it is possible that inverter overshoot will cause C_1 to charge way above 400 volts when the ignition is on with the engine stationary; s.c.r. destruction may result. To check against this danger, use a high-impedance (20,000 Ω /volt or greater) meter to measure the voltage across the s.c.r. under the above condition; if the voltage greatly exceeds 400, reduce the value of R_5 until the potential is correct: R_5 readily absorbs the surplus overshoot energy that is released when the zener diodes are removed.

Readers may be interested in a progress report on my own C-D unit. This unit has been in constant use for some eighteen months in a 1959 Hillman Minx. It has consistently given very easy starting, even under the severest winter conditions. Acceleration is outstandingly good, and high speed performance is definitely improved. Until recently the car was used twice each day on a thirty-mile journey, and topped 70 m.p.h. with ease each time.

The most impressive feature of the C-D system, however, is the way in which it improves the life of spark plugs and contact-breaker points, and eliminates the need to adjust them with any precision. My old Minx was exchanged for a 1962 model a few days ago. It had covered a total of 22,000 miles with the C-D system installed, and had not had a single adjustment made to either its spark plugs or c.b. points in all that distance. Before I finally got rid of it, I checked its plug and c.b. gaps. They were 0.060in and 0.008in respectively; their correct values should have been 0.025in and 0.015in respectively! The vehicle was still running perfectly.

Gadget-minded car owners may like to know that the C-D article is to be included in a book titled "20 Solid-State Projects for Car and Garage" to be published by Butterworths in December.

R. M. MARSTON.

As several of your readers have been complaining of misfiring with the capacitor-discharge ignition system, may I make a point that I had the same trouble whilst experimenting about two years ago with a 600-volt system? I overcame the problem by adjusting the ignition timing as I found that C-D gives a much faster spark.

M. A. SPENCE,
London S.W.18.

Symmetry in class B

Far be it from me to cross swords with such a personage as P. J. Baxandall, but I was reading his two-page letter on "Symmetry in Class B" (Sept. 1969) which previously I had only skimmed, when I came across the sentence: "now it is of no fundamental importance which point in a circuit is taken as earth . . .". This is, of course, true, but he then proceeds to 'demonstrate' that the output impedance of his driver transistor (Tr_1 in Fig. 1, a simplified version of his circuit) provides shunt feedback! The fallacy is obvious, since one can discard the 'ideal transistor' and consider a signal current flowing into (or out of) point A—

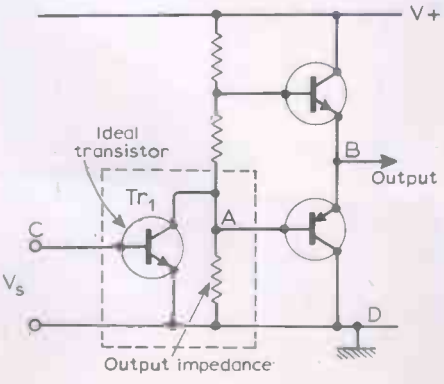


Fig. 1.

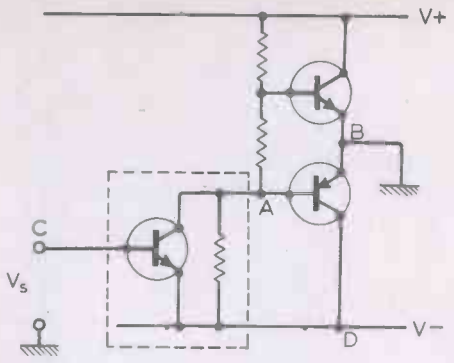


Fig. 2.

the resistor representing the transistor output impedance is simply an additional load on the signal source, and not a feedback element—it is, as he says, non-linear, but the effect is not nearly as bad as he suggests.

Mr. Baxandall's error has arisen because when he earthed point B to simplify the analysis he omitted to 'unearth' his signal source, which meant that he had to disconnect it from the negative line, thus producing a circuit like my Fig. 2, which is not now the same as Fig. 1. Since the signal is applied across B and C instead of C and D. This could be the reason for Mr. Baxandall's circuit requiring extra roll-off components, because now the signal source provides shunt feedback through its own output impedance, which might very well be complex.

I think Mr. Baxandall must at some point have lost sight of the wood for all the trees around, since it is impossible to produce shunt feedback with one resistor earthed at one end, but then, even Homer nods occasionally!

A. H. KING,
Biggleswade,
Beds.

Dynamic range versus ambient noise

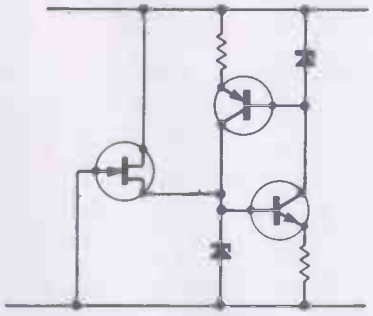
Although my article in the April issue (p. 189) was obviously intended and received as a leg pull, nevertheless, as an electronics engineer, self respect demanded that the circuit should indeed work—and work it does! If one deletes Trs_{10-17} and if one makes Tr_8 and Tr_9 2N3055s and $Trs_{5,6,7}$ 2N1711s with a 60-volt h.t. line, this circuit will deliver 50 watts into 8 ohms at around the 0.1% t.h.d. mark: other circuit details and voltages being amended as necessary, of course. I have, indeed a lash-up of just such an amplifier, and I have made a pair of 15-W, 15-ohm w.w. resistors, in parallel, glow dull red hot on a sinewave input.

G. I. O'VEERING.

Self-starting with ring-of-two

In his article "Stabilized Power Supply", April, 1970, Mr. A. J. Ewins discusses the problem of self-starting with the ring-of-two reference circuit. It may be of interest to users of this and related circuits to note a simple method[1] of ensuring self-starting with no loss of regulation against supply variations. Recognizing the essentially bi-stable nature of the circuit, it is clear that the undesired (non-conducting) state must be suppressed. Thus a component should be added that will not allow the p.d. across either or both of the reference diodes to be zero.

A junction field-effect transistor is included as shown in the diagram. Assume no initial current in the reference circuit. This corresponds to zero gate-source p.d. for the f.e.t. which conducts and drives the reference diode and hence the remainder of the circuit into its desired (conducting) state. If the f.e.t. is not to affect the performance of the reference circuit it must



be cut-off when the circuit is operating normally. As a rough guide the limits of pinch-off voltage that provide self-starting without degrading regulation are given by:— $V_{ref} > V_p > V_{be}$. Fortunately with V_{ref} typically ~6V and V_p ~0.6V the permissible values of V_p correspond to those for commercially available general purpose f.e.ts.

P. WILLIAMS,
Paisley College of Technology

1. "Self-starting of voltage Reference Circuits", *Proc. I.E.E.E.*, Nov. 1969, p.2078.

One-transistor voltmeter

In "Letters to the Editor" (March issue) F.P. Mason describes a one-transistor voltmeter that he invented and patented.

This uses the principle of a meter with rectifiers in a feedback path. It is not clear whether he realized (it does not affect the patent) that this principle was not new.

The writer used it for two- and three-valve meters in 1954 and does not claim to have invented it. (With feedback to the first cathode the input impedance can be kept high.)

In an article in the December 1969 issue G. W. Short gives a detailed account of how to design this type of one-transistor meter.

Unfortunately he misses out two important points, and appears to make a minor error.

Assuming a sinusoidal input voltage, the meter current will have a rectified sine waveform.

Let I_m be the peak value of this.

For 5 times peak current $5I_m r_m + 2V_f = V_{CB}$ surely, not V_{CE} as in the article, where subtraction is done to find V_{CB}. This affects four equations.

Point One. The meter deflection is due to a current I_d, say, which is the average of the meter current. $I_m = (\pi/2)I_d$.

Point Two. Ohm's Law is used to find the value of R_M the input resistor. As V_{in} (f.s.d.) is an r.m.s. value so must be the meter current, say $I_r = I_m/\sqrt{2} = (\pi/2\sqrt{2})I_d = 1.111 I_d$.

1.111 is the form factor and reduces R_M by 10%.

The peaks, for which Mr. Short makes allowance, are averaged in the meter reading.

The writer had designed a simple companion meter to measure the highest and lowest peak levels. This meter will also measure the two levels in square waveforms.

D. L. CLAY,
Coventry,
Warwicks.

G. W. Short replies:

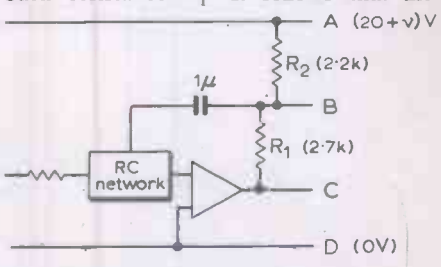
The design formula for V_{CE} is intended to yield a practical value rather than state an absolute truth. While the value of the alternating base-emitter voltage should strictly be added it is only a few tens of millivolts and so is not worth bothering about. For similar reasons the design formula ignores the effect of the collector saturation voltage. Anyone who wants to play safe should add 1V to the calculated value of V_{CE}.

The design procedure did not in fact specify that V_{in} is an r.m.s. value. It would have been clearer to have done so, and adjusted R_M by a factor of 0.9. Step (5) should therefore be altered to read: $R_M = 0.9 V_{in\ rms}/I_m$

Theoretical and measured response

I read with interest Mr. P. M. Quilter's comments in the April issue on the tone control circuit of Dr. A. R. Bailey's preamplifier. I should like to add some comments of my own concerning the feedback attenuator R_1 and R_2.

A small ripple voltage v is present at the +20V supply A. To a first approximation the response of the system to this ripple voltage is that of an operational amplifier with input resistance R_2 and feedback resistance R_1. It follows that the



ripple voltage at point C is $-\frac{R_1}{R_2} v$ and that the point B is a virtual earth with respect to this signal. Thus if the output is taken from B instead of C a dramatic reduction in background noise results, at the expense of a 50% reduction in gain. A similar effect would be given (with increased tone control range as pointed out by Mr. Quilter) by taking the feedback from point C instead of B.

G. J. BIGNOLD,
Worcester Park,
Surrey.

Sinusoidal Oscillator for High Temperatures

*by P. Williams**

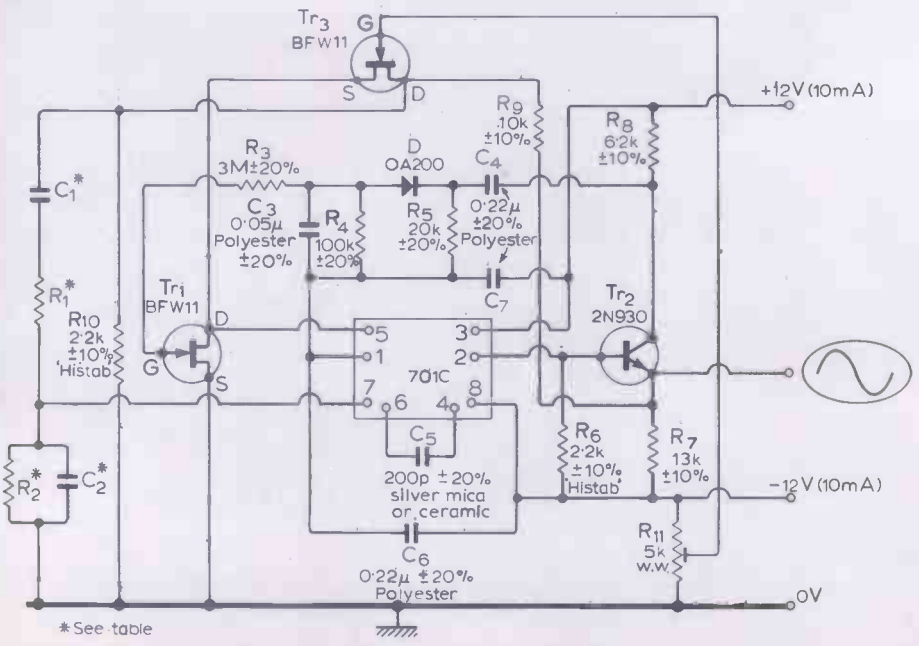
The Wien bridge oscillator circuit has a reputation for providing a sine wave free from harmonics, hum and noise. Conventional circuit design uses a high-gain amplifier with the frequency determining *CR* elements in the positive feedback 'half-bridge' arm and a thermistor or other temperature sensitive resistor element in the negative feedback arm of the bridge[1]. Such an arrangement automatically maintains the oscillator output constant by adjusting the negative feedback. This technique, which does not use a non-linear circuit element (the thermistor resistance changes only slowly, being constant during one cycle of oscillation), has been shown[2] greatly to improve the frequency stability.

Unfortunately the use of a temperature sensitive element in this way only maintains constant output amplitude independent of the ambient temperature if the element temperature is a good deal higher than ambient. Use of a thermistor is thus not usually practical above about 40°C. In the course of some industrial instrumentation circuit development the need arose for an oscillator to provide a constant amplitude sine output at temperatures up to 70°C, with good frequency stability. The circuit shown was developed to meet this need. It provides a sine output of 1 V r.m.s. swinging symmetrically about the earth line. C_1, R_1 and C_2, R_2 are the frequency determining elements of a Wien half-bridge (values shown are for 5 kHz). They provide frequency selective positive feedback from the output of the amplifier system, comprising the 701C integrated circuit and Tr_2, to the non-inverting (positive) input terminal of the 701C. The junction field effect transistors Tr_1 and Tr_3 and resistors R_9, R_{10} constitute a resistive attenuator circuit half-bridge providing negative feedback to the inverting input terminal of the 701C amplifier. The drain-source resistance of Tr_1 is increased, to the value which provides constant amplitude sinusoidal output, by the negative bias on its gate, derived from the rectified output of Tr_2. The potentiometer R_{11} enables the resistance of Tr_3 to be set to a suitable value for control of Tr_1. The fixed resistors R_9 and R_{10} ensure linear operation by reducing the amplitude of the sine input to Tr_1 and Tr_3 to a value well below the pinch off voltage of these transistors. Although the drain-source resistance of both Tr_1 and Tr_3 falls with temperature, the ratio of the two drain-source resistances (and hence the feedback factor) remains approximately constant. In practice a change in temperature from 25° to 70°C produced amplitude changes of about 2% and a frequency change of less than 2%. Operation at frequencies over the range 20 Hz to 70 kHz has been achieved by suitable choice of capacitors C_1 and C_2 and resistors R_1 and R_2 as shown in the table. At frequencies below 50 Hz a 0.02 μF capacitor was connected between the gate of Tr_1 and the earth line to prevent "squegging" (modulated oscillations).

*University of Wales Institute of Science and Technology

Operating frequency	Value of C_1, C_2	Value of R_1, R_2
20 Hz	0.068μF polyester (with 0.022μF shunting gate of Tr_1 to earth)	120 k Ω ± 5%
500 Hz	0.0027μF silver mica	120 k Ω
5 kHz	0.0027μF silver mica	12 k Ω
25 kHz	500pF silver mica	12 k Ω
70 kHz	120pF silver mica	12 k Ω (all 'Histab')

Table of variable components.



Temperature stable oscillator circuit employing a bipolar transistor, two f.e.ts and an i.c.

REFERENCES

1. Hickmann, D. E. D., "Wien Bridge Oscillators", *Wireless World*, Dec. 1959.
2. Bailey, A. R., *Electronic Technology*, vol. 37, p. 64.

Holograms on metal film

Very thin films of metal—bismuth, tellurium, aluminium or gold—deposited on a sheet of glass have been used by R.C.A. engineers in America as an alternative to photographic plates for storing holograms. The resolution obtained is about the same as using photographic methods—more than 1000 lines per mm—but the exposure time is reduced to between 5 and 20 nanoseconds. This means that the extremely stable platform, needed to support the subject during photography to prevent movement and subsequent hologram distortion, can be dispensed with due to the very short exposure time.

The light from a pulsed laser is split into two beams, one of these, the reference, is directed on to the metal film, the other reaches the metal film via the object of which the hologram is to be made. At those points where the two beams interfere constructively (add) the laser light is converted into heat which evaporates the metal film. Where the two beams interfere destructively (cancel out) nothing happens.

No further processing is required and the hologram can be viewed at once without moving the film in any way. This means that the hologram is perfectly positioned for the successive observations required in industrial non-destructive testing of materials and products.

For computer memory applications a glass plate coated in a metal film measuring only 400 × 110mm could store 300 million bits of information.

The Unijunction Transistor

A close look at its behaviour and a guide to its use

by O. Greiter

The design of electronic circuits is considered, if anyone actually turns his mind to this aspect, to be a calm, logical process. Sometimes, however, if you examine the matter calmly and logically, you get a feeling that whim and fashion play a very great part. Some circuits and some devices seem to be particularly sensitive to this favourite son approach. Oscillator circuits are the subject of unending debates. The unijunction transistor is a device which has, I think, been overlooked by many engineers who could use it to advantage. One indication is that, so far as anyone remembers, *Wireless World* has never published an article on unijunctions, and has shown very few circuits containing them. And not everyone can afford to read all the American journals.

It is not as though it were some new-fangled device: it is not as though it were an expensive device. The pound in your pocket will still buy you a couple of unijunctions and a short ride on the underground. The first devices appeared in 1953, and the silicon version in 1956. Changes in manufacturing technique, and the normal time lags before the line began to run, suggest that as a cheap simple device the unijunction has been with us for just about a decade.

The essential function of a unijunction transistor is that it is a voltage sensing device. Used with a *CR* circuit it becomes a timing circuit and also, because of its resetting behaviour, an oscillator. We shall see that the circuits are extraordinarily simple in form.

We must begin by examining the construction of the device itself and its characteristics. The structure shown in Fig. 1(a) is very convenient for those of us who want to understand the device. A small rod of n-type silicon has ohmic, that is non-rectifying, contacts applied to each end. Near the middle an aluminium wire is used to generate and connect a small p-type region. And that is all. At least that is all that really concerns us. Down at the plant they do not like fiddling about at the ends of long narrow rods and two more practical structures have been devised. These are shown as Figs. 1(b) and 1(c). They are known as the bar structure and the cube structure. The characteristics are slightly different, but we can hardly discuss this until we know what the terms we must use mean.

The structure of Fig. 1(a) looks exactly like the basic structure of the field effect transistor and the reader may wonder if new unijunction is but old f.e.t. writ large. In fact it is surprising how totally unlike each other the two devices are, at least when operated at their design biases. I confess to being too lazy to test whether one could persuade either device to operate in the mode appropriate to the other. There is some interest in this, however, as it suggests a way in which one might get very odd effects in a field effect transistor circuit with excessive input.

If we are to understand the unijunction transistor behaviour we must begin with an equivalent circuit. It is convenient to introduce at the same time the standard symbol. This is done in Fig. 2. The total resistance between $B2$ and $B1$, $R_{BB} = R_{B1} + R_{B2}$, is called the interbase resistance. As the two end contacts are ohmic constants, this is just the resistance of the rod of silicon, in the simplified structure. It is about 5–10 thousand ohms. Normally we operate unijunctions at about 10–20 volts, so that the base current will be about 2 mA. It is useful to keep this figure in mind when looking at circuits with additional resistance in series with one or both base connections. At this stage the emitter is assumed to be left open.

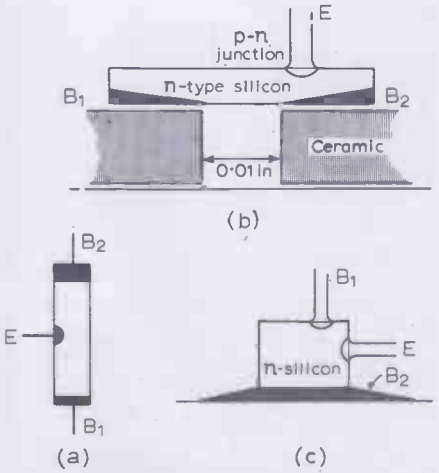


Fig. 1. (a) The early construction technique, with two ohmic connections to an n-type silicon rod and a small p-n emitter junction. (b) The bar structure. (c) The cube structure.

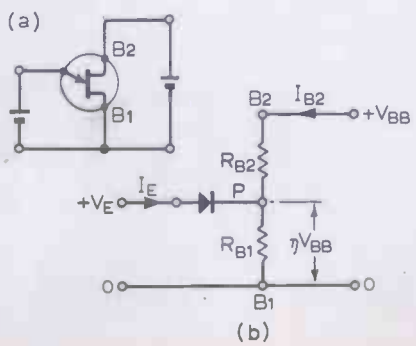


Fig. 2. Circuit and equivalent.

The device is just a rod of resistive material, so the point P in Fig. 2(b) will be at a voltage of $(R_{B1}/R_{BB})V_{BB}$. This ratio, (R_{B1}/R_{BB}), is settled by the geometry, the mechanical construction, and it is known as the stand-off ratio, denoted by the symbol η. A typical value of η might be 0·6, with a range which depends on how well the mechanical tolerances can be held. So far as we are concerned, the tolerances appear in a sorting operation and if you want a tight tolerance you pay for a hand-picked specimen.

We may now apply the battery to the emitter terminal. So long as $V_E < \eta V_{BB}$ the diode shown in Fig. 2(b) will be reverse-biased, and no emitter current will flow. No current is an abstraction here, because there will be a small leakage current, typically 2 microamps, which is not enough to disturb the voltage at P. This current can be significant in some circuits.

As we increase V_E the diode becomes forward biased and will pass current from V_E into the bar. This current consists of holes emitted into the silicon, and these holes drift from the emitter to base one. The presence of these holes causes the number of electrons in the lower half of the bar to increase. The conductivity of this part of the bar increases, so that R_{B1} becomes smaller. Typically, if R_{B1} is 4500 ohms with no emitter current it will fall to 2000 ohms for one milliamp of emitter current, and to 100 ohms for 20 mA. Let us assume we have $V_{BB} = 20$ volts and $\eta = 0{\cdot}6$. When V_E goes to just over 12 volts, so that we get our $I_E = 1$ mA, the value of R_{B1} drops to 2000 ohms, and as R_{B2} is 3000 ohms the voltage at P falls to 8 volts. Immediately I_E shoots up, making R_{B1} get even smaller and the forward bias on the

diode get even larger. If we were foolish enough to use this test circuit the current would rise until the transistor burnt out.

In all simplified pictures there are defects. By this account, even one hole passed from the emitter into the bar should start the proceedings. Of course this is not true. The current needed is, however, extremely small, and a rough value can be taken as one microamp. This current is called the peak point current, I_p.

Another simplication which can cause trouble is that although the holes injected at the emitter should all be drawn towards base one by the field produced by V_{BB}, this just does not happen in the practical structures. Some drift off into the R_{B2} region, hotly followed by their electrons. In consequence R_{B2} drops a little and the current I_{B2} increases by more than one would expect. It is necessary to bear this in mind if the overall circuit is one in which there may be excessive power dissipation at the peaks.

Once the triggering action has taken place the emitter-base one circuit is just that of a rather resistive diode. We need an overall device characteristic, or set of characteristics. The most important group is the static emitter characteristics, which are typified by the curve in Fig. 3. From this it can be seen how the current increases quite normally as the emitter voltage is increased from V_o to V_p: below V_o the diode leakage current is flowing out at the emitter, of course. When the peak point is reached, however, the current can increase without the voltage increasing, and we have a region of negative resistance down to the valley point. A rough guide figure for this point is that it corresponds to an emitter current of 4mA at $V_v = 2$V. Of course it varies from type to type of unijunction, and depends to some extent on the overall working level, as defined by V_{BB}.

Beyond the valley point the characteristic shows the normal positive resistance of the emitter-base one diode. In drawing these typical characteristics one gives this a reasonable slope so that the valley point

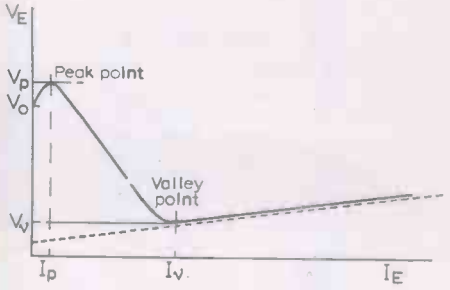


Fig. 3. General static emitter characteristic.

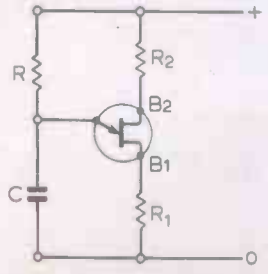


Fig. 4. Circuit of relaxation oscillator.

shows up nicely. Peering closely at some real characteristics the resistance in this region looks as though it might be down as low as 10 ohms, or even lower. It is possible to get very high peak emitter currents: it is essential to make sure that you do not get destructive values of I^2t.

The commonest use of unijunction transistors is probably in relaxation oscillators. A complete circuit is shown in Fig. 4, and includes two resistors which are not vital to its operation. R_1 has the advantage of limiting the emitter-base one current as well as providing a voltage pulse at $B1$. We will discuss R_2 later. What happens when we connect the battery to this circuit? On switch-on, the capacitor is not charged, so that V_E is zero. The odd milliamp flows from $B2$ to $B1$, establishing the bias in the diode of the equivalent circuit. C is charged steadily through R until the capacitor voltage reaches the value of V_p for the particular conditions. The triggering action now takes place, discharging C down to about 2 volts. If all is well, this is where we started, and away we go again. All is only well, however, if the value of R is suitable. Let us draw the characteristic in the form we adopt for other devices. This has been done in the S-shaped curve of Fig. 5. A load line corresponding to a resistance R joins the point $V = V_{BB}$ to $I = V_{BB}/R$. It intersects the device curve at the point P, where the resistance is negative. In drawing the S-curve the upper part has been flattened out to keep the scale of the drawing more convenient, for reasons which will become obvious.

A formal discussion must take into account the effect of the capacitor. When the supply is first connected the capacitor holds no charge, and thus V_E must be zero. The working point moves from B towards D as the capacitor is charged through R, and virtually no current flows in the unijunction emitter. At A, where the peak point current is flowing, we have a situation where V_E wishes to rise above V_p, but for very small time increments is held constant by the capacitor. The only point of the device characteristic at which we have $V_E = V_p + \delta$ is the point B. The circuit triggers and a relatively large current begins to flow. Most of this is supplied by the capacitor, and V_E decreases, with the device working point moving down from B towards C. Finite times may make the triggering follow the broken line to a point between B and C, but the general effect is the same. The slope of BC is in practice that of a fairly small resistance, so that the capacitor discharges very quickly. At C we reach the valley point. Obviously V_E cannot increase rapidly, because the capacitor will see to that. The current I_v cannot be provided by the resistor alone. The only point on the device characteristic which is accessible is D: the device cuts off. And from D there is nowhere to go but A.

The emitter voltage is the sawtooth shown in Fig. 6(a). One current pulse is shown in some detail as Fig. 6(b). This is not the waveform which one observes, because the actual transitions are dominated either by the way the charge concentration builds up or by the circuit strays. The pulse looks,

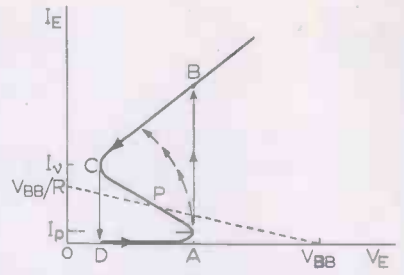


Fig. 5. Trajectory of emitter conditions in relaxation oscillator.

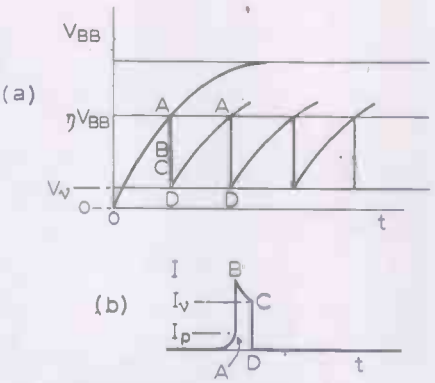


Fig. 6. The emitter voltage (a) as a function of time and the current (b) on a greatly expanded scale.

in practice, pulse-shaped. We usually look at the current pulse across the resistance R_1 in the circuit of Fig. 4. It is a nice clean pulse, conveniently referred to the negative line. We can, however, put a small value of resistance in series with the capacitance, although we may then have problems with the pedestal produced by the capacitor charging current.

A reasonable approximation to the oscillation frequency is obtained by using the time taken for the path OA and neglecting the other terms. This gives us

$$t = CR \log [1/(1-\eta)].$$

If we are lucky enough to get a unit with an η of 0·63, this reduces simply to

$$t = CR, \quad f = 1/CR.$$

When we use the cheaper, wide-tolerance, unijunction we can assume this as a likely centre value, giving us a very quick way of choosing the typical size of component we shall need. For most circuits it is safe to say that R will lie between 10^4 and 10^6 ohms. Typical values of C range from 0·01 μF to 1·0 μF, offering a frequency range of 1 Hz to 10,000 Hz.

This has been, of course, a rather oversimplified picture, but for many applications it is actually sufficient. The circuit of Fig. 4, without R_1 and R_2, provides an oscillator which is stable for small changes of voltage and temperature to better than 1%. It is easily the cheapest way of getting this sort of result provided that the waveform is acceptable. Improved performance is, however, usually wasted sooner or later, and here the two resistors enter the circuit. We must consider them separately, beginning with the dull one, R_1.

The main effect of the resistor added externally in the base-one lead is to change

the shape and position of the valley. It is not precisely correct to say that we simply add a term $I_E R_1$ to the voltage V_E in the curve of Fig. 3. The current which flows out of $B1$ is bigger than I_E, because of the fall in the value of R_{BB}. Qualitatively, however, this describes what happens. The curve beyond the valley point is rotated upwards, moving the valley point up and to the left. Practical circuits use small values of R_1, which do not have very much effect. Typical values are between 15 ohms and 47 ohms and they control the amount you can get out of the circuit much more than they control its oscillation characteristic.

The base-two resistor, R_2, is much more interesting. Looking back at Fig. 2(b) we see that in strict truth the emitter voltage at which the unijunction will trigger is given by

$$V_E = \eta V_{BB} + V_D$$

where V_D is the drop across the diode junction produced by the flow of the peak point current. This voltage, about half-a-volt, is naturally much lower for the high-sensitivity devices than it is for those which have a high value of peak point currents. And the peak point current, from a handy list of characteristics, ranges from 2 microamps to 25 microamps, according to one type of unijunction. Regarded purely as a diode we might expect that the voltage V_D would change 2 mV per °C. For a typical circuit this would correspond to about $2/10^4$ of the voltage excursion, giving a frequency shift of $1/10^3$ for a 5°C change of temperature. This stability figure is much better than we actually obtain, so other effects must be at work. One of these, especially for the cube structure, is the temperature variation of η. For the bar structure this is said to be negligible, and V_D is given the blame. The reader may feel, as I did, that this just does not make sense. In fact, although the resistance R_{BB} does not appear in the expression we have written for V_E, it is the real thing in the wood-pile (and sucks to the Race Relations Board). R_{BB} creeps in because, as the resistance of a lump of semiconductor, it varies quite a lot with temperature. In fact the variation is very nearly 1% per °C. This does not affect η very much, and we can see that in the bar structure η is settled by very simple geometry indeed. It does, however, alter the number of charge carriers normally in the semiconductor and it seems fairly obvious that this will in turn alter the number of carriers injected at the emitter which are needed to disturb the flow. This is what we find. For a rise in temperature of 100°C the interbase current is halved, and the peak point current is also halved. This smaller peak point current is produced, of course, by a smaller excess voltage. In fact the value of V_D is not as one is tempted to think, the voltage across the diode for a fixed current, but rather the voltage for a current which is itself temperature-dependent.

One rather pleasant surprise is that R_{BB} has a conductor-like behaviour, with a roughly constant temperature coefficient. If we do the mathematics we find that we can get quite good compensation by using the right value of R_2. As the temperature rises and the interbase current falls, the voltage at $B2$ will increase by a factor of $\Delta I.R_2$. This tends to balance out the drop in V_D. Notice how the sensing is done by R_{BB}, the very factor which causes the change.

This is by no means the full story. It is, however, the first approximation to the story, and we can now quote the value of R_2 which should give perfect compensation:

$$R_2 = \frac{0{\cdot}7\, R_{BB}}{\eta V_1}$$

Typically $R_{BB} = 7000$ and $\eta V_1 = 10$

(notice that 0·7 is a voltage)

$$R_2 = 500.$$

A correction is needed when we include R_1 in the circuit, because R_1 is an anti-correction term. We must add a factor $R_1(1-\eta)/\eta$, or about $R_1/2$. But if R_1 is 50 ohms, this gives us only a change of 5% in R_2. Round up to 510, rather than down to 470. And only in the electronics industry would anyone round up 500 to 510.

Without temperature compensation a typical figure for the change in frequency with unijunction temperature is between 3% and 6% for 100°C. This is 300–600 p.p.m./°C. However, the capacitor and the resistor will also be changing in value. At temperatures above 20°C a metallized polycarbonate capacitor will have a temperature coefficient of 100 p.p.m./°C and a metal film resistor a temperature coefficient of 50 p.p.m./°C. As both of these are positive, the frequency will fall by 150 p.p.m./°C. Provided that the whole circuit is kept at the same temperature we need only somewhere between $\frac{1}{2}$ and $\frac{3}{4}$ of the predicted compensation.

The net result is that we should not have to work too hard to get a stability of 100 p.p.m./°C. To do a bit better than this we must measure the values of η and R_{BB} for the individual device, rather than just paying a bit more for the close tolerance type. A really cheap unijunction transistor has a range of R_{BB}/η of about 3:1 according to the specification sheet, while the more expensive ones are within a range of about 1·7:1. This means that an average correction could be about 10% in error, which is really better than we know what we are correcting.

The high class thing to do is to temperature-cycle the whole oscillator. If you are sure of the capacitor and resistor you can

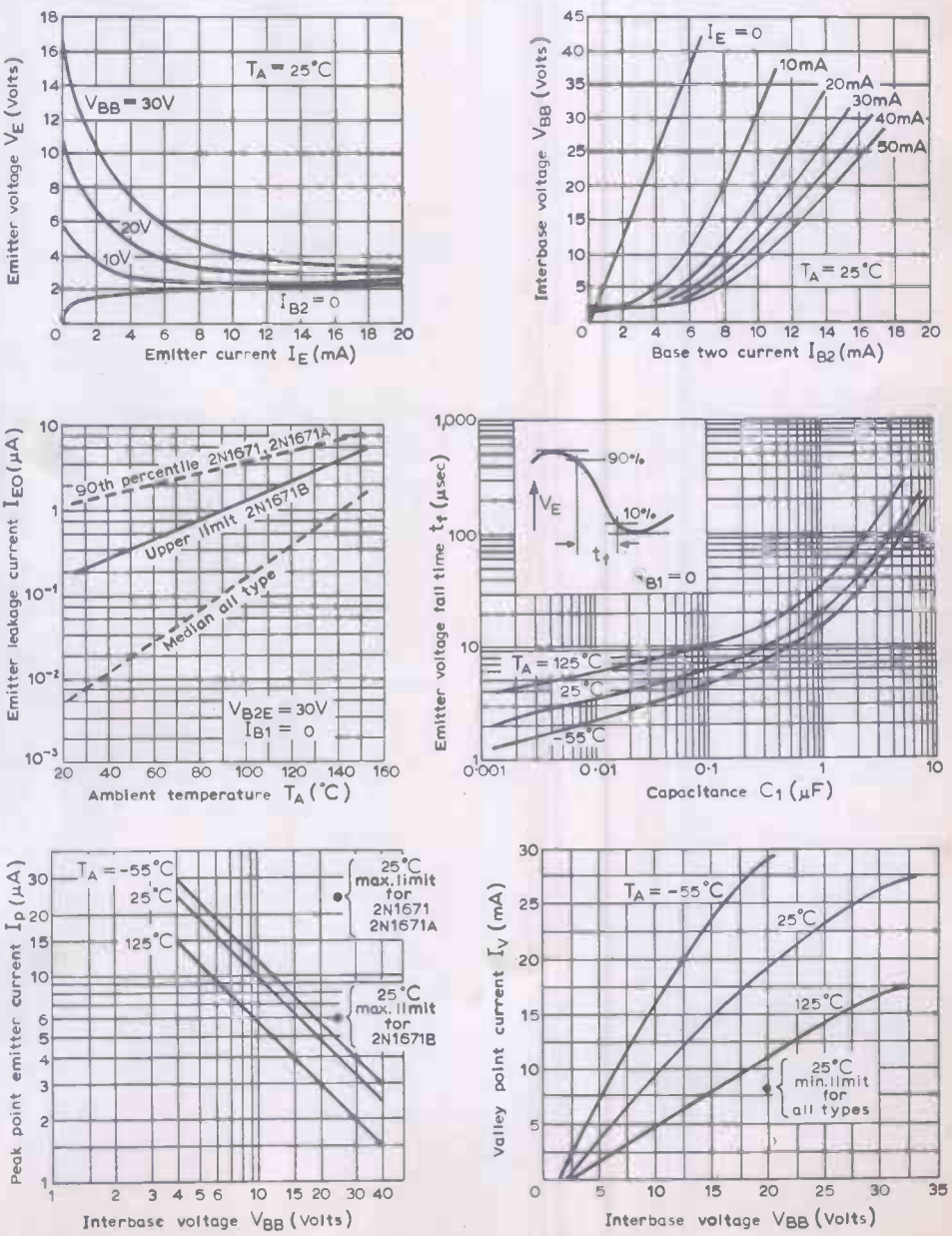


Fig. 7 Data on the General Electric 2N1671. unijunction transistor.

just cycle the unijunction, which is a very fast operation, and trim R_2 to give the theoretically derived positive temperature coefficient. To be sure the capacitor is really warmed up you need a lot of time, and a lot of justification. If you do embark on this path you find that these temperature coefficients you are balancing so nicely are not, in fact, constants. The unijunction is less sensitive at low temperatures, the capacitance is more sensitive if you use the type of polycarbonate unit whose characteristic I quoted. Overall the shape can be called parabolic, the frequency rising at both extremes. It is claimed that one can get 10 p.p.m./°C for a reasonable temperature range around the minimum.

Meanwhile, back in the system, how constant is the supply voltage? Typical for the dependence of frequency on voltage is a figure of 2 parts per thousand for a 10% change in supply voltage, or 200 p.p.m./1% voltage change. When we start talking about 10 p.p.m. per °C we are also talking about supplies which are holding to 0·05% per °C and per everything else. It is found that R_2 also controls the variation with supply voltage, but the value of R_2 needed to give good stabilization against voltage changes is somewhere between 30% and 50% of that needed to stabilize against unijunction changes alone. We have already seen that we do not need this full stabilization, because the capacitor and the resistor are providing some compensation. This, indeed, is one of the things which makes this very simple circuit so pleasant to use. For once, it would appear, nature is on your side.

There are, as always, cunning techniques for using diodes in R_2, and other odd balancing elements, which will shape the overall temperature coefficient. This is a specialist area and before you start on it you need to go through the full analysis in detail. My own feeling is that for a general purpose oscillator you will not go far wrong if you pick R_2 = 220 or 270 ohms, and that it might be cheaper to stick the whole thing in a temperature controlled case instead of fine-tuning every unit. Roll on the days of cheap nuclear min-power, so that we can keep the thermostat system working day and night and avoid waiting for things to settle down—settle up, perhaps, would be more appropriate.

Two additional factors must now be taken into account. In the discussion of the oscillator circuit we took it for granted that only the charging time of the capacitor needed to be considered. For an oscillator operating at 1000 Hz we might conveniently use a 0·1 μF capacitor. It is found that the fall time of such a capacitance ranges from 5 microseconds to 10 microseconds as the temperature increases from 25°C to 125°C. This is a change of −50 p.p.m./°C in oscillation frequency. This fall time depends on the capacitance, but is not directly proportional to it. It also depends on the value of R_1, as you might expect.

The second factor is the ease with which the circuit may be triggered. We have seen that the triggering occurs when the emitter voltage reaches, roughly, ηV_{BB}. This is equivalent to saying that

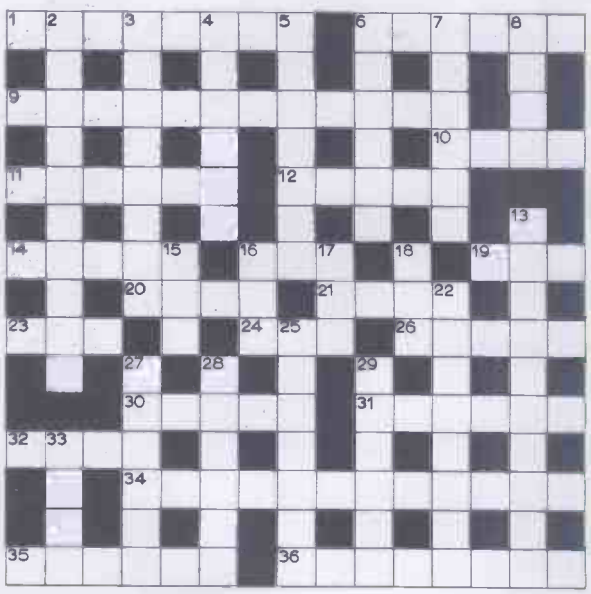
$$V_{BB} = V_E/\eta$$

Assume that the circuit is oscillating at 1000 Hz. It takes 1000 microseconds for V_E to run up to the triggering point. Assume also a linear rise, with V_{BB} = 20V. The instantaneous value of V_{BB} at which triggering can occur is then rising at the rate of 20 millivolts per microsecond. If a noise pulse of 20 mV appears on the supply line just one microsecond before triggering is due, the triggering will occur after 999 μs, and the frequency will be $1/10^3$ in error. Notice that the RC circuit protects V_E from this pulse. We must watch for the danger of synchronization, or partial synchronization, to noise or ripple. It will be noted that we are more likely to get a nuisance effect with a system of low target efficiency, running from a roughly smoothed supply, than a frequency shift in a system of high design stability, in which there will be a voltage regulator which should also keep down the noise and ripple.

The circuit applications of the unijunction transistor, which are by no means limited to the production of pulses and saw-teeth, must be left to another article. It is, however, desirable to provide some typical characteristics of an actual unit, as distinct from the stylized characteristic used to explain the working. Fig. 7 consists of a selection of the material contained in the data sheet for the General Electric 2N1671 family. It must be added that almost all the material published on the unijunction and its uses appears to originate with General Electric.

Crossword

compiled by P. R. Lloyd



Across

1. Waveband crept somehow in addition. (8)
6. Group containing one bit used for checking. (6)
9. Wild mice run after a Greek having letters and numbers. (12)
10. It has no meshes in the middle of the street. (4)
11. A cubic metre with nothing for realistic reproduction. (6)
12. A measure of magnetic flux density in a ferrite slab. (5)
14. Turn English book back. (5)
16. Measure inductance the French returned? (3)
19. Lorry ignition features a ferrite. (3)
20. A resonant circuit of military application? (4)
21. Half the alphabet is something very small. (4)
23. A resistor capacitor discharge. (3)
24. Work using epoxy resin glue initially. (3).
26. Music channels? (5)
30. We would set about infra-red with connections made. (5)
31. One in the class is a mastermind. (6)
32. Penultimate letter to a service-man brings an aerial. (4)
34. Circuit parameter meant cos distribution in colour. (4,8)
35. A course so backward it engenders pity. (6)
36. Fill small room used in weighing. (4,4)

Down

2. Fliers must have grounds for starting discharge. (5,5)
3. Company with gas to hire like a laser beam. (8)
4. Uncontrolled, melted half the domain. (6)
5. Good material for the screen! (7)
6. He raps out a set of notes. (6)
7. Electric talk can show at the corners of the mouth. (6)
8. Half of it to copy for recording perhaps. (4)
13. It's useful in aerodynamics to twist and penetrate the barrier. (4-6)
15. An organ in the middle of the heart. (3)
16. Two-way supplement. (3)
17. Cover with an insulator—not lead! (3)
18. There's nothing in the sideband. Gasp! (3)
22. Attractive enchantment surrounds land. (8)
25. Primitive artist I'd back with about a pound. (7)
27. On-off device possibly faulty with short circuit. (6)
28. Same rf alignment gives unit pictures. (6)
29. Order paper from an aged organization. (6).
33. A piece of ground 100 square metres plus one. (4)

Solution on page 338

A Simple Op. Amp.

A design intended to make life easier for the newcomer to operational amplifier techniques

by D. Griffiths, Ph.D.

Grappling with my first practical use of operational amplifier integrated circuits, my upbringing on discrete component circuitry made me want to have a simplified picture of what was going on inside the little packages. Of course, the circuit did just what the manufacturer said it would with given external connections and there was the astoundingly complex equivalent circuit to gaze at. To get a feel of what was going on, I found it a great help to play around with the simple circuit of Fig. 1. While it correctly demonstrates op. amp. characteristics, it has a poor d.c. performance and a curtailed h.f. response, with the closed loop gain being 3dB down at typically 0.5 to 1 MHz. On the other hand, over the audio frequency band it can show a noise figure of below 2dB and has less than 0.75% harmonic distortion at 1 kHz with 1 V r.m.s. output before feedback is applied.

The "follower with gain" mode of operation is of wide application and is achieved by the type of connection shown in Fig. 2. Here Tr_2 acts as an emitter follower causing the emitter of Tr_1 to follow closely the signal from the feedback network. If the amplifier gain is sufficiently large, the base voltage of Tr_2 accurately follows that on the emitter of Tr_1, since only a very small differential input is necessary to develop an output voltage. This gives a high input impedance and constrains the voltage output to $(R_1+R_2)/R_1$ times that of the input to Tr_1. The decoupling capacitor shown dotted (Fig. 2.) can remove the a.c. feedback and enable the open loop a.c. performance to be assessed while still retaining d.c. stabilization of the operating points.

The input transistors are run at a collector current of just under 100 μA each; the resulting 200 μA or so through R_4 generates the necessary tail voltage of just under 9 V. Decreasing the collector currents would reduce the input biasing current drain but would also lead to decreased gain and frequency response. It was found that a value of 6.8 kΩ for R_5 gave the least harmonic distortion; this is of the same magnitude as suggested by Ridler[1] for similar transistors in his low-distortion oscillator design. This low value of R_5 makes the output emitter follower rather a luxury but it does yield an output resistance of under 30Ω without feedback. The emitter load of 4.7 kΩ for Tr_4 gives a reasonable battery consumption while still coping with quite high capacitance loading on negative-going signals.

With the feedback loop decoupled by an 80-μF capacitor, a mid-band (1 kHz) open loop gain of 1,500 to 2,000 was typically obtained. A greater degree of feedback decoupling can be achieved with a given capacitor if it is put at the centre tap of R_2 rather than across R_1. The gain was 3dB down at about 35 kHz.

When the non-inverting input in Fig. 2 was connected to common via a 1 kΩ resistor (to equal that at the inverting input) the standing output voltage was typically a few tens of millivolts. Increasing this 1 kΩ resistor to 100 kΩ gave an output of some -1.6 V; i.e. 1.6 $\times$ 1/25 V across 100 kΩ, indicating an input current of about 0.6 μA. With the feedback decoupled, it was found that a 100 kΩ resistor in series with the a.c. input reduced the output by 50%, yielding a differential input resistance of 100 kΩ. Similarly, Tr_2 will only lightly load the feedback network. With the a.c. restored as in Fig. 2 to give a gain of 25, the input resistance became about 2.5 MΩ increasing to some 6 MΩ as the gain was reduced to 10.

With the feedback increased to reduce the closed loop gain much below 10, the prototypes tended to oscillate at some 5 to 10 MHz, depending on layout, etc. For stable operation with unity gain, the open loop turnover frequency needed to be reduced from 35 kHz to 4 or 5 kHz. This was achieved by putting 0.01 μF and 100Ω in series across the collector resistor of Tr_1, the 100Ω preserving the risetime in the region of 0.25 to 0.5 μsec. A feedback resistor of some 15 kΩ to 33 kΩ was used in the inverting or non-inverting mode and had to be shunted with 10 pF under these conditions.

With the configuration of Fig. 3 the a.c. input resistance was in the region of 200 MΩ. One must remember though that the source must still supply or pass the input bias current of 0.6 μA. This would be a limitation, for instance, when trying to obtain long time constant displays in a peak reading circuit.

The output resistance was assessed by injecting a 1V r.m.s. signal via a 4.7 kΩ resistor on to the output terminal and measuring the signal impressed on it. Without feedback, the voltage at A in Fig. 4 was 6 mV r.m.s., indicating that:

$$R_{out} = \frac{6 \times 10^{-3}}{1.0} \times 4.7\ \text{k}\Omega \approx 30\Omega.$$

At a gain of 25, R_{out} became about 0.6Ω. This does *not* indicate that the circuit could drive a low impedance device such as a loudspeaker!

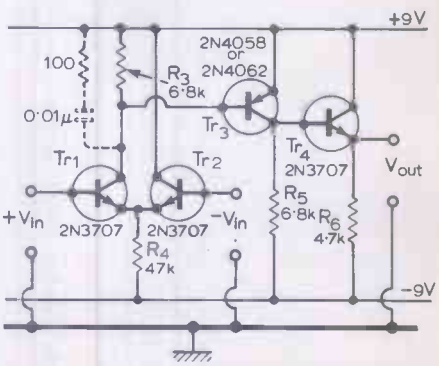


Fig. 1 The circuit of the simple operational amplifier

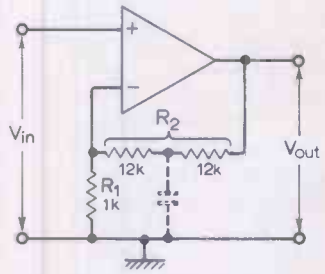


Fig. 2 The amplifier connected for the 'follower with gain' mode of operation. With the component values shown the gain is 25

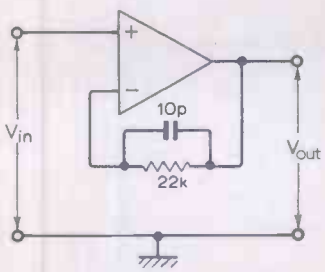


Fig. 3 Source follower with 100% feedback

The amplifier distortion on sinewave drive was estimated with the aid of a passive twin-T null filter, making a rough correction for the attenuation of higher harmonics due to the broad response. Without a.c. feedback, 1 kHz at 1 V r.m.s. output gave a distortion of some 0.75%, rising to about 1.5% at 3 V r.m.s. output; about 4 V r.m.s. output can be expected before clipping starts. With this simple circuit one might expect the distortion to decrease in proportion to the degree of feedback applied. A check at a gain of 25 showed the output distortion to be indistinguishable from the 0.02% contributed by the test oscillator. Excessive capacitance loading on the input will cause distortion which is particularly evident on negative-going signals when the output base-emitter junction tends to be cut off. With up to 0.01 μF loading there was no increase in distortion at 15 kHz but 0.02 μF produced a horrible amount of distortion components although the unfiltered output still looked very reasonable on a 'scope. Halving the value of the output resistor enables twice as much capacitive loading to be withstood at a given frequency.

The noise figure was measured by the elegant method recently described by Baxandall[2], in which the temperature of the amplifier source resistor is varied in order to distinguish between amplifier noise and that introduced by thermal agitation in the source. Small metal oxide resistors were screened by pulling them up inside the braiding of good quality coaxial cable and their temperature was altered between that of liquid nitrogen (77°K) and room ambient. Fig. 5 shows the method of calculation.

At first sight one might expect to get a very poor noise factor with this circuit in the follower mode since the large thermal noise voltages in the high value 47 kΩ tail

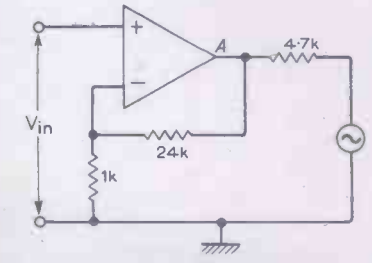


Fig. 4 Circuit employed to assess output resistance

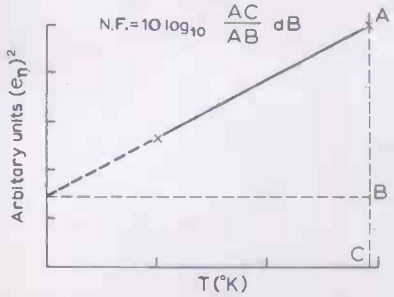


Fig. 5 Square of amplifier noise (e_n) output as a function of the temperature of the source resistance

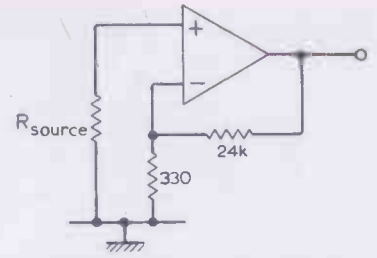


Fig. 6 Circuit used in noise function observations

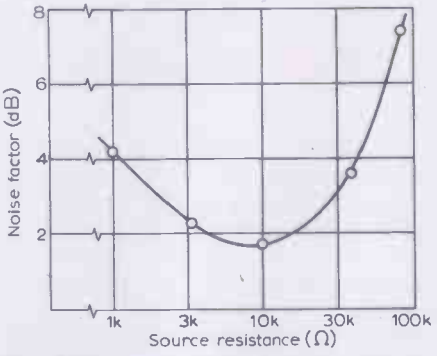


Fig. 7 Noise factor over band 100Hz to 20kHz as a function of source resistance

resistor are apparently in series with the input circuit. However, this viewpoint overlooks the effect of Tr_2 which by its emitter follower action clamps the voltage at the top of the tail resistor at its base potential; thermal noise voltage fluctuations in R_4 would be well suppressed. By the same token, though, the noise voltages in the resistance between Tr_2 base and common will be coupled into the input in this mode of operation, together with a contribution from Tr_2. The 330Ω resistor in Fig. 6 contributes a negligible amount to the amplifier noise factor which is shown in Fig. 7 for a bandwidth of 100 Hz to 20 kHz determined by RC time constants. Due to the logarithmic scale the dependence of noise factor on source resistance appears sharper than it is. The 2dB noise factor at the optimum source resistance of 10 kΩ is only increased by a further 2dB for inputs between 1 kΩ and 40 kΩ; this would still be very satisfactory in most audio applications.

The amplifier can be used in the inverting or see-saw mode. This would probably not be needed too much in hi-fi work except for you know whose virtual earth tone control circuit[3]. For instruction in op. amp. applications, I would recommend references 4 and 5.

REFERENCES

1. P. F. Ridler: *Wireless World*, Aug. 1967.
2. P. J. Baxandall: *Wireless World*, Dec. 1968.
3. P. J. Baxandall: *Wireless World*, Oct. 1952 (See also "Cathode Ray", Nov. 1961.)
4. G. B. Clayton: *Wireless World*, Feb. to Dec. 1969.
5. "Application of Linear Microcircuits", SGS Ltd.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON
July 13-17 — Olympia
Ship's Gear International
(Brintex Exhibitions, 3 Clements Inn, London W.C.2.)
July 22 & 23 — Excelsior, London Airport
Marketing Electronic Products—Conference
(Electronic Business Review, Morley Hse., Holborn Viaduct, London E.C.1)

BANGOR
July 6-10 — University College
Microwave Spectroscopy
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

LANCASTER
July 20-24 — The University
Dielectric Materials, Measurements and Applications
(I.E.E., Savoy Pl., London W.C.2)

LEEDS
June 30-July 2 — The University
Electronics Exhibition
(C.S. Petch, Dept. of Elect. & Electronic Eng., University of Leeds, Woodhouse Lane, Leeds LS2 9JT)

NEWCASTLE-UPON-TYNE
July 7-9 — The University
Scanning Electron Microscopy in Materials Science
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

OVERSEAS
July 14-16 — Anaheim
Electromagnetic Compatibility
(J.C. Senn, P.O. Box 1970, Anaheim, Cal. 92803)
July 16 — Brussels
Conference Equipment Study Group: Simultaneous Interpretation
(H. Fr. Schmidt, Technical Installations, Commission of the European Communities, Berlaymont Bldg, B-1040 Brussels.)
July 21-23 — San Diego
Nuclear and Space Radiation Effects
(I.E.E.E., 245 E. 47th St., New York, N.Y. 10017)

Solution to this month's Crossword *(see p. 336)*

S	P	E	C	T	R	U	M	■	P	A	R	I	T	Y
■	I	■	O	■	A	■	U	■	H	■	I	■	A	■
A	L	P	H	A	N	U	M	E	R	I	C	■	P	■
■	O	■	E	■	D	■	E	■	A	■	T	R	E	E
S	T	E	R	E	O	■	T	E	S	L	A	■	■	■
■	S	■	E	■	M	■	A	■	E	■	L	■	W	■
S	P	I	N	E	■	E	L	L	■	S	■	Y	I	G
■	A	■	T	A	N	K	■	A	T	O	M	■	N	■
A	R	C	■	R	■	E	R	G	■	B	A	N	D	S
■	K	■	S	■	F	■	A	■	A	■	G	■	T	■
■	■	■	W	I	R	E	D	■	G	E	N	I	U	S
Y	A	G	I	■	A	■	I	■	E	■	E	■	N	■
■	R	■	T	I	M	E	C	O	N	S	T	A	N	T
■	E	■	C	■	E	■	A	■	D	■	I	■	E	■
P	A	T	H	O	S	■	L	O	A	D	C	E	L	L

Noise in Transistors

A short explanation of noise performance of bipolar and field effect transistors at frequencies of a few kHz to a few MHz

by F. N. H. Robinson, M.A., D.Phil.*

At low frequencies, below a few kHz, the chief source of transistor noise is flicker, or $1/f$ noise, and no simple, generally valid, theory exists. Above a few hundred MHz the noise behaviour, like the signal behaviour, becomes quite complicated and cannot profitably be discussed in simple terms. In the intervening region, i.e. about 5 decades in frequency, noise in both bipolar and field effect transistors is remarkably simple.

In bipolar transistors the current injected into the base by the emitter consists of electrons which had enough thermal energy to surmount the potential barrier at the depletion layer. It is therefore completely random and displays full shot noise. In a bandwidth df the mean square fluctuations in the emitter current I_e are given by

$$di_e^2 = 2eI_e\,df \qquad (1)$$

where e is the electronic charge. In the base, some electrons recombine and constitute the base current, the remainder reach the collector. This random division, of a random current, leads to two uncorrelated sets of fluctuations in the base current I_b and the collector current I_c. Their magnitudes are

$$di_b^2 = 2eI_b\,df \qquad (2)$$

and

$$di_c^2 = 2eI_c\,df \qquad (3)$$

and, because they are uncorrelated, $d(i_b i_c) = 0$.

Because any equivalent circuit for a transistor must lead to the relation $i_e = i_b + i_c$, we do not need to consider i_e separately. Thus the noise properties are completely specified by i_b and i_c. A complete noise equivalent circuit for the transistor is shown in Fig. 1.

*Clarendon Laboratory, University of Oxford.

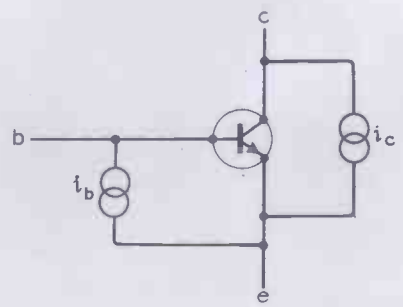


Fig. 1. Noise equivalent circuit for a bipolar transistor, valid up to 200 MHz.

The strengths of the two current generators are given by (2) and (3) and they are uncorrelated. This circuit is valid up to frequencies approaching $f_T/\beta^{\frac{1}{2}}$. If $f_T = 2$ GHz and $\beta = 100$ this can be as high as 200 MHz.

If the transistor is used in the common emitter connection it will have a mutual conductance

$$g_m = \frac{eI_c}{kT} \qquad (4)$$

and we can transfer the current generator i_c to the input as a voltage generator $v = i_c/g_m$. Its strength is therefore

$$dv^2 = \frac{2kT}{g_m}\,df \qquad (5)$$

In Fig. 2 is shown an equivalent circuit for a common-emitter stage connected to a signal source of internal impedance R_s. The

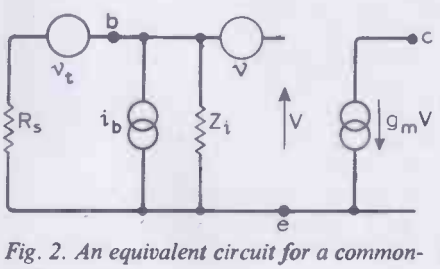


Fig. 2. An equivalent circuit for a common-emitter stage.

circuit includes the two noise generators i_b and v and the thermal noise generator v_t associated with the source at a temperature T_s

$$dv_t^2 = 4kT_sR_s\,df \qquad (6)$$

If we assume that the input impedance Z_i of the transistor is large compared with the source impedance R_s the total noise input is given by

$$dV^2 = 4kT_sR_s\,df + \frac{2kT\,df}{g_m} + 2eI_bR_s^2\,df \qquad (7)$$

The noise figure F is the ratio of this total noise to the noise due to the source alone (the first term in (7)), so that

$$F = 1 + \frac{T}{2T_s}\left(\frac{1}{g_mR_s} + \frac{eI_bR_s}{kT}\right)$$

We can also write this as

$$F = 1 + \frac{T}{2T_s}\left(\frac{1}{g_mR_s} + \frac{I_b}{I_c}g_mR_s\right) \qquad (8)$$

The optimum source resistance is

$$R_s = \frac{1}{g_m}\sqrt{\frac{I_c}{I_b}} = \sqrt{\frac{dv^2}{di_b^2}} \qquad (9)$$

Since the input impedance is approximately $1/g_m\,I_c/I_b$ we see that our initial assumption that $R_s \ll Z_i$ was justified. The optimum noise figure is now

$$F = 1 + \frac{T}{T_s}\sqrt{\frac{I_b}{I_c}} \qquad (10)$$

If for example $T = T_s$ and the d.c. current gain is 100 we have $F = 1{\cdot}1$ or about $\frac{1}{2}$ dB. If the collector current is 1 mA we have $1/g_m = 25\,\Omega$ and $R_s = 250\,\Omega$ compared with $Z_i = 2{,}500\,\Omega$.

Notice first of all that a good low-noise transistor must have a high d.c. current gain and secondly that R_s is quite low. Fortunately an error of a factor 2 in R_s only increases F to 1·125 so that there is no point in attempting to be too precise in designing input stages.

If R_s is fixed then I_c (and thus g_m) should be adjusted to satisfy (9). If R_s is high e.g. 50 kΩ and the d.c. current gain is 400 it is easy to see that the optimum I_c is 10 μA. For this reason low-noise transistors should also have high current gain at low currents. This is not usually compatible with good r.f. response. Provided that the input capacitance of the transistor is tuned out, the formula for the optimum value of R_s is valid up to about $\frac{1}{3}f_T$ but the noise figure begins to deteriorate appreciably at about $f_T/\beta^{\frac{1}{2}}$. At very high frequencies, the effect of base series resistance becomes appreciable and, in any case, F exceeds $1 + f/f_T + (f/f_T)^2$.

In f.e.ts noise arises from thermal noise in the channel. When allowance has been made for the distributed nature of the noise source, the effect is equivalent to a current generator whose strength is

$$di_d^2 = \frac{2}{3}\cdot 4kTg_m\,df$$

connected between drain and source. This is equivalent to a voltage generator of strength

$$dv^2 = \frac{2}{3}\frac{4kT}{g_m}\,df \qquad (11)$$

in the gate lead.

At low frequencies there is also current noise in the gate lead due to leakage I_g

$$di_g^2 = 2eI_g\,df \qquad (12)$$

but at high frequencies this is swamped by induced current noise, produced by fluctuations in the channel under the gate. This noise is to all intents uncorrelated with the drain noise and is of magnitude

$$di^2 = \frac{1}{4}\frac{\omega^2 C^2}{g_m} 4kT\,df \qquad (13)$$

where C is the input capacitance. The complete equivalent circuit is shown in Fig. 3.

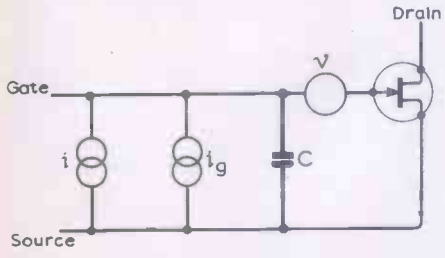


Fig. 3. An equivalent circuit for a field effect transistor.

The optimum source resistance and noise figure at low frequencies are

$$R_s = \left(\frac{dv^2}{di_g^2}\right)^{\frac{1}{2}} = \left(\frac{4kT}{3eI_g g_m}\right)^{\frac{1}{2}} \qquad (14)$$

and

$$F = 1 + \left(\frac{8eI_g}{3kTg_m}\right)^{\frac{1}{2}} \qquad (15)$$

If $I_g = 10^{-9}\,A$ and $g_m = 5$ millimho, we have $R_s \approx 100\ \text{k}\Omega$ and $F \approx 1{\cdot}005$.

At high frequencies the optimum values are

$$R_s = \frac{1}{\omega C}\sqrt{\frac{8}{3}} \qquad (16)$$

and

$$F_o = 1 + \frac{\omega C}{g_m}\sqrt{\frac{2}{3}} \approx 1 + \frac{f}{f_T} \qquad (17)$$

where $f_T = g_m/2\pi C$ is the gain bandwidth product. Obviously good low-noise r.f. amplifiers require f.e.ts with a high gain bandwidth product.

Insulated gate f.e.ts tend to have high flicker noise and these results are only valid above about 1 MHz., but, for junction f.e.ts, they are often valid down to low audio frequencies.

Perhaps the most important part to bear in mind is that there *is* an optimum source impedance, and that for bipolar transistors this is much less than the input impedance. If the source impedance is high, an f.e.t. will usually be the most suitable input stage. Conversely for low source impedances it will be a bipolar transistor. Finally it should be noted that the use of negative feedback, or other connections (e.g. common base) alters neither the optimum source impedance nor the optimum noise figure.

REFERENCE

1. "Equivalent Circuit for Noise in Bipolar Transistors", by H. Sutcliffe, *International Journal of Electrical Engineering Education*, vol. 6, number 3, October 1968.

Domestic video records

Machines for playing recorded vision programmes into domestic television sets are arriving from all directions. Some are players only, for reproducing programme material on records supplied by outside organizations. Others will, in addition, record and reproduce television programmes (broadcast or closed-circuit) selected by the user. The two latest are the Video Cassette Recorder, from Philips (Holland), shown below, and the Cartrivision system, from Avco (U.S.A.).

The Philips machine (called VCR, perhaps for its convenient euphonic relationship with EVR) was demonstrated in the U.K. at a convention of the Film Industry Organization at Brighton. As the name indicates the machine uses cassettes to hold the recording medium, which is ½-inch magnetic tape. The recorded material, colour or monochrome, is reproduced on a domestic television receiver, and connection to the set is made via the aerial socket.

Two versions of the machine have been produced. The first is a player only, intended for reproducing programme material supplied in cassettes by outside organizations—hence the interest of the film industry. This is expected to cost about £120 for a monochrome machine and about £140 for a colour machine. The second version, justifying the name, will record as well as reproduce, and for recording broadcast television programmes it obtains the video signal by means of a built-in tuner which receives its r.f. signal from the aerial connection on the home television set. This machine will cost about £230.

Each cassette contains enough tape for an hour's running. It can be put into or taken out of the machine very easily and at any required moment, regardless of the position of the tape. Programme material may be erased and fresh material recorded in its place, as with a sound tape recorder. No rewinding is required.

The cassettes are interchangeable in the sense that, provided they are of the right type to fit the VCR, they can come from any source. Also, colour and monochrome cassettes are compatible, in that either type can be played on monochrome machines and colour machines. On the ½-inch tape two sound record tracks are available, and these can be used, say, for stereophonic sound or for spoken commentaries in two languages.

Other domestic video reproducing systems already launched or announced have the trade names: EVR (Electronic Video Recording), Vidicord, Selectavision and Sony. Domestic v.t.r. machines are already on the market.

Active Filters

12. The Leapfrog or Active-Ladder Synthesis

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

Certain types of passive filter have low sensitivity to errors in component values. Of these the best known types have the form of a ladder, terminated in equal resistances, but otherwise LC and lossfree. The leapfrog or active ladder synthesis allows a close analogue of such a filter to be made, in which integrators replace the reactances with a one-to-one correspondence, and which has the same low sensitivity (provided certain pairs of resistances keep a sensibly constant ratio). The synthesis is, therefore, especially useful for filters which must be designed to a tight specification.

The synthesis may be regarded as an extension of the use of the two-integrator loop.

Sensitivity

Active filters may be divided into three classes: those with high sensitivity to errors, i.e. those in which errors are exaggerated, so that an error of $x\%$ in some critical component causes an error much greater than $x\%$ in some important performance parameter; those with medium sensitivity, i.e. those in which errors in component values cause no more than proportional changes in important performance parameters; and those with low sensitivity, i.e. those which, at least in the pass band, are relatively insensitive to changes in component values. In any filter, whether active or passive, a change in the value of any component whose value enters into one of the time constants or *LC* products of the transfer function must cause a movement of the response curve along the frequency scale. The sort of change we are discussing is a change in the shape of the response curve such as a broadening or narrowing of the passband, or an increase in unevenness.

In all *CR* active filters positive feedback (in the strictest sense of the term) must operate to raise the *Q* factors of *CR* networks from $\leqslant\frac{1}{2}$ to higher values, and in high-performance filters to much higher values. This means that there are feedback loops for which the input quantity is the vector difference of two larger and nearly equal quantities. In circuits of high sensitivity there is no significant constraint on the relative magnitudes or on the phase difference of the two larger quantities, a not very large change in the value of a critical component can cause the difference to become zero, and a small change can cause a proportionately much larger change in the magnitude of the difference. This causes a change in gain over a narrow band of frequencies with the undesirable effects already mentioned. In circuits of medium sensitivity the difference between the two large vectors can become zero (if it can happen at all) only as a limiting case, when the ratio of some pair of components becomes infinite, and small changes in the value of a component cause no more than proportional changes in the magnitude of the difference. Circuits of this class were described in Parts 5, 6, and 7.

In a filter of low sensitivity there are constraints on the performance which result in errors in component values having a less than proportional effect on the more important characteristics of the response. Thus in a passive filter of this class, in the pass band the (ideally loss-free) *LC* network gives almost optimum power match between load resistance and source resistance and the response is close to the maximum possible. Clearly no error, however great, can raise the response above the maximum possible, and the effect of small errors is minimal. If an active filter is to have a similar low sensitivity it must be subject to similar constraints, and this will be the case if it is an analogue of the passive filter to the extent of copying its internal working, so that an error in a critical component has the same effect as an equal percentage error in the counterpart in the passive filter.

Copying

Active 2nd-order systems such as the integrator-and-lag and the two-lag loop with negative gain discussed in Parts 5 and 6 copy the working of a 2nd-order passive *LCR* network sufficiently closely to have the same sensitivity to component tolerances. And the same is true of the two-integrator loop, Part 7. An explanation is that the coefficients of the denominators of the transfer functions are built up from products and ratios with the dimensions of time such as *CR*, *L/R*, in virtually the same way. Thus the transfer functions of both the low-pass systems of Fig. 1 may be written (if in one case the prefixed minus sign is omitted)

$$\frac{V_{out}}{V_{in}} = \frac{1}{1+T_1p+T_1T_2p^2} \qquad (1)$$

where for the passive circuit $T_1 = CR$ and $T_2 = L/R$, and for the active system $T_1 = C_1R_1$ and $T_2 = C_2R_2$.

When several sections are cascaded to form a higher-order filter as described in Part 9, the system obtained is equivalent to a cascade of 2nd-order *LCR* networks separated by buffer amplifiers, and is virtually Butterworth's filter-amplifier approach (Ref. 1). The sensitivity to component tolerances is clearly the same as that of the individual 2nd-order stages, and it is not the same as for a well designed equally terminated *LCR* filter. In this type of filter, in the pass band, where the *LC* network approximates to an ideal transformer matching the load resistance to the source resistance and the loss is close to the minimum possible (6dB), the effect of changes in the value of a component is as shown in curve *A*, Fig. 2 (see Orchard, Ref. 2), whereas for the factor method a curve such a *B* applies.

Thus for the l-p filter with Chebyshev response shown in Fig. 3(a) a 30% reduction in C_3 gives only the small change in response shown by curve (2) of Fig. 3(c), whereas an equal reduction in the time constant of the first stage of the synthesis by factors shown in Fig. 3(b) causes a much greater change in response, curve (3) of Fig. 3(c). In the equally-terminated filter the response is constrained to remain of equal-ripple type

$$\frac{V_{out}}{V_{in}} = \frac{k}{(1+qpT)(1+pT/q+p^2T^2)} \qquad (2)$$

and the reduction in C_3 causes not only a reduction in the time constant of the 1st-order factor but also reduction in the q of the 2nd-order factor, which has a compensating effect. In the synthesis by factors the reduction in C_3 makes no change in the 2nd-order factor. In the cut-off region, however, there is no significant difference between the two methods. Here the response is dominated by the coefficient of p^3

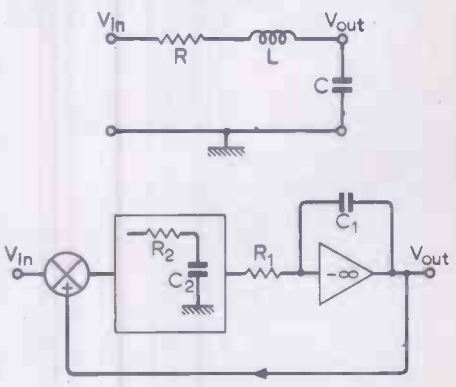


Fig. 1. A lag-and-integrator loop copies a passive 2nd-order network to the extent of having the same sensitivity to errors in component values.

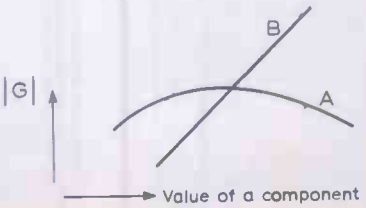


Fig. 2. Two types of sensitivity.

*Royal Radar Establishment.

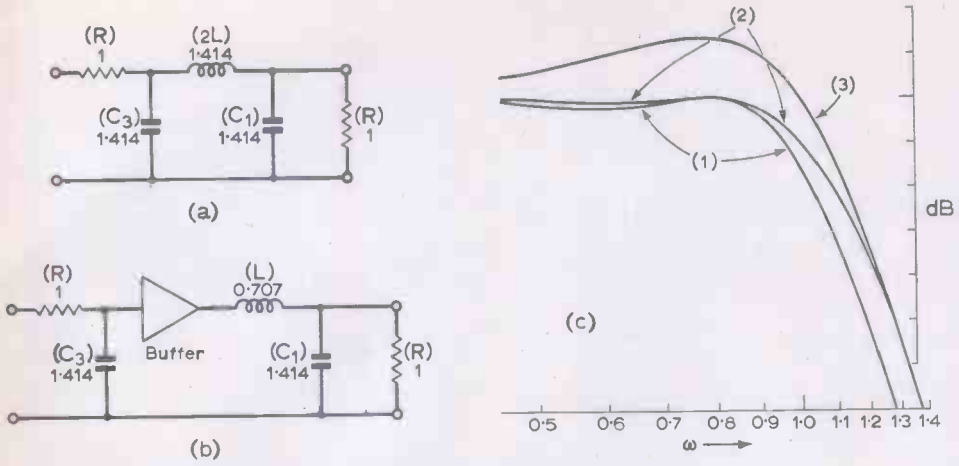


Fig. 3. Two filters which give the same response when component values are accurate, but have different sensitivity.

in the expansion of the denominators of the transfer functions:

$$F(p) = \frac{k}{D(p)} = \frac{k}{1+ap+bp^2+cp^3} \quad (3)$$

For each $c = C_1LC_3R$ and the response at high frequencies (relative to the response at zero frequency) approximates to

$$|G(\omega)| = 1/C_1LC_3R\omega^3 \quad (4)$$

Of course an error of 30% is unrealistically large, and in practice for such a simple filter synthesis by factors would probably be quite satisfactory. The example does illustrate, however, how the equally terminated structure gives in the passband reduced sensitivity to an error in the value of one of the reactances.

In a narrow band-pass filter, where component tolerances must in any case be tight if the specified centre frequency and band limits are to be obtained, the higher sensitivity of a synthesis by factors, calling for even tighter tolerances (or very close matching of components), could be a serious embarrassment, and the lower sensitivity of an equally terminated structure would be of real advantage. Fig. 4 shows schematically a band-pass filter of relative bandwidth 1/10 synthesised by factors and as an equally terminated structure. The factor synthesis is the method of stagger tuning, and Fig. 5(a) shows the effect of mistuning the low-Q factor by 1% (by a 2% error in the respective tuning capacitance). A pronounced tilt appears in the passband, and mistuning of either of the outer factors also causes a considerable change in mean level. In Fig. 5(b)

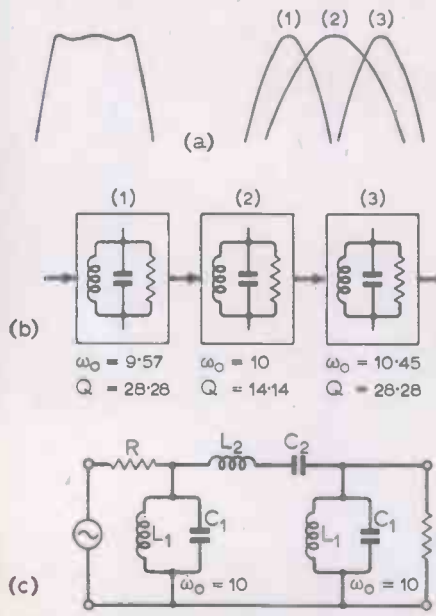


Fig. 4. Realisation of a band-pass characteristic (a): by factors (b); by an equally terminated structure (c).

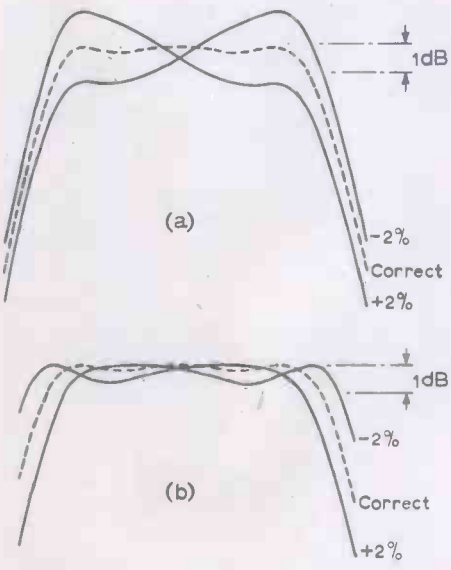


Fig. 5. Sensitivity of the two filters of Fig. 4: (a) synthesis by factors, $C_2 \pm 2\%$, (b) equally terminated filter, $C_2 \pm 2\%$.

are shown the effects of 2% errors in one of the capacitances in the equally terminated structure, and it can be seen that the increase in ripple or unevenness is approximately only $\frac{1}{3}$th as much as shown in Fig. 5(a). So if a $\pm 1\%$ tolerance were needed in the equally terminated structure, a $\pm 0{\cdot}2\%$ tolerance would have to be set for the synthesis by factors (at least for the ratios of the Cs and for the ratio of the Ls).

In the equally terminated structure an error in a component causes reactions throughout the structure, and as the examples show these are to a considerable extent compensatory. If an active structure is to reproduce this behaviour it must be an analogue to the extent of duplicating these internal reactions, and not merely by a system which, when all values are accurate, gives the same transfer function.

Now it has already been shown in Part 7 that a two-integrator loop is an analogue of an LCR tuned circuit, one integrator taking the place of the inductance and the other of the capacitance. Resonance in the LCR circuit arises from the oscillatory interchange of energy between the magnetic field of the coil and the electric field of the capacitor. In the two-integrator loop gain and feedback allow us to use two energy stores of the same kind and so obtain resonance with only one kind of reactance (normally capacitance). The question arises, therefore, can a system of integrators and feedback links be set up to reproduce the performance of more complicated LCR networks—perhaps any LCR network—and in particular a ladder structure in which all the elements except the terminating source and load resistances are lossless reactances?

All-integrator circuits

For a long time it has been obvious to anyone with a knowledge of analogue computing that if the chosen passive model or response curve is reduced to a transfer function, this can be "instrumented" by standard methods and an active filter obtained consisting of integrators and inverting stages. But in the resultant structure it is not possible to identify one of the integrators with one of the reactances of the passive prototype. About all that can be done of that sort is to identify certain resistors as corresponding to the coefficients of the terms of the denominator and numerator of the transfer function. A theoretical schematic for 3rd-order transfer functions is given in Fig. 6. So the method no more produces a filter with the looked-for one-to-one correspondence than a synthesis by factors; and since it can be shown that a finite change in the value of a component can make such a system unstable (oscillate), i.e. cause an infinite change in response, it seems likely that the sensitivity to errors will be greater.

The leapfrog synthesis

Fig. 7(a) shows a 2nd-order l-p filter, or, equally well, the output end of some longer

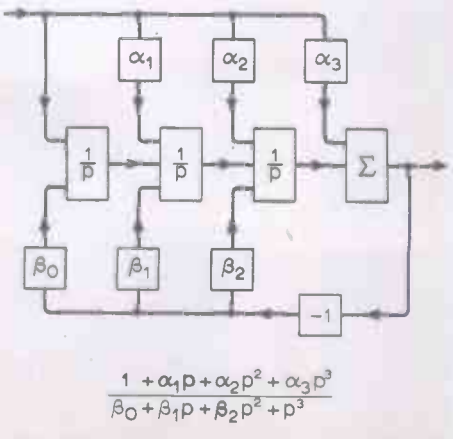


Fig. 6. "Analogue-computer" realisation of a 3rd-order transfer function.

l-p ladder. By dividing all impedances by R in Fig. 7(b) the network has been normalised to make the terminating resistance 1 ohm. This simplifies the synthesis, though it makes some of the equations in the analysis appear dimensionally incorrect.

As usual with a ladder, the network is conveniently analysed by supposing an output voltage and finding the currents and voltages that must exist to produce it:

$$I_0 = V_{out}/(1\ \text{ohm}) \quad (5)$$

$$I_1 = pCRV_{out} \quad (6)$$

$$I_2 = I_0 + I_1 \quad (7)$$

$$V_L = (pL/R)I_2 \quad (8)$$

$$V_{in} = V_{out} + V_L \quad (9)$$

whence

$$V_{in} = (1 + pL/R + p^2LC)V_{out} \quad (10)$$

An active system, using abstract integrators, which is described by an exactly parallel set of equations, is shown in Fig. 7(c). The dependent variables at the inputs and outputs of the integrators and differential gears are designated by θs to indicate the generality of the analogue, for in principle they can be any physical quantity capable of oscillatory motion (e.g. the angular position of a shaft). When electronic integrators are used, however, they will be electrical quantities, and when the ubiquitous Blumlein (or Miller) feedback integrator is used, voltages. Thus voltages will represent both the voltages in the passive circuit, and the currents; and any feeling of dimensional inconsistency which this may give can be removed by supposing the currents multiplied by an arbitrary resistance. In the schematic of Fig. 7(b) this resistance is the 1 ohm termination of the passive network, but in a practical situation some other value may be advisable. If, for example, the system is lightly damped, near the upper end of the passband I_1 will be considerably greater than I_0. But θ_1 and θ_{out} can have equal amplitudes if a suitable scaling factor k is introduced into the paths

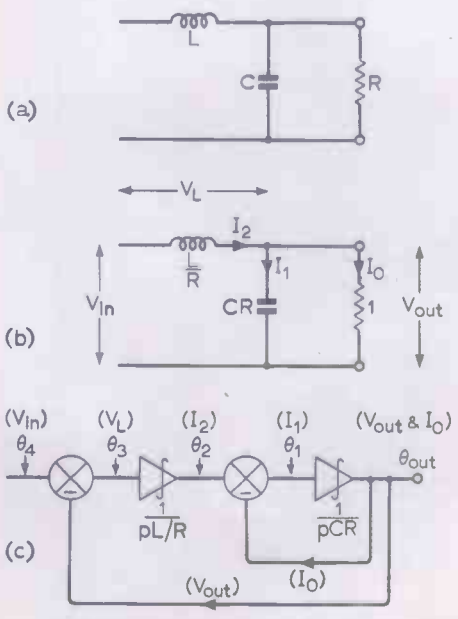


Fig. 7. The two reactances at the output end of a low-pass ladder are replaced by two integrators.

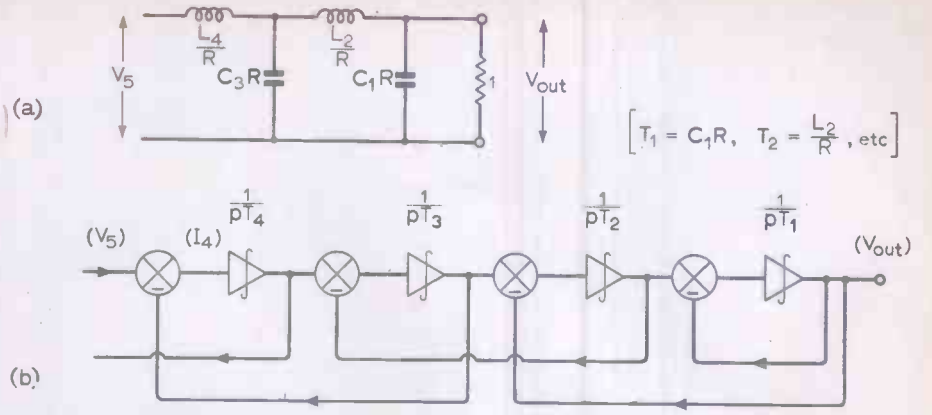


Fig. 8. The ladder is lengthened.

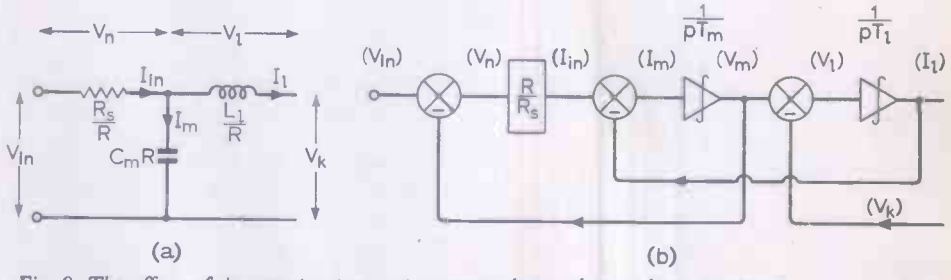


Fig. 9. The effect of the terminating resistance at the sending end is reproduced.

leading both to and away from θ_1, i.e. if the Ts of the integrators are made kL/R and CR/k, and the feedback representing I_0 is reduced to $1/k$. Indeed in principle different scaling constants may be used at each point, since the only rule to be observed to leave the dynamic properties of the system unchanged apart from a scalar multiplier is that for every feedback loop the loop gain (the product of the gains of the forward and feedback parts of the loop) must be unchanged. This flexibility has already been noticed in Part 7, where the two-integrator loop is derived as an analogue of a series LCR circuit, and is helpful in allowing best use to be made of the internal gain and the dynamic range of the integrator amplifiers.

Equations (5) to (9) are of three types: simple summations representing Kirchhoff's laws for the currents at a node or the voltages round a mesh; 1st-order differential equations representing the action of the reactances; and the Ohm's-law equation describing the proportionality of current and voltage for a resistance. When the ladder is extended, Fig. 8(a), no new types of process are brought into action, only the same types of equation are needed in the analysis, and the active analogue can be correspondingly lengthened by adding further integrators and feedback connections as shown in Fig. 8(b). The lengthening of the passive ladder and of the corresponding active system may be continued without limit, the number of integrators in the latter always equalling the number of reactances in the former, and at the input end it is easy to add a final feedback loop to duplicate the action of the source resistance, R_s (Fig. 9). Thus an active synthesis has been found which gives a one-to-one correspondence between the reactances of the passive filter and the integrators of the active system and duplicates not only the overall response of a simple low-pass ladder of any length, but also, as required, the internal workings.

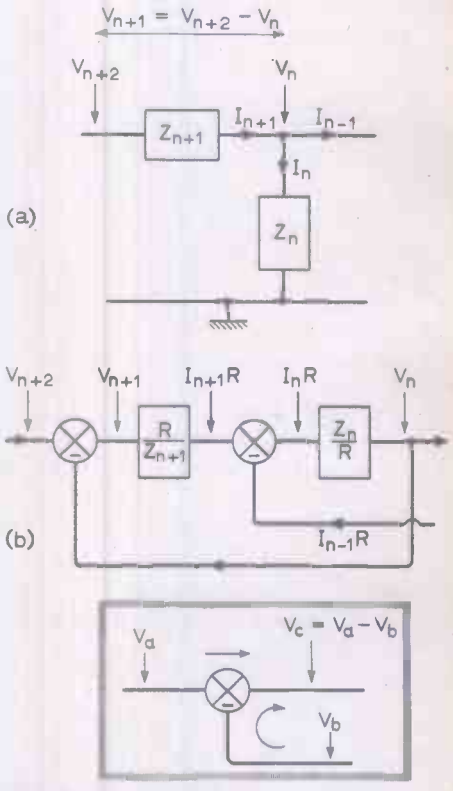


Fig. 10. Formal derivation of the active ladder.

Theorem

A simple ladder working with voltage input and voltage output can be divided into inverted-L sections, and a more formal derivation of the synthesis may be made by first proving the following theorem.

The inverted-L section of a ladder network as shown in Fig. 10(a) gives when passing signals from left to right the same

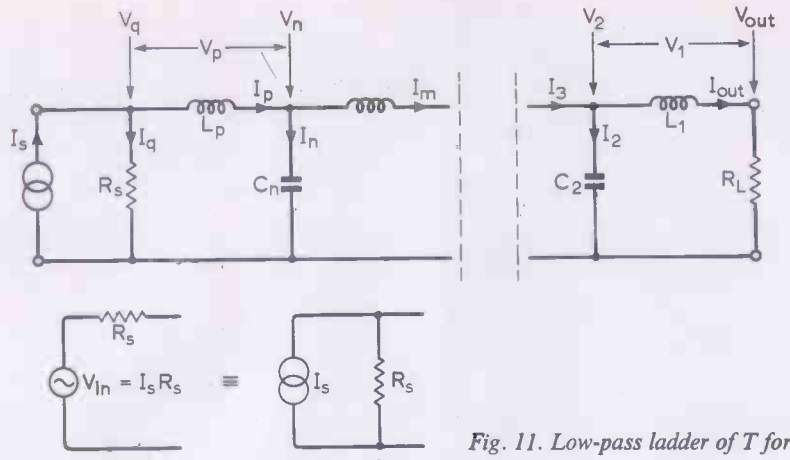


Fig. 11. Low-pass ladder of T form.

transmission as the active analogue shown in Fig. 10(b).

In the passive network

$$\begin{aligned} I_n &= V_n/Z_n \\ I_{n+1} &= I_n+I_{n-1} \\ &= V_n/Z_n+I_{n-1} \\ V_{n+1} &= I_{n+1}Z_{n+1} \\ &= (V_n/Z_n+I_{n-1})Z_{n+1} \\ V_{n+2} &= V_n+V_{n+1} \\ &= V_n(1+Z_{n+1}/Z_n)+I_{n-1}Z_{n+1} \end{aligned}$$

In the active system there are two amplifiers of gain Z_n/R and R/Z_{n+1} respectively and two differential boxes which take the difference of the voltage applied from the left and the feedback voltage, so that $V_a = V_b - V_c$ as shown inset. If then a voltage $= I_{n-1}R$ is available from another section, it can be seen by inspection that

$$\begin{aligned} I_nR &= V_nR/Z_n \\ I_{n+1}R &= I_nR+I_{n-1}R \\ &= V_nR/Z_n+I_{n-1}R \\ V_{n+1} &= I_{n+1}Z_{n+1} \\ &= V_nZ_{n+1}/Z_n+I_{n-1}Z_{n+1} \\ V_{n+2} &= V_n(1+Z_{n+1}/Z_n)+I_{n-1}Z_{n+1} \end{aligned}$$

q.e.d. [R is an arbitrary resistance.]

When the shunt impedance Z_n is $1/pC_n$ the reactance of an ideal capacitor, the gain $Z_n/R = 1/pC_nR$, which is the voltage transfer ratio of an integrator. And when the series impedance Z_{n+1} is pL_{n+1} an ideal inductive reactance, the gain $R/Z_{n+1} = 1/(pL_{n+1}/R)$, which also is the transfer ratio of an integrator. Thus the synthesis allows inductance to be simulated by capacitance, which is the object of the exercise.

For the output section of the ladder a terminating load resistance makes $I_{n-1} = V_{out}/R_L$. Hence in the active system the required feedback is a voltage proportional to V_{out}. Alternatively the load resistance may be taken as in parallel combination with the shunt impedance Z_n and the final amplifier of the active system assigned a gain $Z_nR_L/(Z_n+R_L)R$. If $Z_n = 1/pC$ this reduces to $R_L/R(1+pCR_L)$. So the amplifier should have the response of a simple lag of time constant CR_L combined with a zero-frequency gain R_L/R. If the amplifier has the form of an integrator a resistance is placed across the integrating capacitor. For all other sections the voltage $I_{n-1}R$ is available from the section to the right.

At the input end a source resistance R_s calls for a voltage $I_{n+1}R_s$ to be introduced in series with the input, i.e. a voltage $\propto I_{n+1}R$, which is already present in the active system. Or again alternatively, R_s may be treated as combined with Z_{n+1} and the input amplifier given a gain $R/(Z_{n+1}+R_s)$. And again if $Z_{n+1} = pL_{n+1}$ this has the form $A/(1+pT)$.

A ladder of T type

If the reactances of the passive ladder are connected to form one or more tees, Fig. 11, the analysis of the action proceeds as follows:

$$\begin{aligned} V_{out} &= R_LI_{out} \\ V_1 &= pL_1I_{out} \\ V_2 &= V_{out}+V_1 \\ I_2 &= pC_2V_2 \\ I_3 &= I_{out}+I_2 \\ &\cdots\cdots\cdots\cdots \\ V_n &= V_l+V_m \\ I_n &= pC_nV_n \\ I_p &= I_m+I_n \\ V_p &= pL_pI_p \\ V_q &= V_n+V_p \\ I_q &= V_q/R_S \\ I_S &= I_p+I_q \\ [V_{in} &= I_SR_S] \end{aligned}$$

If these are compared with the parallel set of equations for a π-form ladder, which begins as equations (5) to (9), it is found that the sets are exactly the same except that the roles of voltage and current, and of inductance and capacitance are reversed. And it follows that the same active system, where one kind of quantity (voltage) represents both the voltages and the currents of the passive models, can represent both forms of ladder.

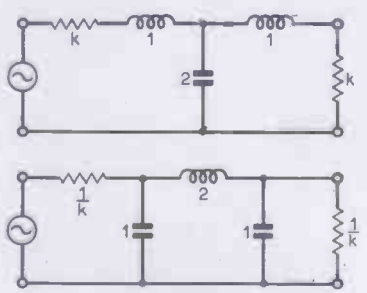


Fig. 12. T-form and π-form filters with the same response.

The correspondence between the two forms of ladder is, of course, well known, and explains why, for example, the two filters shown in Fig. 12 have the same voltage transfer ratio. Because of the exchange of roles between voltage and current, resistance in one form corresponds to conductance in the other; and whereas high values of R_S and R_L give light damping in the π-form filter, Fig. 12 (lower), low values give light damping in the T-form filter, Fig. 12 (upper).

Drawing and naming

The name "leapfrog feedback filter" was suggested by the appearance of the schematic diagrams when all the feedback links are drawn on one side of the row of integrators and difference boxes. If the feedback links are drawn alternately above and below the forward signal path crossings over are avoided, Fig. 13(b), and it is then easy to proceed to drawing the system as a ladder, as will appear in later diagrams.

Electrical circuits

Fig. 13(a) shows two 5th-order low-pass ladders, and Fig. 13(b) the block schematic of the active system which can equally well be the counterpart of either. This schematic is really a diagram of mathematical processes, and by using the precedent of the two-integrator loop it is easily appreciated that the difference boxes need not appear as separate entities and that each feedback loop will be closed in the correct sense if it contains two Blumlein ("Miller") integrators and one phase-inverting amplifier, as this gives, as required, an odd number of sign changes at zero frequency. The inverting amplifiers may be placed in positions $\times_1$ giving Fig. 13(c), or in positions $\times_2$ giving Fig. 13(d). The second is the more economical arrangement as it uses only two inverting amplifiers. The first has the possible advantage that there are fewer stages in the forward path—only the integrators.

In both Fig. 13(c) and in Fig. 13(d) there are considerably more than five resistances. If all have the correct value, then the five capacitances may be identified with the five reactances of the passive models, and the one-to-one correspondence principle is exactly observed. If in Fig. 13(d) one of the resistances marked r is in error, it is equivalent to an equal percentage error in the capacitance of the preceding integrator. So the active system still shows the desired correspondence with the passive models, though with an error in one of the reactances. And lack of infinite gain in the inverting amplifiers is also equivalent to a change in the T of the preceding integrator. An error in only one of a pair of resistances such as R_2, R_2', however, has no exact counterpart in a change in the value of any single component in the passive models, since it

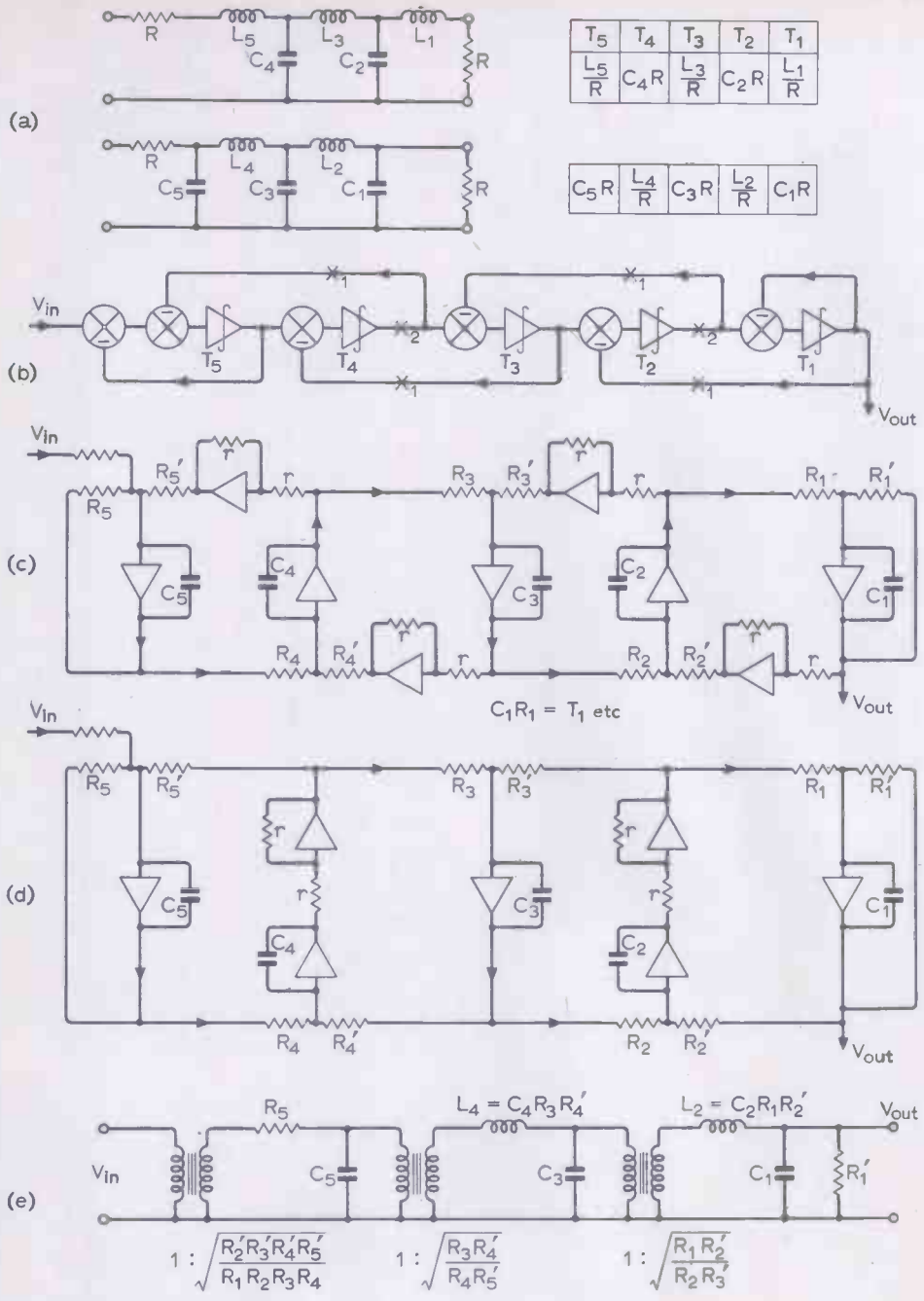


Fig. 13. Derivation of electrical active ladders.

causes one of the integrators to have a different T in one loop from in another.

Suppose in Fig. 13(d) that R_2 is too small. The current in R_2 will be too large, all the signal levels to the right of R_2 will be increased, and in particular the feedback current in R_3' (which represents the current in L_2 in the π-form model) is increased. The effect is the same as if an ideal transformer (effective down to zero frequency) of ratio $1:\sqrt{(R_2(\text{nom})/R_2)}$ is interposed between C_3 and L_2 in the passive model. Similarly the effect of other possible errors in nominally equal resistors can be represented as shown in Fig. 13(e). Clearly, unless one of the terminating resistances R_1' and R_5 is adjusted to compensate, the active system no longer exactly represents a power-matched structure. But with the errors to be expected from modern high-stability resistors, the departure from the ideal will be small and the effect will be no more serious than the effect of inequality in load and source resistance in the passive model repeated a number of times.

In Fig. 13(c) there are an even greater number of resistances to be in error; but by similar reasoning a passive model can again be constructed. That the active systems are analogues of passive models is itself an assurance that they cannot have high sensitivity to errors, since no finite change in component values can make the system unstable. The effects of any unwanted phase shifts are, of course, excluded in this argument.

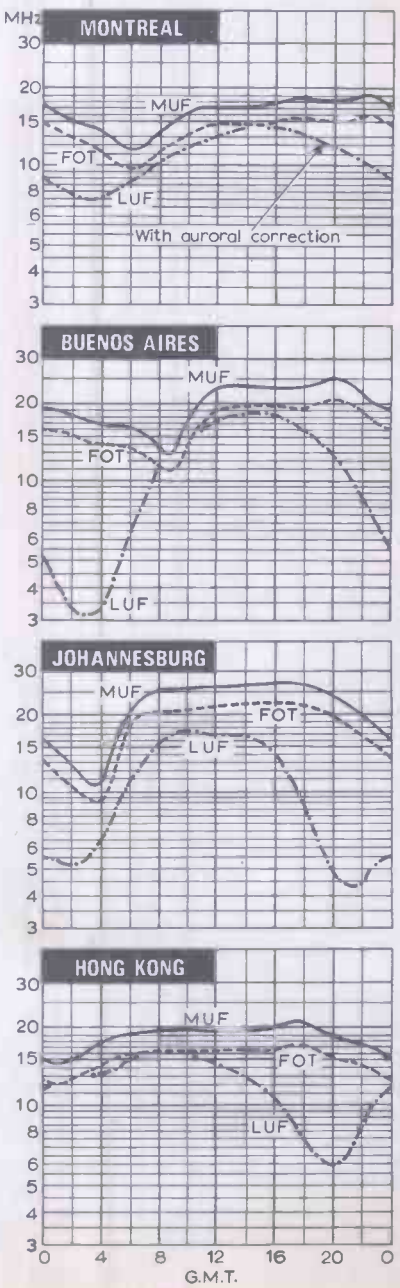
REFERENCES

1. "On the Theory of Filter Amplifiers", by S. Butterworth. *Experimental Wireless and Wireless Engineer*, Oct. 1930, Vol. 7, No. 85, pp. 536–541.

2. "Inductorless Filters", by H. J. Orchard. *Electronics Letters*, June 1966, Vol. 2, No. 6, pp. 224–225.

H.F. Predictions —July

The charts are based on an ionospheric index (IF2) of 94 and sunspot number 84. These values are predicted from smoothed data which include allowance observed during March/April. The Greenwich sunspot number for May was 136 showing that the high activity had, rather surprisingly, not only continued but further increased. If this activity is taken into account the median standard frequency (MUF) for Montreal would be 0.5MHz higher than that shown at 12.00 and 1.5MHz higher at midnight. The correction for the lowest usable frequency (LUF) would be in opposite sense—1MHz higher at 12.00 and unchanged at midnight. Other routes would be similarly affected. Disturbed days have been relatively frequent (April 15 days, May 6 days) and are expected to continue, but rarely intense.



Coding Problems in Iterative Arrays

A logic circuit for multiplying by three is developed as an illustration

*by K. S. Hall**

In a recent article[1] K. J. Dean described how iterative arrays of logical circuits may be used to perform arithmetic operations, giving a number of examples. The purpose of the present article is to discuss some problems which arise in the design of these arrays, partly because the arrays themselves are interesting and useful, and partly because they form a convenient peg on which to hang a discussion of some problems that arise in the design of a wider class of logic circuits.

Dean begins by pointing out how networks for multiplication by two and four may be devised. These are shown in Fig. 1 which has been adapted from his article. As he says they are rather trivial, consisting merely of leads which transfer a digit to a more significant place. However they do serve as a convenient introduction to the next circuit, which is for multiplication by three. The form of the circuit is shown in Fig. 2. It should be pointed out that while there is one input wire A and one output wire B for each block, the number of wires between blocks bearing information about the carry digit C is as yet undetermined. The problem is to design the circuit within each block.

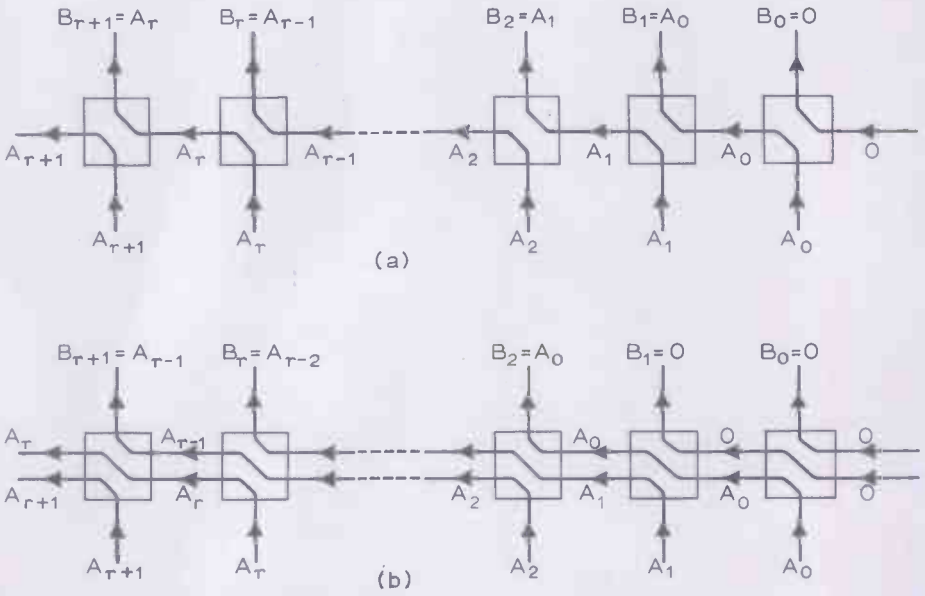


Fig. 1(a). An array for multiplication by two. (b) an array for multiplication by four. In both cases leads merely transfer digits to a more significant position.

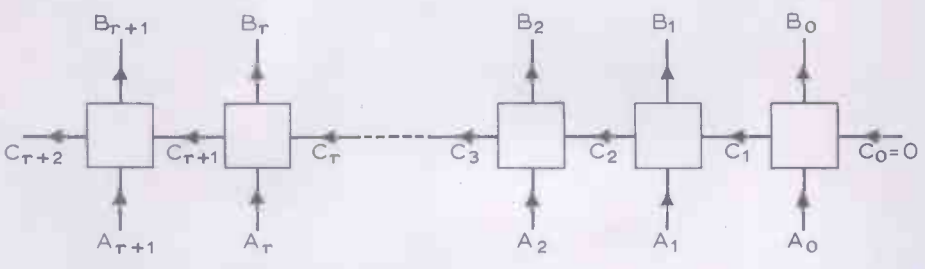


Fig. 2. An array for multiplication by three.

Design of a component block

The function of each block is to add together two numbers. One, which we will call a_r, has the value 0 when $A_r = 0$ and the value 3 when $A_r = 1$. The other, c_r, is carried from the block on the right. The greatest value that c_r can have is given by:

$$2^r c_r \leqslant 3(2^r - 1)$$

so that c_r is 0, 1 or 2. To distinguish these three values requires two binary digits and the coding problem is to decide how best to use the four possible combinations of these digits to convey three alternative messages about the value of the carry digit.

Dean proposed to give the two digits weights of 1 and 2 respectively, so that 00, 01 and 10 represent carry digits of 0, 1 and 2 respectively, and 11 was not used at all. One block of the array may now be redrawn as in Fig. 3, showing the two binary digits separately, and the table of combinations, giving the values of B_r, P_{r+1} and Q_{r+1} in terms of A_r, P_r and Q_r may be drawn up as shown in table one.

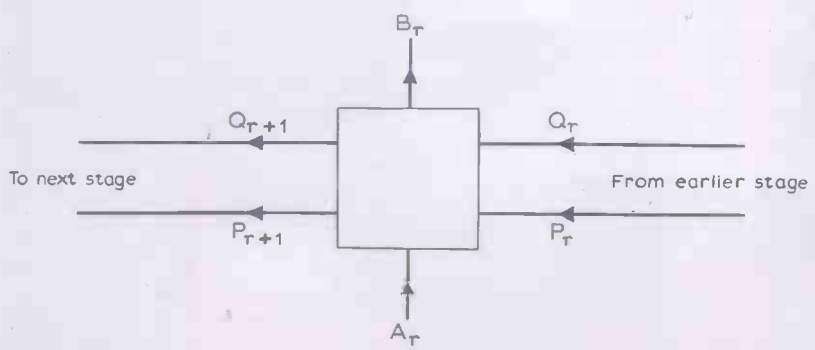


Fig. 3. One block of the array for multiplication by three.

*City University, London.

The information contained in this table can now be plotted on Karnaugh maps, and the logic functions deduced. The maps, which are shown in Fig. 4, are the same as in Dean's Fig. 3, except for the changes in notation. From these maps it can be seen that:

$$B_r = \bar{A}_r Q_r + A_r \bar{Q}_r$$

or

$$B_r = (\bar{A}_r + \bar{Q}_r)(A_r + Q_r)$$

$$\bar{B}_r = \bar{A}_r \bar{Q}_r + A_r Q_r$$

$$P_{r+1} = A_r P_r + A_r Q_r$$

or

$$P_{r+1} = A_r(P_r + Q_r)$$

$$\bar{P}_{r+1} = \bar{A}_r + \bar{P}_r \bar{Q}_r$$

$$Q_{r+1} = \bar{A}_r P_r + A_r \bar{P}_r \bar{Q}_r$$

or

$$Q_{r+1} = \bar{Q}_r(\bar{A}_r + \bar{P}_r)(A_r + P_r)$$

$$\bar{Q}_{r+1} = Q_r + \bar{A}_r \bar{P}_r + A_r P_r$$

The functions were given first in the sum-of-products form, and each of them could be realised using one OR- and two AND-gates, or else three NAND-gates. Secondly the functions were given in product-of-sums form. In this form they require altogether eight gates for their realisation, either five OR- and three AND-gates, or eight NOR-gates. However, not only B_r, P_{r+1} and Q_{r+1} are required, but $\bar{P}_{r+1}$, $\bar{Q}_{r+1}$ and, possibly, $\bar{B}_r$. These may be produced by means of inverters, but it may be more economical to produce the complement directly and complement that.* To see whether this is so expressions for $\bar{B}_r$, $\bar{P}_{r+1}$ and $\bar{Q}_{r+1}$ in sum-of-products form have also been given. To produce $\bar{P}_{r+1}$ with NAND-gates two are required compared with three to produce P_{r+1}. The former is therefore the more economical course. With the other two output variables there is no difference, so that the total number of gates required may be reduced from nine to eight.

Further economy is possible. The expression for $\bar{P}_{r+1}$ may be modified to $\bar{A}_r + A_r \bar{P}_r \bar{Q}_r$ (this may be seen from the map or from the well-known result that $X + \bar{X}Y = X + Y$). When this has been done the term $A_r \bar{P}_r \bar{Q}_r$ is common to the expressions for $\bar{P}_{r+1}$ and Q_{r+1}, so that a further gate may be saved, reducing the number per block to seven. The inverters for P and Q may be placed at the input or output of a block. The former course reduces the number of leads between blocks, and this is the arrangement which has been shown in Fig. 5.

Alternative codings

In the previous circuit a weighted binary code was used for the carry digit. There are, however, many other ways of coding the carry digit and some of these lead to more economical circuits. The first step is to set out the various possibilities and the second is to distinguish those alternatives which lead to different circuits from those which merely lead to the same circuit differently labelled. It is convenient in setting out the alternatives to make use of Karnaugh maps, arranging the three values of the carry digit, 0, 1 and 2, in various ways in the four spaces of a two-variable map. Leaving one space vacant for the present, the opposite space may be occupied by 0, 1 and 2, giving the three possibilities of Fig. 6(a). The three possibilities of Fig. 6(b) differ from those of Fig. 6(a) only in having P_r and Q_r interchanged, so that they lead to designs which are identical, though differently labelled. The three possibilities of Fig. 6(c) are obtained from those of Fig. 6(a) by comple-

*Zissos and Copperwhite[2] have considered the problem of realising a logic function with gates when the complements of the inputs are not available, and have shown that to design a circuit which is minimal when the complements are available, and add inverters, does not always lead to the most economical solution. Although, in general, their results are applicable to the situation considered here, a *systematic* procedure for applying them to multiple-output networks has not been worked out, and no attempt has been made to make use of them here.

Table one

A_r	P_r	Q_r	a_r	c_r	a_r+c_r	c_{r+1}	B_r	P_{r+1}	Q_{r+1}
0	0	0	0	0	0	0	0	0	0
0	0	1	0	1	1	0	1	0	0
0	1	0	0	2	2	1	0	0	1
0	1	1	–	–	–	–	ϕ	ϕ	ϕ
1	0	0	3	0	3	1	1	0	1
1	0	1	3	1	4	2	0	1	0
1	1	0	3	2	5	2	1	1	0
1	1	1	–	–	–	–	ϕ	ϕ	ϕ

ϕ denotes an optional value

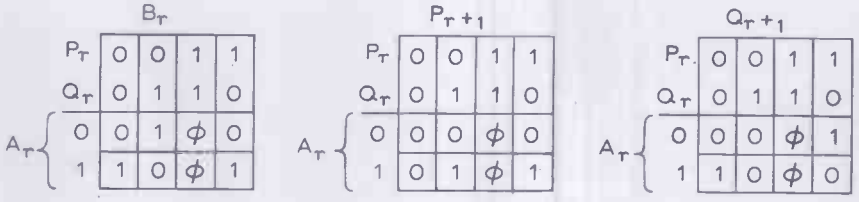


Fig. 4. Karnaugh maps for one block of an array for multiplication by three.

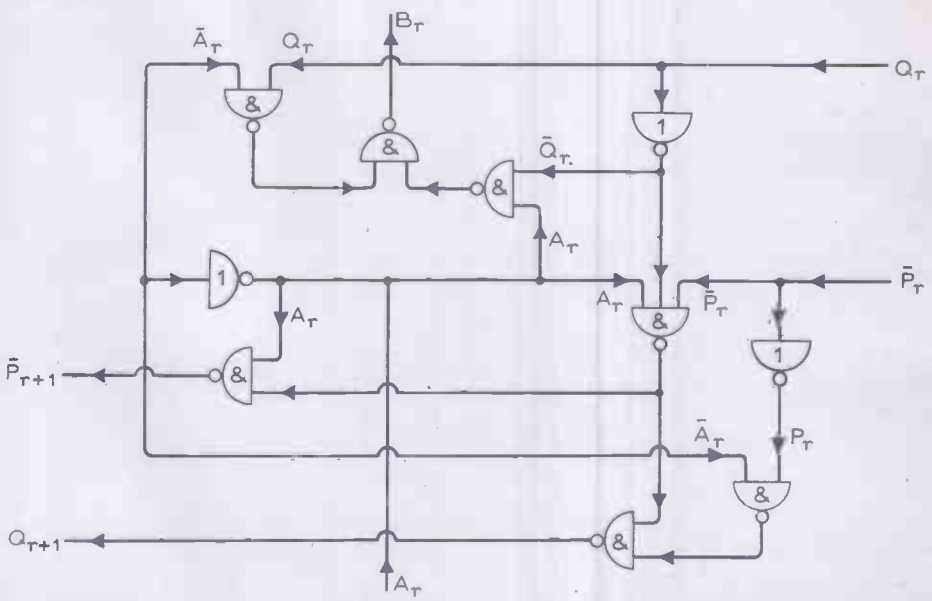


Fig. 5. The logic circuit of a block which will multiply by three.

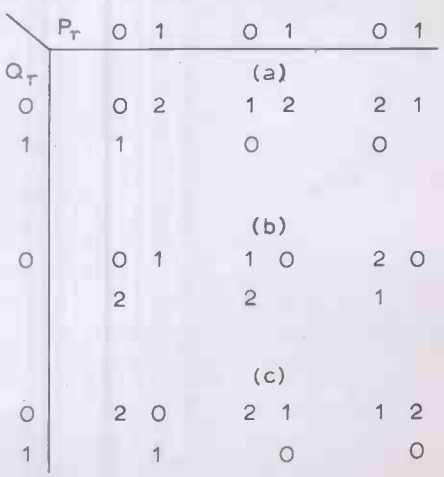


Fig. 6. Coding possibilities, first step.

Q_r \ P_r	0 1	0 1	0 1
	(a)	(b)	(c)
0	0 2	1 2	2 1
1	1 ϕ	0 ϕ	0 ϕ
	(d)	(e)	(f)
0	0 2	1 2	2 1
1	1 0	0 0	0 0
	(g)	(h)	(j)
0	0 2	1 2	2 1
1	1 1	0 1	0 1
	(k)	(l)	(m)
0	0 2	1 2	2 1
1	1 2	0 2	0 2

Fig. 7. Coding possibilities showing all alternatives with some duplication.

Table two

A_r	P_r	Q_r	a_r	c_r	a_r+c_r	c_{r+1}	B_r	P_{r+1}	Q_{r+1}
0	0	0	0	0	0	0	0	0	0
0	0	1	0	1	1	0	1	0	0
0	1	0	0	2	2	1	0	ϕ	1
0	1	1	0	1	1	0	1	0	0
1	0	0	3	0	3	1	1	ϕ	1
1	0	1	3	1	4	2	0	1	0
1	1	0	3	2	5	2	1	1	0
1	1	1	3	1	4	2	0	1	0

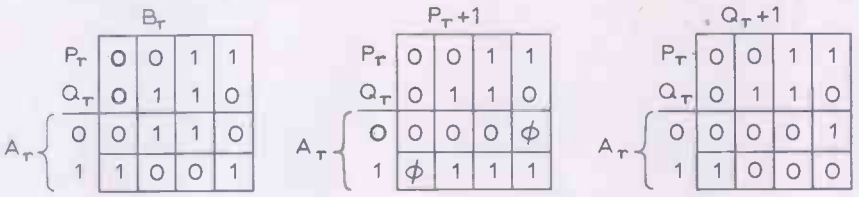


Fig. 8. Karnaugh maps for one block of an array for multiplication by three using an alternative coding.

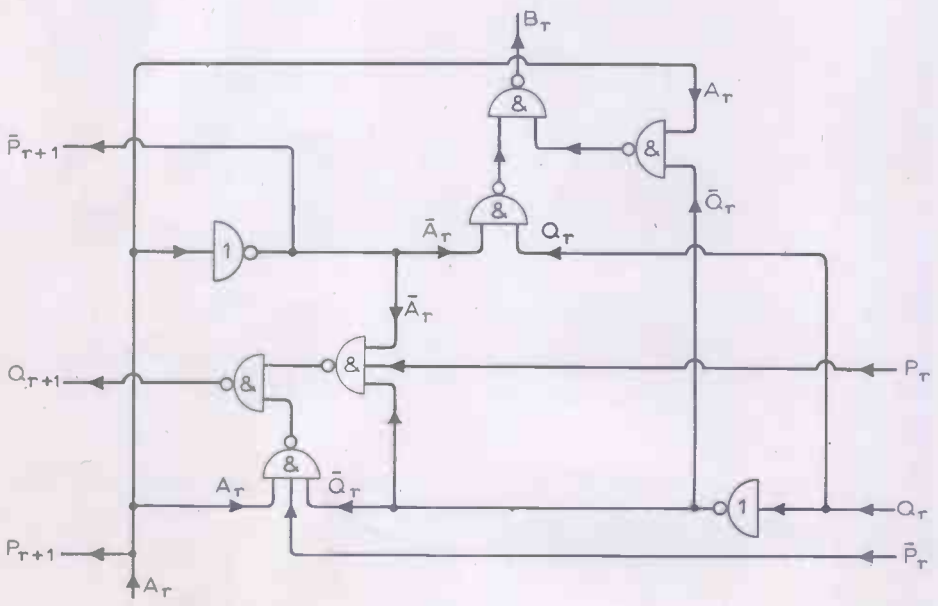


Fig. 9. The logic circuit required when using the alternative coding. Note that fewer gates are now required.

menting P_r, that is, they are the same except that the variable previously called P_r has been called $\bar{P}_r$. In general, since both P_r and $\bar{P}_r$ are required, they lead to identical designs. The same applies if Q_r is complemented.

So far there are only three distinct alternatives. Next it is necessary to decide how to use the spare state. One possibility is not to use it at all. This is what Dean did with the first coding of Fig. 6(a), and it leads to the solution we have already described. On the other hand, the spare state may be used as an alternative way of conveying the information that the carry digit has one of the three values, for example, in Fig. 7(d) when the carry digit is 0 this information may be conveyed by $P_{r+1}Q_{r+1} = 00$ or $P_{r+1}Q_{r+1} = 11$. In Fig. 7(e) the same information is conveyed by $P_{r+1}Q_{r+1} = 01$ or 11. This means that when $Q_{r+1} = 1$ the carry digit is 0 whatever the value of P_{r+1}, so that when the carry digit is 0 the value of P_{r+1} is optional. Thus the flexibility available as a result of having a spare state has not been lost by assigning to that state a specific message—it has been made use of in a different way.

Fig. 7 has been obtained from Fig. 6(a) by inserting $\emptyset$, 0, 1 or 2 in the vacant space. There appear to be twelve alternatives but on inspection it may be seen that (f) becomes the same as (e) on complementing P_r, (l) becomes the same as (k) on complementing Q_r, and (j) becomes the same as (g) on interchanging P_r and Q_r and then complementing P_r, so that there are only nine alternatives.

Designs with alternative codings

Designs for all these alternative codings have been worked out, and the best was found to be (g). It may be noted that this differs from the weighted code only in the use made of the spare state. The table of combinations and the resulting Karnaugh maps are given in Table two and Fig. 8.

From these maps:

$$B_r = \bar{A}_r Q_r + A_r \bar{Q}_r$$

or

$$B_r = (\bar{A}_r + \bar{Q}_r)(A_r + Q_r)$$

$$\bar{B}_r = \bar{A}_r \bar{Q}_r + A_r Q_r$$

$$P_{r+1} = A_r$$

$$\bar{P}_{r+1} = \bar{A}_r$$

$$Q_{r+1} = \bar{A}_r P_r \bar{Q}_r + A_r \bar{P}_r Q_r$$

or

$$Q_{r+1} = \bar{Q}_r(\bar{A}_r + \bar{P}_r)(A_r + P_r)$$

$$\bar{Q}_{r+1} = Q_r + \bar{A}_r \bar{P}_r + A_r P_r$$

Since $P_{r+1} = A_r$, $\bar{P}_{r+1} = \bar{A}_r$ so only two inverters are required, assuming $\bar{B}_r$ is not wanted. If NAND-gates are used, six are required. It is marginally better to produce $\bar{Q}_{r+1}$ directly and use an inverter to obtain Q_{r+1}, rather than the reverse, since then only one of the six NAND-gates will have three inputs. The resulting design for one block is shown in Fig. 9.

REFERENCES

1. K. J. Dean, "Iterative arrays of logical circuits for performing arithmetic", *Electronic Engineering*, Vol. 40, No. 490 (Dec. 1968).
2. D. Zissos and G. W. Copperwhite, "Further Developments in the Design of Minimal NOR (and NAND) Combinational Switching Circuits for N-Variables", *Electronic Engineering*, Vol. 38, No. 461 (July 1966).

Roots and Responses

Showing how the root technique applies to filter design

by Thomas Roddam

When I began writing this group of articles a few months ago it was because I wanted to discuss the question of why we use sine waves, why we go to a good deal of trouble to make sine waves. The answer turned out to be that it is very easy to produce a perfect sine wave, if you are a mathematician. All you need is inductance, capacitance, a battery and a switch. One thing you must not be is a physicist. I assert that my *LC* circuit has a sinusoidal current flowing in it and that the frequency is such and such. Call me a liar and I connect a measuring device. A measuring device, however, must load the circuit down and, to some extent affect the frequency. As a mathematician I can use positive feedback to give me infinite input impedance, but I have the problem of keeping the noise energy finite.

The engineer is not driven into this corner. He has real coils and capacitors producing a straightforward complex frequency. He has two quite separate ways of keeping his signal going. In practical circuits they may get a bit mixed up, but essentially they are totally different. In one method the maintaining circuit can be analyzed into a negative resistance which is used to balance out the resistances in the practical *LC* circuit. Various sorts of a.g.c. circuit are used so that this balance is maintained at a particular level of oscillation. It sounds very easy but it can be a life-time career. Some of the rules are easy to write down. The system must be linear: the negative resistance must appear in the circuit in the same way as the circuit positive resistance. This last rule is normally concealed in a sea of mathematics. The reason behind it is simple. If the circuit loss is, for example, the wire resistance of a coil, and we have a parallel tuned circuit with a parallel maintaining negative resistance, the negative resistance must balance out an admittance term $R/(R^2+\omega^2L^2)$. The self-adjusting property allows this, but there is still a term in R in the frequency expression. What happens, in terms of those root diagrams, is that the root is moved bodily sideways to the $j\omega$ axis. Because R is temperature dependent, the frequency will also be temperature dependent. Because the frequency displacement is normally happening as we move round the top of the root locus semicircle the change will not be very big, and if we start with a good circuit Q may not be the most important change. If we use a series negative resistance and a series *LC* circuit we should go round to oscillate at $\omega^2LC = 1$. Now, however, any shunt losses must be transformed to series losses.

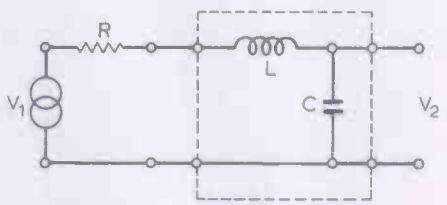


Fig. 1. Simple low-pass filter with high impedance load.

A quite different method generates the tuned circuit root frequency itself. This is the way we produce substantial amounts of sine wave power and have done since I don't know when. In simple terms a reversing switch, or even a simple short contact duration switch is used to flip energy into the tuned circuit every half-cycle, every cycle, or even, in frequency multipliers, every n cycles. One common form of this is the familiar square wave inverter with a simple filter.

A class-C oscillator is a fine example of a mix-up. The *on* period of the amplifier moves the root over into the right-hand half of the plane. If the amplifier saturates, of course, back we go to the left. During the *off* period the tuned circuit is aware only of its own complex frequency. The great days of the class-C oscillator were the days of the self-biased system, in which the circuit itself settled the amount of each cycle spent in each mode. If anyone had stopped to work it out they would never have built an oscillator.

The use of roots in the complex plane, that is the use of the complex natural frequencies of circuits, introduced a new age in the design of filter and frequency dependent networks. The old school grew up on the work of Campbell and Zobel. This followed on the real beginnings, with names like Kelvin, Heaviside, Pupin. The Great Eastern, black smoke pouring from her funnels, lays the transatlantic cable. The loading coil made it possible, with the valve amplifier, for the great moment, in 1915, when no fewer than three telephone circuits connected San Francisco to New York and Washington. Four wires, strung on poles. More wires, strung on poles, and by 1937 there were 140 circuits. *Wireless World* was already being published before it was possible to 'phone across America.

The growth of trunk telephone circuits depended on carrier operation, and this, in turn, depended on filter design. The filter design grew out of the theory of long lines and, in its beginnings, ignored its ends. I suppose that a large number of the filters being built today are still based on the handy summaries of constant-k and m-derived sections which are to be found in all the reference books. These are slices from a long chain of similar sections, with reactance all the way through like the town's name in a stick of seaside rock. In the simple theory the source and the load matched the filter. In reality source and load were resistive: the calculations were patched up by the use of mismatch loss, interaction loss and other delicate corrections.

The first step away from the assembly kit was the result of examining the reactance network as a whole. The filter, by itself, showed a set of characteristic frequencies at which the reactance was either zero or infinite. The distribution of poles and zeros determined the overall response, apart from the patches. Two problems remained: the effect of the losses of the elements themselves and the effect of the resistive terminations. Cauer and Bode are the great names of the classic lattice network period. Reading system into the random walk of the historical development it was the need to allow for the losses of practical components which opened up the great leap forward. The theorists of finite losses moved into the complex plane.

The move was a rather timid one. The whole line of roots was moved bodily sideways, and ideally for all the elements the value of $R/L = G/C$ was the same. But the theory had moved from one dimension to two.

Instead of moving from one dimension to two by introducing the resistances associated with each and every reactive component we may just introduce one or two resistances associated with the source and the load. Let us take the simplest circuit worth considering, the simple low-pass network of Fig. 1, fed from a generator of impedance R and feeding an infinite impedance load. This is a common situation when the load is in fact a high input impedance amplifier.

If you think of the three components as a voltage divider you can write down the proportionality equation

$$\frac{V_1}{R+j\omega L+1/j\omega C} = \frac{V_2}{1/j\omega C}$$

so that

$$\frac{V_1}{V_2} = 1+(R+j\omega L)j\omega C$$
$$= 1+j\omega CR-\omega^2 LC$$

Of course, I should not have used $j\omega$. That's the equation for response, but I want a function,

$$G = 1+pCR+p^2LC$$

in which p can have any value. If we put $G = 0$ we have

$$LCp^2+CRp+1 = 0$$

so that

$$p = \frac{-CR\pm\sqrt{C^2R^2-4LC}}{2LC}$$

giving two roots, p_1 and p_2,

and $G = (p-p_1)(p-p_2)$.

When we take the special case of (V_1/V_2), we see that this corresponds to $p = j\omega$, so that

$$\frac{V_1}{V_2} = G(j\omega) = (j\omega-p_1)(j\omega-p_2)$$

In Fig. 2 we see these two poles, p_1 and p_2. We know from our previous discussion that they are complex conjugate, though we see this in the equation above, too. I have assumed that $4LC > C^2R^2$, to get them up off the negative real axis.

The term $(j\omega-p_1)$ is the vector l_1 in Fig. 2, and l_2 is, of course, $(j\omega-p_2)$. The response is the product l_1l_2. It is rather easy geometry to see that this can be described by Fig. 3 instead of Fig. 2. One method of proceeding from this point is to do some more algebra to show how we can plot frequency responses using an electrolytic tank. I have seen a good many discussions of the use of this sort of analogue technique over the years but I have never actually come across anyone who really built networks for systems in this way. I am pretty certain that now I never shall: if the network needs that sort of approach you hire a mathematician, or computer time, or both.

The really conscientious reader may be

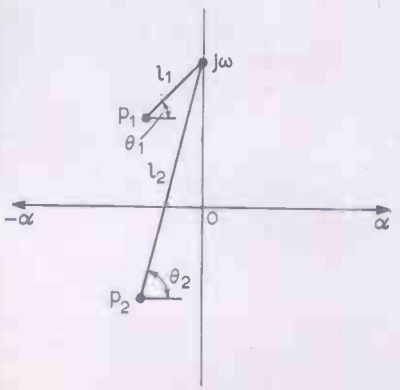


Fig. 2. The poles for the network of Fig. 1.

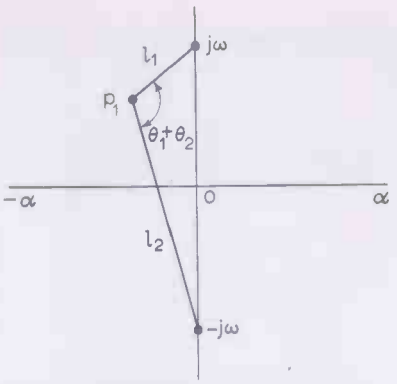


Fig. 3. Another way of getting the quantities in Fig. 2.

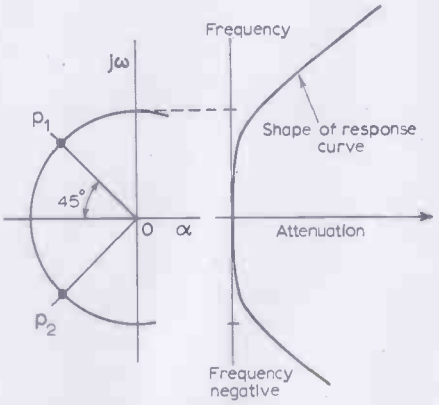


Fig. 4. Position of poles, and network response, sketched sideways compared with usual form, for Butterworth response.

wondering why we have plodded through to

$$\frac{V_1}{V_2} = 1+j\omega CR-\omega^2 LC$$

all over again. Let us get out our Avometers, and measure V_1 and V_2. Phase angle goes overboard, and all we determine is

$$\left|\frac{V_1}{V_2}\right|^2 = 1+\omega^2(C^2R^2-2LC)+\omega^4L^2C^2$$

This is the equation which describes the behaviour of the network as a frequency-selective network. Last month we considered the network as a frequency-dependent one. This distinction is one which can be very real among designers and it can lead to quite serious communication difficulties. Engineers working on radio frequencies use this network, and the slightly more complicated one with a capacitance at each end, as band-pass impedance transformers. They consider it as a kind of tapped tank circuit, and, very often, do all their calculations at a single frequency, the carrier frequency. Sometimes they regard the circuit as a lumped version of a quarter-wave line. The Campbell-Zobel filter man sees it as a low-pass filter, but the element values used in the r.f. coupling circuits indicate very large mismatch effects. In classical filter theory these are exceedingly tedious to work out, and when they have taken charge completely one loses all feel, one doesn't know what is going on. In fact, we are concerned with situations where one important root, p_1, is relatively close to the $j\omega$ axis (should we really call this the ω axis?), and the length l_1 in Fig. 2 takes complete control.

The filter man would like $|V_1/V_2|$ to stay pretty constant up to the cut-off frequency. This would give him a well-defined pass region. Now $|V_1/V_2|^2$ depends on ω^2 and on ω^4, and if these are small the ω^4 term is smaller than the ω^2 term. Put like that it sounds rather a dubious statement. Let us write

$$\omega^2LC = \sigma^2$$

Then

$$\left|\frac{V_1}{V_2}\right|^2 = 1+\sigma^2\left(\frac{C^2R^2-2LC}{LC}\right)+\sigma^4$$

Here $\sigma^4<\sigma^2$ so long as $\sigma<1$. We can guess that to make the coefficient of σ^2 zero will give us a rather simple way of holding $|V_1/V_2|$ near unity over a limited range of frequencies. For this condition,

$$C^2R^2 = 2LC, \quad \text{or} \quad \frac{L}{C} = \frac{R^2}{2}.$$

We now have

$$\left|\frac{V_1}{V_2}\right|^2 = 1+\omega^4L^2C^2$$

This is the simplest form of what is called a Butterworth response. The roots of the basic function

$$G = 1+pCR+p^2LC$$

are at $p = \dfrac{-CR\pm\sqrt{C^2R^2-4LC}}{2LC}$

and if we substitute $CR^2 = 2L$ we get

$$p = \frac{-CR\pm\sqrt{-C^2R^2}}{2LC}$$
$$= \frac{1}{2LC}[-CR\pm jCR]$$

These two poles lie in the positions shown in Fig. 4. Suppose now that we add a capacitance across the input end of the network. In the p form the ratio V_1/V_2 is now:

$$\frac{V_1}{V_2} = 1+p(C_1+C_2)R+p^2LC_2$$
$$+p^3LC_1C_2R$$

The Butterworth, or maximally flat, response takes the form, in terms of ω, of

$$\left|\frac{V_1}{V_2}\right|^2 = 1+g^2\omega^6$$

It is not an insuperable task to substitute $j\omega$ for p, separate out the j terms, square up and solve the equations. There will be two of these, to make the ω^2 and ω^4 terms vanish. We can proceed in a rather different way. We are substituting $j\omega$ for p, and so the network response function could be written

$$1+g^2(p/j)^6$$

This is an expression which must break down into a group of factors of the form $(p-p_k)$. To find the values of p_k we write

$$(1+g^2(p/j)^6) = 0$$

or

$$g^2(p/j)^6 = -1$$

Here the mathematician enters. We know that if

$$x^2 = -1$$

we have

$$x = \pm j.$$

What happens if $x^3 = -1$, or $x^4 = -1$, or $x^n = 1$? It is not enough to say that $x = -1$ if $x^3 = -1$. We expect three roots. The form 1 means unit whatever, but let us take it as a section of a line, a unit movement in a defined direction, and -1 is the same length, the other way. Displaced, or rotated, we say, by 180°. For $x^2 = -1$ we take two bites, moving 90° and then 90° (or $-90°+-90°$). For $x^3 = -1$ we can take $(-180°)+(-180°)+(-180°)$, one and a half times round the compass. We can also try $60°+60°+60°$ round, and go round clockwise or anticlockwise. For higher orders, x^n, we are like a legendary north country figure, whose hat-band went nine times round and wouldn't tie. In case you are confused, he was going to a funeral. In fact, if we settle for the even functions, with

$$g^2x^{2n} = -1, \quad \text{we get}$$

$$x_k = jg^{-1/n} \exp(j(2k-1)\pi/2n)$$

where k is $1, 2 \ldots 2n$.

These roots are arranged round a circle of radius $g^{-1/n}$, and if we collect only the roots for $k \leqslant n$ they all lie in the left-hand half of the plane. For reasons of symmetry the absolute value of the product of the factors produced by the right-hand roots is equal to that of the left-hand roots. We therefore get a set

$$(p-p_1)(p-p_2)\ldots(p-p_n) = \text{II}(p)$$

and

$$|1+g^2\omega^{2n}| = g^2|\text{II}(j\omega)|^2$$

This means that $g|\text{II}(j\omega)|$ can be taken to give us, in the form we are using, $|V_1/V_2|$. And as $|1+g^2\omega^{2n}|$ is the Butterworth response term, the roots are found from the equation for x_k. Since it is not too easy to think in terms of the exp function, we convert it to sines and cosines:

$$p_k = g^{-1/n}[-\sin(2k-1)\pi/2n + j\cos(2k-1)\pi/2n].$$

$$1 \leqslant k \leqslant n$$

We, at the moment, are interested in the case $n = 3$, and so we have angles of

for k =	1	2	3
angle =	$\pi/6$	$3\pi/6$	$5\pi/6$
	30°	90°	150°

All the roots, including those in the right-hand half of the plane, are shown in Fig. 5. Compared with Fig. 4, we see that adding one reactance we have added one root. Symmetry about the vertical axis implies that with 2×3 roots we must get one of the left-hand plane roots on the real axis.

Although this is still a pretty simple network it can be used to give some insight into circuit behaviour. The root p_1 in Fig. 5 is closer to the frequency axis than is p_1 in Fig. 4. The circuit, so far as this pole (and its mate p_3) is concerned, is more like a tuned circuit. It has, in other language, a higher Q. The root p_2, however, corresponds to an RC circuit. The roots taken together are the combination of an underdamped circuit and an overdamped circuit. This is a technique well-known in i.f. amplifier design. Indeed, there are two different

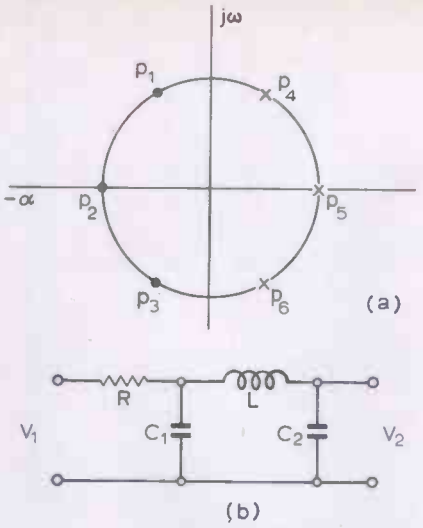


Fig. 5. (a) The six roots, of which only p_1, p_2 and p_3 are needed, for studying $|V_1/V_2|$ for network (b).

ways of getting the effect. One is by choosing the Q values of the i.f. transformers, which are all tuned up to the same frequency. The other is by stagger tuning. In staggered systems each stage produces one root, and they are set around a semicircle whose centre is at the band centre and whose radius is the 3 dB bandwidth. Design is obviously very easy now. For a twenty stage monster, plot out the 20 roots, find the frequency and damping for each and tune them up individually. All you need is sine and cosine tables.

The modern thing, as you cannot help knowing, is active filters. I showed last month how a simple two-stage amplifier with two *RC* circuits could have its roots moved about in the left-hand half of the plane by varying the feedback. Each circuit of this kind can be used to put a pair of roots wherever we like. By tandem connection you can have all the roots you want, where you want. I do not propose to enter the active filter area except to point out that it does rely much more on root-thinking. For younger readers I must add that it is only really sound engineering now that cheap amplifiers are possible. Around 1950, with the transistor just on the way, a rough cost of using a valve was £20, allowing for power consumption and replacements over the life of the equipment. In present terms that would be about £50. I have not done the sum for a transistor, but I will guess £0.5. Amplifiers are much cheaper, nickel is much dearer, and inductors are no longer the economical answer.

Let us go back to our simple low-pass filter. For the designer the advantage of the Butterworth response is obvious: it gives some very easy mathematics. Unfortunately

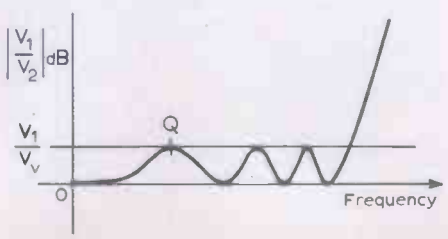


Fig. 6. Typical 'good' filter characteristic.

the customer, whether he is an outsider or just another section or individual inside the same organization, does not really care if the filter designer has an easy life. He wants the best performance, even if that means that you get the best headaches. He knows that a rather wider pass-band for a given tolerance across the band will be obtained if the response rises slightly towards cut-off and then drops away. A very coarse picture of this appeared as Fig. 10(a) in last month's article. Fig. 6 shows a response with a number of peaks and valleys in the pass-band. The important thing to notice is that it is fitted firmly into the space between the zero loss line and the $|V_1/V_v|$ line. The object of the exercise is to use the tolerance as efficiently as possible. It is quite fair to use a slightly different version of this, the section to the right of the point Q, and the special case we have been looking at has only one—what shall we call it, half-cycle? —to the right of Q.

What about the mathematics? It was done for us nearly 100 years ago. The functions we want are called the Tchebyscheff polynominals, and they are good, not only for designing networks, but also for promoting vigorous argument, not about mathematics but about spelling. The Russian letter Ч is the problem, at the beginning, and problems go right through to the end: is it "eff" or "ev"? My own guess is that confusion really set in when the French speakers in St. Petersburg turned into the English students in Leningrad. Whether you are old-fashioned, like me, or a modern who writes Chebishev, many of the texts write $T_n(x)$ for the function. The moderns are thus left with the sort of confusion I feel when old Mr. Weller calls out "Spell it with a wee, my lord".

When we turn to using the T function we write the basic equation in the general form

$$\left|\frac{V_1}{V_2}\right|^2 = \{1+g^2[T_n(\omega)]^2\}N_0^2$$

Where N_0 is the value of $|V_1/V_2|$ at $\omega = 0$. All we need to know now is what the form of $T_n(\omega)$ will be.

By an analytical approach we get

$$T_n(\omega) = \cos(n\cos^{-1}\omega)$$

which is neat but not frightfully convenient.

Fortunately the expression has been expanded for us, in quite a number of publications. As a polynominal,

$$T_n(\omega) = 2^{n-1}\left[\omega^n - \frac{n}{2^2\lfloor 1}\omega^{n-2} + \frac{n(n-3)}{2^4\lfloor 2}\omega^{n-4} - \frac{n(n-4)(n-5)}{2^6\lfloor 3}\omega^{n-6}\right]$$

and so on until the term ω or ω^0 is reached. For our simple little filter, $n = 4$, and we have

$$T_4(\omega) = 8(\omega^4 - \omega^2 + \tfrac{1}{8})$$

$$= 1 - 8\omega^2 + 8\omega^4$$

If $\omega = 0$ this is unity: if ω is large, it is very large indeed: it has one minimum at the response peak, and to find this we differentiate, and get

$$32\omega^3 = 16\omega$$

or

$$\omega^2 = \tfrac{1}{2}$$

Then $T_4(0{\cdot}7) = 1-4+2 = -1$, as we might have guessed from the form $T_n = \cos(n\cos^{-1}\omega)$.

The coefficient g fixes the size of the ripple and if we choose a value of g we can write

$$1+\omega^2(C^2R^2-2LC)+\omega^4L^2C^2 = N_0[1+g^2-8g^2\omega^2+8g^2\omega^4].$$

Solving this equation is always tedious, because specification writers will choose round numbers of decibels, giving very unround values of g. There are, however, charts and tables available. We, in thinking about roots, will write $\omega = p/j$. We use the equation

$$T_n(\omega) = \cos[n\cos^{-1}(p/j)],$$

and since for the roots

$$1+g^2(T_n)^2 = 0$$

we must have $T_n = \pm j/g$, giving us

$$\cos[n\cos^{-1}(p/j)] = \pm j/g.$$

If we now put $\cos^{-1}(p/j) = \alpha - j\beta$ we can solve this equation. I do not propose to write down all the mathematics, even though it means that you must either do it yourself or take the conclusions on trust. The conclusions are that the roots lie on an ellipse. This seems fair enough when you think that the circle is just a special kind of ellipse, in which the equation

$$\frac{x^2}{a^2}+\frac{y^2}{b^2} = 1$$

is simplified by making $a = b$ and losing one control factor. The position of the roots on the ellipse is found by the following procedure. We draw a semi-circle of radius

$$\cosh[1/n\sinh^{-1}(1/g)]$$

This looks complicated, but it consists only of things you look up in tables. If, for example,

$$g = 0{\cdot}1 \text{ and } n = 2$$

$$\sinh^{-1}10 \simeq 3$$

$$\cosh 3/2 = \cosh 1{\cdot}5 = 2{\cdot}35$$

We also need, while the tables are open,

$$\sinh(1/n\sinh^{-1}(1/g)),$$

and $\sinh 1{\cdot}5 = 2{\cdot}13$

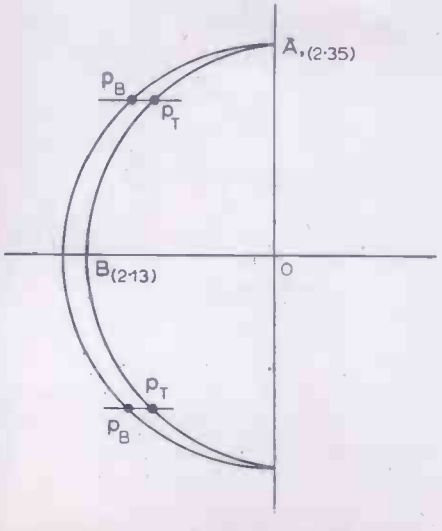


Fig. 7. Butterworth and Tchebyscheff poles.

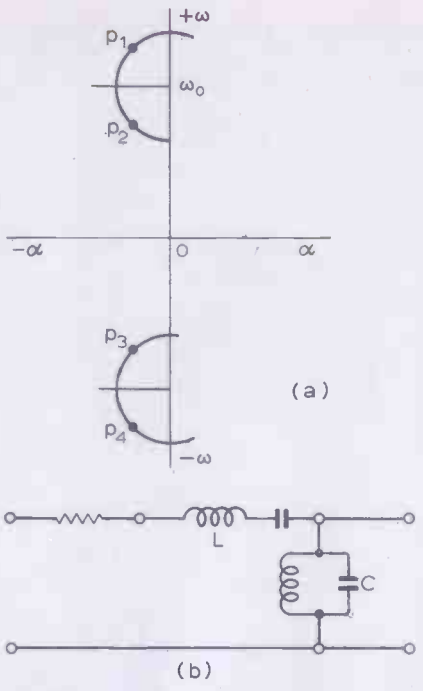


Fig. 8. A set of four roots (a), and the circuit (b).

Now we can draw Fig. 7. We mark off the point A at a distance 2·35 and draw the semicircle. Then we mark B at −2·13. and construct the ellipse. Next, put in the evenly spaced Butterworth roots round the circle. Finally, draw lines parallel to the α axis to intersect the ellipse at the Tchebyscheff poles. With only a small ripple the ellipse is nearly a circle, and the roots have not moved very far. The more the ripple the flatter the ellipse. The picture for more complicated networks is just as easy to draw. We have two roots in the left-hand half of the plane: if we take $n = 20$ we shall get 20 roots, evenly spaced at 9° apart, and it is just as easy to look up cosh 3/20 as to look up cosh 3/2.

The active filter designers, free to move their roots about, can equally get the T response. There thus remain two topics needing mention. Let us suppose that we place roots at the four points shown in Fig. 8. The pair p_1 and p_2 are positioned on a circle with its centre at ω_0. If this is a small circle, on the overall scale, p_3 and p_4 are so far away that we can forget them. We can convert the circle into an ellipse, if we wish. In the region not too far from ω_0 the response shape will be of the kind shown in Fig. 4, except that negative frequencies in Fig. 4 now appear as negative values of $(\omega-\omega_0)$. The design, whether for a B response or a T response, follows the low-pass procedure to establish L and C in the network of Fig. 8(b). When these have been found the centre frequency is moved to ω_0 by tuning these elements separately to ω_0 by the additional C and L. Analysis shows that it is not $(\omega-\omega_0)$ we must consider, but

$$\omega_0\left(\frac{\omega}{\omega_0}-\frac{\omega_0}{\omega}\right)$$

This correction automatically takes into account the effect of p_3 and p_4.

A feature of this way of analysing the circuit of a band-pass system is that it indicates quite clearly why we are liable to get asymmetry with filters of large fractional bandwidth. In a diagram of the scale I have used it is pretty obvious that at $\omega_0/2$ the root p_3 is just about as important as the root p_1 but quite a bit more important than p_4. There is all the makings of asymmetry in this arrangement.

The networks we have analysed have the constant-k behaviour, the steady rise of attenuation outside the pass-band. To produce the sort of characteristic we normally use we want to add some peaks of attenuation, as we do with m-sections in classical theory. Our roots have been at the zeros of the function $|V_1/V_2|$: now we must consider that infinities, the poles, of $|V_1/V_2|$. We can actually place these on the frequency axis if we use resistance-balancing circuits, and they will normally be very close to this axis, because we will go for a high Q at the suppression peaks. In the stop band we can go for Tchebysheff behaviour of the inverse kind, with all the troughs at the same level. Again RC networks combined with amplifiers will give us what we want, but now we must be sure that in bringing a root near to the axis we do not let it stray into the right-hand half of the plane.

From this point on the mathematics gets unwieldy. Once that happens the analysis is a formal operation. The object of this article is to work with circuits which are familiar, so that the root technique is seen to work. For complex circuits you need faith, and hard work. I hope I have provided some foundations for the faith.

Books Received

Beginner's Guide to Radio, by Gordon J. King, is an updated (entirely rewritten) version of F. J. Camm's "A Beginner's Guide to Radio". The twelve chapters treat, by simple physical theory, the fundamental principles of electricity and magnetism, radio waves, and modulation. A simple explanation is given of how valves and transistors function in receivers and transmitters. Stereo radio is introduced, and hi-fi reproduction is given a very good explanation, again in very simple terms. A comprehensive list of circuit symbols is given at the front of the book with abbreviations, units, symbols and standard frequency ranges, at the back. Pp.190 and an index. Price £1.
Butterworth & Co. (Publishers) Ltd, 88 Kingsway, London W.C.2.

Telecommunications Pocket Book, edited by T. L. Squires, is written in twelve chapters, each by an expert in the field concerned. An attempt has been made to give a broad outline of each aspect of telephony, television, telex, data communication etc. The first chapter, "Communications in the Modern World: an Introduction", gives coherence to the more specialized chapters which follow. Pp.139 with a 4-page index. Price £1 4s.
Butterworth & Co (Publishers) Ltd, 88 Kingsway, London W.C.2.

Signal Monitoring Networks

Simple design formulae for rapid evaluation of the basic requirements of monitoring systems

*by A. E. Crump**

The basic problem of monitoring either a.c. or d.c. signals is, that in order to do so, some energy has to be absorbed by the monitoring device. Thus the presence of a monitor modifies the value of the monitored quantity.

Methods for determining whether a passive monitoring device would be suitable for a given application are described, and also the basic methods for calculating amplifier performance should an amplifier be necessary. The design of a monitor circuit is approached by fixing four of the five interrelated parameters shown below and calculating the fifth.

The interrelated parameters are:
Signal level in bearer (P).
Characteristic impedance of bearer (R_0).
Maximum insertion loss tolerable in bearer circuit (l).
Output level required from monitor (V_L).
Load impedance presented to monitor output (R_L).

For our purpose P and l are expressed in dB, V_L in volts, and R_0 and R_L in ohms.

* The Plessey Co., Ltd.

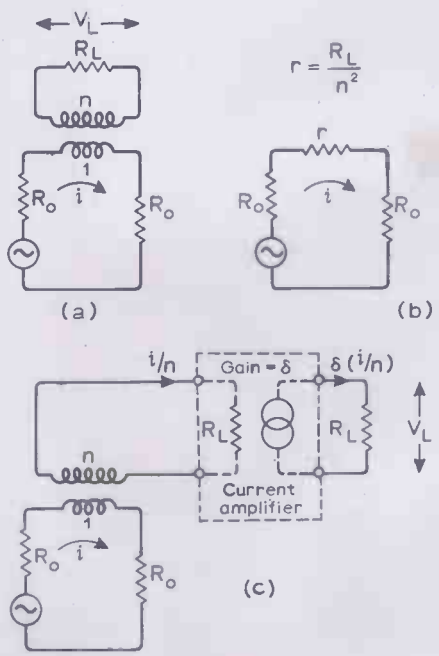


Fig. 1. (a) Current monitor (passive); (b) equivalent primary circuit; (c) method of introducing gain. The input impedance of the amplifier need not equal R_L, but if not, the calculations must be repeated using the input impedance in place of R_L in the formulae.

Current (series) mode

Figure 1(a) shows the arrangement for using a current transformer to produce the necessary output voltage across R_L. Figure 1(b) shows the equivalent impedance of the transformer (r) in series with the bearer circuit.

The insertion loss incurred by the inclusion of r in the signal path can be obtained from the established expression:

$$\text{Insertion loss} = \frac{\text{Power in } R_0 \text{ with } r \text{ short-circuit}}{\text{Power in } R_0 \text{ with } r \text{ in circuit}}$$

$$\text{i.e.} \quad l = 20 \log_{10}\left(1+\frac{r}{2R_0}\right)\text{dB}.$$

But according to transformer theory $r = \frac{R_L}{n^2}$,

$$\text{also} \quad V_L = \left(\frac{i}{n}\right)R_L.$$

By substitution and transposition we obtain the formulae:

$$P = 10 \log_{10}\left[\frac{V_L^2(10^3)}{\{\text{antilog}_{10}(l/20)-1\}2R_L}\right]\text{dBm} \quad (1)$$

$$l = 20 \log_{10}\left[1+\frac{R_L}{2(n^2)R_0}\right] \quad (2)$$

$$n = \sqrt{\left[\frac{R_L}{2 \cdot R_0 \cdot \{\text{antilog}_{10}(l/20)-1\}}\right]} \quad (3)$$

$$V_L = \sqrt{\left[2 \cdot R_L \cdot \left\{\text{antilog}\left(\frac{P}{10}\right)\right\}\left\{\text{antilog}\left(\frac{l}{20}\right)-1\right\}10^{-3}\right]} \quad (4)$$

$$R_L = \frac{V_L^2(10^3)}{2[\text{antilog } P/10][\text{antilog } (l/20)-1]} \quad (5)$$

Having the expressions (1) to (5) it is now possible to substitute known parameters and obtain a guide regarding the validity of the requirement in hand.

Example 1. Consider a system similar to Fig. 1(a) in which the signal level of +18 dBm in 75 Ω is required to produce 6 V r.m.s. across R_L. What transformer turns ratio is required. What is the value of R_L required to guarantee 6 V output without exceeding the maximum permissible insertion loss of 0·3 dB?

$P = +18$ dBm, $R_0 = 75\,\Omega$, $l = 0{\cdot}3$ dB, $V_L = 6$ V. From (5) $R_L \doteq 8{\cdot}15$ kΩ (preferred value 8·2 kΩ). From (3) $n = 39{\cdot}5$.

It is possible thus to satisfy the requirement provided that the output load resistance is 8·2 kΩ and a transformer turns ratio of 39·5 to 1 is used. The high turns ratio precludes use above about 150 kHz because of the practical problems of producing the transformer. The turns ratio would be smaller, of course, if a higher insertion loss figure were permissible.

Example 2. It is required to produce 6 V across a 5000-Ω load without exceeding 0·3 dB insertion loss in the bearer circuit which is 75 Ω characteristic resistance. What turns ratio and power level would be required to achieve this?

$R_L = 5000\,\Omega$, $R_0 = 75\,\Omega$, $l = 0{\cdot}3$ dB, $V_L = 6$ V. From (1), minimum power required = +20 dBm. From (3), turns ratio = 30·8.

Example 3. It is required to produce a 6 V signal across a 5000-Ω load without exceeding 0·3 dB insertion loss, for a signal level of 0 dBm in 75 Ω. Is this possible?

From (3), $n = 952$. This is an unrealistic transformer ratio, therefore some amplification is necessary. Now assume that a practical ratio for the transformer at the frequency under consideration is N, then the current amplification required is $\delta = \frac{952}{N}$ and the system would appear as

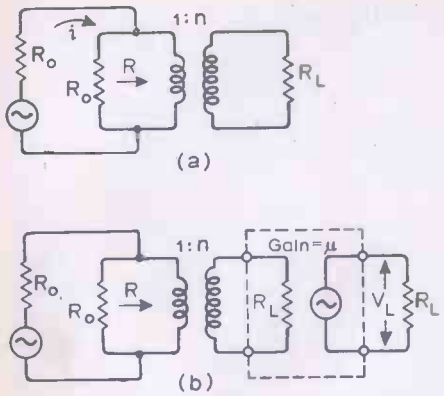


Fig. 2. (a) Voltage monitor (passive); (b) method of introducing gain. As is the case of the current monitor in Fig. 1, if the impedance of the amplifier does not equal R_L the calculations should be repeated using the input impedance in place of R_L.

in Fig. 1(c) where δ = current gain of amplifier.

Voltage (shunt) monitoring

The criterion here is to present a high impedance across the bearer rather than a low impedance in series with it.

Referring to Fig. 2, the insertion loss due to the addition of R can be expressed as:

$$l = 20\log_{10}\left(1+\frac{R_0}{2R}\right)\text{dB}. \qquad (6)$$

Proceeding in the same manner as in the series case:

$$R_L = \frac{n^2R_0}{2[\text{antilog}\,(l/20)-1]} \qquad (7)$$

$$P = 10\log_{10}\left[\frac{(10^3)V_L{}^2}{2R_L\{\text{antilog}\,(l/20)-1\}}\right]\text{dBm} \qquad (8)$$

$$n = \sqrt{\left[\frac{2R_L}{R_0}\left\{\text{antilog}\left(\frac{l}{20}\right)-1\right\}\right]} \qquad (9)$$

$$V_L = \sqrt{\left[\text{antilog}\left(\frac{P}{10}\right)\left\{\text{antilog}\left(\frac{l}{20}\right)-1\right\}2R_L(10^{-3})\right]}. \qquad (10)$$

The versatility of these formulae is comparable to that of the "series" expressions and examples could be given as before. Let us however consider a case where a passive device is insufficient, i.e. the voltage analogy to example (3).

Example 4.

$R_0 = 75\,\Omega$
$R_L = 5000\,\Omega$
$l = 0{\cdot}3\,\text{dB}$
$V_L = 6\,\text{V r.m.s.}$
$P = +10\,\text{dBm}$

From (9) $n = 2{\cdot}16$
From (10) $V_L = 84\,\text{mV}$

A voltage amplifier is necessary with input impedance of 5000 Ω and voltage gain of $\frac{6\,\text{V}}{84\,\text{mV}} = 71{\cdot}4$.

Effect of monitoring on return loss

Now the return loss $= 20\log_{10}\frac{R_0+Z}{R_0-Z}$ or $20\log_{10}\frac{R_0+Z}{Z-R_0}$ (dB) where

R_0 = Characteristic resistance of bearer
Z = load resistance

{ For series case $Z = R_0+(r+jx)$ }
{ †For parallel case $Z = R_0 \| R \| (jx)$ }

∴ for current monitoring (ignoring reactance):

$$\text{return loss} = 20\log\left(1+\frac{2R_0}{r}\right)\text{(dB)} \quad (11)$$

and for voltage monitoring (ignoring reactance):

$$\text{return loss} = 20\log\left(1+\frac{2R}{R_0}\right)\text{(dB)} \quad (12)$$

†The symbol ‖ is coming into use with the meaning "in parallel with". Thus, $R_1 \| R_2 = R_1R_2/(R_1+R_2)$.

Announcements

The British Amateur Electronics Club is holding its fifth annual exhibition of electronic games from July 25th to August 1st at the Shelter on the Esplanade at Penarth, Glamorgan.

The two British subsidiaries of Tektronix Inc.—Tektronix U.K. Ltd and Telequipment Ltd—became a single company, Tektronix U.K. Ltd, on May 1st with two operating units. The Telequipment Division, with Bob Groom as managing director, will remain at Southgate and the Tektronix Division, with Harry Sellers as managing director, will continue to operate from Harpenden.

Lyons Instruments Ltd, Hoddesdon, Herts, have been appointed exclusive U.K. representatives for Frequency Electronics Inc, of Long Island, New York, and their subsidiaries Atomichron Inc, and FKS Communications Inc. Frequency Electronics design and manufacture high-stability frequency standards, digital clocks, digital phase comparators, standard frequency distribution amplifiers and a range of high-stability crystal oscillators. Lyons Instruments have also been appointed exclusive U.K. representatives for TAU-TRON Inc, of Massachusetts. U.S.A., manufacturers of a range of data generators and digital signal generators.

Techmation Ltd, 58 Edgware Way, Edgware, Middx HA8 8JP, have been appointed sole agents in the U.K. and Eire for the range of silicon PIN photodiodes and light measuring instruments manufactured by United Detector Technology, of Santa Monica, California.

Data Recognition Ltd has appointed Teleprint GmbH of Frankfurt, as exclusive distributor in West Germany for their optical mark reading equipment and systems.

The newly formed Hitachi Sales (U.K.) Ltd, of 10th Floor, Winchester House, London Wall, London E.C.2, has announced the cessation of the exclusive U.K. distributorship of Hitachi radio receivers by Lee Products.

The electronics division of Union Carbide Ltd has agreed to sell to Solidev Ltd (the U.K. subsidiary of Solitron Devices Inc.) their semiconductor operation based at Aycliffe. Co. Durham.

GEC-Elliott Space and Weapon Systems Ltd, will in future be known as Marconi Space and Defence Systems Ltd.

Pye of Cambridge Ltd are to establish a marketing company, Pye Business Communications Ltd, to sell, hire and service a comprehensive range of audio and video products.

West Hyde Developments Ltd has moved to new works and sales offices at Ryefield Crescent. Northwood Hills. Northwood. Middx HA6 1NN. Tel: Northwood 24941/26732.

Flann Microwave Instruments Ltd, of Kingston-upon-Thames, Surrey, have moved to a new factory and laboratories at Dunmere Road, Bodmin, Cornwall. Tel: Bodmin 3161.

Hayden Laboratories Ltd, East House, Chiltern Avenue, Amersham, Bucks, have opened an audio equipment showroom, despatch and service department at 12/13 Poland Street, London W1V 3DE. Tel: 01-734 3748.

The communications division of Redifon Ltd, has developed a 100-W s.s.b. military radio station, and an order for the Royal Air Force, valued at £156,000 has been completed. The radio station is all solid-state and designed for mobile or transportable use.

Marconi Instruments Ltd has received an order valued at approximately £80,000 from the Post Office to supply pulse-code modulation test equipment. The order includes pattern generator and selective level measuring sets and regenerator testers.

The South African Post Office has placed an order with Plessey for the supply of eight 10-kW h.f. transmitters. The transmitters are self tuned and cover the frequency band 2-30MHz and are intended for point-to-point and ground-to-air operation.

The Marconi Aeronautical Division has been awarded a contract worth more than £250,000 by the Yugoslav Air Force for the installation of AD370 automatic direction finders.

F. C. Lane Electronics Ltd, has moved from Albion Road to Slinfold Lodge, Horsham, Sussex. Tel: Slinfold 661.

U.K. Solenoid Ltd, of Hungerford, Berkshire, manufacturers and distributors of Blue Line rotary switches have opened a London office at Bondway House, 3/9 Bondway, S.W.8. Tel: 01-735 8859.

The Tripletone Manufacturing Co. Ltd, has moved from 241a The Broadway to Factory No.1. 138 Kingston Road. Wimbledon. London S.W.19. Tel: 01-542 1189.

Farnell-Tandberg Ltd, has moved to Farnell House, 81 Kirkstall Road, Leeds LS3 1HR. Tel: Leeds 35111.

Mordaunt-Short Ltd, has moved from London, to The Courtyard, Heath Road, Petersfield, Hants. Tel: Petersfield 4761.

New Products at the I.E.A. Exhibition

The International Instruments, Electronics and Automation exhibition held at Olympia, London, from 11th-16th May attracted 950 exhibitors with more than 20% coming from overseas. In a statement at the close of the exhibition, chairman William Logan described it as "yet again a record breaker". He was referring to the overseas attendance figures which were 9,658. Total attendance was fractionally down on 1968 at 110,266. Opened officially by Mr. Anthony Wedgwood Benn, Minister of Technology, the show was looked to by British companies to give a boost to business in the electronics export trade. Computer manufacturers in particular, who boast a growing export output, had millions of pounds-worth of equipment on display. These were mostly medium or small size computers, in the £50,000-£120,000 cost bracket, designed for process and production control. Computer aided design was featured by many exhibitors.

A general feature of the many types of measuring instruments on display was their high order of accuracy, a requirement increasingly called for by industry. The demand too for professional class batteries to power the growing number of self-contained instruments and compact communications equipment was met by several exhibitors. Rechargeable batteries are in big demand and a German company was showing a conventional lead-acid accumulator in a form as versatile as an ordinary dry battery. It will also withstand gross ill-treatment. The widening use of electronics in medicine was evidenced by analytical equipment, and instruments for early warning of incipient tumours and high-speed blood sampling. Developments in devices and components for consumer use underlined the way industry is working towards cheaper and more reliable domestic colour receivers and transmitters. There were also several new materials such as self-lubricating plastics and new laminates for printed circuits.

Forty-five American companies with the backing of the U.S. Department of Commerce were combined in a large United States exhibit. Although most of these had contributed to the Apollo space programme. they were said to be taking a "hard sell" approach to the European market and were not engaged on a "national prestige" exercise. "The I.E.A. is a highly effective merchandising device," we were told by their organizers. So much was to be seen that to attempt a general survey of new equipment was far too intimidating. Instead, we have selected a few of the items which are likely to be of particular interest to our readers, brief details of which are given in the pages which follow.

Miniature Tape Recorder

The world's smallest two-hour tape recorder was the claim made by AIM Electronics for the feature exhibit on their stand. This miniature tape recorder combines many conventional recorder facilities, such as fast forward wind and fast and slow rewind, in a case measuring only 80.3 × 122.5 × 28 mm and weighing 468g. By means of a signal operated clip-on unit spasmodic readings can be recorded over a period as long as two years without attention. The recorder is particularly suitable for data collection in arduous environments or small places. It has a remote on/off switch and automatic switch-off when the tape runs out. Tape reels are 56mm in diameter and tape speed is 24mm/s ±3%. Frequency range is 300Hz to 3kHz; wow and flutter better than 1.2%. Input is via a 5kΩ microphone and normal speech can be recorded within a range of 6 metres. External connections are made via screw-in jacks. AIM Electronics Ltd, P.O. Box 10, Cambridge.

WW 328 for further details

Resistor Kit

Electrosil were showing their C3 resistor (the smallest glass-tin-oxide) in a designer's pack. The new kit, made in Perspex, measures 380 × 100 × 65 mm and contains 600 resistors in a range of 30 values from 10Ω to 150kΩ. The resistors are held in clearly labelled tubes making for simple selection of the required component. Electrosil Ltd, Pallion, Sunderland, Co. Durham.

WW 327 for further details

Measuring Amplifier, Filter and Frequency Analyser

Brüel & Kjaer, Denmark, has introduced a new series of measuring amplifiers and octave/third-octave filters. The system consists of the measuring amplifier type 2606, the octave/third-octave filters types 1614 and 1615, and the frequency analyser type 2113 which is a combination of the type 2606 and the type 1615. The measuring amplifier and the frequency analyser have a sensitivity of 10μV for full deflection. A new rectifier gives correct r.m.s. indication for signals with crest factors up to 40. Two indicators light up if the amplifiers are overloaded and allowable crest factor is exceeded. Interchangeable scales give direct reading of both sound and vibration levels with all B & K accelerometers and condenser microphones. An impulse measuring facility with maximum hold enables impulse sound measurements to be made to the proposed I.E.C. standards. All four weighting networks, A, B, C and D, are built-in. The two new bandpass filter sets, of which the 1615 is included in the analyser type 2113, also have new features. Frequency range for the type 1614 filter is from 2Hz to 160kHz and for the 1615 filter is from 22.4Hz to 22.4kHz. Both filter sets are in accordance with the I.E.C. 225-1966 and the U.S.A.S.I. S1.11-1966 class III filters. This means they have a very flat passband, within ±0.25dB; and a very high damping outside the passband, better than 75dB at 5.2 times the centre frequency. The filters below 200Hz are made as active

filters. All filters can be scanned automatically with the B & K level recorder type 2305 for automatic recording of sound-vibration and other spectrograms. B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middx.

WW 320 for further details

Digital-to-synchro Converter

Analogue servomechanisms using synchros may be controlled from digital computers, or other equipment producing pulses by means of a digital-to-synchro converter introduced by Moore Reed. The device accepts 11-bit binary number pulses, in serial or parallel form, representing the desired angular position of the synchro shaft. It converts each number, in a time of 20μs, to a three-phase synchro signal that is proportional to the digital input and is also related to the reference signal of the analogue servo system (50, 60 or 400Hz sinewave, 26 or 115V r.m.s.). Each binary increment represents approximately 10½ minutes of arc in shaft rotation. Digit pulse levels at the input: logic "1" is 5V; logic "0" is 0 to +0.5V.

The converter can be made available as a number of printed circuit cards for wiring into equipment, or as a complete chassis-mounted assembly already wired up and operating. Power supply lines required are +15V and −15V d.c., 1.2A each line. Moore Reed and Company Ltd, Walworth Industrial Estate, Andover, Hants.

WW 315 for further details

Super Megohmmeter

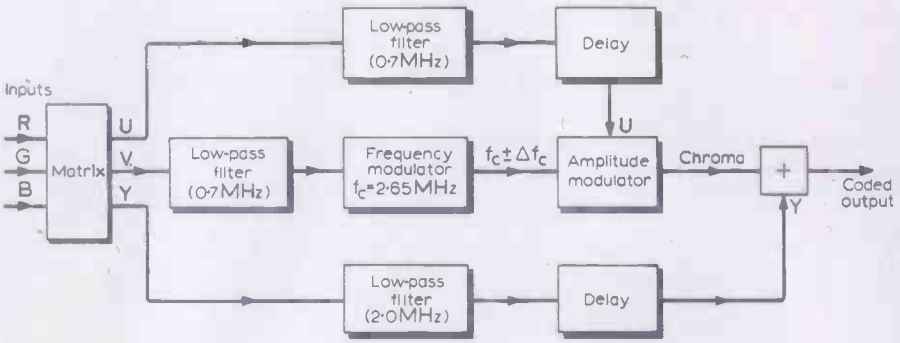
British Physical Laboratories were showing a super megohmmeter, model RM170, covering resistance values of from 500kΩ to 1000TΩ* at 500V test voltage in 17 ranges. It employs an amplifier with m.o.s-f.e.t. input and several i.cs and is produced in modular construction. Basic resistance range is 100kΩ-2MΩ at 100V test voltage with multipliers of ×3, ×10, ×30, × 100 . . . . × 10^8. The RM170 will read currents from 0-10pA to 0-1mA in 17 ranges. Here the basic range is 0-10pA (10^{-12}A). Test voltage is 5-500V d.c. and measurement time 100ms (>1nA or <0.5T at 500V) and 5s (<100pA or <5TΩ at 500V). A special feature is a built-in go/no-go lamp limit indication with an output voltage accessible for driving automated test systems. A selector switch enables earthed or unearthed samples to be measured. The instrument is fully protected against any overload that may occur as a result of use on incorrect range. Operation is from 110-125V or 200-250V 50/60 a.c. mains. Dimensions 330 × 210 ×140mm. British Physical Laboratories, Radlett, Herts.

WW306 for further details

*Teraohms (10^{12})

FAM Colour Adaptor

Readers will be familiar with the characteristics of PAL, N.T.S.C. and SECAM colour television systems but may know little of another system called FAM (frequency-amplitude modulation) which was developed by IRT, Munich, and was once a contender for the European broadcast standard. This system, however, has been adopted by Ampex for a colour adaptor developed by the company for use with their 1-in helical scan videotape recorders. The unit cost about £625 and its chief merit is that it will provide a colour facility on systems which are normally suitable for monochrome transmissions only because of bandwidth restrictions and poor phase response.



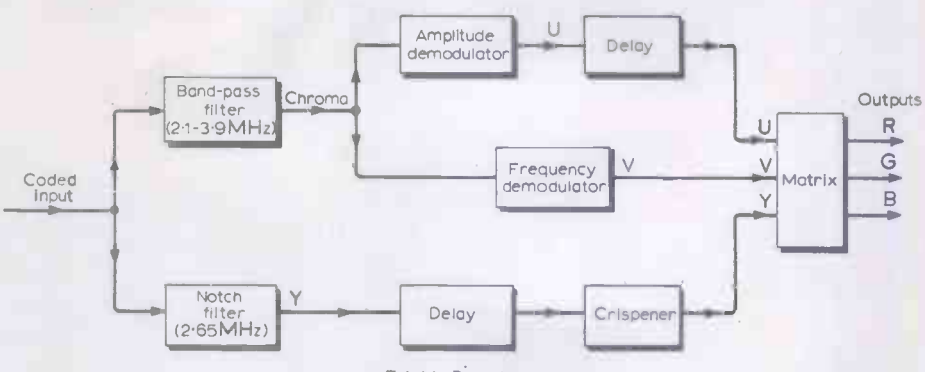
F.A.M. Coder

RGB signals entering the encoder are converted into a luminance signal *Y*, a red difference signal *V* (*R*-*Y*) and blue difference signal *U* (*B*-*Y*). Low-pass filters restrict the bandwidths to 2MHz for the *Y* signal and 0.7MHz for the *U* and *V* signals. The *V* signal is applied to a frequency modulator (centre frequency 2.65MHz) and the f.m. signal is then amplitude modulated by the *U* signal, and added to the luminance signal. The resulting coded signal occupies a total bandwidth of only 3MHz.

In the decoder no phase-sensitive circuits are required. The chrominance information is separated by a bandpass filter with 6dB points at 2.1 and 3.9MHz and is then applied to an f.m. detector and an a.m. detector recovering the respective *V* and *U* signals. Chrominance information is removed from the *Y* signal by a delay line notch filter with maximum attenuation at 2.65MHz, and the three signals (*Y*, *V* and *U*) are fed to a matrix producing *RCB* outputs. Because of the restricted luminance bandwidth, the loss in picture resolution is compensated by a crispening technique which enhances outline detail.

As supplied, the FAM colour adaptor is capable of working on 525/60 or 625/50 standards and synchronizing pulses of broadcast or industrial type without the need for switching or adjustment. It will accept *RCB* inputs with or without synchronizing pulses; with non-composite inputs, an external sync input is required. *RGB* outputs are composite only and an external sync output is provided. Unlike established systems, the FAM sub-carrier is not a function of the line frequency so that it is independent of line and field standards. Although the carrier frequency and bandwidth specifications have been chosen for the Ampex 1-in helical scan recorders, these standards can be varied to suit narrower or wider bandwidths, where available. The FAM encoded signal is not monochrome compatible. That is, an FAM recorded tape cannot be played through a b lack and white monitor. Ampex Great Britain Ltd, Acre Road, Reading, Berks. RG2 0QR.

WW 301 for further details



F.A.M. Decoder

Bright Display Tube

Included in a new range of c.r.ts on the M-O Valve stand was model 2800A, a

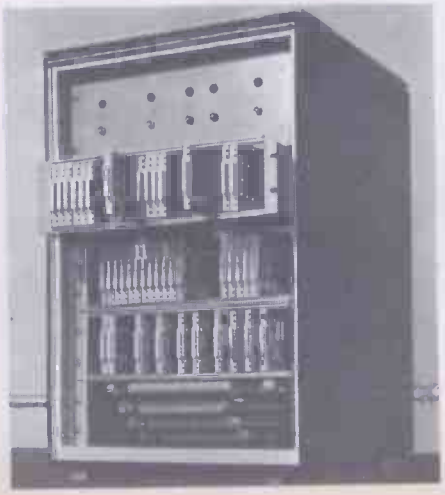
280mm diagonal data display tube operating at 8kV and using P39 phosphor to give a bright display down to 30Hz repetition rate. The manufacturers claim that the electron gun and focusing system design is capable of giving better resolution than conventional c.r.ts of similar size and brightness. The spot has a sharp edge due to non-gaussian distribution of electrons in the beam and resolution at the edge of the display is improved by a reduced beam diameter. This company was also showing several microwave products including a rugged, pulsed, low inter-line noise tunable X-Band magnetron with a rapid warm-up cathode. This was type E3320 which operates at a very low voltage—typically 8-900V and produces up to 300W peak power. The tuning range is ±25MHz. The M-O Valve Co. Ltd, Brook Green Works, London W.6.

WW310 for further details

Telemetry System for Process Control

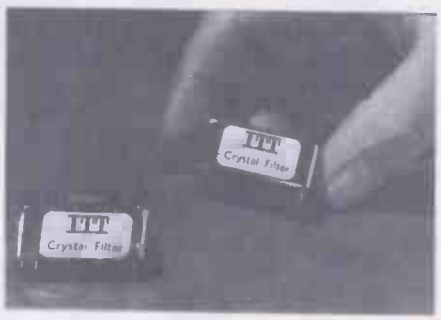
A fully comprehensive telemetry system for industrial data acquisition and remote supervisory control was given its first showing by Kent Instruments. Developed for applications such as petrochemical processing, public utilities and power generation, the telemetry system, designated Dataflex, is claimed to offer economy and flexibility through the use of modern modular components. It is compatible with all modern process control instrumentation and with Kent's K70 computer system. Described as a digital time-division multiplex system, Dataflex incorporates remote control, supervision and monitoring of physical variables between a central control position and up to 64 separate outstations. Each outstation will be basically identical having seven plug-in circuit boards and wired to take additional modules as required. The master station has similar plug-in modules. Information, event signals and commands can be transmitted over Post Office or private lines and u.h.f. radio links. The speed of the system can be 100, 200, 600, 1200 or 4800 bauds through data transmission modems or by direct injection into the transmission line via line drivers. Kent Instruments Ltd, Biscot Road, Luton, Beds.

WW 308 for further details



Monolithic Crystal Filters

Monolithic crystal filters with channel spacings of 50, 25, 20 and 12.5kHz available from ITT Components Group Europe at Harlow, offer 90dB stop-band discrimination. The common input and output impedance for all channel spacings is 910Ω in parallel with 25pF. The standard case sizes are 901 and 923.



The 923 case may be ordered with isolated earth or non-isolated earth as desired. ITT Components Group Europe, Quartz Crystal Product Division, Edinburgh Way, Harlow, Essex.

WW 317 for further details

Tunable Gunn-effect Oscillators

A Gunn-effect oscillator with an output power greater than 5mW and capable of being electronically tuned from 7 to 12.4GHz was shown by Microwave and Electronic Systems. The tuning is achieved by means of an yttrium-iron-garnet sphere magnetically biased to resonance, in which condition it is electrically equivalent to a shunt resonant circuit. There is an isolator on the output of the oscillator, allowing the oscillator to "look at" open- or short-circuited loads

without deterioration in performance. Other similar tunable oscillators available from the company have tuning ranges of 4-8GHz and 12-18GHz. Microwave and Electronic Systems Ltd, 66 Tilehurst Road, Reading, Berks. RG3 2LU.

WW 316 for further details

Industrial Semiconductors

New semiconductor devices exhibited by Mullard included four f.e.ts intended for switching applications and three dual-in-line packages containing four discrete transistors. Three of the f.e.ts, types BSV78-80, are n-channel devices that are electrically symmetrical and have very low "on" resistance and extremely high "off" resistance. Maximum drain-to-source voltage is 40V. The fourth, type BSV81, is a depletion-type, insulated-gate device in a metal envelope with the substrate connected internally to the case. Because of its very high "off" resistance (>10GΩ) it is particularly suitable in applications where extremely low leakage currents are important during the "off" periods. The three new multiple solid-state devices on display contained four transistors of the same type, matched for gain, within a 14-lead d.i.l. encapsulation. This facilitates the layout of printed boards designed for use with i.cs. The transistors are not interconnected and can be used as discrete components. The three devices are development types 272BC7, 273BSX and 274BC7. They contain four BC107, four BSX 19 and four BC177 transistors respectively.

Among piezoelectric material exhibited was a sonic detector type MB4013 which is intended for use in remote control systems operated by sound waves. It has a resonant frequency of 6kHz ±0.4kHz and a 3dB bandwidth of 80Hz (independent of load). Impedance is 7kΩ and capacitance at 100kHz >4,300pF. The MB4013 consists of a disc of PXE5 material mounted centrally on an aluminium diaphragm held by a zinc ring. Because, unlike other forms of sound detector, the

response is limited to a narrow frequency band, no extra stages are required to filter out signals at unwanted frequencies. The sonic detector is unaffected by moisture, large temperature changes or adjacent magnetic fields. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW309 for further details

Power Supplies

Coutant showed two new ranges of power supplies. The GP series of regulated a.c.-d.c. power supplies, comprises a total of 15 units. Within the range, models are available with fixed outputs of 6, 12, 18 or 24V. This series includes various models with current ratings of 2 to 10A in the 6V range and 1 to 10A in the other three voltage ranges; its three physical sizes (which depend on the rating required) are all based on BS 4318 metric preference dimensions. Other principal specifications for the GP series are a

line regulation of 0.01%+1mV; load regulation of 0.03%+3mV (0 to full load); 1.5mV ripple voltage; re-entrant protection; input a.c. voltages of 220 or 240V a.c. ±10%, with a frequency range of 45 to 400Hz; a temperature coefficient of 0.02%+2mV per °C; and nominal d.c. outputs variable ±10%.

Coutant's other new power supply range—the BPS—is an unregulated series offering four voltage ranges (6, 12, 24 and 48V) at 2, 5 and 10A. Like the GPs, they are available in sizes based on BS 4318, and will operate from an a.c. mains input of 220 or 240V ±10%; regulation is 20% for a 10 to 100% load variation; ripple is 2V r.m.s., and the ambient operating temperature range is 0 to 55°C. Coutant Electronics Ltd, 3 Trafford Road, Reading RG1 8JR.
WW 321 for further details

Digital Voltmeter

From Bradley, a small size high performance digital voltmeter, type 173, will measure from 100 μV to 1000V d.c. in four ranges. An additional ×4 range reads down to 25 μV, whilst the provision of a 50% over-range facility extends the

maximum reading to 1500V. Common mode rejection is typically 140dB at line frequency. The accuracy is ±0.01% of reading ± 1 digit and the instrument is calibrated by using an unsaturated standard cell as an internal reference. Automatic indication of polarity is incorporated as standard, and display storage is provided to eliminate flicker. 1-2-4-8 coded data output is avilable at the rear panel. The price complete is £340. G & E Bradley Ltd, Electrical House, Neasden Lane, London N.W.10.
WW 318 for further details

Calibration Sound Source

A pocket-size instrument which produces a standard sound level for calibrating sound level measuring instruments has been introduced in the U.K. by B & K Laboratories. Made by Brüel & Kjaer (Denmark), it generates a sound level of 94dB (this being a dynamic pressure of 1N/m² in SI units) at a frequency of 1kHz. The calibrator uses a piezo-electric transducer driving a diaphragm which creates the standard pressure level in a coupler chamber. Behind the diaphragm is a Helmholtz resonator which gives the system an equivalent coupler volume of more than 200cm³ at its resonant frequency. Driving the system at this frequency therefore results in low distortion and makes the generated sound pressure independent of both the static pressure and the equivalent volume of the microphone to be calibrated. B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middx.
WW 314 for further details

Distortion Factor Meter

Distortion factor meter type DM344 by Sign Electronics Ltd, was being shown on the Aveley Electric stand. This is an instrument comprising two basic sections, a filter and a voltmeter, designed to measure total harmonic distortion in high quality audio amplifiers, recording and transmission equipment. The filter is used to remove the fundamental component of the signal and the voltmeter to measure the residual harmonic components, and to establish the initial reference level. Frequency range is 20Hz-20kHz for fundamental in six third-decade bands. Fundamental attenuation is >80dB and second harmonic <0.5dB. The harmonic bandwidth is 100kHz. The instrument residual distortion is <0.1% from 10Hz to 10kHz. Input impedance is 10kΩ/V or 600Ω, overload protected to 100V. Aveley Electric Ltd, South Ockendon, Essex.
WW 302 for further details

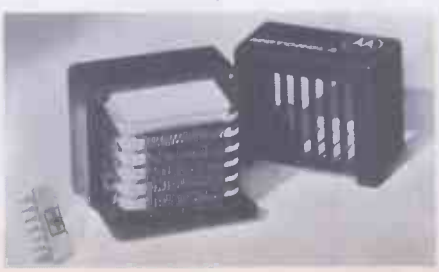
Reference Unit for Lock-in Amplifiers

Lock-in amplifiers, which are signal-recovery devices working on the synchronous detector principle, require a local reference source of oscillation which can be adjusted in frequency and phase. Brookdeal Electronics have produced an instrument called Reference Unit Type 422 which takes an input signal of any wave-shape (frequency range 1Hz to 1MHz), uses it to generate a square-wave output (+3V from 100Ω impedance) and provides means for adjusting the phase of this output signal,

relative to the input signal, in various ways. For example, there are two outputs available, one 90° phase-advanced on the other. Control of phase can be: 0 to 100° variable; 0 or 90° switched; 0 or 180° switched. In addition phase shift may be controlled by an external programming voltage: +1V to −1V gives +90° to −90°. The input level range is 10mV to 100V (pk) and the input impedance is greater than 10kΩ. Brookdeal Electronics Ltd, 1 Market Street, Bracknell, Berks.
WW 313 for further details

Semiconductor Random-access Memory

Full semiconductor memories for computers are possible utilizing a new device launched by Motorola. This was a mono-



lithic high-speed random access memory with an 8192-bit capacity. Constructed with l.s.i. techniques, the module combines the low power of p-channel m.o.s. flip-flops for the storage array with the high operating speed of bipolar transistors for the address decoding, word drive sense and digit drive circuits. No complicated tuning is necessary to operate the module which can be cycled every 100ns. Interface to and from other circuitry is performed at emitter-coupled logic current levels for high speed. It can be easily interfaced to saturated-logic levels with the use of additional interface devices. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx.

WW 311 for further details

Transducer Read-out Unit

Designed primarily for use with their T500 series pressure transducers, Southern Instruments introduced a readout unit type M1861. This displays an output voltage on a panel meter which varies

proportionally to input pressure. The meter can be scaled directly in pressure units and the unit sensitivity can be set to suit any transducer without the need for system calibration. A crystal-controlled reference frequency gives good zero stability and an adjustable reference voltage is provided. Zero drift is less than 0.03% f.s.d./°C. Other characteristics include: linearity ±1%, noise level less than 25mV p-p at output, frequency response better than 0-500Hz (−3dB). Voltage output is 0-10V, output resistance <1Ω. A connection is provided to allow marker pulses to be added into the amplifier output. U.K. price of model 1861 is £96. It measures 200 × 290 × 102mm and weighs 1.6kg. Operation can be from 100/125 or 200/250V, 50-65Hz mains supplies. Southern Instruments Ltd, Frimley Road, Camberley, Surrey.

WW 307 for further details

Computing Counter

One of a new series of digital instruments shown by Racal was a computing counter, model 9521. Of half-rack-width dimensions and incorporating t.t.l. integrated circuits, it has a timebase variable in 100-μs steps from 100μs to 10s. This facilitates direct indication of speed, ratio, time interval etc, on the four-digit display. The com-

puting counter is expected to find wide application in the process control industry where it can provide accurate indication of gallons per minute, r.p.m. or similar parameters. Capabilities include frequency measurement (5Hz-10MHz) on either of two channels, frequency ratio, time interval and totalize. Racal Instruments Ltd, Duke Street, Windsor, Berks.

WW 303 for further information

Modular System for Counting, Storing and Display

For designers of control consoles and panels who need a "building block" system which will relieve them of logic design responsibility, and which does not require rack-mounted hardware, Contraves were showing the Codicount system. This provides ten variations in a module 22mm wide x 33mm high, dimensionally compatible with the new Multiswitch which is used for preselection of constants such as factors and datum levels. Codicount modules employ i.cs, ensuring short transmission lines. Good frequency response, high reliability and freedom from noise problems is claimed. The logic supply terminal, on each module, is decoupled from line noise by a tantalum capacitor. The circuit components will operate at frequencies well in excess of the module rating of 5MHz giving an assured safety margin. Function permutations vary from read-out display with decimal input, to bi-directional counter with memory and read-out, or without read-out. Supply voltages required are +5V for the logic system at 21-105mA depending on the module type, and +250V at 2.2mA for the read-out tube. The Multiswitch, which is compatible dimensionally with the Codicount, is based on five new types in the existing miniature range. Innovations include improved readability and an enclosure for logic components. Contraves Industrial Products Ltd, Times House, Station Approach, Ruislip, Middx.

WW322 for further details

Variable Filter

A new solid-state variable filter instrument, model EF2, was shown by Barr & Stroud. This contains two independent low- and high-pass filter channels and it has a frequency range of 0.1Hz–100kHz in five decades. Attenuation slope can be 36 or 72dB/octave and maximum attenuation 75dB. Bandpass, band stop or band separation functions are selected by switch. Operation is from an integral power supply or external batteries and the output is short-circuit protected. Barr & Stroud Ltd, Caxton Street, Anniesland, Glasgow W.3.

WW 312 for further details

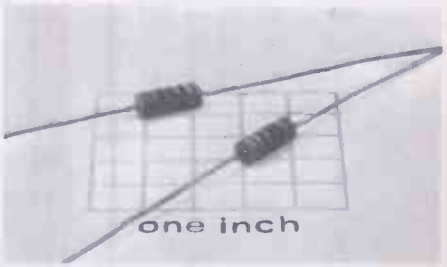
Micro-miniature Potentiometers

Among several new types of potentiometer introduced at the Show by Painton was the 3260 which is only 6.35mm square and has a power rating of 0.2W at 70°C. It is available in a range of eleven values from 10Ω to 20kΩ, and in two configurations —for side adjustment and top adjustment. Nominal resolution of a 100Ω potentiometer is 0.82% and of a 5kΩ device 0.30%. Painton & Co. Ltd., Kingsthorpe, Northampton.

WW324 for further details

Sub-miniature Choke

A sub-miniature choke, type 550-3399, from Cambion is only 0.25in long × 0.095in in diameter, but offers a continuous range of inductance values from 0.1 to 1000μH in 49 discrete steps. Cambion



Electronic Products Ltd., Cambion Works, Castleton, Near Sheffield.

WW 319 for further details

Carrier Servo Generator

Newcomers to the I.E.A. exhibition, Prosser Scientific Instruments used the occasion to announce their A103 carrier servo generator. This instrument is based on the previous A100 waveform generator and is intended for a.c. and d.c. servo and system measurements. It provides a two-phase carrier modulated output and is available with either manual or automatic control of phase and frequency. The instrument can also be used as a multiple output function generator for sine, square, ramp and triangle waveforms. Frequency range is 0.0008Hz to 200kHz and output voltage ±10V peak (maximum). The attenuator has a switched range of 0-10, 20, 30 . . . 60dB with fine control between 20-100% of switched amplitude. Phase is +280 to −100° on variable phase output, +90° on auxiliary output and 0° on main output. Cost of the A103 is £615. It is illustrated at the top of the page. Prosser Scientific Instruments Ltd, Lady Lane Industrial Estate, Hadleigh, Ipswich, Suffolk.

WW326 for further details

Portable A.F. Power Meter

Dymar were showing their new portable a.f. power meter type 585. This comprises the basic meter unit, common to all Dymar instruments, and a plug-in circuit module. A wide power-measuring range is provided in the frequency range 30Hz-30kHz. High accuracy of the terminating impedance and measured power is claimed. Twelve power ranges in 1, 3, 10 sequence give f.s.d. readings from 100μ W to 30W and an auxiliary scale allows direct readings in dBm (0dBm = 1mW) from −20 to +45dBm. A temperature-compensated "square law" detector gives a true power reading irrespective of waveform, particularly useful for accurate measurement of noise. There is a choice of 30 input impedances arranged in 3 decades from 1.25Ω to 1,000 Ω each capable of dissipating 50W with an accuracy of 2%. The 585 is battery-operated and weighs 6kg. An illustration of the Dymar common meter unit, fitted in this case with modulation meter type 765, appears at the foot of the page, left. Dymar Electronics Ltd, Colonial Way, Radlett Road, Watford, Herts.

WW325 for further details

Digital Multimeter

Solartron are aiming at the mass market for the first time with a digital multimeter,

type LM1240. The new instrument has 26 ranges and is capable of measuring a.c. and d.c. voltage and current, and resistance. It is priced at £195 and is claimed to incorporate features regarded as standard in high-priced d.v.ms. These include automatic polarity, high input resistance, an integration technique to eliminate noise, fully isolated input, overload protection and the option of mains or battery operation. By comparison with the traditional analogue meter the LM1240 offers improved accuracy, ease of reading both polarities, and input resistance defined in megohms rather than ohms per volt. The Solartron Electronic Group Ltd, Farnborough, Hants.

WW 305 for further details

Economy S.C.R.

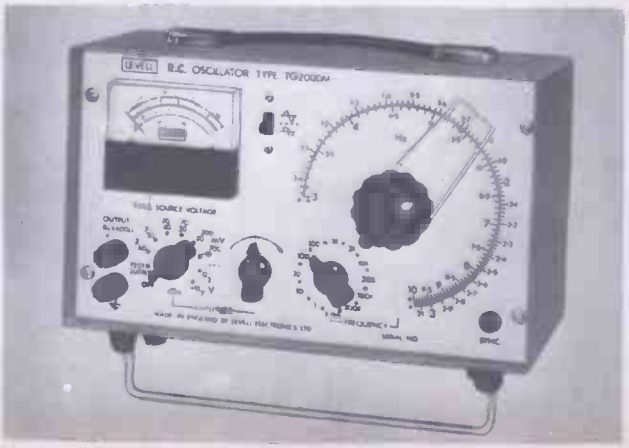
A low-cost s.c.r. designed for use in consumer electronics was shown by Transitron. This is a 4-A type, housed in four alternative plastics flat packs, available in the voltage range 15-400V. Peak forward current of 75A at 75° C is featured. It is designated TC106. Transitron Electronic Ltd, Gardner Road, Maidenhead. Berks.

WW323 for further details

Wide-range Oscillators

A series of oscillators, TG200 series, that cover 1Hz to 1MHz in twelve ranges were introduced by Levell Electronics. Versions are available that generate sine and square waves or sine waves only. Output is variable from 200μV to 7V r.m.s. by a variable control and switched attenuator with 10dB steps up to 70dB. Output impedance is 600Ω at all settings. The circuit uses a single-track linear potentiometer giving frequency control with absence of amplitude bounce, characteristic of Wien bridge circuit with dual-track controls. Amplitude variation is less than ±1% up to 300kHz. Rise time on square waves is less than 150ns at all frequencies. Harmonic content on sine waves is less than 0.1% up to 5V output from 10Hz to 100kHz. Power supply can be from four PP9 batteries or a.c. mains if power unit is fitted. Dimensions of the TG200 are 180 × 250 × 140mm, and weight 4.5kg. It is illustrated below. Levell Electronics Ltd, Park Road, High Barnet, Herts.

WW304 for further details



World of Amateur Radio

Pressure on v.h.f./u.h.f. bands

Further evidence of the mounting pressure being applied by mobile radio interests in efforts to take over amateur sections of the v.h.f. and u.h.f. bands is provided in the recently published annual report (1969) of the Electronic Engineering Association. The section reporting the current activities of the E.E.A. Radio Communications Division contains the following passage: "The lack of spectrum space continues to be seen as the most likely factor which could seriously limit the expansion of mobile radio communications. Negotiations have therefore now begun with the Ministry of Posts and Telecommunications to secure use of the 68 to 71.5 MHz and 420 to 450 MHz bands."

While most amateurs appreciate the increasing demands being made to secure maximum use of all frequencies in this part of the radio spectrum, most will note with considerable concern and regret that the E.E.A. claim includes the entire amateur 4-metre and 70-cm bands (currently 70.025 to 70.7 MHz, and 425 to 450 MHz with a gap from 429 to 432 MHz). Amateurs may thus regard this claim in the nature of a test case in which the outcome may well indicate the future intentions of Minpostel towards amateur frequency allocations. Some may suspect, however, that by putting in claims of this magnitude, the mobile radio industry is aiming primarily at the upper portion of the 70-cm band, with many amateurs seeing the section 440 to 450 MHz at particular risk.

Old timers

Among the many associations and groups of radio amateurs having local or special interests, a few have come to occupy a highly respected role. Undoubtedly one of these is the Radio Amateur Old Timers' Association which was formed some 17 years ago.

The object of R.A.O.T.A. is to maintain and foster a spirit of friendship among amateur transmitters of long standing, and to be mindful of any who may be in special need. Membership is open to all transmitting amateurs who were licensed, with either a radiating or artificial aerial licence, before September 1939, and who currently hold a British transmitting licence. Membership is limited to 300; at present it is about 50 below this figure. The membership fee is £1 1s. Applications may be sent to the honorary secretary, Miss May Gadsden, 79 New River Crescent, London N.13.

President of R.A.O.T.A. is Kenneth Alford, G2DX, whose amateur radio activities stretch back to the pre-World War I era; a 1914 issue of *Wireless World* described the four-wire cage aerial, high-speed mercury turbine "break", his nine Leyden jars and the three "jiggers" with which he could work distances of over 10 miles.

On the h.f. bands

Despite the falling off of maximum usable frequencies due to the approach of summer conditions, plenty of West Coast American, Canadian and Mexican stations have been coming through in the early mornings at good strength and can be worked with simple vertical and dipole aerials. Recent contacts, for example, have been with VU5XX Andaman Islands, 7Q7AA Malawi, UAoYT and JT1AH both in the usually rare Zone 23, SM6CNS maritime mobile in the Mozambique Channel and similarly SM5CTU/MM a Swedish ship off the west coast of Central America. Among the rarer calls heard on 14 MHz c.w. have been DU1OR near Manila, YA2HWI/1 Kabul, Afghanistan, UA1KED Franz Josef Land, and PJ2PS near Curacao. King Hussein, who operates on 28 MHz phone from Amman with the callsign JY1 is known to have worked British amateurs recently. The Thor Heyendahl expedition on the raft *Ra II* is again using the callsign LI2B (s.s.b. on 14214 kHz).

V.H.F. activities

For the first time, a two-way link has been established on 144 MHz between the U.K. and Iceland. John Stace, G3CCH, of Scunthorpe, Lincolnshire, made contact, via meteor scatter, with Finar Palsson, TF3EA, over a distance of about 1100 miles, during the Aquarids meteor shower in early May. Another widespread auroral opening occurred both in Europe and North America on April 21st-22nd. The 70-cm beacon station, GB3SC, is now operating with aerials mounted 300 ft up the B.B.C. Sutton Coldfield mast. One aerial beams north, another towards the south-south-east. The station uses frequency shift keying on 433.5 MHz to a 24-hour schedule. The Rhodesian beacon station, ZE2AZE, is similarly running continuously on 69.998 MHz from a site over 4000 ft above sea level, with just over 20-watts input to a four-element Yagi.

World DX Club conference

The annual conference of the World DX Club takes place over the weekend July 3rd to 5th at the Adelphi Hotel, Micklegate, Yorkshire. During this period the conference station GB2WDX will be in operation. Although this is primarily a club for broadcast-band short-wave listeners, it includes an active amateur radio section.

In Brief: Licences figures to the end of March show that in five months, Class B licences have risen by 187 to 2084 compared with an increase of 73 in Class A licences to 13486. With one additional amateur TV licence (180), U.K. amateur licences (excluding mobile permits) totalled 15,750 . . . Derby and District Amateur Radio Society is holding a mobile rally on August 16th at Rykneld School, Bedford Street, Derby (details T. Darn, G3FGY, "Sandham Lodge", Sandham Lane, Ripley, Derby) . . . The A.R.M.S. mobile rally, announced for July 5th at Alconbury, has been cancelled . . . . The Stourbridge society, in collaboration with the management of the narrow-gauge Welshpool and Llanfair railway are setting up, on July 4th, an amateur station, GW6OI/P, at the Llanfair Caereinion terminal; this will operate during the afternoon mainly on 3.5 MHz . . . . GB3WRA will be set up again this year at the 24th annual High Wycombe show on the Rye on September 5th, operating in all bands from 1.8 to 28 MHz (details A. C. Butcher, G3FSN, 70, Hughenden Avenue, High Wycombe, Bucks.) . . . . When Senator Barry Goldwater, K7UGA, visited Vietnam he left behind slow-scan TV equipment which has been used from Cam Ranh Bay on the U.S. military-affiliate radio system frequency of 19.2 MHz to transmit pictures back to Senator Goldwater's MARS station AF7UGA in Pheonix . . . . George Grammer, W1DF, who joined A.R.R.L. staff in 1929 and has been technical editor of *QST* since 1939, has recently retired. Doug De Maw, W1CER/W8HHS, has been appointed acting technical editor. He has strong "family connections" with amateur radio, apart from his own two callsigns his wife is W1CKK and his son WN1LZQ . . . . Contests for home-constructed equipment will again be a feature of the R.S.G.B. Show which this year is being held from August 19th to 22nd, in the New Horticultural Hall, London.

PAT HAWKER, G3VA

Literature Received

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

ACTIVE DEVICES

"Designers Guide" gives pin connections and loading rules for the series 54/74 t.t.l. integrated circuits produced by Transitron Electronic Ltd, Gardner Rd, Maidenhead WW401
Price list for above range WW402

The 54/74 range of t.t.l. is also the subject of a 29-page catalogue from Fairchild Semiconductor Ltd, Kingmaker House, Station Rd, New Barnet, Herts. Performance data and other relevant details are given WW403
Price list for above range. WW404

"Integrated Circuits t.t.l. series (TL. . . . 74N)" is a 119-page booklet giving pin connections, loading rules, performance data, and application information on the 74 series t.t.l. integrated circuits available from AEG-Telefunken, Fachbereich Halbleiter Vertrieb, 71 Heilbronn, Postfach 1042, West Germany WW405

The 1970 edition of the ever popular "Mullard Data Book" is available. It lists valves, semiconductors, television tubes and other components. The price is 4s to individuals outside the radio and television trade. It may be obtained from bookshops and component dealers.

We have received a batch of data sheets from Brimar, Thorn Radio Valves and Tubes Ltd, 7 Soho Square, London, W1V 6DN.

D14-170GH. 10 × 8cm oscilloscope tube. WW406
"GV Screen for Data Display and Radar". Very long persistance phosphor WW407
D14-180GH, 10 × 8cm oscilloscope tube. WW408
"Monoscopes". Character generating tubes—gives some application information. WW409
M38-100GH, -100W, -101GH, -111GH, 38cm data display/monitor tubes. WW410
D13-600GH, 13.3cm oscilloscope tube. WW411

An equivalents chart for Vidicon camera tubes is available from E.M.I. Electronics Ltd, Hayes, Middlesex WW412

The range of potted amplifiers produced by Ancom Ltd, Devonshire St, Cheltenham, GL50 3LT, are the subject of a leaflet; all the significant characteristics are given WW413

"Application Report No. 5" from Brookdeal Electronics Ltd, Market St, Bracknell, Berks, deals with the automatic measurement of semiconductor junction capacitance WW414

"Data Distribution No. 6" contains a number of leaflets for insertion in the Ferranti Microspot Cathode Ray Tubes and Display Equipment Manual. Ferranti Ltd, Gem Mill, Chadderton, Oldham, Lancs WW415

"Issue 15" from AEI Semiconductors, Carholme Rd, Lincoln, contains data sheets for inclusion in the AEI Semiconductors Technical Data Handbook. WW416

We have received the following literature from Westinghouse Brake and Signal Co. Ltd., 82 York Way, Kings Cross, London N.1.

Engineering publication D/WB "Silicon Diodes". Low, medium and high power. WW417
Technical publication T17. "Thyristor type 17TX, 16A". WW418
Technical publication T20. "Thyristor type 20TX, 20A". WW419
Technical publication 36-113. "Power transistor type 2N3054". WW420
Technical publication 36-114. "Power transistors, type 2N3371-3". WW421

PASSIVE COMPONENTS

Termiswitches are rail mounted terminal units which incorporate a relay—they are described in a leaflet from Lion Systems Developments (Gerrards Cross) Ltd, 45/47 Station Rd, Gerrards Cross, Bucks WW422

A catalogue from Fairchild Controls, 225 Park Ave, Hicksville, L.I., New York 11802, U.S.A., describes a range of trimming potentiometers WW423

"Siemens Electronic Components Bulletin, 2-70" contains articles on the demagnetization of colour tubes using p.t.c. resistors, pulse transformers, a surge voltage protector, miniature switches, low-speed logic etc. It is available from Cole Electronics Ltd, Lansdowne Rd, Croydon CR9 2HB WW424

We have received the following literature from Erie Electronics Ltd, South Denes, Great Yarmouth, Norfolk, which is intended for inclusion in the Erie catalogue:

PCF/5, metallized film capacitors, polycarbonate series PE31A. WW425
PCF/4, metallized film capacitors, "Metalmac" series ML30A. WW426
EC/6, aluminium electrolytic capacitors, 201 series. WW427

Mullard have produced a wall chart (36 × 26 inches) dealing with their electrolytic, film and variable capacitors. Copies of the chart can be obtained from A. Stewart, I.E.D., Mullard Ltd, Torrington Place, London, WC1E 7HD WW428

A triple-sheet wall chart (20 × 22 inches) has been prepared by Ultra Electronics (Components) Ltd, Fassetts Rd, Loudwater, Bucks. From this it is possible to select a variety of wafer switches. WW429

EQUIPMENT

An interesting self-powered tachometer system (0 to 500, 1,000, 2,000, 5,000, 10,000 or 20,000 r.p.m.) requiring no mechanical link to the shaft being monitored is described in a leaflet from the Dynalco Corporation, 4107 N.E. 6th Avenue, Ft Lauderdale, Florida 33308, U.S.A. WW430

A four-terminal resistance bridge (type K.B.5) is the subject of a leaflet from the Croydon Precision Instrument Company, Hampton Rd, Croydon, CR9 2RU. It covers 0 to 111, 110 Ω with five decade dials and incorporates eight switch-selected standard resistors WW431

A capacitor-discharge ignition system is described in a leaflet obtainable from Argent Electronics Company, 805 Kam Chung Building, 54 Jaffe Rd, Hong Kong. WW432

Nuclear Enterprises Ltd, Bath Rd, Beenham, Reading, have prepared a 129-page catalogue which lists a huge range of electronic and scientific test and measuring apparatus WW433

A decade resistance box, amplifiers, various oscillators and other measuring equipment are described in the catalogue of Levell Electronics Ltd, Park Rd, High Barnet, Herts WW434

A 47-page catalogue devoted entirely to power supplies is available from Lambda Electronics, Marshlands Rd, Farlington, Portsmouth PO6 1ST WW435

We have received the following leaflets from Sivers Lab, Old Haverhill Rd, Little Wratting, Suffolk.

PM7512, Coaxial video detectors, 2-18GHz. WW436
PM7550, Coaxial switches d.c. -18GHz. WW437
PM7101X, Rotary vane attenuator, 0-60dB. 8.2-12.4GHz. WW438

The following data sheets dealing with lasers have been received from Ferranti Ltd, Dunsinane Ave, Dundee. Scotland.

DDF/501/370. Argon Laser Type 200 ..... WW447
DDF/502/370. High-power CO_2 laser WW448
DDF/503/370. CO_2 laser powermeter WW449

HARDWARE

"Helpful Hints on Threaded Fastenings" is the title of a 52-page booklet which is produced by Firth Cleveland Fastenings Ltd. It sets out the basic engineering facts and figures that determine the best choice of fastener type, grade and size for a particular application WW439

"Southern's Tool Catalogue", complete with price list, lists a wide variety of tools for electronic and other purposes. Southern Watch and Clock Supplies Ltd, Industrial Tool Division, Precista House, 48-56 High St, Orpington, Kent, BR6 0JH WW440

Cabinets for housing printed circuit cards are described in a revised catalogue from the Elco Corporation, Willow Grove, Pennsylvania, 19090, U.S.A. It lists 32 standard models which are made in aluminium WW444

A booklet called "PTFE/polyester glass fibre insulators for power transmission" is available from I.C.I., Plastics Division, P.O. Box No. 6, Bessemer Rd, Welwyn Garden City, Herts WW445

Also from I.C.I. a booklet called "Better cleaning the I.C.I. way" which discusses industrial cleaning products and solvents. I.C.I. Mond Division, Thames House North, Millbank, London S.W.1 ..... WW446

GENERAL INFORMATION

The following information is available from the International Telecommunication Union, Place des Nations, Geneva, Switzerland.

Wall chart describing the organization of the Union and the Consultative Committees. WW441
Eighth report by the International Telecommunication Union of telecommunications and the peaceful uses of outer space WW442

If you are interested in the performance of nickel/cadmium batteries a new technical bulletin published by the Marketing Services dept, Power Sources Division, Alkaline Batteries Ltd (P.O. Box No. 4, Redditch, Worcs) will be of value. It deals with sealed cells of the sintered plate cylindrical type WW443

The latest book in the "Circuit Concepts series" from Tektronix U.K. Ltd, Beaverton House, P.O. Box 69, Harpendon, Herts, is called "Sampling Oscilloscope Circuits". The price is 10s per copy including postage.

B.S.1568, Part 1:1970, "Specification for Magnetic Tape Recording Equipment" may be obtained from the British Standards Institution, 2 Park St, London W.1. ..... Price 14s each

Personalities

Stuart Sansom, M.I.E.R.E., chief engineer of Thames Television (formerly ABC Television) since 1966, has become technical controller. He will be responsible for all technical and engineering facilities of the company (which provides the weekday programmes for the London I.T.A. station) at Teddington, Hanworth & Euston studios. Mr. Sansom, who is 40, spent two years with the Royal Corps of Signals and then joined E.M.I. to continue his technical training, moving to High Definition Films in 1953. Four years later he joined T.W.W., the South Wales I.T.A. programme company, as a vision engineer, afterwards taking charge of electronic maintenance. He joined ABC Television Ltd, as head of engineering equipment group in 1959.

J. C. Akerman, head of Mullard's Consumer Electronics Division, has been appointed a director of the company. Mr. Akerman, who is 52, joined Mullard in 1936. After six years' wartime service with the R.A.F. he was made assistant sales manager of the company's Radio Sales Department. He transferred to the Setmaker Department in 1950 and was appointed product manager for cathode-ray tubes three years later. In 1966 he moved to the Industrial Electronics Division as commercial product manager for semiconductor components and subsequently became a director of Associated Semiconductor Manufacturers Ltd—the company responsible for the development and production of Mullard semiconductor devices. He was appointed to his present post in 1969. He is vice-chairman of the British Radio Valve Manufacturers' Association.

J. C. Akerman

G. H. Sturge, M.I.E.R.E., who joined the B.B.C. in 1962, has been appointed assistant head of the Engineering Information Department in succession to **H. T. Greatorex,** B.Sc.(Eng.), who has retired. Mr. Sturge trained as an electrical engineer at Faraday House and from 1946 to 1962 held posts in the service, export and distribution departments of Murphy Radio Ltd. He joined the B.B.C. as an assistant to the Engineering Recruitment Officer and since 1967 he has been head of the engineering section of the Grading Department, with responsibility for the application of job evaluation to technical staff. Mr. Greatorex, who is retiring after 37 years' service, graduated at the City and Guilds College, London, and joined the B.B.C. as an assistant maintenance engineer. In 1935 he went into what is now the Engineering Information Department, of which he has been assistant head for the last 16 years. During this time his responsibilities have included the organization and management of the B.B.C. technical enquiry stands at exhibitions and conferences.

Brian Shone, head of the systems development unit in the B.B.C's Transmitter Planning and Installation Department has received the Royal Television Society's Geoffrey Parr award for his pioneering work in the design and development of a four-channel combining unit. This system has made it technically possible to use common transmitting aerials for high- and low-power u.h.f. stations.

Stephen Cox, a post-graduate research assistant in the department of electrical and electronic engineering at Plymouth Polytechnic, has won the 1970 Baird Travelling Scholarship of the Royal Television Society. The award, valued at £500 and financed by Radio Rentals, will be used by him to visit North America in order to gain experience in the theory and practice of educational television production. Mr. Cox is studying the relation of colour to learning in education TV and hopes to present his Doctoral Thesis at Exeter University in 1972/1973.

Denzil Bradbury has joined Brookdeal Electronics Ltd as senior designer at their factory in Market Street, Bracknell. Mr. Bradbury joined Hirst Electronic Developments as an improver in 1946 and, after National Service, was with Sperry Gyroscope from 1950-1960. Since then he has undertaken contract work as a design engineer, including projects for Decca Electronics, Nuclear Enterprises and Taylor Electronics.

Denzil Bradbury

Decca Radio & Television Ltd have announced two appointments in the audio field. **P. B. Cooper,** who is appointed commercial manager (audio) has been associated with Decca for over 20 years and has latterly been manager of special products. He will retain responsibility for this Division in his new post while at the same time extending his sphere of activity to cover all audio products: radio receivers, radiograms, test apparatus and the Deccasound audio systems. **Peter Earthy,** who joined the company in 1965, has become audio development manager.

Charles Dain has joined the Electron Tube and Microelectronics Division of EMI Electronics Ltd as facilities director. He will be responsible for all production facilities throughout the Division and for the manufacture of all established product lines. This will include responsibility for factories; and product operations including camera-tubes and c.r.ts, non-scanning photoelectric devices and microelectronics. Mr. Dain was previously in the Automation Division.

D. F. Downie has been appointed product manager of the newly formed Computer Peripherals Division at S.E. Laboratories (Engineering) Ltd (part of the EMI Group). Mr. Downie was previously in the EMI Central Research Laboratories, where he managed the development of the new S.E. Labs. alpha-numeric display terminal.

Ted Tingay, who joined Guest International Ltd two years ago, has become marketing manager with the Industrial Electronic Components Division. He has latterly been product promotion manager. Before joining Guest Mr. Tingay was with Ether Ltd, of Stevenage, for one year as a sales engineer and prior to that spent 12 years with Thorn Electrical Industries Ltd as a development engineer.

Dr. P. Feltham, formerly Reader in the Physics Department of Brunel University, Uxbridge, Middx. has been appointed to a new Chair of Applied Physics at the University. He is known internationally for his work in the field of metal physics and semiconductors.

Jack R. Piddington, O.B.E., M.C., has joined Electronic Facilities Design Ltd, electronics consultants and systems designers of Wargrave, Berks, as chief executive. He was formerly assistant director of electronics research and development (telecommunications) at the Ministry of Aviation.

OBITUARY

John Alexander Ward, chief engineer of Data Recognition Ltd, died recently at the age of 32. He began his career with Solartron Ltd, where he was one of the small team of British pioneers working on the development of document reading machines. He later joined Montague Burton Ltd as the senior engineer in charge of the operation and further development of their optical mark reading equipment. He joined Data Recognition when it was founded in December 1966 and was responsible for all the electronic and logic circuit design for the company's OMR systems and equipment.

Real & Imaginary

by Vector

Off the record

There are two schools of thought about birds—the feathered, not the mini-skirted variety—and in particular their irresponsible summer habit of performing a dawn chorus long before the aforesaid dawn has arrived. Some citizens rave about it. I know several who think nothing of rising at some ungodly hour to crawl through half a mile of ditches and brambles to get the maximum number of dBs. Others, however, awakened by the first twitterings, twist restlessly between the sheets, cursing the day they forsook the bright lights for the rural life.

Myself, I'm a sort of floating voter between the two viewpoints. You will not find me out and about at 04.00 to capture the mating call of the lesser spotted milkboy; but neither do I lie infuriated in my bed, stuffing my ears against the fluting and screaming from without, for the simple reason that I sleep through it. At least, I did until this morning when a maniac cuckoo chose to practise his circuits and bumps from my bedroom window-sill and banished all sleep in so doing.

Now, ordinarily I have a great respect for cuckoos and in particular for their laudable habit of laying eggs in an alien nest and then zooming off, leaving somebody else to do the dirty work. I always feel that in their next existence they will take human shape and grow up to be group chiefs or lab. managers. As knocker-uppers, however, they do not have my vote. I mean, one can fling a shoe at a caterwauling cat with a reasonable probability of the missile landing in the target area—but how does one deal with an erratically-flying cuckoo? To design a radar-controlled shot-gun with a cuckoo-voice-operated firing mechanism seems to me to be carrying the matter a shade too far.

The incident did, however, fulfil one useful purpose. It served to remind me of a letter received from a reader whose identity shall be shrouded in the initials 'S.T.C.' (no connection with Standard Telephones & Cables). The cloak of anonymity is one of which I'm sure he will approve, since if it were removed the full majesty of the law would clamp a firm hand on his shoulder.

It seems that S.T.C. has purchased what was described in the small ad. as a "record-player transmitter". I haven't seen this device but presumably it is a low-power oscillator with sockets for applying external modulation and some form of output that is capable of radiating over a very limited range. I would guess that its radiation is in the m.f. or possibly h.f. band, because S.T.C. says that he uses it to provide music from his indoor tape recorder to his transistor radio in the garden on warm summer afternoons.

He is, of course, fully aware that he is, to all intents and purposes a pirate transmitter but as he has been using the device for a year or so now without attracting the attentions of a Post Office detector van it is obvious that the device is used with restraint and causes offence to no one. Which is more than can be said for electric bells and unsuppressed car ignition systems. Spark transmission was made illegal donkey's years ago but, illogically, no legal steps can be taken to compel a car driver to fit suppressors and cease transmission.* The electricity cables, too, are notorious radiators of interference and can carry man-made static over many miles without let or hindrance; yet it is illegal for a re-diffusion service to use the electricity mains for programme transmissions.

What brought me, via the dawn chorus, to S.T.C's letter was his mention of another project of his, namely the enjoyment of his local bird choir at a reasonable hour of the day. What he proposes to do is to plant a microphone and his "record player transmitter" in an appropriate thicket and connect his home radio to his tape recorder. The two latter devices could be switched on automatically at the requisite ungodly hour and the consequent recording could then be enjoyed later.

He goes on to point out other instances in which the eleventh commandment—"Thou shalt not be found out"—operates. The recording of B.B.C. programmes, for instance, is illegal but (he says) in a radio talk on hi-fi a year or so ago it was mentioned that of all the uses to which tape recorders are put, over half the recorded material is of radio programmes. He also instances the fact that it is illegal to re-record discs and yet most tape recorders have sockets for doing this and include instructions in their manuals. Indeed, the record players themselves very often have sockets inscribed "Tape" (I've just looked at my own, and it has). So we have a situation in which the record manufacturers frown on the practice of tape recording from their products, but are also manufacturers of record players which directly invite one to do so!

S.T.C. also mentions another way in which he may, or may not, be falling foul of the law. For good and sufficient reasons he does, on occasion, record telephone conversations. I haven't consulted the Post Office but I imagine that it all depends on how you go about this. The automatic telephone-answering device is in widespread use, so any Post Office-approved method of carrying out the operation is presumably valid for normal private conversations.

As my correspondent mentions, recording from the telephone raises the larger and far more serious issue of bugging and snooping. Does much of this go on in industrial concerns I wonder? Certainly one does not read of specific instances in the papers, but possibly this is because firms which have been victimized do not wish their business to be further noised abroad. On the other hand, dire hints of widespread malpractice have been given, both in the Press and on television. I would have thought, however, that a simpler and less 'Paul Templish' approach to industrial spying would be to cultivate the acquaintance of a selection of key secretaries and, after judicious wining and dining, take it from there. I'm not in any sense disparaging the sense of loyalty of the bosses' secretaries, but many are inadequately paid in relation to their responsibilities and a cash-down offer of, say, £50, to a girl who is struggling to make a Majorcan holiday on a weekly income of perhaps £15, would be a considerable temptation. Most, I'm sure, would resist it, but there are bound to be exceptions. Telephone bugging, the picking of filing cabinet locks and the photographing of documents with a micro-min camera is glamorous on TV but in real life the insertion of an extra carbon when copying a confidential document is much less likely to be spotted.

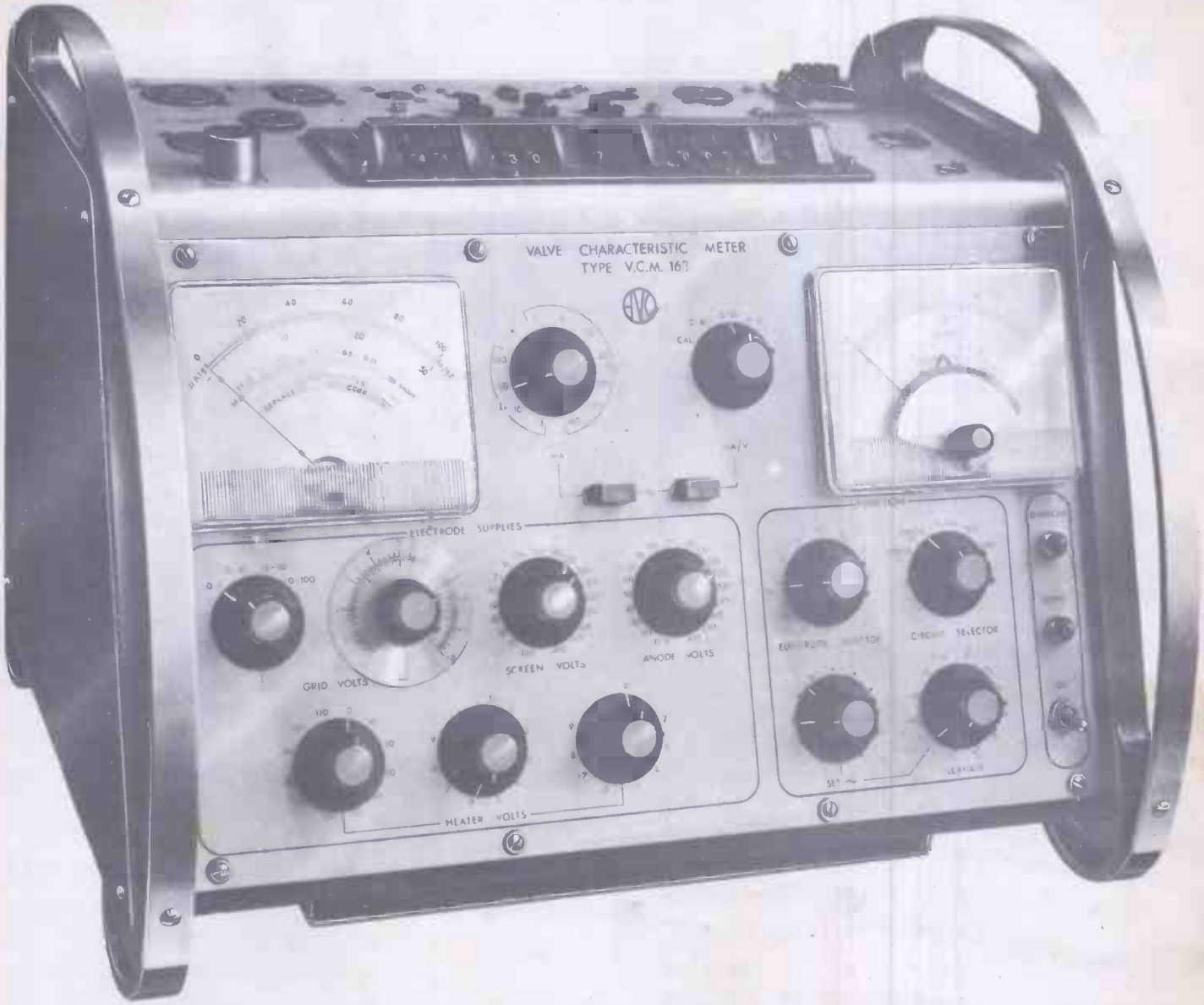
But to return to the anomalies of the law in the matter of illicit transmitters and tape recordings. If S.T.C. continues to use his illegal "record player transmitter" he is liable to have the Post Office running him in for illicit transmission of programmes. But if, by way of revenge, he instals an electric motor with the dirtiest brushes and commutator he can find, the most the P.O. can do is to knock on the door and ask politely if they may inspect it.

The trouble is, I suppose, that the law is not only an ass but a mechanical ass. Its regulations have to be designed to protect the commonsensical majority from the knavish minority. If no curbs on signal radiation were made, the frequency bands would be in chaos; if the same law makes criminals of responsible electronics engineers in the process, it's just too bad.

Anyway, S.T.C., many thanks for a most interesting letter.

*Since 1953 it has been obligatory to fit suppressors on all new cars and it is an offence to remove them. ED.

Don't doubt your valves, check them with an Avo VCM163



The Avo VCM163 Valve Characteristic Meter is one of the most versatile valve testers ever developed. With facilities for testing valves with as many as 13 pin connections (and 2 top caps), plus recently introduced types such as nuvistors and compactrons, the VCM163 provides both rapid fault diagnosis and comprehensive static/dynamic characteristics data. Nevertheless, it is even simpler to use than previous models – no backing-off is required. A separate meter displays mutual conductance values continuously during testing, and there is pushbutton monitoring of screen parameters. The full range of h.t. voltage – 12.6V to 400V – can be applied to anode and screen, heater voltage is adjustable in 0.1V steps from 0 to 119.9 and grid voltage may be varied continuously from 0 to 100V (calibrated). Get complete information about the VCM163 from your local dealer or Avo Ltd, Avocet House, Dover, Kent. Telephone Dover 2626. Telex 96283.

Remember it's not **only** Amps, Volts and Ohms at Avo now.

THORN
A Member of the Thorn Group

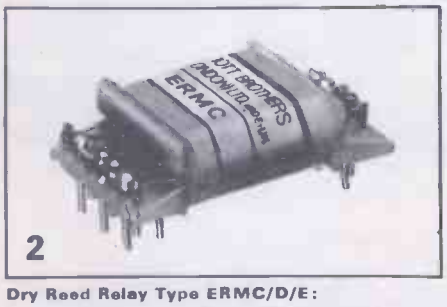
WW—006 FOR FURTHER DETAILS

SHRINK YOUR SWITCHING PROBLEMS...

with 4 new improved miniature relays from **Associated Automation**

1

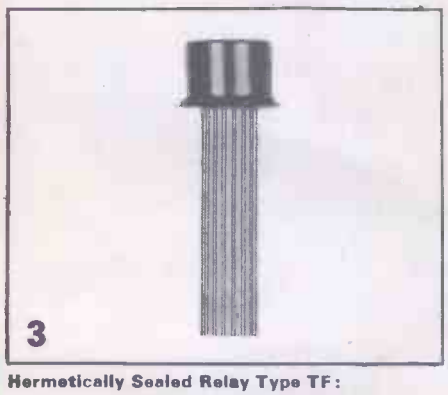
Mercury Wetted Contact Relay Type EBRM:
Height only 10mm for low profile pcb mounting; 20mW bi-stable, 40mW single-side-stable; operate time 1ms nominal at max. coil power; life over 25 x 10^9 operations at rated load of 100VA; bounce-free for both Form C or D contact resistance.



2

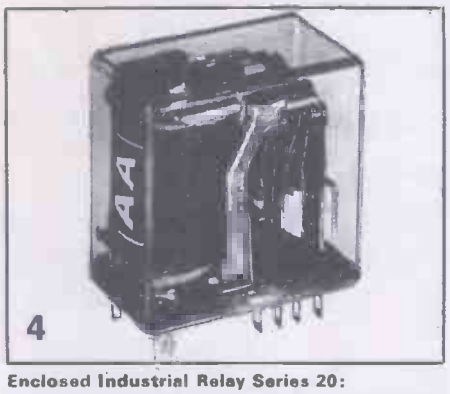
Dry Reed Relay Type ERMC/D/E:
Miniature open, shielded and encapsulated styles with up to 5 poles, offering all the advantages of reeds at low cost; standard relays operate from 35mW depending on contact arrangement; electrostatic shielding, high voltage insulation and low thermal types can be specified; life expectancy 10 x 10^6 operations at full load, contact rating 10VA.

Whatever your switching problem – we can reduce it to size. These new additions increase an already comprehensive range of switches and relays for all communication and control purposes. All competitively priced and backed by Britain's most outstanding applications engineering service. Try us . . . for size.



3

Hermetically Sealed Relay Type TF:
All-welded, T.O.5 transistor can envelope giving high isolation switching with high shock and vibration characteristics; full CPL approval for standard versions; switching capability 1 amp at 28V·D.C. to low level; single and double pole; operate powers down to 40mW.



4

Enclosed Industrial Relay Series 20:
Wide range of coils, contact arrangements and mountings; up to 6 poles, up to 5 amp 100W; life over 10 x 10^7 operations; single or twin contacts in wide range of materials; low-priced, readily available, easy to apply.

All these illustrations are full size.

TO: ASSOCIATED AUTOMATION LIMITED,
ELECTROMAGNETICS,
70, DUDDEN HILL LANE,
LONDON, N.W.10. Tel: 01-459 8070.
Manufacturers of Clare Elliott and Elliott Relays

Please send me your fully illustrated literature on (tick box applicable)

1☐ 2☐ 3☐ 4☐

NAME.....

COMPANY.....

ADDRESS.....

.....

.....

A member of the G.E.C. Group of Companies WW 6/70

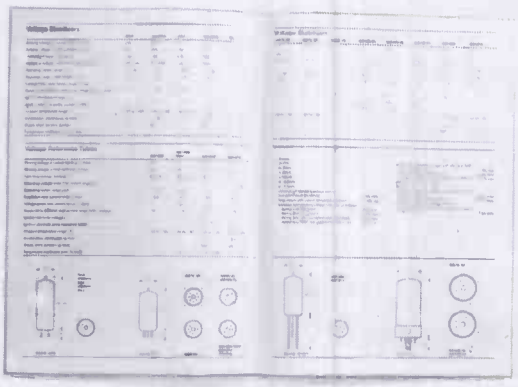
TA 11085

Voltage stabilisers and reference tubes in four easy pages.

Easy-to-check tables of performance facts and figures. Clearly laid-out dimension diagrams. An index of replacement equivalents containing over 80 items.

They're all here in EEV's four-page data digest on voltage stabilisers and voltage reference tubes.

Send for your copy now. Then, when you're looking for reliability plus extreme economy, you'll know where to find it.



English Electric Valve Co Ltd, Chelmsford, Essex, England. Telephone: 0245 61777. Telex: 99103. Grams: Enelectico Chelmsford.

To: English Electric Valve Co Ltd, Chelmsford, Essex, England.
Please send free data digest on EEV voltage stabilisers and reference tubes.

Name & Position

Company

Address

Tel: exchange or code

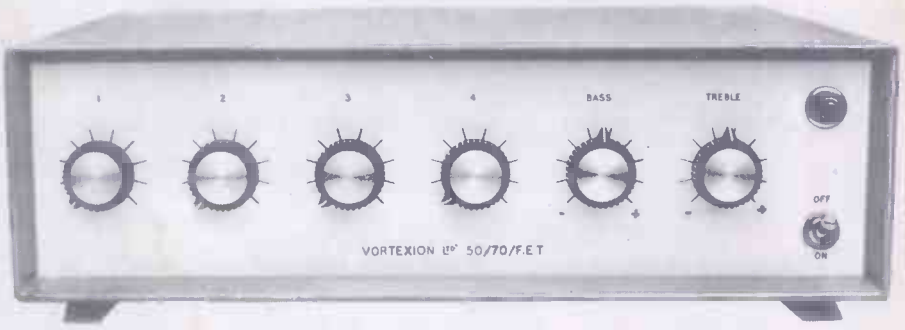
Number Ext.

ENGLISH ELECTRIC VALVE CO LTD

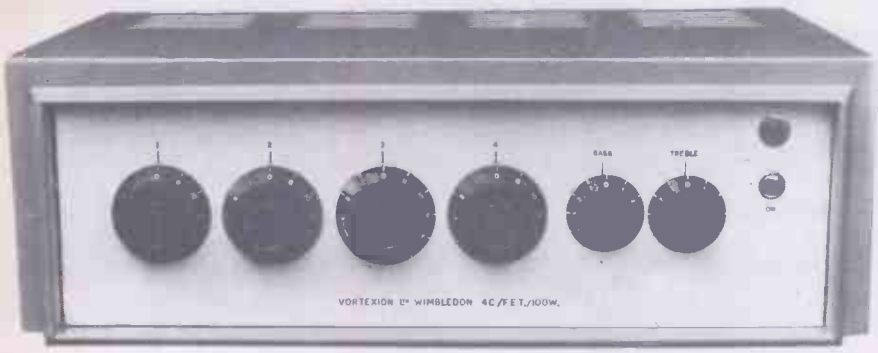
Vortexion

This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable—100 Watt Amplifier (no failures to date) with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer amplifier, again fully protected against overload and completely free from radio breakthrough. The mixer is arranged for 3-30/60Ω balanced line microphones, and a high impedance line or gram. input followed by bass and treble controls. 100 volt balanced line output.

THE VORTEXION 50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.



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



THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4 channel F.E.T. mixer, 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.

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms–15 ohms and 100 volt line. Bass and treble controls fitted.
Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s–20 Kc/s ±1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 mW 600 ohms. Output 100–120 V or 200–240 V. Additional matching transformers for other impedances are available.

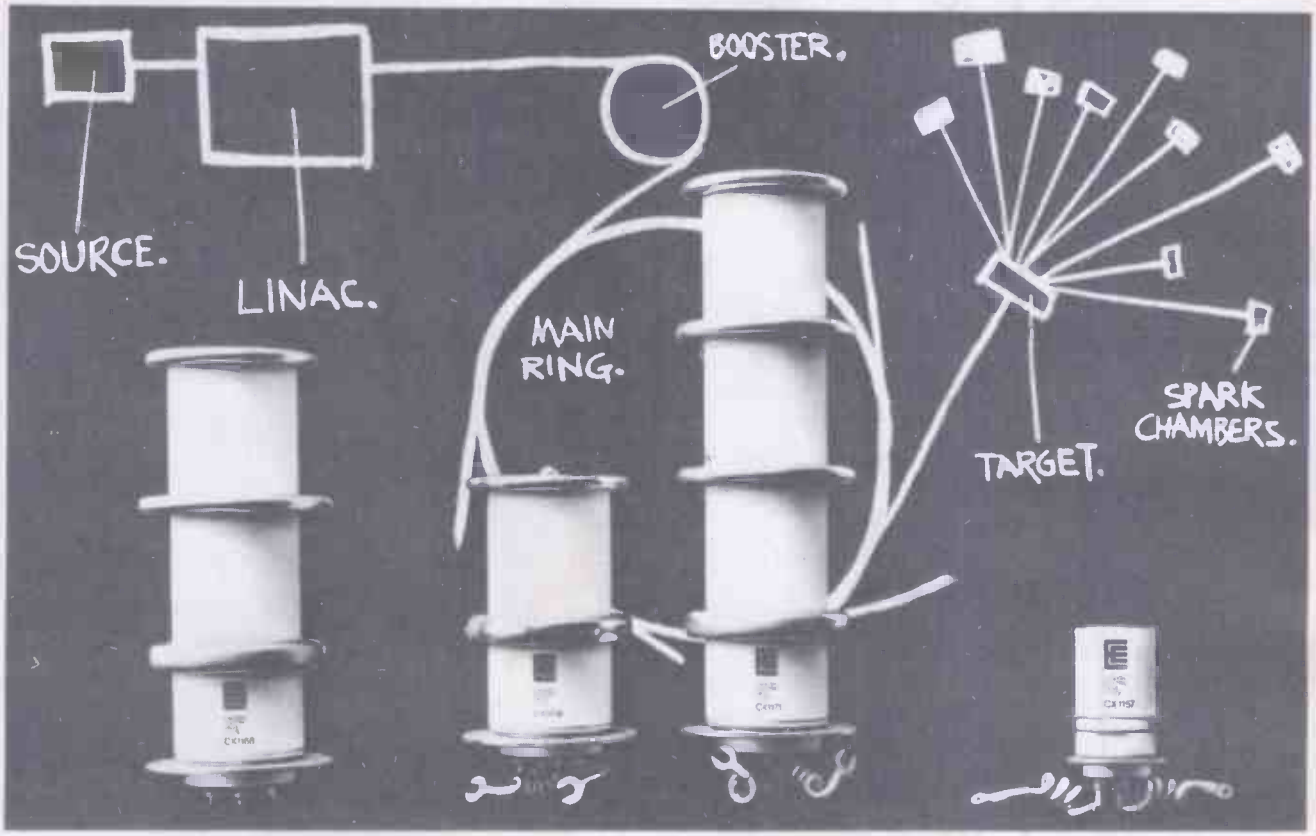
20/30 WATT MIXER AMPLIFIER. High fidelity all silicon model with F.E.T. input stages to reduce intermodulation distortion to a fraction of normal transistor input circuits. The response is level 20 to 20,000 cps within 2 dB and over 30 times damping factor. At 20 watts output there is less than 0.2% intermodulation even over the microphone stage at full gain with the treble and bass controls set level. Standard model 1-low mic. balanced input and HiZ gram.

ELECTRONIC MIXERS. Various types of mixers available. 3-channel with accuracy within 1 dB Peak Programme Meter. 4-6-8-10 and 12-way mixers. Twin 2, 3, 4 and 5 channel stereo. Built-in screened supplies. Balanced line mic. input. Outputs: 0.5 V at 20K or alternative 1 mW at 600 ohms, balanced, unbalanced or floating.

VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, S.W.19

Telephone: 01-542 2814 and 01-542 6242/3/4 **Telegrams: "Vortexion, London S.W.19"**

EEV thyratrons give greater accuracy and better performance in three major nuclear physics applications:



Linear accelerators

☐ EEV thyratrons can withstand peak inverse voltages up to 20 kV following a pulse.
☐ Their operation is unaffected by small reservoir voltage variations.
☐ EEV thyratrons need no servicing and give trouble-free operation in oil-filled equipment.

Particle accelerators

☐ EEV thyratrons ensure reliable firing. They give nano-second accuracy.
☐ There are very few missing pulses.
☐ They require no external gas supply.
☐ Because they have an annular current flow EEV thyratrons can switch peak currents very rapidly without risk of arc extinction. When fitted into coaxial housings rates of rise of current up to 100kA/μsec are possible.

Spark chambers

☐ Long life is important for spark chamber operation – and EEV thyratrons have given 10,000 hours service in some cases.
☐ Spurious firing is virtually eliminated.
☐ Jitter is kept as low as 1 ns.
☐ They make possible repetition rates of up to 50 kHz due to very rapid deionisation characteristics.
☐ EEV thyratrons operate over a wide range of H.T. voltages at currents up to 10 kA without change in characteristics – so drive units may be used with different chambers.
☐ The low trigger voltage means that simple firing circuits are possible.

English Electric Valve Co Ltd,
Chelmsford, Essex, England.
Telephone: 0245 61777 Telex: 99103.
Grams: Enelectico Chelmsford.

To: English Electric Valve Co Ltd, Chelmsford, Essex, England
I am interested in thyratrons for_____(application

Name & Position _____

Company _____

Address _____

_____

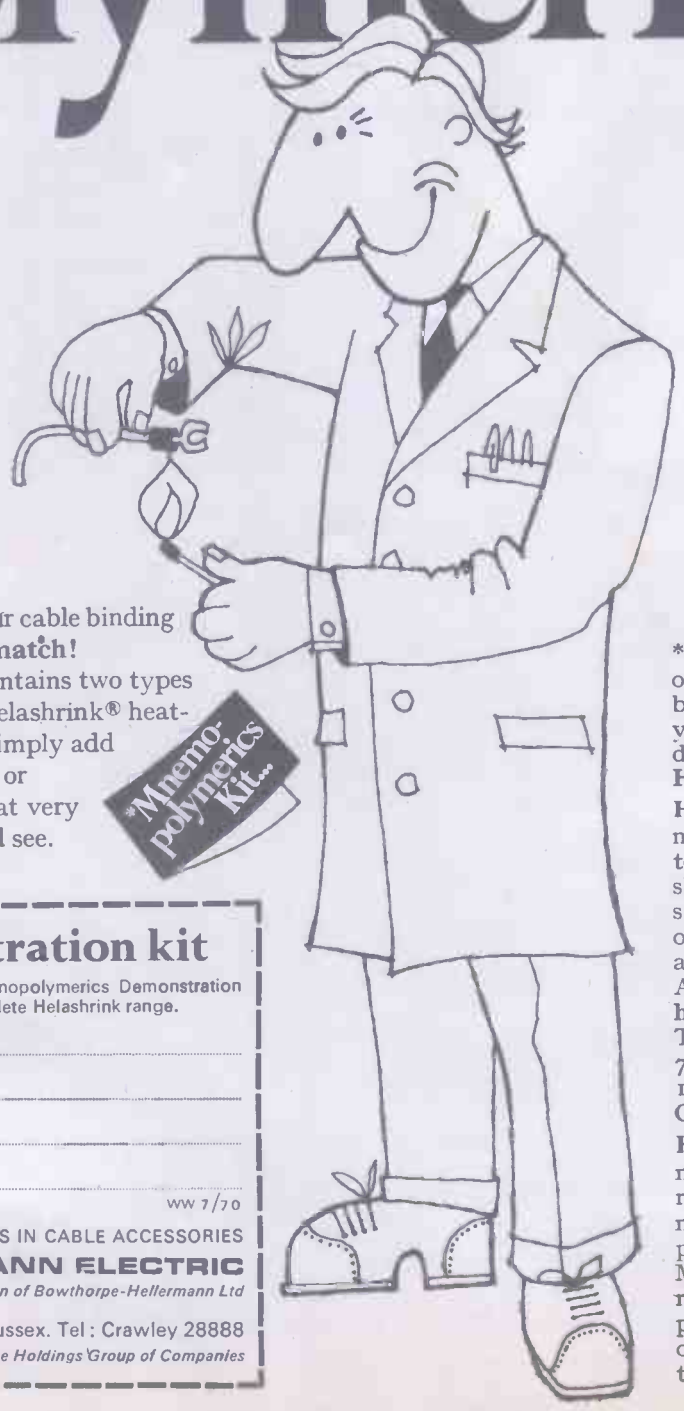
Tel: exchange or code _____

Number _____ Extension _____

ENGLISH ELECTRIC VALVE CO LTD

WW—010 FOR FURTHER DETAILS

How to be a mnemo-polymericist*



All you need to shrink your cable binding and sleeving costs – **is a match!** Our demonstration kit contains two types of wired terminals and Helashrink® heat-shrinkable sleeves. You simply add heat for a tight shrink-fit or shroud. In seconds – and at very low cost. Post coupon and see.

Free demonstration kit

Please send me your free Mnemopolymerics Demonstration Kit – plus full details of the complete Helashrink range.

Name.....

Company.....

Address.....

.....

WW 7/70

WORLD LEADERS IN CABLE ACCESSORIES

HELLERMANN ELECTRIC

A division of Bowthorpe-Hellermann Ltd

Gatwick Road, Crawley, Sussex. Tel: Crawley 28888

A member of the Bowthorpe Holdings Group of Companies

***Mnemopolymerics** – the science of heat-shrinkable polymers with a built-in memory – perfected after many years of intensive research and development by Hellermann-Electric. Helashrink products include:

Helashrink Electrovin® – sleeves, markers and tubing in PVC – designed to cut the cost of cable harness sleeving, terminal insulation, plug shrouding, identification, insulation of condenser and transistor cans, and general mechanical protection. Also for creating multicore cables, harness work and bus-bar protection. Two grades: Thin-wall, shrinking at 70°C; Standard-wall, shrinking at 135° to 150°C. Both self-extinguishing. Good storage stability.

Helashrink Insultite® – sleeves, markers, tubing and end caps in a range of irradiated and non-irradiated materials designed to provide the right product for the job – at the right price. Materials can be selected for flexibility, rigidity, shock and vibration protection, resistance to contaminants over a range of operating temperatures from –55°C to 300°C.

WW—011 FOR FURTHER DETAILS

You can view X-ray pictures in daylight using only a 5 micro-Röntgen dosage

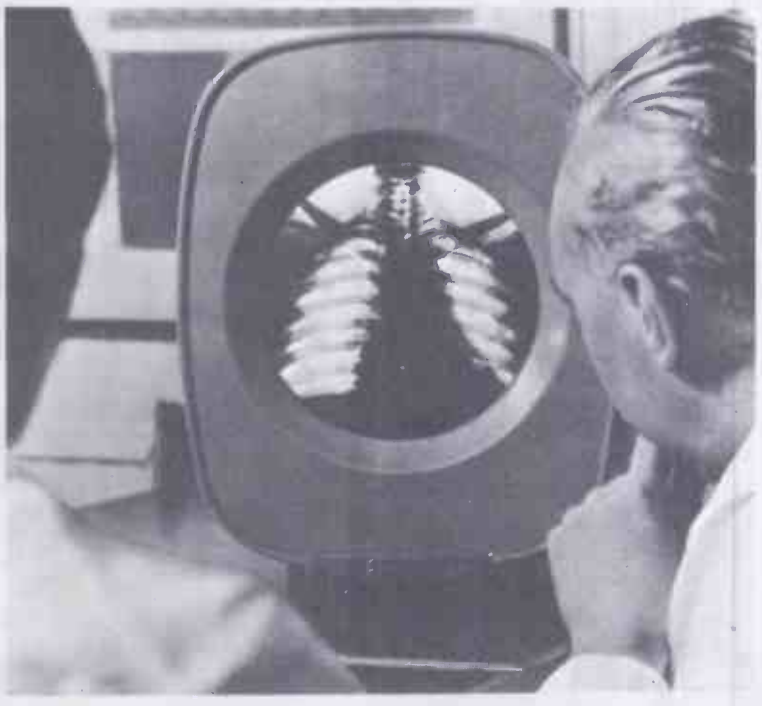
What would it mean to you? An X-ray picture that is so bright you can view it in direct daylight as it happens. EEV's Image Isocon is now being used in X-ray equipment for this very purpose – reducing X-ray dosages to as little as 5 micro-Röntgens, allowing longer exposure times for 'live' X-ray picture study, saving time by eliminating the need for operators' eyes to become 'dark-adapted'.

The Image Isocon is so sensitive that it can convert a very low dosage-level picture to a bright, clear picture on a cathode-ray tube. This in turn means simple direct-from-screen photography.

The Image Isocon is another product of EEV advanced tube technology. For complete data, please post the coupon.

English Electric Valve Co Ltd Chelmsford, Essex, England. Telephone: 0245 61777. Telex: 99103. Grams: Enelectico Chelmsford.

with the EEV Image Isocon



To: English Electric Valve Co Ltd Chelmsford, Essex, England.
Send for full details of EEV Image Isocon range.

Name & position _____

Company _____

Address _____

_____

Tel. exchange or code _____

Number _____ Ext. _____

ENGLISH ELECTRIC VALVE CO LTD

WW—012 FOR FURTHER DETAILS

EEV flash flash flash tubes make light of the toughest jobs

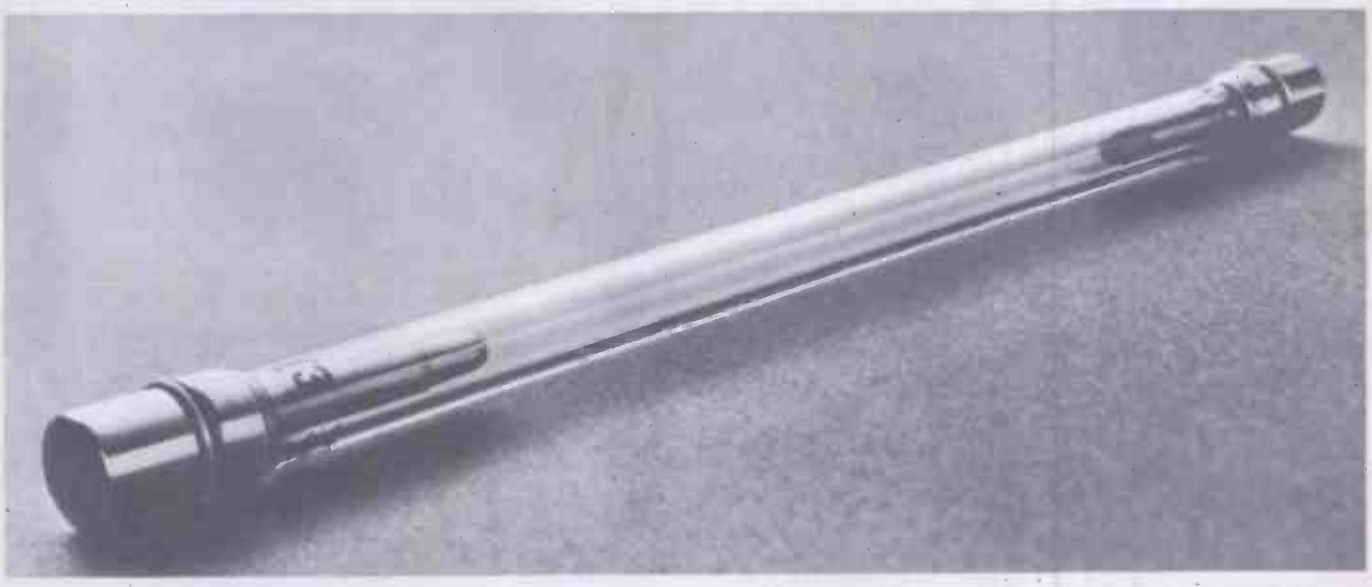
For pumping lasers. For strobing. For photography. For any application in which quality, reliability and performance are vital, that's where you'll find EEV flash tubes.

There's almost certainly a flash tube in the EEV range that has the right characteristics for your application – and if there isn't we can probably make one!

EEV flash tubes have extra heavy-duty electrodes. They give you long life, with up to 10^6 flashes, *and* they give you high conversion efficiency. Our air-cooled xenon flash tubes have a wide range of input energy levels and can operate at high repetition rates.

Isn't it time you had the full facts about EEV flash tubes? Just post the coupon.

English Electric Valve Co Ltd, Chelmsford, Essex, England. Telephone: 0245 61777 Telex: 99103
Grams: Enelectico Chelmsford



Type	Energy input per flash max. (J)	Arc length (in.)	Bore diameter (mm)	Typical operating conditions: Voltage (kV)	Series inductance (μH)	*Flash rate	Trigger voltage (kV)
XL615/4/3	400	3	4.0	2.5	400	1 per 30 sec.	12-16
XL615/7/3	600	3	7.0	2.5	400	1 per 15 sec.	12-16
XL615/9/4	1500	4	9.0	2.5	400	1 per 30 sec.	16-20
XL615/10/5.5	3500	5.5	10.0	2.5	400	1 per 60 sec.	16-20
XL615/10/6.5	5000	6.5	10.0	2.5	800	1 per 2 min.	20-25
XL615/10/12	9000	12	10.0	2.5	800	1 per 2 min.	25
XL615/13/6.5	10000	6.5	13.0	2.5	800	1 per 2 min.	25
XL615/13/12	18000	12	13.0	2.5	800	1 per 2 min.	25

*At maximum input levels (air-cooled)

To: English Electric Valve Co Ltd, Chelmsford, Essex, England
Send for full data on EEV flash tubes.

I am interested in _____ (application)

Name _____

Position _____

Company _____

Address _____

_____

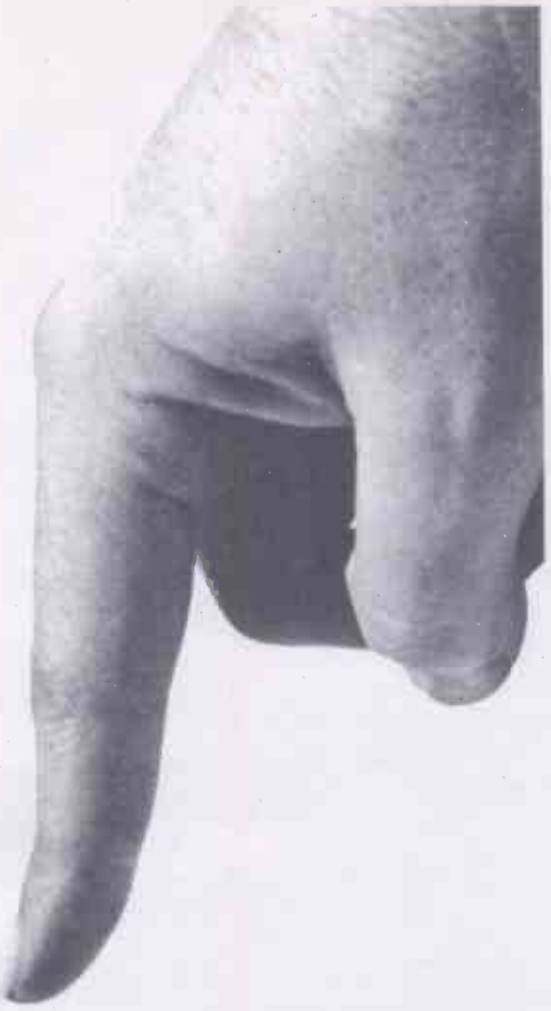
_____

Tel. exchange or code _____

Number _____ Ext. _____

ENGLISH ELECTRIC VALVE CO LTD

CRC 6



Looking for a reliable 3mm lamp?

You will find it in this new Vitality T-1 Range.

Never have such small lamps been so reliable, so competitively priced. With a diameter of only 3mm they are capable of up to 200,000 hours of life at rated voltage and come either wire ended or based to fit available holders. With wide application in peripheral equipment for the computer industry, this new range is also providing truly reliable integral lighting of instruments and is much used in equipment where space is minimal. Folder NPR details the whole range.

VITALITY BULBS

Vitality Bulbs Limited, a General Instrument Electro-Optical Products Group company.

BEETONS WAY, BURY ST. EDMUNDS, SUFFOLK. *Tel: 0284-2071, Telex 81295.*

WW—016 FOR FURTHER DETAILS

Buying a scope

First ask DYNAMCO

Save yourself time by talking about your applications (PCM, TV, pulse, HF, etc) to our specialist engineers. If we can't meet your requirements from our own extensive range, then we'll tell you who can. Call Chertsey 2636.

The scope specialists

Dynamco
Hanworth Lane
Chertsey Surrey England

World Wide Sales & Service

DYNAMCO

WW—017 FOR FURTHER DETAILS

NEW ADVANCE MULTIMETER

in the handiest pack

PRICE IN U.K.

£99

Discounts for quantities of 5 or more.

DMM2 Digital Multimeter

Versatility

Measures :-
DC & AC Volts 200mV–1000VFS
DC & AC Current 200μAFS–
External shunts extend ranges to 2A. Ohms. 200Ω–2MΩFS
Operates from AC Supply.
External 12V DC or optional rechargeable battery pack.

Stability

Dual Slope Integration with stabilized zero point and storage display provides completely stable operation.

LSI Reliability

Single LSI chip performs all counting and storage functions.
Full overload protection.

ADVANCE ELECTRONICS LIMITED

INSTRUMENTS DIVISION SALES OFFICE

Raynham Road, Bishop's Stortford, Herts. Telephone: 0279 55155.

POST THIS COUPON OR TELEPHONE – TODAY.

I WOULD LIKE

☐ A DEMONSTRATION

☐ A COPY OF THE DMM2 LEAFLET

NAME .....

POSITION .....

COMPANY .....

ADDRESS .....

.....

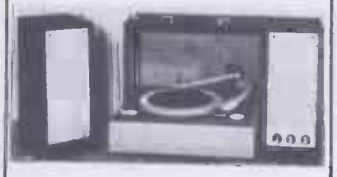
TELEPHONE NO. .....

A/WWP

WW—018 FOR FURTHER DETAILS

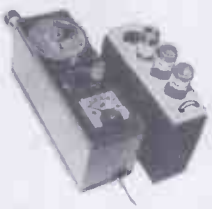
Never Built a Kit Before?

Why not prove how easy it is the HEATHKIT way. Build one of these beginner kits.



Stereo Record Player
Exciting Sound—Budget Price
Kit K/SRP-1 **£27-6** *Carr. 11/-*

Portable 'VVM'
For Hobbyists-Householders
Kit K/IM-17 **£14-8** *Carr. 6/-*



Grid Dip Meter
Covers 1-8 to 230 MHz
Kit K/GD-1U **£11-10** *Carr. 5/-*

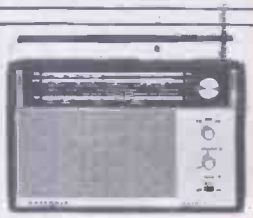
Technicians Versatile 'VVM'

7AC, 7DC.
7 ohm ranges
Kit K/IM-18U **£16-14** *Carr. 5/-*

Solid State Metal Locator
Find Buried Coins
Kit K/GD-48
£29-16
Carr. 5/-

FM Mono Receiver
Modest Price—Natural Sound
Kit K/AR-27 **£22-10** *Carr. 11/-*
(Cab Extra)

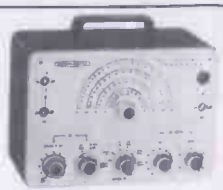
Deluxe Car Radio
Top Value—Powerful output
Kit K/CR-1 **£12-12** *Carr. 5/-*
(Spkr. Extra)



AM/FM Radio
Looks Good—Luxury Sound
Kit K/Severn **£18-18** *Carr. 5/-*

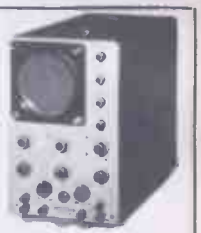
FM Stereo Tuner/Amplifier
Unbeatable Value
Kit K/AR-17 **£36-10** *Carr. 11/-*
(Cab Extra)

Deluxe SW Receiver
Many extras for price
Kit K/GR-54 **£48-16** *Carr. 9/-*



RF Signal Generator
100 KHz—200 MHz
Kit K/RF-1U **£15-18** *Carr. 6/-*

Wide-Band Oscilloscope



Excellent Service Aid
Kit K/10-18U **£38-18** *Carr. 11/-*

Car Tune-Up Meter
For D.I.Y. Motorists
Kit K/ID-29 **£17-8** *Carr. 5/-*

3-Speaker and Cross over System
Build into own Cabinet
Kit K/SCM-3 **£12-6** *Carr. 6/-*

Model Makers Tachometer
Measure RPM the easy way!
Kit K/GD-69 **£11** *Carr. Pd.*

Avon Mini Speaker
Luxury Sound—Small Size
Kit K/Avon **£13-8** *Carr. 11/-*

Berkeley Slimline Speaker
Uses 1 sq ft. Floor Space
Kit K/Berkeley **£21-4** *Carr. 14/-*

12w + 12w Stereo Amplifier
8 or 15 Ω outputs
Kit K/TSA-12 **£32-16** *Carr. 11/-*
(Cab Opt. Extra)

HEATHKIT

DAYSTROM LTD,
GLOUCESTER, GL2-6EE
Tel: 29451 Telex: 43216

A Schlumberger Company

Tick requirements

☐ Please send me FREE Catalogue

☐ Please send me full details models .....

.....

NAME .....

ADDRESS .....

.....

..... POST CODE .....

29/7

DAYSTROM LTD, GLOUCESTER, GL2-6EE

Cable binding is so much easier with Insulok MS ties

Insulok Series MS one-piece plastic cable ties are designed for quick, simple cable fixing—by hand, or using the Insulok tensioning tool—without metal fastening pins or locking devices. The ties are manufactured in accordance with American Mil Specs. 17821, 18034 and 23190 to meet tough aerospace and electronics requirements. They come in a full range of sizes—with or without panel fixing heads—to handle cable bundles from ·625" to 4" diam. All ex. stock. Accessories include standard, screw, bolt or adhesive-fixed cradles, tie guides and markers.

try them... Please send me samples of Insulok MS Cable Ties – and full technical information.

NAME_____

COMPANY_____

ADDRESS_____

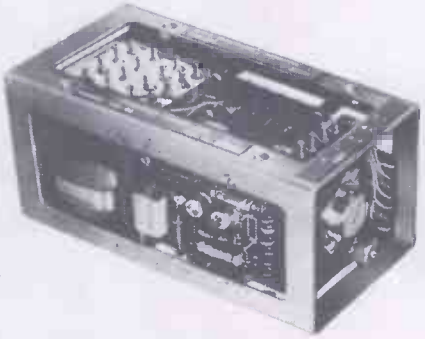
W W 7/70

INSULOID MANUFACTURING CO.
A division of Bowthorpe-Hellermann Ltd.,
LEESTONE RD., WYTHENSHAWE, MANCHESTER. M22 4RH
Tel: Wythenshawe 5415
(A member of the Bowthorpe Holdings Group of Companies)

WW—025 FOR FURTHER DETAILS

DESIGNED FOR TIGHT SPACES

. . . that's what the TSU 0500 was designed for.
Ask Maru who works in our test department, she knows that from this tiny unit you get high performance and reliability at a price you can afford.
But then it's made by A.P.T. so it goes without saying.



For further details, write to:
A.P.T. ELECTRONIC INDUSTRIES LTD.,
CHERTSEY ROAD · BYFLEET · SURREY
TEL: BYFLEET 41131/4

WW—027 FOR FURTHER DETAILS

Record Trimmer

Morganite 0.75" Cermet Trimming Potentiometers are breaking all our sales records at the moment.

And we can't say we're surprised.

We designed our models 82, 84 and 86 with a power rating of 0.33W at 70°C. We manufactured them to give a tolerance of ±10% under rough, tough industrial conditions. We packed them into that tight little 0.75" construction. And we trimmed down the price tag to match.

Result, they sell like hot cakes. Ask us for samples for evaluation or development projects, and you'll see for yourself.

What you won't see, though, is the work that's put into our record trimmers at our new, expanded cermet production set-up. The examination of components at 50-to-500 times life size. The survival-of-the-fittest electrical testing. And all the crucial assembly stages in between.

All you'll see is the solid, high reliability that you're entitled to expect from each and every Morganite potentiometer..The reliability that makes us a leader in the field of cermet technology.

Don't settle for less.

MORGANITE RESISTORS LIMITED

Bede Industrial Estate, Jarrow, County Durham.
Telephone: Jarrow 897771 Telex: 53353

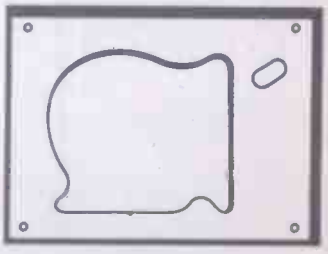
Morgan

WW—028 FOR FURTHER DETAILS

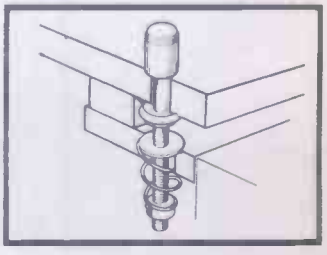
the DESIGN CENTRE LONDON

MODEL 2000
PLINTH SYSTEM

The SME model 2000 plinth system is more than a handsome and convenient housing for your turntable and SME precision pick-up arm. It meets the mechanical requirements under which the best performance will be obtained. High-quality workmanship is combined with ease of assembly. The basic unit is finished in selected veneers of teak, straight-grained walnut, or rosewood. A one-piece hinged lid in heavy acrylic is reinforced with a polished stainless-steel trim.



Motor boards in matching veneers are ready cut and drilled for screwdriver assembly with the appropriate pick-up arm and turntable. An uncut board is also available.



Four-point spring suspension adjustable for height and damping protects the motor board from acoustic feedback and external vibration.

SME

Write for details to: **SME LIMITED · STEYNING · SUSSEX · ENGLAND**

Looking for a wide range oscillator with ✳output greater than 30 volts✳sinewaves from 10Hz to 10MHz ✳quality squarewaves to 100kHz...plus✳four output impedances?

✳Here it is!

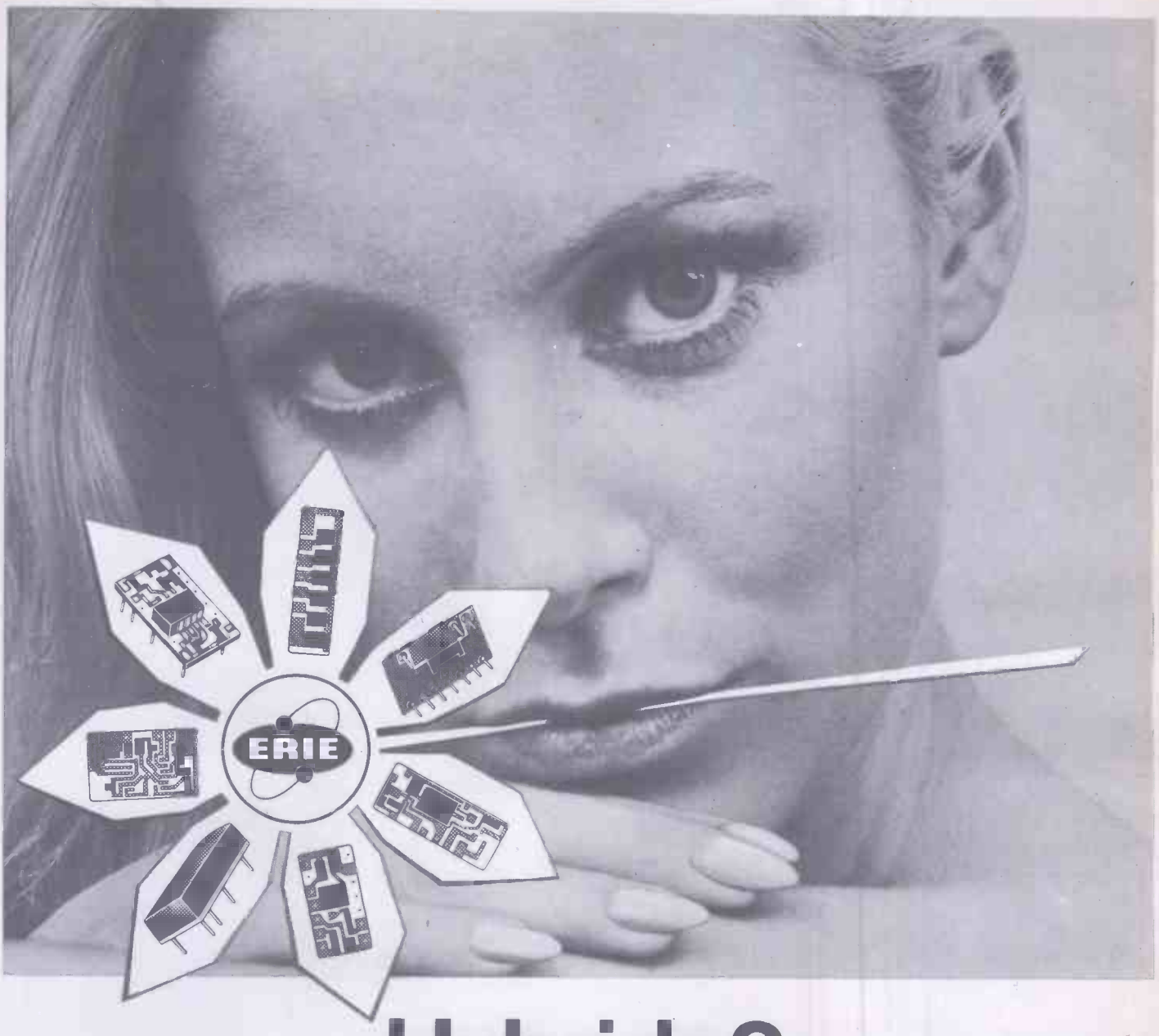
The Marconi TF 1370A gives sinewaves from 10 Hz to 10 MHz, in six decade bands – *plus* quality squarewave to 100 kHz and four output impedances of 75, 100, 130 and 600 ohms.
Its excellent handleability includes a particularly smooth frequency control. Especially useful is the frequency coverage of 1-10 MHz in one band, which makes the instrument ideal for response testing in the video and lower h.f. bands.

Primarily a signal source for measurements and tests on a.f. and video amplifiers and networks, the TF 1370A is ideal for use with transmission lines, filters, attenuators, etc. Price £320.
Full details from:

MARCONI INSTRUMENTS LTD
A GEC-Marconi Electronics Company
Longacres, St. Albans, Hertfordshire, England.
Tel: St. Albans 59292. Telex: 23350

TA 11193

WW—035 FOR FURTHER DETAILS



Hybrids?

We make them by the million!

That's our Jo*. . . We gave her seven words and a daisy; and the wall came tumbling down.

The wall of silence. Distinct among the major suppliers of hybrid IC's and passive networks, we at Erie soft-pedalled our publicity. We had to. Because keen commercial minds in UK and Continental companies snapped at the fact that Erie hybrids give complete circuit functions *in less time, at less cost,* than if you select, buy and assemble your own discrete components . . . and give you a hefty bonus in increased reliability. So our order books were full. And stayed full; even with output rates of 2.5 million units a year.

But now we are coming to you with all this experience. Because now we can give you the only kind of service our reputation will permit. Prompt, personal service. With teams of physicists, chemists, microelectronics specialists, waiting to tackle your problem. With an advanced manufacturing capability that will lift output to the multi-million level, raise reliability even higher, make prices even more competitive. A capability backed by a Quality Assurance laboratory approved to BS 9000, and all of Erie's world-wide experience.

Send for Publication No. 1. It gives you all the facts. Better still, send for an Erie sales engineer. He will understand your problem.

ERIE ELECTRONICS LIMITED

* *Short for Joshua??*

ERIE ELECTRONICS LTD.,
Great Yarmouth, Norfolk.
Tel: 0493 4911.
Telex: 97421

ERIE THICK FILM INTEGRATED CIRCUITS

WW—042 FOR FURTHER DETAILS

Over 3,500 specific types

FOR EXPORT

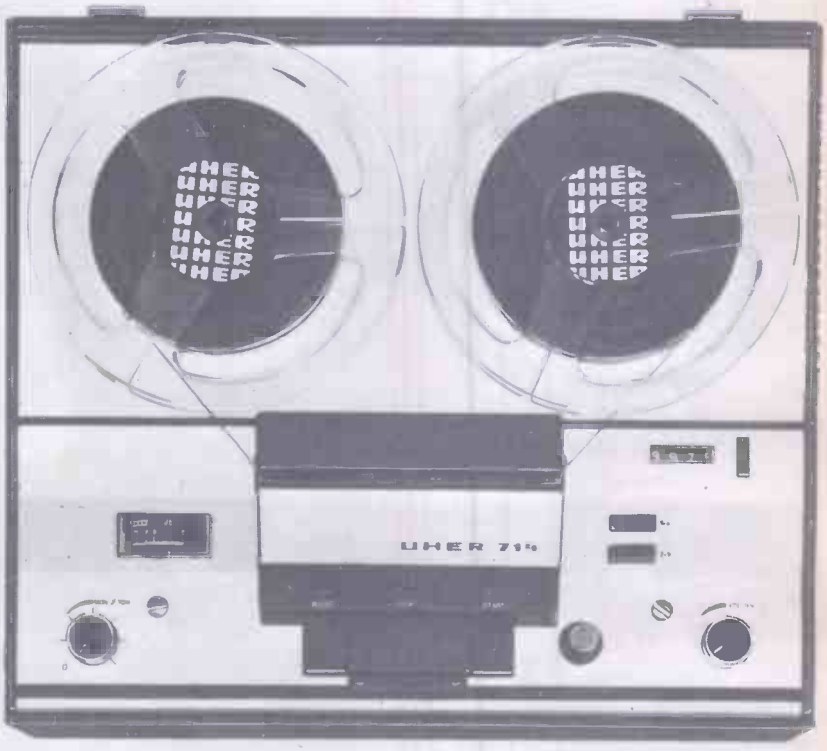
For quality, reliability and world-wide availability you can rely on Haltron valves . . . and on Hall Electric's speed, intelligence and reputation.
Ministry of Technology EID approval
Air Registration Board approval.

HALTRON
Radio Valves and Tubes

Hall Electric Limited
Haltron House, Anglers Lane
London, N.W.5.
Telephone: 01-485 8531 (10 lines) Telex: 2-2573
Cables: Hallectric, London, N.W.5.

NATO, NASA, Royal Navy, BBC use Uher. Now you can..

..the Uher 714 for less than £60



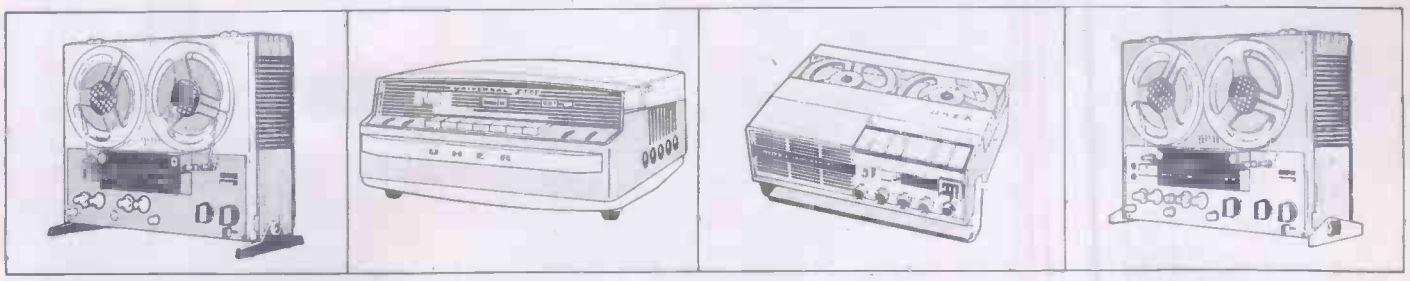
The same exacting standards of technical excellence demanded by these world pacesetters are applied to producing the Uher 714 which, for the first time, brings the superb quality of Uher below £60.

See and hear the Uher 714.

It incorporates many features associated with much more expensive instruments.

- All round tape speed of 3¾ ips
- Perfect four-track recording
- 7" reels
- Plays back stereo tapes as mono
- 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.



VARIOCORD 23 | UNIVERSAL 5000 | UHER 4000 REPORT L | ROYAL DE LUXE

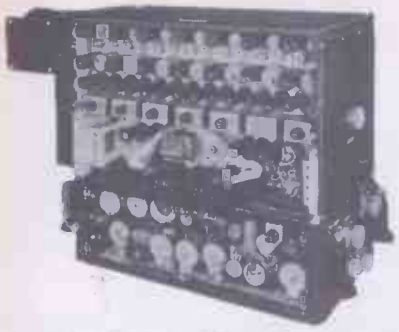
UHER

DISTRIBUTED IN THE U.K. BY

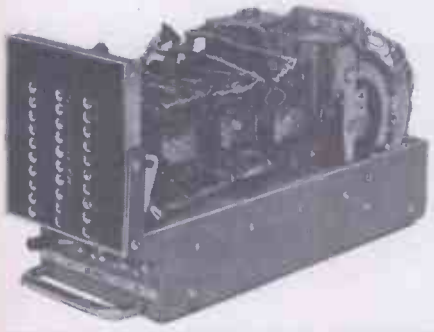
BOSCH

BOSCH LIMITED, WATFORD, WD2 4LB, HERTS. TELEPHONE: WATFORD 44233

WW—050 FOR FURTHER DETAILS



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.

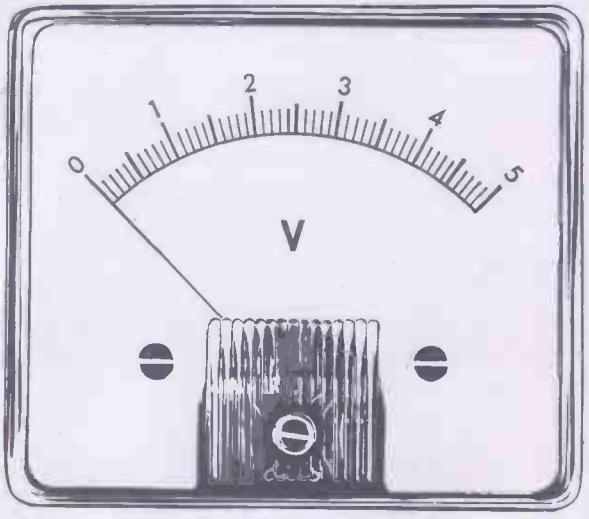
PUNCHES, READERS, VERIFIERS AND TELEPRINTERS. NEW COMPUTER ENGINEERING SURPLUS MATERIALS, AT REALISTIC PRICES. MOBILE SHOWROOM. CALLS ON REQUEST TO SUITABLE LOCATIONS.
Elliott 803B computers 4K store, 803C 8K store, film handlers, two tape readers, two tape punches. ICL 1901 Central Processers 8K store Lineprinter, 600 LPM. Elliott 903 8K store tape readers & punch. Prices on application.

COMPUTER TRAINING PRODUCTS

2 Lordship Lane, LETCHWORTH, HERTS. Tel: 4536 0462/6

WW—051 FOR FURTHER DETAILS

METER PROBLEMS?



A very wide range of modern design instruments is available for 10/14 days' delivery.

Full information from:

HARRIS ELECTRONICS (London)

138 GRAYS INN ROAD, W.C.1 Phone: 01/837/7937

WW—052 FOR FURTHER DETAILS

ATES

PRONOUNCED R-TEZ

SEMICONDUCTORS

Write now for catalogue

ATES ELECTRONICS LTD., MERCURY HOUSE, PARK ROYAL, LONDON W5

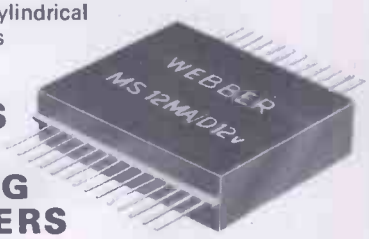
TEL: 01-998 6171 TELEX: ATES LONDON 262401

WW—053 FOR FURTHER DETAILS

ENCAPSULATION –

low tool cost method for cylindrical coils and potting. Enquiries also for—

REED RELAYS
SOLENOIDS
COIL WINDING
TRANSFORMERS
to 8 K.V.A.



Relay module 12-way "MS" range

R. A. WEBBER LTD.

Knapps Lane, Bristol 5. 0272 657228

WW—054 FOR FURTHER DETAILS

NOMBREX INSTRUMENTS

TRANSISTORISED—MODERN STYLING—COMPACT

- 4 Ranges 10Hz–100KHz.
- Sine or square wave output.
- Dual calibrated attens.
- Stabilised output level.

- 4 ranges, 1 μH–100H.
- Q Factor 0.1–1000.
- Oscillator freq. 1592Hz.
- Hay/Maxwell switch.

- Sizes: Height 5⅛". Depth 3¾". Width 7½".

A.F. GENERATOR MODEL 30 £19-10-0

ALSO

R.F. GENERATOR	29-S	£20	0	0
R.F. GENERATOR	29-X	£27	10	0
R.F. GENERATOR	31	£12	10	0
C.R. BRIDGE	32	£10	10	0

Post and Packing 6/6 extra.

INDUCTANCE BRIDGE MODEL 33 £20-0-0

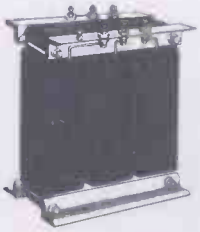
SEND FOR FULL TECHNICAL LEAFLETS

NOMBREX (1969) LTD., EXMOUTH, DEVON

TRADE & EXPORT ENQUIRIES WELCOME

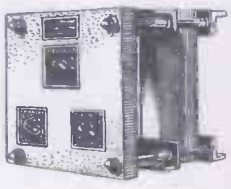
WW—055 FOR FURTHER DETAILS

Transformers, Chokes
Saturable Reactors
Voltmobile voltage regulators
Rectifier Sets



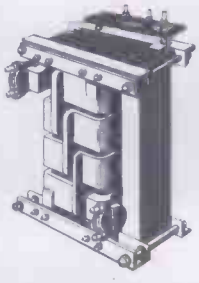
Transformers

Air cooled power transformers from 0.5 to 300kVA at voltages up to 2kV. 1 or 3 phase, double or auto wound, step-up or step-down. We have manufactured transformers to over 5,000 different designs for many applications and the experience which has been accumulated from these designs is built into every Harmsworth, Townley transformer



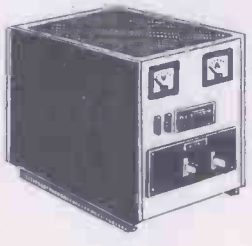
Voltmobiles

The most robust and useful control device for loads such as furnaces, ovens, bar heating and high temperature research. Our Voltmobiles are in use in their thousands to control transformers and rectifier sets or they can be used directly between supply and load. 64 step on load switching. Voltmobiles are auto-transformers which give control from 1.6% to 100% of input volts. Over-Volts up to 125% of input is also available. Standard models are made for single and 3 phase supply and for outputs from 20 Amps to 200 Amps with on-load switching.



High Current Transformers

Years of experience have gone into the design and production technique s used in the manufacture of our low voltage, high current transformers for use in furnaces, high temperature research, heating and other applications. These techniques enable us to produce transformers with output currents up to tens of thousands of amps at economical prices



Rectifiers

Sturdily built air cooled equipment from 50W to 500kW for plating, plasma arc welding, electrolytic machining and many other applications. Equipment incorporates either silicon or selenium rectifiers and can be built with fixed or variable output. Variable outputs are obtained by the use of continuously variable auto transformers, saturable reactors or Voltmobile regulator.

Saturable Reactors

From 5kVA up to 300kVA for controlling the outputs from transformers or rectifier units. Saturable reactors are infinitely variable reactors which can control outputs from transformers etc, from 10% to 100% of full output.

Chokes

A.C. and D.C. chokes

Specific enquiries are invited

Harmsworth, Townley

Transformers
Rectifiers

HARMSWORTH, TOWNLEY & CO. LTD.
2 Hare Hill, Todmorden, Lancs.
Telephone Todmorden 2601 Extension 22

WW—056 FOR FURTHER DETAILS

WIRELESS WORLD

ENQUIRY SERVICE FOR PROFESSIONAL READERS

To obtain further details of any of the coded items mentioned in the Editorial or Advertisement pages of this issue, please complete one or more of the attached cards entering the reference number(s). Your enquiries will be passed on to the manufacturers concerned and you can expect to hear from them direct in due course. Cards posted from abroad require a stamp. **These Service Cards are valid for six months from the date of publication.**

PLEASE USE CAPITAL LETTERS

Pour obtenir tout renseignement complémentaire sur les produits mentionnés dans les articles ou dans les pages publicitaires de ce numéros nous vous prions de remplir une ou plusieurs des cartes ci-jointes en inscrivant le ou les numeros de référence. Vos demandes de renseignement seront transmises aux fabricants intéréssés qui, en temps voulu, vous feront parvenir une réponse. Il est nécessaire d'affranchir les cartes postées a l'étranger. **Ces cartes de service sont valides pendant six mois à partir de la date de publication.**

PRIÈRE D'ECRIRE EN LETTRES MAJUSCULES

Weitere Einzelheiten über irgendwelche Artikel, die auf Redaktion-oder Anzeigenseiten erscheinen, erhalten Sie, indem Sie eine oder mehrere der beigelegten Karten ausfüllen und die Kenn-Nummer(n) angeben, Ihre Anfrage wird an den Hersteller weitergeleiter, und Sie werden dann direkt von ihm hören. Karten die im Ausland aufgegeben werden, müssen frankiert werden. **Diese Service-Karten sind sechs Monate vom Ausgabetag gültig.**

BITTE IN BLOCKSCHRIFT AUSFÜLLEN

Per ulteriori particolari in merito agli articoli menzionati nel testo o nelle pagine pubblicitarie di questo numero Vi preghiamo di completare una o più delle schede allegate citando il numero o i numeri di riferimento. La Vostra richiesta sarà inoltrata ai fabbricanti interessati che Vi risponderanno direttamente. Le schede dall'estero devono essere regolarmente affrancate. **Questo scontrino di servizio é valido per sei mesi dalla data di pubblicazione.**

SI PREGA DI COMPILARE LE SCHEDE STAMPATELLO

Con objeto de obtener mas detalles de cualquiera de los articulos mencionados en las páginas editoriales o de anuncios de este número sirvase rellenar una o más de las unidas tarjetas citando el número o números de referencia. Sus consultas serán transmitidas a los fabricantes interesados de quines tendrán noticias directamente a su debido tiempo. Las tarjetas enviadas desde el extranjero requieren franqueo. **Estas tarjetas de servicio son validas durante 6 meses a parir de la fecha de publicacion.**

SIRVASE ESCRIBIR CON LETRAS MAYUSCULAS

Anders meter problem-face to face

If you have a meter problem, share it with Anders. Our customers find the answer to most of their problems in our vast stock of standard meters. In fact the Anders range is the largest and most comprehensive in the country including, Panel Mounting and Portable . . . Moving Coil, Moving Iron, Electrostatic, Thermo-Couple, Moving Iron Motammeters, Frequency Meters, Wattmeters, Contact Meters . . . plus Current transformers, Shunts and other ancillary items. We also have the facilities for design and production of non-standard instruments, and printing Dial Faces with unusual Scales and Legends.

Where production deadlines loom large the need for meters in small or large quantities can present the kind of problem Anders will be glad to solve, fast and efficiently.

ANDERS ELECTRONICS LIMITED

48/56 Bayham Place, Bayham Street, London, N.W.1.
Telephone 01-387 9092.

Manufacturers and distributors of Electrical Measuring Instruments and Electronic Equipment. Sole U.K. distributors of FRAHM Resonant Reed Frequency meters and Tachometers.

Anders means meters

WW—005 FOR FURTHER DETAILS

OMRON PROCESS TIMERS

SYS TIMER

- ★ SYNCHRONOUS MOTOR & CLUTCH
- ★ 10 MILLION OPERATIONS
- ★ Instantaneous & Timed out 6 AMP contacts
- ★ Repeat Accuracy ± ½%
- ★ Dial ranges 0-10 secs up to 0-28 hrs. May also be used as impulse start

£11 dependent on quantity

NSY TIMER

- ★ 2 sets 5 amp changeover output contacts
- ★ 5 Million operations
- ★ Repeat accuracy ±½%
- ★ Set time can be altered whilst in operation

Dial ranges from seconds to hours

Approx. **£8.10.0** each dependent on quantity.

STP TIMER

SYNCHRONOUS MOTOR & CLUTCH
Matchbox size frontal area
Automatic re-set

- ★ PLUG-IN OCTAL BASE
- ★ INSTANTANEOUS AND TIMED OUT 2 AMP CONTACTS
- ★ RANGES 6 SECS TO 72 MINS

£6 dependent on quantity

TDS TRANSISTORISED TIMER

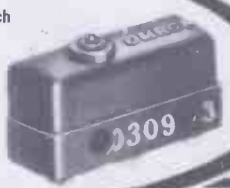
- ★ On/Off Signal Lamps fitted.
- ★ Instantaneous & timed out contacts.
- ★ Plug in Octal base.
- ★ Time Ranges up to 180 secs.

Approx. **£10** dependent on quantity

S-I-A

- ★ Sub-miniature Micro-Switch
- ★ 5 amp c/o contacts
- ★ Size less than 2cm x 1cm x 0.5cm

Approx. **3/2** dependent on quantity



IMMEDIATE DELIVERY OF LIMIT & MICRO SWITCHES
FLOATLESS LIQUID LEVEL CONTROLS, PROXIMITY SWITCHES

OMRON APPROVALS: CSA. US Mil Spec. SEV.UL

OMRON PRECISION CONTROLS

VARIABLE TRANSFORMERS

★ OUTPUT 0-260V ★ INPUT 230V 50/60CPS

I·M·O (ELECTRONICS) LTD.

★ SHROUDED FOR BENCH OR PANEL MOUNTING

Inset shows latest pattern Brush gear ensuring smooth continuous adjustment.

1 amp **£5.10.0**

2.5 amp £6.15.0 8 amp £14.10.0 12 amp £21.0.0
5 amp £9.15.0 10 amp £18.10.0 20 amp £37.0.0

50 AMP 0-24V DC L.T. SUPPLY UNIT

- ★ Continuously Rated.
- ★ Large Ammeter and Voltmeter.
- ★ Ideal for Plating Units.
- ★ Fully protected with Instantaneous cut-out & Fuse.
- ★ Infinitely variable up to 24V DC

Size and weight 16" x 12" x 27" High 70lbs. Rear wheels fitted for ease of handling.

£85 C&P (inland) £3.

20 AMP 24 & 12V DC L.T. SUPPLY UNIT

£35

C & P 40/-

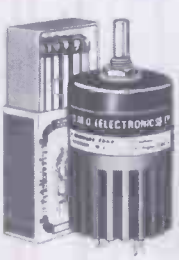
COMPLETE PHOTO-ELECTRIC SENSOR in one unit

- ★ REFLECTIVE TYPE WITH BUILT-IN LIGHT SOURCE
- ★ WILL ALSO OPERATE FROM REMOTE LIGHT SOURCE
- ★ MATCHBOX SIZE
- ★ SENSES ANY OBJECT— COLOURS, THICK SMOKE

Operates from 12 V.A.C. Output signal 0.2 amp. 100 V.

Approximately **£5.10.0** dependent on quantity

SOLID STATE VARIABLE VOLTAGE CONTROL



- ★ Output 25-240V
- ★ Input 240V 50 CPS
- ★ 5 amp & 10 amp models
- ★ Completely sealed

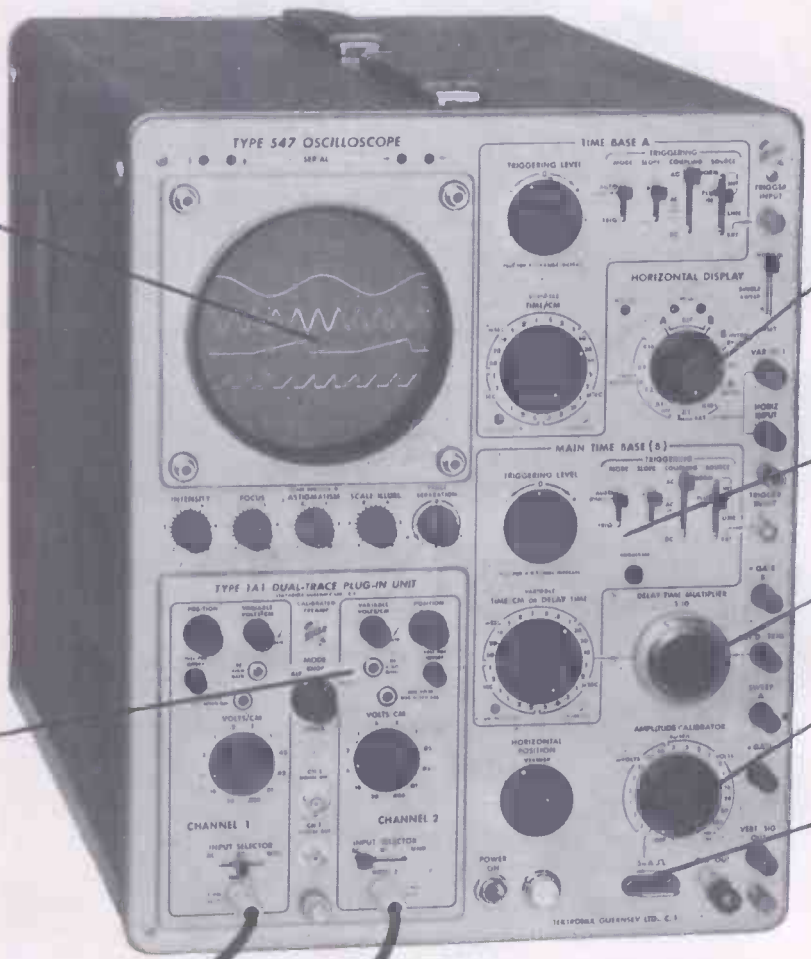
5 amp model **£8.7.6**

10 amp model **£13.15.0**

I.M.O. PRECISION CONTROLS
(Dept WWX) 313 EDGWARE ROAD, LONDON, W.2. TEL. 01-723 2232

WW—059 FOR FURTHER DETAILS

TEKTRONIX TYPE 547 VERSATILITY WITH AUTOMATIC DISPLAY SWITCHING



6 x 10 cm High-resolution Display, Bright Uniform Trace, Illuminated Parallax-free Graticule

25 Plug-in Units Vertical Display Switching up to 4 channels and Special Purpose, Differential, Spectrum Analyzers and Sampling

Horizontal Display Switching views two time scales simultaneously

DC—50 MHz Full Bandwidth Triggering

Calibrated Sweep Delay

0·2 mV to 100 V Square Wave Amplitude Calibrator

Current Probe Calibrator

Price:
£873 delivered U.K.
(without plug-in unit)

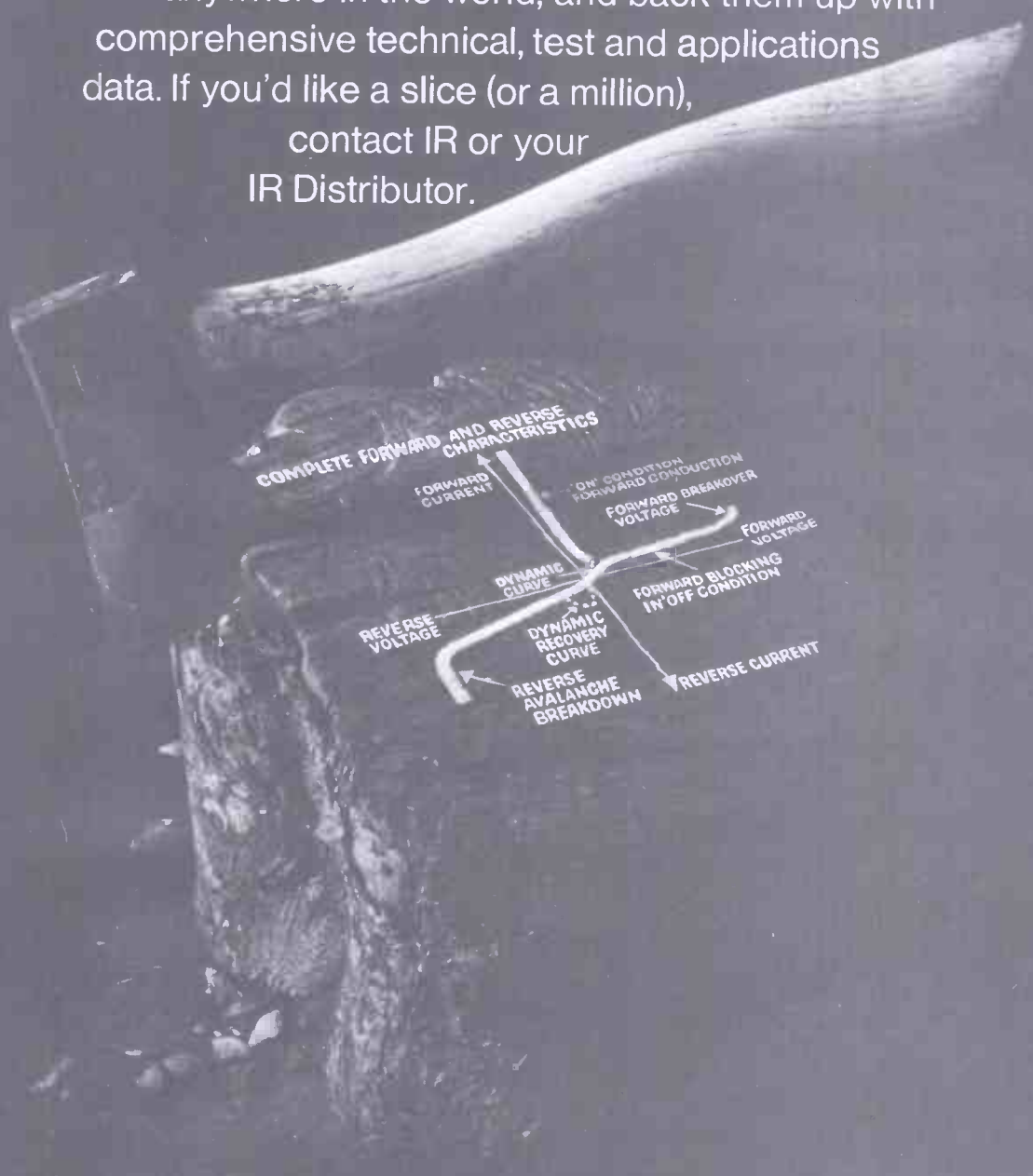
For detailed information on any of our products, please fill in reader reply card or write, telephone or telex.

Tektronix U.K. Ltd. *Beaverton House, P.O. Box 69, Harpenden, Herts.*
Telephone Harpenden 61251. Telex 25559

For overseas enquiries: **Australia:** Tektronix Australia Pty. Ltd., 80, Waterloo Rd., North Ryde, N.S.W. 2113 **Canada:** Tektronix Canada Ltd., Montreal, Toronto & Vancouver. **France:** Relations Techniques Intercontinentales, S.A. 91, Orsay, Z.I. Courtaboeuf, Route de Villejust (Boite Postale 13) **Switzerland:** Tektronix International A.G., P.O. Box 57, Zug, Switzerland. **Africa, rest of Europe, and the Middle East:** Tektronix Ltd., P.O. Box 36, St. Peter Port, Guernsey, C.I. *All other territories: Tektronix Inc., P.O. Box 500, Beaverton, Oregon, U.S.A.*

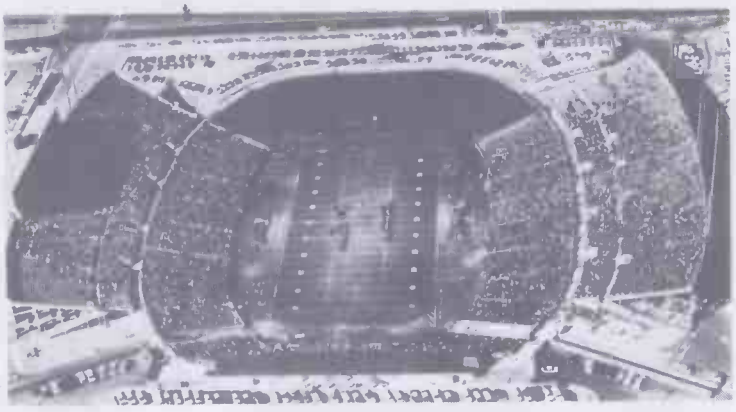
WW—060 FOR FURTHER DETAILS

A slice from the exclusive Thyristor range by IR—The Current Slicers. What IR don't know about thyristors isn't worth knowing. Which is hardly surprising, since IR are the world's largest independent manufacturers of power semiconductors. The world's largest. And often the cleverest too. IR offer you the reliable, high-performance, state-of-the-art thyristors you need, deliver them fast anywhere in the world, and back them up with comprehensive technical, test and applications data. If you'd like a slice (or a million), contact IR or your IR Distributor.



IR the current slicers

International Rectifier · Oxted · Surrey



You can depend on Altec sound

When it comes to selecting a sound system you want a lot of things. Loud and clear sound to the farthest corner. 100 per cent reliability. The most modern components. Proper installation. Back up from a company with experience. And a minimum cost. All that and more.

Altec sound systems have been selected by all types of users throughout the world. Large and small. Famous and not so famous. At indoor sports arenas. Outdoor stadiums. Fieldhouses and auditoriums. Concert halls and theatres. Airports. And all types of religious structures. Before you select your sound system, find out more about Altec.

Write for complete details and a free catalogue today.

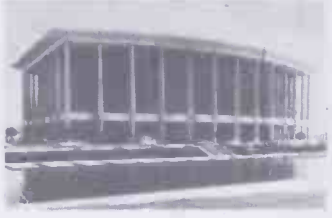
LTV Ling Altec Ltd., Baldock Road, Royston, Herts; or LTV Ling Altec, International Division, 1515 S. Manchester Avenue, Anaheim, California, U.S.A. 92803.

To reproduce and record realistic and crystal-clear sound, it takes good equipment. And that is where we come in with a complete line of products for the broadcast and recording industries.

- ☐ Monitor speaker systems—large and small.
- ☐ Speaker components.
- ☐ Power amplifiers—transistorized and even portable.
- ☐ Input equipment—including master studio control consoles, mixer-amplifiers and pre-amplifiers.
- ☐ Audio controls—including mixers, equalizers, attenuators and custom console components.
- ☐ A full line of professional and general-purpose microphones.

30 years of Altec experience is proof of quality performance in studios, concert halls, theatres, auditoriums and arenas throughout the world. You can depend on Altec—as a standard for performance, reliability and low operating expense.

Write for details to:
LTV Ling Altec Ltd., Baldock Rd., Royston, Herts; or LTV Ling Altec, International Division, 1515 S. Manchester Avenue, Anaheim, California, U.S.A. 92803.



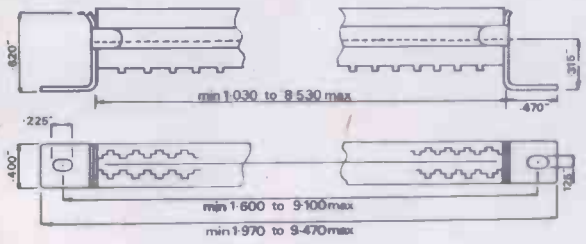
ALTEC LANSING

A Quality Co. of LTV Ling Altec, Inc.

ALTEC LANSING

A Quality Co. of LTV Ling Altec, Inc.

McMurdo's new 0.100" Pitch Connector - "RL" Series



5 to 85 way single sided with solder and printed wiring tails.
10 to 170 way double sided with solder and printed wiring tails.

Working Voltage	700 v. AC/Peak
Proof Voltage	1750 v. DC
Insulation resistance (dry)	10^6 Megohms min.
Contact resistance to test gauge	10 Milli-ohms max.
Insertion and withdrawal forces	6 oz. per contact max.
Contact finish	Flow tin or hard gold (specify when ordering)

Another new product from:
McMurdo Instrument Co. Ltd., Rodney Road, Portsmouth, Hampshire. Telephone: Portsmouth 35361. Telex: 86112.

mcmurdo
great facility for service

Member of the Louis Newmark Group, with access to the combined facilities of all other member companies.

Authorised Stockists:—**Lugton & Co. Ltd.**, 209/210 Tottenham Court Road, London W.1. Tel: 3261
I.T.T.—electronic services, Standard Telephones & Cables Ltd., Edinburgh Way, Harlow, Essex. Tel: Harlow 26777,
and agents in principal overseas countries.

QUAD 50 is a single channel 50 Watt amplifier designed for Broadcast, Recording and other applications in the Audio industry, completely proof against misuse and giving the highest quality of reproduction.

INPUTS – 0·5 Vrms unbalanced with provision for an optional plug-in transformer for bridging 600 ohms lines.
OUTPUTS – isolated providing 50 watts into almost any impedance from 4 to 200 ohms.
DIMENSIONS – $12\frac{3}{4}$" x $6\frac{1}{4}$" x $4\frac{1}{2}$"

Complete the coupon and post today.

Please send me full details of the QUAD 50 Amplifier

NAME .....

POSITION .....

COMPANY .....

ADDRESS .....

.....

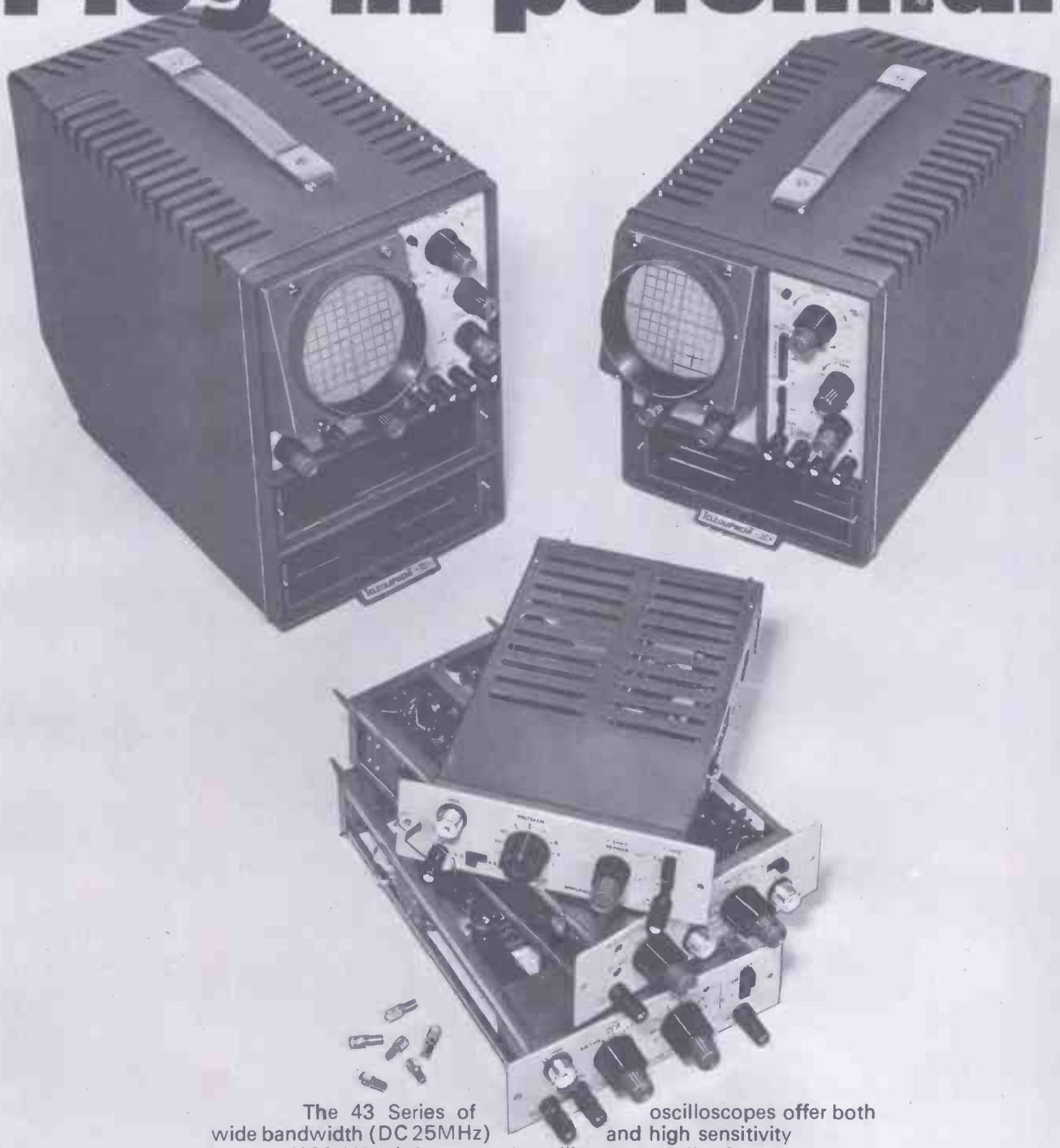
(BLOCK CAPITALS)

ACOUSTICAL MANUFACTURING CO. LTD.,
HUNTINGDON. Telephone: Huntingdon (0480) 2561/2

WW

QUAD
for the closest approach to the original sound

Plug-in potential



The 43 Series of oscilloscopes offer both wide bandwidth (DC 25MHz) and high sensitivity (100μV/cm) for general oscilloscope applications. With a choice of 7 plug-ins (5 amplifiers and 2 time bases) it is possible to assemble an oscilloscope capable of meeting almost any measurement requirement. Combining such versatility with excellent tube geometry and high writing speeds makes the D.43 illustrated outstanding value for money.

Write for full details Now ! !·!

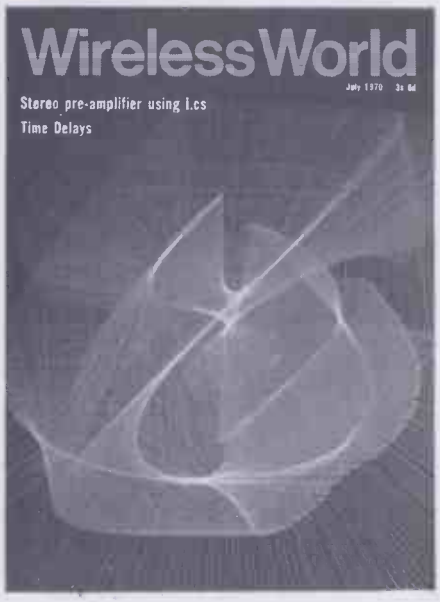
TELEQUIPMENT

Telequipment, 313 Chase Road. · Southgate · N.14. Telephone: 01-882 1166. Telex 262004

Wireless World

Electronics, Television, Radio, Audio

Sixtieth year of publication **July 1970** **Volume 76 Number 1417**



Our **cover picture** this month was selected on its artistic merits rather than to highlight any particular technical point. The design was produced by a Univac computer and graphic display unit as described on page 315.

IN OUR NEXT ISSUE

The first of a short series of articles on the design and construction of a **television wobbulator.**

Colour EVR. An outline of the system of colour electronic video recording developed by Dr. Goldmark of RCA.

Morse keyer using four m.o.s. logic circuits.

Contents

311 **"Together we stand. . . ."**

312 **Integrated Circuit Stereo Pre-amplifier** *by L. Nelson-Jones*

315 **Computer Graphics**

316 **Circuit Ideas**

317 **Time Delays** *by H. D. Harwood*

320 **Mechanical Filters for TV Receivers**

321 **15-20W Class AB Audio Amplifier** *by J. L. Linsley Hood*

325 **Electronic Building Bricks—2** *by James Franklin*

326 **News of the Month**

329 **Letters to the Editor**

332 **Sinusoidal Oscillator for use at High Temperatures** *by P. Williams*

333 **The Unijunction Transistor** *by O. Greiter*

336 **Crossword Puzzle**

337 **A Simple Op. Amp.** *by H. N. Griffiths*

338 **Conferences & Exhibitions**

339 **Noise in Transistors** *by F. N. H. Robinson*

340 **Domestic Video Records**

341 **Active-Filters—12** *by F. E. J. Girling & E. F. Good*

345 **H.F. Predictions**

346 **Coding Problems in Iterative Arrays** *by K. S. Hall*

349 **Roots and Responses** *by Thomas Roddam*

353 **Signal Monitoring Networks** *by A. E. Crump*

354 **Announcements**

355 **New Products at the I.E.A. Exhibition**

361 **World of Amateur Radio**

362 **Literature Received**

363 **Personalities**

364 **Real & Imaginary** *by "Vector"*

A89 **APPOINTMENTS VACANT**

A108 **INDEX TO ADVERTISERS**

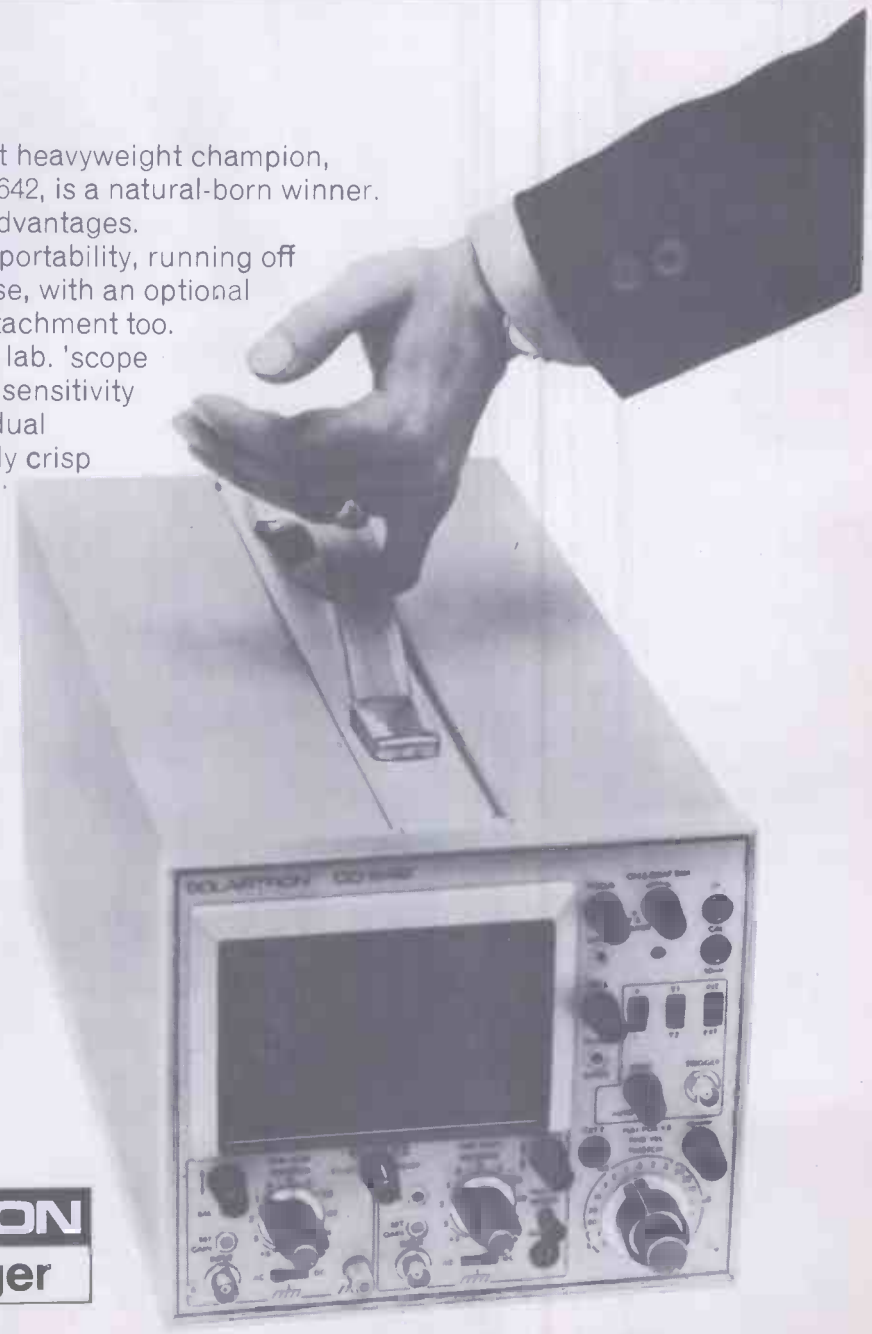
ibpa
International Business Press Associates

I.P.C. Electrical-Electronic Press Ltd
Managing Director: Kenneth Tett
Editorial Director: George H. Mansell
Advertisement Director: George Fowkes
Dorset House, Stamford Street, London, SE1

PUBLISHED MONTHLY (3rd Monday of preceding month). *Telephone:* 01-928 3333 (70 lines). *Telegrams/Telex:* Wiworld Bisnespres 25137 London. *Cables:* "Ethaworld, London, S.E.1." *Annual Subscriptions: Home;* £3 0s 0d. *Overseas;* 1 year £3 0s 0d. (*Canada and U.S.A.;* $7.50). 3 years £7 13s 0d. (*Canada and U.S.A.;* $19.20). Second-Class mail privileges authorised at New York N.Y. Subscribers are requested to notify a change of address four weeks in advance and to return wrapper bearing previous address. BRANCH OFFICES: *BIRMINGHAM:* 202, Lynton House, Walsall Road, 22b. *Telephone:* 021-356 4838. *BRISTOL:* 11, Elmdale Road, Clifton, 8. *Telephone:* OBR2 21204/5. *GLASGOW:* 2-3 Clairmont Gardens, C.3. *Telephone:* 041-332 3792. *MANCHESTER:* Statham House, Talbot Road, Stretford, M32 OEP. *Telephone:* 061-872 4211. NEW YORK OFFICE U.S.A.: 205 East 42nd Street, New York 10017. *Telephone:* (212) 689-3250.

The light heavyweight champion wins on points

Solartron's light heavyweight champion, the CD1642, is a natural-born winner. Look at its advantages. Fully transistorised portability, running off every power source you use, with an optional rechargeable battery attachment too. And you lose nothing in full-size lab. 'scope performance. It has 10 mV/cm sensitivity at 15 MHz, triggering to 25 MHz, dual trace, D.C.—15 MHz, brilliantly crisp displays and exceptional focus right to the edges. And to top it off, we AGREE test every machine for a week in the toughest conditions to assure top performance. So stop worrying about losing performance in the field. The CD1642 gets a load off your mind as well as your arm. Post the magazine's reply-paid card and we'll send you our data sheet of full details.

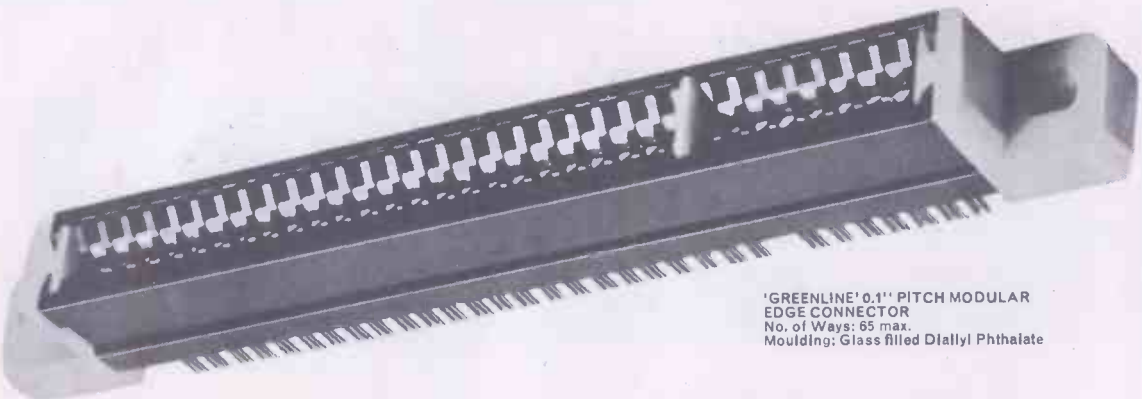


SOLARTRON
Schlumberger

The Solartron Electronic Group Ltd Farnborough Hampshire England Telephone 44433

WW—068 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

SUB-MINIATURE CONNECTORS
No. of Ways: 9, 15, 25, 37 and 50
Light alloy shell and base

CINCH

RADIO AND ELECTRONIC CONNECTORS

OPTIMUM-RELIABILITY COMPONENTS FOR HIGH-PRECISION ELECTRONIC APPLICATIONS

CARR FASTENER

CARR FASTENER CO. LTD. STAPLEFORD NOTTINGHAM Telephone 0602-39-2661 Telex 37637

the firm with the best connections

C50

WW—069 FOR FURTHER DETAILS

The professional one

Here it is, Solartron's outstanding 1240.

The multimeter that's not just a toy but a real step forward in instrument technology.

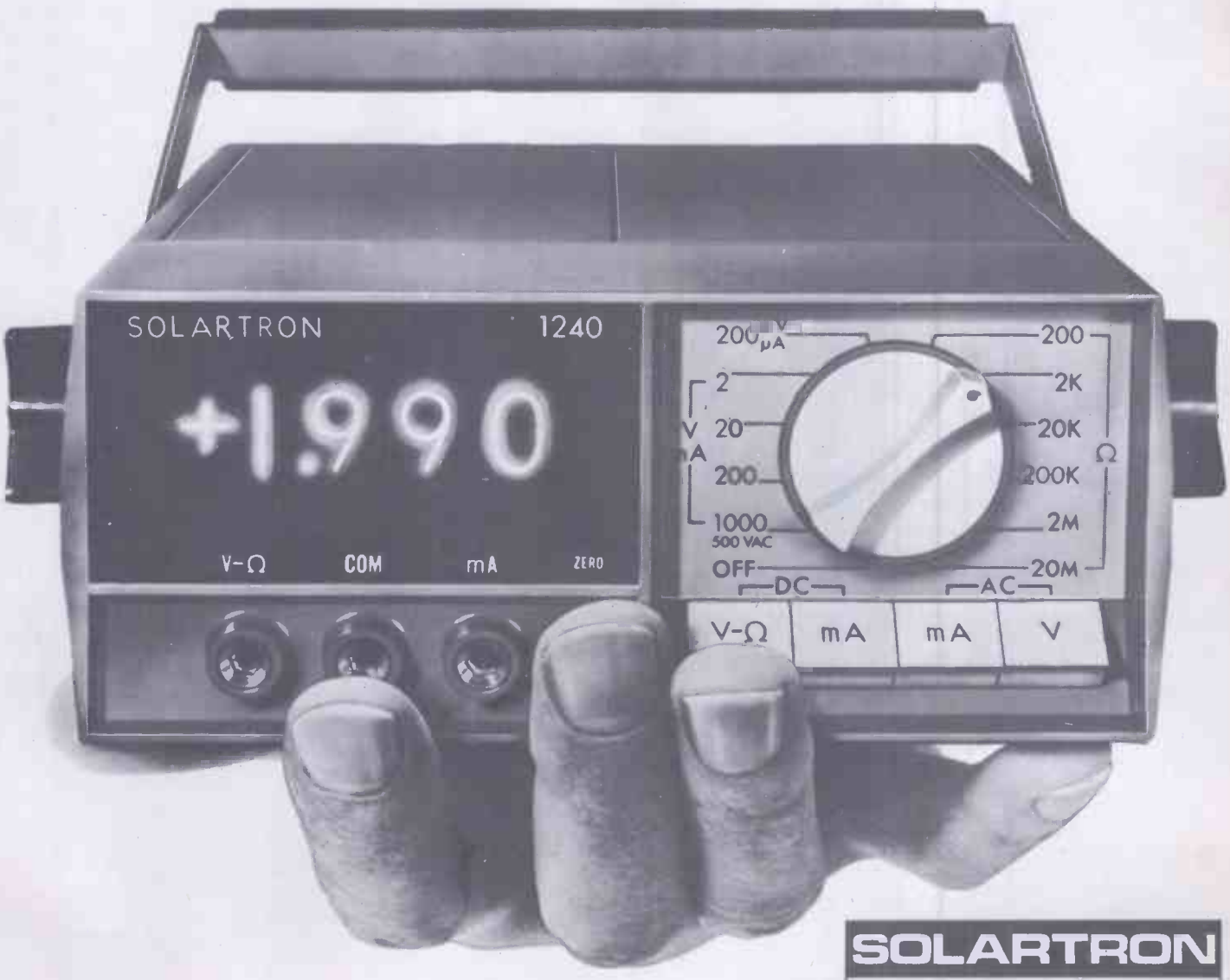
Now everyone can go digital!

You get Amps, Volts, Ohms – a.c. and d.c. – down to 100 microvolts and dual slope integration for noise rejection.

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.



SOLARTRON
Schlumberger

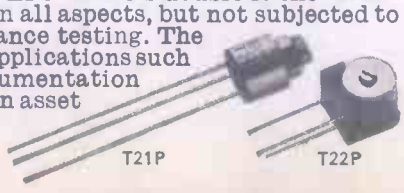
The Solartron Electronic Group Ltd Farnborough Hampshire England Telephone 44433

WW—070 FOR FURTHER DETAILS

The top performer in potentiometers...

has a double which costs less

Both operate from −55°C to +150°C. Both offer resistance range 50Ω to 20kΩ. Both are power rated 0·5W at 70°C. Both are well established products with proven reliability. Both come from Electrosil and were formerly products of M.E.C. Ltd. Add those two reputations together and you've got an unsurpassed combination. What's the difference, then? Well, one is the 'T20' series, a military version and is guaranteed to an exacting Electrosil specification based on DEF5124A. Its double is the **MT20P** ... precisely the same in all aspects, but not subjected to such intensive performance testing. The **MT20P** is suggested for applications such as computors and instrumentation where saving in cost is an asset to be considered.



Either way you get supreme reliability, the hallmark of anything Electrosil turn out. Each basic type is available in three alternative styles: printed circuit mounting top adjustment; p.c. mounting side adjustment; and panel mounting.

Write now for full details of Electrosil trimming potentiometers.

ELECTROSIL LIMITED, P.O. Box 37, Pallion, Sunderland, Co. Durham. Telephone Sunderland 71481. Telex 53273.

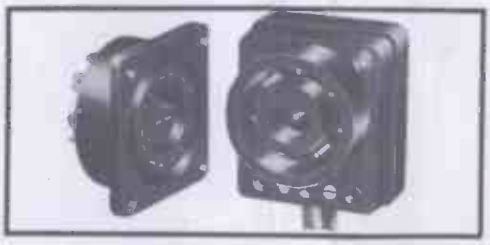
Electrosil LIMITED have the experience

WW—071 FOR FURTHER DETAILS

ARE YOU UP TO DATE WITH NEW PRODUCT DATA?

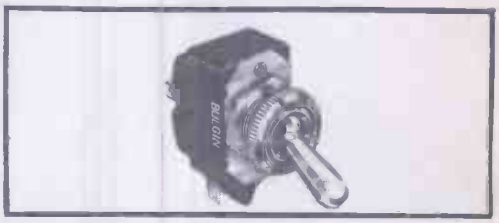
EIGHT POLE CONNECTOR

P.550 is a versatile 7-pole + Earth connector rated 6A. 250V. A.C. with both members designed so that when un-mated live parts are shrouded and safe to handle thus enabling use of both mains inlet and outlet applications. Of rugged, all moulded plastic construction with positive keying which prevents incorrect insertion. The Plug has screw Terminal connections, and the Socket tags accepting 187 series push-on-tabs. The advantages of this connector are obvious and the extra safety conscious design will appeal to all users.



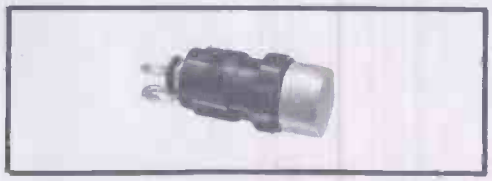
NEW D.P.M.B. MOULDED SWITCHES

The fine range of over 100 varieties of Moulded Insulation Switches is extended by these New D.P.M.B. contacting models. They are identical in size (except that two contacts and an insulation web are omitted), rating (2A. at 250V. A.C.) and performance to their well established D.P.C.O. counterparts; and are also dimensionally interchangeable with the obsolete laminated models which they are replacing. The complete range of D.P.M.B. operating means available are as follows: Toggle (illustrated right); Biased Toggle; Biased Push; Push-Push; Semi-Rotary; Key; and Slider.



NEW MINIATURE SIGNAL LAMP

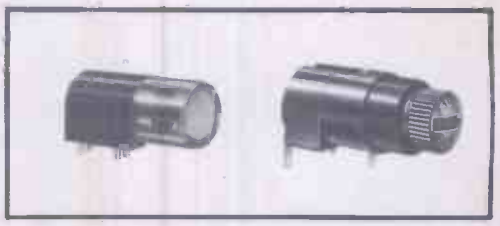
Now under development and shortly to go into production, is this New Sub-Miniature Signal Lamp (illustrated right at actual size). The T-I Sub-Miniature flange cap lamp is used and solder tags, isolated from the fixing, are provided for cable connection. The lens is available in five transparent or translucent colours, and fixing is by a keyed panel hole with a push or rear spring clip.



PRINTED CIRCUIT COMPONENTS

D.965-D.966 P.C. Signal Lamp, illustrated right, is available with two lens styles, flat (illustrated) on domed end, each in five transparent or translucent colours. Working Date: 30V. max., 1.5W. max., L.E.S. Lamps, mounting/contact pins on 0.1 x 0.3 centres. A new version is now under development for rear mounting.

F.330 P.C. Fuseholder, illustrated far right, accepts 5 x 20mm fuses. The screw-in cap is legended fuse with a coin slot to assist with removal. Provisional rating 250V. 5A max.



COMPETA INTERNATIONAL PRODUCTS

MINIATURE SLIDE SWITCHES

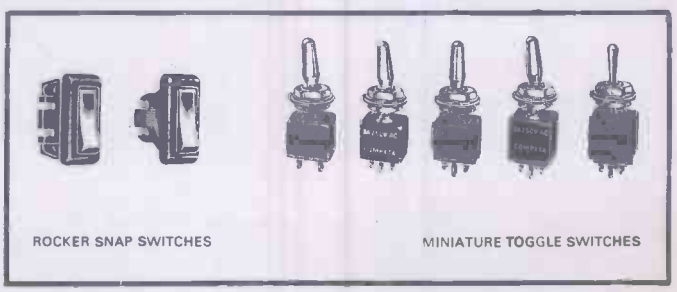
A new range of Miniature Printed Circuit Mounting Slide Switches of advanced design suitable for use in a wide variety of equipment. Switching covers 2, 4 or 6 pole types with a choice of momentary or locking push action. Contacts are fine silver or gold plated, all metal parts are corrosion proof, sliders and bases are phenolic mouldings and contact/fixing pins are designed for plug-in or dip-solder mounting.

MINIATURE TOGGLE SWITCHES

A range of high quality, Sub-Miniature Toggle Switches of proven technical excellence. All models are metal clad, have moulded insulation, silver plated contacts and solder tags and come complete with a lock-to-panel washer. The highly polished chrome operator can also be fitted with a choice of five coloured sleeves and switching is S.P.M.B., S.P.C.O., S.P.C.O. + centre off, D.P.C.O. and D.P.C.O. + centre off. Ratings are 3A. at 250V. A.C.

ROCKER SNAP SWITCHES

A range of Single-Pole on-off Rocker-Action Switches for all Voltages up to 250V. A.C. Mains, at up to 2 Amps. Moulded in Black or White with a wide range of coloured operators and screw terminal connections. Extremely reliable having Fine Silver contacts and light but positive snap action. Two types are available, rear nut or push fixing.



SEND FOR NEW PRODUCTS BROCHURE 1541/C

BULGIN

A. F. BULGIN & COMPANY, LIMITED

MANUFACTURERS OF ELECTRONIC COMPONENTS

BY-PASS ROAD, BARKING, ESSEX **01-594 5588**

WW—072 FOR FURTHER DETAILS

SSB

TRIO'S TS-510 ULTRA-ACCURATE RECEIVER

PS-510 **TS-510** **VFO-5D**

TRIO's TS-510 has opened countless SSB vistas through its creative design that enables it to operate at constant maximum power with top durability. This transceiver uses a high frequency crystal filter and covers all ham bands from 3.5-29.7 MHz. Because the TS-510's frequency coverage has been compressed to 25 KHz for one complete dial rotation, tuning in on SSB signals is easy. By using TRIO's PS-510 (Power supply and speaker) and VFO-5D (Variable frequency oscillator) optimum results may be obtained. The PS-510 operates on an AC power supply through a 6-1/2" speaker. The VFO-5D has a double-gear dial covering 25 KHz per rotation.

TS-510 SSB TRANSCEIVER
- Receive and Transmit Frequencies: 3.5 MHz-29.7 MHz
- Receive Sensitivity: 0.5 μV, S/N ratio of 10 dB at 2.5 MHz-21 MHz; 1.5 μV, S/N ratio of 10 dB at 28 MHz
- DIMENSIONS: 13"(W), 7"(H), 13-5/8"(D).

VFO-5D VARIABLE FREQUENCY OSCILLATOR
- Frequency Range: 3.5 MHz-29.7 MHz
- Oscillator Method: VFO unit-clapp Osc. Circuit Xtal Osc. Unit-Pierce C-B Circuit
- DIMENSIONS: 7-7/8"(W), 8-21/32"(H), 7-9/16"(D).

PS-510 POWER SUPPLY AND SPEAKER
- Designed as an A.C. power supply unit exclusively for the SSB transceiver TS-510
- 6-1/2" communication speaker is incorporated
- DIMENSIONS: 8"(W), 7-1/8"(H), 14-5/8"(D).

the sound approach to quality

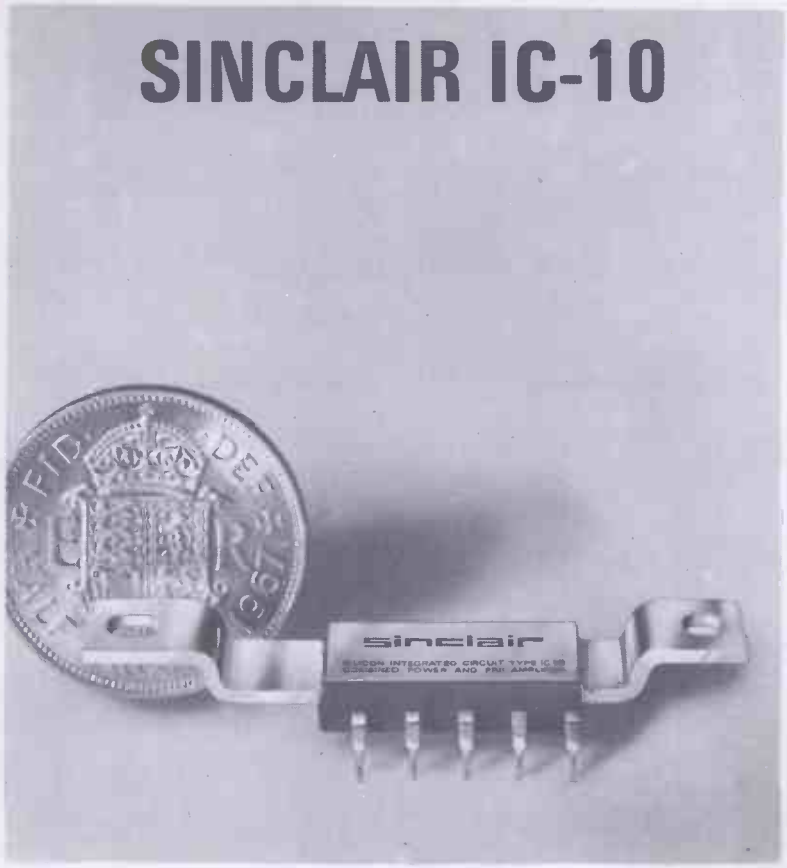
TRIO

TRIO ELECTRONICS, INC.

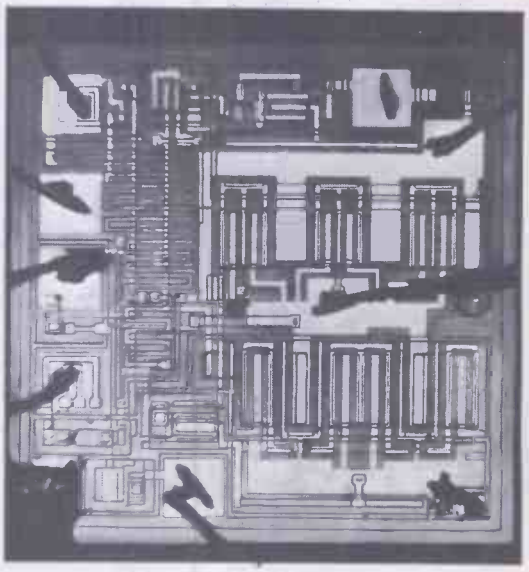
TRIO KENWOOD ELECTRONICS S.A.
160 Ave., Brugmann, 1060 Bruxelles, Belgium
Sole Agent for the U.K.
B.H. MORRIS & CO., (RADIO) LTD.
84/88, Nelson Street, Tower Hamlets, London E.1. Phone: 01-790 4824

WW—073 FOR FURTHER DETAILS

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.

■ 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**

MORE SINCLAIR DESIGNS ON PAGES FOLLOWING

sinclair

SINCLAIR RADIONICS LTD. 22 NEWMARKET ROAD, CAMBRIDGE
Telephone: 0223 52731

WW—074 FOR FURTHER DETAILS

Project 60

laboratory-standard high fidelity modules

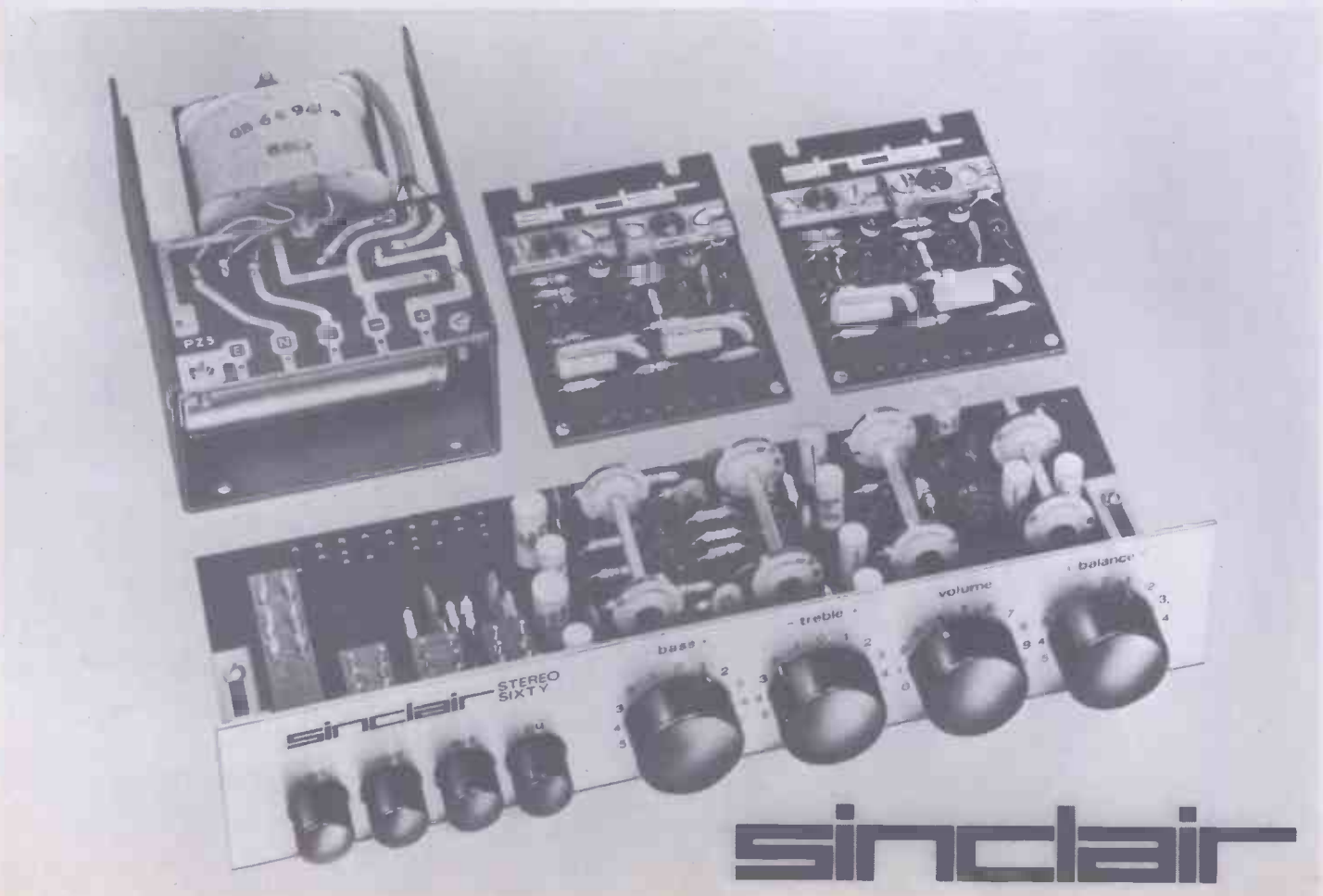
Sinclair Project 60 comprises a range of modules which connect together simply to form a complete stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare in overall performance. Now with the addition of three new modules to the range, the constructor has choice of assemblies with either 20 or 40 watts output per channel, with or without filter facilities.

The modules are: **1.** The Z-30 and Z-50 high gain power amplifiers, each of which is an immensely flexible unit in its own right. **2.** The Stereo 60 pre-amplifier and control unit. **3.** The Active Filter unit with both high and low audio frequency cut-offs. **4.** The PZ-5 and PZ-6 power supplies. A complete system could comprise, for example, two Z-30's, one Stereo-60, and a PZ-5. The P-Z6 is stabilised and should be used where the highest possible continuous sine wave rating is required. An A.F.U. may be added as required. In a normal domestic application, there will be no significant difference between using a PZ-5 or PZ-6 unless loudspeakers of very low efficiency are being used, in which case the PZ-6 will be required. For assemblies using two Z-50's there is the new PZ-8 stabilised supply unit to ensure maximum performance from these more powerful amplifiers.

All you need to assemble your Project 60 system is a screwdriver and 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. Project 60 modules have been carefully designed to fit into virtually all modern plinth or cabinets and only holes need be drilled into the wood of the plinth to mount the control unit and the A.F.U. Any slight slip here will be covered by the aluminium front panels of these two units.

The Project 60 manual gives all the building and operating instructions you can possibly want, clearly and concisely. Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future as the latest additions to the range show. A stereo F.M. tuner is next to come. These and all other modules we introduce will be compatible with those already available and may be added to your system at any time. And because Sinclair are the largest producers of constructor modules in Europe, Project 60 prices are remarkably low.

SINCLAIR RADIONICS LIMITED · 22 NEWMARKET ROAD CAMBRIDGE · Telephone 0223 52731

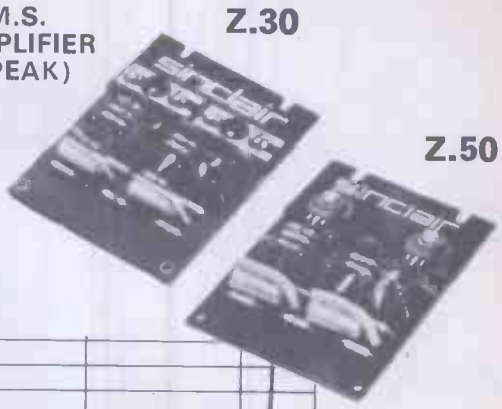


sinclair

WW—075 FOR FURTHER DETAILS

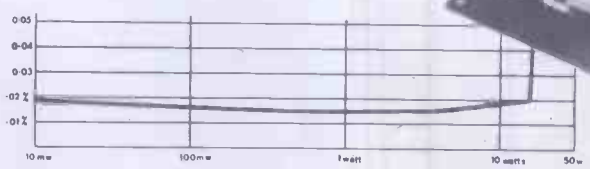
Z.30 20 Watt R.M.S. POWER AMPLIFIER (40 WATTS PEAK)

Z.50 40 WATT R.M.S. POWER AMPLIFIER (80 WATTS PEAK)



The Z.30, together with the higher powered Z.50 are both of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use the Z.30 or Z.50 power amplifiers in your Project 60 system will depend on personal preference. But they are both the same physical size and may be used with other units in the Project 60 range equally well. The Z.30 is unique in that it may be used with any power source between 8 and 35 volts without need for adjustment and may thus be driven from a car battery for example. For operating from mains, for the Z.30 use PZ.5 power supply unit for most domestic requirements, or P.Z.6 if you have very low efficiency loudspeakers. For Z.50, use the PZ.5, PZ.6 or PZ.8 described below.

Power versus distortion curve for Z.30 and Z.50



SPECIFICATIONS

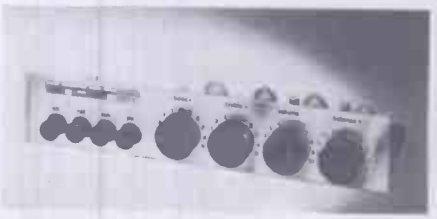
Power Outputs Z.30 15 watts R.M.S. into 8 ohms, using 35 v.. 20 watts R.M.S. into 3 ohms using 30 volts.
Z.50 40 watts R.M.S. into 3 ohms: 30 watts R.M.S. into 8 ohms, both continuous, operating on 50 v.
Frequency response—30 to 300,000 Hz ±1dB
Distortion 0.02% into 8 ohms
Signal to noise ratio better than 70dB unweighted
Input sensitivity 250mV into 100 K ohms
For speakers from 3 to 15 ohms impedance
Size 3½in. x 2½in. x ½in.

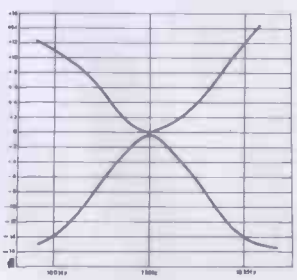
Z.30 Built, tested and guaranteed, with manual **89/6**

Z.50 Built, tested and guaranteed, with manual **109/6**

STEREO 60 Pre-amp Control Unit

The Stereo 60 is a stereo preamplifier and control unit designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout and great attention has been paid to achieving a really high signal-to-noise ratio and excellent tracking between the two channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs. The tone controls are also very carefully designed and tested.





Treble and bass cut and boost curves

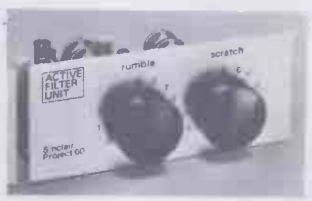
SPECIFICATIONS FOR STEREO 60

- Input sensitivities—Radio—up to 3mV Magnetic P.U.—3mV: correct to R.I.A.A. curve ± 1dB; 20 to 25,000 Hz. Ceramic P.U.—up to 3mV. Aux.—up to 3mV.
- Output—250mV.
- Signal-to-noise ratio—better than 70dB.
- Channel matching—within 1dB.
- Tone Controls—TREBLE +15 to —15dB. at 10 kHz: BASS +15 to —15dB at 100 Hz.
- Front panel—brushed aluminium with black knobs and controls.
- Size 8¼ x 1½ x 4 ins.

Built, tested and guaranteed **£9.19.6**

ACTIVE FILTER UNIT

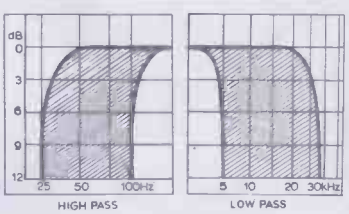
The purpose of the filter unit is to reject frequencies *above* (scratch) or *below* (rumble) a specific cut off frequency when they contain unwanted interference. The Sinclair A.F.U. is unique in that the cut off frequency is continuously variable for both the scratch and rumble units and, as the attenuation in the rejection band is rapid (12dB per octave), the removal of interference can be achieved with less loss of the wanted signal than has previously been possible.
Each channel has an overall gain of unity and the unit may be connected between the pre-amplifier and power amplifier sections of any system. Both amplitude and phase distortion have been made quite negligible by careful design and generous negative feedback employed.



SPECIFICATIONS

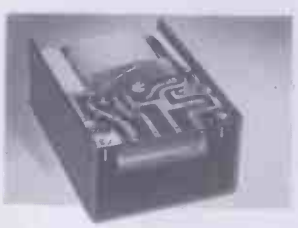
Employs two Sallen & Key type active filter stages, one rumble (high pass) and one scratch (low pass)
The two stages use complementary transistors to minimise distortion.
Supply voltage 15 to 35 V Current 3mA max.
Gain at 1 kHz, filters flat 0.98 (—0.2dB)
H.F. cut off (—3dB) variable from 28kHz to 5kHz at 12dB/octave
L.F. cut off (—3dB) variable from 25Hz to 100Hz at 12dB/octave
Distortion at 1 kHz (35V supply) 0.02% at rated output

Built, tested and guaranteed **£5.19.6**



BUILDING A PROJECT 60 ASSEMBLY

The illustration here shows quite clearly how easily Project 60 can be contained in one of today's slim, modern plinths. Very little space is required to house these Sinclair units, and within the space of the motor plinth, you can install a stereo amplifier of the very highest quality. If, for example you have already put together an assembly as illustrated here, adding the Active Filter Unit would be very easy.



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..... £4.19.6
PZ-6 35 volts stabilised—ideal for driving two Z.30's and a Stereo 60 when very low efficiency speakers are employed £7.19.6
PZ-8 45 volts stabilised power supply unit for use with Z-50 amplifiers (less mains transformer) £5.19.6
PZ-8 Mains Transformer £5.19.6

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 services thereafter. No charge for postage by surface mail. Air-mail charged at cost.

sinclair

SINCLAIR RADIONICS LIMITED, 22 NEWMARKET ROAD, CAMBRIDGE Tel 0223 52731

To: SINCLAIR RADIONICS LTD., 22 NEWMARKET RD., CAMBRIDGE

Please send .....

.....

.....

.....

.....

for which I enclose cash/cheque/money order

NAME .....

ADDRESS .....

.....

.....

..... WW770

WW—076 FOR FURTHER DETAILS

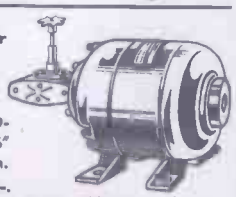
Electro-Tech Sales

NEW HYSTERESIS MOTORS BY WALTER JONES. Type 14050/12, 240v. 50 c/s 1500 RPM cont. rating, output 2.0 oz./in. Size: Length (less spindle) 3¼". Width 2½"×2¼". Spindle 1"×3/16". Weight 3 lb. Maker's price in region of £22.10.0. Our price £6.10.0. each.

NEW "CROYDON" 240v. A.C. reversible motors. Choice of 1/50th HP, 1,500 RPM, or 1/100th HP 750 RPM (identical in appearance). Size 3⅜" high × 5" long plus spindle 1⅜"×¼" dia. A beautiful motor at less than half maker's original price. £6.10.0 each.

"Parvalux" Reversible 100 RPM Geared Motor

Type S.D.14, 230/250v. A.C. 22 lb./in. Standard foot mounted, variable angle final drive. Removable 9-tooth chain spiggot on 3/16" spindle. 1st class condition. £7.10.0 each. P. & P. 10/-. Also limited number only as above. Without spiggot. Brand New. £12.10.0 each. P. & P. 10/-.



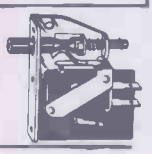
NEW "CARTER ELECTRIC" 12 r.p.m. MOTOR.—Non-reversible, ¼" spindle. 240v. A.C. Open frame with cast aluminium cased gearbox. Stoutly constructed. Approx. 25 lbs./in. Overall size (approx.) 3"×3"×4" plus spindle. 45/-. P. & P. 5/-.

English Electric ½ h.p. Motors. 240v. single-phase, standard foot mounted, 1,425 r.p.m., continuous rating. £4.15.0. Carriage 20/-.

Isolation Transformers. By Majestic Winding Co. 1 to 1 ratio. 240v. Input, 240v. centre tapped out, at 2K.V.A., mounted in metal case measuring 8¾"×8¾"×11" high. Weight 65lb. £16.10.0. Plus £1.10.0 carriage.

GENERAL ELECTRIC "TELETYPE". 115v. 50 cps. Synchronous motor, 3,000 RPM, double ended 5/16" spindle. These motors are precision built to a very high standard, silent running, continuous rating, drawing 70 watt on run. Original cost is believed to be in region of £25 each. We are offering these Brand New at 45/- each.

"HONEYWELL" TYPE 23AC-NE—15 amp. change-over switch is fitted on angled metal mount with spring loaded plastic rod operating cam. 10/- each.



"HONEYWELL" V3 SERIES.—Flush micro-switch 10 amp. c/o. The side panel is insulated. End-plate size: 2"×⅝". 36/- per doz.

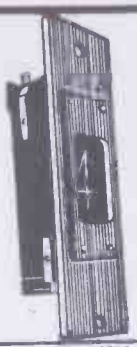
OMRON MICRO SWITCH. Type VV—15—1A. Single c/o 10 amp. at 250v. 1⅛"×⅝"×⅜". 30/- per dozen.

"HONEYWELL" MICROSWITCH.—Single and double bank, manual-push. Ideal for vending machines, etc. Each bank comprises a change-over rated 15 amps. 240v. A.C. The through-panel mounting assembly is in heavy polythene surmounted by black knob. Neck dia. ⅝". Single 10/- each. Double 15/- each. Also few only 3 bank. 20/- each.

"GOYEN" PRESSURE SWITCH.—Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. ½ p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube ⅛" dia. Projection 11/16". Overall size: dia. 3½", depth 2" plus 11/16" (air tube). 25/-.

"BONNELLA" 15 AMP. 240v. TOGGLE SWITCHES.—Single pole change-over, ¼" Long Dolly. Standard single hole mounting. 30/- per doz. (minimum ½ doz.).

THORN DIGITAL INDICATOR. A modular unit easily read through a wide angle of view even under bright lighting. 12 characters, 0 to 9, decimal point and minus sign. Characters 13/16" high on acrylic, edge-lit by 1 watt midget lamp. Front panel 4¾"×1⅜", depth overall 1", matt black finish. Supplied with 12 lamps. Choice of the following ratings—6v. .1A. or 12-14v. .08A. £4.0.0 each, spare lamps 24/- per dozen.



Welwyn high value Resistors Type GA 36501. Values between 9.4 and 10.9 kilo-meg ± 1%, glass encapsulated 15/-.

"WELWYN" RESISTORS.—Type H12. One value only. 1 kilo-meg ±20%. 5/- each. (Minimum order 2.)

SPECIAL OFFER. Enclosed Relay, complete with base. Brand New. Type MQ308 600Ω 24v. 4 c/o. Size 1½"×1½"×¾", £5 per dozen. 12/- each.
Type MQ508 10,000Ω 100v. 4 c/o. £5 per dozen. 12/- each.
Type MQ108 40Ω 6v. 4 c/o. £6 per dozen, 13/6 each.
Type MQ208 150Ω 12v. 4 c/o. £6 per dozen. 13/6 each.

SPECIAL SUMMER OFFER

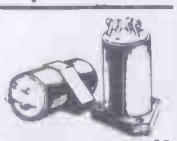
LIMITED PERIOD ONLY FROM NOW UNTIL 31st JULY 1970. DISCOUNT OF 15% (3/- in £1) WILL BE DEDUCTED ON ALL ORDERS OF £3 AND OVER.

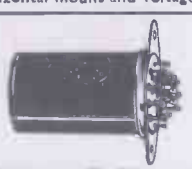
NEW "F.I.R.E." PLUG-IN RELAY.—115v. Coil 50/60 c.p.s. 3 heavy duty silver change-over contacts. Very robust. 17/6.

NEW DIAMOND "H" 240v. A.C. RELAY.—3 heavy duty silver change-over contacts. 17/6.

SEIMENS HIGH SPEED RELAY, Type 89L. 1,700Ω + 1,700Ω coil. New 15/- each.

MINIATURE "LATCH-MASTER" RELAY 6, 12, or 24v. D.C. operation. One make one break, contacts rated 5 amps. at 30v. Once current is applied, relay remains latched until input polarity is reversed. Manufactured for high acceleration requirements by Sperry Gyroscope Co. Size: Length ⅞", dia. 9/16" (including mount). Please state vertical or horizontal mount and voltage. £2.5.0 each.





DIAMOND "H" SEALED RELAY Type. BR 115 C.I.T.—1C 26v. 150Ω 4 P.D.T. Completely encapsulated in heavy gauge brass case, glass sealed terminals, very robust. 17/6 each.

K.L.G. Sealed Terminals. Type TLSI AA, overall length 11/16", box of 100, 25s. Type TLSI BB, overall length 1", box of 100, 35s.

CENTRIFUGAL BLOWER BY AIR CONTROL LTD. 240v. AC. 9" dia. 2,850 RPM. 1/10th HP. Ideal for organ blowing, powerful, low noise level. 1st class condition. Photo on request. £12.10.0. Carriage £1.

GARDNERS AUTO-TRANSFORMERS. 110/115/200/250v. 1500 watts. Weight 23lb. Few only. £10.10.0. P. & P. 25/-.

GARDNERS CASTLE SERIES. Isolation transformer type CAS 934. 240v. fused. Primary 24v. 4½ amps. out. These units are constructed for outside use with fitted 5' mains lead and 3 socket outlet with plug supplied. Brand New. Makers price £7.18.6. Other price £4.15.0. P. & P. 15/-.

WE WELCOME OFFICIAL ORDERS FROM ESTABLISHED COMPANIES, EDUCATIONAL DEPTS., ETC.

BRAND NEW "KLAXON" GEARED MOTORS. 230/250v. 250 r.p.m. Cont. 45lb./in. Few only. £25.0.0. Carriage £1.10.0.

POWER SUPPLY UNIT. 240v. A.C. To 112 or 125 D.C. at 3 amps. Ripple at 3 amps less than 500 millivolts. Output resistance 5Ω. Size 15"×9⅜"×7" high. Weight 44lb. £8.10.0. C. & P. £1.10.0.

SYLVANIA MAGNETIC SWITCH—a magnetically activated switch operating in a vacuum. Switch speed—4ms. temperature −54 to + 200° C. Silver contacts normally closed rated 3 amps. at 120v. 1.5 amp. at 240v. 10/- each. 80/- per dozen. Special quotations for 100 or over. Reference Magnets available 1/6 each.

SYLVANIA CIRCUIT BREAKERS gas filled providing a fast thermal response between 80° and 180°C. Will withstand pressures up to 2,000 lb. sq./in. rated 10 amp. at 240v. continuous. Fault currents of 28 amps. at 120v. or 13 amp. at 240v. silver contacts. Supplied in any of the following opening temperatures (degs. cent.) 80, 85, 95, 100, 105, 110, 120, 125, 130, 135, 140, 145, 150, 155, 160, 170, 175, 180. 10/- each or 80/- per dozen.

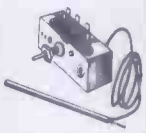
ATLAS SUB-MINIATURE LAMPS type L1122 and L1123—a high efficient light-source with excellent light-output and low power demand. Ratings 5v. 60 ma. .35± 25% lumens. Life expectancy 60,000 hours or at 6 v. 70 ma. .75± 25% lumens 5,000 hours. Dimensions: Uncapped 6.3 × 3.1 mm. leads 12.7 mm. capped 9.1 × 3.1 mm. Ideal for instrument lighting normally sold in excess of 12/- each, our price 30/- per dozen or boxes of 50 at £5 per box.

ATLAS MIDGET PANEL LAMPS unrivalled for indication purposes requiring a brilliant but tiny light source. Available with flange cap or wire ended in the following ratings: Capped: 6v. .1A and 12-14v. .08A. Uncapped: 4v. .25A., 6v. .1A., 6v. .2A. 24/- per dozen or boxes of 50 at £4 per box.
INDICATOR LAMP HOLDERS AND CAPS for MIDGET PANEL LAMPS (as above) available red, green, blue, 2/6 each (complete) minimum order 4 units.

"DECCO" MAINS SOLENOID.—Compact and very powerful. 16 lb. pull. ⅜" travel which can be increased to 1" by removing captive-end-plate. Overall size 2"×2¼"×2¼" high. 35/-. P. & P. 5/-.

New "Magnetic Devices" solenoid 240v. A.C. Type 42117, 1 to 3 lb. pull, frame size 1½"×1¼"×1". 20/- each.

"TEDDINGTON" CONTROLS THERMOSTAT.—Adjustable between 75° and 100°C. A further internal adjuster takes the maximum up to 120°C. Circuit cuts in again at 3° below cut-out setting. 42" capillary and sensor probe. The thermostat actuates a 15 amp. 250v. c/o switch. A second single pole on/off switch is incorporated in the adjustment mechanism. 17/6.



New 75-0-75 Micro-ammeter by Sifam. 750 ohm movement, clear reading, 5μa divisions × ⅛"; plastic front, projection ½" (tapering forward). Size: 4½"×3¼", 57/6 each.

Ernest Turner 5"×4" 0-1 Ma. meter calibrated 0-10 in 50 divisions mirrored scale, handsome chrome escutcheon for flush mounting. A quality instrument. £6.10.0.

MINIATURE B.P.L. 500-0-500 Micro-Ammeter. 13/16" Diam. scale. Through-Panel mounting. Hermatically sealed. 45/-.

TRIMPOTS. "Painton" Types: 200S-1-502 5KΩ; 200S-1-103 10KΩ; 200S-1-501 500KΩ; 200S-1-503 50KΩ; 224P-1-202 2KΩ; 224S-1-102 1KΩ; 200S-1-203 20KΩ; 275-1-252 2.5KΩ. "Ril" Type: 321 10KΩ. "Morganite" Type: 80 1KΩ. "Mec" Type: 025 (tubular) 200Ω; T20P 50Ω. All types 12/- each.

GARDNERS CHOKES. Type C237: 20H 180MA 30/- P. & P. 5/-. Type C570: 0.05H 3.5A 35/- P. & P. 5/-. Type C549: 0.1H 2.5A 20/- P. & P. 5/-. Type C271: 5H 500MA 37/6 P. & P. 7/6. Type C576: 0.05H 7.5A 50/- P. & P. 10/-. Type C527: 0.5H 4A 50/- P. & P. 10/-. Type SK7486: 35 MH 3A D.C. 30/- P. & P. 5/-. Type F9719: 25H 60MA 8/6 P. & P. 3/6.

"KNOWLE" (U.S.A.) MINIATURE MICROPHONE CAPSULES. Impedance 2000Ω. Output about 100dB at 1 KC (Type A). As above, but output 60dB (Types B & C), as used in miniature hearing-aids, bugging devices, etc. All tested. 20/- each.
Also **"KNOWLE" M/C SUB-MINIATURE EAR TRANSDUCERS.** Type 1530. Size 7/16"×7/32"×⅛" thick. 15/- each.

WHERE NO CARRIAGE CHARGE IS INDICATED PRICE IS INCLUSIVE. PERSONAL CALLERS WELCOME.

ELECTRO-TECH SALES

BUSINESS HOURS: 9.30-6 (1 p.m. Sats.)

264 PENTONVILLE ROAD, LONDON, N.1
(ONE MIN. FROM KINGS X STATION) Tel. 01-837 7401

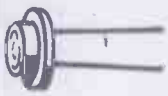
OPTOELECTRONICS from PROOPS

New Science Projects combine fascination of Optics with Electronics.

PHOTOCONDUCTIVE CELLS

CADMIUM SULPHIDE CELLS (Cds)

Inexpensive light sensitive resistors which require only simple circuitry to work as light triggering units in a wide range of devices, such as: flashing or breakdown lights, exposure meters, brightness controls, automatic porch lights, etc. Not polarity conscious — use with A.C. or D.C. Spectral response covers whole visible light range.



MKY101-C

Epoxy sealed, ⅜ in. diam. x ⅛ in. thick. Resistance at 100 Lux – 500 to 2,000 ohms. Maximum voltage 150 A.C. or D.C. Maximum current 150 mW. **10/6** *post free*

MKY71

Glass sealed with M.E.S. base, Glass envelope ⅝ in. diam., overall length 1 in. Resistance at 100 Lux – 50 Kohms to 150 Kohms. Maximum voltage 150 A.C. or D.C. Maximum current 75 mW. **8/6** *post free*

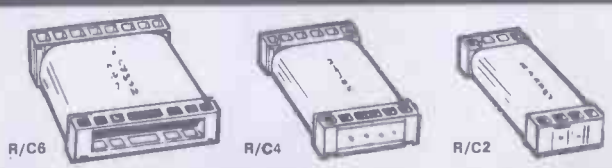
PHOTOGENERATIVE CELLS

Selenium cells in which light energy is converted into electricity directly measurable on microammeter or used with amplifier as light trigger for alarm and counting devices, luminous fluxmeters, exposure meters, colorimeters, etc., Spectral response covers visible light range.

Type 1—1½ x 1⅛ in. Output 1 mA at 0.6 volts at 1,000 Lux **5/-** *post free*

Type 3—100 x 50 mm. Output 4 mA at 0.6 volt at 1,000 Lux **22/6** *post free*

REED SWITCH COILS & CAPSULES



R/C6 R/C4 R/C2

Compact assemblies of reed switches and operating coils that permit the design of an infinite variety of multiple switch circuits in an extremely small space. They eliminate the bulk and open contact disadvantage of electro-mechanical relays; hermetically sealed contact isolation ensures longlife reliability. Small enough to combine with solid-state components on printed circuit boards. Ideal for switching matrices, binary kits, control systems, etc. These were removed intact from highly expensive computer mechanisms and are guaranteed to be in perfect working order. Each capsule consists of a rare-metal screened, 24 volt DC operating coil on a nylon former with one detachable end for the removal and replacement of reed switches.

Types available:

R/C2 Two reed switches, contacts normally open. Size overall: 1½ x ⅝ x ⅜ in. **5/-** *post free*

R/C4 Four reed switches, contacts normally open Size overall: 1½ x ⅝ x ⅜ in **10/-** *post free*

R/C6 Six reed switches, 4 contacts normally open, 2 normally closed. Size overall: 1½ x 1½ x ⅜ in. **15/-** *post free*

RCA TRIAC — CA40432 45/- *post free*

Suitable for light dimming and motor control circuits

Gate-controlled, full-wave, A.C. silicon switch with integral trigger that blocks or conducts instantly by applying reverse polarity voltage. Suitable for A.C. operation up to 250 volts; controls currents up to 1440 watts. Size only ⅜ in. diam. x ⅞ in. high. **Complete with heat sink, data and applications information.**

CONTROL THERMISTOR

Type A25 by STC retained on 1 x 1½ in. paxolin board with solder tags and mounting lug with captive screws. Bead type thermistor is contained in 1 in. long x 5/32 in. diam. gas filled glass bulb and is particularly suitable for amplitude control, timing devices, current surge suppression, etc. Safe power dissipation, 60 mW. Sensitivity 3.5°C/mW. Maximum temperature – Ambient 150°C, – Bead 300°C. Resistance at 20°C: 200,000 ohms. Average dissipation at 60 mW in free air at 20°C: 575 ohms. Usual price 15/9 each. **Brand new. Special bargain offer: 5 for 15/- post free.**

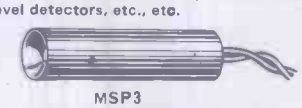
POWER TRANSISTOR HEAT SINKS

Heavy gauge aluminium extrusions with fitment for one pair of power transistors. Size overall: 4 x 3¾ x 1½ in. high. Base is 3/16 in. thick and ready punched to accept all standard types. Seven cooling fin surfaces ensure adequate heat dissipation. **Brand new. Special offer: two for 12/6 post free.**

INFRA-RED TRANSMITTERS & RECEIVERS

Unique devices in a brand new electronic field that can be exploited in a wide range of applications. Miniaturized construction and solid state circuit design is combined with outstanding modulation and switching capabilities to provide infinite possibilities as short distance speech and data links, remote relay controls, safety devices, burglar alarms, batch counters, level detectors, etc., etc.

MGA 100 **35/-** *post free*



MSP3 **85/-** *post free*

GALLIUM ARSENIDE LIGHT SOURCE—MGA 100

Filamentless, infra-red emitter in a robust, sealed cylinder coaxial with beam to facilitate optical alignment and heat sinking.

MAX RATINGS

Forward current I_F max. D.C.....400mA. Forward peak current I_F max.* (pk).....6A*
Power dissipation.....600mW. Derating factor for T_{amb} greater than 25°C.....7.5mW/°C.*
Reverse voltage V_R max 1-0V.
**When mounted on an aluminium heat sink 1 in. x ½ in. x ⅛ in.*

INFRA-RED PHOTO RECEIVER — MSP3

Ultra sensitive detector/amplifier for infra-red (Gallium Arsenide) or visible light optical links reception. Spectral response 9500 A. Robust, cylindrical package is coaxial with incident light to facilitate optical alignment and heat sinking.

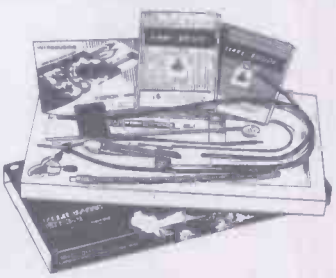
MAX RATINGS

Total dissipation (in free air, T_{amb} = 25°C.).....100mW. Derating Factor.....2mW/°C.
Output Current Intensity.....100mA. Voltage.....25V. Operating Temperature.....from —30° to +125°C.

Supplied complete with suitable lenses, full Technical Data and Application Sheets, including Line of Sight Speech Link.

FIBRE OPTICS

Highly flexible light guides that transmit light to inaccessible places as easily as electricity is conducted by copper wires. Fibre optics make it possible to control, miniaturize, split, reflect or transfer light from one source to many places at once, and to operate photo devices, logic circuits, or illuminate in ways never before possible. Proops offer both glass fibre optics or inexpensive Crofon plastic fibres for hundreds of experiments or serious applications in a fascinating new science.



RANK TAYLOR-HOBSON ENGINEERS KITS

Basic fibre optic components that demonstrate new ways of employing light in serious applications. Two kits are available: each contains high-grade glass-fibre light guides consisting of thousands of fibres tightly bundled in flexible sheaths with ferruled, optically polished ends, together with connecting and light source components. Each is supplied complete with card wallets containing technical and application data.

KIT 1 **£16** *Post free*

Contains: 1.5 mm. x 24 in., 3 mm. x 18 in., and 6 mm. x 12 in. light guides, plus 24 in. long x 2 exit component for punched card or coding applications. Also battery operated light source, 2-way 'Y' adaptor with non-random separation, and 3 mm./3 mm. and 3 mm./1.5 mm. connectors.

KIT 2 **£28** *Post Free*

Contains: 3 mm. x 18 in., 6 mm. x 12 in. light guides; 1.5 mm. 'Y' guide with two 12 in. long tails; 24 in. long 12 exit component for coding or punched card applications, 24 in. lengths of Crofon 64 filament and monofilament plastic light guide. Also, coherent solids consisting of 25 mm. diam. field flattening lens, 6 mm. x 12 in. image conduit with polished ends, 4 mm. x 25 mm. Image invertor. Complete with 2-way adaptor, fibre optic torch and batteries, 3 mm./3 mm. and 3 mm./1.5 mm. connectors.

● Special offer of IMAGE FIBRESCOPES £5 *Post Free* ●

Between 50,000 and 60,000 coherently arranged, 15 micron glass fibres that provide (with appropriate optics) perfect visual inspection into otherwise inaccessible areas. Originally made by Rank Taylor-Hobson for use in industrial and medical fibrescopes at £72 each, these have slight, superficially imperceptible faults and are assembled in transparent, lay-flat tubing instead of opaque, flexible conduit, as usual. Ends are ground, polished and metal capped. Absolutely ideal for demonstration in Schools and Technical Colleges and for many other applications that require highly sophisticated means of access to enclosed, difficult to get at places. Length overall: 3 ft. Cross sectional area: 3 x 3 mm. Resolution: 10 LP/mm. to 20 LP/mm.

LOW COST CROFON FLEXIBLE LIGHT GUIDES

Newly developed plastic light transmitting media by Dupont, which can be used for both serious projects and inexpensive prototype work. Ends can be ground flat, dyed or capped with epoxy resin. Temperature range: —40° to + 170°F. No loss of light through bending. **12 page Data and Applications booklet supplied free with each order. Types available:**

Multi-strand– 64 special plastic fibres, tightly bundled together in a tough, flexible conduit. **8/6 per foot. Minimum order two feet, 17/– p & p 1/6.**

Monofilament– single 0·040" plastic fibre which is specially useful for light indication in confined spaces. **4/– per foot. Minimum order three feet, 12/– p & p 1/–.**

PROOPS

Proops Bros. Ltd., 52 Tottenham Court Road, London W1P 0BA
Telephone: 01-580 0141

MICRO SWITCH

5 amp. changeover contacts. 1/9 each 18/- doz. 15 amp model 2/- ea. or 21/- doz.

COMPUTER MULTI-CORE CABLES

12, 14/0076 copper cores, each one insulated by coloured P.V.C. then separately screened, the 12 metal braided cores laid together and P.V.C. covered overall making a cable just under ¼ in. dia. but quite pliable. Price 7/6 per ft. Any length cut. Other sizes available 7 core 5/- ft., 6 core 4/- ft. 4 core 3/6 ft.

FLEX BARGAINS

Screened 2 Core Flex. Each core 14/0076 Copper P.V.C. insulated and coloured, the 2 cores laid together and metal braided overall. Price £2.15 per 100 yds. coil.

15 Amp 3 Core Non-kink Flex. 70/7076 insulated coloured cores, protected by tough rubber sheath, then black cotton braided with white tracer. A normal domestic flex as fitted to 3 Kw fires. Regular price 3/6 per yd. 50 yd. coil £4.10. or cut to your length 2/6 per yd.

10 Amp 3 Core Non-kink Flex. As above but cores are 20/0076 Copper. Normal price 2/6 per yd. 100 yd. coil £7.10. or cut to your length 1/9 per yard.

6 Amp 2 Core Flex. As above, but 2 cores each 23/0076 as used for Vacuum Cleaners, Electric Blankets, etc., 39/6 100 yd. coil.

23/0076 triple core P.V.C. covered, circular, normally sold at 1/6 yd. Our price 100 yd. coil £3.19.6. Post and ins. 6/6.

CONSTRUCTORS' PARCEL

1. Plessey miniature 2-gang tuning condenser with built-in trimmers and wave gang switch. 2. Ferrite slab aerial with coils to suit the above tuning condenser. 3. Circuit diagram giving all component values for 6-transistor circuit covering full medium wave and the long wave band around Radio 2. The three items for only 7/6 which is half of the price of the tuning condenser alone.

10 AMP 24V BATTERY CHARGER

Ideal unit for garage, boat station, etc. £22.10.0 each, plus carriage at cost.

BEHIND-THE-EAR DEAF AID

Made by a very famous maker. Thoroughly overhauled, cleaned and re-conditioned. Guaranteed 6 months. Regular price around £50. Our price £10.

ISOLATION TRANSFORMERS 200-250 Mns

A must if you work on mains equipment. Prevents accidents and shocks even in damp conditions. Input and output separately screened by connection block. 100 watt £3.10.0. 250 watt £5.

SLOW MOTION DRIVES

For coupling to tuning condensers, etc. One end ¼in. shaft, the other end fits to a ¼in. shaft with grub screws. Price 4/6 each; 48/- dozen.

LARGE PANEL MOUNTING MOVING COIL METERS

Size 5in. × 4in. Centre zero 200-0-200 micro amp, made by Sangamo Weston. Regular price probably £8. Our price 59/6. Ditto but 100-0-100 79/6.

A.C. AMMETER

0-5 amps., flush mounting, moving iron. Ex-equipment but guaranteed perfect 29/6.

CIRCUIT BOARDS

Heavy copper on 3/32 paxolin sheet, ideal for making power packs, etc., as sheet is very strong and thick enough to allow copper to be cut away with hacksaw blade. 5in. × 5in. 1/8 each. 15in. × 5in. 4/6 each.

6KVA AUTO-TRANSFORMER

In ventilated sheet steel case—tapped 110v-140v-170v-200v-230v. Ex-equipment but guaranteed perfect. £19.10.0. Carriage at cost.

REED SWITCHES

Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types:

Miniature. 1in. long × approximately ¼in. 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.

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 ¼in. × ¼in. × ¼in. 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.

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. This unit is not isolated from the mains.

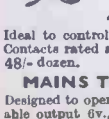
CHART RECORDER MOTOR

Small (2in. diameter approx.) instrument motor with fixing flange and spindle (¼in. long, ¼in. diameter); integral gear-box gives 1 rev. per 24 hours. 19/6.

IGNITION (E.H.T.) TRANSFORMER

Made by Parmeko Ltd. Primary 240v, 50 c.p.s. Secondary 5Kv at 23mA. Size approx. 4¼in. × 3¼in. × 2¼in. thick. Price 29/6 + 4/6.

12-VOLT EXTRACTOR FAN BY DELCO



Ideal for ventilation in caravan, car or boat. 6-bladed 5in. diameter fan inside heavy duty cylinder with 3-point fixing flange. 5½in. diameter fixing hole. Length approx. 8½in. Exceptional bargain. 27/6 plus 5/6 post and insurance.

4-PUSH SWITCH

Ideal to control fan heater, etc. 3 on switches and 1 off. Contacts rated at 15 amp on all switches. Price 4/6 each. 48/- dozen.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only 16/6, plus 3/6 postage.

INTEGRATED CIRCUITS

A parcel of integrated circuits made by the famous Plessey Company. A once in a lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first grade device definitely not sub-standard or seconds. The ICs are all single silicon chip General Purpose Amplifiers. Regular price of which is well over £1 each. Full circuit details of the ICs are included and in addition you will receive a list of 50 different ICs available at bargain prices 5s. upwards with circuits and technical data of each. Complete parcel only £1 post paid or List and all technical data.

ERGOTROL UNITS

These units made by the Mullard Group are for operating and controlling d.c. Motors and equipment from A.C. mains.

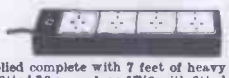
Thyristors are used and these supply a variable d.c. resulting in motor speed control and operating efficiency far superior to most other methods.

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:

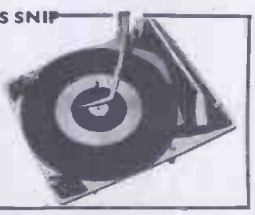
Model 2410 for up to 5 amps £17.10.0
Model 2411 for up to 10 amps £27.10.0
Model 2413 for up to 45 amps £47.10.0
Model 2415 for up to 80 amps £95. 0.0
Note: 2415 is a floor mounting unit.

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.

THIS MONTH'S SNIP



THE "PRINCESS" 4 SPEED AUTOMATIC RECORD CHANGER for beauty, long-life. Will take up to ten records which may be mixed, stylus brush cleans stylus after each playing—other features include pick up-height adjustment and stylus pressure adjustment. This truly is a fine instrument, part of a cancelled export order, which has travelled back and forth. The changer, therefore, may need mechanical re-adjustment but we supply service manual. We offer these at less than the price of a single player—only 49/6 + 6/6 p. & p.

MOTORISED CAM SWITCH

These have a normal mains 200-240v motor which drives a ratchet mechanism geared to give one ratchet action every ¾ minute approx. The cam operates 8 switches (6 changeover and 2 on/off thus approx. 600 circuit changes per hour are possible). Contacts, rated at 15 amps have been set for certain switch combinations but can, no doubt, be altered to suit a special job. Also other switch wafers or devices can be attached to the shaft which extends approximately one inch. 47/6. Post and ins. 4/6.

STANDARD WAFER SWITCHES

Standard size 1½ 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

MICROSONIC KEYCHAIN RADIOS

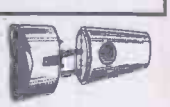
7 transistor Key chain Radio in very pretty case, size 2¾ × 2½ × 1¼ in.—complete with soft leather zipped bag. Specification: Circuit: 7 transistor superheterodyne Frequency range: 530 to 1600 Kc/s. Sensitivity: 5 mv/m. Intermediate frequency: 465 Kc/s, or 455 Kc/s. Power output: 40mW. Antenna: ferrite rod. Loudspeaker: Permanent magnet type. In transit from the East, these sets suffered slight corrosion as the batteries were left in, but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. 24/6 plus 2/6 post and insurance. Rechargeable batteries 8/6 pair. Plug-in mains charger 12/6.

OUT OF SEASON BARGAIN

3kW TANGENTIAL HEATER UNIT

This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only. Comprises motor, impeller, 2kW. element and 1kW. element allowing switching 1, 2 and 3kW. and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only need control switch. 59/6. 2kW. Model as above except 2 kilowatts 39/6. Postage and insurance 6/6. Don't miss this.

RE-CHARGEABLE TORCH



Neat flat torch, fits unobtrusively in your pocket, contains 2 Nicad cells and built-in charger. Plugs into shaver adaptor and charges from our standard 200/240 volt mains. American made, sold originally at over 4 dollars. Our price only 19/6 each.

3 STAGE PERMEABILITY TUNER

This Tuner is a precision instrument made by the famous "Cyldon" Company for the equally famous Radiomobile Car Radio. It is a medium wave tuner (but set of longwave coils available as an extra if required) with a frequency coverage 1,620 Kc/s-525 Kc/s and intended to operate with an I.F. value of 470 Kc/s. Extremely compact (size only 2¼in. × 2in. × ¼in. thick) with reduction gear for fine tuning. Snip price this month, 12/6 with circuit of front end suitable for car radio or as a general purpose tuner for use with Amplifier. Post Free.

PROTECT VALUABLE DEVICES

FROM THERMAL RUNAWAY OR OVERHEATING: Thyristors, rectifiers, transistors, etc., which use heat sinks can easily be protected. Simply make the contact thermostat part of the heat-sink. Motors and equipment generally, can also be adequately protected by having thermostats in strategic spots on the casing. Our contact thermostat has a calibrated dial for setting between 90 deg. to 190 deg. F, or with the dial removed range setting is between 80 to 800 deg. F. Price 10/-

NEED A SPECIAL SWITCH

Double Leaf Contact

Very slight pressure closes both contacts. 1/3 each. 12/- doz. Plastic push-rod suitable for operating, 1/- each, 9/- doz.

3-CORE LEADS

Heavy duty 23/36, average length 5ft. 10/- per dozen lengths, plus 4/6 post and ins.

PAPST MOTORS

Est. 1/40th h.p. Made for 110-120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. 30/- each.

INSTRUMENT KNOBS

¼in. dia. head with 3in. shank for flatted ¼in. spindle, 9d. each, 8/- dozen. Ditto but with metal disc, 1/- each, 11/- dozen

MIDGET OUTPUT TRANSFORMER

Ratio 140 : 1. Size approx. 1in. × ¾in. × ¾in., primary impedance 450Ω. Connection by flying leads. 4/6 each. 48/- doz.

MIDGET OUTPUT TRANSFORMER

Ratio 80 : 1. Size approx. 1¼in. × 1in. × ¾in. Primary impedance 132Ω. Printed circuit board connection. 5/6 each. £3 doz.

4-GANG AIR-SPACED TUNING CONDENSER

For AM/FM circuits. AM rf section 200 pf, osc section 80 pf, both with trimmers—FM rf section 9·5 pf, osc section 11.2 pf—integral slow-motion drive. 9/6 each.

MAINS CONNECTOR

A quick way to connect equipment to the mains safely and firmly—L, N. and E. coded to new colour scheme; disconnection by plugs prevents accidental switching on; has sockets which allow insertion of meter without disconnection; cable inlets firmly hold one hair wire on up to four 7.029 cables. 12/6 each.

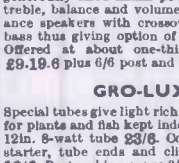
THE 5 × 5 WATT STEREO AMPLIFIER

Made by one of our most famous makers for a de-luxe player. This amplifier has a quality of reproduction much better than average. Using a total 16 transistors and a generously sized mains power pack. Controls include bass, treble, balance and volume. Suitable for 8-16 ohms impedance speakers with crossovers for tweeter mid-range and bass thus giving option of 1, 2 or 3 speakers per channel. Offered at about one-third of its original price, only £9.19.6 plus 6/6 post and insurance.

GRO-LUX LIGHTING

Special tubes give light rich in U.V. and other rays necessary for plants and fish kept indoors away from natural sunlight. 12in. 8-watt tube 23/6. Control kit comprising choke and starter, tube ends and clips, starter holder and diagram 19/6. Post and insurance 3/6 on either; or 4/6 on both items. Other tube sizes in stock, so send for List.

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.

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, 36/9 less than the value of the clock alone—post and insurance 2/9

COLOURED FLUORESCENT TUBES

For special lighting effects. Wonderful for lighting on summer garden. All tubes perfect not seconds. Made by Atlas, Echo or similar companies. 2 ft. suitable for working at 20 or 40 watts depending upon choke used. Available in the following colours: Red, Yellow, Blue, Peach, Daylight, Natural, White. Special snip price (about half regular price) 9/6 each plus 5/- postage and insurance on any quantity up to 12 when they would be post free. Note: Two tubes may be run off one choke. We can supply suitable choke, two starters and all other fittings required for 29/6 plus 4/6 post per kit.

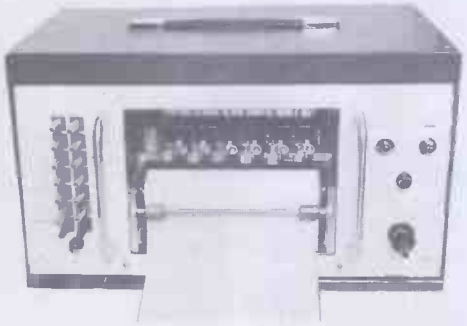
EXTRACTOR FAN

Cleans the air at the rate of 10,000 cubic feet per hour. At the pull of a cord it extracts grease, grime and cooking smells before they dirty decorations. Suitable for kitchens, bathrooms, factories, changing rooms, etc., it's so quiet it can hardly be heard. Compact, 5½ in. casing with 5½ in. fan blades. Suitable wherever it is necessary to move air fast. Kit comprises motor, fan blades, sheet steel casing, pull switch, main connector and fixing brackets. 39/6 plus 4/6 post and insurance.

Where postage is not stated then orders over £5 are post free. Below £5 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

ELECTRONICS (CROYDON) LTD
Dept. WW, 266 London Road, Croydon CRO-2TH
Also 102/3 Tamworth Road, Croydon

ELECTRONIC



NEW 6-CHANNEL TIME AND EVENT RECORDER

A self-contained instrument, specifically for recording events without the need for a combined recorder.

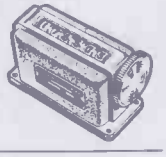
There is a separate and independent paper drive, with a monitor lamp indicating when it is in operation. The pens are displaced 1/16", activated by a close contact system. Each of the 6 channels works independently of each other, with the pens writing at 72 hours per filling at a maximum speed of 10 pulses per second.

The recorder is supplied either in a portable cabinet or with rack mounting adaptions and the size is 15" × 9" × 9½" deep. It weighs 10 lb. and is available in 220-240 volt A.C. (50 cycles) or 110-115 volt A.C. (60 cycles). The 6-channel time and event recorder is available at the following speeds: 30, 20, 10, 5, 1 per minute. 18, 12, 9, 6 per hour. Width of paper roll is 6", maximum diameter of roll is 3", length on standard 3" diameter paper roll is 200'. Price of the event marker is £79-10-0, plus £5-0-0 for the special vinyl-treated portable case.

The instrument is guaranteed for one year, and is available with a complete range of accessories, including teledotos paper, graphic paper, plain paper, pens, pen containers and time bases. Prices of these items are available on application.

COUNTERS

VEEDER ROOT 6 DIGIT COUNTER

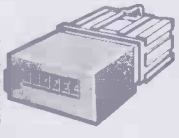


Suitable for counting all kinds of production runs, business machine operation. Mechanically driven Type KA1337. Reset manual knob. Ex-equipment .but new condition. Special price 25/- plus 5/- P. & P.

MINIATURE SQUARE COUNTER 6 DIGIT

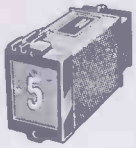
By Veeder Root. Rotary ratchet type, adds 1 count for each 36° movement of shaft. 9/6 plus 2/6 P. & P.

6 DIGIT ELECTRICAL IMPULSE COUNTER



With electrical and mechanical reset. Counter driven by a 110 v. D.C. 4,400 ohms coil. Reset 110 v. D.C. 800 ohm coil. Housed in plastic-alloy case. The units can be interlocked with each other to give vertical or horizontal displays. Ex. equipment. Price 59/6 plus 5/- P. & P.

EAC DIGIVISOR Mk. II DIGITAL READ-OUT DISPLAY



Ideally suitable for use in conjunction with transistorised decade counting devices. No need for amplifiers or relays as only a few milliwatts of power are required to change the digits. The DIGIVISOR incorporates a moving coil movement which moves a translucent scale through an optical system and the resultant single plane image is projected on a screen. The translucent scale is made to represent digits 0-9 Specification: lamp 6.3 volt movement sensitivity 250 microamp. Image. height ¼ in. Size 4 9/16 × 2 39/64 × 1¾ in. Our price £3/13/6. List price 8½ gns.

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.C. 150v D.C. Cut-on or Cut-off—15v. Size 5½ × 5¾ in. × ¾ in. Price 65/- p. & p. 5/-.

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/-.

HI-SPEED ELECTRIC RESET ELECTRO MAGNETIC COUNTER

6 Digit 24v. D.C. 3¼W. 20 counts/second. Size 3¾ × 2¾. Panel Mounting. List £10/19/6.
Our Price £4/9/6. P. & P. 5/-.
4 Digit 24v. 79/6. P. & P. 5/-.

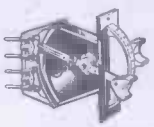
HIGH STABILITY D.C. POWER SUPPLY TYPE D.C. 200 AND D.C. 202

A stabilised ex-equipment power pack made to a tight specification. Type D.C.200: Input 200/250v. 50Hz; D.C. Output +20v. at 12A. —10v. at 4A, —20v. at 2A. Type D.C. 202: Input 200/250v. 50Hz; D.C. Output —35v. at 9A, +24v. at 4A, +10v. at 0A. Dimensions: Length 18 in. Height 9½ in. Width 12 in. Weight 92 lbs. Price £65. Carriage extra.

ALL ORDERS ACCEPTED SUBJECT TO OUR TRADING CONDITIONS A COPY OF WHICH MAY BE INSPECTED AT OUR PREMISES DURING TRADING HOURS OR WILL BE SENT ON APPLICATION THROUGH THE POST.

HIGH GRADE COMPONENTS

DOUBLE AUDIO FADERS 1W



1000 plus 1000 ohms. Each resistive dimmer is adjustable and independent of each other. Ex-equipment but in an almost new condition. Price £3/19/6. P. & P. 7/6.

VOLSTATS

VOLSTATS and constant voltage transformers. Large range in stock. Prices from £8/10/0.
I/P 190-260v 50Hz. O/P from 6v. to 240v. Loads 25w to 1000w.

OSCILLOSCOPES

Solartron CD513	£49.10
Solartron CD 513/2	£49.10
Solartron AD 557	£55. 0
Solartron CD 711	£65. 0
Solartron CD 7118-2	£80. 0
Solartron QD 910	£275. 0
Solartron 5238-2	£52.10
Furzehill 0.100	£25. 0
Airmec 249	£25. 0
Airmec 723	£19.10
Philips PM 3230	£85. 0
Mullard L101 Double Beam	£75. 0
Cossor 1035	£25. 0
Cossor 1049	£35. 0

SOLARTRON C.D. 1014/2 Double beam portable oscilloscope very suitable as a general purpose equipment. 3½ in. Flat Face tube with the following features. Auto trigger mode. Provision for external "Z" modulation. TV line and Frame Sync separator with D.C. restoration. Accurate "X" and "Y" Calibration and stabilised E.H.T. Specification: Bandwidth D.C. to 5MHz. Sensitivity 1 millivolt/cm on "Y2". Time Base six positions from 1 micro/sec/cm to 1/sec/cm. Velocity 1 cm/micro sec to 1 cm/sec. "X" Shift approximately 10 diameters. Power Supply 100/125v. and 200/250v, 45-440Hz. at 75VA. Dimensions: Width 9½ in. Height 11½ in. Depth 15 in. Weight 25 lb. Price £40. Carriage EXTRA.

TEKTRONIX. Type 524AD specifically designed for maintenance and adjustment of television transmitters and studio equipment. Price £175.

HEATHKIT. Laboratory and general purpose scope. Mode. 10-12 U. Single Beam. Price £15. Carriage extra.

DARTRONIC. Model 381 Single Beam. Bandwith D.C. to 9MHz. Sensitivity 100 mV/cm. Time Base 9 switched steps from 0.7 sec/cm to 0.5 micro sec/cm. Power Supplies 200/250v. 50/100Hz. 95 watts. Price £29/10/0. Carriage extra.

MOTORS

HYSTERESIS REVERSIBLE MOTOR

Incorporating two coils. Each coil when energised will produce opposite rotation of output shaft. 240V 50 Hz. ¼ r.p.m., ½ r.p.m., 1/6 r.p.m., 120V 60 Hz, 1/10 r.p.m., 30/- each. P. & P. 3/-.

HIGH TORQUE INDUCTION MOTOR

3-30 oz/inch. Available in the following speeds only 240V 50 Hz ½ r.p.m., 1 r.p.m., 2 r.p.m. 120 V 50 Hz. 20 r.p.m 30/- each. P. & P. 3/-.

LOW TORQUE HYSTERESIS MOTOR MA23

Ideal for instrument chart drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting torque enable relative high inertia loads to be driven up to 6-oz/in. Available in the following speeds and ranges: 240V 50 Hz 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., ¼, 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., 1/440 r.p.m. 25/- each. P. & P. 3/-.

HIGH PRECISION MAINS MOTOR 3 Phase—1 Phase

230V 50 Hz 1/8 h.p. continuously rated. 3000 r.p.m. Made by Croydon Engineering. Model KA 60 JFB. Suitable for capstan motor. Size 8 in. long, 4¾ in. diameter with 6 in. diameter flange and 4 fixing holes. £4/10/0 each. P. & P. 25/-.

SYNCHRONOUS MOTORS

Model S 71 r.p.h. and 1/60 r.p.h. Self starting complete with gearing shaft ¼ in. dia. ½ in. long, 200/250V 50 Hz. New condition Ex. Equipment. 40/-. P. & P. 3/-.

DATA TRANSMISSION—SYNCHROS

	Type	Maker	Voltage	Hz	Price £ s. d.
Torque Receiver	11TR4a	Sperry	90/115v	400	7 10 0
Torque Receiver	ACN 155OC	Smith	26,12.3	400	7 10 0
Torque Receiver	11TR4a	Pullin	90/115v	400	7 10 0
Control Transformer	11CT4RT	Muirhead	26v	400	6 10 0
Control Transformer	26v08CT4c	Muirhead	11/8v	400	10 10 0
Control Transformer	11CT4b	Sperry	1/90/deg	400	6 10 0
Control Transformer	11CX4a	Pullin	11.8/26v	400	6 10 0
Control Transformer	11CX4b	Ketay	90/115v	400	6 10 0
Torque Transmitter	AC8/AE	Smith	90/115v	400	6 10 0
Torque Transmitter	11CX4a	Elliott	90/115v	400	6 10 0
Torque Transmitter	15M1B1	Muirhead	90/115v	400	10 10 0

CARRIAGE EXTRA

A.C. MOTOR GENERATOR

Type G1005 Motor Spec. 6000 r.p.m. Torque 25gm/cm. Control winding 20v., 400Hz. Ref. Winding 26v., 400Hz. Generator Spec. Ref. Winding 26v., 400Hz. O/PO 4v/1000 r.p.m. Length 2 in., dia. 1 in. Price £7/10/0 p. & p. 5/-.

D.C. TACHOGENERATOR

Type 9c/106 16v. at 1000 r.p.m. Drive shaft dia. 3/16 in., 3/8 in. long. Price £16/10/0.

SYNCHRONOUS MOTOR WITH GEARBOX

Motor 11M83 gearbox type 11H21. This unit is an 8000 r.p.m., 115v., 400Hz motor fitted with concentric epicycle reduction gearbox of 9.92/1. Motor torque 6 oz./in. length c/w gearbox 2 5/8 in. × 1 in. diameter.

RAGONOT MOTOR

220V 3-phase 50Hz 1/20 HP, 1500 RPM. Precision Ex-COMPUTER TAPE DRIVES. Rotor moves ¼ in. axially on "Switch on" to take up drive and on "Switch off" is spring returned to disengage drive. 45/- each. P. & P.10/-.

FRACMO

240/250v., 50Hz single phase. 1/20 h.p., 2800 r.p.m., shaft dia. ⅛ in. Price 45/-.

EVERSHED & VIGNOLES SPLIT FIELD SERVO MOTOR

Type FB6A—A1/B ¼ in. keyed shaft. Price £12/10/0 each.

GENERATORS

A.M. SIGNAL GENERATOR

Marconi Model TF 144/HS
This is a current model instrument with all the desirable features that have been such important factors in achieving the popularity of this range of instruments. The layout of controls is extremely neat and easy to use. The frequency range is divided into 12 bands each having a range cover of more than 2/1. This way a large effective scale length is obtained on the turning dial which carries a separate scale for each band. The medium band for example coincides with a single tuning band of the signal generator specification: Frequency Range 10KHz to 72MHz. Stability 0.002 per cent. High discrimination plus crystal calibrator. Good R.F. waveform at all frequencies. Protected thermocouple level monitor. Output normal 2 volts. High 2.75 volts. Power requirements 200/250v and 100/150v. 40-100Hz. 80 watts. Can also be used with D.C. battery supply. Dimensions: Height 14½ in. Width 19½ in. Depth 11 in. Weight 58 lbs. Used in equipment in V.G. condition. Price £195. Carriage EXTRA.

BROKERS

MEASURING INSTRUMENTS AND RECORDERS

PORTABLE AC/DC PEN RECORDER

A most versatile pen recorder. Produces a trace on a curvi-linear 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 ohm Impedance Source. Chart speed: 1 in. and 6 in./hr. Chart width: 3½ in. curvi-linear. Power supply: 230V 50 Hz driving Synchronous Motor.
Price: £52.10.0. P. & P. £1.5.0.

STRIP-CHART INDICATING RECORDER

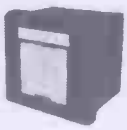


Chart width 9½ in. 10 mV. Sensitivity ±0.17 of full scale. Source impedance 100 ohms. Speed of operation 33 sec. for full-scale travel. Chart speed ½ in., 3 in., 6 in. per hour. Single point. £49.10.0. P. & P. 30/-. 12 Multi-point recorder available.

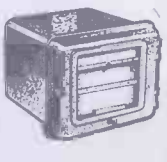
PORTABLE D.C. 3 inch SINGLE PEN RECORDER (Panel Mounting)

Made to G.P.O. specification, this is a very compact and accurate instrument. Available 0-1mA and 0-500 micro amp. Fitted with alarm circuit which operates when current exceeds preset values. Specifications: Chart width 3 ins. Chart speed 1 in. and 6 in./hr. Other speeds available by changing gears. Resistance 400 ohm (1mA range). Resistance 1.53 K ohms. (500 micro amp range). Power Supply 190/250v. 50Hz for synchronous drive motor. Dimensions: Width 6 in., Height 7½ in. Depth 9 in. Weight 22 lb. Price 0-1mA £49/10/0; 0-500 micro-amp £55.

PEN RECORDER

Portable 1, 2 and 4 channel pen recorders by Kelvin Hughes. General purpose recorders providing clear instantaneous and permanent records of phenomena with comparatively high rates of change. The torsion-strip suspension of the moving-coil renders the instrument immune to the effects of vibration and acceleration.
Six possible chart speeds, chart width 55 mm., length 150 ft., linearity 8 v. at 3 m.A. response D.C. to 100 c/s. Single pen with amplifier £99; 2 pen recorder £85, 4 pen with amplifier £149. Also 5 pen recorder complete with amplifiers, specification as above but housed in cabinet £225. P. & P. extra.

POTENTIOMETRIC 6 POINT STRIP CHART RECORDER BRAND NEW



For use with thermocouplers, pyrometers and other e.m.f. sources. 6 point. Range (—100)—0—(+100) mV; 0—1,600 deg. C. 6½ in. chart width; pen speed 8 secs. Accuracy ±0.5%; 10 chart speeds 20-720 mm/hr. Tropicalised. Including tools and spares. Listed at over £200. Our price £79.10.0. Also available 0-100 mW F.S.D. £89.10.0.

SERVORITER Model FWS

By well-known American manufacturer. Power supply 120 v 50 Hz. Response time 24 secs. Resistance source 16 K ohms max. Chart width 11 in. This is a slow-speed recorder that can be used for measuring any quantity with a comparatively slow rate of change such as temperature, humidity etc. Supplied with electrovolt controller that enables the sensitivity, reset, proportional band and rate to be adjusted. This unit enables the demanded temperature to be controlled and the actual temperature recorded. Size: 16½in. wide, 17½ in. high, 13½ in. deep. Price £175. Carriage extra.

METERS

DIGITAL VOLTMETERS

Type LM902-2. 4 digit £75. LM902-2R. 4 digit £75. LM1010. 4 digit £75. All the above units have been calibrated.
DM2006. An all solid state D.V.M. having a wide application. Scale 9999. D.C. accuracy 0.017s.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.
DM2010. Scale 109999. D.C. Accuracy 0.001 per cent. D.C. Range 10 micro volts to 1.1 kV. I/P Z greater than 25000 Megohms. Outputs Parallel BCD. Price £500.
DM2001. Scale 19995 DC. Accuracy 0.025% FSD. DC RANGE 50 microvolt to 2 KV I/P impedance greater than 10,000 M ohm Parallel BCD Output or Decimal (not isolated). Price £235.

A.C.-D.C. CONVERTERS TYPE 2140/A1-B1 and 2140/A3-B3

A flexible modulor system for use with a DVM for accurate mean (RMS) or true (RMS) Voltage measurements. Module A1 LF Amplifier X 0.1 to X 1000. Module A3 LF Amplifier X 0.1 to X 100. 2140/A1-B1 1000 V True RMS Converter. Price £175.
2140/A3-B3 200 V Mean (RMS CALIBRATED) Converter. Price £150.

BRAND NEW SENSITIVE A.C. MILLIVOLTMETER

A very neat attractive instrument at a very modest price. Extremely high input impedance maintained over 10 overlapping ranges. Battery powered giving portability and freedom from mains hum. Specification: 30mV to 1000v. —20 to 2 decibels. Frequency: 5Hz to 50KHz. Input Impedance: 100 Megohms. Overall Accuracy: 10 per cent of F.S.D. Power Supply: 9v. PP9 battery. Consumption: 8.5mA giving approximately 500 hours use. Supplied c/w screened input cable. Dimensions: Width 6 in. Height 4½ in. Weight 3½ lbs. Price: £9/10/0. P. & P. 10/-.

PRECISION POTENTIOMETERS

TEN TURN 3600° ROTATION BRAND NEW

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
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/-
500		Colvern	26/1000/11	60/-
500	1.0	Relcon	HELI07-10	45/-
1K		Relcon	HEL0710	45/-
2K	0.5	Beckman	8A1101	60/-
2K	0.25	Beckman	7216.	60/-
2K		Reliance	GPM15	40/-
2K		General Controls	GPA15/4.	40/-
5K		Relcon	07-10	50/-
5K		Colvern	CLR2503.	60/-
10K	0.5	Beckman	A	60/-
10K	0.1	Beckman X	A	70/-
10K	0.1	Colvern	CLR26/1001	70/-
15K		Colvern	CLR2402.	60/-
18K		Beckman	A	60/-
25K	0.5	Helipot	SAJ337	60/-
29K	0.05	Beckman	8A1244	90/-
30K		Colvern	2402.	30/-
30K		Beckman	8A95C	60/-
30K	0.1	Beckman	A.88	70/-
30K	0.5	Beckman	8A1692	60/-
30K	0.25	Beckman	8A1679	65/-
30K	1.0	Colvern	2402/1	30/-
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	C 60/-
100/100		Beckman	Type C 60/-
300		Beckman	9303 45/-
1K		Fox	PX2/H3 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 £6.10/-
46/K/46K		Beckman B.	10 watts £6/10/-

TWENTY TURN 7200° ROTATION

1 Meg		General Controls	PXM130 80/-
50K		Reliance	40/-

156 TURN 56160° ROTATION

460		Kelvin Hughes	KTP0701 £9/10/-

FIVE TURN 1800° ROTATION

200		Relcon	HELO7.05 -F/11 45/-
500		Colvern	CLR2505. 40/-
U1.5K		Colvern	CLR2605. 40/-

FIVE-&-A-HALF TURN

500		Colvern	2405 40/-

SINE COSINE

Values	Type	Maker	Price
5 Kohms	CLR 8601	Colvern	£17/10/0
14 Kohms	SCP 5	Smith	£22/10/0
15 Kohms	CLR 8601	Colvern	£17/10/0
20 5 Kohms	CLR 8602	Colvern	£22/10/0
25 Kohms	CLR 9602	Colvern	£17/10/0
30 Kohms	CLR 8601	Colvern	£17/10/0
32 Kohms	SCP 4	Kelvin-Hughes	£17/10/0
35 Kohms	SCP 1	Smiths	£17/10/0

P. & P. EXTRA

BOURNS KNOB POT

New 10-turn precision potentiometers consisting of potentiometer, knob and readout dial in one extremely compact assembly. A very attractive unit finished in black plastic with white dial. Available in 100K, 20K, 5K, 1K. 1½W. Resistance tolerance 5%. Accuracy correlation of dial reading to O/P 0.5%. Weight 0.6 oz., overall length 1 11/16 in., diameter ½ in. New price £7.15.0 each. Our price £4/10/0. P. & P. 2/6.

NUMICATORS

Type NI 1. End reading as shown. Price £1 each. P. & P. 2/6.
Cold cathode gas-filled, in-line 0-9 digital display tubes. Long life expectancy. Minimum striking voltage 180v. Side reading type XN 13. Price 18/6 each. P. & P. 2/6.

MERCURY WETTED RELAYS

Type (new) HG4B1007 relay is capable of an operating time as short as 5 milliseconds. A BILLION OPERATIONS! Small chassis space required. Convenient mounting. Environment-free. Tamper-proof. High sensitivity. Maintenance-free. No contact wear. Performance is made possible by the presence of a film of mercury which at one and the same time cushions the contacts and provides an unbroken metallic path for the electrical circuit. This mercury film, constantly renewed by capillary action, prevents wear, dissipates heat and thus avoids contact erosion and eliminates bounce or chatter in the electrical circuit. Hermetic sealing of the switch and mercury pool in a glass capsule eliminates dirt and assures constant adjustment.

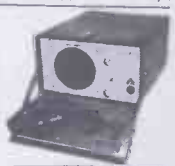
Type	Coil Resistance	Voltage	Contacts
HG2B 1004	5000 ohm	24	2SPST
HG2b 1006	1300 ohm	24	2SPST
HG2b 1010	1300 ohm	24	2SPST
HG4B 1005	1300 ohm	24	4SPST
HG4B 1007	1300 ohm	24	4SPST

BOTH NEW AND EX-EQUIPMENT AVAILABLE
New Relays £2/10/0. Ex-equip. £1/10/0. P. & P. 5/-.

PHOTOMULTIPLIER VMP11/44 (CV 2317) by 20th Century Electronics

Cathode sensitivity 40μA/L. Operating volts for 10 A/L 1100 volts. DARK current 0.004μA. £9/10/0.
E.M.I. 6097 and 20th Century CV 2317 £9/10/0. P. & P. 5/-.

ANIMAL SONARAY Type 1803B by Dawes



An instrument for measuring the thickness of fat on an animal by the use of ultrasonics using the pulse echo principal. The animal sonary was specifically designed for the measure of back fat thickness for use under field conditions. Fully portable weighing only 26 lb. With handbook, price: £149/10/0.

CRYSTAL OVENS

Redifon Fitted Bi-Metal Strip 75°C 5°C. Octal Base Type A 4260 EDN"C" 6V AC and 12V AC or DC. Price £4/10/0 P. & P. 2/6.
Type A 4260 EDN"A" 12V/24V AC/DC. Price £4/10/0. Marconi Type F 3006-01 £12/10/0. P. & P. 2/6.

VARIABLE VOLTAGE TRANSFORMERS

Various types available, including single- and three-phase manual or motor drive. Contact us by phone or letter for stock appraisal and delivery.

SYNCHRONOUS CHOPPERS

Base B-9. Coil 6.3 v., 50-60 Hz. Proportion of time contacts are closed 45%. Also available 100 Hz and 400 Hz. Price £6/10/0. P. & P. 5/-.

NEW COMPLETE TELEPHONE DIAL ASSEMBLIES

Clear Perspex dials—no markings. 20/- each. P. & P. 5/-.

LINEAR THYRISTER CONTROLLED LIGHT DIMMER

600w. module. Ideally suitable for photoflood or speed controller, etc. Will mount into standard socket boxes. Our price 59/6. P. & P. 3/-.

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 finish stove enamel. List price £60. Our price £22/10/0.

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: V. Dry battery. Dimensions: 200 × 110 × 65mm. Weight: 0.9 kg. List price £25. Our price £9/19/6.

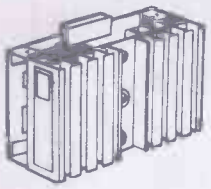
MUTUAL INDUCTANCE COIL TYPE R.7006

Specification. Value: 0.001H. 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/-.

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 Kc/s for all decades except X1 = 0-15 Kc/s. Maximum current: 0.5A for decades 1A for variometer (both primary and secondary wingings). Case: Polished teak. List price £65. Our price £26/10/0.

HENRY'S RADIO LTD. ENGLAND'S LEADING COMPONENT AND EQUIPMENT CENTRES



LOOK AT THE SPECIFICATIONS!

25 WATT & 50 WATT RMS SILICON AMPLIFIERS

- At full power 0.3% distortion.
- At full power—1dB 11c/s to 40 kc/s.
- Response—1dB 11 c/s to 100 kc/s.

NEW! Self-powered Stereo Pre-amplifiers—every facility. Slim modern designs, push-button selections, silicon transistors, FET's and IC's.

★FET154 Stereo £16.10.0

★IC Stereo £24.0.0

PA 25 10 transistor all silicon differential input 400 mV sensitivity. 25 watts Rms into 8 ohms. Supplied with edge connector harness size 5" × 3" × 2".

PA 50 12 transistor version 50 watts Rms into 3 to 4 ohms. Size 5" × 3" × 4".

MU 442. Power supply for one or two PA 25 or one PA 50.

PA 25 £7.10.0. PA 50 £9.10.0. MU 442 £6

No soldering—just edge connectors!

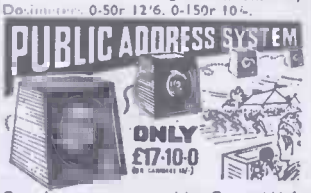
SINCLAIR EQUIPMENT Z30 75/-, project 60 amp £8.10.0, Pz5 79/6, Pz6 £6.19.6, z50 £5.9.6, Pz8 £5.19.6.

★Two Z30 Pz5 up 60 pre-amp (usually £23.10.0) (or with Pz6 in place of Pz5 £21) **£19**

PORTABLE GEIGER COUNTERS £9.10.0. Carriage 15/-

FOR MEASUREMENT OF RADIO ACTIVITY Supplied complete with instructions, haversack, cables and probe. List price £70. Our price, new, tested, complete with 4 cell H.T. Eliminator. Plug in mains units 75/-

Decimeters 0-50r 12'6. 0-150r 10/-.



Complete system comprising Control Unit, 4 Tannoy loud hailers, microphone and headphones, etc., 12V D.C. operation. Low battery drain. 8 watts power output. The ideal system for mobile use, outdoor meetings, sports days, factories, garden fetes, etc. Speakers can be spaced effectively over hundreds of yards. Also has talk back facility. Guaranteed Brand New in sealed cartons. Original cost over £60.

QUANTITIES AVAILABLE FOR EXPORT

HENRY'S STOCK EVERY TYPE OF COMPONENT YOU NEED A CATALOGUE IS A MUST!

HENRY'S LATEST CATALOGUE SEND NOW!

350 pages fully detailed and illustrated. All audio and electronics complete with 10/- value discount voucher for use with purchases. Price 7/6 p.p. 2/-.

A must for the home constructor and professional engineer.

FREE to schools, colleges and companies on written request.

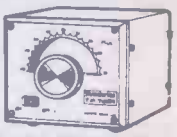
COMPLETE STEREO SYSTEM

(usually £50) Price £39.10.0

British made 5-5 amplifier input for ceramic cartridge tuner/aux etc. Full controls, output for 8 to 15 ohm speakers fitted headphone socket. Complete system uses above amplifier, Garrard model 50 or 3000 with 9TAH/C diam. Pair EMI 10 watt speakers with twin tweeters and cross over. Polished speaker, cabinets and plinth/cover.

- Complete stereo system £39.10.0 p.p. 20/-.
- Amplifier only £13.19.6 p.p. 7/6.
- DHO 25 stereo phones 45/-.

BUILD THIS VHF FM TUNER



5 MULLARD TRANSISTORS 300 kc/s BAND-WIDTH. 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.

PARTS TOTAL COST £6.19.6 p.p. 3/6

ASK FOR BROCHURE No. 3.

DECODER £3.19.6 (FOR STEREO) p.p. 3/6

TEST EQUIPMENT

For Educational, Professional and Home Constructors

SPECIAL PRICES FOR QUANTITIES

AF105 50k/volt multi-meter (illus.). Price £8.10.0 p.p. 3/6. Leather case 28/6.

200H 20k/volt. Price £3.17.6 p.p. 3/6. Case 12/6.

THL 33A 2k/volt. Price £4.2.6 p.p. 3/-. Leather case 22/6.

TE65 Valve voltmeter (illus.). £17.10.0 p.p. 7/6.

VM51 Transistorised AF/RF multimeter. Price £32.

TE20D RF generator (illus.). Price £15 p.p. 7/6

TE22D Matching audio generator. Price £17 p.p. 7/6.

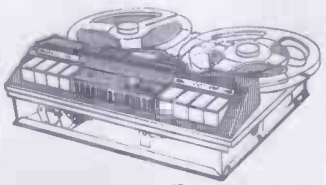
TE15 Grid dip meter. Price £12.10.0 p.p. 3/6.

TO3 Scop (illus.). 3" tube. Price £37.10.0 p.p. 10/-.

PANEL METERS COMPLETE RANGE IN STOCK— SPECIAL PRICES FOR QUANTITIES

***FULL RANGE IN THE LATEST CATALOGUE SEE FOR YOURSELF**

NEW ¼-TRACK TAPE DECK



British made, takes 7" spools, operates horizontally or vertically, piano key operation. Fitted three-speed Marriot XRPS17 and XES II heads. Size: 13 × 10 × 5½ in. Price £13.19.6 p.p. 7/6

HIGH CAPACITY ELECTROLYTICS

40,000 mfd 10 volt .. 10/0
35,000 mfd 15 volt .. 12/6
25,000 mfd 25 volt .. 15/-
46,000 mfd 25 volt .. 19/6
Discounts for quantities. At a fraction of normal price. MADE BY MALLORY, USA.

E.A.C. DIGIVISOR mk. II

At a fraction of normal price. Moving Coil 0 to 9 Display. One inch character size. Light beam lens operated meter. Movement 500μA. Character lamp 6.3 volts. Also lamp for decimal point. Overall size: 4½ × 1½ × 2½. Brand new. Price 79/6.

STC TIME DELAY MODULE

Ideal for experimenters, educational projects as well as for practical uses. Delay adjustable 3-15 secs. Operates 9-12 volts. Heavy Duty Relay Contacts. Complete with suggested applications sheet. Price 35/-, or 3 for 90/-.

GRAVINER FIRE DETECTOR UNIT

Fire Detector Unit containing 931A photo multiplier and cold cathode tube. Shock and fire proof. Originally made for £74. Price complete with data sheet £6 Brand new.

YOU CAN SAVE 25%

BRAND NEW FULLY GUARANTEED

SP25 mkII £11.19.6. AP75 £16.19.6. SL65 B £14.19.6. SL72 B £25. SL75 B £31. SL95 B £39. A70 mkII £11.19.6. P.p. 7/6.

SPECIAL OFFER. Above supplied with cartridge 9TAH/C diam. add £2, magnetic 940 add £3.10.0, with G800 add £8.10.0. De-luxe plinths and covers for above (except A70) Price £8.10.0 p.p. 6/-.

GARRARD TURNTABLES FREE COMPLETE LIST ON REQUEST no. 16/17.

Goldring GL69 deck only. £22 p.p. 2/6. With G800 £30 p.p. 7/6. With G800 plinth and cover £39.10.0 p.p. 10/-.

Garrard Model 50 £8.10.0. 3000lm £9.15.0 (fitted 9TAHC diam. carts.) p.p. 7/6. Plinths/covers 99/6 p.p. 8/-.

ELECTRONIC ORGANS

★MODERN ALL BRITISH TRANSISTORISED DESIGNS AVAILABLE AS KITS OR READY BUILT

★VENEERED CABINETS FOR ALL MODELS

★49 NOTE, 61 NOTE SINGLE MANUAL DESIGNS ALSO TWO MANUAL 49 NOTE

★KITS AVAILABLE IN SECTIONS AS REQUIRED

★HP and CREDIT SALE FACILITIES

When in London call in and try for yourself.

FREE! 16 PAGE ORGAN BROCHURE COVERING ORGANS IN KIT FORM AND READY BUILT—WRITE OR PHONE TO ORGAN DEPT. ASK FOR PETER ELVINS.

HI-FI equipment to suit EVERY POCKET

*Complete systems and individual units at special low prices—choose from 100 selected stereo systems. Call in for a demonstration when in London.

***Free 10-page stock/systems List No. 16/17.**

LOW CASH AND CREDIT/HP PRICES

(Credit terms for purchases from £30—callers only.)

HENRY'S RADIO LTD.

Mail Order Dept, Electronic Components and Equipment, and Electronic Organ Dept.
303 EDGWARE ROAD, LONDON W2.
Telephone: 01-723 1008/9
Open Mon-Sat. 9am–6pm, Thurs. 9am-1pm

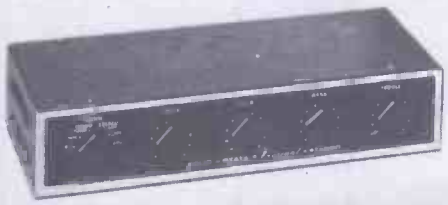
High Fidelity and Audio Centre
309 EDGWARE ROAD, LONDON W2.
Telephone: 01-723 6963
Open all day Saturday.

Complete Stereo System £41

This superb stereo system is a real price breakthrough. It comprises the VISCOUNT F.E.T. amplifier on which full details are given below, the famous Garrard SP 25 Mk II (including teak veneer base and transparent cover) with diamond cartridge or 2025 TC and the very successful DUO type 2 speakers.

Measuring 17½" × 10½" × 6¼", the Duo type 2 speakers are beautifully finished in teak veneer with matching vynair grills. They incorporate a 10½" × 6¼" drive unit and high frequency speaker, both of which are of 3 ohms impedance. The Duo speaker system is also available separately at £6 6 0 each plus 15/- P & P. Complete stereo system **£41** plus £2 10 P & P.

The Viscount F.E.T. £14.5s. plus 7/6 P & P



High fidelity transistor stereo amplifier employing field effect transistors. With this feature & accompanying guaranteed specifications below, the Viscount F.E.T. vastly surpasses amplifiers costing far more.

Specification: Output per channel 10 watts r.m.s. Frequency bandwidth 20 Hz to 20 kHz ± 1db @ 1 watt.
Total distortion: @ 1 kHz @ 9 watts 0.5%
Input sensitivities: CER. P.U. 100mV into 3 meg ohms. Tuner 100mV into 100K ohms. Tape 100mV into 100K ohms.
Overload factor: Better than 26db.
Signal to noise ratio: 70db on all inputs (with vol. max).
Controls: 6 position selection switch (3 pos. stereo & 3 pos. mono) Separate Vol. controls for left & right channels. Bass ± 14db @ 60 Hz Treble (with D.P.S. on/off ± 12db @ 10 kHz. Tape Recording output sockets on each channel.
Size: 12½" × 6" × 2¾" in teak-finished case.

BUILT & TESTED.
Mk II (MAG. P.U.) £15.15.0.
Post & packing 10/- extra

Specification same as Mk I, but with the following inputs. Mag. P.U. CER. P.U. Tuner. Spec. on Mag. P.U. 3mV @ 1 kHz Input impedance 47K Fully equalised to within ± 1db RIAA. Signal to noise ratio—65db (vol. max).

LIQUIDATED STOCK
DANSETTE
TOURISTE MK3 CAR RADIO

Beautifully designed to blend with the interiors of all cars. Permeability tuning and long wave loading coils ensures excellent tracking, sensitivity and selectivity on both wave bands. R.F. sensitivity at 1 MHz is better than 8 micro volts. Power output into 3 ohm speaker is 3 watts. Pre-aligned I.F. module and tuner together with comprehensive instructions guarantees success first time. 12 volts negative or positive earth. Size 7" × 2" × 4½" deep.

ORIGINALLY SOLD COMPLETE FOR £15.4.6.

SET OF PARTS £6.6.0. PLUS 7/6 P & P.

Speaker, baffle, and fixing kit 25/- extra plus 4/- P & P.

50 WATT AMPLIFIER

AC MAINS 200-250V
£28 10s.
plus 20/- p. & p.

An extremely reliable general purpose valve amplifier. Its rugged construction yet space age styling and design makes it by far the best value for money.

TECHNICAL SPECIFICATIONS
3 electronically mixed channels with 2 inputs per channel, enables the use of 6 separate instruments at the same time. The volume controls for each channel are located directly above the corresponding input sockets. **SENSITIVITIES AND INPUT IMPEDANCES.** Channels 1 & 2 4mV at 470K. These 2 channels (4 inputs) are suitable for microphone or guitars. Channels 3 & 4 300mV at 1m. Suitable for most high output instruments (gram, tuner, organ, etc.). Input sensitivity relative to 10w output. **TONE CONTROLS ARE COMMON TO ALL INPUTS.** Bass Boost + 12db at 60 Hz. Bass Cut—13dB at 60 Hz. Treble Boost + 11dB at 15 KHz. Treble Cut — 12dB at 15 KHz. With bass and treble controls central — 3dB points are 30 Hz and 20 KHz. **POWER OUTPUT:** For speech and music 50 watts rms 100 watts peak. For sustained music 45 watts rms. 90 watts peak. For sine wave 38.5 watts rms. Nearly 80 watts peak. Total distortion at rated output 3.2% at 1KHz. Total distortion at 20 watts 0.15% at 1KHz. **NEGATIVE FEEDBACK** 20dB at 1 KHz **SIGNAL TO NOISE RATIO** 60dB. **MAINS VOLTAGES** adjustable from 200-250V. A.C. 50-60 Hz. A protective fuse is located at the rear of unit. Output impedance 3.8 and 15 ohms.

R+TV

RADIO & TV COMPONENTS (Acton) LTD
21a High Street, Acton, London, W.3.
Also 323 Edgware Road, London, W.2. ALL ORDERS BY POST to Acton
Goods not dispatched outside U.K. Terms C.W.O. All enquiries S.A.E.

New 1970 prices LST Electronic Components Ltd.

AC107	14/6	BD119	15/–	NKT121	11/–	OC71	3/–	2G306	8/6	2N3133	6/–	2S003	12/6
AC126	5/–	BD121	18/–	NKT122	8/–	OC72	4/6	2G339A	5/–	2N3135	6/–	2S004	15/–
AC127	5/6	BD123	21/6	NKT123	6/–	OC75	4/6	2G371	3/–	2N3136	6/–	2S005	15/–
AC127Z	9/6	BD124	12/–	NKT125	5/6	OC76	2/6	2G371B	3/–	2N3235	28/6	2S006	15/–
AC128	4/–	BF115	5/–	NKT127	5/6	OC77	5/6	2G374	5/–	2N3234	27/6	2S012	25/–
AC176	5/–	BF152	13/6	NKT128	5/6	OC81	4/6	2G378	7/–	2N3391A	6/–	2S012A	22/6
AC187	12/–	BF154	9/–	NKT129	6/–	OC81D	3/–	2G381	5/–	2N3392	5/–	2S017	15/–
AC188	12/–	BF159	15/–	NKT141	7/–	OC82	5/–	2N109	11/–	2N3393	5/–	2S018	17/6
ACY17	5/–	BF163	9/–	NKT142	6/–	OC82D	3/–	2N174	16/–	2N3394	4/9	2S019	19/6
ACY18	3/6	BF167	5/–	NKT143	5/6	OC83	4/6	2N217	7/6	2N3402	5/6	2S104	12/6
ACY19	4/5	BF173	6/–	NKT144	8/–	OC84	5/–	2N370	15/–	2N3403	5/6	2S301	8/6
ACY20	3/7	BF178	10/6	NKT161	6/–	OC123	7/–	2N384	17/–	2N3404	7/6	2S302	7/6
ACY21	4/–	BF179	12/6	NKT162	6/–	OC139	5/–	2N386	12/–	2N3414	5/6	2S303	10/–
ACY22	2/9	BF180	6/–	NKT163	5/6	OC140	7/–	2N385A/		2N3415	6/–	2S304	12/6
ACY40	3/–	BF181	6/6	NKT164	5/6	OC170	5/–	2N388A	15/–	2N3416	7/6	2S306	15/–
ACY41	4/4	BF184	7/–	NKT165	6/–	OC171	6/–	2N404	4/6	2N3436	15/–	2S320	9/–
ACY44	8/–	BF185	8/–	NKT211	6/–	OC200	6/3	2N410	8/–	2N3525	21/9	2S321	6/–
AD140	11/–	BF194	3/6	NKT212	6/–	OC201	9/6	2N458A	25/–	2N3528	19/–	2S323	10/–
AD149	11/6	BF200	10/6	NKT213	4/–	OC202	18/–	2N511A	49/6	2N3606	5/6	2S701	8/6
AD161	6/–	BFX13	5/–	NKT214	4/–	OC203	7/6	2N513A	122/6	2N3607	4/6	2S703	12/6
AD162	6/–	BFX29	8/–	NKT215	4/–	OC204	8/–	2N599	10/–	2N3702	3/3	2S720	25/–
ADT140	12/6	BFX44	8/–	NKT216	10/–	OC205	9/–	2N601	25/–	2N3703	3/–	2S732	8/6
AF102	12/6	BFX84	7/6	NKT217	13/–	OC206	10/6	2N657	20/–	2N3704	3/3	2S1002	10/–
AF106	7/6	BFX85	9/–	NKT218	5/3	OC207	7/6	2N696	4/–	2N3705	3/–		
AF114	5/–	BFX86	6/6	NKT219	6/–	OC309	12/–	2N697	4/–	2N3706	2/9	**DIODES AND**	
AF115	5/–	BFX88	5/–	NKT221	5/6	OCP71	19/6	2N698	6/–	2N3707	3/–	**RECTIFIERS**	
AF116	5/–	BFY50	4/6	NKT222	4/–	ORP12	9/6	2N706	2/6	2N3708	2/–		
AF117	5/–	BFY51	3/9	NKT223	3/6	ORP60	8/–	2N706A	2/6	2N3709	3/–	AA119	2/–
AF118	12/6	BRY52	4/6	NKT224	4/6	ORP61	8/–	2N708	4/–	2N3710	3/–	AAY11	2/–
AF121	6/–	BFY53	3/2	NKT225	3/6	ORP63	9/–	2N711	7/6	2N3711	3/–	AAZ12	6/–
AF124	4/6	BFW57	6/–	NKT226	10/–	P346A	5/–	2N711A	7/6	2N3819	8/–	AAZ13	2/6
AF126	3/6	BFW58	5/6	NKT227	5/6	RAS310AF		2N715	7/6	2N3820	18/9	BA110	6/–
AF127	3/6	BFW59	5/–	NKT228	6/–		6/–	2N716	7/6	2N3826	6/–	BA111	6/–
AF139	7/6	BFW60	4/6	NKT261	4/3	RAS508AF		2N743	4/6	2N3854	5/6	BA112	18/–
AF178	9/6	BSX19	3 6	NKT262	4/3		15/–	2N744	6/–	2N3854A	5/6	BA115	1/6
AF179	11/6	BSX20	3/4	NKT264	4/3	S1M	19/–	2N753	5/6	2N3855	5/6	BA130	3/–
AF180	12/6	BSX21	7/6	NKT271	4/–	S4M	33/6	2N914	4/6	2N3855A	6/–	BAY31	2/6
AF181	8/6	BSX76	4/–	NKT272	4/–	ST140	3/–	2N918	7/6	2N3856	6/–	BAY38	3/–
AF186W	9/–	BSX77	6/–	NKT273	4/–	ST141	5/–	2N929	5/6	2N3856A	6/–	BY100	5/–
AF186G	9/–	BSX78	6/6	NKT274	4/–	ST2	9/9	2N930	7/6	2N3858	5/–	BY125	3/6
AF239	7/6	BSY27	4/–	NKT275	5/–	TI407	9/8	2N1090	6/6	2N3858A	6/–	BY127	4/–
AFY19	22/6	BSY29	5/–	NKT276	3/6	TIS34	17/6	2N1091	6/6	2N3859	5/6	BY234	2/3
AFZ11	8/–	BSY32	5/–	NKT279A	2/6	TIS44	1/9	2N1131	6/6	2N3859A	6/3	BYX10	3/–
ASY26	5/–	BSY36	5/–	NKT281	5/–	TIS45	3/3	2N1132	8/–	2N3860	6/–	BYX36	
ASY27	6/–	BSY37	5/–	NKT301	16/–	TIS46	3/3	2N1302	4/–	2N3866	25/–	150	2/6
ASY28	5/–	BSY38	4/–	NKT302	11/–	TIS47	3/3	2N1303	4/–	2N3877	9/–	BYX36	
ASY29	6/–	BSY95A	3/6	NKT303	10/–	TIS48	3/3	2N1304	5/–	2N3877A	9/6	300	2/10
ASZ21	7/6	BSW41	8/6	NKT304	9/6	TIS49	3/6	2N1305	5/–	2N3900	10/6	BYX36	
ATZ10	40/–	BSW70	5/6	NKT351	8/–	TIS50	5/6	2N1306	5/–	2N3900A	11/6	600	3/9
AUY10	30/–	BTX39		NKT352	7 6	TIS51	4/–	2N1307	5/–	2N3903	7/–	BYY21	25/–
B2M	12/6	600	120/–	NKT401	17/6	TIS52	4/–	2N1308	7/–	2N3904	7/–	BYY23	26/3
B3M	15/–	BTX40		NKT402	24/–	TIS53	6/6	2N1309	7/–	2N3905	7/6	BYY25	31/9
BC107	2/9	600	120/–	NKT403	15/–	TIS60	6/6	2N1496	34/–	2N3906	7/6	BYY142	3/9
BC108	2/9	BTY87		NKT404	12/6	TIS61	7/–	2N1507	4/8	2N4037	15/–	BYZ10	9/–
BC109	2/9	150R	31/–	NKT405	15/–	TIP31A	19/6	2N1613	5/6	2N4058	4/6	BYZ12	6/–
BC113	5/–	C106FI	9/–	NKT406	15/–	TIP32A	22/6	2N1671A	29/6	2N4059	5/–	BYZ13	5/–
BC115	6/6	C111	18/–	NKT451	12/6	TSW30C	18/–	2N1711	6/6	2N4060	5/–	CG6E	4/–
BC116	8/–	C111E	12/–	NKT452	12/6	U23AAA	5/–	2N1893	10/–	2N4061	4/–	CG63	2/–
BC118	5/–	C400	9/–	NKT453	10/–	V205	20/–	2N2147	17/–	2N4062	4/6	EA403	3/6
BC125	11/–	C426	8/3	NKT613F	5/–	V405A	9/3	2N2152	27/6	2N4284	3/–	EC401	5/–
BC126	11/–	C444	9/8	NKT674F	5/–	XA102	6/–	2N2148	12/6	2N4285	3/–	EC402	4/8
BC134	5/–	DI3TI	10/–	NKT675	5/–	XA702	15/–	2N2160	14/9	2N4286	3/–	EB383	3/6
BC135	6/–	GET102	6/–	NKT676	5/–	ZT22	19/–	2N2243	26/–	2N4287	3/–	GEX45/1	4/–
BC136	8/–	GET113	4/–	NKT677F	5/–	ZT86	27/6	2N2368	5/–	2N4288	3/–	GJ3M	4/–
BC137	8/6	GET114	4/–	NKT703	8/–	ZT2270	19/6	2N2369	5/–	2N4289	3/–	OA5	3/8
BC138	12/–	GET120	6/6	NKT713	7/6	40250	12/6	2N2369A	5/6	2N4290	3/–	OA10	6/–
BC140	13/3	GET880	9/–	NKT773	5/–	40309	9/6	SN2432	67/–	2N4291	3/–	OA47	1/6
BC147	2/9	GET887	4/–	NKT10339		40310	13/–	2N2484	8/–	2N4292	3/–	OA70	1/6
BC148	3/3	GET889	6/–		6/6	40311	10/6	2N2613	7/6	2N4871	6/9	OA73	1/6
BC149	3/–	GET890	6/6	NKT10419		40312	13/6	2N2614	4/–	2N5027	10/6	OA79	1/6
BC154	12/–	GET896	4/6		6/–	40313	10/6	2N2646	10/–	2N5028	11/6	OA81	1/6
BC167	3/6	GET897	4/6	NKT10429		40314	10/6	2N2711	6/–	2N5029	9/6	OA85	1/6
BC168	3/9	GET898	6/–		11/–	40315	10/6	2N2712	6/–	2N5030	8/6	OA90	1/6
BC169	3/9	GEX45/1	3/–	NKT10519		40316	13/–	2N2713	5/6	2N5172	3/–	OA91	1/6
BC182L	3/–	MAT100	5/–		6/6	40317	11/–	2N2904	8/6	2N5174	10/6	OA95	1/6
BC183L	2/6	MAT101	5/6	NKT16229		40319	15/–	2N2904A	8/–	2N5175	10/6	OA200	2/–
BC184L	3/–	MAT120	5/–		11/–	40320	10/6	2N2905	10/–	2N5176	9/–	OA202	2/–
BC212L	3/9	MAT121	5/6	NKT20329		40323	10/6	2N2905A	8/–	2N5232	5/6	SD19	–/7
BCY10	10/–	MJ400	21/6		11/–	40324	12/6	2N2923	4/–	2N5249	13/6	TD716	12/–
BCY12	12/–	MJ420	22/6	OC20	19/6	40326	10/6	2N2924	4/–	2N5249A	13/6	1N34A	4/–
BCY30	5/–	MJ421	22/6	OC22	8/–	40329	7/6	2N2925	3/6	2N5305	7/6	1N60	4/–
BCY31	5/6	MJ430	20/6	OC23	8/–	40344	8/–	2N2926		2N5306	8/–	1N64	4/–
BCY32	10/–	MJ440	19/6	OC24	8/–	40347	9/6	Green	2/–	2N5309	12/6	1N82A	9/6
BCY33	4/–	MJ480	20/6	OC25	7/6	40348	14/6	2N2926		2N5354	5/6	1N87A	4/6
BCY34	5/–	MJ481	27/–	OC26	6/6	40360	11/6	Yellow	2/–	2N5355	5/6	1N191	5/–
BCY38	6/–	MJ490	22/6	OC28	12/–	40361	12/–	2N2926		2N5356	10/6	1N914	1/9
BCY40	10/–	MJ491	29/6	OC29	15/–	40362	14/–	Orange	2/–	3N128	18/6	1N4001	2/–
BCY42	4/–	MPF102	8/6	OC35	9/–	40370	8/6	2N2926		3N140	19/6	1N4005	4/–
BCY43	4/–	MPF103	7/6	OC36	12/6	40406	16/–	Brown	2/–	3N141	21/6	1N4007	5/–
BCY54	7/6	MPF104	7/6	OC41	4/6	40408	14/–	2N3011	12/6	3N142	16/6	1N4148	1/9
BCY70	4/6	MPF105	8/–	OC42	4/6	40467	16/6	2N3036	39/–	3N143	19/6	IS44	1/9
BCY71	8/–	MPS3638	6/6	OC43	4/6	40468A	16/6	2N3053	5/–	3N152	24/–	IS130	2/–
BCY72	4/–	NKT12/152		OC44	3/–	40602	9/9	2N3054	12/6	2S001	10/–	IS131	2/6
BCY87	86/9		5/5	OC45	3/–	2G301	3/9	2N3055	15/–	2S002	12/6	IS132	3/–
BCZ11	7/6	NKT0013	9/6	OC70	2/6	2G302	3/9					IS113	4/6

LOWEST I.C. PRICES YET!

IC10	59/6	Sinclair IC amp.
PA230	20/–	IC Preamplifier
PA234	20/–	1 watt audio amp.
PA237	32/6	2 watt audio amp.
PA246	52/6	5 watt audio amp.
SL403A	42/6	3 watt Plessey amp.
SL702C	29/6	Plessey linear amplifier
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
3N84	26/–	Silicon controlled switch

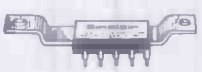
Data sheets available on request 1/– per copy.

PLEASE NOTE: Only new—full specification integrated circuits, no below-specification types.

FAIRCHILD MICRO-LOGIC

	1–6	7–11	12+
ul 900	9/9	9/–	8/–
ul 914	9/9	9/–	8/–
ul 923	12/6	11/9	11/–

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 transducers can transmit and receive.
FREE: With each pair our complete transmitter and receiver circuit.
PRICE £5.18.0 Pair (Sold only in pairs)

ZENER DIODES

400mW 10% GLASS CASE TEXAS Mfr.

IS2036	3·6 volt
IS2039	3·9 volt
IS2043	4·3 volt
IS2047	4·7 volt
IS2056	5·6 volt
IS2062	6·2 volt
IS2068	6·8 volt
IS2075	7·5 volt
IS2082	8·2 volt
IS2100	10 volt
IS2110	11 volt
IS2120	12 volt
IS2160	16 volt
IS2180	18 volt
IS2270	27 volt
IS2300	30 volt

1-24 3/6d. 25-99 2/9d. 100+ 2/3d.

2N3819 7/-

Texas FET
25+6/- 100+5/3

2N4871 6/9

Motorola unijunction
25+5/9 100+4/9

2N3055 15/-

115 watt silicon power transistor
25+13/- 100+11/-

IRC 20 8/6

Plastic SCR Thyristor, 200 piv 1·2amp (similar C106B1)
25+7/9 100+7/-

BC107/8/9 2/9

NPN Planar transistors
BC107 & 9 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/-

2N2926 2/-

NPN Planar transistors
25+1/8 100+1/6

INFRA-RED DEVICES

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+8/- 100+8/-

OCP 71 19/6

Mullard Phototransistor
25+17/3 100+14/9

ADDRESS YOUR ORDERS TO:

L.S.T. LTD. 7 COPTFOLD ROAD, BRENTWOOD, ESSEX
DIRECT LINES TO SALES DEPT: BRENTWOOD (ESSEX) 226470/1

Prices quoted are current at time of going to press and may be subject to variation without notice.
Semiconductors offered in this advertisement bear the relevant Manufacturers' original markings and are subject to our full replacement guarantee if not to published specifications.
WE DO NOT offer "Re-marked" makers' rejects or similar out of specification devices.
Please enclose a stamped self-addressed envelope with any query.
Quantity prices on application: many more types in stock and expected daily. If you buy in bulk we can save you money!
Export enquiries particularly welcome. Cable Address: Lestroco Brentwood.
TERMS OF BUSINESS: Retail orders; cash with order please.
TRADE: Please furnish references if credit account required.
POSTAGE: 1/- per order inland; 4/- Europe; 12/- Commonwealth.

HRO RECEIVER. Model 5T. This is a famous American High Frequency superhet, suitable for CW, and MCW, reception crystal filter, with phasing control. AVC and signal strength meter. Complete HRO 5T SET (Receiver, Set of 5 Coils & Power Unit) for **£27/10/-**, carr. 30/-.

COMMAND RECEIVERS; Model 6-9 Mc/s., as new, price **£5/10/-** each, post 5/-.

COMMAND TRANSMITTERS, BC-458: 5.3-7 Mc/s., approx. 25W output, directly calibrated. Valves 2 × 1625 PA; 1 × 1626 osc.; 1 × 1629 Tuning Indicator; Crystal 6,200 Kc/s. New condition—**£3/10/-** each, 10/- post.
(Conversion as per "Surplus Radio Conversion Manual, Vol. No. 2," by R. C. Evenson and O. R. Beach.)

AIRCRAFT RECEIVER ARR. 2: Valve line-up 7 × 9001; 3 × 6AK5; and 1 × 12A6. Switch tuned 234-258 Mc/s. Rec. only **£3** each, **7/6** post; or Rec. with 24 v. power unit and mounting tray **£3/10/-** each, 10/- post.

RECEIVERS: Type BC-348, operates from 24 v D.C., freq. range 200-500 Kc/s, 1.5-18 Mc/s. (New) **£35.0.0** each; (second hand) **£20.0.0** each, good condition, carr. 15/- both types.

MARCONI RECEIVER 1475 type 88: 1.5-20 Mc/s, second-hand condition **£10.0.0** each. New condition **£25.0.0** each, carr. 15/-.

RACAL EQUIPMENT: Frequency Meter type SA20: **£35** each, carr. **£1**. Frequency Counter type SA21: **£65** each, carr. 30/-. Converter Frequency Electronic VHF Type S.A.80 (for use with the SA.20): 25 Mc/s-160 Mc/s, **£40** each, carr. **£1**.

ROTARY CONVERTERS: Type 8a, 24 v D.C., 115 v A.C. @ 1.8 amps, 400 c/s 3 phase, **£6/10/-** each, 8/- post. 24 v D.C. input, 175 v D.C. @ 40mA output, **25/-** each, post 2/-.

CONDENSERS: 150 mfd, 300 v A.C., **£7/10/-** each, carr. 15/-. 40 mfd, 440 v A.C. wkg., **£5** each, 10/- post. 30 mfd, 600 v wkg. D.C., **£3/10/-** each, post 10/-. 15 mfd, 330 v A.C. wkg., **15/-** each, post 5/-. 10 mfd, 1000 v, **12/6** each, post 2/6. 10 mfd, 600 v, **8/6** each, post 5/-. 8 mfd, 1200 v, **12/6** each, post 3/-. 8 mfd, 600 v, 8/6 each, post 2/6. 4 mfd, 3000 v wkg., **£3** each, post 7/6. 2 mfd, 3000 v wkg., **£2** each, post 7/6. 0.25 mfd, 2Kv, 4/- each, 1/6 post. 0.01 mfd. MICA 2.5 Kv. Price **£1** for 5. Post 2/6. Capacitor: 0.125 mfd, 27,000v wkg. **£3.15.0** each, 10/- post.

OSCILLOSCOPE Type 13A, 100/250 v. A.C. Time base 2 c/s.-750 Kc/s. Bandwidth up to 5 Mc/s. Calibration markers 100 Kc/s. and 1 Mc/s. Double Beam tube. Reliable general purpose scope, **£22/10/-** each, 30/- carr.
COSSOR 1035 OSCILLOSCOPE, £30 each, 30/- carr.
COSSOR 1049 Mk. 111, £45 each, 30/- carr.

RELAYS: GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., **£2** each, 6/- post.
12 Small American Relays, mixed types **£2**, post 4/-.

Many types of American Relays available, i.e., Sigma; Allied Controls; Leach; etc. Prices and further details on request 6d.

GEARED MOTORS: 24 v. D.C., current 150 mA, output 1 r.p.m., **30/-** each, 4/- post. Assembly unit with Letcherbar Tuning Mechanism and potentiometer, 3 r.p.m., **£2** each, 5/- post.

SYNCHROS: and other special purpose motors available. British and American ex stock. List available **6d.**

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price **25/-**, post 5/-.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, **£2/10/-** each post 6/-.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps., **£2/10/-** each, carr. 12/6.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 2.6 ohms at 4 amps. Price (either type) **£2** each, 4/6 post each.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, **£4/10/-** each, 15/- carr.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 × 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19"Wx11"Hx14"D. (All connections at the rear). Excellent condition **£6.10.0.** each, Carr. **£1.**

AUTO TRANSFORMER: 230-115V, 50-60c/s, 1000 watts. mounted in a strong steel case 5" × 6½" × 7". Bitumin impregnated. **£5** each, Carr. 12/6. 230-115V, 50-60c/s, 500 watts. 7" × 5" × 5". Mounted in steel ventilated case. **£3** each, Carr. 10/-.

POWER UNIT: 110 v. or 230 v. input switched; 28 v. @ 45 amps. D.C. output. Wt. approx. 100 lbs., **£17/10/-** each, 30/- carr. SMOOTHING UNITS suitable for above **£7/10/-** each, 15/- carr.

CORPORAL ROCKET ELECTRONIC GUIDANCE EQUIPMENT: Beacon Radio DRN.7. Rec/Trans. Assembly MX.2048DPW-8. Electronic Control Amplifier AM1510/DJW3. Transmitter C-1493/MRQ.1. Power Units and miscellaneous spares available.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7/10/-** each, 15/- carr.

NIFE BATTERIES: 4 v. 160 amps, new, in cases, **£20** each, £1 10/- carr.

FUEL INDICATOR Type 113R: 24 v. complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in a 3in. diameter case. Price **30/-** each, postage 5/-.

FREQUENCY METERS: BC-221, meter only **£30** each, BC-221 complete with stabilised power supply **£35** each, carr. 15/-. LM13, 125-20,000 Kc/s., **£25** each, carr. 15/-. TS.175/U, **£75** each, carr. **£1.**

CANADIAN HEADSET ASSEMBLY: Moving coil headphones 100Ω, with chamois leather earmuffs. Small hand microphone complete with switch and moving coil insert. New condition. Price **35/-** each, post 5/-.

AUDIO OSCILLATOR 382/F: Input 115 v. A.C., 50 c/s, 20-200,000 c/s per sec. in 4 ranges. Cont. wave. Output 0-10 v. in 7 ranges. Power output 100 mW. Output impedance 1,000Ω. **£27/10/-** each, £1 carr.

RACK CABINETS (totally enclosed) for std. 19in. panels. Size: 6ft. high × 21in. wide × 16in. deep. With rear door. **£12** each, £2/10/- carr. OR 4ft. high × 23in. wide × 19in. deep. With rear door. **£8/10/-** each, £2 carr.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3/10/-** each, post 7/6.

APNI ALTIMETER TRANS./REC., suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. 3 relays, 11 valves, price **£3** each, carr. **10/-.**

TEST EQUIPMENT

MARCONI	TF–1274	VHF Bridge Oscillator	£75 each
	TF–1275	VHF Bridge Detector	£75 each
	TF–1067/1	Heterodyne Frequency Meter	£85 each
	TF–899	Valve Millivoltmeter	£35 each
	TF–978	VHF Admittance Bridge	£85 each
	TF–894A	Audio Tester	£55 each
	TF–329G	Circuit Magnification Meter	£45 each
	TF–428/2	Valve Voltmeter	£12/10/- each
	TF–428/1	Valve Voltmeter	£8/10/- each
	TF–726C	UHF Signal Generator	£65 each
	TF–934	Deviation Test Meter	£35 each
	6075A	Deviation Test Meter	£65 each
	TF–987/1	Noise Generator	£20 each
	TF–956	(CT.44) A.F. Absorption Wattmeter	£20 each
FIRZ HILL	V.200	Sensitive Valve Voltmeter	£35 each
	B.810	Incremental Inductance Bridge	£75 each
SOLATRON	CD–513	Oscilloscope	£45 each
	CD–513–2	Oscilloscope	£47/10/- each
	AW–553	Power Amplifier	£30 each
AIRMEC	Type 701 Signal Generator		£50 each
PHILLIPS	Type GM–6008 Valve Voltmeter		£35 each
DAWE	Type 402C Megohm Meter		£12 each

CANADIAN C52 TRANS/REC.: Freq. 1.75-16 Mc/s on 3 bands. R.T., M.C.W. and C.W. Crystal calibrator etc., power input 12V. D.C., new cond., complete set **£50.** Carr. £2/10/-. Power Unit for Rec., new **£3/5/-.** Carr. 10/-.

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each 0.9 ohms. Tolerance ±1% **£3** each, 5/- post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ±1% **£3/10/-** each, 5/- post.

TELESCOPIC ANTENNA: In 4 sections, adjustable to any height up to 20 ft. Closed measures 6 ft. Diameter 2 in. tapering to 1 in. **£5** each + 10/- carr. Or **£9** for two + £1 carr. (brand new condition).

COAXIAL TEST EQUIPMENT: COAXWITCH—Mnftrs. Bird Electronic Corp. Model 72RS; two-circuit reversing switch, 75 ohms, type "N" female connectors fitted to receive UG-21/U series plugs. New in ctns., **£6/10/-** each, post 7/6. CO-AXIAL SWITCH—Mnftrs. Transco Products Inc., Type M1460-22, 2 pole, 2 throw. (New) **£6/10/-** each, 4/6 post. 1 pole, 4 throw, Type M1460-4. (New) **£6/10/-** each, 4/6 post.

PRD Electronic Inc. Equipment: FREQUENCY METER: Type 587-A, 0.250-1.0 KMC/SEC. (New) **£75** each, post 12/6. FIXED ATTENUATOR: Type 130c, 2.0-10.0 KMC/SEC. (New) **£5** each, post 4/-. FIXED ATTENUATOR: Type 1157S-1, (new) **£6** each, post 5/-.

FOR EXPORT ONLY
BRITISH & AMERICAN COMMUNICATION EQUIPMENT

VRC.19X Trans-ceiver, 150-170Mc/s, 2 Channel, 20 Watts, Output 12/24V d.c. operation. General Electric Transmitter, 410-419Mc/s, thin line tropo scatter system, with antennae. W.S. Type 88, Crystal controlled, 40-48 Mc/s. W.S. Type HF-156, Mk. II, Crystal controlled, 2.5-7.5 Mc/s. W.S. Type 62, tunable, 1.5-12 Mc/s. C.44, Mk. II, Radio Telephone, Single Channel, 70-85 Mc/s, 50 watts, output, 230V. a.c. input. G.E.C. Progress Line Tx Type DO36, 144-174 Mc/s, 50 watt, narrow band width. A.C. input 115V. BC-640 Tx, 100-156 Mc/s, 50 watt output, 110V or 230V input. STC Tx/Rx Type 9X, TR1985; RT1986; TR1987 and TR1998, 100-156 Mc/s. TRC-1 Tx/Rx, Types T.14 and R.19, FM 60-90 Mc/s. With associated equipment available. Redifon GR410 Tx/Rx, SSB, 1.5-20 Mc/s. Sun-Air Tx/Rx Type T-10-R. Collins Tx/Rx/Type 18S4A. Collins Tx/Rx Type ARC-27, 200-400 Mc/s, 28V d.c. With associated equipment available. ARC-5; ARC-3; and ARC-2 Tx/Rx. BC-375; 433G; 348; 718; 458; 455 Tx/Rx. Directional Finding Equipment CRD.6 and FRD.2 complete Sets available and spares. Telephone Installation type XY, (U.S.A.), 600 Line Automatic Telephone Exchange. Complete system with full set of Manuals. Mobile Communications Installation mounted in a trailer with 4 × pneumatic tyres. Consisting of 3xARC-27 Tx/Rx with all associated equipment (as new).

ALL GOODS OFFERED WHILST STOCKS LAST IN "AS IS" CONDITION UNLESS OTHERWISE STATED

CALLERS BY TELEPHONE APPOINTMENT ONLY

W. MILLS

3-B TRULOCK ROAD, TOTTENHAM, N.17
Phone: 01-808 9213

BEDFORD STORES: Elstow Depot., Bldg. 10C7, Kempston Hardwick. Tel: Wilstead 605

ARF-100 COMBINED AF-RF SIGNAL GENERATOR

AF. SINE WAVE 20-200,000 cps. Square wave 20-30,000 cps. O/P HIGH IMP. 21 v. P/P 600Ω 3.8 v. P/P. R.F. 100 kc/s-300 Mc/s. Variable R.F. attenuation. Int./Ext. Modulation. Incorporates dual purpose meter to monitor. AF output and % mod. on R.F. 220/240 v. A.C. £32.10.0 Carr. 7/6.

TE-20RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 kc/s-260 Mc/s. on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions. £15.

P. & P. 7/6. S.A.E. for details.

PEAK SOUND PRODUCTS

Full range of Amplifiers, kits, Speakers in stock.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 30 kc/s. Output impedance 5,000 ohms. 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads, £16.10.0. Carr. 7/6.

LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER

2 pf-2,000 mfd. 2 ohms-200 megohms. Also checks impedance turns ratio insulation, 200/250 v. A.C. Brand New, £17.10 Carr. 7/6.

TY75 AUDIO SIGNAL GENERATOR

Sine Wave 20 CPS—200 Kc/s. Square Wave 20 CPS—30 Kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts A.C. Brand new with instructions. £16. Carr. 7/6. Size 210 × 150 × 120 mm.

TE-20D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 Kc/s—500 Mc/s on 6 bands. Directly calibrated. Variable RF. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. £15. Carr. 7/6. Size 140 x 215 x 170 mm.

ADVANCE TEST EQUIPMENT

Brand new and boxed in original sealed cartons.

JIB. AUDIO SIGNAL GENERATOR
15 c/s to 50 Kc/s. Sine wave. Output 600 ohms or 5 ohms. £30.0.0.

VM79. UHF MILLIVOLT METER
100 Kc/s to 1,000 Mc/s. A.C. 10 mV to 3v. D.C. 10 mV. to 3v. Current 0.01 uA to 0.3 mA. Resistance 1 ohm to 10 megohm. £125.0.0.

TTIS. TRANSISTOR TESTER
Full range of facilities for testing PNP or NPN transistors in or out of circuit. £37.10.0.

Carriage 10/- per item.

SOLARTRON CD 711S2 DOUBLE BEAM OSCILLOSCOPES

D.C. to 9 Mc/s. Perfect order. £65. Carr. 50/-. Few available less C.R.T. £25. Carr. 50/-.

AVO CT.38 ELECTRONIC MULTIMETERS

High quality 97 range instrument which measures A.C. and D.C. Voltage. Current, Resistance and Power Output Ranges D.C. volts 250 mV-10,000v. (10 meg Ω-110 meg Ω input). D.C. current 10μA-25 amps. Ohms. 0-1,000 meg Ω A.C. volt 100mv.-250V (with R.F. measuring head up to 250 Mc/s) A.C. current 10μA-25 amps. Power output 50 micro-watts-5 watts. Operation 0/110/200/250V. A.C. Supplied in perfect condition complete with circuit lead and R.F. probe. £25. Carr. 15/-.

RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPE

5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. × 4in. C.R.T. Calibrated triggered sweep from .2 μ/sec. to 100 milli-sec. per cm. Free running time base 50c/s-1mc/s. Built in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. £87. Carr. paid.

Latest Catalogue

The latest edition giving full details of a comprehensive range of HI FI EQUIPMENT, COMPONENTS, TEST EQUIPMENT and COMMUNICATIONS EQUIPMENT. . . . Over 230 pages, fully illustrated and detailing thousands of items — many at bargain prices. FREE DISCOUNT COUPONS VALUE 10/-.

SEND NOW—ONLY 7/6 P&P1/6

GARRARD

Full current range offered brand new and guaranteed at fantastic savings

1025 Stereo	£7.19.6	SL65B	£14.19.6
40 Mk II Stereo	£8.8.0	SL72B	£25. 0.0
2025 T/C Stereo	£8.17.6	AP75	£16.19.6
3000 Stereo	£9.19.6	SL75B	£28. 0.0
SP25 Mk II	£11. 9.6	SL95B	£35. 0.0
SL55	£11.12.6	A70/11	£11.19.6
		401	£25. 0.0

Carriage 7/6 extra each item.

TEAK BASES AND PERSPEX COVERS

1. For SP25, SL65, SL55, 3000, 2025T/C, 2025, 1000, £4.10.0.
2. For AP75, SL75, SL95, £5.19.6.
3. For SP25 etc. to operate with lid in place £5.19.6. Carriage 7/6 extra each type.

SPECIAL OFFERS

Garrard SP25 fitted Goldring G800 cartridge and wooden plinth. Total list price £32.8.5.
OUR PRICE £19. 15. 0. Carr. 10/-

GOLDRING GL69 fitted Goldring G800 cartridge complete with de luxe base and cover. Total list price £50.16.0.
OUR PRICE £39. Carr. 20/-

RTC 249 4-TRACK TAPE DECK

British made. Speeds 1¼in., 3¾in., 7½in. p.s. Marriott heads. 7in. reel size. Push button controls, fully interlocking. Size 13in. × 10in. × 1¼in. above unit plate, 4¼in. below. Full instructions. £13.19.6. Carr. 7/6.

Variable Voltage TRANSFORMERS

Brand new, guaranteed and carriage paid.
High quality construction. Input 230 v. 50-60 cycles
Output full variable from 0-260 volts. Bulk quantities available.
1 amp.— £5/10/-; 2.5 amp.— £6/15/-; 5 amp.— £9/15/-;
8 amp.—£14/10/-; 10 amp.—£18/10/-; 12 amp.—£21; 20 amp.—£37

MULTIMETERS for EVERY purpose!

TE-900 20,000Ω/VOLT GIANT MULTIMETER Mirror scale and overload protection. 6in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0 / 25 / 12.5 / 10 / 50 / 250/1,000/5,000 v. D.C. 0/50μA/110/1. . /500mA/10 amp. D.C. 02K/200K/20 MEG. OHM. £15/-/-. P. & P. 5/-.

MODEL AS-100D. 100K Ω/Volt. 5in., mirror scale. Built-in meter protection 0/3/12/60/120/300/600/1,200 v. D.C. 0/6/30/120/300/600 v. A.C. 0/10μA/6/60/300MA/12 Amp. 0/2K/200K/2M/200MΩ. —20 to +17dB. £12/10/-. P. & P. 3/6.

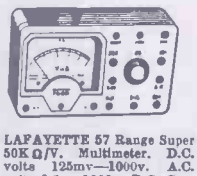
MODEL TE-90 50,000 O.P.V. Mirror scale, overload protection. 0/3/12/60/300/600/1,200 v. D.C. 0/6/30/120/300/1,200. v D.C. .03/6/60/600 MA. D.C. 16K/160K/1.6/16 MEG Ω. —20 — + 63db. £7/10/0. P. & P. 3/-.

MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/30μA/3/30/300mA. 0/16K/160K/1.6M/16 Meg Ω. £5/10/-. P. & P. 3/-.

MODEL TE-80. 20,000 O.P.V. 0/10/50/100/500/1,000 v. A.C. 0/5/25/50/250/500/1,000 v. D.C. 0-50μA. 5/50/500mA. 0/6K/60K/600K/6 meg. £4/17/6. P. & P. 3/-.

MODEL TE-12. 20,000 O.P.V. 0/0.6/6/30/120/600/1,200/3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/60μA/6/60/600mA. 0/6K/600K/6 Meg./60 Meg. Ω. 50 PF. .2 MFD £5/19/6. P. & P. 3/6.

TE-51. NEW 20,000Ω/VOLT MULTIMETER, with overload protection and mirror scale, 0/6/60/120, 1,200 v. A.C. 0/3/30/60/300/600/3,000v. D.C. 0/60μA/12/300m A.D.C. 0/60K/6 meg. ohm. 92/6. P. & P. 2/6.



MODEL PT-34. 1,000 O.P.V.0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K Ω 39/6. P. & P. 1/6.

LAFAYETTE 57 Range Super 50K Ω/V. Multimeter. D.C. volts 125mv—1000v. A.C. volts 1.5v—1000v. D.C. Current 25μA—10 Amp. Ohms 0—10 Meg Ω. D.B.—20 to +81 db. Overload protection. £12/10/-. P. & P. 3/6.

SAVE UP TO 33⅓% ON HI-FI EQUIPMENT
Send for full discount price list

AVO CT471A MULTIMETER

Battery operated, fully transistorised. Sensitivity 100 MΩ/v. Measures A.C./D.C. voltages 12mV. to 1,200V. A.C./D.C. current 12uA. to 1.2 Amp. Resistance 12 ohm to 120 mΩ H.F., V.H.F., U.H.F. voltage with multiplier 4V. to 400V. up to 50 Mc/s., 40mV. to 4V. up to 1,000 Mc/s. Offered in perfect condition. £55 each. Carr. 10/-.

SINCLAIR EQUIPMENT

Project 60 range of new models now in stock

Z30 Amplifier	£4/9/6
Stereo 60 Control Unit	£9/19/6
PZ5 Power Supply	£4/19/6
PZ6 Power Supply	£7/19/6
Q16 Speakers	£8/19/6

All Post Paid

SPECIAL PACKAGE OFFER!

2 × Z20 Amplifier, Stereo 60 and PZ5 Power Supply (Carr. 7/6).	£19
or with 2 × Q16 Speakers (Carr. 7/6).	£25
Micromatic Radio Kit.	49/6
Micromatic Radio Built.	59/6
Sinclair IC/10 in stock.	59/6
2000 Amplifier £23/10/0. Carr. 7/6.	
Neoteric Amplifier £46/0/0. Carr. 7/6.	

ECHO HS-606 STEREO HEADPHONES

Wonderfully comfortable. Lightweight adjustable vinyl headband, 6ft. cable and stereo jack plug, 25-17,000 cps., 8Ω imp. 67/6. P. & P. 2/6.

HOSIDEN DH04S 2-WAY STEREO HEADPHONES

Each headphone contains a 2½in. woofer and a ½in. tweeter. Built in individual level controls. 25-18,000 c.p.s. 8Ω imp. with cable and stereo plug. £5/19/6. P. & P. 2/6.

HOSIDEN DH-02S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable headband. 8 ohm impedance. 20-12,000 cps. Complete with lead and stereo jack plug. ONLY 47/6 P. & P. 2/6.

TRANSISTORISED TWO-WAY TELEPHONE INTERCOM

Operative over amazingly long distances. Separate call and press to talk buttons. 2-wire connection. 1000's of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets. £6/19/6 pair. P. & P. 3/6.

TE111 DECADE RESISTANCE ATTENUATOR

Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db × 10) + (1 db × 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db). Accuracy: 0.05 db. + indication db × 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Braod new £27/10/-. P. & P. 5/-.

RECORDING HEADS

Cosmocord ¼ track heads: Post extra.

Record/replay. High imp.	65/-
Erase. Low imp.	20/-
Marriott ¼ track heads. Post extra.	
Record/Playback, high imp.	65/-
Erase, low imp.	20/-

AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities. Postage 2/-. Over £3 post paid.	3in. 225ft. L.P. Acetate	3/6
	3½in. 600ft. T.P. Mylar..	10/-
	5in. 600ft. Std. plastic..	8/6
	6in. 900ft. L.P. acetate..	10/-
	5in. 1,200ft. D.P. Mylar	15/-
	5½in. 1,200ft. L.P. acetate	12/6
	5½in. 1,200ft. L.P. Mylar	16/-
	5½in. 1,800ft. D.P. Mylar	22/6
	5½in. 2,400ft. T.P. Mylar	39/6
	7in. 1,200ft. Std. acetate	12/6
	7in. 1,800ft. L.P. acetate	15/-
	7in. 1,800ft. L.P. Mylar	20/-
	7in. 2,400ft. D.P. Mylar	25/-
	7in. 3,600 ft. T.P. Mylar	45/-

TAPE CASSETTES

Top quality in plastic library boxes.
C60— 60 min. 8/6 ; 3 for 24/6.
C90— 90 min. 12/6; 3 for 36/-.
C120—120 min. 15/-; 3 for 43/6.
Cassette Head Cleaner 11/3 All Post Extra.

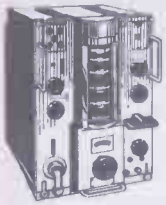
G.W.SMITH & CO.(RADIO) LTD

All Mail Orders to—
147, Church Street, London, W.2
Tel: 01-262 6562
(Trade supplied)

3, LISLE STREET, LONDON, W.C.2 Tel: 01-437 8204
34, LISLE STREET, LONDON, W.C.2 Tel: 01-437 9155
311, EDGWARE ROAD, LONDON, W.2 Tel: 01-262 0387

OPEN 9-6 MONDAY TO SATURDAY (EDGWARE ROAD ½ DAY THURSDAY)

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 x 13½ x 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.

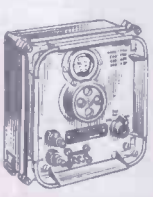
180-260v. Input. Output 230v. Available 150w or 225w. £12.10.0. Carr. 5/-.

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 x 180 x 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 x 215 x 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. x 7½in. x 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

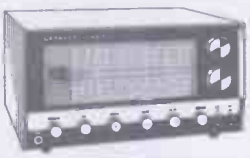
Large quantity available for EXPORT! Excellent condition. Enquiries invited.

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.



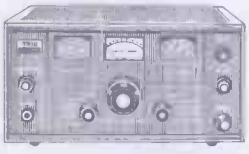
LAFAYETTE SOLID STATE HA600 RECEIVER

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 ● 24in. Bandspread ● 230 v. A.C./12 v. D.C. neg earth operation ● RF gain control. Size 15in. x 9½in. x 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 12½" x 4½" x 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 x 15 x 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. £180
TRIO JR 500SE 10-80 Metre Amateur Receiver £65

LAFAYETTE HA.800 SOLID STATE AMATEUR COMMUNICATION RECEIVER SIX BANDS 3.5-4, 7-7.3, 14-14.35, 21-45, 28-29.7, 50-54 Mc/s.

Dual conversion on all bands. 2 x 455 Kc/s mechanical filters. Product detector. Variable B.F.O 100 Kc/s crystal calibrator. 'S' meter. Huge slide rule dial. Operation 230v AC or 12v DC. Size 15" x 9½" x 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 £65. Carr. £2.

LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER

A completely new transistorised receiver covering 152-174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built-in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75 Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. £37/10/-. Carr. 10/-.

TELETON MODEL CR-10T AM/FM STEREO TUNER AMPLIFIER

A new model from Teleton. 31 solid state devices. 4+4 watt output. Inputs for ceramic/crystal cartridge. Frequency range AM 540-1600 KHz, FM 88-108 MHz. Automatic FM Stereo reception. Stereo Indicator. Controls: Tuning, function selector, Tone and R & L volume controls. AFC switch. Stereo headphone socket. Size 13½in. x 3½in. x 9½in. approx. Price £34/0/0. Carr. 7/6.

SEW PANEL METERS

Type MR.38P. 1 21/32in. square fronts.

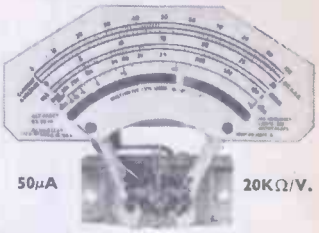
50μA	40/-	50mA	27/6	100V. D.C.	27/6
50-0-50μA	37/6	100mA	27/6	150V. D.C.	27/6
100μA	37/6	150mA	27/6	300V. D.C.	27/6
100-0-100μA	35/-	200mA	27/6	500V. D.C.	27/6
200μA	35/-	300mA	27/6	750V. D.C.	27/6
500μA	30/-	500mA	27/6	15V. A.C.	27/6
500-0-500μA	27/6	750mA	27/6	50V. A.C.	27/6
1mA	27/6	1 amp	27/6	150V. 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 89/6 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.

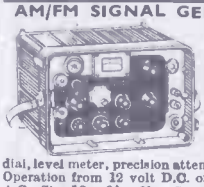
TE-65 VALVE VOLTMETER

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.

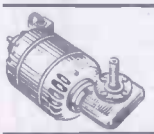
COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

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/-.



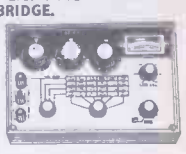
GEARED MAINS MOTOR

Paralux type 8D19 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" x 5½" x 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 7½" x 5" x 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. 65/-, 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

CONVERTOR/BATTERY CHARGER. Input 240v 50 c/s, output 12v 5 amp DC. Input 12v DC, output 240v AC. 170 watt max. With fuse and indicator lamps. Size 9½ × 10 × 4½in. Weight 19lb. An extremely compact unit that will give many years' reliable service. Supplied with plug and lead. Only **£4/10/-.** P. & P. 15/- extra.
As above—fully serviceable—perfect interior but soiled exterior cases, **£3.** P. & P. 15/-.
G.M. TUBES. Brand new. G24/G38/G60 at **27/6** ea. G53/1, brass cased, **£6** ea.

MULLARD MX 115 GM TUBE with holder. Plat app 300 volts. **30/-** ea. P. & P. 3/6.

PHOTOMULTIPLIERS. EMI 6097X at **£8/10/-** ea.
TRANSISTOR OSCILLATOR. Variable frequency 40 c/s to 5 kc/s. 5 volt square wave o/p. for 6 to 12v DC input. Size 1⅞ × 1½ × 1½in. Not encapsulated. Brand new. Boxed. **11/6** ea.

RACAL Diversity unit. **£10** each. Carriage **£1.**

CRAMER TIMER 28V DC Sweep 1/100th sec & sweep 60 secs. 4" dial. Remote control stop/start reset **£6.10.0.**

RELAYS
Omron/Schrack octal based plug-in relays. 2 pole c/o 5A, 6v only. Brand new. Boxed. **12/6** ea.
G.E.C. 4 pole c/o 6/12v operation 180 ohms. Platinum contacts. Brand new. Boxed **12/6** ea.

Miniature STC Plug in relays Plastic dust cover, 4 pole c/o 7.5-18 v. operation. 185 Ohms **8/-** each. **6/-** each per 100.

S.T.C. sealed 2 pole c/o, 2,500 ohms. (okay 24v) **2/6** ea.; 12v—**7/-** ea.
CARPENTERS polarised Single pole c/o 20 and 65 ohm coil as new, complete with base **7/6** ea. Single pole c/o 680, 1,110 and 1,570 ohm coil. As new **6/6** ea.
Single pole c/o 14 ohm coil **6/6** ea.; Single pole c/o 45 ohm coil 6/6 ea.
Brand New. Single Pole c/o (type 5A2), 2 × 1200 ohms. **8/6** ea.

POTENTIOMETERS
COLVERN Brand new. 5; 10; 50; 100; 250; 500 ohms; 1; 2.5; 5; 10; 25; 50k all at **2/6** ea. Special Brand new **MORGANITE** 250K 1 in. sealed. Normal price 9/-, our price 3/6 ea.
INSTRUMENT 3" Colvern. 5; 25; 100 ohms. **7/-** ea.
TRIM POTS. Paignton-solder lugs 5, 10 & 25K at **5/-** each: Pins 10; 20; 50; 100; 200; 250; 500 ohms; 2.5; 25 and 50K at **10/-** each.
DARSTAN-preset-sealed ¼" dia, ½ high. 1; 2 and 5K **1/6** ea.
HIGH RESOLUTION 25K 80 turns. Complete with knob **6/6**
ALMA precision resistors 100K; 400K; and 998K—0.1% **5/6** ea: 3.25K—0.1% **4/-** ea.
DALE heat sink resistors. non-inductive 50 watt. Brand new. 15 ohms—**6/6** ea.; 8.2K **4/6** ea. Excellent dummy load.

Wheatstone Bridge by **TINSLEY** type 1138 **£75.**

CAPACITORS
ERIE feed through ceramicons 1000 pf—**9d.** ea.
Sub-min. **TRIMMER** ½ square. 8, 5pf. Brand new **2/6** ea.
Concentric **TRIMMER** 3/30 pf. Brand new **1/6** ea.
ELECTROLYTICS. Brand new. 2500 mfd 64V **9/6** ea. 4000 mfd 40V **9/6** ea.; 250 mfd 70V **4/6** ea.; 2000 mfd 16V **7/-** ea.
EHT 2 mfd 5 KV. Brand new **£2** each.
VISCONOL EHT. Brand new 0.0005 25 kV, **16/-** ea.
E.H.T. 0.02mfd 8KV- **6/-** ea.; 0.1mfd 2.5 KV-nitrogel—**4/6** ea.; 0.5mfd 5KV—**11/-** ea.; 0.5mfd 2.5KV **7/-** ea.

DECADE DIAL UP SWITCH. Finger-tip. Engraved 0/9. Gold plated contacts. Size 2½" high, 2½" deep ½" wide. **30/-** ea. Bank of 4 with escutchin plates etc. 2½" high 2½" deep, 2½" wide. **£5.**

DIODES 1N914. Brand new **1/3** ea.; **12/-** doz.; **£4**—100; **£25**—1,000.
PHOTOCELL equivalent OCP 71 **2/6** ea.
BURGESS Micro Switches V3 5930. Brand new **2/6** ea.
BULGIN panel mounting Lamp holders. Red. Brand new **2/3** ea.
TRANSISTORS BC 114—NPN Low noise high gain audio, etc.; BC 116—PNP General purpose 200 mc/s. Ex brand new equipment. Guaranteed perfect. Good lead length. **2/-** ea.

NUCLEONIC INSTRUMENTS
SCALER type 1009 by Dynatron. Suitable Beta/gamma counts. Built in test signal. Calibrated adjustable discriminator. Read out 2 decade neons and 4 digit counter. Supplied in as new condition at **£5** ea. Carr. 30/-.
As above but with resettable counter **£8** ea. Carr. 30/-.
Few only **RATEMETER** type 1161B Complete with built in EHT supply. Separate metering EHT and Count. EHT available for external equipment 0 to 3 kv. As new **£35.** Carr. 30/-.
Portable Geiger Counter in haversack, complete £5 ea. P. & P. 10/-.
100 CHANNEL PULSE HEIGHT analyser type 1363B. As new **£75.** As above but type 1363C. **£120.**
ECKO PULSE HEIGHT ANALYSER type N101 **£25.** Carr. 30/-.
DEKATRON Display unit type NIS 223. **£20.** Carr. 30/-.
CINTEL Transistorised Nucleonic Scaler with adjustable discriminator. 6 meter display 0-9 giving count of 10 to the 5. New Condition. Now ONLY **£18.** Carr. 15/-.
PULSE Generator type 1147A. **£6.** Carr. 30/-.

BRAND NEW BC114 TRANSISTORS. 5/- ea; 4/3 ea. per 100; 3/6 ea. per 1,000.

MINIATURE SPEAKERS 15 ohm 2in. diameter. Brand new. **7/-** ea. P. & P. 2/6 ea.

TEST GEAR

OSCILLOSCOPES

E.M.I.	WM 2 DC—13 mc/s **£35**
E.M.I.	WM 8—**£80**
SOLARTRON	711S.2 D.B. DC—9 mc/s **£60**
SOLARTRON	643 DC—15 mc/s NOW only **£65.**
SOLARTRON	DC—10 mc/s. CD513—**£35,** 513.2—**£40,** CD523—**£45**
SOLARTRON	568 DC—6 mc/s **£18**
COSSOR	1035 DB. **£20**
COSSOR	1049; 1049 Mk. 3. DB. **£22/10** and **£30**
HARTLEY	13A DB. **£18/10/-**

All carefully checked and tested. Carriage 30/- extra.

MARCONI
TF 956 (CT44) Audio Freq. Wattmeter **£15.** Carr. 10/.
TF 886 Magnification Meter **£45** Carr. **£1**
TF 369 N. 5 Impedance Bridge **£55** Carr. 30/-
TF 144G Signal Generator, Serviceable, Clean **£15** In exceptional condition **£25.** Carr. 30/-
TF 885 Video Oscillator Sine/Square **£35** Carr. 30/-
TF 195M Sine wave oscillator 0/40kc/s **£12** Carr. **£1**
TF 1343/2 'X' Band gen. **£35** Carr. 30/-
TF 428B/1 Valve voltmeter **£4** Carr. 10/-
TF 428B/2 Valve voltmeter **£8** Carr. 10/-
Type 801 Sig. Gen. **£35,** Carr. 30/-
TF 934/2 FM Deviation Meter **£25.** Carr. 30/-
TF 791B Carrier Deviation Meter **£35.** Carr. 30/-

SOLARTRON
Pulse generator POS 100C 50 c/s—1 mc/s **£18** Carr. **£1**
Laboratory amplifier AWS51A. 15c/s—350kc/s **£35** Carr. **£1**
Stabilised P.U. SRS 151A **£20** Carr. 30/-
Stabilised P.U. SRS 152 **£15** Carr. 30/-
Stabilised P.U. AS 516 & AS 517 **£3,** and **£6** Carr. 10/-
Calibration Unit type AT203. **£25.** Carr. 30/-
Process Response Analyser. Fine Condition **£250**
Oscillator type OS 101. **£35** ea. Carr. 30/-

AVO
AVO TRANSISTOR ANALYSER—**£75** only.
Testmeter No. 1 **£14** Carr. 15/-
Electronic Testmeter CT 38. Complete **£18** Carr. **£1**
SPECIAL by **G. & E. BRADLEY.** Multimeter type CT471B. Battery operated, fully transistorised, sensitivity 100 M ohm/V, measures a.c./d.c. voltage (12mV-1200V scales, +/— 3% /+ /— 2% f.s.d.) a.c./d.c. current (12 microA-1.2A scales, +/— 3% / +/— 2% f.s.d.) resistance (12 ohm-120M ohm scales, +/— 3% m.s.d.), h.f./vhf/uhf. voltage with multiplier (4V-400V scales up to 50 MHz; 40 mV-4V up to 1000 MHz). Brand new. Few only. **£60** Carr. 30/-

CINTEL
Wide Range Capacitor Bridge **£25** Carr. 15/-
Sine and Pulse Generator type 1873 **£25** Carr. 15/-

AIRMEC
Valve Millivoltmeter type 264. 3MV-1V **£20** Carr. **£1**
Counter type 865. 6 decades. Bright Vertical display gate facilities. Very good condition **£25.** Carr. 30/-
Klystron Power Supply 698B **£25** Carr. **£1**
Signal Generator type 701. **£35.** Carr. 30/-

OSCILLOSCOPE CAMERA. Shackman 25ft. Exp 270 frames. Times from 1/250 to 1 secs. auto. Dalmere Fl. 9 Focal 1¼in. with standard 4in. to 5in. fitting. **£30.**

BECKMAN MODEL A. Ten turn pot complete with dial. 100k 3% Tol 0.1%—only **52/6** ea.

E.H.T. Base B9A in Polystyrene holder with cover. Brand new. **2/6** ea.
ZENITH E.H.T. Tester, with Probes. Metered 0-3.5 kv. **£25** Carr. 30/-.
DVM & RATIOMETER BIE 2116 by Blackburn **£75** ea.
DENCO S band low noise travelling Wave amplifier **£35.** Carr. 30/-.
SIGNAL Generator CT 53. Complete with leads. Good condition. **£10** Carr. 15/-. With copy of charts.
FREQUENCY Meter LM 14. Modulated version of BC 221 with charts and covers. Brand new **£30.** Carr. 30/-.
SPECIAL. FURZEHILL V200 Valve millivolt meter. 10 mv to 1 kv. **£25** Carr. **£1.**
FURZEHILL Valve Voltmeter type 378B/2. Range 0-80 dbs & 10 millivolts to 100 Volts in 5 ranges. Size 11 x 8½ x 7in. **£12.** Carr. 15/-.
MIC-O-VAC type 22 (CT54) Volts; Current; Ohms. DC to 200 mc/s with probe, leads etc. As new **£8/10/0** P. & P. 10/-.
VIBRATING REED ELECTROMETER type N 572 by ECKO. Range 10 to the -14. Max sensitivity FSD for 1 of 0.03 Micro-microamps. **£20** ea. Carr. **£1.**

3 CM Wave Guide, some flex; Sanders Attenuators; Decca Waveguide Switches; Delay lines, etc. Phone or call.

DISTRIBUTED AMPLIFIER type 2C/3 50 c/s 100 mc/s Gain 300. **£30** each.
Type 2C 50 c/s to 100 mc/s **£16** each.
DAWE Wide Range oscillator type 400A. 20 cs to 20 kc/s Sine wave. 500, 600 and 2000 ohm. Fine condition. **£25.** Carr. 30/-.

PAIGNTON ATTENUATORS 0.1 db. to 100 db. in 3 decades, 600 ohm. 19" rack mounting. **£20** ea. Carr. 15/-
PISTON ATTENUATOR in carrying case. 30-140 mc/s calibrated 0/70 db. **£10** ea. Carr. **£1**
Precision **THERMISTOR** by YSI. 100 k. at 25°C. Range: 40°C. to 150°C. Supplied with charts giving ohms for each degree over entire range. Brand new. **£2** ea.
ADVANCE Signal Generator type D1. 2 mc/s to 190 mc/s. Sine and square mod. With original charts. Excellent condition **£12/10/0** P. & P. **£1**
CLAUDE LYONS Main Stabilizer. Type 7000C. Input 212-252 volts 47/65 c/s. Output 238 volts 0.5% 53 amps. **£40.** Carriage at cost.
SERVOMEX Mains Stabilizer. Type AC7 Mk. 11. 200/250 volts 0.1%, 45/65 c/s-60 amps. New Condition. **£75.** Carriage at cost.
ROBAND P.U. Type M39A. Stabilized 300 volts 2 amps. **£22** inc. carriage.
HOLGATE 6 channel Event recorder. 1in. or 10in. inches per second. Size 4½ × 5 × 8in. Excellent condition. **£20.**
HEWLETT PACKARD Recorder and Decoder type 20610. As new. Write or phone for further details.
19in. Rack Mounting **CABINETS** 6ft. high 2ft. deep. Side and rear doors. Fully tapped, complete with base and wheels. **£12/10/0** Carriage at cost.
Double Bay complete with doors. Fine condition. **£25.** Carriage at cost.
MULLARD Transistorised Analogue to Digital Convertor Model L 281. As new. **£20** Carr. 15/-
SUNVIC DC chopper Amplifier type DCA 1. Superb condition. **£22/10/0** ea. Carr. 20/-
CINTEL Universal Counter **£30.** Carr. 30/-.
PROCESS TIMERS 8 individual timer circuits. each with 0-100 sec calibrated dials. Ideal displays, processes, etc. Standard mains input **£20** Carr. 25/-.
ISOLATING TRANSFORMERS 240V in 240V 7 KVA out. As new. **£25** ea. Carr. £2/10/-
DIECAST ALLOY boxes. Size 4 × 2½ × 1½ in. Drilled ends for Belling Coax socket. 3 compartments link holes between. **6/6** each. P. & P. 2/-.
CONVERTOR 50 c/s single ph. to 400 c/s 3 ph. 250w. in 6ft. enclosed 19" rack cabinet. **£35** ea. Carr. at cost.
AMPEX FR400 with Benson-Layner 'XY' Plotter. Large vacuum table. Auto paper feed. **£500.**

4 DIGIT RESETTABLE COUNTERS. 1000 ohm. coil. Size 1½ × ¾ × 4½in. As new, by Sodeco of Geneva. **£2/10/0** each.
As above but 350 ohm. **£3/10/0** ea.

METERS—WESTON 25-0-25 microamp. Scaled -100-0-+100. 5½" × 4". **£4** ea.
TRANSFORMERS. All standard inputs.
STEP DOWN ISOLATING trans. Standard 240v AC to 120v tapped 60-0-60 700w. Brand new. **£6** ea. As above but 500w. **£4** ea.
75 WATT Constant voltage transformer. 195 to 255 volts—240v out. **30/-** each. P. &. P. 5/-.
MODULATION trans. PP—6 BW6. **30/-** each. P. & P. 5/-.
Transformer 0-215-250 120 MA; 6.3V 4A CT × 2; 2 × 6.3v 0.5A and separate 90v 100 MA **25/-** each P. & P. 4/-.
Matching contact cooled bridge rectifier **7/6** each.
350-0-350 75mA, 5v 2 amps × 2, **21/-** ea.
Gardners 6·3v 2A; 6·3v 1·5A; 6·3v 0·1A. Size 3 × 1½ × 4½in. As new. **9/6** ea. P. & P. 3/- ea.
Parmeko/Gardners. Potted. 475-60-0-60-475 at 160 mA; separate winding 215-0215 at 45mA; 6·3v 5A; 6·3v 0·75A; 5v 3A. As new. **£3** ea.
Gardners/Gresham. Potted 450-400-0-400-450 180 ma; 0-4-6.3 3A x 2; 0-4-6.3 4A; 0-4-5V 3A. In original boxes £4 ea. incl. postage.
Gardners 2kV 10MA and 4 volts × 2. **£4/10/-** ea incl. postage.
Parmeko 65v 1 amp. Separate 0-18-24v at 0·5 amp. **30/-** ea. Gard/Parm/Part. 450-400-0-400-450. 180 MA. 2 × 6.3v. **£3** ea.
ADVANCE Constant Voltage Trans. 3KW **£50.** Also 1.5 KW available **£30.**
ADVANCE Constant Voltage Trans. 6 volts 50 watt. As new **£3** P. & P. 10/-
Gardners 5v 30amp. Brand new **£1/10** each incl. postage.
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.
Panel switches DPDT ex eq. **2/6** ea.; DPST Brand new **3/6** ea.; DPDT twice. brand new **6/-**; heavy duty DPST brand new **6/-** ea.
SPECIAL. 813 valves. Brand new, boxed **£2/10/0.**
MOTOR DRIVEN SWITCHES. 4 to 24 volt, 6 pole, 24 way. Brand new. **£6** ea. P. & P. 5/-.
PRECISION continually rotarable stud switches. Single pole. 80 way, can be stacked if required. **£3** ea.
PRECISION rotary stud switches 2 pole 12W size 2" sq., ¼" shaft. **£2/10/0** ea.
Min. **SEALED** 4 pole 3 way and 3 pole 4 way rotary switches. ¼" shaft ½" dia. × ½" **10/-** ea.
Must go—American Pressure Gauges. Scaled 0-200/0-2800, KSC/PSI; 270° dial 5". **22/6** ea. P. & P. 5/-.
Solartron Storage. Oscilloscope type QD 910. MUST GO. Now only **£100** each.

CASH WITH ORDER **OFFICIAL ORDERS WELCOMED**

FOR CALLERS. Always a large quantity of components, transformers, chokes, valves, capacitors, odd units, etc., at 'Chiltmead' prices. Callers welcome 9 a.m. to 10 p.m. any day.

CHILTMEAD LTD.

22 Sun Street · Reading · Berks · Tel. No. 65916

now at 7-9-11 ARTHUR ROAD, 300 yds. east (near Tech. College) Tel. No. 582605

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	2¼ 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.

HEAVY DUTY L.T. TRANSFORMERS

Pri. 220-240v. Sec. 12v. 175 a. Open type flying leads. Size 8 × 8 × 7 ins. £36 carr. £2. 12v. 90a. Size 7½ × 6½ × 6 ins. £18.10.0 carr. 20/-.

Pri. 220-240v. Sec. tapped 14-15-2-28-31v. 20a. Open type table top connections. £12.10.0 carr. 15/-.

Pri. tapped 110-220-240v. Sec. 55v. 24a., 14v. 10a., 60v. 2a. All windings conservatively rated. Tropically finished. Terminal connections. Size 9 × 7½ × 7 ins. Weight 65 lbs. £15 carr. 17/6.

110 volt primary only. Sec. 46v. 29a. Very conservatively rated. Size 11 × 7 × 7 ins. Weight 75 lbs. By Partridge Transformer Co. £10 carr. 15/-.

Samson's

(ELECTRONICS) LTD.

9 & 10 CHAPEL ST., LONDON, N.W.1

01-723-7851 01-262-512

AMERICAN HIGHLY STABILISED POWER SUPPLY UNIT

Regulation between 7-15 volts D.C. at 20 amps. Fitted 0-30 D.C. ammeter, 0-15 D.C. voltmeter and overload protection switch. Built to a very high specification. Bench or rack mounting. Size 19 × 8 × 17 ins. A.C. input 110v. 50 cycles. Ex equipment but guaranteed in perfect condition. Maker's price in excess of £200. Our price £29.10.0. Carr. 30/-. 240/110 volt, 400 watts, Mains Transformer available if required. £3 extra.

G.P.O. L.T. SUPPLY UNIT

Type 19. A.C. input, tapped 200-250v., 100-120v. D.C. output, 12 or 24 volts, very conservatively rated at 3 amps. Can be connected to give 12 volts 6 amps. Built into strong metal case size 19 × 7 × 6½ ins. With fitted fuses. On/off switch. Socket outlet. Circuit supplied, £7.19.6, carriage 15/-.

ZENITH DOUBLE-WOUND VARIABLE TRANSFORMERS

Input 240v., output 0-80v., 15 amps or 0-40v. 30 amps. Open-type slider control. Size: length 2 ft. 8 ins. × 8 ins. × 7 ins. Carr. extra.

OIL-FILLED BLOCK CAPACITORS

T.C.C. 8 mfd. 2500v. wkg. at 70°C. 37/6, P. & P. 8/6. 0·5 mfd. 10,000v. wkg. at 70°C. 37/6, P. & P. 8/6. Dubilier 4 mfd. 2500v. wkg. at 70°C. 25/-, P. & P. 7/6. 2 mfd. 4000v. wkg. at 70°C. 25/-, P. & P. 7/6. 0·25 mfd. 7500v. wkg. 17/6, P. & P. 4/6. American Micamold 8 mfd. 600v. wkg. at 100°C. 10/6, P. & P. 2/-. 4 mfd. 600v. wkg. Tubular S-hole fixing. 6/6, P. & P. 2/-. T.C.C. Visconol tubular S-hole fixing. 1 mfd. 2500v. wkg. at 60°C. 12/6, P. & P. 2/6. 0·1 mfd. 8000v. wkg. at 60°C. 10/6, P. & P. 2/-. 0·1 mfd. 5000v. wkg. at 60°C. 7/6, P. & P. 2/-. 0·05 mfd. 10,000v. wkg. at 60°C. 8/6, P. & P. 2/-.

HEAVY DUTY ISOLATION TRANSFORMER

Pri 240v. Sec. 120v. 85 amp. conservatively rated. Size 19 × 14 × 8 ins., weight 1¾ cwt. £55 + carr. One only.

SPECIAL OFFER OF PARMEKO NEPTUNE SERIES TRANSFORMERS ALL PRIMARIES TAPPED 115-230v.

Sec. 6·3v. CT 5a. 6·3v. CT 3a. 6·3v. CT 2a. 37/6 P. & P. 5/-.
Sec. 9-10v. 0·5a. 6·3v. 3·5a. 6·3v. 1·2a. 19/6 P. & P. 4/-.
Sec. 400-0-400v. 150 m/a. 50/- P. & P. 7/6.
Sec. 350-0-350v. 100 m/a. 3-8-12-18v. 5a. £3.19.6 P. & P. 8/6.
Sec. 6·3v. CT 5a. 6·3v. 1·2a. 6·3v. 1·2a. 27/6 P. & P. 5/-.
Sec. 6·3v. 1·8a. 6·3v. 1a. 6·3v. 1a. 17/6 P. & P. 3/6.
Sec. 29·5-32·5v. 2a. 32/6 P. & P. 5/-.
Sec. 4v. 0·5a. four times. 15/- P. & P. 3/6.
Sec. 6·3v. CT 0·6a. 6·3v. 0·6a. 12/6 P. & P. 3/6.
Sec. 250-0-250v. 50 m/a. 6·3v. 1a. 22/6 P. & P. 4/6.
Pri. 200-240v. Sec. 250-0-250v. 60 m/a. 6·3v. 2a. 6·3v. 3a. 5v. 2·5a. 30/- P. & P. 7/6.

GARDNERS HT TRANSFORMERS ALL PRIMARIES TAPPED 200-250v.

Sec. 500-0-500v. 250 m/a. 6·3v. 4a. 6·3v. 4a. 6·3v. 3a. 5v. 3·5a. Fully shrouded. £6.10.0. Carr. 10/-.
Sec. tapped 350-360-370-380-390-400v. 350 m/a. 15v. 2a. 6·3v. 3a. × 3. 6·3v. 2a. 6·3v. 1a. Fully shrouded. £4.19.6. Carr. 8/6.
Sec. 350-0-350v. 60 m/a. 4·6·3v. 4a. 4·5v. 2·5a. Fully shrouded, 27/6. P. & P. 5/-.
Sec. 500-0-500v. 80 m/a. 6·3v. 2a. 6·3v. 2a. 5v 2a. Fully shrouded. 47/6. P. & P. 5/-.
Sec. 63v. 1·6a. 24v. 0·8a. 6·3v. 1a. Open type. Table top connections. 65/-. P. & P. 7/6.
Sec. 12v. 1a. Twice open type T.T. connections. 17/6. P. & P. 3/6.
Sec. 3·75v. 9a. 6·3v. 0·5a. Fully shrouded. 17/6. P. & P. 3/6.
Sec. 7v. 5a. 6·4v. 4a. 6·4v. 2·2a. 6·4v. 2·2a. 5v 2·8a. 4v. 1a. Oil-filled potted type. 50/-. Carr. 8/6.
Sec. 370-390-410v. 6 m/a. Open 'C' core type. 12/6. P. & P. 2/6.
Sec. 12v. 6a. and 15·6v. 1·5a. Fully shrouded. 37/6. P. & P. 7/6.
Sec. tapped 20-40-700-760v. 50 m/a. 6·3v. 1·5a. Fully shrouded. 17/6. P. & P. 4/6.
Sec. 300v. 37·5 m/a. 4kv. D.C. wkg. Twice. 4v. 1a. 4v. 0·3a. 19/6. P. & P. 4/6.
600 watts auto tapped 200-210-220-230-240-250v. Open type. T.T. connections.

H.T. TRANSFORMERS

Parmeko Neptune. Pri. 115-230v. Sec. 2000v. 5 m/a. 4v. 1a. 47/6. P. & P. 5/-. Gardners Pri. 200-240v. Sec. 2250v. 22 m/a. 75/-. P. & P. 7/6. Pri. 200-240v. Sec. 1650v. 25 m/a. 75/-. P. & P. 7/6. Pri. 200-240v. Sec. tapped 3000-3300v. 10 m/a. 4·6·3v. 1·5a. 3kv. wkg. 2·4v. 2a. 3kv. wkg. £4.19.6. Carr. 10/-.

PARMEKO C CORE TRANSFORMERS

Pri. tapped 110-200-240v. Sec. 1 250v. 197 m/a. Sec. 2 161v. 110 m/a. Sec. 3 152v. 76 m/a. Sec. 4 124v. 25 m/a. Sec. 5 28v. 0·4a. Sec. 6 6·4v. 6·2a. 6·3v. 3·25a. 6·3v. 1·4a. Table top connections. Size 5 × 4 × 4 ins. Brand new boxed. 35/-. P. & P. 7/6. Special prices for qtys.

ADVANCE C/V TRANSFORMERS

Type CV 15/95. Input 95-130v., 190-260v. Output 4v. rms + or — 1%. 3 watts. Open frame type. 25/-, P. & P. 5/-.

Type MT140. Input 190-260v. Output 230v. 150w. £5.15.0. Carr. 10/-.

Type 500. Input 190-260v. Output 240v. 500 watts. £12.10.0 Carr. 15/-.

Lasky's

AUDIO TRONICS 1970

The 1970 edition of Lasky's famous Audio Tronics catalogue is now available FREE on request. The 28 tabloid pages—equal to over 100 pages of our normal "WW" advertising—are packed with 1,000's of items from the largest stocks in Great Britain of everything for the Radio and Hi-Fi enthusiast. Electronics Hobbyist, Servicemen and Communications Ham. Over half the pages are devoted exclusively to every aspect of Hi-Fi (including Lasky's budget Stereo Systems and Package Deals), tape recording and Audio accessories etc. All the goods shown are available from any of our branches or by Mail Order—bringing the benefits of shopping at Lasky's to you in the comfort of your home. **PLUS Lasky's amazing money saving vouchers worth over £25.** Over 150,000 customers have already received their copy of the "Audio Tronics" catalogue—don't delay.

This month vouchers worth 40/-

Send: Your name, address and 2/- to cover post only and the inclusion of your name on our regular mailing list.

Lasky's Radio Limited
3-15 Cavell Street, London, E1 2BN

LASKY'S RADIO ESTABLISHED OVER 36 YEARS

EX COMPUTER PRINTED CIRCUIT PANELS 2" × 4" packed with semi-conductors and top quality resistors, capacitors, diodes, etc. Our price, 10 boards 10/-. P. & P. 1/6. With a guaranteed minimum of 35 transistors. Transistor Data included.

SPECIAL BARGAIN PACK. 25 boards for £1. P. & P. 3/6. With a guaranteed minimum of 85 transistors. Transistor Data included.

PANELS with 2 power transistors sim. to OC28 on each board plus components. 2 boards (4 × OC28) 10/-. P. & P. 1/6.

9 OA5, 3 OA10, 3 Pot Cores, 26 Resistors, 14 Capacitors, 3 GET872, 3 GET872B, 1 GET875. All long leaded on panels 13" × 4". 4 for 20/-. P. & P. 5/-.

EX COMPUTER "MEMORY" CORE STORE PLANES

160 BITS £1 P. & P. 2/-
4000 BITS £4 P. & P. 4/-

250 MIXED RESISTORS ¼ and ½ Watt **12/6**

DIODES EX EQPT. SILICON

10 Amp 150 PIV 4 for 10/-
20 Amp 150 PIV 4 for £1 -
35 Amp 450 PIV 4 for 45/-
P. & P. 1/-

EXTRACTOR/BLOWER FANS (Papst)

100 c.f.m. 4½" × 4½" × 2", 2800 r.p.m.
50/- each. P.& P. 5/-.

RELAY OFFER

Single Pole Changeover Silver Contacts 2" × 6" × 7". 2.5KΩ Coil operates on 25 to 50V. 8 for 10/-. P. & P. 1/6.

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 ¼ and ½ watt . . . diodes, miniature silicon types OA90, OA91, OA95, IS130, etc. . . . capacitors including tantalum, electrolytics, ceramics and polyesters . . . inductors, a selection of values . . . 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/-. P. & P. 6/6—U.K. New Zealand 20/- P. & P. Limited stocks only.

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.

150 High Stabs ¼, ½ and 1 Watt, 5% and Better **12/6**

LARGE CAPACITY ELECTROLYTICS
RIPPLE CURRENT 6A

1,500 mfd 150V
4,000 mfd 72V
5,000 mfd 36V
16,000 mfd 12V
7/6 each P. & P. 1/6
£3.10.0 doz. P. & P. 10/-

EXTENSION TELEPHONES

19/6 ea. P. & P. 5/-
35/- for 2 P. & P. 10/-

These phones are extensions and do not contain bells.

KEYTRONICS

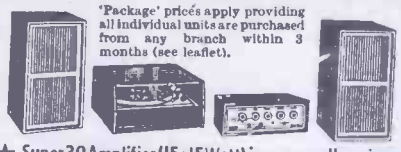
MAILING ADDRESS
52 EARLS COURT ROAD, LONDON W.8
WAREHOUSE AND DISPATCH
01 478 8499

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 (15+15 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).

★ Super 30 Amplifier (15+15 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/-

★ TA 12 6·5+6·5W Amplifier in veneered housing.
★ Pair of Dorchester Loudspeaker Units.
★ Garrard SP25 Mk II 4-speed Player on Plinth.
★ Goldring CS90 Ceramic P.U. Cartridge with diamond Stylus. Special total price. Carr. 25/- **53 Gns.**

Transparent Plastic cover 3 gns extra
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.** Carr. 25/-
Transparent cover 3 gns. extra

AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS

Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround or 'L' indicates Roll Rubber surround. "D" indicates Tweeter Cone providing extended frequency range up to 15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 15 ohms.

WHEN ORDERING PLEASE STATE IMPEDANCE					
HF 801D 8"	8W	54/3	HF 120	12" 15W	79/9
HF 102D 10" 10W		67/11	HF 120D	12" 15W	89/9
HF 100D 10" 15W		£4/19/9	HF 126	12" 15W	£5/5/-
HF 105DL 10" 10W		£6/6/0	HF 126D	12" 15W	£5/15/-

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. Iuc.carr. **16Gns.**

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. TA6 6 Watt HIGH FIDELITY SOLID STATE AMPLIFIER

200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, approx. 9½ × 2½ × 5½in. Attractive brushed silver finish facia plate 10½ × 3½in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. **7 Gns.** Carr. 7/6. OR FACTORY BUILT with 12 months' guarantee. £8.19.9.

R.S.C. COLUMN SPEAKERS

Covered in Rexine and Vynair, ideal for vocalists and Public Address. 15 ohm matching.

TYPE C488, 30 watts. Fitted four 8in. high flux 8 w. speakers. Overall size approx. 48 × 10 × 5in. Or deposit 67/- and 9 mthly pmts. 34/9 (Total £18/19/9.) Carr. 10/-. **16 Gns.**

TYPE C4128, 50 watts. Fitted four 12in. 11,000 lines 15 watt speakers. Overall size 56 × 14 × 9in. approx. Or deposit £5/17/6 and 9 monthly payments of 54/6 (Total £30/7/-). Carr. 15/- **26 Gns.**

AUDIOTRINE HI-FI SPEAKER SYSTEMS

Consisting of matched 12in. 11,000 line 15 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. Carr. 5/9 **£5.15.0**
Or SENIOR 15 WATT inc. HF 126 15,000 line Speaker £6/15. Carr. 6/6.

HI-FI LOUDSPEAKER ENCLOSURES Teak or Afrormosia veneer finish. Modern design. Acoustically lined. All sizes approx. Carr. 7/6 extra.
JE8 Size 16×11×9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **£4.14.6**
SE8 For optimum performance with any 8in. Hi-Fi 'speaker. 22×15×9in. Ported **£5.15.0**
SE10 For outstanding results with Hi-Fi 10in. speaker. 24×15×10in. Ported **£5.19.9**
SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25×16×10½in. Pressurised. **£6.19.9**

THE 'YORK' HIGH FIDELITY 3 'SPEAKER SYSTEM

Moderate size (approx. 25 × 14 × 10 in.). Range 30-20,000. Complete kit 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. **20 Gns.** Carr. 12/6
REMARKABLE VALUE HEAR IT AT ANY BRANCH

TA12 Mk II 6·5 + 6·5W STEREO AMPLIFIER

FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL
Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 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).

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.

SELENIUM RECTIFIERS

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.

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., A.C. mains. For 3 & 15 ohm speakers. Complete Kit parts wiring diags., instructions. Twin-handled perforated cover 35/-. Or factory built with EL34 output valves and 12 months' guarantee for 18 gns. Tech. figs. apply to factory built units. Carr. 12/6. TERMS: Deposit £6.3.0 and 9 monthly payments of 34/- (Total £21/9/0.) Send S.A.E. for leaflet. **15 Gns.**

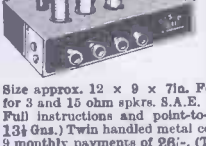
R.S.C. MAINS TRANSFORMERS

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., 6v. 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.	

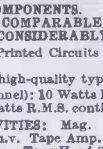
INTEREST CHARGES REFUNDED On Credit Sales settled in 3 months

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 35/-. 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.)

HIGH QUALITY LOUDSPEAKERS



In teak or afrormosia veneered cabinets.
L13 13" × 8" 8-10 Watt Model Gauss 10,000 lines. 3 or 15 ohms.
£4/19/9 Carr. 7/6
L12 12" 20 Watt Model. 15 ohm. Size 18 × 18 × 10in. approx. Gauss 10,000 lines. Finish as above 10/- extra. Carr. 8/9 **£8/19/9**

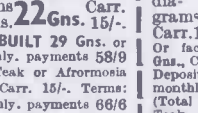
FANE ULTRA HIGH POWER L'SPEAKERS

High flux ceramic magnets. Imp. 8-15Ω. 2 yrs. guarantee.
12" 50w 10 Gns.
15" 60w 12 Gns.
18" 100w 21 Gns.
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 Post 4/3

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 units carriage 9/6 extra.

R.S.C. SUPER 30 Mk II HIGH FIDELITY STEREO AMPLIFIER

HIGH GRADE COMPONENTS.
SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE
Employing Twin Printed Circuits 200/250v. A.C. mains operation.
TRANSISTORS: 9 high-quality types per channel.
OUTPUT (Per channel): 10 Watts R.M.S. continuous into 15Ω 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: ±2 dB. 10-20,000 c.p.s.
TREBLE CONTROL: +17 dB to —14 dB at 10 Kc/s.
BASS CONTROL: +17 dB to —15 dB at 50 c/s.
HUM LEVEL: —80 dB.
HARMONIC DISTORTION: 0.1% at 10 Watts 1,000 c.p.s.
CROSS TALK: 52 dB at 1,000 c.p.s.

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" with silver background. 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. Carr. **22 Gns.** 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. Carr. 12/6. **12½ Gns.**
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, SP25 etc. etc. Available with Transparent plastic cover. **3 Gns** AT60, **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. Carr. 10/6 **23Gns.**
RP5C Garrard 2025 Auto Unit fitted GC823 Stereo Cartridge with diamond tip. Plinth and Cover as RP2C. Carr. 10/6 **15Gns.**
Various other types with Magnetic P.U. Cartridges and 'Lift off' or 'Roll over' transparent covers at lowest prices.

FANE 'POP' 30C LOUDSPEAKER

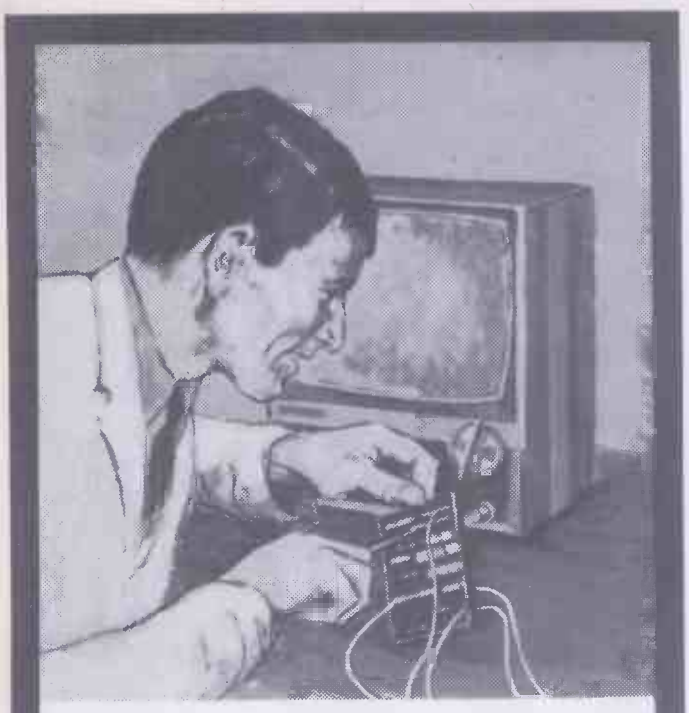
12" 25 w 15Ω Dual cone
Post Free **£5.19.9**

BRADFORD 10 North Parade (Half-day Wed.). Tel. 25349
BLACKPOOL (Agent) O & C Electronics 227 Church St.
BIRMINGHAM 30/31 Gt. Western Arcade. Tel.: 021-236 1279. Half-day Wed.
DERBY 26 Osmaston Rd. The Spot (Half-day Wed.). Tel. 41361
DARLINGTON 18 Priestgate (Half-day Wed.). Tel. 68043
EDINBURGH 133 Leith St. (Half-day Wed.). Tel. Waverley 5766
GLASGOW 326 Argyle St. (Half-day Tues.). Tel. CITy 4158
HULL 91 Paragon Street (Half-day Thurs.). Tel. 20505

R·S·C HI-FI CENTRES LTD.

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.

LEICESTER 32 High Street (Half-day Thurs.). Tel. 56420
LEEDS 5-7 County (Mecca) Arcade, Briggate (Half-day Wed.) Tel. 28252
LIVERPOOL 73 Dale St. (Half-day Wed.). Tel. CENtral 3573
LONDON 238 Edgware Road, W.2 (Half-day Thurs.). Tel. PAD 1629
MANCHESTER 60A Oldham Street (Half-day Wed.) Tel. CENtral 2778
MIDDLESBROUGH 106 Newport Rd. (Half-day Wed.). Tel. 47096
NEWCASTLE UPON 41 Blackett Street (opp. Fenwicks TYNE Store) (Half-day Wed.). Tel. 21469
SHEFFIELD 13 Exchange Street (Castle Market Bldgs.) (Half-day Thurs.). Tel. 20716



Train for tomorrow's world in Radio and Television at The Pembridge College of Electronics.

The next full-time 2 year College Diploma Course which gives a thorough fundamental training for radio and television engineers starts on 2nd September, 1970.

The course includes theoretical and practical instruction on Colour Television receivers and is designed to cover the syllabus of the new City and Guilds Radio, Television and Electronics Technicians' Course. Pembridge College diplomas are awarded to successful students.

The way to get ahead in this fast growing industry—an industry that gives you many far-reaching opportunities—is to enrol now. Minimum entrance requirements 'O' Level, Senior Cambridge or equivalent in Mathematics and English.

To: The Pembridge College of Electronics (Dept. WW13), 34a Hereford Road, London, W.2

Please send, without obligation, details of the Full-time Course in Radio, Television and Electronics.

NAME .....

ADDRESS .....

.....

.....

R.S.T. VALVE MAIL ORDER CO.

BLACKWOOD HALL, 16A WELLFIELD ROAD STREATHAM, S.W.16

A61 9/6	ECL83 10/3	PL84 7/-	XH8/100 300/-	7Y4 8/6	2G382 6/-
ACT9 500/-	ECL86 9/-	PL508 29/-	XR13/200 120/-	10F1 14/9	2G401 5/-
ARP38 16/-	ECLL800 30/-	PL509 29/-	Z66 15/-	11E3 70/-	2G402 6/-
AZ31 10/-	EF9 20/-	PL802 16/6	Z319 25/-	12AC6 10/-	2G414 6/-
BT19 60/-	EF37A 7/-	PT15 15/-	Z759 30/-	12AD6 11/-	2G415 6/-
BT79 57/-	EF39 8/-	PX4 24/-	Z800 20/-	12AE6 9/6	2G416 6/6
BT89 67/-	EF41 10/-	PX25 27/6	Z801 30/-	12AT6 4/9	2G417 6/-
C1C 20/-	EF50 5/-	PY32 10/9	Z803U 15/-	12AT7 6/-	2N247 9/6
CBL31 16/-	EF80 4/6	PY33 10/9	OA2 6/3	12AU7 5/9	2N555 12/6
CCH35 15/-	EF86 6/6	PY81 5/9	OB2 6/-	12AX7 6/3	AC107 5/6
CV5 95/-	EF89 5/6	PY82 5/3	OZ4 4/6	12BA6 6/-	AC127 5/-
CV74 80/-	EF91 3/6	PY83 7/-	1B3GT 7/3	12BE6 6/3	AC128 4/6
CV82 50/-	EF92 2/6	PY500 18/6	1Z2 25/-	12E1 20/-	ACY19 5/-
CV315 80/-	EF98 15/0	PY800 9/6	2C39A 140/-	12K7GT 7/-	ACY20 5/-
CV354 110/-	EF183 6/6	PY801 9/6	2C43 70/-	12K8GT 8/-	ACY21 4/6
CV370 300/-	EF184 7/-	PZ30 10/-	2D21 6/6	12Q7GT 6/-	AD140 8/-
CV372 57/-	EF804 21/-	QF41 400/-	2E26 20/-	13E1 190/-	AF114 5/-
CV408 50/-	EFP60 10/-	QQV02/6 45/-	2K25 160/-	20P4 20/-	AF115 5/-
CV428 45/-	EH90 7/6	QQV03/10 27/6	3A/167M 80/-	24B1 110/-	AF116 4/6
CV429 350/-	EL33 12/6	QQV03/20 105/-	3A5 20/-	25Z4 6/3	AF117 7/-
CV450 25/-	EL84 10/6	QQV04/15 105/-	3B24 29/-	25Z5GT 8/-	BY100 4/6
CV1144 60/-	EL36 9/3	QQV06-40A 100/-	3B240M 110/-	25Z6GT 8/6	GET571 5/-
CV1385 140/-	EL38 22/6	QQV06/40 90/-	3B241M 110/-	27M1 72/6	GET575 6/-
CV1522 180/-	EL41 11/-	QQV5/10 70/-	3B28 40/-	30C15 15/-	NKT211 6/6
CV1526 65/-	EL42 11/6	Q870/20 5/6	3C24 60/-	30C17 16/-	NKT214 4/4
CV2155 32/6	EL81 9/-	Q875/20 5/6	3C45 65/-	30F5 17/-	NKT216 6/4
CV2306 350/-	EL84 4/9	Q875/60 20/-	3D21A 35/-	30FL1 15/-	NKT217 8/4
CV2312 35/-	EL85 7/9	Q883/3 7/3	3E29 70/-	30L15 17/-	NKT218 22/6
CV4003 10/-	EL86 8/3	Q892/10 4/-	4C35 300/-	30L17 17/-	NKT228 6/-
CV4004 10/-	EL90 6/3	Q895/10 5/6	4CX250B 240/-	30P4 22/6	NKT404 12/6
CV4005 8/-	EL95 6/6	Q8108/45 15/-	4X150A 95/-	30P19 15/-	NKT675 6/-
CV4006 18/-	EL360 24/-	Q8150/15 8/-	4X150D 200/-	30PL1 16/-	NKT677 5/-
CV4007 7/-	EL820 6/-	Q8150/30 6/-	4X250B 180/-	30PL13 18/6	NKT713 7/6
CV4014 7/-	EL821 7/6	Q8150/36 20/-	5B/254M 37/-	30PL14 15/-	OC16 15/-
CV4015 10/-	EL822 16/-	Q8150/45 20/-	5B/255M 37/6	35L6 9/-	OC19 8/6
CV4024 6/-	ELL80 20/-	Q8150/80 20/6	5C22 320/-	35L6GT 9/-	OC20 20/-
CV4025 7/-	EM34 16/-	Q81209 7/3	5R4GY 10/6	35W4 4/6	OC24 9/-
CV4031 7/-	EM80 7/6	QVO3-12 12/-	5U4G 5/6	35Z4GT 8/6	OC25 7/6
CV4033 7/-	EM81 10/-	QV04-7 12/6	5V4G 8/-	50C5 6/3	OC26 6/-
CV4044 12/-	EM84 7/6	QV05-25 9/-	5Y3GT 6/-	50CD6G 31/-	OC28 12/6
CV4045 10/-	EN32 25/-	QV06-20 27/6	5Z4G 7/-	80 7/6	OC29 14/6
CV4046 90/-	EY51 7/6	QY3-125 130/-	6/30L2 15/-	85A1 25/-	OC35 6/3
CV4048 12/6	EY81 7/-	R10 15/-	6AK5 5/-	85A2 7/3	OC44 4/-
CV4062 17/6	EY83 8/6	R17 8/-	6AK6 12/6	88L 160/-	OC45 3/3
CV4064 30/-	EY84 9/-	R18 7/6	6AL5 3/-	90AG 45/-	OC71 3/-
CY30 12/6	EY86 7/-	R19 7/9	6AM6 3/6	90AV 45/-	OC72 4/-
DAF91 4/6	EZ40 9/-	RG3/1250 120/-	6AN8 10/-	90C1 12/-	OC74 4/6
DAF96 7/6	EZ41 9/6	RG5/500 80/-	6AQ4 4/-	90CG 25/-	OC75 4/6
DCC90 20/-	EZ80 5/6	S1M2 32/6	6AQ5 6/3	90CV 25/-	OC76 3/-
DET3 1,000/-	EZ81 5/6	S11E12 70/-	6A86 6/-	150B2 11/6	OC77 8/-
DET19 6/8	GT1C 57/6	S130 40/-	6A87 15/-	150B3 8/6	OC78 3/-
DET20 2/6	GU20 100/-	S130P 40/-	6AT6 4/9	705A 10/-	OC81 4/-
DET22 110/-	GU21 100/-	SP41 3/6	6AU5GT 20/-	723A/B 120/-	OC81D 3/-
DET23 110/-	GY501 15/-	SP61 3/6	6B4G 20/-	725A 240/-	OC81M 5/-
DET24 50/-	GZ30 10/-	STV280/40 25/-	6BA6 5/-	801 9/6	OC81DM 3/-
DET25 15/-	GZ32 10/-	STV280/80 95/-	6BE6 5/-	803 35/-	OC82 3/-
DF91 4/-	GZ34 11/-	SU2150 12/6	6BH6 9/-	807 9/-	OC82D 3/-
DF96 7/6	GZ37 15/-	SU2150A 12/6	6BJ6 9/-	811 35/-	OC83 4/6
DH63 6/-	H63 18/-	T41 17/6	6BK4 21/6	813 75/-	OC169 6/-
DH77 4/9	HL41DD 13/6	TD03-5 110/-	6BN6 7/6	813U8A 160/-	OC170 5/6
DK32 7/9	KT8 35/-	TD03-10 110/-	6BQ7A 7/-	829B 60/-	OC171 6/-
DK91 6/-	KT61 22/6	TZ40 40/-	6BR7 17/-	833A 360/-	OC200 5/6
DK92 9/-	KT66 30/-	U19 35/-	6BR8 12/6	837 17/6	SX642 3/6
DK96 7/9	KT67 45/-	U24 24/-	6BS7 25/-	866A 15/-	XA101 3/6
DL66 25/-	KT81(7C5) 22/6	U25 15/6	6BW6 14/6	872A 57/6	XA111 3/6
DL92 6/3	KT81 (GEC) 35/-	U26 15/6	6BW7 13/-	931A 72/6	XA112 4/6
DL94 6/9	KT88 34/-	U33 30/-	6C4 5/-	954 5/3	XA125 5/-
DL96 7/9	KTW61 12/6	U37 20/-	6CB6 5/-	955 3/-	XA141 7/-
DL810 12/6	KTW62 12/6	U191 13/9	6CD6G 24/-	2050 15/-	XA142 5/-
DL816 30/-	M505 600/-	U404 7/6	6CH6 7/6	5644 40/-	XA143 5/-
DL819 30/-	M513 600/-	U801 23/6	6CL6 8/6	5651 7/3	
DY86 6/-	ME140025/-	UABC80 6/6	6CW4 13/6	5654 8/-	TUBES
DY87 6/6	ME150125/-	UAF42 10/6	6D4 15/-	5672 7/-	2AP1 80/-
DY802 12/6	ML4 17/6	UBC41 9/3	6DK6 9/-	5687 10/-	3BP1 60/-
E88CC 12/-	N37 17/6	UCH42 10/6	6F23 16/-	5691 25/-	3DP1 40/-
E180F 17/6	N78 19/-	UCH81 7/-	6F32 2/9	5694 30/-	3EG1 65/-
E182CC 22/6	PC86 11/6	UCL82 7/6	6F33 19/6	5702 15/-	3FP7 29/-
E810F 50/-	PC88 11/6	UCL83 10/-	6J5G 4/-	5749 10/-	3GP1 40/-
EABC80 6/6	PC97 8/9	UL41 12/-	6J6 3/6	5763 12/-	5BP1 80/-
EAF42 10/-	PC900 8/6	UL84 7/-	6J7G 6/-	5784 35/-	5CP1 55/-
EAF806 17/6	PCC84 6/6	UU6 21/-	6K6GT 8/	5842 65/-	5FP7 35/-
EB91 3/-	PCC85 8/-	UU7 21/-	6K7 1/9	5876 60/-	88L 80/-
EBC33 8/6	PCC89 10/6	UU8 21/-	6K7G 2/-	5879 22/6	88D 200/-
EBC41 9/9	PCC189 10/6	UY41 8/6	6K8 2/9	5893 150/-	ACR22 80/-
EBC90 4/9	PCF80 6/9	UY85 6/6	6K8G 3/-	5899 10/-	C27A 160/-
EBF80 7/6	PCF86 9/-	VL8631 30/-	6L6G 7/9	5902 17/-	CV960 76/-
EBF83 9/-	PCF200 16/-	VP4B 25/-	6L6WGB 17/6	5963 10/-	CV966 35/-
EBF89 6/6	PCF201 15/6	VR105/30 6/8	6Q7G 6/-	6057 10/-	CV1526 65/-
EBL21 12/-	PCF801 9/9	VR150/30 6/-	68Q7M 7/6	6058 10/-	CV1587 60/-
EBL31 27/6	PCF802 9/9	W81M 12/6	68G7 6/-	6059 18/-	CV1588 35/-
ECC33 15/-	PCF806 13/-	XH8/100 300/-	68J7M 7/-	6060 6/-	E4504/B/16 76/-
ECC40 17/6	PCH200 12/6	XR13/200 120/-	68L7GT 6/-	6061 12/-	ECR30 60/-
ECC70 15/-	PCL82 7/9	Z66 15/-	68N7GT 5/6	6062 14/-	ECR35 50/-
ECC81 6/-	PCL83 10/3	Z319 25/-	6V6G 4/6	6063 7/-	MW-2 100/-
ECC82 5/9	PCL84 8/6	Z759 30/-	6X4 4/6	6064 7/-	O9D 80/-
ECC83 6/3	PCL85 9/3	Z800 20/-	6X5G 4/6	6065 9/-	O9G 80/-
ECC85 5/-	PCL86 9/3	Z801 30/-	7B7 7/6	6067 10/-	O9L 80/-
ECC88 7/6	PD500 29/-	Z803U 15/-	7C5 22/6	6072 12/-	VCR97 45/-
ECF80 6/6	PENB4 20/-	OA2 6/3	7C6 15/-	6080 25/-	VCR13860/-
ECF82 6/6	PEN45DD 12/-	OB2 6/-	7H7 6/6	6111 12/6	VCR138A 60/-
ECH35 11/6	PFL200 14/-	OZ4 4/6	787 45/-	6146 27/6	VCR139A 45/-
ECH42 13/-	PL36 10/9	1B3GT 7/3	Diodes Transistors	7475 14/-	VCR516 80/-
ECH81 5/9	PL81 9/6	1Z2 25/-	18113 3/-	9003 9/-	VCR517A 46/-
ECH83 8/6	PL82 8/6	2C39A 140/-	18115 4/6	9004 2/6	VCR517B 46/-
ECL80 7/-		2C43 70/-	18131 2/6		VCR517C 46/-
ECL82 7/-		2D21 6/6	2G210 12/6		
		2E26 20/-	2G381 5/-		

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

BI-PRE-PAK LIMITED

FULLY TESTED AND MARKED

AC107	3/-	OC170	3/-
AC126	2/6	OC171	4/-
AC127	3/6	OC200	3/6
AC128	2/6	OC201	7/-
AC176	5/-	2G301	2/6
ACY17	3/-	2G303	2/6
AF114	4/-	2N711	10/-
AF115	3/6	2N1302-3	4/-
AF116	3/6	2N1304-5	5/-
AF117	3/6	2N1306-7	6/-
AF239	12/6	2N1308-9	8/-
AF186	10/-	2N3819 F.E.T.	9/-
AF139	10/-	Power Transistors	
BFY50	4/-	OC20	10/-
BSY25	7/6	OC23	10/-
BSY26	3/-	OC25	8/-
BSY27	3/-	OC26	5/-
BSY28	3/-	OC28	7/6
BSY29	3/-	OC35	5/-
BSY95A	3/-	OC36	7/6
OC41	2/6	AD149	10/-
OC44	2/6	2S034	10/-
OC45	2/6	2N2287	20/-
OC71	2/6	2N3055	15/-
OC72	2/6	Diodes	
OC73	3/6	AAY42	2/-
OC81	2/6	OA95	2/-
OC81D	2/6	OA79	1/9
OC83	4/-	OA81	1/9
OC139	2/6	IN914	1/6
OC140	3/6		

FREE!

PACKS OF YOUR OWN CHOICE UP TO THE VALUE OF 10/- WITH ORDERS OVER £4

ANOTHER SCOOP FOR BI-PRE-PAK

JUST RELEASED FROM STOCK. A.E.I. INTEGRATED CIRCUITS

These are brand new genuine surplus stocks, marked and guaranteed to full makers specification and not remarked rejects.

NE808A	Single 8 I/P Nand Gate TTL	7/-
NE816A	Dual 4 I/P Nand Gate TTL	7/-
NE825A	D.C. Clocked J-K Flip-Flop TTL	17/6
NE840A	Dual 4 I/P Exclusive OR Gate TTL	7/-
NE855A	Dual 4 Power Gate TTL	7/-
NE870A	Triple 3 I/P Nand TTL	7/-
NE880A	Quad 2 Nand TTL	7/-
SP616A	Dual 4 Nand Gate DTL	7/-
SP631A	Quad 2 I/P Gate Expander DTL	7/-
SP670A	Triple 3 Nand Gate DTL	7/-
SP806A	Dual I/P Expander TTL	7/-
SP808A	Single 8 I/P Nand Gate TTL	7/-
SP816A	Dual 4 I/P Nand Gate TTL	7/-
SP825A	D.C. Clocked J-K Flip-Flop TTL	17/6
SP840A	Dual 4 I/P Exclusive OR Gate TTL	7/-
SP855A	Dual 4 Power Gate TTL	7/-
SP870A	Triple 3 I/P Nand TTL	7/-
SP880A	Quad 2 I/P Nand TTL	7/-
NE500K	Video Amplifier	40/-
NE501K	Video Amplifier 40 MHz	40/-
NE806J	Dual 4 I/P Expander TTL	7/-
NE808J	Single 8 I/P Nand Gate TTL	7/-
NE816J	Dual I/P Nand Gate TTL	7/-
NE825J	D.C. Clocked J-K Flip-Flop TTL	17/6
NE840J	Dual 4 I/P Exclusive OR Gate TTL	7/-
NE855J	Dual 4 Power Driver TTL	7/-
NE880J	Quad 2 I/P Nand TTL	7/-
ST620A	J-K Flip-Flop DTL	17/6
ST659A	Dual 4 Buffer/Driver DTL	7/-

Suffix: A = DIP 14 lead K = 10 lead TO.5
J = Flat Pack

NEW TESTED & GUARANTEED PAKS

H8	4	BY127 Silicon Recs. 1000 P.I.V. 1 amp Plastic. Replaces the BY100	10/-
B79	4	1N4007 Sil. Rec. Diodes. 1,000 P.I.V. 1 amp. Plastic.	10/-
B81	10	REED SWITCHES MIXED TYPES LARGE & SMALL	10/-
B89	2	5 SP5 LIGHT SENSITIVE CELLS LIGHT RES. 400 Ω DARK 1 M Ω	10/-
B91	8	NKT163/164 PNP GERM. TO —5 EQUIVALENT TO OC44, OC45	10/-
B92	4	NPN SIL TRANS. AO6 = BSX20, 2N2369, 500MHz, 360mW	10/-
B93	5	GET113 TRANS. EQUIV. TO ACY17-21 PNP GERM.	10/-
B96	5	2N3136 PNP SIL. TRANS. TO—18 HPE100-300 IC, 600mA, 200MHz	10/-
B98	10	XB112 & XB102 EQUIV. TO AC126 AC156, OC81/2, OC71/2, NKT271, ETC.	10/-
B99	200	CAPACITORS. ELECTROLYTICS, PAPER, SILVER MICA, ETC. POSTAGE ON THIS PAK 2/6.	10/-
H4	250	MIXED RESISTORS POST & PACKING 2/-	10/-
H7	40	WIREWOUND RESISTORS MIXED TYPES & VALUES. POSTAGE 1/6	10/-

LOOK! TRANSISTORS ONLY 6d EACH

TYPE A
PNP SILICON ALLOY
TO-5 CAN

Spec:—
ICER AT VCE = 20v
1mA MAX.
HFE. 15-100

These are of the 2S300 type which is a direct equivalent to the OC200/205 range.

TYPE B
PNP SILICON
PLASTIC ENCAPSULATION

Spec:—
ICER AT VCE = 10v
1mA MAX.
HFE. 10-200

These are of the 2N3702/3 and 2N4059/62 range.

TYPE E
PNP GERMANIUM
FULLY MARKED AND TESTED. STATE R.F. OR A.F. WHEN ORDERING.

Return of the unbeatable P.1 Pak. Now greater value than ever

Full of Short Lead Semiconductors & Electronic Components, approx. 170. We guarantee at least 30 really high quality factory marked Transistors PNP & NPN, and a host of Diodes & Rectifiers mounted on Printed Circuit Panels. Identification Chart supplied to give some information on the Transistors.

Please ask for Pak **P.1.** Only **10/-**
2/- P & P on this Pak.

NEW UNMARKED UNTESTED PAKS

B78	12	INTEGRATED CIRCUITS, DATA & CIRCUITS OF TYPES, SUPPLIED WITH ORDERS	10/-
B80	8	DUAL TRANS. MATCHED O/P PAIRS NPL-SIL. INTO—5 CAN.	10/-
B82	10	OC45, OC81D & OC81 TRANS. MULLARD GLASS TYPE	10/-
B83	200	200 TRANSISTORS. MAKERS REJECTS. NPN-PNP. SIL. & GERM.	10/-
B84	100	SILICON DIODES DO—7 GLASS EQUIV. TO OA200, OA202	10/-
B66	150	HIGH QUALITY GERM. DIODES MIN. GLASS TYPE	10/-
B86	50	SIL. DIODES SUB. MIN. IN914 & IN916 TYPES	10/-
B87	100	GERM. PNP TRANS. EQUIV. TO OC44, OC45, OC81, ETC.	10/-
B88	50	SIL TRANS. NPN, PNP, EQUIV. TO OC200/1, 2N706A, BSY95A, ETC.	10/-
B60	10	7 WATT ZENER DIODES, MIXED VOLTAGES	10/-
H5	16	1 AMP. PLASTIC DIODES 50–1000 VOLTS	10/-
H6	40	250mW. ZENER DIODES DO-7 MIN. GLASS TYPE	10/-

Make a Rev. Counter for your Car. The 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a perfectly linear and accurate rev. counter for any car. 20/- each

FREE CATALOGUE AND LISTS for:—

ZENER DIODES
TRANSISTORS, RECTIFIERS
FULL PRE-PAK LISTS
& SUBSTITUTION CHART

MINIMUM ORDER 10/- CASH WITH ORDER PLEASE. Add 1/- post and packing per order. OVERSEAS ADD EXTRA FOR AIRMAIL.

P.O. RELAYS
VARIOUS CONTACTS AND COIL RESISTANCES.
NO INDIVIDUAL SELECTION.
POST & PACKING 5/-
8 for **20/-**

FREE! A WRITTEN GUARANTEE WITH ALL OUR TESTED SEMICONDUCTORS

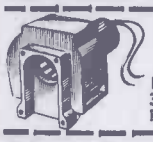
BI-PRE-PAK LTD DEPT. B, 222-224 WEST ROAD, WESTCLIFF-ON-SEA, ESSEX
TELEPHONE: SOUTHEND (0702) 46344

SERVICE TRADING CO

Postage and Carriage shown below are inland only. For Overseas please ask for quotation. We do not issue a catalogue or list.

VEEDER ROOT COUNTER

230 v. A.C. 50 cycle 5 figure counter (non resetable). 18/6, P. & P. 1/6.



Ex. W.D. MINIATURE BLOWER UNIT

18-24 v. D.C. operation, overall length 3¾ in. Blower 2⅝ x 2⅜ in., 20/-. P. & P. 2/6.

SOLID STATE INTERVAL TIMER

24-30v. D.C. operation. Stabilised uni-junction Timer and S.C.R. (30v. 1Amp.), encapsulated in metal core. Timing interval adjustable from a fraction of a second to several minutes by means of external resistor or pot. By adding a 24v. Relay many other complex timing Functions are possible. Price: 16/6 incl. circuit, p. & p. 2/6. Suitable relay 9/6. P. & P. 1/6.

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.

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.
RT.2KVA	1.5 turns per volt,	£10	10 0	+9/6 p. and p.
RT.3KVA	1.5 turns per volt,	£14	0 0	+10/- p. & p.

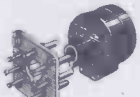
L.T. TRANSFORMERS

All primaries 220-240 volts.

Type No.	Sec. Taps	Price		Carr.
1	12 v. at 5A	£1	17 6	5/6
2	30, 32, 34, 36 v. at 5 amps.	£4	13 6	6/-
3	30, 40, 50 v. at 5 amps.	£6	17 6	6/6
4	10, 17, 18 v. at 10 amps.	£4	19 0	4/6
5	6, 12 v. at 20 amps.	£6	8 6	6/6
6	17, 18, 20 v. at 20 amps.	£7	5 6	6/6
7	6, 12, 20 v. at 20 amps.	£6	17 6	7/6
8	24 v. at 10 amps.	£5	4 6	5/6
9	4, 6, 24, 32 v. at 12 amps.	£7	3 0	6/6

AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3/12/6 each, P. & P. 4/6. 500 watt type £5/2/6 each, P. & P. 6/6. 1,000 watt type £7/2/6 each, P. & P. 7/6.

MULTI WAY PLUGS AND SOCKETS



10 way plug and socket. (Socket chassis mounted.)
7 way reversed plug and socket. Plug chassis mounted. (Illustrated.)
Price: either type 3/6 pair. 9d. P.&P.

BURGESS MICRO SWITCH

Lever operated c/o contacts. Price 4/- plus 9d. P. & P. 10in maker's carton. 35/- post paid.

INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 2/- each.

LIGHT SENSITIVE SWITCHES

Kit of parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. Price 25/-, plus 2/6 P. & P. ORP. 12 and Circuit 12/6 post paid.

220/240 A.C. MAINS MODEL

Incorporates mains transformer rectifier and special relay with 2 x 5 amp. mains c/o contacts. Price inc. circuit 47/6, plus 2/6 P. & P.

LIGHT SOURCE AND PHOTO CELL MOUNTING

Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair £2/15/0 plus 3/6 P. & P.

MOTORISED SWITCHING UNIT (Ex-W.D.)

Powerful, precision-made, ex-W.D., 12 v. D.C., reversible motor, drives multiple gear train with outputs approx. 4 r.p.m. and 5 r.p.m. Price 25/- P. & P. 4/6.

POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 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 3¼in. Shaft length ⅝in. dia. ¼in., 27/6. P. & P. 1/6. **50 WATT** 1/5/10/25/50/100/250/500/1K/1·5K/2·5K/5K ohm. All at 21/-, P. & P. 1/6. **25 WATT** 10/25/50/100/250/500/1K/1·5K/2·5K ohm. All at 14/6, P. & P. 1/6.

Black Silver Skirted knob calibrated in Nos. 1-9. 1¾ in. dia. brass bush. Ideal for above Rheostats, 3/6 each.

MOTOROLA MAC/II PLASTIC THYRISTER 400 PIV 8 AMP

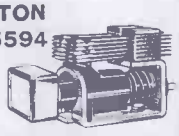
Now available EX STOCK supplied complete with full data and applications sheet. Price 21/- plus 1/6 P. & P.

230/240V 10 RPM MOTOR

(Non Reversible)

Extremely powerful. Continuously rated. Offered at the low price of 35/- post paid.

T.M.C. ILLUMINATED LATCHING PUSH BUTTON KEY SWITCH No. S525594 LOCK 4 c/o



Complete with mounting bracket, Push Knob and Lenses (GREEN, AMBER, RED or CLEAR — state colour preference). PRICE 14/6 each excluding bulb, Post Paid. Discount for quantities of 200 or over.

STROBE! STROBE! STROBE!

- THREE EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES. SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION. The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.
- **EXPERIMENTERS "ECONOMY" KIT** Adjustable 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + Instructions £5.5.0 plus 5/- P. & P.
- **NEW INDUSTRIAL KIT** Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor Adjustable 1-80 f.p.s. Price 9 gns. 7/6 P. & P.
- **HY-LYGHT STROBE** This strobe has been designed for use in large rooms, halls and the photographic field, and utilizes a silica tube for longer life expectancy, printed circuit for easy assembly, also a special trigger coil and output capacitor. Speed adjustable 1-30 f.p.s. Light output approx. 4 joules. Price £10.17.6. P. & P. 7/6.
- **7-INCH POLISHED REFLECTOR.** Ideally suited for above Strobe Kits. Price 10/6 and 2/6 P. & P. or post paid with kits.

COMPLETE NI. CAD. BATTERY OUTFIT (EX W.D.)

2 metal carrying cases each containing 10 x 1.2 volt 7 AH (12v) batteries, also 10 x 1.2v 22 AH (12v) batteries (40 batteries in all). 1 Dual voltage, dual meter, thyristor controlled charging unit. Designed for charging the 7AH and 22AH batteries simultaneously. Input voltage can be adjusted between 100-250v AC. Built to ministry specification. Ideal power supply for field work. Offered at fraction of makers price. 2 sets of batteries, 1 charging unit. The set £45 c. & p. 30/-.

MINIATURE UNISELECTOR

3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6, plus 2/6 P. & P.

UNISELECTOR SWITCHES *NEW*

4 BANK 25 WAY FULL WIPER

25 ohm coil, 24 v. D.C. operation. £5.17.6, plus 2/6 P. & P.

6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. operation. £6.10.0, plus 2/6 P. & P.

8-BANK 25-WAY FULL WIPER

24 v. D.C. operation, £7.12.6, plus 4/- P. & P.

RELAYS

NEW SIEMENS PLESSEY, etc. MINIATURE RELAYS AT A HIGHLY COMPETITIVE PRICE.

COIL —	WORKING D.C. VOLT	CONTACTS	PRICE
52	6—9	6M	12/6
170	9—12	4 c/o H.D.	14/6
170	9—12	3 c/o + 1 H.D. c/o	12/6
230	6—12	2 c/o	12/6
280	6—12	2 c/o incl. base	14/6
700	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
1250	36—45	6M	12/6
2500	36—45	6M	12/6
5800	80—85	4 c/o	12/6
9000	40—70	2 c/o incl. base	10/-

H.D. = Heavy Duty *POST PAID*

MINIATURE RELAYS

9—12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1in. x ⅞ x 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 x ⅞ x 1⅛in. 8/6 post paid.

SPECIAL OFFER

Relay 18/24 v. D.C. 2 c/o 3 Amp contacts. 400 ohm coil. NEW. 9/6 P. & P. 1/6 or 4 for 30/- post paid.

TYPE A.G.C. 1M 1B 12v. A.C. 3 amp contacts. NEW 9/6 + 1/6 p. & p. or 3 for 30/- post paid.

230 VOLT AC RELAY LONDEX four c/o 3 amp contacts. 18/6, incl. base. Post Paid.

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.

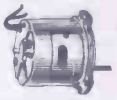
PANEL METERS AT BARGAIN PRICES

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/-

RECHARGEABLE NICKEL CAD. BUTTON CELLS.

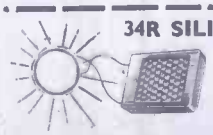
2 x 1.2 v. 250 MA/HR Nickel Cad. Cells, connected to give 2.4 v., at 25 milliamp/10 hour rate, complete with 200/250 v. A.C. charger. Fully tested and unused. Price 9/6 each plus 1/6 p. & p. or 2 units for £1 post paid.

SANGAMO WESTON SYNCHRONOUS GEARED MOTOR



New. Two Types. 1 Rev per hour. 12 Rev per hour. All at 17/6 each, p. & p. 2/6.

34R SILICON SOLAR CELL



4 x .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.

ALL MAIL ORDERS. ALSO CALLERS AT:
57 BRIDGMAN ROAD, LONDON, W.4. Phone: 995 1560
Closed Saturdays.

SERVICE TRADING CO.
SHOWROOMS NOW OPEN
AMPLE PARKING

PERSONAL CALLERS ONLY
9 LITTLE NEWPORT STREET, LONDON, W.C.2.
Tel.: GER 0576

BRAND NEW SEMICONDUCTORS & COMPONENTS GUARANTEED

TRANSISTORS Brand new and fully guaranteed. **PLEASE NOTE**—A large number of our transistors have now been reduced in price. Many more semi-conductors in stock. Please enquire for types not listed.

2G301	4/-	2N3402	4/6	3N143	17/6	BCI59	4/-	BFY90	13/6	NKT261	4/-
2G302	4/-	2N3403	4/6	3N152	22/6	BCI60	12/6	BFW58	5/6	NKT264	6/-
2G303	4/-	2N3404	7/6	R.C.A.:		BCI67	3/-	BFW59	5/-	NKT264	4/-
2G306	8/6	2N3405	9/-	40050	13/6	BCI68B	2/9	BFW60	5/-	NKT271	4/-
2G308	6/-	2N3414	5/6	40250	10/-	BCI68C	3/-	BPX25	37/-	NKT272	4/-
2G309	6/-	2N3415	5/6	40251	19/6	BCI69B	2/9	BPX29	36/-	NKT274	4/-
2G371	3/-	2N3416	7/6	40309	8/-	BCI69C	3/-	BPY10	29/-	NKT275	4/-
2G374	4/-	2N3417	7/6	40310	11/6	BCI70	3/6	B5X19	3/6	NKT281	5/6
2G381	4/6	2N3439	26/-	40311	9/6	BCI71	3/6	BSX20	3/6	NKT401	17/6
2N388A	12/6	2N3440	19/6	40312	12/6	BCI72	3/6	BSX21	7/6	NKT402	18/-
2N404	4/6	2N3570	17/6	40314	9/6	BCI75	5/6	BSX26	9/-	NKT403	15/-
2N696	4/-	2N3572	17/6	40315	9/6	BCI82	4/6	BSX27	9/6	NKT404	12/6
2N697	4/-	2N3605	5/6	40316	12/6	BCI83	4/6	BSX28	6/6	NKT405	15/-
2N698	5/-	2N3606	5/6	40317	9/6	BCI84	4/6	BSX60	16/6	NKT406	12/6
2N699	12/6	2N3607	4/6	40319	13/6	BCI82L	4/-	B5X61	12/6	NKT451	12/6
2N706	2/6	2N3662	7/6	40320	9/6	BCI83L	3/6	BSX76	4/6	NKT452	12/6
2N706A	2/6	2N3663	7/6	40323	8/6	BCI84L	4/-	BSX77	5/6	NKT453	9/6
2N708	3/-	2N3702	3/6	40324	• 11/6	BC212L	4/6	BSX78	5/6	NKT603F	6/6
2N709	12/6	2N3703	4/6	40326	19/6	BCY10	5/6	BSY10	5/6	NKT613F	6/6
2N718	5/-	2N3704	4/6	40329	7/-	BCY12	5/6	BSY11	5/6	NKT674F	6/-
2N718A	6/-	2N3705	4/-	40344	7/-	BCY30	5/6	BSY24	3/-	NKT677F	6/-
2N726	6/-	2N3706	4/6	40347	8/6	BCY31	5/6	BSY25	3/-	NKT713	5/-
2N727	6/-	2N3707	4/-	40348	12/6	BCY32	7/6	BSY26	3/6	NKT717	8/6
2N914	3/6	2N3708	3/6	40360	11/-	BCY33	4/-	BSY27	3/6	NKT734	5/6
2N916	3/6	2N3709	3/6	40361	12/6	BCY34	4/6	BSY28	3/6	NKT736	7/-
2N918	6/-	2N3710	4/-	40362	13/6	BCY38	4/6	BSY29	3/6	NKT773	5/-
2N929	4/6	2N3711	4/-	40370	7/6	BCY39	8/6	BSY32	5/-	NKT781	6/-
2N930	5/6	2N3713	30/-	40406	14/6	BCY40	7/6	BSY36	5/-	NKTI0339	6/6
2N987	10/6	2N3714	35/-	40408	12/6	BCY42	3/-	BSY37	5/-	NKTI0419	6/-
2NI131	5/6	2N3819	7/-	40467	16/6	BCY43	3/-	BSY38	4/6	NKTI0439	7/6
2NI132	6/6	2N3823	22/6	40467A	14/6	BCY54	6/6	BSY39	4/6	NKTI0519	6/6
2NI302	3/6	2N3854	5/6	40468A	14/6	BCY58	4/6	BSY40	6/6	NKT20329	9/6
2NI303	3/6	2N3854A	5/6	ACI07	6/-	BCY59	4/6	BSY51	6/6	NKT20329	9/6
2NI304	4/6	2N3855	5/6	ACI26	4/-	BCY60	19/6	BSY52	6/6	NKT80111	15/6
2NI305	4/6	2N3855A	6/-	ACI27	5/-	BCY70	4/-	BSY53	7/6	NKT80112	19/6
2NI306	5/-	2N3856	6/-	ACI28	4/-	BCY71	8/6	BSY54	8/-	NKT80113	22/6
2NI307	5/-	2N3856A	7/-	ACI54	4/6	BCY72	3/6	BSY56	18/-	NKT80211	18/6
2NI308	6/-	2N3858	5/-	ACI76	5/-	BCZI0	5/6	BSY78	9/6	NKT80212	18/6
2NI309	6/-	2N3858A	6/-	ACI87	12/6	BCZII	7/6	BSY79	9/-	NKT80213	18/6
2NI507	5/6	2N3859	5/6	ACI88	7/6	BDI16	22/6	BSY82	10/6	NKT80214	18/6
2NI613	5/-	2N3859A	6/6	ACY17	5/6	BDI21	13/-	BSY90	11/6	NKT80215	18/6
2NI631	8/6	2N3860	6/-	ACY18	5/-	BDI23	16/6	BSY95A	2/6	NKT80216	18/6
2NI632	8/6	2N3866	30/-	ACY19	5/-	BDI24	12/-	BSW41	8/6	OC20	15/-
2NI637	8/6	2N3877	8/-	ACY20	5/-	BDI31	24/-	B5W70	5/6	OC22	10/-
2NI638	7/6	2N3877A	8/-	ACY21	5/-	BDI32	24/-	D16P1	7/6	OC23	10/-
2NI639	7/6	2N3900	7/6	ACY22	4/-	BDY10	27/6	D16P2	8/-	OC24	11/6
2NI701	32/6	2N3900A	8/-	ACY28	4/-	BDYII	37/6	D16P3	7/6	OC25	10/-
2N1711	5/-	2N3901,	19/6	ACY40	4/-	BDY17	37/6	D16P4	8/-	OC26	6/6
2N1889	6/6	2N3903	7/-	ACY41	5/-	BDY18	49/6	GETI02	6/-	OC28	12/6
2N1893	8/6	2N3094	7/-	ACY44	8/-	BDY19	62/6	GETI13	4/-	OC29	15/-
2N2147	14/6	2N3905	7/6	ADI40	8/-	BDY20	22/6	GETI14	4/-	OC35	8/-
2N2148	12/6	2N3906	7/6	ADI49	11/6	BDY38	19/6	GETI18	4/-	OC36	12/6
2N2160	11/6	2N4058	5/6	ADI50	12/6	BDY60	36/-	GETI19	4/-	OC41	4/6
2N2193	9/6	2N4059	5/-	ADI61	7/6	BDY61	36/-	GETI20	10/6	OC42	5/-
2N2193A	10/-	2N4060	5/-	ADI62	7/6	BDY62	27/6	GET873	2/6	OC44	4/-
2N2194A	4/6	2N4061	4/6	AFI06	8/6	BFII5	5/-	GET880	6/-	OC45	2/6
2N2217	5/6	2N4062	4/6	AFI14	5/-	BFII7	9/6	GET887	4/-	OC46	3/-
2N2218	6/6	2N4244	9/6	AFI15	6/-	BFI63	7/6	GET889	4/6	OC70	3/-
2N2219	6/6	2N4245	8/6	AFI16	5/-	BFI67	5/-	GET890	4/6	OC71	2/6
2N2220	5/-	2N4254	8/6	AFI17	5/-	BFI73	6/6	GET896	4/6	OC72	2/6
2N2221	5/-	2N4255	8/6	AFI18	12/6	BFI77	6/6	GET897	4/6	OC74	6/6
2N2222	6/-	2N4284	3/6	AFI19	4/-	BFI78	12/6	GET898	4/6	OC75	4/6
2N2287	21/6	2N4285	3/6	AFI24	4/6	BFI79	14/6	MAT100	6/-	OC76	4/6
2N2297	6/-	2N4286	3/6	AFI25	4/-	BFI80	7/-	MATI01	6/-	OC77	6/-
2N2368	3/6	2N4287	3/6	AFI26	4/-	BFI81	6/6	MAT120	6/-	OC81	4/-
2N2369	3/6	2N4288	3/6	AFI27	3/6	BFI84	6/6	MAT121	6/-	OC81D	4/6
2N2369A	4/-	2N4289	3/6	AFI39	7/6	BFI85	8/6	MJ400	21/6	OC83	5/-
2N2410	8/6	2N4290	3/6	AFI78	11/-	BFI94	4/6	MJ420	22/6	OC84	5/-
2N2483	5/6	2N4291	3/6	AF179	14/6	BFI95	5/6	MJ421	22/6	OC139	6/6
2N2484	6/6	2N4292	2/6	AFI80	10/6	BFI96	8/6	MJ430	20/6	OC140	6/6
2N2539	4/6	2N5027	10/6	AFI81	8/6	BFI97	8/6	MJ440	19/-	OC170	6/-
2N2540	4/6	2N5028	11/6	AF239	8/6	BFI98	8/6	MJ480	19/6	OC171	6/-
2N2613	7/-	2N5029	9/6	AF279	9/6	BF200	10/6	MJ481	25/-	OC200	6/6
2N2614	6/-	2N5030	8/6	AF280	12/6	BF224	6/-	MJ490	20/-	OC201	9/6
2N2646	11/6	2N5172	3/-	AFZII	6/6	BF225	6/-	MJ491	27/6	OC202	12/6
2N2696	6/6	2N5174	10/6	ASY26	5/-	BF237	6/6	MJI800	43/6	OC203	8/6
2N2711	6/-	2N5175	10/6	ASY27	7/6	BF238	6/6	MJE340	12/6	OC204	8/6
2N2712	6/-	2N5176	9/-	ASY28	5/6	BFX12	4/6	MJE520	17/6	OC205	8/6
2N2713	5/6	2N5232A	6/-	ASY29	5/6	BFX13	4/6	MJE521	17/6	OC207	12/6
2N2714	6/-	2N5245	12/6	ASY36	5/-	BFX13	4/6	MPFI02	8/6	OCP71	8/6
2N2865	12/6	2N5246	12/6	ASY50	5/-	BFX29	7/-	MPFI03	7/6	ORPI2	12/6
2N2904	7/-	2N5249	13/6	ASY51	6/6	BFX43	7/6	MPFI04	7/6	ORP60	10/-
2N2904A	8/-	2N5249A	13/6	ASY53	5/-	BFX44	7/6	MPFI05	7/6	ORP61	10/-
2N2905	8/-	2N5265	65/-	ASY54	5/-	BFX68	13/6	MPS3638	6/6	P346A	4/6
2N2905A	9/-	2N5266	53/-	ASY62	5/-	BFX84	6/-	NKT0013	9/6	TIS34	12/6
2N2906	6/-	2N5267	52/6	ASY63	3/6	BFX85	7/-	NKTI24	8/6	TIS43	8/-
2N2906A	6/6	2N5305	7/6	ASY72	5/-	BFX86	6/-	NKTI25	5/6	TIS44	2/6
2N2907	8/-	2N5306	8/-	ASY83	5/-	BFX87	6/-	NKTI26	5/6	TIS45	3/6
2N2923	3/6	2N5307	7/6	ASY86	6/6	BFX88	5/-	NKTI28	5/6	TIS46	3/6
2N2924	3/6	2N5308	7/6	ASZ20	7/6	BFX89	12/6	NKTI35	5/6	TIS47	3/6
2N2925	3/6	2N5309	12/6	ASZ21	8/6	BFY10	6/6	NKTI37	6/6	TIS48	3/6
2N2926		2N5310	8/6	AUY10	30/-	BFYII	8/6	NKT210	6/-	TIS49	3/6
Green	2/9	2N5354	5/6	BC107	3/-	BFYI7	4/6	NKT211	6/-	TIS50	4/6
Yellow	2/6	2N5355	5/6	BC108	3/-	BFYI8	6/6	NKT212	6/-	TIS51	3/6
Orange	2/6	2N5356	6/6	BC109	3/-	BFYI9	6/6	NKT213	6/-	TIS52	3/6
2N3011	6/-	2N5365	9/6	BCII3	5/6	BFY20	12/6	NKT214	4/6	TIS53	6/-
2N3014	6/6	2N5366	6/6	BCII4	7/6	BFY21	8,6	NKT215	4/6	TIS60	6/-
2N3053	5/6	2N5367	11/6	BCII5	6/6	BFY24	9/-	NKT216	7/6	TIS61	6/-
2N3054	11/-	2N5457	7/6	BCII6	12/6	BFY25	5/-	NKT217	8/6	TIP29A	13/6
2N3055	15/-	2S005	15/-	BCII6A	7/6	BFY26	4/-	NKT219	6/-	TIP30A	15/-
2N3133	6/-	2S020	37/6	BCII8	6/6	BFY29	10/-	NKT223	5/6	TIP31A	16/6
2N3134	6/-	2S102	6/6	BCI21	4/-	BFY30	10/-	NKT224	5/-	TIP32A	19/6
2N3135	5/-	2S103	6/6	BCI22	4/-	BFY41	10/-	NKT225	4/6	ZTX107	3/6
2N3136	5/-	2S104	6/6	BCI25	11/-	BFY43	12/6	NKT229	6/-	ZTX108	3/6
2N3340	19/6	2S501	5/6	BCI26	11/-	BFY50	4/6	NKT237	7/-	ZTX109	3/6
2N3349	26/-	2S502	5/6	BCI40	7/6	BFY51	4/6	NKT238	5/-	ZTX300	3/6
2N3390	7/6	2S503	5/6	BCI47	3/6	BFY52	4/6	NKT240	5/6	ZTX301	3/6
2N3391	4/-	3N83	37/6	BCI48	3/-	BFY53	4/6	NKT241	5/6	ZTX302	4/6
2N3391A	6/-	3N128	18/6	BCI49	3/6	BFY56A	11/6	NKT242	4/-	ZTX303	4/6
2N3392	4/-	3N140	19/6	BCI52	3/6	BFY75	6/-	NKT243	12/6	ZTX304	6/6
2N3393	4/-	3N141	19/6	BCI57	4/-	BFY76	8/6	NKT244	3/6	ZTX500	4/6
2N3394	4/-	3N142	19/6	BCI58	3/6	BFY77	11/6	NKT245	4/-	ZTX501	5/-

PANEL METERS

38 Series—FACE SIZE 42 x 42 mm. All prices for 1-9 pieces.

50	Microamp	37/6	5	Milliamp	25/-
100	,,	35/-	10	,,	25/-
200	,,	32/6	50	,,	25/-
500	,,	27/6	100	,,	25/-
50-0-50	,,	35/-	500	,,	25/-
100-0-100	,,	32/6	1	Amp	25/-
500-0-500	,,	25/-	5	,,	25/-
1	Milliamp	25/-	10	Volts	25/-
			20	,,	25/-
			50	,,	25/-
			300	,,	25/-
			500	,,	25/-

SPEAKERS (3ohm)

10" x 6"	..	37/6	3"	..	12/6
9" x 4"	..	23/6	5"	..	14/6
8" x 5"	..	19/6	8"	..	27/6
7" x 4"	..	15/6	12"	..	39/6
5" x 3"	..	12/6	Post and packing 2/9.		

PRESETS Carbon Miniature and Sub miniature. Vertical and Horizontal. 0.1 watt 1/-, 0.2 watt 1/3, 0.3 watt 1/6.

CARBON POTENTIOMETERS

Log. and Lin. Less switch 3/-
Log. and Lin. With switch 4/6

Wire-wound Pots (3 watts) 5/6
Twin Ganged Stereo Pots. Log. and Lin. Less Switch 7/6

HEAT SINKS

4.8" x 4" x 1" Finned. For Two To-3 Trans. .. 9/6
4.8" x 2" x 1" Finned. For One To-3 Trans. .. 6/6
For SO-1 6d. For TO-5 1/- Finned
For TO-18 1/- Finned For TO-1 1/- Finned

ZENER DIODES

400 m W (from 3.3v to 33v) 5/-
1 Watt (from 2.4 to 200v) 7/6
10 Watt (from 3.9v to 100v) 7/6
20W, BZY93 Series (from 7.5v to 75v) 12/6

CIR-KIT

5 ft. x 1/16 in. or ¼ in. 2/-
D.G. 30 W. Soldering Irons .. .. .. 17/6 each

POSTAGE & PACKING CHARGES

U.K. 1/6
EUROPE .. .. 5/- (minimum)
COMMONWEALTH (AIR) .. .. 13/- (minimum)

SILICON RECTIFIERS

PIV	50	100	200	400	600	800	1000	1200	1400
1A	2/9	3/-	3/3	3/6	3/9	4/-	4/6	—	—
3A	3/-	—	—	4/6	—	6/-	—	—	—
6A	—	—	5/-	6/-	6/6	7/-	10/-*	—	—
10A	—	10/6	11/6	13/-	15/6	17/6	19/6	25/-	32/-
17A	—	11/6	12/6	15/6	18/-	19/6	24/-	31/6	37/6
35A	—	27/6	32/-	39/6	47/6	54/-	62/-	70/-	90/-

* 5 amp only. 1 amp are plastic encapsulation.

DIODES & RECTIFIERS

IN461	2/-	AA119	2/-	BAY38	2/6	OA5	2/6
IN914	1/6	AA129	2/-	BY100	4/6	OA10	2/6
IN916	1/6	AAZI3	2/-	BY103	4/6	OA9	2/-
IN4007	4/6	AAZI5	2/6	BY122	7/6	OA47	1/6
IS010	3/-	AAZI7	2/6	BY124	3/-	OA70	1/6
IS021	4/-	BAI00	3/-	BY126	4/-	OA73	2/-
IS025	5/-	BAI02	4/6	BYI27	4/6	OA79	1/9
IS44	2/-	BAIIO	6/6	BYXI0	4/6	OA81	1/6
ISII3	3/-	BAII5	1/6	BYZI0	7/-	OA85	1/6
IS120	3/-	BAI44	2/6	BYZII	6/6	OA90	1/6
IS121	3/6	BAXI3	2/6	BYZI2	6/-	OA91	1/6
IS130	2/6	BAXI6	2/6	BYZI3	5/-	OA95	1/6
IS131	2/6	BAYI8	3/6	FST3/4	4/6	OA200	2/-
IS132	3/-	BAY31	1/6	FST3/8	6/-	OA202	2/-
IS940	1/6						

MAINS TRANSFORMERS

1 amp Charger. Sec. 0-3.5-9-17v 19/6
2 amp Charger. Sec. 0-3.5-9-17v 25/6
1 amp (Douglas) MT103 Sec. tappings from 6v to 50v .. 32/6
2 amp (Douglas) MT104 Sec. tappings from 6v to 50v .. 42/6
Post and packing 4/6.
5 amp (Douglas) MT107 Sec. tappings from 6v to 50v .. 110/-
Post and packing 7/6.
Various other Douglas Transformers ranging from ½A to 5A in stock (details in catalogue).

TRIACS

SC41A (GE) 6 amp 100v 19/6
SC41B (GE) 6 amp 200v 22/-
SC41D (GE) 6 amp 400v 27/6
SC50D 15 amp 400v 60/-
40512 (RCA) TO-5 mod. 6 amp 400v 33/-
40430 (RCA) TO-66 6 amp 400v 27/6
40486 (RCA) TO-5 mod. 6 amp 400v 24/-

Economy Range Triacs (Delivery end of May)

TC4/10 (Pressfit) 4 amp 100 PIV 15/-
TC4/20 (Pressfit) 4 amp 200PIV 17/-
TC4/40 (Pressfit) 4 amp 400 PIV 19/6
TC3/40 (TO-5) 3 amp 400 PIV 22/6
ST2 DIAC 9/6

INTEGRATED CIRCUITS
SEE OUR SEPARATE ADVERTISEMENT ON PAGE 123 SHOWING NEW I.C.s AT NEW LOW PRICES.

THYRISTORS

PIV	50	100	200	300	400
1A	5/-	5/6	7/6	8/-	9/6
3A	6/-	7/6	8/-	9/-	10/6
5A	—	11/-	13/-	—	15/-
7A	—	11/-	13/-	14/-	19/6
25A	27/6	30/-	33/-	—	37/6

TIC47 0.6 amp. 200 PIV 14/-.
Also 12 Amp 100 PIV 15/-, 600 PIV 35/6, 2N3525 at 25/6

VEROBOARD

	.15 Matrix	.1 Matrix
2½" x 3½"	3/6	4/-
2½" x 5"	4/3	4/9
3½" x 3½"	4/3	4/9
3½" x 5"	5/6	5/6
2½" x 17"	12/6	—
3½" x 17"	16/-	21/6
3½" x 17" (Plain)	—	11/6
5" x 17" (Plain)	17/-	—
2½" x 17" (Plain)	9/6	—

Vero Pins (Bag of 50) 5/-. (Bag of 100) 8/-
Vero Cutter 9/-.
Pin Insertion Tools (.1 and .15 matrix) at 11/-.

RESISTORS

Carbon Film

¼ watt 5% .. .. 4d. 1 watt 10% .. 6d.
½ watt 5% .. .. 5d.
2 watt 10% .. .. 1/- ½ watt 5% .. 3d.

Wire Wound

2.5 watt 5% (Up to 270 ohms only) 1/6
5 watt 5% (Up to 8.2k ohms only) 2/-
10 watt 5% (Up to 25k ohms only) 2/6

CAPACITORS. Polyester, ceramics, Polystyrene, silver mica, tantalum, trimmers etc.

Electrolytics

MFD.	V.		MFD.	V.		MFD.	V.	
1	40	1/6	25	50	1/6	320	10	1/6
1.6	25	1/6	32	40	1/6	400	16	2/9
2	350	2/-	32	450	5/6	500	6	2/6
2.5	16	1/6	40	6.4	1/6	500	25	3/9
4	10	1/6	40	16	1/6	500	50	4/9
4	40	1/6						
4	350	2/3	50	12	1/6	640	16	3/6
5	18	1/6	50	25	1/6	640	25	5/-
5	50	1/6	50	50	2/-	1000	16	5/-
6.4	6.4	1/6	64	25	1/6	1000	25	5/-
8	40	1/6	80	16	1/6	1000	50	7/6
8	450	3/-	80	25	1/6	2000	25	8/6
10	12	1/6				2000	50	12/6
10	25	1/6	100	6.4	1/6	2500	12	5/-
12.5	25	1/6	100	12	1/6			
16	10	1/6	100	25	2/-	2500	25	9/6
16	15	1/6	100	50	2/6	2500	50	13/6
16	450	3/3	125	10	1/6	2500	64	15/6
25	6.4	1/6	200	10	1/6	3000	25	10/6
25	10	1/6	250	25	2/9	5000	25	12/6
25	25	1/6	250	50	3/9	5000	50	19/6

THERMISTORS (MULLARD)

R53 (STC) 25/6	VA1010	2/6	VA1039	3/-	VA1077 4/-
	VA1015	3/9	VA1040	2/6	VA1091 4/6
K151 (Siemens) 1K 2/6	VA1033	2/6	VA1053	2/6	VA1096 4/-
	VA1034	2/6	VA1066	3/9	VA1097 4/-
	VA1037	2/6	VA1074	2/6	VA1098 4/-
VA1005 3/-	VA1038	2/6	VA1075	4/6	

Send 2/6 for our latest comprehensive catalogue containing transistor selection charts and all prices, and free vouchers value 6/-.

Telex 21-492
Tel: 01-452 0161/2/3

A. MARSHALL & SONS LTD
28 CRICKLEWOOD BROADWAY, LONDON, N.W.2

CALLERS WELCOME
Hours: 9-6 pm Mon-Fri 9-5 pm Sat

from Poland

electronic components
receiving valves for radio and TV receivers
picture tubes
guns for TV
getters

HIGHLY STABLE PARAMETERS
LONG OPERATIONAL LIFE

are offered by
Foreign Trade Enterprise
UNIVERSAL
Warszawa, A1.Jerozolimskie 44, Poland
P.O. Box Warszawa 1 No 370
Telex No 81437

CATALOGUE, PRICES, AND FULL DETAILS AVAILABLE UPON REQUEST

WW—093 FOR FURTHER DETAILS

SILICON TRANSISTORS 1,000,000 FOR SALE

Clearance of *pnp* Silicon Alloy Transistors from the 2S300 (TO-5) and 2S320 (SO-2) range and similar to the OC200-205 and BCY30-34 series. Available only from us at a fraction of the manufacturing cost. All these devices would normally be subject to re-selection for industrial use but owing to company policy change have been made available to us surplus to requirements. Offering these transistors in varied quantities make them ideal for *Amateur Electronics, Radio Hams and for experimental use in Schools, Colleges and Industry.*

Supplied uncoded (no warranty by the manufacturers). But our assurance given that a minimum of 80% will be found to be good usable Silicon Alloy Transistors. Please state preference of type, i.e., TO-5 2S300 or SO-2 2S320.

Approximate count by weight:
100 off—**15s.** (plus p. & p. 2s.)
300 off—**£1 15s.** (plus p. & p. 3s.)
500 off—**£2 10s.** (plus p. & p. 3s. 6d.)
1,000 off—**£4** (plus p. & p. 5s.)
10,000 off—**£35** (plus p. & p. 11s.)

Large quantities quoted for on request.
EXPORT ENQUIRIES WELCOME
All correspondence, cheques, postal orders, etc., to:

DIOTRAN SALES
P.O. BOX 5
63a High Street, Ware, Herts.
Tel: WARE 3442

4-STATION INTERCOM

Our Price Only
£7/5/0

Solve your communication problems with this new **4-Station Transistor Intercom** system **(1 master and 3 subs)**, in de luxe plastic cabinets for desk or wall mounting. Call/talk/listen from **Master** to **Subs** and **Subs** to **Master.** Operates on one 9 v. battery. On/off switch. Volume control. Ideally suitable to modernise Office, Factory, Workshop, Warehouse, Hospital, Shop, etc., for instant inter-departmental contacts. Complete with 3 connecting wires, each 66ft. and other accessories. Nothing else to buy. P. & P. 7/6 in U.K.

INTERCOM/BABY ALARM

OUR PRICE ONLY
3 gns.

Same as 4-Station Intercom for two-way instant conversation from MASTER to SUB and SUB to MASTER. Ideal as Baby Alarm and Door Phone. Complete with 66ft. connecting wire. Battery 2/6. P. & P. 4/6.

MAINS INTERCOM

No wires—no batteries. Just plug in and it is ready to use. Room to room or house to house. Both units must be on the same side of power line distribution. Lock button. Light indicator. Also useful as baby alarm. Price per pair **£11.19.6.** P. & P. 8/6.

Transistor TELEPHONE AMPLIFIER

59/6

Why not increase efficiency of Office, Shop and Warehouse with this incredible De-Luxe Portable Transistor **TELEPHONE AMPLIFIER** which enables you to take down long telephone messages or converse without holding the handset. A useful office aid. A must for every telephone user. Useful for hard of hearing persons. On/off switch. Volume Control. Operates on one 9 v. battery which lasts for months. Ready to operate. P. & P. 3/6 in U.K. Add 2/6 for Battery.

Full price refunded if returned in 7 days.

WEST LONDON DIRECT SUPPLIES (W.W.), 169 Kensington High Street, London, W.8

For electronic components fast...

Radiospares P.O. Box 427, 13-17 Epworth St., London E.C.2. Tel: 01-253 9561. Telex: 262341.

WW—094 FOR FURTHER DETAILS

LEARN HOW COMPUTERS WORK WITH COMPUKIT

ONLY 7 GNS (P&P 2/6)
from LIMROSE ELECTRONICS, Lymm, Cheshire

WW—106 FOR FURTHER DETAILS

VALVES

CY31	7/-	PL83	7/3	6K8GT	7/3
DAF96	7/9	PL84	6/6	6K25	14/-
DF96	7/6	PL500	14/9	6L6GT	9/-
DK96	7/6	PL504	16/-	6P25	11/-
DL92	6/6	PL509	30/-	68A7	7/-
DL94	6/6	PX4	14/-	68A7GT	6/6
DM70	6/-	PX25	30/-	68C7	13/-
DM71	7/6	PY33	12/-	68C7GT	5/-
DY86	6/-	PY80	6/6	68G7	6/-
DY87	6/6	PY81	5/6	68J7	7/6
DY802	9/9	PY82	5/6	68J7GT	6/6
E88CC/01	27/-	PY83	7/-	68K7	7/-
EABC80	6/6	PY88	7/6	68L7GT	6/6
EAF42	10/-	PY800	9/6	68N7GT	6/-
EB91	2/-	PY801	9/6	68Q7	7/9
EBC33	8/-	QQV03-10	25/-	68Q7GT	7/9
EBC41	10/6	QQV06-40	85/-	6V6G	3/6
EBC81	6/6	QQV06-40A	100/-	6V6GT	6/3
EBF80	7/6	R17	8/-	6X4	4/9
EBF83	8/6	R19	7/6	6X5G	5/-
EBF89	6/-	STV280/40	60/-	6X5GT	5/6
ECC81	6/-	STV280/80	180/-	676G	11/-
ECC82	5/9	TT21	51/-	6-30L2	14/-
ECC83	5/6	U25	14/6	6Z4	5/-
ECC84	6/-	U26	14/6	7B7	7/-
ECC86	7/6	U27	8/-	7C5	14/6
ECC88	7/-	U191	14/-	7C6	6/-
ECC189	9/9	U301	11/6	7E7	5/6
ECF80	6/6	U801	20/-	7Y4	12/-
ECF82	6/8	UABC80	6/6	9D6	7/6
ECF83	15/6	UAF42	10/6	11E2	30/-
ECF801	12/8	UBC41	9/6	12AT6	4/8
ECF802	12/6	UBC81	9/6	12AT7	4/-
ECH35	12/-	UBF80	7/-	12AU7	5/9
ECH42	13/-	UBF89	7/-	12AV6	5/6
ECH81	5/9	UCF80	10/-	12AX7	6/-
ECH83	8/6	UCH42	12/6	12BA6	6/-
ECH84	7/6	UCH81	6/6	12BE6	6/-
ECH200	12/6	UCL82	7/6	12BH7	3/6
ECL80	9/-	UCL83	12/-	12C8	5/6
ECL82	6/6	UF41	10/-	12E1	17/-
ECL83	10/6	UF80	7/3	12K5	10/-
ECL86	8/6	UF89	6/9	12K7GT	6/9
EF36	3/6	UL41	12/-	12K8GT	7/6
EF37A	7/-	UL84	6/6	12Q7GT	5/6
EF39	6/-	UU5	7/-	128G7	7/-
EF40	10/-	UY41	8/6	1487	15/-
EF41	12/6	UY85	5/9	19AQ5	7/9
EF80	5/-	VR105/30	6/-	19G3	70/-
EF83	9/7	VR150/30	6/-	19G6	20/-
EF85	6/6	Z759	35/-	19H4	85/-
EF86	6/3	Z800U	29/-	20P4	17/6
EF89	5/3	Z801U	25/-	25L6GT	7/3
EF91	3/-	Z900T	12/-	30C15	15/-
EF92	7/6	IL4	2/6	30C17	16/-
EF95	5/-	IR5	6/-	30C18	15/-
EF183	6/6	IS4	5/-	30F5	16/9
EF184	7/-	1S5	4/6	30FL1	15/-
EF800	20/-	IT4	3/-	30FL12	18/6
EF812	15/6	1X2A	7/6	30FL13	9/3
EFL200	15/6	1X2B	7/6	30FL14	15/6
EL34	10/6	3A4	4/-	30L15	17/-
EL41	11/6	3D6	3/-	30L17	17/-
EL42	10/6	3Q4	7/6	30P12	16/-
EL84	4/9	3S4	6/9	30P19	14/-
EL85	8/-	3V4	8/-	30PL1	13/-
EL86	8/-	5B254M	36/-	30PL14	17/-
EL90	6/-	5B/255M	35/-	35L6GT	9/6
EL91	7/-	5R4GY	10/6	35W4	5/-
EL95	7/-	5U4G	5/6	35Z4GT	9/-
EL500	17/-	5V4G	7/6	42	7/-
EL8035	17/-	5Y3GT	6/-	50C5	7/-
EM31	5/-	5Z4	14/-	50CD6G	30/-
EM80	7/6	6AB7	4/-	50EH5	12/-
EM84	7/-	6AC7	3/-	75	5/6
EM87	11/-	6AH6	11/6	76	6/-
EY51	8/-	6AK5	5/-	78	5/-
EY86	7/-	6AK8	6/-	80	9/-
EY81	7/-	6AL5	3/-	803	60/-
EY88	8/6	6AL5W	7/-	805	160/-
EZ41	8/6	6AM6	3/-	807	9/-
EZ80	5/-	6AN8	10/-	813	75/-
EZ81	5/-	6AQ5	6/-	832A	55/-
GZ34	10/6	6AQ5W	9/-	866A	15/-
KT66	27/6	6AS6	6/-	954	4/6
KT88	33/-	6AS7G	16/-	955	4/-
N78	25/-	6AT6	4/6	956	2/-
OA2	6/-	6AU6	5/-	957	6/-
OB2	6/-	6AX4	8/-	991	6/-
PABC80	7/6	6AQ5W	9/-	1622	17/-
PC97	9/-	6AS6	6/-	2051	10/-
PC900	9/6	6AS7G	16/-	8933	22/6
PCC84	6/6	6AT6	4/6	6057	10/-
PCC89	9/6	6AU6	5/-	6060	7/6
PCC189	11/6	6AX4	8/-	6064	7/-
PCE800	15/-	6AX5GT	13/-	6065	13/-
PCF80	6/6	6B7	5/6	6080	27/6
PCF82	6/9	6BK7	8/-	6146	28/-
PCF84	9/3	6BA6	4/6	8020	35/-
PCF86	10/-	6BE6	5/-	9001	3/-
PCF200	15/6	6BG6G	11/-	9002	4/6
PCF201	15/6	6BJ6	5/6	9003	10/-
PCF801	9/9	6BQ7A	6/9	9004	2/6
PCF802	9/9	6BR7	16/-	9006	2/6
PCF805	14/6	6BW6	16/-	C.R. Tubes	
PCF806	13/-	6BW7	13/-	VCR97	32/6
PCF808	14/6	6C4	5/9	VCR517B	55/-
PCH200	14/-	6C6	4/-	VCR517C	45/-
PCL81	9/6	6CH6	11/-	5FP7	26/7
PCL82	7/6	6CL6	9/9	88D	180/-
PCL83	13/-	6D6	3/-	88J	80/-
PCL84	8/6	6EA8	11/-	88L	90/-
PCL85	9/3	6EH7	7/6	Photo Tubes	
PCL86	9/-	6F23	15/-	CMG25	25/-
PFL200	14/-	6F33	20/-	931A	62/6
PL36	10/9	6H6M	3/-	6097C	350/-
PL81	8/9	6J4WA	14/-	Special Vlvs.	
PL82	7/6	6J5	7/-	CV1031	100/-
PL83	8/-	6J5GT	5/-	CV2339	£20
PL84	6/6	6J6	3/6	JP9/7D	750/-
PL500	14/9	6J7G	5/-	K301	£4
PL504	16/-	6J7M	8/-	K305	£12
PL509	30/-	6K6GT	8/-	K308	£12
PX4	14/-	6K7	6/6	K337	£12
PX25	30/-	6K7G	2/-	KRN2A	70/-
PY33	12/-	6K8G	4/-	WL417A	30/-
PY80	6/6	6K8GT	7/3	3J/92/E	£3710/-
PY81	5/6	6K25	14/-	5C22	£15
PY82	5/6	6L6GT	9/-	714AY	£4
PY83	7/-	6P25	11/-	725A	£10
PY88	7/6	68A7	7/-		
PY800	9/6	68A7GT	6/6		
PY801	9/6	68C7	13/-		
QQV03-10	25/-	68C7GT	5/-		
QQV06-40	85/-	68G7	6/-		
QQV06-40A	100/-	68J7	7/6		
R17	8/-	68J7GT	6/6		
R19	7/6	68K7	7/-		
STV280/40	60/-	68L7GT	6/6		
STV280/80	180/-	68N7GT	6/-		
TT21	51/-	68Q7	7/9		
U25	14/6	68Q7GT	7/9		
U26	14/6	6V6G	3/6		
U27	8/-	6V6GT	6/3		
U191	14/-	6X4	4/9		
U301	11/6	6X5G	5/-		
U801	20/-	6X5GT	5/6		
UABC80	6/6	676G	11/-		
UAF42	10/6	6-30L2	14/-		
UBC41	9/6	6Z4	5/-		
UBC81	9/6	7B7	7/-		
UBF80	7/-	7C5	14/6		
UBF89	7/-	7C6	6/-		
UCF80	10/-	7E7	5/6		
UCH42	12/6	7Y4	12/-		
UCH81	6/6	9D6	7/6		
UCL82	7/6	11E2	30/-		
UCL83	12/-	12AT6	4/8		
UF41	10/-	12AT7	4/-		
UF80	7/3	12AU7	5/9		
UF89	6/9	12AV6	5/6		
UL41	12/-	12AX7	6/-		
UL84	6/6	12BA6	6/-		
UU5	7/-	12BE6	6/-		
UY41	8/6	12BH7	3/6		
UY85	5/9	12C8	5/6		
VR105/30	6/-	12E1	17/-		
VR150/30	6/-	12K5	10/-		
Z759	35/-	12K7GT	6/9		
Z800U	29/-	12K8GT	7/6		
Z801U	25/-	12Q7GT	5/6		
Z900T	12/-	128G7	7/-		
IL4	2/6	1487	15/-		
IR5	6/-	19AQ5	7/9		
IS4	5/-	19G3	70/-		
1S5	4/6	19G6	20/-		
IT4	3/-	19H4	85/-		
1X2A	7/6	20P4	17/6		
1X2B	7/6	25L6GT	7/3		
3A4	4/-	30C15	15/-		
3D6	3/-	30C17	16/-		
3Q4	7/6	30C18	15/-		
3S4	6/9	30F5	16/9		
3V4	8/-	30FL1	15/-		
5B254M	36/-	30FL12	18/6		
5B/255M	35/-	30FL13	9/3		
5R4GY	10/6	30FL14	15/6		
5U4G	5/6	30L15	17/-		
5V4G	7/6	30L17	17/-		
5Y4G	7/-	30P12	16/-		
5Y3GT	6/-	30P19	14/-		
5Z4	14/-	30PL1	13/-		
6AB7	4/-	30PL14	17/-		
6AC7	3/-	35L6GT	9/6		
6AH6	11/6	35W4	5/-		
6AK5	5/-	35Z4GT	9/-		
6AK8	6/-	42	7/-		
6AL5	3/-	50C5	7/-		
6AL5W	7/-	50CD6G	30/-		
6AM6	3/-	50EH5	12/-		
6AN8	10/-	75	5/6		
6AQ5	6/-	76	6/-		
6AQ5W	9/-	78	5/-		
6AS6	6/-	80	9/-		
6AS7G	16/-	803	60/-		
6AT6	4/6	805	160/-		
6AU6	5/-	807	9/-		
6AX4	8/-	813	75/-		
6AX5GT	13/-	832A	55/-		
6B7	5/6	866A	15/-		
6BK7	8/-	954	4/6		
6BA6	4/6	955	4/-		
6BE6	5/-	956	2/-		
6BG6G	11/-	957	6/-		
6BJ6	5/6	991	6/-		
6BQ7A	6/9	1622	17/-		
6BR7	16/-	2051	10/-		
6BW6	16/-	8933	22/6		
6BW7	13/-	6057	10/-		
6C4	5/9	6060	7/6		
6C6	4/-	6064	7/-		
6CH6	11/-	6065	13/-		
6CL6	9/9	6080	27/6		
6D6	3/-	6146	28/-		
6EA8	11/-	8020	35/-		
6EH7	7/6	9001	3/-		
6F23	15/-	9002	4/6		
6F33	20/-	9003	10/-		
6H6M	3/-	9004	2/6		
6J4WA	14/-	9006	2/6		
6J5	7/-	C.R. Tubes			
6J5GT	5/-	VCR97	32/6		
6J6	3/6	VCR517B	55/-		
6J7G	5/-	VCR517C	45/-		
6J7M	8/-	5FP7	26/7		
6K6GT	8/-	88D	180/-		
6K7	6/6	88J	80/-		
6K7G	2/-	88L	90/-		
6K8G	4/-	Photo Tubes			
6K8GT	7/3	CMG25	25/-		
6K25	14/-	931A	62/6		
6L6GT	9/-	6097C	350/-		
6P25	11/-	Special Vlvs.			
68A7	7/-	CV1031	100/-		
68A7GT	6/6	CV2339	£20		
68C7	13/-	JP9/7D	750/-		
68C7GT	5/-	K301	£4		
68G7	6/-	K305	£12		
68J7	7/6	K308	£12		
68J7GT	6/6	K337	£12		
68K7	7/-	KRN2A	70/-		
68L7GT	6/6	WL417A	30/-		
68N7GT	6/-	3J/92/E	£3710/-		
68Q7	7/9	5C22	£15		
68Q7GT	7/9	714AY	£4		
6V6G	3/6	725A	£10		
6V6GT	6/3				
6X4	4/9				
6X5G	5/-				
6X5GT	5/6				
676G	11/-				
6-30L2	14/-				
6Z4	5/-				
7B7	7/-				
7C5	14/6				
7C6	6/-				
7E7	5/6				
7Y4	12/-				
9D6	7/6				
11E2	30/-				
12AT6	4/8				
12AT7	4/-				
12AU7	5/9				
12AV6	5/6				
12AX7	6/-				
12BA6	6/-				
12BE6	6/-				
12BH7	3/6				
12C8	5/6				
12E1	17/-				
12K5	10/-				
12K7GT	6/9				
12K8GT	7/6				
12Q7GT	5/6				
128G7	7/-				
1487	15/-				
19AQ5	7/9				
19G3	70/-				
19G6	20/-				
19H4	85/-				
20P4	17/6				
25L6GT	7/3				
30C15	15/-				
30C17	16/-				
30C18	15/-				
30F5	16/9				
30FL1	15/-				
30FL12	18/6				
30FL13	9/3				
30FL14	15/6				
30L15	17/-				
30L17	17/-				
30P12	16/-				
30P19	14/-				
30PL1	13/-				
30PL14	17/-				
35L6GT	9/6				
35W4	5/-				
35Z4GT	9/-				
42	7/-				
50C5	7/-				
50CD6G	30/-				
50EH5	12/-				
75	5/6				
76	6/-				
78	5/-				
80	9/-				
803	60/-				
805	160/-				
807	9/-				
813	75/-				
832A	55/-				
866A	15/-				
954	4/6				
955	4/-				
956	2/-				
957	6/-				
991	6/-				
1622	17/-				
2051	10/-				
8933	22/6				
6057	10/-				
6060	7/6				
6064	7/-				
6065	13/-				
6080	27/6				
6146	28/-				
8020	35/-				
9001	3/-				
9002	4/6				
9003	10/-				
9004	2/6				
9006	2/6				
C.R. Tubes					
VCR97	32/6				
VCR517B	55/-				
VCR517C	45/-				
5FP7	26/7				
88D	180/-				
88J	80/-				
88L	90/-				
Photo Tubes					
CMG25	25/-				
931A	62/6				
6097C	350/-				
Special Vlvs.					
CV1031	100/-				
CV2339	£20				
JP9/7D	750/-				
K301	£4				
K305	£12				
K308	£12				
K337	£12				
KRN2A	70/-				
WL417A	30/-				
3J/92/E	£3710/-				
5C22	£15				
714AY	£4				
725A	£10				

P. C. RADIO LTD.
170 GOLDHAWK RD., W.12
01-743 4946

PLEASE NOTE Unless offered as "as seen" ALL EQUIPMENT ordered from us is completely overhauled mechanically and electrically in our own laboratories

MARCONI TEST EQUIPMENT

SIGNAL GENERATOR TF 801/A. 10-300 Mc/s. in 4 bands. Internal at 400 c/s. 1 kc/s. External 50 c/s to 10 kc/s. Output 0-100 db below 200 mV from 75 ohms source. **£85.** DITTO but **801/A/1** with additional high level output. **£89.** Both P. & P. 20/-, including necessary connectors, plugs, and instruction manual.
TF 899 VALVE VOLTMETER, 10mV to 2V, **£17.10.0.** Carriage 30/-.
VIDEO OSCILLATOR TF 885A & 885A/1, £55 and **£85** resp. Carr. 30/-.
FM DEVIATION METER TYPE TF-791B. Frequency range: 4-250MHz, deviation 1-75kHz. **£62.10.0**
TF 144 SIGNAL GENERATOR. To clear. In very good "as seen" condition. Complete with mains and battery cables, etc. **£15.**
IGNITION TESTER TYPE TF 1348 For all vehicale electrical fault-finding and tuning **£60.**

IMPEDANCE BRIDGE TYPE TF 369 (No. 5). Measures L & C at 80Hz, 1kHz, 10kHz. Ranges:—L: 1μH-100H. C: 1mF-100μF. R: 0.1ohms-100mohms. AC Bridge volts monitored and variable. Automatic detector sensitivity control. **£105.** Carriage 30/-.

VALVE VOLTMETER TYPE TF 958. Measures AC 100mV; 20 c/s to 100 mc/s, DC 50mV to 100V, multiplier extends ac range to 1·5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. **£32.10.0.**

DISTORTION FACTOR METER TYPE TF 142E. Frequency range: 100-8,000Hz in four ranges. Distortion range: 0.05 to 50%. Input impedance 600Ω, attenuation 0-60db continuously variable. Sensitivity 1mW. **£42.10.0.** Carrlage 20/-.

BRADLEY PORTABLE ELECTRONIC MULTIMETER TYPE CT471B. This instrument operates from three 1½V cells, is fully transistorised and measures A.C. and D.C. current, A.C. and D.C. voltage and D.C. resistance. Built-in battery check and calibration check. Full spec. and price on request.

As above but MODEL CT 471A manufactured by AVO, full spec and price on request.

AVO VALVE CHARACTERISTIC METER complete with manual, **£45** Carriage. 30/-.

AVO SIGNAL GENERATOR CT 378, 2-225MHz. **£38.10.0.** Carriage 18/-.

AVO'S METERS
Model 8 with leads, **£18.**
Model 7X with leads **£15.10.0.**
Model 7 with leads, **£14.10.0.**
Model 48A complete with multiplier shunts, etc., in special fitted wooden case, **£14.10.0.**
Model 47A **£12.**
Carriage for each of above 7/6.

PANEL METERS. See our last month's advertisement for list and prices.

29/41FT. AERIALS each consisting of ten 3ft., ¾in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod. Insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag, **£3/9/6.** P. & P. 10/6.

SOLARTRON EQUIPMENT

LAB. AMP AWS 151A, Frequency: 15Hz to 350kHz. Metered output, 'scope viewing, etc. **£29.10.0.** Carriage 20/-.
Regulated and stabilised **P.S.U. SRS 151A,** 20 to 500V positive at 300mA in two ranges. Variable and fixed 170V negative output, **£35.** Carriage 20/-.
CD 711S.2. Double beam, DC to 7MHz 'scope, **£85.** Carriage 30/-.
CD 643.2. Single beam Laboratory Model, DC to 14MHz price upon application.
QD 910. Storage Oscilloscope, as new. Price on request.

FIELD TELEPHONE TYPE "F". Housed in portable wooden cases. Excellent for communication in and outdoors for up to 10 miles. Pair including batteries, fully tested. **£6.10.0,** or with 220 yds field cable in drum **£7.10.0.**

4, 5 and 8 bank 25 way uniselectors, 24V, guaranteed perfect, **£3.15.6; £4.10.0; £6.17.6** respectively.

DAWE STORAGE OSCILLOSCOPE complete wtih trace shifter, complete as new, specification and price on request.

FURZEHILL VALVE VOLTMETER TYPE 378B/2. 10mV to 100V. To clear in "as seen" condition. **£12.10.0.**

HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.

BOONTON Q METER TYPE 160A. Freq. range 50kHz to 75MHz, main capacitor 30 to 500pF. Vernier capacitor ± 3pF; q range. 0-250 with 2.5 x multiplier. **£85** plus carriage.

BOONTON SIGNAL GENERATOR TS 497/B/URR, 2-400MHz. **£95.**

TS 418 B/U SIGNAL GENERATOR, 400-1000MHz. **£105.** Carr. 30/-.

TELEPHONE ENQUIRIES relating to **TEST EQUIPMENT** should be made to 01-748 8006 Extension 23.
To view **TEST EQUIPMENT** please phone for appointment

TELEMETRY STATION

We are able to offer, one only, Telemetry Station of very recent American manufacture. Comprising Helical Antenna, oscilloscope receiver and associated units, Ampex tape recorder and power supply for the entire installation. Interested clients with a knowledge of this type of equipment are invited to phone or write for further particulars.

230v, 3 pole, 10 amp plug in change over relays. 11 pin base, perspex cover. 25/-. P. & P. 1/-

PHASE MONITOR ME-63/U. Manufactured recently by Control Electronics Inc. Measures directly and displays on a panel meter the phase angle between two applied audio frequency signals within the range from 20-20,000 c.p.s. to an accuracy of ± 1.0°. Input signals can be sinusoidal or non-sinusoidal between 2 and 30 v. peak. In excellent condition. **£75.** Carriage 30/-.

TF144H SIGNAL GEN. Freq. range 10 KHz-72 MHz. R.F. output 2uV to 2V at 50 ohms 400 and 1000 Hz internal mod. Limited qty. only available. Full spec. and price on request.

TF1041C VTVM A.C. voltage range 300 MV to 300V in 7 ranges. 20 Hz-1500MHz. D.C. voltage ranges 300 MV-1000V in 8 ranges, D.C. reistance 50 ohms to 500 Mohms. Price **£62.10.0.**

AR88 SPARES. We hold the largest stock in U.K. Write for list.

WEE MEGGERS. 250v **£12.0.0.** 500v **£14.10.0.**

GENERAL RADIO AMPLITUDE MODULATION MONITOR TYPE 1931A. £45 plus carriage.

A.F. SWEEP FREQUENCY OSCILLATOR. Range 12.5 to 25,000Hz, sweep rate 0-7 octaves/min. Variable output, automatic or manual frequency control. **£55** plus carriage.

FOR EXPORT ONLY

MULLARD N.W.S./T TRANSMITTER/RECEIVER. Self contained in one floor-standing unit approx. 4ft. x 2½ft. x 2ft. The transmitter is crystal controlled with eight switched channels, the receiver is continuously tuned over the range 1.5 to 13MHz. The transmitter delivers up to 2A into the aerial. Complete with built-in handset.

COLLINS TYPE 231D 4KW TRANSMITTERS. 10 channel, autotune and manual tuning. Complete with very comprehensive spares. Full specification and price on application.

Complete installations and all spares. No. 19 WIRELESS SETS. H.P. SETS and all spares R.210 RECEIVERS with all necessary accessories.

PYE PTC 2002N A.M. Ranger Mobile Radio Telephone, brand new and complete, **£45.**

SPECIAL OFFER O9J TUBE 35/- TRANSISTORS, ZENER DIODES

OA5	2/6	OC38	8/6	IN43	4/-	3F100	12/6	AFY19	22/6	CR81/40	12/6
OA10	6/-	OC44	4/-	IN70	4/-	3F85	6/6	ASY26	5/6	CR83/05	6/-
OA70	2/-	OC45	2/6	IN702-725	7/3	3N128	17/6	ASY28	5/6	CR83/20	10/-
OA71	2/-	OC70	3/-	IN746A series	5/3	3N139	35/-	ASY67	22/-	CR83/30	11/6
OA73	1/6	OC71	2/6	IN821A	21/-	3N140	19/6	BAW19	5/6	CRS25/025	15/-
OA74	2/-	OC72	4/-	IN823A	26/-	3N154	19/-	BC107	3/6	CR83/40	12/6
OA79	1/9	OC73	11/-	IS44	3/6	3N159	29/-	BC108	4/-	GET103	4/-
OA81	1/6	OC75	4/6	IZMT5	7/-	6FR5	7/9	BC113	6/-	GET115	9/-
OA91	1/3	OC76	5/-	IZMT10	8/9	12FR60	14/9	BC118	7/6	GET116	8/-
OA200	1/9	OC81	4/-	IZT5	13/6	10D1	3/4	BCY10	9/-	GEX66	15/-
OA202	2/-	OC81D	3/-	IZT10	12/9	40594	27/6	BCY72	7/9	NKT222	4/-
OA210	7/8	OC81DM	3/-	2G385	10/6	40595	27/6	BF115	5/-	NKT304	7/-
OA211	9/6	OC82	5/-	2G403	10/6	40636	29/-	BF173	6/-	8D918	5/3
OAZ200	11/-	OC82DM	3/-	IN607	22/-	40668	27/-	BFY51	4/6	8D928	6/3
OAZ201	10/-	OC83	4/6	IN4785	11/-	40669	29/-	BFY52	4/6	8D938	6/6
OAZ202	to	OC83B	3/-	2N1304	6/-	AC126	4/6	BS05	7/6	8D94	4/4
OAZ206	8/6	OC84	5/-	2N1306	6/6	AC127	4/6	BS	9/1	8D968	7/3
OAZ207	9/6	OC122	10/-	2N1307	6/6	AC128	4/-	B82	9/3	8D988	9/3
OAZ208	to	OC139	6/8	2N2147	17/6	AC176	7/8	B8Y29	3/6	V405A	7/9
OAZ213	6/6	OC140	8/-	2N2904	7/6	ACY17	5/-	BU100	38/-	Z Range Zener diodes 3/6 ea.	
OAZ223	to	OC170	5/-	2N3053	6/6	ACY28	4/-	BYZ13	5/-		
OAZ225	10/-	OC171	6/-	2N3054	12/6	AD149	11/-	BYZ16	15/-		
OC16	15/-	OC172	7/6	2N3055	15/-	AD161	7/-	CR81/10	5/-		
OC22	8/6	OC200	6/-	2N3730	25/-	AD162	7/-	CR81/20	9/6		
OC25	7/6	OC201	7/6	2N3731	25/-	AF117	4/9	CR81/30	10/-		
OC26	5/-	OC206	10/-	2N5109	41/-	AF118	10/-	CR81/35	11/6		
OC28	8/-	IN21	3/6	S2303	10/-	AF139	10/-				
OC29	15/-	IN21B	5/-			AF178	12/6				
OC35	8/6	IN25	12/-			AF186	9/-				

All preferred voltage
¼W 3/8
1W 7/8
1·5W 5/-
7W 7/6

MANY OTHERS IN STOCK include Cathode Ray Tubes and Special Valves. U.K. P. & P. up to 10/- 1/-; to £1 2/-; over £1 2/- in £, over £3 post free. C.O.D. 4/- extra.

Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.

INTEGRATED CIRCUITS
MANY OTHERS IN STOCK

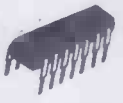
RCA
CA 3005 wide band R.F. Ampl. 300mW diss 27/-
CA 3012 wide band ampl. 150mW diss 22/-
CA 3020 Audio power ampl..... 30/-
CA 3036 Audio pre-ampl. 19/-
STC
MIC 9301B Digital dual 4 imput gates 86/-
MIC 709-1C Linear operational ampl. 190/-
MIC 9005D Highspeed flip-flop.... 54/-
Plessey. SL402A 2·5W 42/6 SL403A 3·5 52/6

All overseas enquiries & orders please address to:

COLOMOR (ELECTRONICS) LTD.
170 Goldhawk Rd., London, W.12
Tel. 01-743 0899

BI-PAK=LOW COST I.C's VALUE ALL THE WAY

BI-PAK Semiconductors now offer you the largest and most popular range of I.C's available at these EXCLUSIVE LOW PRICES. TTL Digital 8N74N Series fully coded, brand new to manufacturers' specifications. Dual in-line plastic 14 and 16 pin packages.



BI-PAK Order No.	Description	Price and qty. prices 1–24	25–99	100 up
BP00 = SN7400N	Quad 2-Input NAND GATE	6/6	5/6	4/6
BP01 = SN7401N	Quad 2-Input NAND Gate—OPEN COLLECTOR	6/6	5/6	4/6
BP04 = SN7404N	HEX INVERTER	6/6	5/6	4/6
BP10 = SN7410N	Triple 3-Input NAND GATE	6/6	5/6	4/6
BP20 = SN7420N	Dual 4-Input NAND GATE	6/6	5/6	4/6
BP30 = SN7430N	Single 8-Input NAND GATE	6/6	5/6	4/6
BP40 = SN7440N	Dual 4-Input BUFFER GATE	6/6	5/6	4/6
BP41 = SN7441AN	BCD to decimal decoder and NIT Driver	22/6	20/–	17/6
BP42 = SN7442N	BCD to decimal decode (TTL O/P)	22/6	20/–	17/6
BP50 = SN7450N	Dual 2-Input AND/OR/NOT GATE —expandable	6/6	5/6	4/6
BP53 = SN7453N	Single 8-Input AND/OR/NOT GATE—expandable	6/6	5/6	4/6
BP60 = SN7460N	Dual 4-Input—expandable	6/6	5/6	4/6
BP70 = SN7470N	Single JK Flip-Flop—edge triggered	9/–	8/–	7/–
BP72 = SN7472N	Single Master Slave JK Flip-Flop	9/–	8/–	7/–
BP73 = SN7473N	Dual Master Slave JK Flip-Flop	10/–	9/–	8/6
BP74 = SN7474N	Dual D Flip-Flop	10/–	9/–	8/6
BP75 = SN7475N	Quad Bistable Latch	11/–	10/–	9/6
BP76 = SN7476N	Dual Master Slave Flip-Flop with preset and clear	11/–	10/–	9/6
BP83 = SN7483N	Four Bit Binary Adder	26/–	22/6	20/–
BP90 = SN7490N	BCD Decade Counter	22/6	20/–	17/6
BP92 = SN7492N	Divide by 12 4 Bit binary counter	22/6	20/–	17/6
BP93 = SN7493N	Divide by 16 4 Bit binary counter	22/6	20/–	17/6
BP94 = SN7494N	Dual Entry 4 Bit Shift Register	22/6	20/–	17/6
BP95 = SN7495N	4 Bit Up-Down Shift Register	22/6	20/–	17/6
BP96 = SN7496N	5 Bit shift register	24/–	21/–	18/6

Data is available for the SN 74N Series of Integrated Circuits in booklet form. Price 2/6

INTEGRATED CIRCUITS

Manufacturers' "Fall outs"—out of spec. devices including functional units and part functional but classed as out of spec. from the manufacturers' very rigid specifications. Ideal for learning about I.C's and experimental work, on testing some will be found perfect.

PAK No.		PAK No.		PAK No.	
UIC00 = 5 × 7400N	10/–	UIC42 = 5 × 7442N	10/–	UIC80 = 5 × 7480N	10/–
UIC01 = 5 × 7401N	10/–	UIC50 = 5 × 7450N	10/–	UIC82 = 5 × 7482N	10/–
UIC02 = 5 × 7402N	10/–	UIC51 = 5 × 7451N	10/–	UIC83 = 5 × 7483N	10/–
UIC03 = 5 × 7403N	10/–	UIC60 = 5 × 7460N	10/–	UIC86 = 5 × 7486N	10/–
UIC04 = 5 × 7404N	10/–	UIC70 = 5 × 7470N	10/–	UIC90 = 5 × 7490N	10/–
UIC05 = 5 × 7405N	10/–	UIC72 = 5 × 7472N	10/–	UIC92 = 5 × 7492N	10/–
UIC10 = 5 × 7410N	10/–	UIC73 = 5 × 7473N	10/–	UIC93 = 5 × 7493N	10/–
UIC20 = 5 × 7420N	10/–	UIC74 = 5 × 7474N	10/–	UIC94 = 5 × 7494N	10/–
UIC40 = 5 × 7440N	10/–	UIC75 = 5 × 7475N	10/–	UIC95 = 5 × 7495N	10/–
UIC41 = 5 × 7441AN	10/–	UIC76 = 5 × 7476N	10/–	UIC96 = 5 × 7496N	10/–
		PAK No. UICX1 = 20 × Assorted 74's		30/–	

Packs cannot be split but 20 assorted pieces (our mix) is available as PAK UICX1. Every PAK carries our BI-PAK Satisfaction or money back GUARANTEE.

MOTOROLA DIGITAL I.C's

	Price
MDTL dual in-line package.	
Type MC844P expandable dual 4-input NAND Power Gate	10/– each
Type MC845P Clocked Flip-Flop	15/– each

FULL DATA SUPPLIED WITH UNITS

BRAND NEW. FULL TO MANUFACTURERS' SPECIFICATION	Price each 1–24	25–99	100 up
BP709 Operational Amplifier, dual-in-line 14 pin package = SN72709 and similar to MIC709 and ZLD709C	10/6	9/–	8/–

This is a high performance operational amplifier with high impedance differential inputs and low impedance output.

FAIRCHILD (U.S.A.) I.C's

RTL Micrologic Circuits	Qty. 1–11	prices each 12–24	25–99	100 up
Epoxy case To-5 temp. range 15°C to 55°C.	9/9	8/–	7/6	6/6
μL 900 Buffer	9/9	8/–	7/6	6/6
μL 914 Dual two-input GATE	9/9	8/–	7/6	6/6
μL 923 J–K Flip-Flop	12/6	11/–	10/6	9/6

Full data and circuits for I.C's in Booklet form 1/6 each.

μA 703E Linear RF–IF AMPLIFIER	11/–	10/–	9/–	8/3

PLASTIC CASE To-5 6 lead up to 100 m/cs. Full Data and Circuits available.

INTEGRATED CIRCUITS

BI-PAK MONOLITHIC AMPLIFIERS (TO-5 8 lead)

BP709C, Operational amplifier.....15/– each

BP701C, Operational amplifier (with Zener output).....12/6 each

BP702C, Operational amplifier (with direct output).....12/6 each

BP501, Wide band amplifier.....18/– each

BP521, Logarithmic wide band amp.....14/– each

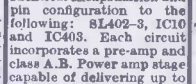
BP20/C, General purpose amplifier (TO-5 8 lead) (voltage or current amp.) 12/6 each

LC. Operational amplifier with Zener output. Type 701C. Ideal for P.E. Projects. 8 lead TO-5 case. Full data.

Our price 12/6 each

5 off 11/– each. Large Quantity Prices quoted for.

IC AMPLIFIER



Identical encapsulation and pin configuration to the following: SL402–3, IC10 and IC403. Each circuit incorporates a pre-amp and class A.B. Power amp stage capable of delivering up to 3 watts RMS. Fully tested and guaranteed. Supplied complete with circuit details and data. CODED BP.1010. OUR LOWEST PRICE 30/– each, 10 up 25/– each.

OTHER MONOLITHIC DEVICES

D13D1 Silicon Unilateral switch ..... 10/– each

A Silicon Planar, monolithic integrated circuit having thyristor electrical characteristics, but with an anode gate and a built-in "Zener" diode between gate and cathode. Full data and application circuits available on request.

MULLARD I.C. AMPLIFIERS

TAA243, Operational amplifier.....44/– each

TAA263, Linear AF amplifier.....15/– each

TAA293, General purpose amplifier .... 20/– each

TAA320 .....12/6

CA3020 RCA (U.S.A.) LINEAR INTEGRATED CIRCUITS

Audio Power Amplifier. 30/– each

BI-PAK MONOLITHIC DIGITAL CIRCUITS (10 lead TO-5)

BP305A, 6-Input AND gate .....9/6 each

BP314A, 7-Input NOR gate .....9/6 each

BP315A, Dual 3-Input NOR gate.....9/6 each

BP316A, Dual 2-Input NOR gate (expandable). 9/6 each

BP320A, J–K–Binary element .....11/6 each

BP332A, Dual 3-Input OR gate.....9/6 each

QUALITY-TESTED PAKS

6 Matched Trans. OC44/45/81/81D	10/–
20 Red Spot AF Trans. PNP	10/–
16 White Spot RF Trans. PNP	10/–
5 Silicon Rects. 3A 100–400 PIV	10/–
2 10 A Silicon Rects. 100 PIV	10/–
2 OC1 140 Trans. NPN Switching	10/–
1 12 A SCR 100 PIV	10/–
3 Sil. Trans. 2S303 PNP	10/–
3 200 Mc/s Sil. Trans. NPN BSY26/27	10/–
3 Zener Diodes 1W 33V 5% Tol	10/–
4 High Current Trans. OC42 Eqvt	10/–
2 Power Transistors 1 OC26 1 OC35	10/–
5 Silicon Rects. 400 PIV 250mA	10/–
4 OC75 Transistors	10/–
1 Power Trans. OC20 100V	10/–
10 OA202 Sil. Diodes Sub-min	10/–
2 Low Noise Trans. NPN 2N929/30	10/–
1 Sil. Trans. NPN VCB 100 ZT86	10/–
8 OA81 Diodes	10/–
4 OC72 Transistors	10/–
4 OC77 Transistors	10/–
4 Sil. Rects. 400 PIV 500mA	10/–
5 GET884 Trans. Eqvt. OC44	10/–
5 GET883 Trans. Eqvt. OC45	10/–
2 2N708 Sil. Trans. 300Mc/s NPN	10/–
3 GT31 LF Low Noise Germ Trans.	10/–
6 IN914 Sil. Diodes 75 PIV 75mA	10/–
8 OA95 Germ. Diodes Sub-min. IN69	10/–
3 NPN Germ. Trans. NKT773 Eqvt	10/–
2 OC22 Power Trans. Germ.	10/–
2 OC25 Power Trans. Germ.	10/–
4 AC128 Trans. PNP High Gain	10/–
4 AC127/128 Comp. pair PNP/NPN	10/–
3 2N1307 PNP Switching Trans.	10/–
7 CG62H Germ. Diodes Eqvt. OA71	10/–
3 AF116 Type Trans.	10/–
12 Assorted Germ. Diodes Marked	10/–
4 AC126 Germ. PNP Trans.	10/–
4 Silicon Rects. 100 PIV 750mA	10/–
3 AF117 Trans.	10/–
7 OC81 Type Trans.	10/–
3 OC171 Trans.	10/–
5 2N2926 Sil. Epoxy Trans.	10/–
7 OC71 Type Trans.	10/–
2 28701 Sil. Trans. Texas	10/–
2 10 A 600 PIV Sil. Rects. IS45R	10/–
3 BC108 Sil. NPN High Gain Trans.	10/–
1 2N910 NPN Sil. Trans. VCB 100	10/–
2 1000 PIV Sil. Rect. 1.5 A R53310 AF	10/–
3 BSY95A Sil. Trans. NPN 200Mc/s	10/–
3 OC200 Sil. Trans.	10/–
2 GET880 Low Noise Germ. Trans.	10/–
1 AF139 PNP High Freq. Trans.	10/–
3 NPN Trans. 1 ST141 and 2 ST140	10/–
4 Madt's 2 MAT100 and 2 MAT120	10/–
3 Madt's 2 MAT101 and 1 MAT121	10/–
4 OC44 Germ. Trans. AF	10/–
3 AC127 NPN Germ. Trans.	10/–
1 2N3906 Sil. PNP Trans. Motorola	10/–
2 Sil. Power Rects. BYZ13	15/–
1 Sil. Power Trans. NPN 100Mc/s TK201A	15/–
2 2N1132 PNP Epitaxial Planar Sil.	10/–
3 2N697 Epitaxial Planar Trans. Sil.	15/–
4 Germ. Power Trans. Eqvt. OC16	15/–
1 Unijunction Trans. 2N2646	15/–
2 Sil. Trans. 200Mc/s 60Vch ZT83/84	15/–
20 NKT Trans. AF, RF, VHF, Coded + Eqvt. List	10/–
2 2N2712 Sil. Epoxy Planar HFE2225	15/–
8 BY100 Type Sil. Rects.	20/–
25 Sil. and Germ. Trans. Mixed, all marked, New	30/–

KING OF THE PAKS Unequalled Value and Quality

SUPER PAKS NEW BI-PAK UNTESTED SEMICONDUCTORS

Satisfaction GUARANTEED in Every Pak, or money back.

Pak No.		
U1	120 Glass Sub-min. General Purpose Germanium Diodes	10/–
U2	60 Mixed Germanium Transistors AF/RF	10/–
U3	75 Germanium Gold Bonded Diodes sim. OA5, OA47	10/–
U4	40 Germanium Transistors like OC81, AC128	10/–
U5	60 200mA Sub-min. Sil. Diodes	10/–
U6	40 Silicon Planar Transistors NPN sim. BSY95A, 2N706	10/–
U7	16 Silicon Rectifiers Top-Hat 750mA up to 1,000V	10/–
U8	50 Sil. Planar Diodes 250mA OA/200/202	10/–
U9	20 Mixed Volts 1 watt Zener Diodes	10/–
U11	30 PNP Silicon Planar Transistors TO-5 sim. 2N1132	10/–
U12	12 Silicon Rectifiers EPOXY BY126/127	10/–
U13	30 PNP-NPN Sil. Transistors OC200 & 2S104	10/–
U14	150 Mixed Silicon and Germanium Diodes	10/–
U15	30 NPN Silicon Planar Transistors TO-5 sim. 2N697	10/–
U16	10 3-Amp Silicon Rectifiers Stud Type up to 1000 PIV	10/–
U17	30 Germanium PNP AF Transistors TO-5 like ACY 17-22	10/–
U18	8 6-Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	10/–
U19	30 Silicon NPN Transistors like BC108	10/–
U20	12 1.3-amp Silicon Rectifiers Top-Hat up to 1,000 PIV	10/–
U21	30 A.F. Germanium alloy Transistors 2G300 Series & OC71	10/–
U23	30 Madt's like MAT Series PNP Transistors	10/–
U24	20 Germanium 1-amp Rectifiers GJM up to 300 PIV	10/–
U25	25 300Mc/s NPN Silicon Transistors 2N708, BSY27	10/–
U26	30 Fast Switching Silicon Diodes like IN914 Micro-min	10/–
U28	Experimenters' Assortment of Integrated Circuits, untested Gates, Flip-Flops, Registers, etc., 8 Assorted Pieces	20/–
U29	10 1 amp SCR's TO-5 can up to 600 PIV OR8I/25-600	20/–
U30	15 Plastic Silicon Planar trans. NPN 2N2924-2N2926	10/–
U31	20 Sil. Planar NPN trans. low noise Amp 2N3707	10/–
U32	25 Zener diodes 400mW D07 case mixed Volts, 3-18	10/–
U33	15 Plastic case 1 amp Silicon rectifiers 1N4000 series	10/–
U34	30 Sil. PNP alloy trans. TO-5 BCY26, 2S302/4	10/–
U35	25 Sil. Planar trans. PNP TO-18 2N2906	10/–
U36	25 Sil. Planar NPN trans. TO-5 BFY50/51/52	10/–
U37	30 Sil. alloy trans. SO-2 PNP, OC200 2S322	10/–
U38	20 Fast Switching Sil. trans. NPN, 400Mc/s 2N3011	10/–
U39	30 RF Germ. PNP trans. 2N1303/5 TO-5	10/–
U40	10 Dual trans. 6 lead TO-5 2N2060	10/–
U41	30 RF Germ. trans. TO-1 OC45 NKT72	10/–
U42	10 VHF Germ. PNP trans. TO-1 NKT667 AF117	10/–

Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

FREE One 10/– Pack of your own choice free with orders valued £4 or over. **FREE**

NEW LOW PRICE TESTED S.C.R's

PIV	1A (TO-5 case) each	3A (TO-66 case) each	7A (TO-48 case) each	16A (TO-48 case) each	30A PIV each
50	4/6	5/–	9/6	10/6	25 20/–
100	5/–	6/6	10/6	12/6	50 23/–
200	7/–	7/6	11/6	15/–	100 28/–
400	8/6	9/6	13/6	18/6	200 32/–
600	10/6	11/6	15/6	25/–	400 35/–
800	12/6	14/–	18/–	30/–	600 80/–

2A POTTED BRIDGE RECTIFIERS.			
200V.. 10/–	600V.. 15/–	800V.. 20/–	

TRANSISTOR EQVT. AND SPECIFICATION BOOK. (German Publication.) A complete cross reference and equivalent book for European, American and Japanese Transistors. Exclusive to BI-PAK.....15/– each

PRINTED CIRCUITS EX-COMPUTER

Packed with semiconductors and components. 10 boards give a guaranteed 30 trans. and 30 diodes. Our price 10 boards 10/–, plus 2/– P. & P.

DUAL-IN-LINE LOW PROFILE SOCKETS

14 AND 16 Lead Sockets for use with Dual-in-Line Integrated Circuits.

Order No.	Price each 1–24	25–99	100 up
TS014 14 pin type	7/6	6/–	5/3
TS016 16 pin type	10/–	8/6	7/9

CADMIUM CELLS

ORP12 8/6

ORP60, ORP61 8/– ea.

FET's

2N 3819 ....10/–

2N 3820 ....20/–

MPF105 .... 8/–

PHOTO TRANS.

OCP71 Type 8/6

BY130 .....4/–

SIL. RECTS. TESTE

PIV	750mA 3A	10A	30A
50	1/– 2/9	4/3	9/6
100	1/3 3/3	4/6	15/–
200	1/9 4/–	4/9	20/–
300	2/3 4/6	6/6	22/–
400	2/6 5/6	7/6	25/–
500	3/– 6/–	8/6	30/–
600	3/3 6/9	9/–	37/–
800	3/6 7/6	11/–	40/–
1000	5/– 9/3	12/6	50/–
1200	6/6 11/6	15/–	

TRIACS

VBOM	2A (TO-1)	6A (TO-66)	10A (TO-48)
100	14/–	15/–	22/6
200	17/6	20/–	28/–
400	20/–	24/–	35/–

VBOM Blocking voltage in either direction.

SILICON DIAC

For use with Triacs

BR100 ..... 7/6 each

LUCAS 35A SIL. RECTS.

Branded. 400 PIV. Special Price, stud type, flying lead....22/6 each

UNIJUNCTION

UT46. Eqvt. 2N2646, Eqvt. TI843. BEN3000 5/6 each; 25-99 5/–; 100 up 4/–.

NPN SILICON PLANAR

BC107/8/9, 2/– each; 50–99, 1/10; 100 up, 1/8 each; 1,000 off, 1/6 each. Fully tested and coded TO-18 case.

SILICON HIGH VOLTAGE RECTIFIERS

10-Amp 3-K.V. £3000 P.I.V.) Stud Type with Flying Leads. 16/– each

DNPN DIFFUSED SILICON PHOTO-DUO-DIODE TYPE IS701 (2N2175) for Tape Readout, high switching and measurement indicators, 50V, 250mW. Our Price 10/– each; 50 or over 8/6 each. FULL DETAILS.

EX-EQUIPMENT MULLARD AF 117 TRANSISTORS

Large can 4 lead Type. Leads cut short but still usable. Real value at 15 for 10/–.

Silicon MICROWAVE DIODES—SYLVANIA (U.S.A.)

IN21B and IN21BR MATCHED PAIR S. BAND MIXER. Max. overall noise faction 13,7 dB at 3000 m/cs. BRAND NEW AND BOXED. CLEARANCE PRICE.... 6/– PAIR

★ GIRO No. 388-7006 ★

AD161 *NPN*
AD162 *PNP*

MATCHED COMPLEMENTARY PAIRS OF GERM. POWER TRANSISTORS For mains driven output stages of Amplifiers and Radio receivers. OUR LOWEST PRICE OF 12/6 *PER PAIR*

HIGH POWER SILICON PLANAR TRANSISTORS. TO-3. FERRANTI ZT1487

	NPN
VCB60	1c6A fT, 1M/cs
VCE40	Ptot, 75W
VEB8	hFE15–45
PRICE	15/– EACH.

2N3055 115T WAT SIL. POWER NPN OUR PRICE 12/6 EA.

FULL RANGE OF ZENER DIODES VOLTAGE RANGE 2-16V. 400mV (DO-7 Case) 2/6 ea. 1¼W (Top-Hat) 3/6 ea. 10W (80-10 Stud) 5/– ea. All fully tested 5% tol. and marked. State voltage required.

BRAND NEW TEXAS GERM. TRANSISTORS Coded and Guaranteed

Pak No.		EQVT.
T1	8 2G371A	OC71
T2	8 2G374	OC78
T3	8 2G3744A	OC81D
T4	8 2G381A	OC81
T5	8 2G382T	OC82
T6	8 2G344A	OC44
T7	8 2G345A	OC45
T8	8 2G378	OC78
T9	8 2G399A	2N1302
T10	8 2G417	AF117

All 10/– each pack.

2N2060 NPN SIL. DUAL TRANS. CODE D1699 TEXAS. Our price 5/– each.

120 VCB NIXIE DRIVER TRANSISTOR. Sim BSX21 & C407, 2N1893 FULLY TESTED AND CODED ND120. 1-24 3/6 each. To-5 NPN., 25 up 3/– each.

Please send all orders direct to our warehouse and despatch department.

Postage and packing add 1/–. Overseas add extra for Airmail. Minimum order 10/–. Cash with order please. BY RETURN POSTAL SERVICE

BI-PAK SEMICONDUCTORS
P.O. BOX 6, WARE, HERTS.

KING OF THE PAKS BI-PAK GUARANTEE SATISFACTION OR MONEY BACK

SODECO IMPULSE COUNTERS

Will accept 10 Imp/s—mechanical reset, 220 v. D.C. 27 ma coil can be used on A.C. 240 with suitable rectifier. 4 digit type offered brand new 45/- ea.
Also as above with 160 v. 3200 Ω coil type ATCEZ4E. New boxed. 35/- ea.

ADVANCE VOLT STAT CV500/31

Input 162-276 v. A.C., 50 c/s. 1 phase output 115 v. constant at 410 watt. Offered BRAND NEW at only £8. P. & P. 15/-.

ADVANCE D.C. SERIES

Output 24 v. D.C. at 5 amps. Input 200-245 v. A.C. ± 15%. Fully smoothed and protected. BRAND NEW units at only £10 each.

HIGH VOLTAGE TRANSFORMERS

Input 240 v., output 2560 v. and 2820 v. at 1 amp. Weight 75 lb. Price £15.

NICKEL-CADMIUM BATTERIES

D.E.A.C. manufacture RS 3·5 rating 3·5 Ah 1·24 v. Size as British U2, fully rechargeable. Offered BRAND NEW 19/6 each. P. & P. 1/6.

INSTRUMENT CONNECTING CABLES.

Terminated with Plessey Mk. III Free Plugs/Free Sockets. In stock now 25-way, 12-way, 6-way, 3-way. Supplied in nominal 6-ft. lengths. Price 50/- 25-way and 12-way each; 35/- 6-way and 3-way each. All Connectors Brand New. P. & P. 2/6.

OHMITE RHEOSTATS

40 ohms, 500 watts. Torodial wound on ceramic formers. BRAND NEW high quality units. Size 5 in. dia. Price 35/- each. P. & P. 5/-.

BERCO RHEOSTATS
3000 Ω AT 100 Watts

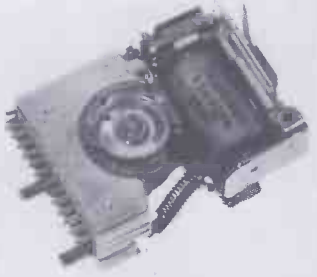
Torodial wound on ceramic former with control knob. BRAND NEW at 12/6. P. & P. 1/6.

HEWLETT PACKARD RF. POWER METER—Type 431B

Measures RF. power in 7 ranges, from 0·01 MW to 10 MW. This instrument is fully completely solid state, small portable, current series equipment. Mains or battery powered C/W thermistor mount either 478A 10 Mc/s to 10 K.Mc/s. Supplied in good used condition with thermistor mounts. £95.

A.E.I. MINIATURE UNISELECTOR SWITCHES

No waiting, straight off the shelf and into your equipment the Catalogue Nos. are 2202A, 4/33A63/1; coil resistance is 250 ohms. Complete with base, and the price is £4.19.6. Limited quantity only available.
Also: 2203A, 2200A, 2202A.



FOSTER VOLTAGE REGULATING EQUIPMENT TYPE 12A80

Input 250 A.C. max., input variation ±5·15% output 250 v. A.C. constant. Load 80A max. As new £65. Carr. £4.

AVO METER CALIBRATION TEST UNIT TYPE CT155

A modern precision instrument, giving 7 standard voltages 1 v. A.C.-2·5 v. A.C.-10 v. A.C.-25 v. A.C.-100 v. A.C. and 250 mV. A.C. Also 250 mV. D.C. from internal standard cell. Internal power supply 110-250 v. A.C., contained in portable carrying case. Size 11 × 8 × 7in. Brand new equipment. £7.10.0 P. & P. 10/6.

SPECIAL OFFER

"INSULATION TESTERS" TYPE No. 11 METROHM by famous British manufacturer. All solid state. No handles to crank. Runs off 9 volt transistor battery. Simply press button for function. Range 0·1 to 25M ohms for insulation testing. Also 0·1 to 100 ohms for resistance and continuity checking. Clear, concise scale. Small size modern instrument, complete with carrying strap and protecting cover. Offered in good used condition with battery ready to work. For 250 volt pressure only. List Price £19.10.0. Our Price £5.19.6 plus 4/6 post/packing.

Rhode & Schwarz ESM300	UHF Receiver AM/FM	85MHz—300 MHz.
Rhode & Schwarz BN15031	Field strength test receiver AM/FM	90 MHz—470 MHz.
Rhode&SchwarzBN4151/2'60	Noise generator	3 MHz—1000 MHz.
Rhode & Schwarz BN18042	Unbalanced standard Attenuator	0-100db 50 ohm 0 MHz—600 MHz.
Rhode & Schwarz BN33664/50	UHF Load resistor 100 watt 50 ohm	0 MHz—600 MHz.
Rhode & Schwarz BN4521	Vibration Meter	30Hz—12 KHz.
Rhode & Schwarz	ZD Diagraph.	
	Advance Q meter type T.I.	100 kHz—100 MHz.
	Marconi Q meter type 329G	50 kHz— 50 MHz.
	Marconi Q meter type 886A	15 MHz—170 MHz.

Marconi Impedance Bridge type TF936
Marconi Universal Bridge type TF868/1
Marconi Universal Bridge type TF868

Wayne Kerr Inductance meter type M149 Extremely sensitive 0-100 mH first indication 0·8 microhenrie. Price £22

RF GENERATORS

Marconi Standard Signal generator TF867 15 kHz—30 MHz	£200
Marconi UHF signal generator TF762C 300—600 MHz	£75
Marconi FM/AM Signal Generator 2-216 MHz TF995A/3	P.U.R.
Services type CT212 AM/FM signal generator 85 kHz—32 MHz	£45
Services type CT211 AM/FM signal generator 20-80 MHz	£40
Avo Signal generator portable 50 kHz—80 MHz	£15
Hewlett Packard 616B 1·8 GHx—4 GHz, also special generators up to X band	
Hewlett Packard 540A Transfer function Oscillator	£75
Marconi signal generator TF144H/4. Range 10 kHz to 72 MHz	P.U.R.
General Radio 1021A 250—920 MHz	£95

D.C./A.C. ELECTRONIC VOLTMETERS

	Price
Philips GM6010 Sensitive D.C. Millivolt Meter 1MV/FSD to 300 volts in twelve ranges	£45
Philips GM6505 Transistor measuring test unit designed for labs' test departments etc.	£125
Advance VM77 wide range A.C. Valve Voltmeter 1 mv-300 v.	£25
Philips GM6016 3 mv-1000 v. 1 kHz- 30 mHz.	£30
Philips GM6014 1 mv-300 v. 1 kHz-30 mHz	£25
Rohde & Schwarz UHF Millivoltmeter type URV with Insertion unit for measurements up to 2400 mHz	£95
Hatfield Millivoltmeter LE48C 0·3 MV- 30 volts. Large eight inch scale indication balance and unbalanced inputs	£30

CAMBRIDGE INSTRUMENT Co. Ltd. Precision test meters. Electrodynamic A.C. Ammeter 0 to 15 amps with test certificate	£35
Dynamometer A.C. Ammeter range 0 to 15 amps	£45
Cambridge Dynamometer A.C. test set 0-225 Watts/0-330 v./0-30 v.	£55

Tinsley Universal Shunt type 4309C	£5
Tinsley Vernier Potentiometer type 4363E Auto	P.U.R.
Foster Thermocouple potentiometer type DX	P.U.R.

Digital Voltmeter Solartron LM902·2 four digit readout	£85
Solartron A.C. Convertor LM 903 matching unit for LM902	£75
Hewlett Packard DVM 405CR four digit readout auto polarity	£75
Glouster DVM BIE 2123 A.C./D.C. transistor portable 0-1000 v.	£75

Frequency Counters Analogue/Digital

Marconi TF1345/2 digital 10 Hz to 220 mHz C/W full complement plug in's	£300
Racal Digital frequency meter SA520 as new 10 Hz to 400 kHz	£55
Racal Digital frequency meter older type valve model 10 Hz-300 kHz	£25
Rank Cintel Counter/timer transistorised model 10 Hz-1 mHz	£45
Venner Counter/timer type TS a3 Mains or portable Digital meter readout	£25
U.S.A. BC221 Heterodyne frequency meter 125 kHz-20 mHz new or used from	£18
U.S.A. TS175/U 85-1000 mHz Modulated, reception/emission CW, MCW, as new	£85
U.S.A. TS186/D Heterodyne frequency meter 100-10,000 mHz CW, MCW, pulse	£95

P. F. RALFE

10 Chapel St London N.W.1

Phone 01 - 723 8753

Coutant Stabilised Power Supplies Model ED50/18/18. Double module units Variable between 3-30 volts 500 ma twice, high quality units of recent manufacture offered new boxed at only £25 each.

LUCAS CAR RELAYS.

12 v. Heavy duty make. Suitable for spotlights, horns, overdrives, etc. Brand new. Only 7/6. Special price for quantities.

BARGAIN OFFER

200-yard reels equipment wire, size 1/024, STC quality, various colours. Brand new reels only 15/-. P. & P. 2/6.

HIGH SPEED RELAYS.

"Suitable for transistor circuits."
Plessey. Type mini sealed. 1 C/O contacts. 12 v. 3100Ω. Brand new. 15/- each.
Siemens High Speed. Type H96E. Twin 1700Ω coils. 48 v. 15/-.
Siemens High Speed. Type H96D. Twin 500Ω coils. 12 v. 15/-.

GEC UNISELECTOR U.301

GPO pattern 3 bank full wipe 3 bridging contacts. 75 ohm. Coil. 25 position. Brand New 40/-. P. & P. 4/6.

GEC UNISELECTOR.

GPO pattern. 5 bank full wipe 5 bridging contacts. 25 position. 75 ohm. Coil 28-36 v. Brand new 50/-. P. & P. 4/6.

R.D.O. UHF. RECEIVER.

38-1000 mHz offered with 3 tuning units to cover full frequency range. Ideal communications receiver/or can be supplied with Pan-adaptor for laboratory work. £95.

WATSON MARLOW ORBITAL LOBE PUMPS

Specially designed for corrosive liquids etc. Rated output against 10 ft. head—110 G.P.H. direction of flow reversible. Supply 240 v. A.C. mains. Nett weight 14 lb. Supplied as new. Price £12.10.0 P. & P. 10/-. List £22.10.0.

DOUGLAS No. 6 COIL WINDER

With motor tailstock and special Swedish reel carrier, plus gears. Offered in good operative condition. Price £85.

CAMBRIDGE SPOT GALVANOMETER.

Type 41153/1-3. Offered brand new with hand book. Price £22.

ERNEST TURNER LTD. Model 32.

100 microamp meter scaled 0-100. On 5 in. mirrow scale, MC type. Flush fitting. Supplied brand new, boxed only 75/-. P. & P. 5/-.

MARCONI 100 KHz QUARTZ CRYSTAL

Type Qm120/F contained in B7G envelope with flying lead connections. Brand new only 20/- each.

MORGANITE GLASS ENCLOSED RESISTORS

Value 2.5k. meg ohms, tolerance 10%. 25/- per carton of four.

COMPLETE C.R.T. KIT

comprising 2API C.R.T. mumetal screen/tube base and graticule. The lot 45/-. P. & P. 2/6.

TMC MINIATURE KEY SWITCHES

Two change-overs, non-biased, two position offered. New, only 8/6 each.

PAXOLIN PC BOARDS

contains five Mullard OC36 power transistors—made up as solenoid drive unit. Guaranteed. Brand new, only 30/- inc.

PAXOLIN PC BOARD

contains ten GET113 transistors with polythene holders, ten miniature glass diodes and 25 ¼W. resistors. BRAND NEW 19/6, P. & P. 6d.

Z AND I AERO SERVICES LTD

ZAERIX BRAND

INTEGRATED CIRCUIT AMPLIFIERS

CA3005 RF amplifier, 100mc/s bandwidth	27/-
CA3012 Wide Band Amplifier for IF applications	23/-
CA3020 550mW Audio Amplifier	30/-
CA3036 Two super-alpha pairs for stereo pick-up systems	19/-
CA3052 Latest addition to RCA range. Four-in-one amplifier	42/-
PA222 1.2 watt Audio Amplifier	65/-
PA234 1 watt Audio Amplifier	27/6
PA237 2 watts Audio Amplifier	40/-
MC1709G—G.P. operational Amplifier	40/-
TAA263 3-stage direct coupled Amplifier	15/-
TAA293 3-stage direct coupled Amplifier	20/-
TAA320 MOST input + bi-polar stage	13/-
TAD100 All active components required to construct an AM receiver	45/-
SL403A 3 watts Audio Amplifier	49/6

ZENER DIODES

BZY88 series, from 3.3V to 9.1V ± 5% 400mW	3/6	each
BZY94 series, from 10.0V to 12.0V ± 5% 400mW	4/1	each
D814 series, from 7.5V to 13.0V ± 10% 340mW	3/-	each
D815 series, from 4.7V to 18.0V ± 10% 8 Watts	7/6	each
D816 series, from 22V to 47V ± 10% 5 Watts	7/6	each
D817 series, from 56V to 100V ± 10% 5 Watts	7/6	each

Outlines: BZY series—miniature—wire ended
D814—'Top Hat' type
D815-D817—stud mounted, supplied complete with hardware

Please state voltage required—nearest standard voltage will be supplied.

TRANSISTORS

2N404 3/6
2N410 3/6
2N412 3/6
2N444A 5/-
2N696 4/6
2N697 4/6
2N698 8/6
2N705 15/-
2N706 3/-
2N708 3/6
2N753 4/9
2N916 8/6
2N929 6/-
2N930 6/8
2N987 6/6
2N1131 8/6
2N1132 9/6
2N1184 25/-
2N1301 7/-
2N1302 7/-
2N1304 4/6
2N1305 4/6
2N1306 5/-
2N1307 6/-
2N1308 7/6
2N1309 9/6
2N1711 6/-
2N1756 15/-
2N2147 14/9
2N2160 23/-
2N2217 6/6
2N2218 7/9
2N2219 8/6
2N2369A 4/6
2N2477 12/6
2N2646 12/6
2N2905 10/-

ASY74 16/-
2N2923 3/-
2N2924 3/-
2N2926'b' 3/-
2N2926'r' 3/-
2N2926'o' 3/-
2N2926'y' 3/-
2N2926 'g' 5/6
2N3053 6/3
2N3055 15/-
2N3133 7/-
2N3133 7/-
2N3134 8/6
2N3391 4/-
2N3392 3/2
2N3393 2/6
2N3394 2/6
2N3395 3/6
2N3402 5/-
2N3403 5/-
2N3404 6/6
2N3414 4/-
2N3415 4/3
2N3416 4/6
2N3417 5/2
2N3702 4/6
2N3703 3/10
2N3704 5/6
2N3707 4/-
2N3709 3/5
2N3710 3/-
2N3819 12/-
2N3906 6/-
AC113 3/-

AC125 6/6
AC126 5/-
AC127 5/6
AC128 4/6
AC132 7/6
AC153 5/-
AC154 3/-
AC157 4/-
AC169 2/-
AC176 6/9
AC188 6/6
ACY17 6/-
ACY18 4/-
ACY19 4/9
ACY20 4/-
ACY21 3/11
ACY22 2/8
AD140 16/-
AD149 12/6
AD161 9/-
AD162 9/-
AF102 15/6
AF114 6/-
AF115 6/-
AF116 5/6
AF117 4/6
AF118 10/-
AF125 6/-
AF126 5/3
AF127 5/3
AF178 12/6
AF186 11/-
AF239 10/-
AFY19 22/6
AFZ11 9/-
ASY26 6/-
ASY27 6/6
ASY28 6/6
ASY29 6/-
ASY54 6/-
ASY73 10/-

ASY77 7/-
ASY82 4/-
ASY86 4/6
BC107 3/-
BC108 3/-
BC109 4/-
BC113 8/6
BC118 8/6
BC147 4/6
BC148 3/3
BC149 3/6
BC152 3/2
BC175 5/6
BC187 6/-
BCY30 7/-
BCY31 5/-
BCY33 5/-
BCY34 5/-
BCY39 5/-
BCY72 3/10
BCZ11 7/6
BD121 18/-
BD123 25/-
BF115 4/9
BF167 5/-
BF173 6/-
BF181 6/-
BF184 7/6
BF185 4/9
BF194 3/6
BF195 3/-
BF196 4/6
BF197 4/6
BFX88 5/4
BFY17 8/6
BFY18 5/-
BFY19 5/-
BFY50 5/-
BFY51 4/6
BFY52 4/10
BSY26 5/-

BSY27 5/6
BSY28 5/-
BSY65 4/6
BSY95A 3/9
D29A4 3/6
OC16 15/-
OC22 13/-
OC23 12/6
OC24 15/-
OC25 7/6
OC26 6/-
OC28 14/6
OC29 14/9
OC30 15/-
OC35 11/3
OC36 12/6
OC42 6/6
OC44 4/-
OC45 3/6
OC71 3/6
OC72 5/-
OC73 7/6
OC75 5/-
OC76 5/-
OC78 5/-
OC78D 3/3
OC81 4/6
OC81D 3/-
OC83 4/6
OC84 5/-
OC139 7/6
OC140 9/6
OC170 5/-
OC171 5/6
OC200 4/4
OC201 10/-
OC202 13/-
OC203 16/3
OC204 6/-
OC205 13/-
OC206 14/-

TWO NEW OSCILLOSCOPES FROM RUSSIA

CI-5 SINGLE BEAM OSCILLOSCOPE

10 mc/s passband, triggered sweep from 1 μ sec. to 3 millisec. Free running time base from 20 c/s to 200 kc/s. Built-in time marker and amplitude calibrator, 3-in. cathode ray tube with telescopic viewing hood. £39.0.0

CI-16 DOUBLE BEAM OSCILLOSCOPE

5 mc/s passband. Separate Y1 and Y2 amplifiers, rectangular 5 in. × 4 in. cathode ray tube. Calibrated triggered sweep from 0.2 μ sec. to 100 millisec. per cm. Free running time base 50 c/s to 1 mc/s. Built-in time base calibration and amplitude calibrator £87/10/0

Full details on request. Full servicing facilities and spares available.

WHEN ORDERING BY POST PLEASE ADD 2/6 IN £ FOR HANDLING AND POSTAGE.
NO C.O.D. ORDERS ACCEPTED
ALL MAIL ORDERS MUST BE SENT TO HEAD OFFICE AND NOT TO RETAIL SHOP.

FULLY GUARANTEED ZAERIX BRAND FIRST QUALITY VALVES

OA2 6/6
OA3 9/-
OA4G 22/-
OB2 6/6
OB3 10/-
OC2 17/-
OC3 7/-
OD3 6/6
1A3 5/-
1A5GT 5/6
1A7GT 7/6
1B3GT 7/6
1B24A 80/-
1C5G 6/-
1G4GT 8/6
1G6GT 7/6
1H5GT 7/6
1L4 3/6
1N5GT 8/6
1Q5QT 10/-
1R4 7/-
1R5 7/-
1S2 6/6
1S4 5/6
1S5 5/-
1T4 4/6
1T5GT 8/-
1U4 6/-
1U5 9/6
1V2 9/-
1X2B 7/6
2A3 7/-
2C26A 10/-
2C39A 140/-
2C40 65/-
2C51 8/6
2C53 75/-
2CW4 12/-
2D21 6/6
2E24 50/-
2E26 30/-
2X2 7/-
3A4 4/-
3A8GT 10/-
3B4 10/-
3B28 42/6
3BP1 55/-
3C45 65/-
3D6 3/3
3D21A 50/-
3E29 65/-
3Q4 8/-
3Q5GT 8/-
3S4 7/-
3V4 8/-
4-125A 160/-
4-400 300/-
4B32 80/-
4HA5 9/6
4THA 8/-
5AR4 11/-
5B/254M 45/-

5R/255M 45/-
5D21 80/-
5J6 8/-
5R4GY 11/-
5U4G 6/-
5U4GB 7/6
5V4G 8/-
5W4GT 7/-
5X8 10/-
5Y3GT 6/-
5Z3 9/-
5Z4G 7/6
5Z4GT 8/-
6/30L2 15/-
6A8G 6/6
6AB4 6/6
6AC7 4/6
6AF4A 9/6
6AG5 4/-
6AG7 7/6
6AH6 10/-
6AJ8 5/9
6AK5 6/-
6AK5W 8/-
6AK6 11/6
6AK7 6/6
6AL3 8/6
6AL5 3/3
6AM5 5/-
6AM6 4/6
6AN8 10/-
6AQ5 6/6
6AQ6 10/-
6AR5 6/6
6AR6 6/6
6AS5 7/-
6AS7G 16/-
6AT6 5/-
6AU6 5/-
6AV5GTA 13/-
6AV6 6/-
6AW8A 11/-
6AX4GTB 9/-
6AX5GT 13/-
6B4G 16/6
6B7 7/6
6B8G 3/-
6BA6 4/6
6BE6 5/-
6BF5 16/-
6BF6 9/-
6BG6G 12/-
6BH6 8/6
6BJ6 8/6
6BK7A 10/-
6BL7GTA 12/-
6BN6 8/-
6BQ5 5/-

6BQ6GTB 13/-
6BQ7A 7/6
6BR7 17/-
6BR8 13/-
6BS7 26/-
6BW6 16/-
6BW7 13/6
6BX6 5/-
6BX7 14/-
6BZ6 6/6
6C4 6/-
6CB6 5/6
6CD6GA 23/-
6CG7 9/-
6CH6 11/-
6CL6 10/-
6CU6 13/-
6CW4 12/6
6CY5 8/-
6CY7 12/-
6D3 8/-
6DC6 13/6
6DK6 8/6
6DQ6B 12/-
6DS4 15/-
6EA8 11/-
6EH7 6/6
6EJ7 7/-
6F5 8/-
6F6 14/-
6F6G 5/-
6F11 6/6
6F13 7/-
6F14 12/-
6F15 11/-
6F17 9/-
6F18 8/-
6F22 6/6
6F23 15/6
6F24 13/6
6F25 15/-
6F28 14/-
6GH8 11/-
6GK6 12/-
6J4 9/6
6J5GT 6/-
6J7 8/6
6K6GT 10/-
6K7 6/6
6K8G 6/-
6K23 10/-
6K25 15/-
6L6GT 9/-
6L7 6/6
6L18 6/-
6LD20 6/6
6N7GT 7/-
6P1 12/-
6P25 21/-
6P28 12/6
6Q7 7/6
6R7G 7/-
6S2 8/-

6SA7 7/6
6SC7 13/-
6SG7 6/6
6SH7 5/-
6SJ7 7/6
6SK7 6/6
6SL7GT 6/6
6SN7GT 6/-
6SQ7 8/-
6SR7 7/6
6SS7 4/-
6T8 6/6
6U4GT 12/6
6U8 7/-
6V6GT 6/6
6X4 5/-
6X5GT 5/6
6X8 11/-
6Y6G 12/-
6Z4 5/6
7B5 12/-
7B6 12/6
7B7 7/6
7C5 15/-
7F8W 17/6
7Y4 12/-
7Z4 8/6
9A8 6/6
9BW6 8/6
10C2 10/-
10D1 8/-
10D2 8/-
10F1 18/-
10F9 10/-
10F18 8/-
10L1 8/-
10LD11 11/-
10P13 11/-
10P14 20/-
10Y 20/-
11D3 8/-
11D5 8/-
11E2 40/-
11E3 70/-
12AB5 10/-
12AC6 7/6
12AD6 7/6
12AH7GT 5/-
12AL5 8/-
12AQ5 8/-
12AT6 5/-
12AT7 6/6

12AU6 5/6
12AU7 6/-
12AV6 6/-
12AV7 9/-
12AX4GTB 9/-
12AX7 6/-
12AY7 13/6
12B4A 10/-
12BA6 6/6
12BA7 6/6
12BE6 6/6
12BH7 6/6
12BY7 10/-
12C8 6/-
12CU6 15/-
12E1 26/-
12F8 8/-
12J5GT 4/-
12J7GT 8/-
12K5 10/-
12K7GT 7/-
12K8 10/-
12Q7G 5/-
12SC7 5/-
12SG7 7/-
12SH7 5/-
12SJ7 5/-
12SK7 8/-
12SL7GT 8/-
12SN7GT 8/-
12SQ7 8/-
12SR7 6/6
12X4 8/-
14S7 16/-
20CV 62/6
20D1 9/-
20L1 20/-
20P1 10/-
20P3 12/-
20P4 20/-
20P5 20/-
25C5 9/-
25L6GT 7/6
25Z4G 6/-
25Z6GT 12/-
30A5 8/-
30AE3 8/-
30C1 6/6
30C15 15/-
30C17 16/-

30C18 15/-
30F5 17/-
30FL1 15/-
30FL12 18/6
30FL13 18/6
30FL14 15/6
30L1 7/-
30L15 17/-
30L17 17/-
30P12 16/-
30P18 7/-
30P19 15/-
30PL1 15/6
30PL13 18/-
30PL14 17/-
35A5 11/-
35B5 13/-
35C5 7/-
35D5 13/-
35L6GT 9/6
35W4 5/-
35Z3 11/-
35Z4G 5/-
35Z5GT 7/-
42 8/-
50A5 13/-
50B5 7/-
50C5 7/-
50CD6G 35/-
50EH5 11/6
50L6GT 8/-
52KU 7/6
53KU 16/-
75B1 9/-
75C1 8/-
80 9/-
83 20/-
85A1 25/-
85A2 7/6
85A3 9/-
90AV 48/-
90C1 12/-
90CV 25/-
108C1 6/6
150B2 12/-
150B3 11/-
150C4 11/-
305 12/6
310A 27/6

311A 37/6
328A 40/-
329 20/-
329A 35/-
715B 70/-
715C 80/-
723A/B 140/-
807 9/6
807W 27/6
811A 30/-
813 75/-
829B 60/-
833A 340/-
837 15/-
866A 14/-
872A 57/6
889RA 1000/-
927 55/-
931A 65/-
955 4/-
2050 15/-
4378 25/-
5544 120/-
5551A 320/-
5654 8/-
5670 10/-
5751 12/-
5796 280/-
5814A 12/-
5894 110/-
6072 15/-
6080 27/6
6146 30/-
6146B 47/6
6267 6/6
6360 25/-
6550 33/-
6883 47/6
6922 12/6
6939 42/-
7199 15/-
7586 25/-
7591 20/-
7895 25/-
8005 135/-
9002 6/6
9003 10/-
A1834 16/-
A2293 23/-
AC/HL/DD 9/-
AC/TH1 8/-

BT19 90/-
C1A 90/-
C1K 80/-
CBL1 16/-
CBL31 17/-
CL4 12/-
CL33 17/6
CY31 7/-
DAF41 10/-
DAF91 5/6
DAF92 9/6
DAF96 7/9
DC90 9/-
DF91 4/6
DF92 3/6
DF96 7/9
DH76 6/6
DH81 11/-
DH101 10/-
DK40 10/-
DK91 7/-
DK92 9/-
DK96 8/-
DL66 25/-
DL68 13/-
DL69 35/-
DL91 5/6
DL92 7/-
DL93 4/-
DL94 8/-
DL95 8/-
DL96 7/6
DM70 6/6
DM160 11/6
DY70 12/-
DY86 6/6
DY87 7/-
DY802 10/-
E55L 55/-
E80CC 21/-
E80CF 29/-
E80L 18/-
E81L 22/-
E83F 20/-
E84L 9/6
E88C 24/-
E88CC 12/6
E88CC/01 29/-
E90CC 9/-
E91H 10/-
E180F 19/-

E182CC 24/-
E186F 24/-
E188CC 16/6
E280F 42/-
EA50 4/-
EA52 90/-
EAF42 10/-
EAF801 9/6
EB34 3/-
EB91 3/3
EBC33 9/-
EBC41 10/6
EBC81 6/6
EBC90 5/-
EBC91 6/-
EBF80 8/-
EBF83 8/6
EBF89 6/6
EBL31 25/-
EC53 10/-
EC86 12/-
EC88 12/-
EC90 6/-
EC92 6/6
EC93 9/6
ECC34 8/-
ECC35 17/-
ECC40 11/-
ECC70 17/-
ECC81 6/6
ECC82 6/-
ECC83 6/-
ECC84 6/-
ECC85 5/6
ECC86 9/6
ECC89 8/-
ECC91 4/-
ECF80 7/-
ECF82 7/-
ECF83 15/-
ECF86 12/6
ECF804 30/-
ECH35 12/-
ECH42 13/-
ECH81 5/6
ECH83 8/6
ECH84 9/-
ECL80 9/-
ECL81 8/6
ECL82 6/6
ECL83 12/6
ECL84 11/-

ECL85 10/6
ECL86 8/6
ECLL800 30/-
EF9 9/-
EF39 9/-
EF40 10/-
EF41 12/6
EF42 14/-
EF80 5/-
EF83 10/-
EF85 7/-
EF86 6/6
EF89 5/6
EF91 4/6
EF92 7/6
EF93 4/6
EF94 5/-
EF95 5/-
EF96 4/-
EF97 10/-
EF183 6/6
EF184 7/-
EF800 20/-
EF811 15/-
EF812 15/6
EF814 13/6
EH90 8/-
EK2 15/-
EK90 5/-
EL5 11/-
EL34 10/6
EL36 9/6
EL41 11/-
EL42 11/6
EL81 10/-
EL83 7/6
EL84 5/-
EL85 8/6
EL86 8/6
EL90 6/-
EL91 5/-
EL95 7/-
EL360 23/-
EL803 17/-
EL821 11/-
EL822 18/-
ELL80 15/-
EM34 16/-
EM71 12/6
EM80 8/-
EM81 11/-
EM84 7/6

EM87 11/-
EN10 70/-
EN11 70/-
EN32 30/-
EN91 6/6
EY51 8/-
EY80 9/-
EY81 8/-
EY83 11/-
EY84 10/-
EY86 8/-
EY87 8/6
EY88 8/6
EZ35 5/6
EZ40 7/6
EZ41 9/-
EZ80 5/6
EZ81 5/6
EZ90 5/-
FG17 90/-
FW4/500 13/6
GN4 30/-
GR10M 30/-
GS10C 100/-
GS10D 115/-
GS10H 70/-
GS12D 140/-
GS47X 55/-
GU50 35/-
GY501 16/-
GZ30 7/6
GZ31 6/-
GZ32 9/6
GZ33 16/-
HABC80 8/6
HBC90 5/-
HBC91 6/-
HF93 6/6
HF94 5/6
HK90 6/6
HL23 7/6
HL23DD 7/6
HL42DD 9/-
HL92 7/-
HL94 8/-
KT8 40/-

KT36 20/-
KT44 8/6
KT45 30/-
KT66 27/6
KT71 8/-
KT76 8/-
KT88 33/-
KTW63 6/-
LL4 9/-
ME91 8/-
MH4 8/-
MHL4 8/-
ML4 9/-
ML6 8/-
MSPEN/T 10/-
MT17 90/-
MU12/14 10/-
N78 21/-
NSP1 70/-
NSP2 70/-
PABC80 8/-
PC86 11/6
PC88 13/-
PC900 9/6
PCC84 7/-
PCC85 8/-
PCC88 12/-
PCC89 10/6
PCC189 11/-
PCC805 17/-
PCC806 17/-
PCE800 15/-
PCF80 6/6
PCF82 6/9
PCF84 9/-
PCF86 11/-
PCF87 16/-
PCF800 15/-
PCF801 10/-
PCF802 10/-
PCF805 15/-
PCF806 13/-
PCF808 15/6
PCH200 14/-
PCL81 10/-
PCL82 7/9

PCL83 13/-
PCL84 8/9
PCL85 9/6
PCL86 9/6
PCL88 17/-
PCL800 18/-
PCL801 15/6
PD500 30/-
PE06-40N 80/-
PEN4DD 8/-
PEN45 7/-
PEN45DD 15/-
PEN46 7/6
PEN383 10/-
PEN384 10/-
PEN453DD 11/-
PF86 11/-
PF818 17/-
PFL200 14/-
PL33 7/-
PL36 11/-
PL81 9/6
PL82 9/-
PL83 8/-
PL84 7/-
PL302 15/-
PL504 16/-
PL508 17/6
PL509 30/-
PL801 16/-
PL802 14/-
PLL80 11/-
PM84 9/-
PX4 30/-
PX25 30/-
PY31 5/-
PY33 12/6
PY80 6/6
PY81 6/-
PY82 6/-
PY83 7/6
PY88 8/-
PY500 20/-
PY800 10/-
PY801 10/-
PZ30 7/-
QQV02-6 42/-
QQV03-10 25/-
QQV03-20A 105/-
QQV06-40A 110/-
QS83/3 7/6
QU37 30/-

QV03-12 13/-
QY3-125A 160/-
QY4-400A 300/-
R10 20/-
R18 9/-
RG3-250A 14/-
RL18 10/-
S130 35/-
S130P 35/-
SP2 9/-
SP4 9/-
SP41 7/-
SP42 12/-
SP61 7/-
T41 17/-
TP22 11/-
TP25 6/-
TT21 48/-
TT22 50/-
U17 10/-
U18/20 13/6
U19 50/-
U20 13/6
U25 15/-
U26 15/-
U31 9/-
U33 30/-
U37 30/-
U50 6/-
U52 6/-
U76 5/-
U78 5/-
U81 13/-
U191 14/-
U201 7/-
U281 8/-
U282 8/-
U301 11/6
U403 10/-
U404 7/6
U801 20/-
UABC80 6/9
UAF41 10/-
UAF42 10/6
UB41 11/-
UBC41 9/6
UBC81 8/-
UBF80 7/3
UBF89 7/-
UBL1 10/-
UBL21 12/-
UC92 6/6
UCC85 8/-
UCF80 10/6
UCH21 11/-
UCH42 13/-
UCH43 12/-
UCH81 6/6

UCL81 11/-
UCL82 7/-
UCL83 12/-
UF9 11/-
UF11 10/-
UF41 10/-
UF42 12/-
UF43 11/-
UF80 7/6
UF85 8/-
UF89 7/-
UL41 12/-
UL84 6/6
UM4 5/6
UM84 4/-
UU5 10/-
UY1N 10/-
UY11 11/-
UY21 11/-
UY41 8/-
UY82 10/-
UY85 6/-
VLS631 38/-
VP23 6/6
VP41 7/-
VP133 15/-
VR75/30 9/-
VR105/30 7/-
VR150/30 6/6
VU33 10/-
VU39A 10/-
VU111 10/-
VU120 15/-
VU133 10/-
W76 8/-
W107 8/-
W729 12/-
X65 10/-
X66 10/-
X76M 9/-
XC11 15/-
XC12 6/6
XC12T 8/-
XC15 4/6
XC15T 7/-
XC23 17/-
XC25 7/-
XR1-1600 280/-
XR1-3200 120/-
Z329 17/-
Z520M 30/-
Z700U 8/-
Z700W 15/-
Z719 5/-
Z729 6/6
Z749 15/6
Z800U 30/-
Z801U 30/-
Z900T 13/-

PLEASE NOTE THAT VALVES LISTED ABOVE ARE NOT NECESSARILY OF U.K. ORIGIN

Head Office:

44a WESTBOURNE GROVE, LONDON, W.2

Tel.: **PARK 5641/2/3**
Cables: **ZAERO LONDON**

Retail branch (personal callers only)
85 TOTTENHAM COURT RD., LONDON W.2. Tel: LANgham 8403

A.R.B. Approved for inspection and release of electronic valves, tubes, klystrons, etc.
E.I.D. Approved stockists.

OUR 1969/1970 CATALOGUE IS AVAILABLE. PLEASE SEND QUARTO S.A.E. FOR YOUR FREE COPY

WE WANT TO BUY:

SPECIAL PURPOSE VALVES. PLEASE OFFER US YOUR SURPLUS STOCK. MUST BE UNUSED.

TELEX 261306

APPOINTMENTS VACANT

DISPLAYED SITUATIONS VACANT AND WANTED: £7 per single col. inch.
LINE advertisements (run-on): 8/- per line (approx. 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 1/-.
SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to THURSDAY, 12 p.m., 9th JULY for the AUGUST issue, subject to space being available.

RADIO OPERATORS

There will be a number of vacancies in the Composite Signals Organisation for experienced Radio Operators in 1971 and in subsequent years.

Specialist training courses lasting approximately nine months, according to the trainee's progress, are held at intervals. Applications are now invited for the course starting in January, 1971.

During training a salary will be paid on the following scale:

Age 21	£848 per annum
„ 22	£906 „
„ 23	£943 „
„ 24	£981 „
„ 25 and over	£1,023 „

Free accommodation will be provided at the Training School.

After successful completion of the course, operators will be paid on the Grade 1 scale:

Age 21	£1,023 per annum
„ 22	£1,087 „
„ 23	£1,150 „
„ 24	£1,214 „
„ 25 (highest age point)	£1,288 „

then by six annual increases to a maximum of £1,749 per annum.

Excellent conditions and good prospects of promotion. Opportunities for service abroad.

Applicants must normally be under 35 years of age at start of training course and must have at least two years' operating experience. Preference given to those who also have GCE or PMG qualifications.

Interviews will be arranged throughout 1970.

Application forms and further particulars from: **Recruitment Officer, Government Communications Headquarters, Oakley, Priors Road, CHELTENHAM, Glos., GL52 5AJ**
Telephone No. Cheltenham 21491, Ext. 2270

92

AUDIO TECHNICIAN

to be responsible to Senior Engineer for the maintenance of professional sound recording systems. Applicants should be capable of developing/wiring and maintaining a wide range of audio equipment. Minimum qualifications C. & G. Electronics Tech. or Radio and TV 1st year. Age 18-21. Commencing salary £850. North London.

Write details to: Rupert Chetwynd Recruitment Ltd., 1 Crane Court (Ref. A/T), London, E.C.4.

573

Broaden your engineering experience

Work in the rapidly moving computer industry

Our Quality Assurance Engineers play a major role in ICL's future and are involved in a wide variety of activities on the whole range of computer equipment.

We can offer you challenging and rewarding opportunities in the following fields:-

- **reliability prediction**
- **equipment evaluation**
- **quality control techniques**
- **circuit and logic design review**
- **production feasibility studies**

Although HNC is ideal, emphasis will be placed on previous experience.

Why not telephone now? Ring Stevenage 3361, extension 221, and ask for C. Atkinson, Manager, Quality Assurance Planning, or write quoting reference no. WW212M to C. W. Squires, Area Personnel Recruitment Office, International Computers Ltd., Cavendish Road, Stevenage, Herts.

International Computers | **ICL**

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

SENIOR INSTALLATION ENGINEERS AND INSTALLATION ENGINEERS

Required for the engineering, installation and commissioning of L.F., M.F. and H.F. communications schemes, principally for overseas administrations.

Engineers suitable for these vacancies should have wide experience of as many as possible of the following:—

A.M., S.S.B. and I.S.B. Transmitters and Receivers
F.S.K. Equipment
V.F. Telegraphy
Erection and matching of antennae
Marine Coastal Radio Stations
Airfield Radio Communications
Military and Police Communication Systems.

They would need to be able to work on their own initiative to effect the installation and commissioning of equipment. The ability to train the staff of the overseas territory would be desirable.

Applicants should be able to show not less than two years' Overseas experience in this career and applicants for senior posts must have had experience in a supervisory capacity.

Good basic salaries are offered which are supplemented by a generous allowance payable during periods of overseas service. Applications, stating the grade of post for which application is made and giving a résumé of experience and qualifications, should be addressed to:

The Personnel Officer,
REDIFON LIMITED
Broomhill Road,
Wandsworth, London, S.W.18.

1970

REDIFON

A Member Company of the Rediffusion Organisation

585

If you can put a 'Yes' in every box, you might just make a RADIO TECHNICIAN in Air Traffic Control

An all-consuming interest in telecommunications ☐

At least one year's practical experience in telecommunications, preferably with 'ONC' or 'C and G' technical qualifications ☐

A highly developed sense of responsibility ☐

Willingness to undergo a rigorous programme of training ☐

Aged 19 or over ☐

To the right man, the National Air Traffic Control Service offers the prospect of an interesting and steadily developing career as a Radio Technician in air traffic control.

The work involves the installation and maintenance of some of the very latest electronic equipment at civil airports, radar stations and other specialist establishments all over the country. Important today, the job will become increasingly vital as Britain's air traffic continues to grow, and prospects for promotion are excellent. Starting salary varies from £1,044 (at 19) to £1,373 (at 25 or over). Scale maximum £1,590 (higher rates at Heathrow). The annual leave allowance is good, and there is a non-contributory pension for established staff.

If you feel you can meet the demands of this rather special job—and you have a strong determination to succeed—you are invited to complete the coupon below.

Send this coupon for full details and application form
To: A. J. Edwards, C Eng, MIEE,
The Adelphi, Room 705, John Adam Street, London WC2,
marking your envelope "Recruitment".

Name.....

Address.....

.....WWT/G1.

Not applicable to residents outside the United Kingdom

NATCS
National Air Traffic Control Service

575

Electronic design/ development engineers...

...now Pye Telecom provide twice the opportunity- and more!

A high-salaried career now—and massive scope in the near future. If that's what you want, that's exactly what your experience can earn you at Pye Telecom.

Because Pye Telecom plan to double turnover within the next 5 years. What's more, after 1975, this forward-thinking Company—already at the top in radio-telephone manufacture—will be launching even further expansion. Which means rapid change —and early promotion to management for everyone with the right qualities.

When you start...

Yours will be a vital job. For Pye Telecom new innovations are the key to success. You will be deeply concerned in evolving products to take over from those marketed today. New techniques, new components, more efficient and effective ways of doing things—these will be your business. With your skills, Pye Telecom will go on giving customers the sophisticated up-to-the-minute equipment which will bring increasing rewards for everyone in the organisation. All possible help is given for you to succeed.

In particular:

- Extensive research facilities throughout Europe are on-line to Pye design teams.
- Computers—frequently used as a design aid.
- Among the best company benefits in British industry.
- Company-paid relocation expenses.
- A choice of locations to live and work—Cambridge or Southend.

Your qualifications...

With either an electronics degree or equivalent, you should also ideally have 2/3 years' UHF/VHF radio telephone design experience. Experience in other fields, such as radar, broadcasting or television, will be an additional advantage. An absolute essential is circuitry experience.

Action...

Ready to go with Pye towards an expansive, exciting tomorrow . . . for the change to growth, responsibility and high rewards? Good. Phone (reverse the charges) or write now to: M. Timmins, Senior Personnel Officer,

1966

Pye Telecommunications Ltd

Newmarket Road, Cambridge.

597

FLIGHT SIMULATOR SERVICE ENGINEERS

Redifon Flight Simulator Division are designers and manufacturers of highly sophisticated simulators of current civil and military aircraft and linked products for use in the U.K. and world wide export markets.

We need skilled Service Engineers to keep this complex and hard worked equipment in continuous first class condition.

You should have a minimum of O.N.C. or City and Guilds Certificate, theoretical and practical experience of digital computing, hardware, software and computer peripherals. Knowledge of analogue computing and hydraulics would be advantageous. We will train those who have good experience in transistorised and integrated circuits.

The job is varied and interesting and in an expanding business. Promotion prospects are good. But you must expect to travel anywhere in U.K. and overseas at short notice, perhaps for extended periods.

Excellent welfare benefits include contributory pension and free life assurance. Our Sussex factory is only 25 miles from Brighton.

There are vacancies at both Aylesbury, Bucks and Crawley locations.

Send brief details or ring now:

H. C. Hall, Personnel Manager,
REDIFON LIMITED
Flight Simulator Division
Gatwick Road, Crawley, Sussex
Tel: Crawley 28811

1966 REDIFON 1970
A Member Company of the Rediffusion Organisation

495

RACECOURSE TECHNICAL SERVICES LIMITED

OPERATE A

TELEVISION UNIT FOR HORSERACING

and require a

TELEVISION ENGINEER

for operation and maintenance of the MCR

QUALIFICATIONS

★HNC, City & Guilds or equivalent.
★Experience in operation and maintenance of high grade television equipment.
★Willing to travel.

OPPORTUNITIES

★The Company is planning further expansion in the fields of television and electronics.
★Good salary and prospects.
★Expenses paid on location.

Applications stating age and experience should be sent to:

RACECOURSE TECHNICAL SERVICES LTD.,
88 Bushey Road, Raynes Park, London, S.W.20. 598

QUAD

require an

ELECTRONICS ENGINEER

with particular interest in high quality audio reproduction. This new post is primarily to provide liaison between lab and production, with responsibility for specifying test procedures and designing the gear for full production testing of high quality audio and VHF equipment.

As part of a small specialised design team this provides an excellent opportunity for a young, qualified engineer, preferably with some production experience, and a genuine interest in high quality reproduction.

Non-contributory pension scheme, free life insurance, and all the advantages of working with a small firm, acknowledged leaders in their field, and determined to stay there.

Apply in writing giving main details of qualifications and experience to:

J. H. Walker
Acoustical Mfg. Co. Ltd.
St. Peter's Road
HUNTINGDON

571

The Government of Malawi

ENGINEERING OFFICER (MAINTENANCE)

Required by the Posts and Telecommunications Department, to serve on contract for one tour of 24-36 months in the first instance. Salary, according to experience, in scale rising to £M.1,223 a year plus Overseas Addition rising to £Stg.682 a year. A Supplement of up to £Stg.244 a year is also payable by the British Govt. direct to the officer's bank in the U.K. Gratuity 25% total emoluments (excluding Supplement) on completion of 30 month tour. Liberal paid leave. Furnished accommodation. Free passages. Education and outfit allowances. Contributory pension scheme available.

Candidates, 25-45, must possess appropriate City and Guilds Certificates and have had a minimum of two years approved training, with not less than five years subsequent experience, on the maintenance of carrier systems, H.F., V.H.F. or U.H.F. radio. Experience in the maintenance of X-ray equipment would be an advantage.

The officer will be required to undertake the maintenance of multiplex carrier, telephone and telegraph equipment, H.F., V.H.F. and microwave radio and electromedical equipment, and to give assistance and guidance to local staff under training.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/680847/WF.

Electronic Video Recording

The development of our EVR Project at Basildon in Essex is now reaching an advanced stage and we now wish to recruit further staff who have experience in television or sound recording and outside broadcasting work for engagements in one of the following fields.

VTR Engineers

with good working knowledge of 2" quadruplex video tape recorder operations and maintenance.

Senior Audio Engineer

to be responsible for the operation and maintenance of broadcast quality magnetic and optical sound equipment. A working knowledge of automation and digital techniques would be an advantage.

Shift Control Engineer

The man we require will be responsible for the overall operation of the video tape and sound transfer facilities on shift basis and will preferably have experience of video tape recording and editing, telecine operation, telerecording and film characteristics, sound transfer optical and magnetic, vision and sound mixing, apparatus room equipment and staff control in a senior television engineering capacity.

Applicants for the above positions must be prepared to work on a shift system. Commencing salaries will be negotiable in line with responsibilities and experience. Generous assistance will be given with relocation expenses and rented accommodation will be available under the Basildon New Town scheme. We operate a contributory pension scheme and free life assurance. Interviews will be arranged in London.

Ilford is a subsidiary of CIBA, the international chemical group. Career prospects are international too.

Applications in writing, giving details of your career to date, should be addressed, quoting reference ZH.12, to the Personnel Manager, Ilford Limited, Christopher Martin Road, Basildon, Essex.

ILFORD

CONTINUOUS EXPANSION

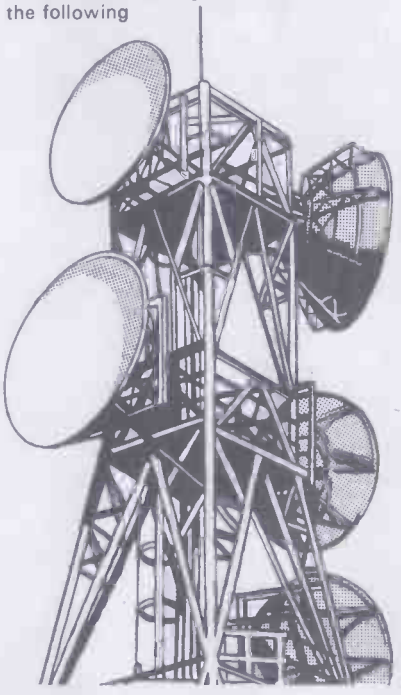
Standard Telephones & Cables, Microwave and Line Division based at Basildon are growing fast. In order to keep pace with this consistent growth rate we require the following

Installation Engineers Technicians & Testers

Ref. 25720

To test and commission Multiplex, Co-axial Line and Microwave Radio Systems.

Ideal candidates will be less than 45 years of age with practical experience on some of the above equipment. These challenging posts call for drive, initiative and common sense. It is necessary for applicants to be prepared to work anywhere in the U.K.



Test Technicians

Ref. 27221

The diversity of products manufactured at the Basildon Plant demands experienced testing staff for work on complex transmission systems.
Candidates should hold an ONC in electrical engineering and be able to offer considerable practical experience in the field of testing and fault clearing all types of land-unit, pcm and microwave equipment.

Applications should be addressed to
The Personnel Officer,
STC Chester Hall Lane,
Basildon, Essex.

STC

91

BBC tv

SCOTLAND ASSISTANT FILM RECORDIST

BBC tv requires Assistant Film Recordist in Glasgow to assist in the balance, control and recording of sound for television film.
Essential Qualifications: Practical knowledge of modern film recording techniques with particular emphasis on magnetic recording.
Salary: £1,185 (may be higher if qualifications exceptional) x £72 to £1,545 p.a.
If no fully qualified candidate available, consideration given to appointment as Trainee Assistant Film Recordist (Salary £1,016 x £61 to £1,312 p.a. with promotion when fully qualified). Qualifications: G.C.E. standard of education and practical interest in the film medium. (Evidence normally sought is membership of film making group.)

Write for application form (enclosing addressed foolscap envelope and quoting reference 70.G.717W.W.) to Appointments Department, BBC, London, W1A 1AA, by June 22nd.

1969

582

---

computer engineering

NCR requires additional ELECTRONIC, ELECTRO MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.

Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.

Starting salary will be in the range of £900/£1,350 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.

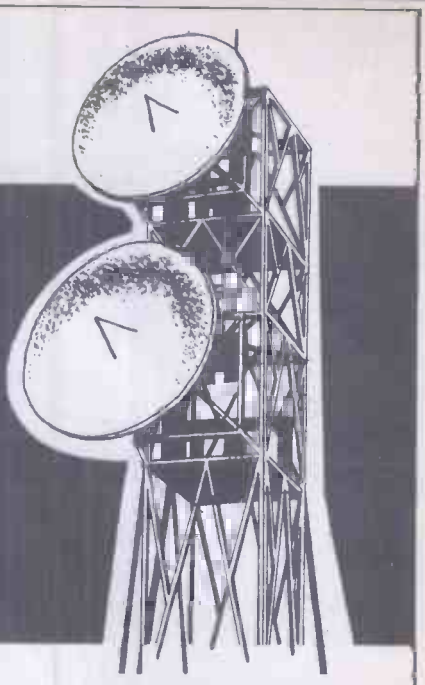
Excellent holiday, pension and sick pay arrangements. Please write for Application Form to
Assistant Personnel Officer
NCR, 1,000 North Circular Road,
London, NW2
quoting publication and month of issue.

Plan your future with **NCR**

85

East African Posts and Telecommunications Corporation

ASSISTANT ENGINEERS GRADE 1 (RADIO)



To serve on contract for one tour of 24 months in the first instance. Basic salary E.A.Shg.24,300 (Approx. £Stg. 1417) a year rising to E.A.Shg.27,780 (Approx. £Stg.1620) a year plus an Inducement Allowance, normally TAX FREE, of £Stg.822-886 a year, paid direct into the officer's bank in the U.K. Gratuity 25% of total emoluments drawn. Liberal paid leave. Furnished accommodation. Overseas Installation Grant. Free passages. Contributory pension scheme available.

Candidates, 28-45 years, should possess the City and Guilds Intermediate Certificate (Telecomms.) plus a pass in Radio Grade 2 and must have a thorough knowledge of the installation and maintenance of HF and VHF radio equipment. A knowledge of microwave, carrier and telegraph equipment would be an advantage.

The officers' duties will be connected with the installation and maintenance of radio stations and will involve travelling to outlying stations at a considerable distance from their headquarters, sometimes for periods of a week or more.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/690815/WF.

584

UNIVERSITY OF STIRLING

Department of Psychology

TECHNICIAN/SENIOR TECHNICIAN

Applicants should have completed a recognised apprenticeship, or other appropriate training, and have interests in A.F. techniques and instrumentation, including use of digital and linear integrated circuits. Formal qualifications an advantage, day release facilities if required. Salary: Technician £935-£1,303; Senior Technician £1,278-£1,586. Applications, with names of two referees, should be received by the Deputy Secretary (WW), University of Stirling, Stirling, by 10 August, 1970. 600

ASTRO COMMUNICATION LABORATORY (U.K.)

require

VHF/UHF

Development Engineers

Vacancies exist for a number of development Engineers in the field of VHF/UHF radio.

Applicants should preferably have H.N.C. or B.Sc. qualifications and Laboratory experience is a definate advantage. The applicants should be capable of guiding a development project from its conception to the final stages of quantity production.

Successful applicants will be offered a substantial salary with a 12 month renewable contract and where applicable moving expenses. Apply in writing to:

The Chief Engineer, Astro Communication Laboratory (U.K.), Tower Street, Coventry, Warwickshire.

599

GEC-Marconi Electronics

TECHNICIANS AND ENGINEERS FOR ST. ALBANS AND LUTON

QUALIFIED OR NOT!

VACANCIES exist for work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.

APPLICATIONS are invited from people of all ages with experience or formal training in electronics and from ex-Armed Services technicians.

HIGHLY COMPETITIVE SALARIES, negotiable and backed by valuable fringe benefits.

RE-LOCATION EXPENSES available in many instances.

CONDITIONS excellent; free life assurance, pension schemes, canteen, social club.

37½-hour, 5-day, office-hours week.

WRITE or phone Personnel Department stating age, details of previous employment, training, qualifications, approximate salary required, quoting WW3.

mi

MARCONI INSTRUMENTS LIMITED,
Longacres, St. Albans, Herts.
Tel: St. Albans 59292
Luton Airport, Luton, Beds.
Tel: Luton 31441.
A GEC-Marconi Electronics Company

531

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.

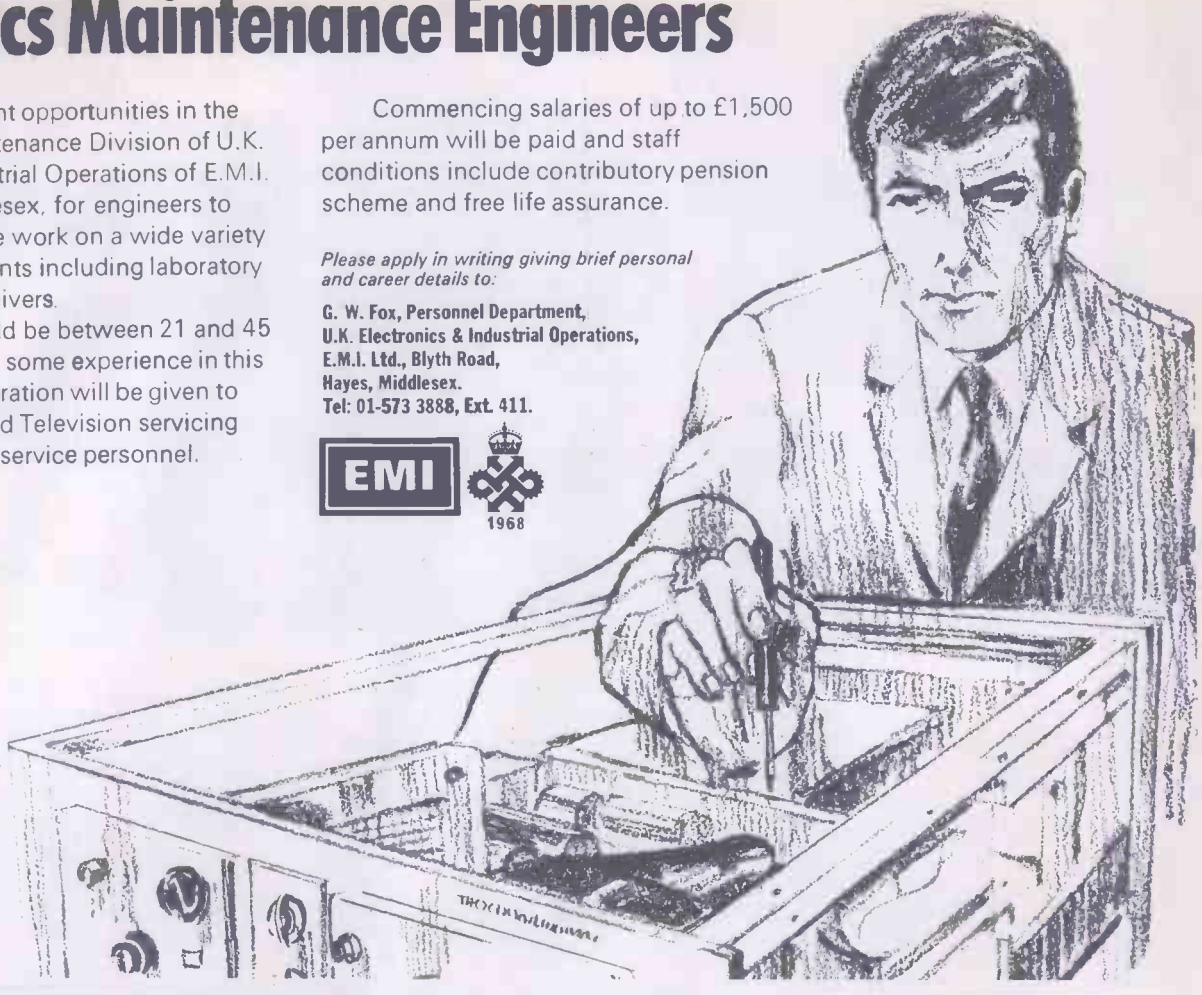
Candidates should be between 21 and 45 years of age and have some experience in this type of work. Consideration will be given to experienced Radio and Television servicing technicians and to ex service personnel.

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



576

NORFOLK EDUCATION COMMITTEE

THE COUNTY TECHNICAL COLLEGE · KING'S LYNN

LECTURER GRADE I

to teach LIGHT ELECTRICAL ENGINEERING to C. & G. 49 final level. Telegraphy and telephony essential. Applicants must hold appropriate qualifications and preferably have experience of Post Office systems. Salary on Lecturer Grade I scale (£1230-£2075), point of entry depending upon the qualifications and experience of the successful candidate.

Further details and forms of application may be obtained from the Registrar at the College.

F. LINCOLN RALPHS
Chief Education Officer.

County Hall,
Martineau Lane,
Norwich, NOR 49A

565

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

SENIOR TECHNICIAN

specialising in electronics and instrumentation work required to work on the development and servicing of instruments and systems applied to biochemistry research.

The position will involve responsibility and the supervision of junior staff. Applicants should have experience in a relevant field and possess a Higher National Certificate or equivalent qualifications.

Salary according to age and experience in the range of £1,271 to £1,613 per annum. Superannuation scheme, good conditions of service.

Applications in writing to:
Departmental Superintendent,
Department of Biochemistry,
Imperial College, London, S.W.7.

578

BROADCASTING ENGINEERS UGANDA

★ **Salary £2,010—£2,506 according to experience**
★ **Low Taxation.**
★ **25% Gratuity.**
★ **Contract 21-27 months.**
★ **Subsidised accommodation.**
★ **Education Allowances.**

Duties will include the maintenance of broadcasting equipment in transmitting stations and studios and outside broadcasts and recordings in remote districts.

Candidates should possess City and Guilds Final Certificate in Telecommunications (with Radio) or equivalent and have wide practical experience of technical broadcasting equipment including high power M.F. transmitting and studio control equipment.

Apply to CROWN AGENTS 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference M2K/690995/WF

606

UNIVERSITY OF SOUTHAMPTON
ELECTRICAL ENGINEERING DEPARTMENT

ELECTRONIC ENGINEER required for interesting post as **EXPERIMENTAL OFFICER.** The work concerns the electronics associated with electrical machine research. The successful applicant will be expected to advise on instrumentation, signal acquisition and processing and, where necessary, to design special purpose equipment both analogue and digital. Candidates should have a university degree or equivalent qualification, a broad knowledge of electronics and appropriate industrial experience.

Salary scale from £1355 to £2230 plus F.S.S.U. depending on age and ability.

Applications giving date of birth and details of qualifications and experience together with the names of two referees should be sent to the **Deputy Secretary, The University, Southampton, SO9 5NH** by 22 June, quoting ref. WW 583

METEOROLOGICAL OFFICE

ELECTRONIC ENGINEER

UP TO £2438

Post of Assistant Signals Officer at the Meteorological Office Headquarters in Bracknell, Berks.

DUTIES relate to the planning, provision and installation of meteorological landline and radio telecommunication systems embracing transmission by both low/medium/high speed data and analogue/digital facsimile, and including facilities for reception from satellites. A particular objective will be to automate the U.K. system making optimum use of computers.

QUALIFICATIONS: Either (a) Corporate Membership of the Insitution of Electrical Engineers, the Institute of Electronic and Radio Engineers or the Royal Aeronautical Society, or exemption from their requirements, or (b) 1st or 2nd class honours degree in Electrical Engineering, Physics or Applied Physics, together with at least 2 years' training and experience. Wide knowledge of telecommuncations and aptitude for planning expected. Some experience of planning for automation in telecommunications an advantage.

STARTING SALARY: within the scale £1405—£2438 according to qualifications and experience. Non-contributory pension.

WRITE to Civil Service Commission, 23 Savile Row, London W1X 2AA, or **TELEPHONE** 01-734 6010 ext 229 (after 5.30 pm 01-734 6464 "Ansafone" service), for application form, quoting S/7249/69. Closing date 2 July 1970.

588

METROSOUND AUDIO PRODUCTS LTD

Due to increased expansion Metrosound now have a few well paid vacancies for **TESTING AND FAULT FINDING ENGINEERS.**

Applicants, who must be throughly conversant with Transistorised Audio Amplifier circuitry and be rapid and accurate workers should apply in person, by letter or telephone to: **Mr. R. Bishop, METROSOUND AUDIO PRODUCTS LTD., Cartersfield Road, Waltham Abbey, Essex. Tel.: Waltham Cross 31933.** 572

CHALLENGING OPPORTUNITIES in CANADA

Radio and Electronic Technicians with a desire to see more of the world can find rich rewards by joining Canadian Marconi Company. Technicians are required for maintenance duties on Northern installations.

Successful applicants will enjoy minimum salaries of $8,000 plus first-class prospects for rapid advancement and further substantial rises during the first year. There are also genuine opportunities for promotion to supervisory grades with salary ranges of over $14,000 per annum.

Food and accommodation is provided free for the employee (no family accommodation), in addition to heavy duty clothing. Assistance with air passage is available.

A chance of a lifetime is offered to accrue substantial savings.

Formal training and experience in maintenance of communications-type equipment is required with special emphasis on:

Microwave
Tropospheric Scatter
Communications Systems
Telephone and Carrier (Multiplex)

If you have three or more years' experience in installation or maintenance on this type of equipment together with recognized qualifications, i.e. City and Guilds, Higher National or equivalent, the answer is Yes! Interviews will be held in London in the near future. Please send brief career details, quoting P.O. Box 540, to **Mr. D. S. Howell, Canadian Marconi Company, Station "O", Montreal 379, Quebec, Canada.**

CAN YOU QUALIFY?

CANADIAN MARCONI COMPANY

RADIO TECHNICIANS

with sound knowledge of at least three of the following types of equipment required immediately for Meteorological Office Ocean Weather Ships: MF, HF, VHF and UHF, Single and Double side-band transmitters, Radar (Navigational), Radar (Height finding), Radio Receivers, MF and VHF, Auto DF, Digital telemetering equipment, Low voltage servo-recorders, Loran and echo sounders.

Salary Scale £885-£1500 per annum according to age (£1295 at 25 age point), plus £162 per annum overtime allowance. Liberal leave allowance. Free food and accommodation provided on board ship.
Applicants must be natural born British subjects.

Full details from Shore Captain, Ocean Weather Ship Base, Great Harbour, Greenock. Telephone 24291.

568

SERVICE ENGINEERS

required for maintenance of tape recorder and dictating machines, training given to suitable applicants on dictating machines. Salary £130 per month.

Apply:

Tape Recorder Maintenance Co.
Telephone: 01-735 9683

589

JUNIOR ELECTRONIC ENGINEER

A vacancy with very good prospects occurs for a versatile energetic and conscientious young man to act as an assistant in the Service department of an expanding Electronic Company.

Chief requirements are a good all round theoretical training and some mechanical training, plus the ability to quickly relate this in practical terms to the servicing of a wide variety of electronic and electro-mechanical instruments.

Salary will be commensurate with experience and a permanent and very progressive position is assured for the right man. Write stating age, experience and present salary to:

Personnel Manager, B & K Instruments Ltd., 59 Union Street, London, S.E.1

581

UNIVERSITY OF SOUTHAMPTON

INSTITUTE OF SOUND AND VIBRATION RESEARCH

Person required to help with development and operation of instrumentation systems for noise and vibration measurement, including analysis of data and routine maintenance of equipment. Salary on scale—either £456-£771 or £905-£1,273 with supplementary allowances for qualifications. Please write stating date of birth, experience and qualifications and giving the names of two referees to the Deputy Secretary, **The University, Southampton, SO9 5NH,** quoting ref. WW

601

ASSISTANT ENGINEER GRADE II (BROADCASTING) BOTSWANA

★ **Salary up to £2,387**
★ **Low taxation**
★ **Appointments grant £100 or £200 in certain circumstances**
★ **25% gratuity on basic salary**
★ **Contract 24—36 months**
★ **Subsidised accommodation**
★ **Education Allowances**

The Posts and Telecommunications Department requires an officer to undertake operational duties including the installation and maintenance of broadcasting equipment in transmitting stations and to assist with the training of junior engineering staff.

Candidates, aged 30–45, must possess the City and Guilds Intermediate Certificate (Telecommunications) or equivalent and have had five years relevant practical experience, (additional to any period of approved training) of technical broadcasting equipment including M.F. and H.F. transmitting equipment up to 10 KW.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/690420/WF.

JUNIOR TECHNICAL OFFICER or TECHNICIAN

required at our Hampstead Laboratories, Holly Hill, N.W.3, to assist scientists engaged on new concept of medical research of 'Human Aerodynamics.' Suitable for applicant in early 20's with some experience of workshop practice and interest in electronic instrumentation. Salary according to experience and qualifications (O.N.C./H.N.C.) on scale £759-£1,508 p.a. Please apply quoting our reference WW 51/1 to: Mr. J. H. Woodcock, **National Institute For Medical Research, The Ridgeway, Mill Hill, London, N.W.7.** Telephone: 959 3666.
605

THE UNIVERSITY OF SUSSEX SCHOOL OF MOLECULAR SCIENCES

Engineer required to work on Electronics and Instrumentation in the Chemical Laboratory. Candidates should be skilled in fault clearing in modern electronic equipment.
Salary scale: £1278-£1583. Three weeks paid holiday. Protective clothing provided. Superannuation and sickness benefit schemes.
Applications and/or enquiries for further information should be addressed to: **The Laboratory Superintendent, School of Molecular Sciences, University of Sussex, Brighton, BN1 9QJ.** 564

ELECTRONICS ENGINEERS
Imaging Systems

Applications are invited for two vacancies in our Electronics Laboratory from Engineers holding a Degree or Higher National Certificate and having several years' development experience. These positions will be in a team developing television and I.R. Imaging Systems. Experience in video and/or digital techniques would be an advantage.

The firm is engaged in a wide variety of instrument work much of it combining mechanical, electronics and optical features. The Electronics Laboratories cover medical instrumentation, laser applications, filters and microwave serials for both Government and Commerical Contracts.

In appropriate cases a flat may be made available and removal expenses given to suitable applicants.

Apply stating age, qualifications and experience to:
The Personnel Manager,
Barr & Stroud Limited,
Anniesland, Glasgow W.3.

BARR AND STROUD

587

Electronic Technicians

Are you interested in joining the leading Manufacturer of Magnetic Recording Equipment?

If you think you have experience in any one of the following fields, backed by O.N.C. or City and Guilds, we want to hear from you.

- FINAL COMMISSIONING OF CORE MEMORY PRODUCTS
- FINAL COMMISSIONING OF COMPUTER TAPE HANDLERS
- EXPERIENCE OF DIGITAL CIRCUIT TECHNIQUES
- FAULT DIAGNOSIS OF SOLID STATE PRINTED CIRCUIT ASSEMBLIES

Ampex Corporation is a world-wide organisation employing some 12,000 people. This is an ideal opportunity for you to expand your knowledge of sophisticated computer peripheral equipment with a modern progressive Company.

An attractive salary will be paid and the Company operates an excellent range of Life Assurance, Pension and Sickness Benefit Schemes. Three weeks annual holiday, Canteen, Sports and Social Club.

Please write or telephone for application form to the Personnel Officer, Ampex Electronics Limited, Acre Road, Reading, Berkshire. (Telephone Reading 84411).

AMPEX

602

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.**

596

TV MECHANICS FOR NEW ZEALAND

RADIO and TV MECHANICS—are you dissatisfied with your present working conditions, high taxation and lack of progress? Why not shift to the sunny South Pacific and join the friendly team at TISCO, New Zealand's largest Service Company! Being purely in Television Service, our mechanics are important people, not just numbers on a time sheet.

All 30 of our Branch Managers are mechanics. You can be with us in 3 months if you write now. Requirements: 5 years' experience and £20 towards the family's fare, remainder of which will be paid. Age limit for persons wishing to come to New Zealand is 45.

**Mr. B. I. Wells, Tech. Supervisor,
TISCO Ltd.,
Private Bag, Royal Oak, Auckland,
NEW ZEALAND.** 351

BROADCAST RELAY ENGINEERS

are required for the

ISLAND OF MASIRAH

(Off the coast of Muscat and Oman)

Applications for contract employment for a one year unaccompanied tour of duty are invited from engineers with experience of the operation and maintenance of high power radio transmitters and who are of third year City and Guilds Telecommunications Technicians Certificate or equivalent standard.

Salary £4,000 per annum plus a tax free allowance of £350 per annum for single, or £865 for married unaccompanied officers.

Free furnished accommodation and passages are provided.

Further details and application forms can be obtained from:

**The Personnel Officer,
Diplomatic Wireless Service
Foreign & Commonwealth Office,
Hanslope Park,
Wolverton, BUCKS.** 535

DISPLAYED SITUATIONS VACANT AND WANTED: £7 per single col. inch.
LINE advertisements (run-on): 8/- per line (approx. 7 words), **minimum** two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 1/-.
SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

SENIOR TECHNICIAN (GRADE III)

with electrical and preferably some mechanical experience to maintain Cobalt and Caesium and Therapeutic X-ray equipment at the Royal Marsden Hospital, Fulham Road, London, S.W.3. The successful candidate will also have the opportunity to develop new equipment.

Minimum qualifications, O.N.C. in Electrical Engineering. Salary scale £1270-£1590 per annum.

Applications with details of experience and names of two referees to the Deputy Administrator, The Royal Marsden Hospital, Downs Road, Sutton, Surrey. Further details may be obtained from Mr. E. Hawkins, Chief Technician, telephone 01-642 6011, Ext. 278. 567

ELECTRONIC ENGINEERS

Service Engineers required for Offices, throughout the United Kingdom, of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic Electronics with experience in Electronics, Radar, Radio and T.V. or similar field. Position is permanent and pensionable. Comprehensive training on full pay will be given to successful applicants. Please send full details of experience to the Service Manager, Sumlock Comptometer Ltd., 102/108 Clerkenwell Road, London, E.C.1. 82

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., 92 Tottenham Court Road, London, W.1. Tel. 01-387 7467/8. [21

BERKSHIRE COLLEGE OF EDUCATION. Television Technician for expanding CCTV system and mobile units, responsibility for VHF distribution system, experience of helical scan video tape recorders an advantage but not essential (training course provided). Salary Technician Grade III £965-£1,130. Application forms and further particulars from the Bursar, Berkshire College of Education, Woodlands Avenue, Early, Reading, Berks, return within 10 days. [862

ELECTRONICS Workshop Senior Technician. Nuclear Engineering Laboratory, Queen Mary College (University of London), Mile End Road, E.1. Work includes development, construction and maintenance of instrumentation for reseach. Adaptability, initiative and experience in electronic techniques required. Salary at present in the range £1,029-1,300 p.a. (but a substantial increase is under review), plus London Weighting up to £125 p.a. and possible £30 or £50 qualification supplement. Five-day week. Four weeks annual leave. Pension scheme. Excellent working conditions. Letters only to Registrar (N/ST) should state full details of experience and present work. [517

REDIFON LTD. require fully experienced TELECOMMUNICATIONS TEST ENGINEERS and ELECTRONICS INSPECTORS. Good commencing salaries. We would particularly welcome enquiries from ex-Service personnel or personnel about to leave the Services. Please write giving full details to—The Personnel Manager, Redifon Ltd., Broomhill Road, Wandsworth, S.W.18. [26

SENIOR technician/technician required for the construction, development and servicing of an interesting variety of electronic apparatus in modern chemistry teaching and research laboratories. Salary in ranges £1,026-£1,281 p.a. and £743-£1,047 p.a. according to age and experience (but a substantial increase is under review) plus London Weighting £125 p.a. and possible £30 or £80 qualification allowance. Five-day week. Four/five weeks annual leave. Pension scheme. Letters only to Registrar (C/T/ST), Queen Mary College, Mile End Road, E.1, stating which post applied for, age, past and present experience, any qualifications. [523

SENIOR ELECTRONIC TECHNICIAN required by a new company to head a research/development workshop. Duties will include design and construction of new products and improvement to existing lines, some service work may be necessary initially. Free use of company vehicle. Age 25-35 with good experience in transistorised circuit design, adaptable and able to work on own initiative. Starting salary £1,500-£2,000. Reply stating age, experience, qualifications. Box No. W.W. 574, Wireless World.

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

ARTICLES FOR SALE

BUILD IT in a DEWBOX quality plastics cabinet. 2 in. × 2¼ in. × any length. D.E.W. Ltd. (W), Ringwood Rd., FERNDOWN, Dorset. S.A.E. for leaflet. Write now—Right now. [76

CAPACITORS, 0·25mfd., 32·5KV DC working, £6. 0·5mfd., 7·5KV, 17/6. 0·01mfd., 5KV, 4/-. Rotax rotary inverters, 24v DC/115v, 3 phase, 400Hz., 1·8 amps., £6. Carbon pile voltage regulators, 12/24v, 17/6. Carriage extra. Westover Electronics, Braidley House, St. Paul's Lane, Bournemouth. Tel. 23944. [604

WITWORTH TRANSFORMERS LTD.

Dept. WW., 26 All Saints Road,
North Kensington, W.11
Telephone: 01-229 9071. 9 a.m. till 5 p.m.

TELEVISION LINE OUTPUT TRANSFORMERS

PRACTICALLY ANY MAKE OR MODEL SUPPLIED OR REWOUND

EKCO, FERRANTI, DYNATRON

Replacement cases 16/- each, please state model.

S.A.E. for return of post quotation.
TERMS: Cash with order or C.O.D., please add 4s. for postage.
C.O.D. orders will be charged 6s.
Transformers fully guaranteed. 516

COIL WINDER. Avo. Douglas No. 6 coil winder, complete with motor and gears, etc. Cost £150. As new, £50 o.n.o. Contact A. C. E. Stuart, Department of Chemistry, The University, Southampton. [524

COLOUR TELEVISION COMPONENTS. All specialist parts for home constructed colour receivers, including W.W. design (reprints now obtainable from W.W.) Catalogue from: Forgestone Components, Ketteringham, Wymondham, Norfolk. [542

FOR SALE—"Wireless World," 1930-1948, 25/- dozen. W1, 43 Dundonald Road, Colwyn Bay. [527

MUSICAL MIRACLES. Send S.A.E. for details of Cymbals and Drum Modules, versatile independent bass pedal unit for organs, pianos or solo, musical novelties, waa-waa kits (49/-). Also bargain components list reed switches etc. D.E.W. Ltd., 254 Ringwood Road, Ferndown, Dorset. [95

AMAZING VALUE

NEW BRANDED FULL SPECIFICATION SEMICONDUCTOR DEVICES BEST FOR PERFORMANCE AND RELIABILITY

G.E. D40C1 4W. Darlington Amplifier.
Very High Gain 10,00 minimum 13/6
ITT 1 Amp Plastic Rectifiers:

IN4001, 50V ..	1/9	IN4004, 400V ..	2/5
IN4002, 100V ..	2/-	IN4005, 600V ..	2/9
IN4003, 200V ..	2/2	IN4006, 800V ..	3/5
IN4007, 1000V ..	4/-		

P. & P. 1/- per order. Overseas 7/6
Cash With Order. Mail Order only.

JEF ELECTRONICS (W.W.6)
York House, 12 York Drive, Grappenhall, Warrington, Lancs.
Money back if not satisfied 592

NEW CATALOGUE No. 18, containing credit vouchers value 10/-, now available. Manufacturers' new and surplus electric and mechanical components, price 4/6, post free. Arthur Sallis Radio Control Ltd., 28 Gardner Street, Brighton, Sussex. [94

NEW Precision 1MHz crystal oscillators in even-7 transistor circuit 6"×3"×3", £5 each. Details and further lists s.a.e. B. M. Sandall, Amber Croft, Higham, Derbyshire, DE5 6EH [560

NEW SONY CRF-230 GLOBAL RADIO. Amateur, Commercial and Professional reception. Brings you everything that's on the air, anywhere in the world! 23-band reception. Covers AM, SW, MW, LW and FM. Operates from batteries or AC mains! Built-in voltage selector permits use in any country. Numerous control features that put it in a class by itself! Retails at £290, yours for £250 or near offer. Phone: Herongate 359 (2 Billericay Road, Essex). [590

PUBLIC ADDRESS EQUIPMENT FOR SALE. 3 Philips outfits, each containing an EL 6400 Mixer Amplifier (2×EL81 output) and an ET 3108, 6 speaker column. UNIT 1 AM/FM radio changer, mike input. UNIT 2 AM/FM radio, auto changer, tape deck, mike input. UNIT 3 auto changer, mike input. Call J. Fagg, Bedford 55233. [595

RADIO MIKE (S.N.S.). as new, £60. C.C.T.V. 1" Vidicon tube and lens, £16. D. F. Buckby, London Apprentice, St. Austell, Cornwall. [544

UHF, COLOUR and TV SERVICE SPARES. Leading British makers' surplus Colour Frame and Line time base units incl. EHT transformer, £5, carriage 10/-. Integrated UHF/VHF 6 position push button tuner, 4 transistors, knobs, circuit data. Easily adjusted for use as 6 position UHF tuner, £4/10/-, P/P 4/6. UHF 3 transistor tuner incl. circuit, £2/10/-, P/P 4/6. MURPHY 600/700 series complete UHF conversion kits incl. tuner, drive assy, 625 IF amplifier, 7 valves, accessories, housed in special cabinet plinth assembly, £8/10/- or less tuner £2/18/6, P/P 10/-. SOBELL/GEC 405/625 switchable IF amplifier and output chassis, 32/6, P/P 4/6. UHF tuners incl. valves, slow motion drive assy, knobs, aerial panel. £5/10/-, P/P 4/6. UHF list available on request. New or manufacturer tested VHF tuners, AT7650 Philips 19TG170, Sobell 1010, KB Featherlight 35/-. AT7639 Peto Scott, Decca, Ekco, Ferranti, Cossor 50/-, Cyldon C 20/-, AB miniature with UHF injection incl. valves 78/6, Ekco 283/330, Ferranti 1001/6 25/-. New fireball tuners, Ferguson, HMV, Marconi type 37/6, Plessey 4 position push button tuners with UHF injection, incl. valves, 58/6. Many others available. P/P all tuners 4/6. Large selection channel coils. Surplus Pye. Ultra, Murphy, 110° scan coils 30/-, Sobell 110° Frame O/P transformers 17/6, P/P 4/6, Perdio "Portorama" LOPT assy incl. DY86, suitable for transistorised TV, 40/-, P/P 4/6. LOPTs, Scan Coils, FOPTs available for most popular makes. PYE/LABGEAR transistorised booster units B1/B3 or UHF, battery-operated 75/-, UHF Masthead £5/5/0, post free. COD despatch available. MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6 (No.. 28 Bus or W. Hampstead Tube Station). MAIL ORDER: 64 GOLDERS MANOR DRIVE, LONDON, N.W.11. [60

"WIRELESS WORLD" substantially complete, 1937, onwards, some 1935, 1936, "Electronic Engineering, 1941 to 1962, four missing, offers, Haydon, Byron House, Slines Oak Road, Woldingham, Caterham, Surrey. [543

YAXLEY SWITCHES, 1 pull 24 way 1" spindle, 5/6 each p.p. Holly Electronics, 167 Folkestone Road, Dover. [561

770U/2 Eddystone VHF 150/500 Mc/s, £105. 770R Eddystone VHF 19/165 Mc/s (with muting), £75. Private sale. Good condition. Telephone 01-656 1350 Croydon. [579

PATENT NOTICES

TRADE MARK No. B.878772 consisting of the letters R-F-T and device and registered in respect of "Electronic Valves" was assigned on 23 July, 1969, by T.O. Supplies (Export) Limited of 2a Westbourne Grove Mews, London, W.11, to VEB Funkwerk Erfurt of 47 Rudolfstrasse, 101 Erfurt, East Germany: WITHOUT THE GOODWILL OF THE BUSINESS IN WHICH IT WAS THEN IN USE. [515

TEST EQUIPMENT — SURPLUS AND SECONDHAND

SIGNAL generators, oscilloscopes, output meters, wave voltmeters, frequency meters, multi-range meters, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [64

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

HRO Rx5s, etc., AR88, CR100, BRT400, G209, S640, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [65

NEW GRAM AND SOUND EQUIPMENT

CONSULT first our 76-page illustrated equipment catalogue on Hi-Fi (6/6). Advisory service, generous terms to members. Membership 7/6 p.a.—Audio Supply Association, 18 Blenheim Road, London, W.4. 01-995 1661. [27

GLASGOW.—Recorders bought, sold, exchanged; cameras, etc., exchanged for recorders or vice-versa.—Victor Morris, 343 Argyle St., Glasgow, C.2. [1]

SHURE GOLDRING Cartridges post free, G800 £7.17.6, M3D £5.5, M44/5/7 £7.10, M44E £8.19.6, M55E £9.19.6, M75E/2 £16.10, Garrard SP25/2 £10.17.6, AP.75 £16.17.6, P. & P. 7/6 U.E. 30 Achilles Road, London, N.W.6. Mail order only. [96

TAPE RECORDING ETC.

IF quality, durability matter, consult Britain's oldest transfer service. Quality records from your suitable tapes. (Excellent tax-free fund raisers for schools, churches.) Modern studio facilities with Steinway Grand.—Sound News, 18 Blenheim Road, London W.4. 01-995 1661. [28

YOUR TAPES TO DISC—£6,000 Lathe. From 25/-. Studio/Location Unit. S.A.E. Leaflet. Deroy Studios, High Bank, Hawk St., Carnforth, Lancs. [70

VALVES

VALVE cartons by return at keen prices; send 1/- for all samples and list.—J. & A. Boxmakers, 75a Godwin St., Bradford, 1. [10

FOR HIRE

FOR HIRE CCTV equipment, including cameras, monitors, video tape recorders and tape—any period. —Details from Zoom Television, Chesham 6777 [75

ARTICLES WANTED

WANTED, all types of communications receivers and test equipment.—Details to R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [63

WANTED, televisions, tape recorders, radiograms, new valves, transistors, etc.—Stan Willetts, 37 High St., West Bromwich, Staffs. Tel. Wes. 0186. [72

WANTED. WIRELESS WORLDS, Feb., March, May, June, 1964, July, 1965. Richardson, 162 Buckingham Road, Hampton, Middlesex. 01-979 4322 evenings. [593

VALVES WANTED

WE buy new valves, transistors and clean new components, large or small quantities. all details, quotation by return.—Walton's Wireless Stores, 55 Worcester St., Wolverhampton. [62

SERVICE & REPAIRS

AVO and Selectest repairs, John Baggs Electric Ltd., Relay Works, Hollins Road, Oldham. Tel. 061-681 3785. [603

CAPACITY AVAILABLE

AIRTRONICS LTD., for Coil Winding—large or small production runs. Also PC Boards Assemblies. Suppliers to P.O., M.O.D., etc. Export enquiries welcomed. 3a Walerand Road, London, S.E.13. Tel. 01-852 1706 [61

ELECTRONICS WRITING/EDITING for industry. Reports, application notes, manuals, hand-outs, written to specified length. Send full details for competitive quote. Fast turnround. ELECTROSCRIPT SERVICES, 18 Grange Road, Bournemouth, BM6 3NY. [566

METALWORK, all types cabinets, chassis, racks, etc., to your own specification, capacity available for small milling and capstan work up to 1in bar.—PHILPOTT'S METALWORKS, Ltd., Chapman St., Loughborough. [17

PRODUCTION/SERVICE MANAGERS don't take up valuable on line assembly time, for small/medium printed circuit/wiring runs, let us have the problem. Also installation contracts large or small are invited; i.e. internal telephones, security systems, electrical, etc. UNIT ELECTRONICS, Pound Hill 2390, Sussex. [594

SMALL servicing and repair contracts undertaken. Field service any distance. Best possible rates for top-quality work. Cambrian Electronics, 96a High St., Frimley, Surrey. [474

TECHNICAL TRAINING

BECOME "Technically Qualified" in your spare time, guaranteed diploma and exam. home-study courses in radio, TV, servicing and maintenance. R.T.E.B., City & Guilds, etc., highly informative 120-page Guide—free.—Chambers College (Dept. 837K), College House, 29-31 Wrights Lane, Kensington, London, W.8. [16

CITY & GUILDS (Electrical, etc.), on "Satisfaction or Refund of Fee" terms. Thousands of passes. For details of modern courses in all branches of electrical engineering, electronics, radio, T.V., automation, etc.; send for 132-page handbook—free.—B.I.E.T. (Dept. 152K), Aldermaston Court, Aldermaston, Berks. [13

TECHNICAL TRAINING IN Radio, TV and Electronics through world-famous ICS. For details of proven home-study courses write: ICS, Dept. 443, Intertext House, London, S.W.8. [24

TV and radio A.M.I.E.R.E., City & Guilds, R.T.E.B.; certs., etc., on satisfaction or refund of fee terms; thousands of passes; for full details of exams and home training courses (including practical equipment) in all branches of radio, TV, electronics, etc., write for 132-page handbook—free; please state subject.—British Institute of Engineering Technology (Dept. 150K), Aldermaston Court, Aldermaston, Berks. [15

TUITION

ENGINEERS.—A Technical Certificate or qualification will bring you security and much better pay. Elem. and adv. private postal courses for C.Eng., A.M.I.E.R.E., A.M.S.E. (Mech. & Elec.), City & Guilds, A.M.I.M.I., A.I.O.B., and G.C.E. Exams. Diploma courses in all branches of Engineering—Mech., Elec., Auto, Electronics, Radio, Computers, Draughts, Building, etc.—For full details write for FREE 132-page guide: British Institute of Engineering Technology (Dept. 151K), Aldermaston Court, Aldermaston, Berks. [14

KINGSTON-UPON-HULL Education Committee. College of Technology. Principal: E. Jones, M.Sc., F.R.I.C.
FULL-TIME courses for P.M.G. certificates and the Radar Maintenance certificate.—Information from College of Technology, Queen's Gardens, Kingston-upon-Hull. [18

BOOKS, INSTRUCTIONS, ETC.

MANUALS, circuits of all British ex-W.D. 1939-45 wireless equipment and instruments from original R.E.M.E. instructions; s.a.e. for list, over 70 types.—W. H. Bailey, 167a Moffat Road, Thornton Heath, Surrey, CR4-8PZ. [66

RADIO JOURNALS available, 1911-1940. Lambert, 60 Salhouse Road, Rackheath, Norwich. [415

AGENCIES

AGENTS WANTED to sell on commission basis direct to the dealer a new range of quality hi-fi speaker kits and complete loudspeaker systems marketed by an already well-known company. Future agents will have existing connections with hi-fi dealers and preferably carry non-conflicting lines. Applications to be accompanied by personal history, qualifications, experience, etc. Box W.W. 514 Wireless World. [514

Send an S.A.E. for New Comprehensive I.C. and Semiconductor price lists.

INTEGRATED CIRCUITS

NEW LOW PRICES · FULLY GUARANTEED

RCA	
CA3000	39/6
3005	25/6
7	57/6
11	16/6
12	19/6
13	24/-
14	27/-
18	19/6
18A	25/-
19	19/-
20	27/-
20A	37/-
21	34/-
22	27/6
23	28/-
26	21/-
28A	16/6
28B	24/-
29	19/6
29A	38/6
30	31/-
35	27/-
36	16/6
39	19/6
41	25/-
42	25/-
43	29/-
44	27/-
45	27/-
46	19/6
47	29/-
48	45/-
49	35/-
50	39/6
51	28/-
52	36/6
53	12/-
54	50/-
55	24/-
59	27/-
64	35/-

MOTOROLA	1-9	10+	25+
MC724P	17/6	15/-	13/6
MC788P	19/6	17/6	16/-
MC789P	17/6	15/-	13/6
MC790P	27/6	24/6	23/-
MC792P	17/6	15/-	13/6
MC799P	17/6	15/-	13/6
MC1303P	57/6	—	—
MC1304P	79/6	—	—
MC708P	59/6	—	—
MC7490P	69/6	—	—
MC788P	19/6	—	—
MC838P	130/-	—	115/-
MC1552G	89/6	—	79/6

FAIRCHILD	1-5	6-11	12+	50+
L900	9/9	9/-	8/-	—
L914	9/9	9/-	8/-	—
L923	12/6	11/9	11/-	—
L702C	36/6	32/6	29/6	—
L709C	21/-	19/6	18/-	17/-
L710C	21/-	19/6	18/-	17/-
L711C	21/-	19/6	18/-	17/-
L716C	56/-	50/-	—	—

TEXAS		MULLARD LOGICS	
SN7400N	18/-	FJH101	17/6
SN7401N	18/-	FJH121	17/6
SN7402N	18/-	FJH141	17/6
SN7403N	18/-	FJH161	17/6
SN7404N	19/3	FJH171	18/3
SN7405N	19/3	FJH221	17/6
SN7410N	18/-	FJJ101	27/6
SN7413N	22/-	FJJ121	37/6
SN7420N	18/-	FJJ141	62/6
SN7430N	18/-	FJJ191	37/6
SN7440N	18/-	FJJ251	62/6
		FJY101	16/-

Data Sheets all 1/- per type except L900/914/923 and Plessey 2/6.
8 Pin To-5 I.C. Holders, 10/6
14 Pin Dual-in-Line I.C. Holders, 11/-
16 Pin Dual-in-Line I.C. Holders, 12/6

MULLARD LINEAR	
TAA241	32/6
242	85/-
243	30/-
263	15/6
293	19/6
300	35/-
310	25/-
320	14/6
350	35/-
435	29/6
521	26/6
522	72/-
530	99/-
811	89/-
TAB101	19/6
TAD100	39/6
TAD110	39/6

SINCLAIR	
IC-10	57/6

PLESSEY	
SL402A	42/6
SL403A	42/6
SL701C	15/6
SL702C	29/6

GENERAL ELECTRIC	
PA222	67/6
PA230	22/6
PA234	21/6
PA237	38/-
PA246	57/6
PA424	49/6

Please send a S.A.E. for our new comprehensive I.C. price list
Post and Packing 1/6d. per order. Data sheet free if ordered with I.C.s. Send 2/6d. for catalogue

TELEPHONE 01-452 0161 **A. MARSHALL & SONS LTD.** TELEX 21422
28 CRICKLEWOOD BROADWAY, LONDON, N.W.2
CALLERS WELCOME 9-5.30 SATURDAY 9-5
SEE OUR MAIN ADVERTISEMENT ON PAGE 80 FOR SEMICONDUCTORS

ITN

has a vacancy for a SOUND ASSISTANT 'B' Grade H. Salary £1,415 per annum, plus minimum 4% increase from July 1st, for operation of magnetic film and tape recordings and tape and disc replay machines for television transmission and film dubbing.
Applicants should have practical experience in one or more of these operations and possess a basic technical knowledge of electronics as applied to sound recording techniques.

Application forms are available from the Recruiting Office, telephone 01-637 2424 extension 392.

WE KNOW YOU WANT A BETTER JOB
and what is more
WE WILL HELP YOU FIND IT.

EAL TD

Experienced engineers in Design and Development, Systems Test, Technical Sales, Production Engineering, Field Service or Technical Writing should

Contact Electronics Appointments Ltd.

and we will help you.

Our placement service is professional, specialised and completely confidential. We are in consultation with over 800 companies on all aspects of electronics engineering. Phone or write at any time quoting EW 101.

MACLEANS 6" FAN
230 v AC. 3 Amp. 2,800 rpm.
55/- pp **6/-.**

IMLOCK COLLAPSIBLE ALUMINIUM CHASSIS FRAMES 10½" × 8¾" × 6½".
20/- pp **3/-.**

AIR CONTROL INST. BLOWER MOTORS
Single phase 200-250v AC 2,800 rpm.
Outlet size 2½" × 1½". **£3 15s. 0d.** pp **7/6.**

20-WAY 3-POLE P.O. TYPE JACK STRIPS
10½" × 3½". **19/6** pp **3/6.** Ex-equip.

12 VOLT SOLENOIDS PULL ACTION
Size 2" × 1" × ½".
4/6 each pp **1/6.**

SOLAR CONSTANT VOLT TRANSFORMERS.
Harmonic neutralized. Primary volts 95/190-130/260
Rated V.A. 250 50 Hertz. Enclosed in case.
Sec.: 118v AC 2.12 Amps.
Size 8" × 12" × 4"
£9 0s. 0d. each. Carr. **20/-.**
New condition ex. equip. Tested

STC SEALED RELAYS DOUBLE POLE CHANGEOVER
48v 2 500 Ω Ex-equip.
2/6 each pp **1/6.**

HONEYWELL MICRO-SWITCH, LEVER OPERATED
10A 250v. AC
Lever action ex-equip. **3/6** each pp **2/-.**

ANALEX POWER SUPPLIES
Size 7" × 19" × 13". 230v AC Input.
Output 6v 5 amp × 2; 18v. 7.5 Amp. DC
Fully Transistorised
Marginal adjustment on output
£35 0s. 0d plus **£3** carriage.

ANALEX POWER SUPPLY
Size 13" × 19" × 5½". 230v AC Input.
36v 14A Output. Stabilized
Ex. Equip. Fully Tested. New condition.
£27 0s. 0d. plus **£2 10s.** carriage.

VEEDER-ROOT MECHANICAL COUNTERS
5 digit; lever operated; resettable.
3" × 1¾" × 1¼". Ex-equip. **10/6** pp **2/6.**

DORMAN LOADMASTER
250/44v AC. 5 amp triple pole circuit breaker.
29/6 plus 5/- pp.
Brand new with fixing bracket.

TRANSFORMERS
Input 230v AC
Output: 6.3v 8 amp × 2; 6.3v 4Amp × 3.
Size 4¾" × 4¾" × 6" approx.
New condition tested. **45/-** pp **12/6.**
Input 230v. Output: 6.6v 122Amp
Size 6½" × 7¾" × 9" including terminals
Brand new. **£15 0s. 0d.** plus **£2** carriage.

ASHGROVE TRANSFORMER
0-240v AC in
228v AC 6.6 Amp Out
6" × 6½" × 7¾".
£8 8s. 0d. plus **30/-** Carriage.

TRANSFORMER
0-250v AC In
0-240v AC 15 Amp Out
9" × 9" × 7½".
£12 0s. 0d. plus **40/-** Carriage.

PARMEKO TRANSFORMER
0-115/250 49/60 Hertz
0-125v AC 13 Amp Out
8" × 11" × 9". 2 only.
£15 0s. 0d. pp **50/-.**

PARTRIDGE TRANSFORMER
0-115/265 AC In
240v AC 13 Amp Out
9¼" × 9" × 12".
£15 0s. 0d. plus **50/-** Carriage.

ADVANCE VOLTSTAT TRANSFORMER
190-260v AC In
240v RMS Out
3 000 watt
30" × 12" × 12".
£30 0s. 0d. plus carriage.

GARRARD 2 TRACK TAPE DECKS MAG TYPE
Solenoid operated 230v, 1/7ips 50v Solenoid
Ideal for contin. tape players etc
£7 10s. 0d. each. Brand new in manufacturers cartons. pp **22/6d.**

OMRON MIDGET POWER RELAY
Type MK1 230v AC. New **9/6d.** each pp. **1/6d.**

TELESCOPIC AERIALS CHROMED
7" closed **28"** extended. 6 section
Ball jointed base **4/6d.** each pp. **1/6d.** New

4 MULLARD DM160 INDICATORS
Size approx. 1¾" × 1¼" × ¼" in plastic holder; green plastic cover ex-equipment. **7/6.** pp **1/6.**

CERAMIC STEREO CARTRIDGE
Output 135 m/v at 1 cm/sec.
Freq. response 40-12 000 cps. Load 1 meg.
Separation better than 15db.
Tracking weight 5-6 grams. **30/-, pp 2/6.**

MALLORY ELECTROLYTICS

25,000, MFD 25v DC	55,000, MFD 15v DC
40,000, " 10v DC	27,000, " 15v DC
20,000, " 30v DC	32,000, " 25v DC
37,500, " 15v DC	

All at **10/-** each. p.p. **2/6.** Screw terminals.

POWER SUPPLIES
AC INPUT 200-250v;
20v 4.5 Amp; 10v 3 Amp; 10v 300 MAmp. **DC**
£15 0. 0. pp. **30/-.**
Toggle Switches, single pole, double throw.
Ex-equip. New condition. **10/-** doz., pp **2/6.**

FIELD ELECTRIC LTD.

3 SHENLEY ROAD, BOREHAMWOOD, HERTS.
Adjacent Elstree Mainline Station. Callers welcomed
Telephone Elstree 6009

TACHOS

TACHOMETERS TACHOGENERATORS

- ★ Very accurate-linearity ·1%
- ★ Bidirectional output to ¼ of 1% tolerance
- ★ Brush life 100,000 hrs. or 10 years continuous operation
- ★ Low driving torque
- ★ Temperature compensated
- ★ Ideal as speed transducers

NECO ELECTRONICS (EUROPE) LIMITED

WALTON ROAD, EASTERN ROAD
COSHAM PO6 1SZ, HANTS.
Tel: COSHAM 71711/5. Telex. 86149

WW—099 FOR FURTHER DETAILS

RCA Electronic Components

RCA Semiconductors from stock

Cat. & Price List by return
Hams-free QSL cards & 'Ham Tips' with every order.

Ring HITCHIN 50551 for immediate delivery

This month's offer:

40w. Peak-Envelope-Power amplifier for 118 to 136 MHz AM. Transmitters, comprising:

Transistors

2N 3866	21/9 ea.	40291	99/- ea.
40290	23/- ea.	40292 (2)	113/6 ea.
1N3193 (2)	3/3 ea.		

(send for leaflet AN-3749 for circuit details 2/-)

Magnetic tape keying system for code recording and transmission, comprising:

Transistors

1N3193(7)	3/3 ea.	2N2614	5/- ea.
2N3242A(7)	7/9 ea.		

(send for Ham Tips Vol. 29 No. 3. for circuit details 2/-)

A wide range of semiconductors always in stock. Make sure of your copy of 'Ham Tips' and QSL card, both free with order, by placing your order with us NOW.

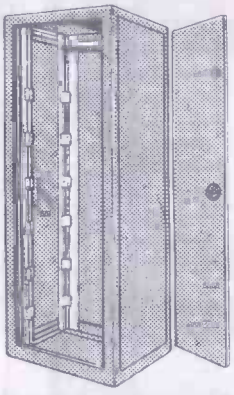
Send for catalogue to:

REL EQUIPMENT AND COMPONENTS LTD.
Croft House, Bancroft, Hitchin, Herts
Telephone: Hitchin 50551/2/3 and 52202

WW—100 FOR FURTHER DETAILS

EXCLUSIVE OFFERS

LATEST TYPE HIGHEST QUALITY CABINETS FOR STANDARD 19" RACK PANELS TOTALLY ENCLOSED



TYPE A: 84" high × 24" deep × 24" wide.
TYPE B: 78" high × 30" deep × 24" wide.
DOUBLE SIDED. These cabinets will take rack panels both sides, that is back and front and are drilled and tapped all the way down every ½" for this purpose. They are fitted with "Instantit" patent fully adjustable rack mounts which are vertically and horizontally adjustable—these allow the panels to be recessed when they are fitted with projecting components and it is desired to enclose them by doors.

★Other features include—all corners and edges rounded. Interior fittings tropicalised. Removable built in cable ducts. Removable built in blower ducts. Ventilated and insect proofed tops. Detachable side panels. Full length instantly detachable doors fitted expanding bolts if ordered with cabinets. Made in U.S.A.—cost the American Government £107 before devaluation. Finished in grey primer and in new condition.

PRICE £26.10.0 each (Carriage extra)
Full length door £5 each extra

Doors are not needed if panels are mounted back and front and they are not required to be enclosed.

TYPE C: 80" high × 27" deep × 22" wide. American Standard First Grade totally enclosed ventilated 19" rack panel mounting cabinets, made by Dukane, U.S.A. Open front fitted rack mounts drilled and tapped all the way down every ½". Full length rear door with latch. Finished in grey these cabinets have been used but are in good condition but if decoration is of importance it is recommended they are re-sprayed before use.

PRICE £15.0.0 each (Carriage extra)

TYPE D: 76" high × 18" deep × 22" wide. These are slightly smaller and finished in black otherwise they are similar in construction and condition to Type C above. Made by E.C.A. of U.S.A.

PRICE £12.10.0 each (Carriage extra)

TYPE E: 68" high × 16" deep × 22" wide, totally enclosed ventilated rack-mounting cabinets made by Motorola, U.S.A. These units have front and rear doors and rack mounts internally recessed within the cabinet. The rack mounts are standard 19" wide. The actual front panel height is 4' 10", the remaining 9" being fitted with removable glazed panel.

PRICE £9.10.0 each (Carriage extra)

TRANSPORT: We have made special economical transport arrangements for these cabinets to ensure they arrive undamaged and to avoid expensive crating. Full details on request.

FREE
40-page list of over 1,000 different items in stock available—keep one by you.

★Servomex A.C.7 Automatic Voltage Regulator, 30 amps, 250v., 50 c/s	£275 0
★R.C.A. 5-Element Yagi Arrays 420 mc/s	£3 10
★AN/GMD-1 Rawin Receivers	£125 0
★3M Secretary Photo Copiers	£15 0
★Xerox 1385 Photo Copiers	£175 0
★Memovox 8½" Plastic Spool Cases	15/-
★E.M.I. (U.S.A.) ½" Finest Quality Computer tapes suitable video work. 2400 ft. spooled and in transparent outer plastic case	£4 0
★10 foot long 6" sides Triangular Lattice Steel Mast Sections with mating lugs for joining up to 200 feet. New condition	£7 0
★Collins R-390 Communications Receivers 0.5/30.0 m/cs	£325 0
★Hoffman CV-157 ISB/SSB Converters	£200 0
★Mackay 128 AY L.F. Receivers 15/600 Kcs.	£22 10
★E.M.I. Tape Recorders BTR-1	£175 0
★Weston 2½-D.B. Meters —10/+6	£2 0
★Redifon RA-10 ISB Adaptors	£40 0
★TT-4 Lightweight Teleprinters	£45 0
★TT-63 Telegraph Repeaters	£35 0
★Candlestick microphones with push to talk switch	£2 0
★Lattice lightweight steel triangular Aerial Masts 12 to 16 inch sides up to 200 ft. high	According to height

WANTED ½" VIDEO TAPE
Good price paid

★I.C. Testers with plug boards	£95 0
★54 inch. dia. Meteorological Balloons	£1 10
★½" New Magnetic Recording Tape made by E.M.I. (USA) 3600 ft on N.A.B. Spools	£5 10
★1" Used ditto "Scotch" Brand 4800 ft	£4 0

MONTH'S BARGAIN, POWER SUPPLY, rack mtg. 3½ in., inp. 230v. A.C./12v. D.C.; outp. 130v. 25 m/a D.C., inc. FREE twin amplifier, spares, manual, in wood transit/tool box 20in. × 8in. × 9in.; all unused, usually £8 bargain (carr. pd. England & Wales) 50/-.

★8 Track Data High Speed Tape Readers	£40 0
★Mason Illuminated Drawing Tables 50" × 36"	£17 10
★Steima Telegraph Distortion Monitors	£25 0
★Teletype Model 14 Tape Punches	£29 10
★TS-497/URR Signal Geuerators 2/400 m/cs	£85 0
★Sarah Trans/Receivers and Aerials	£3 0
★Freix Airport "Weather Man" Masts	£25 0
★Uniselectors 10 bank 25 way full wipe ex. new	£1 15
★Precision Mains Filter Units new	£1 10
★Avo Geiger Counters new	£7 10

Carriage extra at cost on all above.
All goods are ex-Government stores.

We have a large quantity of "bits and pieces" we cannot list—please send us your requirements we can probably help—all enquiries answered.

P. HARRIS

ORGANFORD — DORSET
BH16 6ER
WESTBOURNE 65051

MAINS
Keynector

A REVOLUTIONARY NEW PRODUCT

cuts out plugs

It's the Newest, Safest and Quickest way to connect Electrical Equipment to the mains

No plugs—no sockets—no risk of bare wires. To connect anything electrical, from an oscilloscope to an electric drill, simply open the fuse housing, depress the keys, insert the wires and close the housing. A neon light on the front of the Keynector glows to indicate proper connection. Multi-parallel connections can be made up to 13 amps. Keys are colour coded and lettered LEN for quick identification. Price 46/6 plus 5/- p. & p.

issued by

E.B. INSTRUMENTS

DIVISION OF ELECTRONIC BROKERS LTD
49-53 Pancras Road, London, N.W.1.
Telephone: 01-837 7781

WW—103 FOR FURTHER DETAILS

★ **ALL PURPOSE TRANSISTOR PRE-AMPLIFIER** ★
ENCAPSULATED MODULE · BRITISH MADE
9-12v. and 200-300v. D.C. operation. Size 1¼×1¼×¼ in. Response 25 c.p.s. to 25 Kc/s, 26 db gain. For use with valve or transistor equipment. Full instructions. Brand new. Guaranteed. Details S.A.E. **17/6 each**

BAKER 12 in. MAJOR £8

30-14,500 c.p.s., 12in. double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 45 c.p.s. Rated 20 watts. Voice coils available 3 or 8 or 15 ohms. Price £8.

Module kit, 30-17,000 c.p.s. Size 19×12½ in. with tweeter, crossover, baffle and instructions. Ideal for Hi Fi or P.A.

Post Free **£10.19.6**

LOUDSPEAKER CABINET WADDING 18 in. wide, 3/- per ft. run. Post 2/6 per order.

ELECTRIC MOTORS

(120v. or 240v. A.C.)
Clockwise 1,200 R.P.M. off load
Heavy duty 4 pole 50mA.
Spindle ¼ × 3/20 in. diameter.
Size 2½ × 2½ × 1½ in.

BARGAIN PRICE **17/6** Post 2/6

TRANSISTOR AMPLIFIER WITH LOUDSPEAKER

A self-contained portable mini p.a. system. Many uses—Parties, Baby Alarm, Intercom, Telephone or Record Player Amplifier. Attractive rexine covered cabinet size 12×9×4 in., with powerful 7 × 4 in. speaker and four transistor one watt power amplifier. Uses PP9 battery. Brand new in Maker's carton with full maker's guarantee.

All for only **75/-** Post 4/6

THE INSTANT BULK TAPE ERASER AND RECORDING HEAD DEMAGNETISER

200/250 A.C.
Leaflet S.A.E. **42/6** Post 2/6

RETURN OF POST DESPATCH — CALLERS WELCOME
HI-FI STOCKISTS — SALES — SERVICE — SPARES

RADIO COMPONENT SPECIALISTS

337 WHITEHORSE ROAD, CROYDON. Tel: 01-684 1665

OSMABET LTD.

WE MAKE TRANSFORMERS AMONGST OTHER THINGS
AUTO TRANSFORMERS. 0-110-200-220-240 v a.c. up or down, fully shrouded fitted terminal blocks. 30 w **26/6**; 50 w **34/-**; 75 w **41/6**; 100 w **49/-**; 150 w **60/-**; 200 w **75/-**; 300 w **97/6**; 400 w **120/-**; 500 w **142/6**; 600 w **165/-**; 750 w **195/-**; 1000 w **240/-**; 1500 w **345/-**; 2000 w **480/-**; 3000 w **600/-** and up to 8000 watt to order.
MAINS TRANSFORMERS. Prim 200/240 v a.c. TX1. 425-0-425 v 250 Ma, 6.3 v 4 a, CT, 6.3 v 4 a, CT, 0-5-6.3 v 3 a, **135/-**; TX2, 250-0-250 v 150 Ma, 6.3 v 4a, CT, 0-5-6.3 v 3 a, **78/6**; TX3, 250-0-250 v 100 Ma, 6.3 v CT, 2 a, 6.3 v 1 a, **60/-**; TX4 300-0-300 v 60 Ma, 6.3 v 2 a CT, 6.3 v 1 a, **60/-**; TX5 300-0-300 v 120 Ma, 6.3 v 2 a CT, 6.3 v 2 a, 6.3 v 1 a, **78/6**; TX8 250-0-250 v 65 Ma, 6.3 v 1.5 a, **42/-**; MT1 200 v 30 Ma, 6.3 v 1 a, **24/-**; MT2 230 v 45 Ma, 6.3 v 1.5 a, **29/6**.
MULTIVOLT TRANSFORMERS. Prim 200/240 v a.c. OMT4/1 One tapped sec, 5-20-30-40-60 v giving 5-10-15-20-25-30-35-40-55-60, 10-0-10, 20-0-20, 30-0-30 v a.c. 1 amp, **45/-**; ditto tran 2 amp OMT4/2, **67/6**; OMT5/1 One tapped sec, 40-50-60-80-90-100-110 v, giving 10-20-30-40-50-60-70-80-90-100-110, 10-0-10, 20-0-20, 30-0-30, 40-0-40, 50-0-50 v a.c. 1 amp. **67/6**; OMT40/3 one sec 40 v CT 3 amp, **67/6**.
DUOVOLT TRANSFORMERS. Prim 200/240 v a.c. "D12V" Sec 1, 12 v 4 a, Sec 2, 12 v 4 a, **71/6**; "D25V" Sec 1, 10-20-25 v 2 a, Sec 2, 10-20-25 v 2 a, **71/6**.
LT AUTO TRANSFORMERS. Prim 200/240 v a.c. output 24 v a.c. 150 watt **90/-**; 250 watt **135/-**; for quartz iodine lamps.
HEATER TRANSFORMERS. Prim 200/240 v a.c. 6.3 v 1.5 a **16/9**; 3 a **20/-**; 6 a CT **34/-**; 12 v 1.5 a **21/-**; 3 a CT **34/-**; 6 a CT **45/-**; 18 v 1.5 a CT **26/6**; 24 v 1.5 a CT **34/-**; 3 a CT **56/6**; 5 a **75/-**; 8 a **112/6**; 12 a **165/-**.
MIDGET RECTIFIER TRANSFORMERS. For FW rectification, size 1¼ × 2 × 1½ ins., Prim 200/240 v a.c. output PPT1 9-0-9 v 0.3 a; PPT2 12-0-12 v 0.25 a; PPT3 20-0-20 v 0.15 a, **21/-** each. Size 2 × 2¼ × 1¾ ins., MT12V 12-0-12 v 1 a, MT20V 20-0-20 v 0.75 a, **22/6** each.
OUTPUT TRANSFORMERS. Mullard 5/10 UL **67/6**; 7 watt stereo UL **60/-**; 3 watt PP3 **30/-**; PP 11K/ 3-8-15 ohm **21/-**; Multi ratio 7/10 watt **33/-**; 30 watt (KT66 etc.) 3-15 ohm **78/6**; 50 watt (KT88 etc.) **135/-**; 100 watt **225/-**; auto matching tran, 10 watt 3-18-15 ohm up or down **15/-**.
W.W. IGNITION CIRCUIT tran to spec **50/-** plus 4/6 p.p.
W.W. COLOUR TELE. Choke L1, **60/-**; Tran T1 **57/6**; Field O/P **60/-**.
Carriage extra on all transformers 4/6 minimum.
BULK TAPE ERASERS. 200/250 v a.c. immediate erasure of any size spool of magnetic tape, new boxed **42/6** p.p. 3/-.

FLUORESCENT LOW VOLTAGE LIGHTING
12 v d.c. fittings and transistor inverters.
Fitted perspex diffusers, 12 ins. 8 watt, **70/-**; 21 ins. 13 watt, **95/-**; less diffuser, 18 ins. 15 watt, **70/-**. Transistor inverters for 40 watt or twin 20 watt tubes at **150/-**, for single 20 watt tube **100/-** plus postage. New and guaranteed.

CONDENSERS. Electrolytics, 1000 mfd 25 v, **4/6**; 2500 mfd 50 v, **10/6**; 6000 mfd 15 v, **5/-**; 1500 mfd 150 v, **12/6**; 80 mfd 450 v, **5/-**; 100 × 200 mfd 350 v, **7/6**; 60 × 100 mfd 450 v, **7/6**.
LOUDSPEAKERS. New boxed, famous makes, 25 watt **107/-**; 35 watt **130/-**; 50 watt **180/-**; 60 watt **215/-**; 100 watt **350/-**; 13 × 8 ins. **40/-**; 13 × 8ins. fitted 2 tweeters and crossover **70/-**.
LOUDSPEAKER. Ex-equip, perfect Elac etc., 6 ins. 3 ohms, **10/-** plus 3/- min. carriage.
Carriage extra on all orders.

S.A.E. ALL ENQUIRIES PLEASE. MAIL ORDER ONLY
46 KENILWORTH ROAD, EDGWARE, MIDDX.
HA8 8YG. Tel: 01-958 9314

WW—104 FOR FURTHER DETAILS

SURPLUS HANDBOOKS

19 set Circuit and Notes	7/- p/p 9d.
1155 set Circuit and Notes	7/- p/p 9d.
H.R.O. Technical Instructions	6/- p/p 9d.
38 set Technical Instructions	6/- p/p 9d.
46 set Working Instructions	6/- p/p 9d.
88 set Technical Instructions	7/6 p/p 9d.
BC.221 Circuit and Notes	6/- p/p 9d.
Wavemeter Class D Tech. Inst.	6/- p/p 9d.
18 set Circuit and Notes	6/- p/p 9d.
BC. 1000 (31 set) Circuit and Notes	6/- p/p 9d.
CR. 100/B.28 Circuit and Notes	10/6 p/p 9d.
R.107 Circuit and Notes	7/6 p/p 9d.
AR.88D Instruction Manual	18/6 p/p 10d.
62 set Circuit and Notes	7/- p/p 9d.

Circuit Diagram 5/6 each post free. R.1116/A, R.1224/A, R.1355, R.F. 24, 25 and 26, A.1134, T.1154, CR.300, BC.312, BC.342, BC.348J, BC.348 (E.M.P.), BC.624, 22 set.
52 set Sender and Receiver circuits 8/- post free.
Colour Code Indicator 2/6, p/p 6d.
S.A.E. with all enquiries please.
Postage rates apply to U.K. only.
Mail order only to:

INSTRUCTIONAL HANDBOOK SUPPLIES
Dept. W.W. Talbot House, 28 Talbot Gardens, LEEDS 8

THE ONLY COMPREHENSIVE RANGE OF RECORD MAINTENANCE EQUIPMENT IN THE WORLD!

Send P.O. 2/6 for 48 page booklet providing all necessary information on Record Care.

CECIL E. WATTS LIMITED
Darby House
Sunbury-on-Thames, Middx.

AMATRONIX LTD

ALL GOODS MINT AND GUARANTEED TO SPEC.

2N706	2/7	2SB187	2/-	BF224	5/-
2N2926G	2/6	AD161/2	12/-	BF225	5/-
2N3702	3/-	AF239	10/-	BFY51	4/6
2N3704	3/6	B-5000G	11/3	IS44	1/4
2N3707	3/6	BD121	18/-	MC140	4/-
2N3794	3/-	BD145	50/-	OA90	1/3
2N3819	7/6	BC107	3/-	SF115	3/-
2N3983	6/6	BC168	2/3	T1407	6/6
2N4058	4/-	BC169	2/6	40468A	7/6
2N4284	3/-	BF178	9/-	CA3020	28/-
2N4289	3/-	BF196	5/-	TAB101	21/-
2N4291	3/-	BF167	5/3	MEM564C	16/-

CERAMIC I.F. RESONATORS
Tailor-make 455kHz selectivity to your own needs with new **Brush Clevite Identical Resonators.** A wide choice of bandwidths by adding fixed capacitors. Resonators Type **TF04-442, 10/-** each, four for 30/-, with brief data and hints on use.

SPECIAL OFFER (Closes July 31)
CA3020 i.c. amp., with data, 25/-.
AF239 low-noise TV head amp. transistor, 7/6.
B-5000G hi-gain 25W npn Si, 10/-.
2N3819 junction FET, 7/-.

MINI MAINS TRANSFORMERS 30×30×37mm.
NEW! **MT7**, 7-0-7V, 120mA, **13/6**. **MT9**, 9-0-9V 80mA, **12/6**. **MT12**, 12-0-12V, 50mA, **13/6**. All normal mains primaries.

MAIL ORDER ONLY. CASH WITH ORDER. ORDERS OVER 10/- U.K. POST FREE. DISCOUNTS: 10% on orders over £3. 15% over £10.

396 SELSDON ROAD, SOUTH CROYDON, SURREY, CR2 0DE

—PRINTED CIRCUITS—

PROTOTYPE AND BATCH PRODUCTIONS

Instrument panels and dials
In Metal and Perspex

★ *SCREEN PROCESS PRINTERS* ★

Brooklands Plating Co. Ltd.
Spice's Yard, South End, Croydon CR0 1BF 01-688-2128

COMPONENT PARTS EX STOCK FOR FOLLOWING HI FI DESIGNS

BAILEY, LINSLEY-HOOD, TEXAS INSTRUMENTS

For list of parts and other information send S.A.E. to:

TELERADIO ELECTRONICS
325 FORE STREET, N.9 807 3719

LAWSON BRAND NEW TELEVISION TUBES

12" £4.10.0
14" £4.19.0
17" £5.19.0
19" £6.19.0
21" £8. 5.0
23" £9.15.0
19" Panorama £8.10.0
23" Panorama £11.10.0
19" Twin Panel £9.17.6
23" Twin Panel £12.15.0

Carriage and insurance
12"-19"—12/6
21"-23"—15/0

The continually increasing demand for tubes of the very highest performance and reliability is now being met by the new Lawson "Century 99" range of C.R.T.s.

"Century 99" are absolutely brand new tubes throughout manufactured by Britain's largest C.R.T. manufacturers. They are guaranteed to give absolutely superb performance with needle sharp definition. Screens of the very latest type giving maximum Contrast and Light output; together with high reliability and very long life.

"Century 99" are a complete range of tubes in all sizes for all British sets manufactured 1947-1970.

Complete fitting Instructions are supplied with every tube.

2 YEARS FULL REPLACEMENT GUARANTEE

LAWSON TUBES
18 CHURCHDOWN ROAD MALVERN, WORCS.
Tel. MAL 2100

WW—105 FOR FURTHER DETAILS

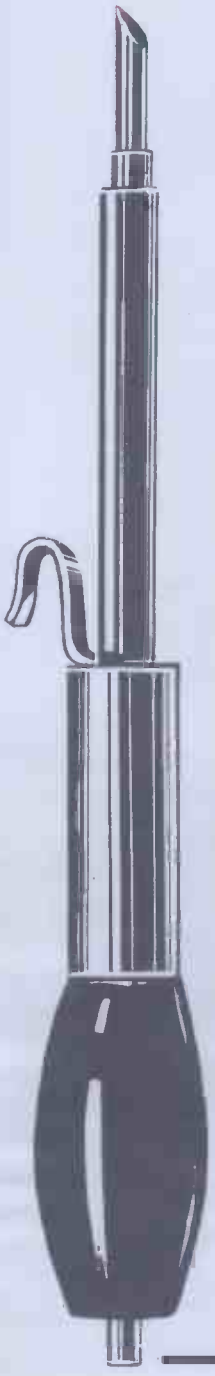
INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 89-102

	Page
A1 Factors	106
Acoustical Mfg. Co. Ltd.	41
Adcola Products Ltd.	Cover iii
A. H. Supplies	104
Advance Electronics Ltd.	11
Altec Lancing International	38
Amtronix	107
Anders Electronics Ltd.	20, 34
A.P.T. Electronics	16
Associated Automation Ltd.	2
Associated Elec. Eng. Ltd.	18
Ates Electronics Ltd.	30
Audix, B. B., Ltd.	22
Auriema Ltd.	14
Avo Ltd.	1
Bantex Ltd.	28
Barnet Factors Ltd.	81
Barrett, V. N.	106
Batey, W., & Co.	54
Bentley Acoustical Corporation Ltd.	72
Bentley K. J. & Partners	103
B.I.E.T.	13
Bi-Pak Semiconductors	84
Bi-Pre-Pak Ltd.	77
Black, J.	103, 106
Bosch Ltd.	29
Bowthorpe-Hellerman Ltd.	6, 16
Brooklands Plating Co. Ltd.	107
Brown, S. G., Ltd.	8
Bulgin, A. F., & Co. Ltd.	49
Butterworth & Co. (Pub.) Ltd.	103
Carr Fastener Co. Ltd.	46
Carston Electronics Ltd.	28
Cesar Products Ltd. (Yukan)	103
Chiltmead Ltd.	73, 104
Clarke, David, Co. Messrs.	78
Computer Training Products	30
Daystrom Ltd.	15
Deimos Ltd.	103
Diathane Ltd.	106
Diotran Ltd.	82, 104
Drake Transformers Ltd.	33
Dynamco Ltd.	10
E.B. Instruments	107
Electronic Brokers	60, 61, 106
Electronics (Croydon) Ltd.	59
Electrosil Ltd.	48
Electrovalue	87
Electro-Tech Sales	56
Electro-Winds Ltd.	58
English Electric Valve Co. Ltd.	3, 5, 7, 9
Enthoven Solders Ltd.	24
Erie Electronics Ltd.	25
Esmanco Ltd.	64
Field Electric Ltd.	105
Firnor-Misilon Ltd.	58
Foulsham, W., & Co. Ltd.	104
Goldring Manufacturing Co. Ltd.	12, 22
Grampian Reproducers Ltd.	103
Greenwood W. (London), Ltd.	39
Hall Electric Ltd.	27
Harmsworth Townley & Co.	31
Harris Electronics (London) Ltd.	30
Harris, P.	105
Hart Electronics	104
Hatfield Instruments Ltd.	55
Henry's Radio Ltd.	62, 63
Henson	106
I.C.S. Ltd.	66, 106
I.M.O. (Electronics) Ltd.	35
Instructional Handbook Supplies	107
International Rectifier Co. Ltd.	37
Johns Radio	103
K.S.M. Electronics	66
Keytronics	74
Kingston Electrical Supplies	106
Lasky's Radio Ltd.	74
Lawson Tubes	107
Ledon Instruments Ltd.	26
Light Soldering Developments Ltd.	8
Lind-Air Optronics (Industrial) Ltd.	58
Livingston Hire Ltd.	108
L.S.T. Components	67
Magnetic Tapes Ltd.	66
Marconi Instruments	21
Marshall, A., & Son (London) Ltd.	80, 102
Mills, W.	68, 69
Modern Book Co.	104
Morganite Resistors Ltd.	17
Mullard Ltd.	62
Multicore Solders Ltd.	Cover iv
McMurdo Instrument Co. Ltd.	40
Neco Electronics (Europe) Ltd.	105
Nombrex Ltd.	30
Omron Precision Controls	35
O. & R. Electronics Ltd.	64
Osmabet Ltd.	107
Oxley Developments Co. Ltd.	55
Pattrick & Kinnie	72
P.C. Radio Ltd.	83
Pembridge College, The	76
Proops Bros. Ltd.	57
Quality Electronics Ltd.	55
Quartz Crystals Co. Ltd.	103
Radio & TV Components Ltd.	65
Radio Components Specialists	107
Radio Exchange Co.	104
Radiospares Ltd.	82
Ralfe, P. F.	85
Rank Audio Visual Ltd.	24
R.E.L. Equipment & Components Ltd.	105
Reslo Mikes	14
R.S.C. Hi-Fi Centres Ltd.	75
R.S.T. Valves	76
Samsons (Electronics) Ltd.	74
Sankyo Seiki Mfg. Co. Ltd.	39
Service Trading Co.	78, 79
Servo & Electronic Sales Ltd.	68
Sinclair Radionics Ltd.	51, 52, 53
S.M.E. Ltd.	19
S.P. Loudspeakers, Messrs.	103
S.T.C. Mobile Radio Telephone	Cover ii
Smith, G. W. (Radio), Ltd.	70, 71
Smith, H. L., Co. Ltd.	20
Smith, J., Ltd.	32
S.N.S. Communications Ltd.	26, 54
Solartron Electronic Group Ltd.	45, 47
Special Products Ltd.	55
Starman Tapes	103
Stephens Electronics	86
Sugden, J. E.	55
Sutton Electronics	106
Teclare Ltd.	103
Tektronix Ltd.	36
Telequipment Ltd.	42
Teleradio, The, Co. (Edmonton) Ltd.	107
Telford Products Ltd.	106
Teonex Ltd.	24
Thorn Radio Valves & Tubes Ltd.	44
Tinsley, H.	54
Trio Corporation	50
Trio Instruments Ltd.	28
Turner, E., Electrical Insts. Ltd.	32
Universal	82
University of Leeds	58
Valradio Ltd.	20, 26
Vitality Bulbs Ltd.	10
Vitavox Ltd.	64
Vortexion Ltd.	4
Watts, Cecil E., Ltd.	107
Wayne Kerr, The, Co. Ltd.	23
Webber, R. A., Ltd.	30
Wel Components Ltd.	32
West Hyde Developments Ltd.	103
West London Direct Supplies	82
Wilkinson, L. (Croydon), Ltd.	64
Winter Trading Co. Ltd.	18
Z. & I. Aero Services Ltd.	13, 88

Printed in Great Britain by Southwark Offset, 25 Lavington Street, London, S.E.1, and Published by the Proprietors, ILPC. Electrical-Electronic Press, Ltd., Dorset House, Stamford St., London, S.E.1, telephone 01-928 3333. *Wireless World* can be obtained abroad from the following: Australia and New Zealand: Gordon & Gotch, Ltd. India: A. H. Wheeler & Co. Canada: The Wm. Dawson Subscription Service, Ltd.: Gordon & Gotch Ltd. South Africa: Central News Agency, Ltd.: William Dawson & Sons (S.A.) Ltd. United States: Eastern News Co., 306 West 11th Street, New York 14.

CLEARWAY to lower production costs with ADCOLA Precision Tools



For increased efficiency find out more about our extensive range of ADCOLA Soldering Equipment—and we provide:

★ THREE DAY REPAIR SERVICE ★ INTERCHANGEABLE BITS—STOCK ITEMS ★ SPECIAL TEMPERATURES AVAILABLE AT NO EXTRA COST.

ADCOLA TOOLS have been designed in co-operation with industry and developed to serve a wide range of applications. There is an ADCOLA Tool to meet your specific requirement. Find out more about our extensive range of efficient, robust soldering equipment.

No. 107. GENERAL ASSEMBLY TYPE

Fill in the coupon to get your copy of our latest brochure:

ADCOLA PRODUCTS LTD
(Dept. H) Adcola House, Gauden Rd., London, SW4
Tel. 01-622 0291/3 Telegrams: Soljoint, London, Telex
Telex: Adcola, London 21851

ADCOLA PRODUCTS LIMITED (Regd Trade Mark)

Please rush me a copy of your latest brochure:

NAME .....

COMPANY .....

ADDRESS .....

..... WW3

The world's industry uses a mile of Ersin Multicore solder every...

3 minutes?
3 hours?
3 days?

The answer is every 3 minutes!

A mile of Ersin Multicore Solder is used every 3 minutes during normal working hours. That shows how the world's leading electronic manufacturers rely on Ersin Multicore 5 core Solder for thousand upon thousand of fast, economic and consistently reliable joints.

If in Britain or overseas you make or service any type of equipment incorporating soldered joints, and do not already use Ersin Multicore Solder, it must be to your advantage to investigate the wide range of specifications, which are available.

Besides achieving better joints – always – your labour costs will be reduced and substantial savings in overall costs of solder may be possible. Solder Tape, Rings, Preforms, and Pellets – Cored or Solid – and an entirely new type of cored disc, can assist you in high speed repetitive soldering processes.

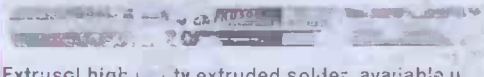
EXTRUSOL The first oxide free high purity extruded solder for printed circuit soldering machines, baths and pots, is now available to all international specifications, together with a complete range of soldering fluxes and chemicals.

Should you have any soldering problems, or require details on any of our products, please write on your company's note paper to:

MULTICORE SOLDERS LTD.,
HEMEL HEMPSTEAD, HERTS.
Tel. No. Hemel Hempstead, 3636, Telex: 82363.

1966

EXTRUSOL



Extrusol high purity extruded solder, available in 1 lb. and 2 lb. cartons, and also Extrusol pellets, for printed circuit soldering machines, pots and baths, polythene protected.

½lb. REELS

Available in standard wire gauges from 10-22 swg., on strong plastic reels.

1lb. REELS

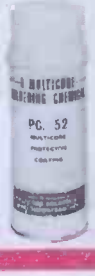
Available in all standard wire gauges from 10-34 swg., on unbreakable plastic reels. (From 24-34 swg. only ½ lb. is wound on one reel)

GALLON CONTAINERS

All liquid chemicals and fluxes supplied in 1 gallon polythene 'easy pouring' containers, with carrying handle.

AEROSOLS

PC.21A, PC.10A, and PC.52 available in 16 oz. aerosol sprays.



SOLDER TAPE, RINGS, PREFORMS, WASHERS, DISCS & PELLETS

Made in a wide range solid or cored alloys. Tape, rings and pellets are the most economical to use.

ERSIN Multicore 5 CORE SOLDER

THE FINEST CORED SOLDER IN THE WORLD