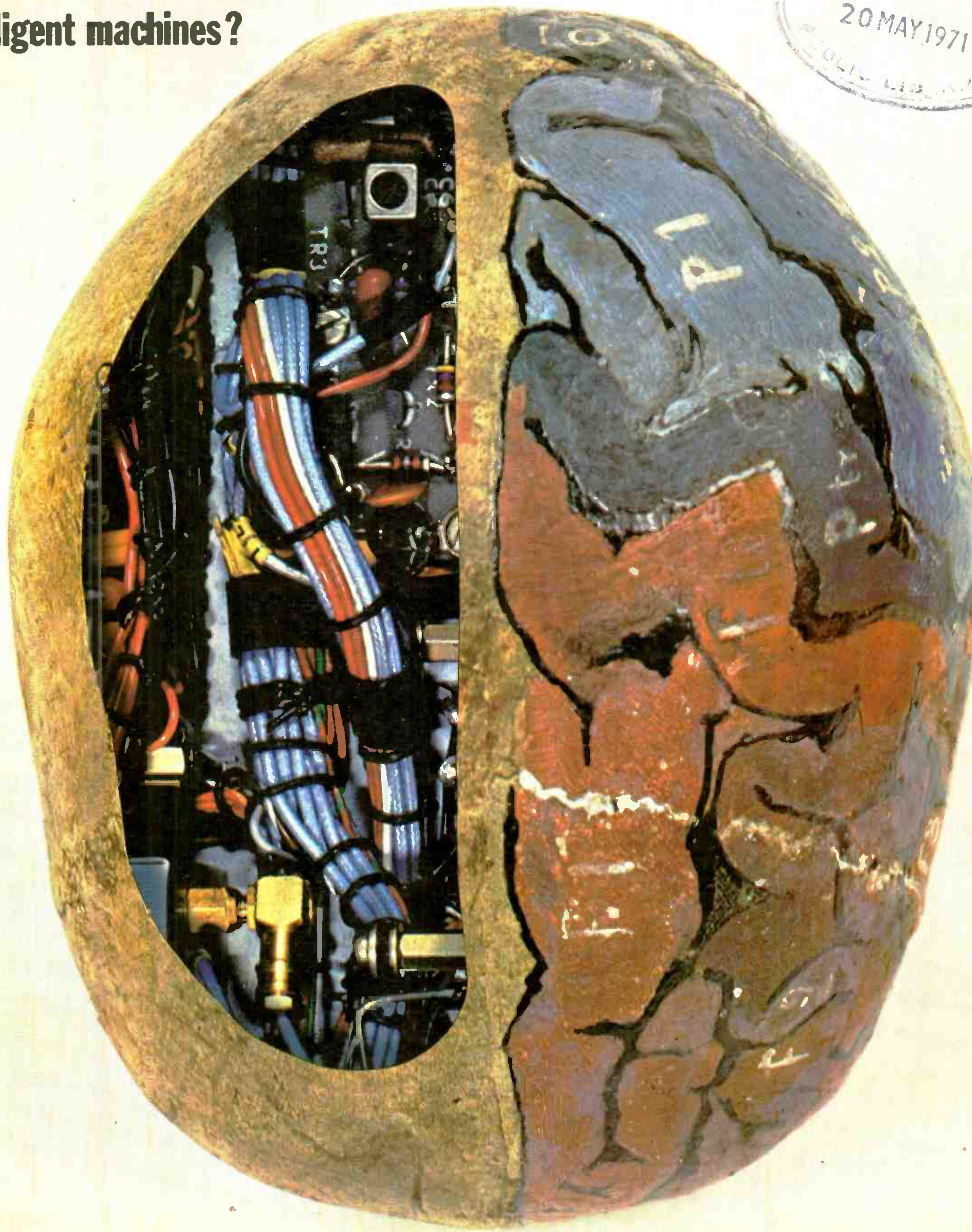
Wireless World

June 1971 17½p

Low-range linear ohmmeter

Intelligent machines?

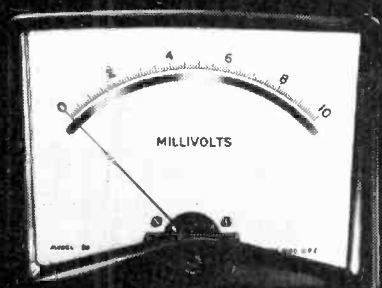



P

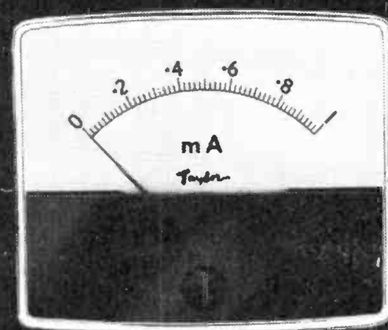
Designers specify them for their reliability and modern styling.
Buyers choose them for their competitive prices and delivery.

Taylor panel meters

are selected by equipment manufacturers everywhere.



new

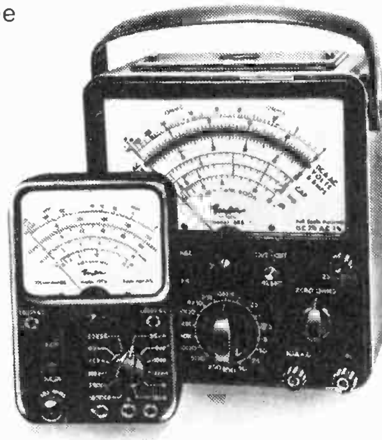


Vista Series
Popular, reliable panel meters with robust phenolic mouldings and scale lengths from $1\frac{3}{4}$ in to $4\frac{1}{2}$ in. This range combines compact functional styling with easy readability and excellent performance. Mechanically interchangeable with the Fyneline range.

Edgewise Series
Here's the latest in the range of three Edgewise panel meters, the Model 330 with a $2\frac{1}{4}$ in scale length. Ideal for today's crowded instrument panels, other scale lengths are $1\frac{1}{16}$ in (Model 11) and $1\frac{3}{4}$ in (Model 220).

Fyneline Series
Adaptable versatile series with scale lengths from $1\frac{3}{4}$ in to $4\frac{1}{2}$ in. Contemporary styling and clear shadow-free readings ensure maximum readability. This modern range maintains the Taylor reputation for reliability and sensitivity.

Taylor offers a comprehensive range of moving-coil and moving-iron panel meters. The moving-coil meters feature the proven Taylor centre-pole movement with practically friction-free operation, inherent magnetic shielding and high torque/weight ratio. They are sensitive, accurate instruments that conform generally to BS 89/54 with contemporary or conventional styling. Ask for the Panel Meter Shortform Catalogue.



Taylor makes test equipment too!
Two typical models are Taylor Model 88B, a robust, wide-range multimeter with automatic cut-out and polarity reversal facility, and the popular Taylor Type 127A, a pocket-sized multimeter for the service engineer and hobbyist. Ask for the Instrument Shortform Catalogue.

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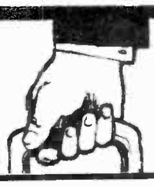
7V r.m.s. Sine or Square from 1Hz to 1MHz

FREQUENCY:	1 Hz to 1 MHz in 12 ranges. Accuracy ± 2% ± 0·03 Hz.
SINE WAVE OUTPUT:	7Vr.m.s. reducible to < 200µV with R_S = 600Ω at all levels.
DISTORTION:	< 0·1% up to 5V output, < 0·2% at 7V from 10Hz to 100kHz.
AMPLITUDE STABILITY:	< ± 1% variation with frequency up to 300kHz.
SQUARE WAVE OUTPUT:	7V peak reducible to < 200µV. Rise time < 150nS.
SYNC. OUTPUT:	>1V r.m.s. sine wave in phase with the main output.
SYNC. INPUT:	± 1% frequency lock range per volt r.m.s. input.
SIZE & WEIGHT:	7" high × 10¼" wide × 5½" deep. 10 lbs.

type TG200 **£42** type TG200D **£45** type TG200M **£52** type TG200DM **£55**

Prices include batteries with 400 hour life. Mains power units are £10 extra.

Types TG200 and TG200M generate only sine waves. Types TG200M and TG200DM have a meter calibrated 0/2V, 0/7V and —14/+6dBm. Types TG200 and TG200D have a calibrated control instead of a meter.



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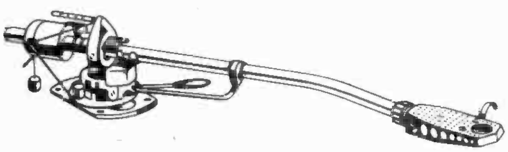


Model 9R-59DS BUILT IN MECHANICAL FILTER 8 TUBES COMMUNICATION RECEIVER

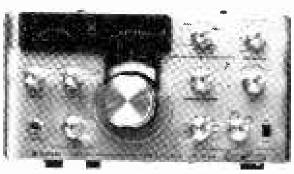
TRIO'S 9R-59DS FOR SELECTIVE SUPERIORITY

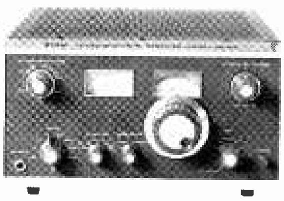
The thrills of amateur short wave communication can be a joy forever. With TRIO's 9R-59DS communications receiver you can be assured of repeated adventure. TRIO's modern engineering techniques are especially apparent in its mechanical filter which achieves amazingly superior selectivity. For the thrill of a lifetime tune in with TRIO's 9R-59DS.

Specifications:

• Frequency Ranges: Band A 550-1600KHz, B 1.6-4.8MHz, C 4.8-14.5MHz, D 10.5-30MHz. • Sensitivity: 2μV for 10dB S/N Ratio (at 10MHz) • Selectivity ±5KHz at −50dB • Power Consumption: 45 watts • Audio Power Output: 1.5 watts • Tube & Diode Complement: 6BA6×3, 6BE6×2, 6AQ8×2, 6AQ5, SW-05S×2, SW-05×2, IN60×2. • Dimensions: Width 15", Height 7", Depth 10".

ALL BAND COMMUNICATION RECEIVER JR-599





SSB COMMUNICATIONS RECEIVER JR-310

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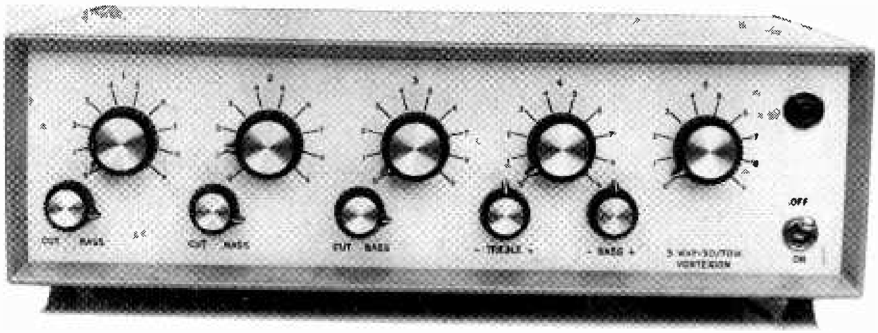
Vortexion

50/70 WATT ALL SILICON AMPLIFIER
WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.

This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable-100 watt amplifier 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 2-30/60Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output or 5/15Ω and 100 volt line.



This is similar to the 4 way version but with 5 inputs and bass cut controls on each of the three low impedance balanced line microphone stages, and a high impedance (10 meg.) gram stage with bass and treble controls, plus the usual line or tape input. All the input stages are protected against overload by back to back low noise, low intermodulation distortion and freedom from radio breakthrough. A voltage stabilised supply is used for the pre-amplifiers making it undependent of mains supply fluctuations and another stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75% efficient and 100V balanced line or 8-16Ω output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected.

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, 2-30/60Ω balanced microphone inputs, 1-HiZ gram input and 1-auxiliary input 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 and 1 auxiliary input.

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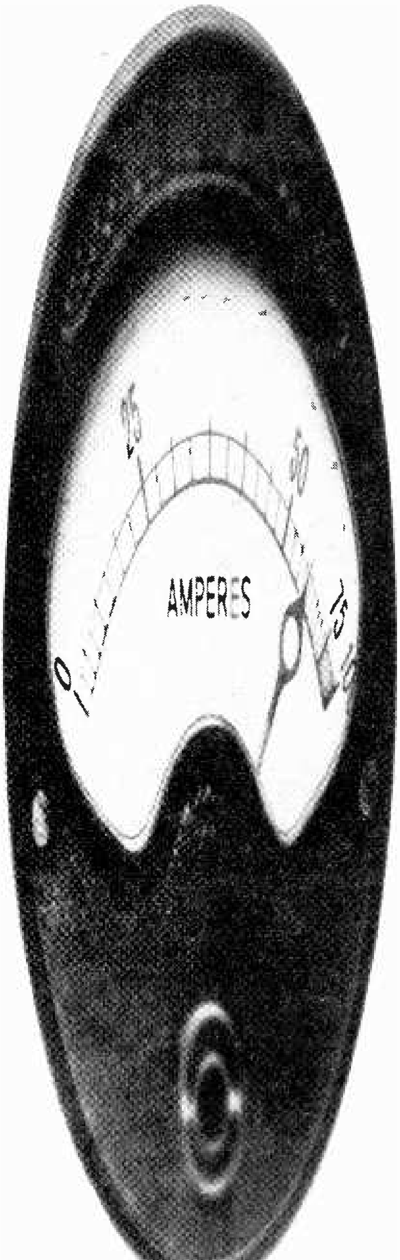
Telephone: 01-542 2814 and 01-542 6242/3/4 **Telegrams: "Vortexion, London S.W.19"**



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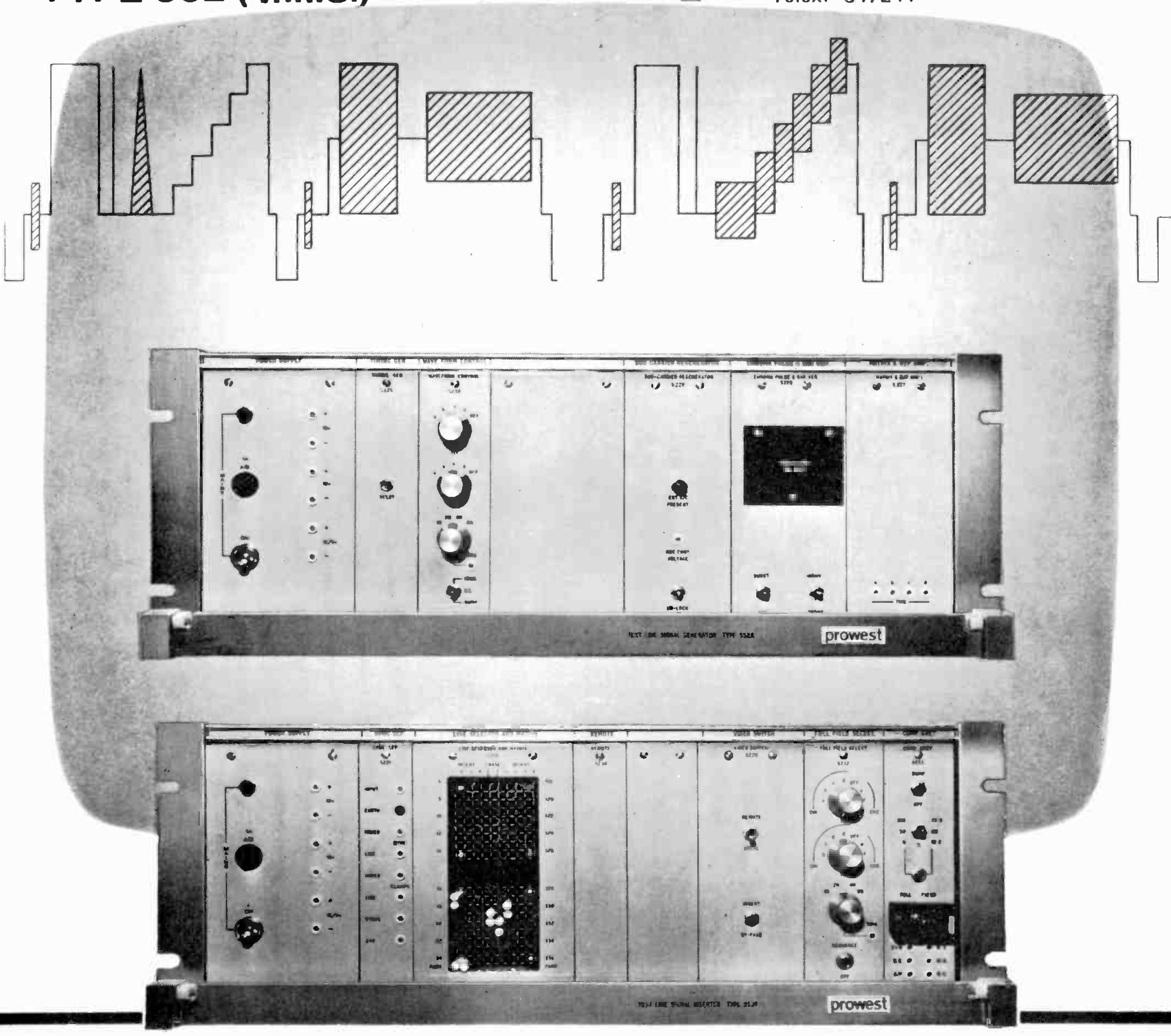

FEATURES

* Integrated circuits and digital techniques ensure the production of colour test line signals to highest standards of accuracy, stability and reliability.
* Programmable to National or International test line standards.
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* Generator will operate separately as free standing unit.
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GENERAL

Insertion test line signal equipment (also known as V.I.T.S.) is essential for monitoring and automatically controlling the performance of PAL or NTSC colour television channels during Program time.

The type 552 equipment, constructed to a design by the Independent Television Authority, generates such signals and provides the means for their insertion or erasure at any standard level video point in a vision channel. During out-of-program time, test lines and comprehensive full field test signals, generated internally, may be substituted for the main signal. Channels are provided for the insertion of control and data signals during the vertical interval.

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UTTING OF THE MONTH

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for similar applications but where a higher input resistance (typically 2500 ohms) is required.
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PC4
EXTRA HIGH IMPEDANCE VERSION OF PC2
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PC9
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PC101

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General replacement for 9V batteries. Suitable PC1, 2, 3, 4, 7, 9, 10, 1006 source for Zener stabilised 5V digital IC supply.
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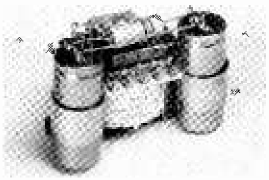

PC102

VERSATILE 21V, 330mA DC POWER SUPPLY UNIT

with separate 21V winding for optional extra DC output, suitable 3W 15 transformerless amps. source 12-18V stabilised supply.
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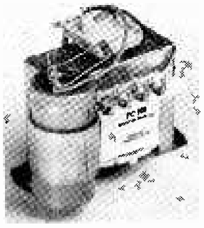

PC106

USEFUL 12V, ½A DC POWER SUPPLY UNIT

General replacement for 12V batteries, suitable PC5, 712. Source for Zener stabilised supplies replacing 6 and 9V batteries.
Price £2.4750 (£2.9.6)

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For higher power applications similar to PC2 but using 12V supply and standard 15 ohm speaker. Driver for high powers.
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The Mark 2 TSV 70 Power Supply

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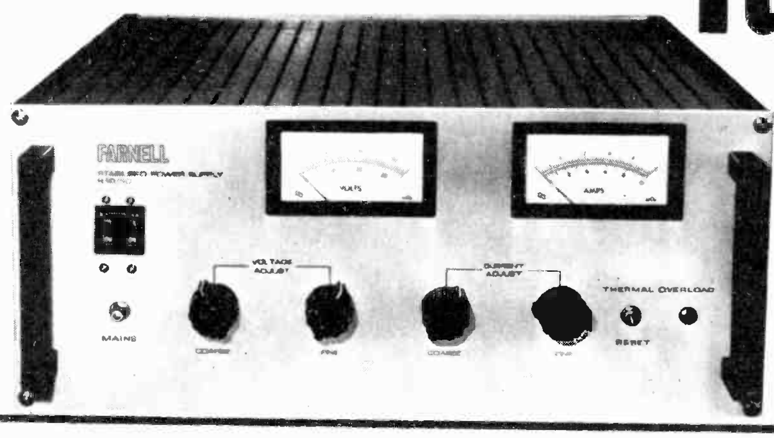
Farnell

The Mk 2 version of the Farnell TSV 70 bench power supply takes up less space, weighs less and costs less - yet gives you better performance than ever. It provides a continuously variable d.c. output at either 0-70V, 5A or 0-35V, 10A and regulates to 0·01%. Its price is £165.
Full information sent on request.

Dimensions: 430mm WIDE (16·93") x 410mm DEEP (16·14") x 177.8mm HIGH (7")
WEIGHT: 26.2Kgs. (57.75lbs)



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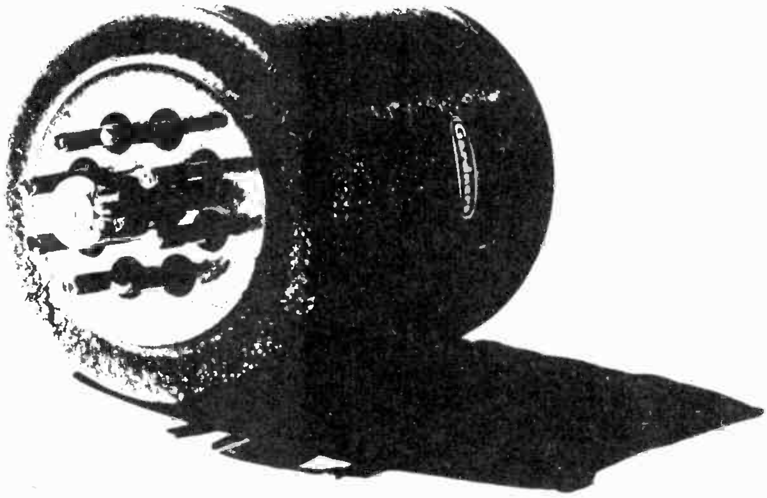
GT5?



GT.5 is an entirely new comprehensive brochure of Audio Transformers and contains details of a wider range of standard types. Recent introductions to Gardners Audio range described in this brochure include super-fidelity transformers with exceptionally low phase-distortion and the ability to handle steep side transient signals without generation of overshoot. Also listed is a range of high proof-voltage transformers for Post Office transmission lines and a new range of ultra miniature transformers with remarkably good performance. A frequency response linear from the lower audio frequencies to the supersonic band is standard to many of the newer types.

Gardners also have nine other GT Catalogues. Whatever your transformer requirement there is more than a possibility that we can supply something suitable from stock. We make the largest range of standard transformers in Europe.

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GT.25	TRANSISTOR POWER SUPPLY TRANSFORMERS.
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Gardners

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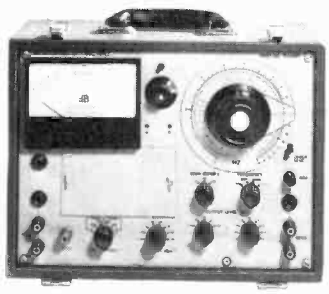
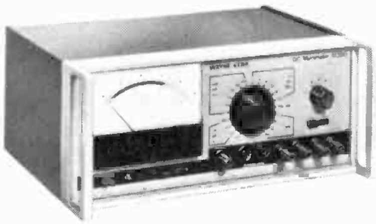
The Newcomers

DC Differential Voltmeter – 6-figure readout from 100mV to 1kV, accuracy 0.01%. Calibrated null meter, analog output for recorders. Ask for M400 Data Sheet.



Transmission Measuring Set – portable equipment for checking a.f. lines and equipments from 20Hz to 120kHz. Suits 75, 140 and 600-ohm circuits, balanced or unbalanced, terminated or unterminated. Details on application, quoting 44C.

Signal Source – 30kHz to 30MHz with 50-ohm attenuated output from —50 to +10dB on 1V p-p. Monitor outlet for counters. Stable in frequency and amplitude. Ask for O200 Data Sheet.



DC Multimeter – full-scale ranges 30µV-300V, 30pA-100mA and 10Ω-1GΩ. Switched filter. Constant 100MΩ for 1% voltage measurements. Analog output. Ask for M300 Data Sheet.

Capacitor Test Set – direct readout of percentage deviation from a pre-set value, and of dissipation, with automatic limit circuits showing pass/high/low. Also 4-figure capacitance measurement. Ask for B700 Data Sheet.

Frequency Counter – direct readout of time, count, period and frequency to 50MHz. Memory, inhibit and gating facilities. Electrical and mechanical stop/start. Clock pulse outputs. Ask for FC50 Data Sheet.

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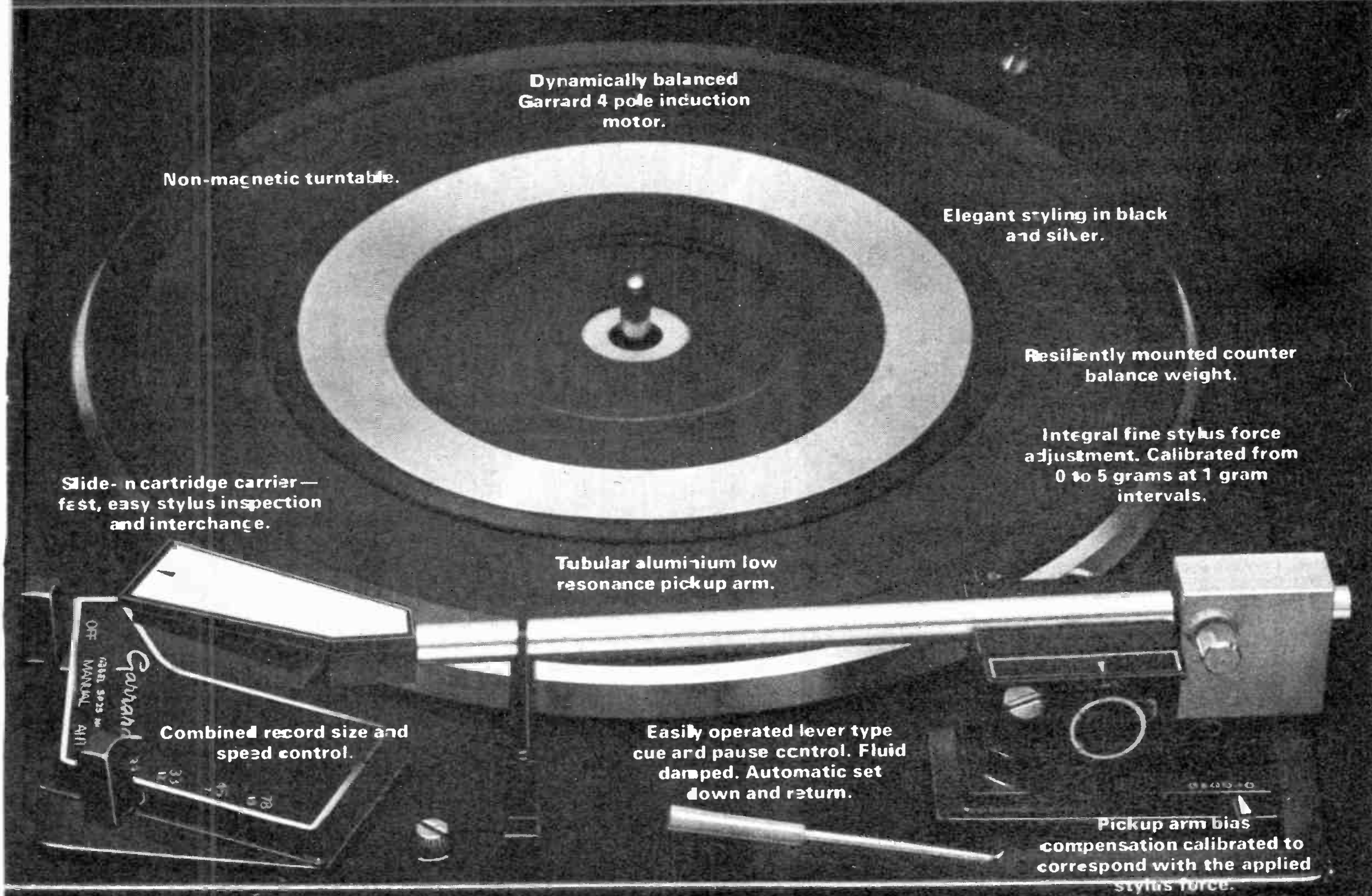
To be sure of good listening use your eyes



The SP25 Mk III single record playing unit has the facility for both automatic and manual play. Complying with DIN 45-500 standards, the SP25 Mk III offers the kind of precision engineering and sophisticated features found in far more expensive players. Superb quality at a budget price

It is just one of the large range of Garrard turntables that are products of Garrard's unsparing attitude to fine engineering and modern design. Which is why you'll find Garrard decks in television, radio and recording studios, where precision and reliability are vital.

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The Model SV 700ED Video Taperecorder— The newest addition to the Shibaden Range

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This remarkable capability permits intermittent recording or the electrical insertion of other programs to a pre-recorded program and can be easily performed without any disturbance.
The outstanding features of this new unit include a built in electronic editor which ensures noise-free editing. There is complete tape interchangeability which means that tapes recorded on one SV-700ED are fully playable on any other Shibaden SV series half-inch video taperecorder and on SV-800EC units. Still frame viewing for close inspection of a critical scene is possible and the automatic gain control system will eliminate troublesome level adjustment against variation of input levels for both the video and audio.
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Write today for a fully detailed brochure and price list of the SHIBADEN range.

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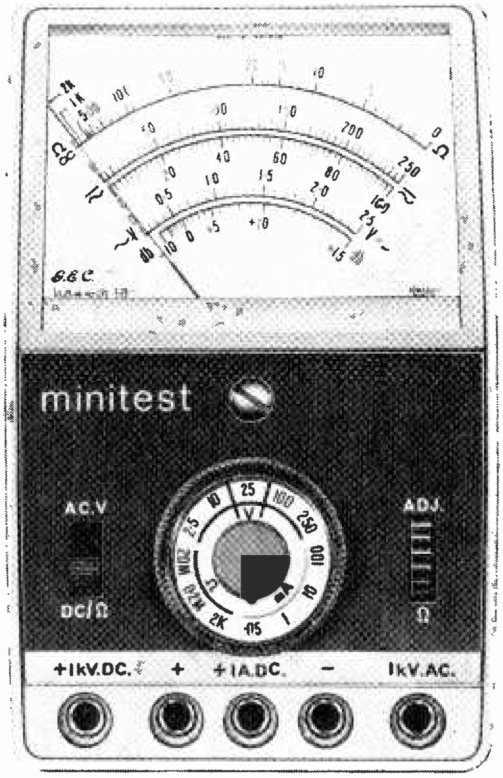
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ADJ.
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+
+1A.DC.
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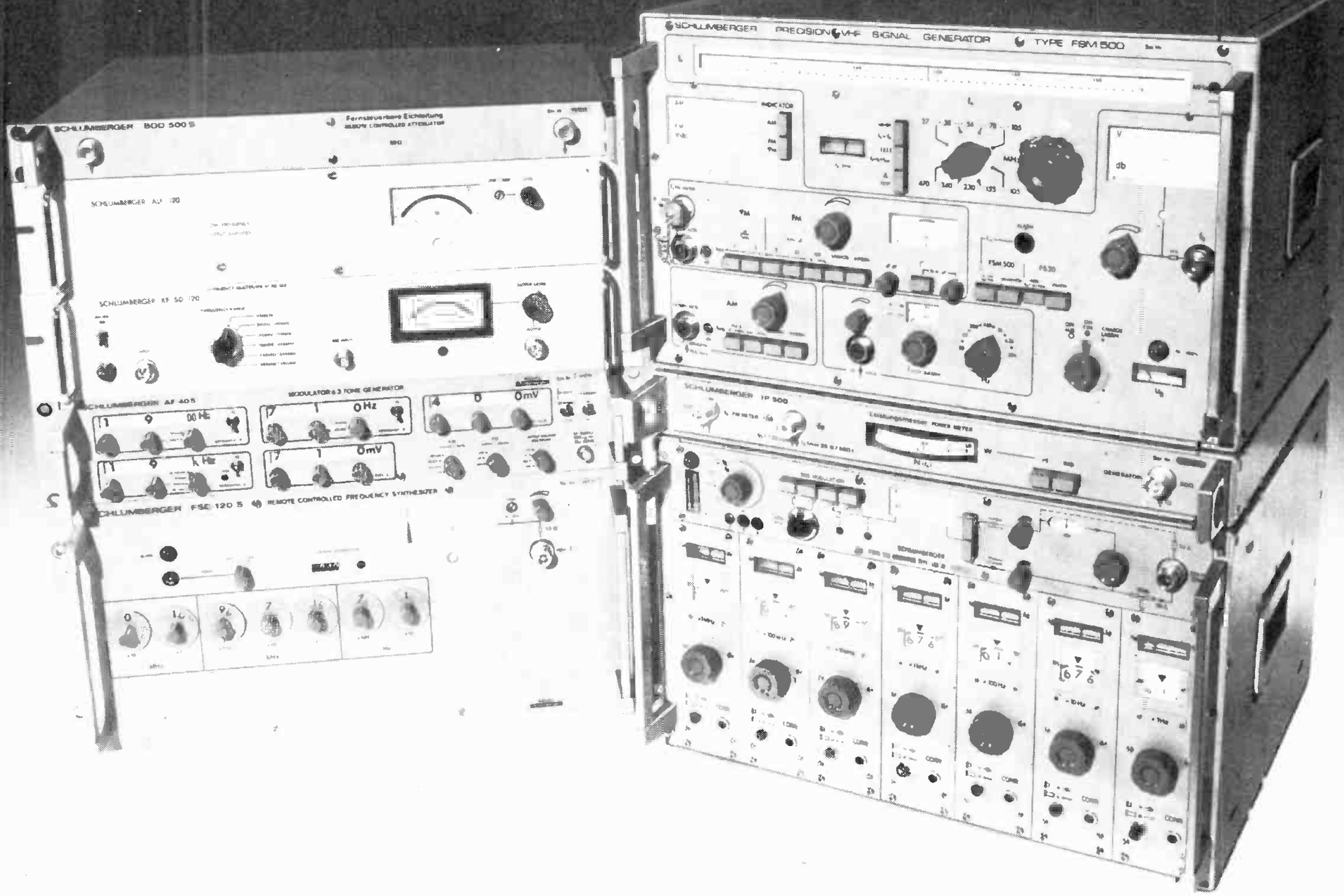

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Just look at these advantages:

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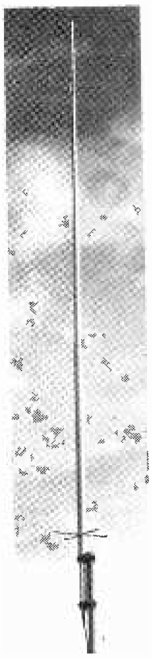

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DC300

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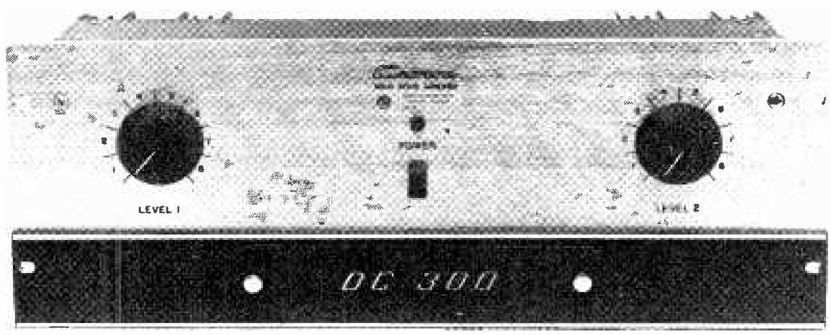

- ★ DC-Coupled throughout!
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- ★ 500 Watts RMS Mono.
- ★ 70 Volt Balanced line out!
- ★ UNEQUALLED QUALITY!
- ★ 3 YEAR PARTS WARRANTY!
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Frequency Response	±0.1db Zero-20KHz at 1 watt into 8 ohms, ±0.6db Zero-100KHz.
Phase Response	Less than 5° 0-10KHz.
Power Response	±1db Zero-20KHz at 150 watts RMS into 8 ohms.
Power at Clip Point	Typically 190 watts RMS into 8 ohms, 340 watts RMS into 4 ohms per channel.
Total Output (IHF)	Typically 420 watts RMS into 8 ohms, 800 watts RMS into 4 ohms.
T.H.D.	Better than 0.03% at 1KHz at 190 watts level.
I.M. Distortion (60-7KHz 4:1)	Less than 0.1% from 0.01 watt to 150 watts RMS into 8 ohms, typically below 0.05% (max 0.05%.
Damping Factor	Greater than 200 (Zero to 1KHZ into 8 ohms at 150 watts RMS).
Hum and Noise (20-20KHz)	100db below 150 watts RMS output (unweighted, typical 110db).
Slewing Rate	8 volts per micro-second. S-R is the maximum value of the first derivative of the output signal.
Dimensions	19in. standard rack mount (W.E. hole spacing), 7in. height, 9¾in. deep (from mounting surface).
Weight	40 pounds net weight.
Finish	Bright-anodized brushed-aluminium front-panel with black-anodized front extrusion, access door, and chassis.

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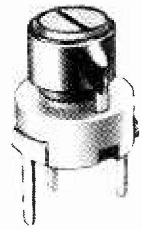

- 2 to 10pF capacitance range.
- P.T.F.E. (Fluorocarbon) Dielectric.
- Easy precise adjustment from above or below.

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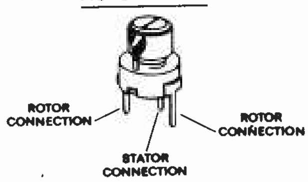
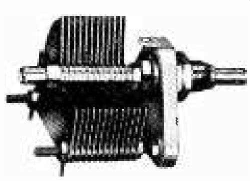


PLUS

- LOW COST.
- PRINTED CIRCUIT TAG FIXING.
- ONLY 8mm DIAMETER 12.7mm MAX. HEIGHT.

WAVEMASTER



'Wavemaster' variable capacitors have brass vanes and a single ceramic end plate. All have 0.248" spindles, extended both ends for ganging by means of our Universal Couplings. All are designed for S.W. working and for one hole fixing. 6mm spindles to order if required. Various capacitances. Largest vane packs 300 pF 0.017 air gap, 50 pF 0.64 air gap.

Type 95 S.L.C. Law Ball bearings, 7/16" dia. fixing bush. Front area 1 7/8" w. × 1 1/2" h.

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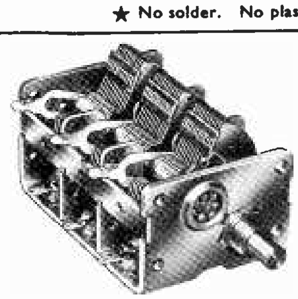

P.30 3-GANG and P.30 F.M. 3-GANG

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★ Trimmers 25pF swing 1.75 in. x 1.8 in. x 2.5 in.

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★ Gear ratio 3:1 or 1:1
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RESPONSE SELECTOR TYPE A 1888

A MUST IN ACOUSTICALLY DIFFICULT SITUATIONS SUCH AS CHURCHES, HALLS, THEATRES etc.

This unit, the result of three years research, can be built into a new, or added into an existing sound system and provides a simple but effective means of adjusting the overall response to suit the particular location.

Eight calibrated thumb wheel controls enable each section of the audio band to be adjusted to reduce troublesome building resonances etc., thereby allowing microphone levels to be increased before "howl back" occurs.

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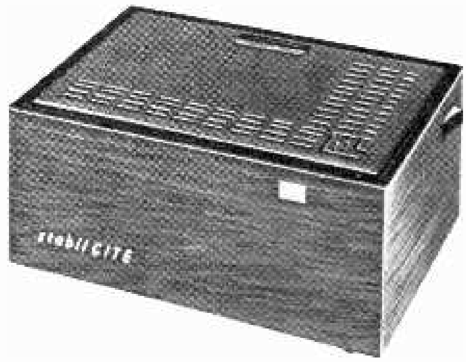

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audix

GRAPHIC EQUALISER Type 901

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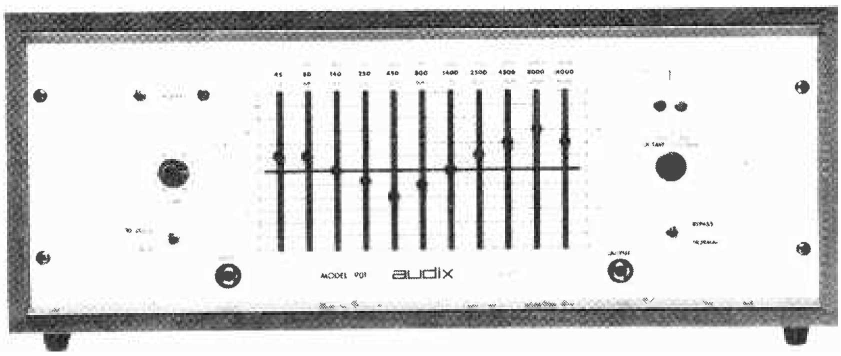
OUTPUT	OdBm into 600Ω floating from 40Ω source and 1Ω unbalanced at rear.
MAX. OUTPUT	+20 dBm.
NOISE	−80 dBm (unweighted).
GAIN	OdB adjustable ± 10dB.
FREQUENCY RESPONSE	Controls mid position ± 0.4dB 20Hz to 20KHz Controls at Max. or Min. ± 1.2dB 35Hz to 18kHz.
DISTORTION	Typical 0.01% at OdBm, out.
EQUALISER	± 12dB with 18dB headroom at maximum boost.
CENTRE FREQUENCIES	45 80 140 250 450 800 1400 2500 4500 8000 14000Hz with switched ± 0.3 of an octave on all frequencies effectively covering 37Hz to 17kHz in 33 bands.
CALIBRATION	Steps of 1dB. resolution 0.5dB.
FILTER	Switched: 3dB down at 30-20,000Hz.
TERMINATIONS	By standard Post Office jack terminations on front panel, also connected to screw terminations at rear.
POWER SUPPLY	110-120/220-240V 50-60Hz.



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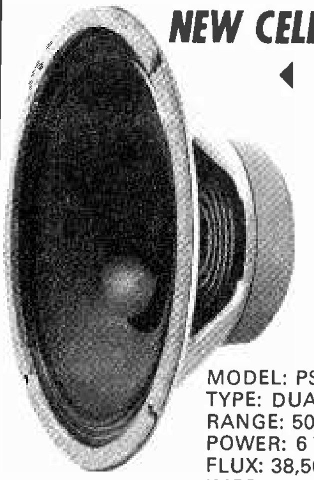

MODEL: PS12 TC 1798
TYPE: DUAL CONE 12″
RANGE: 40Hz - 12KHz
POWER: 20 WATTS RMS
FLUX: 128,000 MAXWELLS
IMPEDANCE: 15 or 4-8 OHMS
PRICE (R.R.P.) **£9·00**

MODEL: PS8 TC 9470
TYPE: DUAL CONE 8″
RANGE: 50Hz - 12·5KHz
POWER: 6 WATTS RMS
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** Both recommended for Unilex*

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RANGE: 40Hz - 8KHz
POWER: 25 WATTS RMS
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POWER: 30 WATTS RMS
FLUX: 180,000 MAXWELLS
IMPEDANCE: 8 or 15 OHMS
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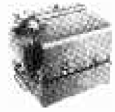

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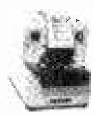

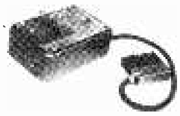

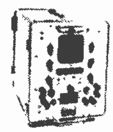

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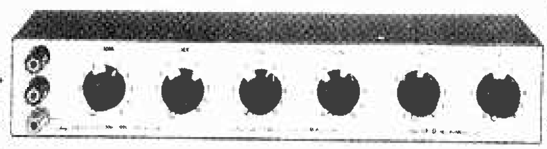
Hatfield will break your resistance



with their New inexpensive Resistance Decade Box type 2901 using metal film resistors that provide high accuracy over 6 decades with steps from 1Ω to 100KΩ.
Step accuracies are 0·1% on the 4 highest decades 0·2% on the 10Ω decade and 1% on the 1Ω decade.
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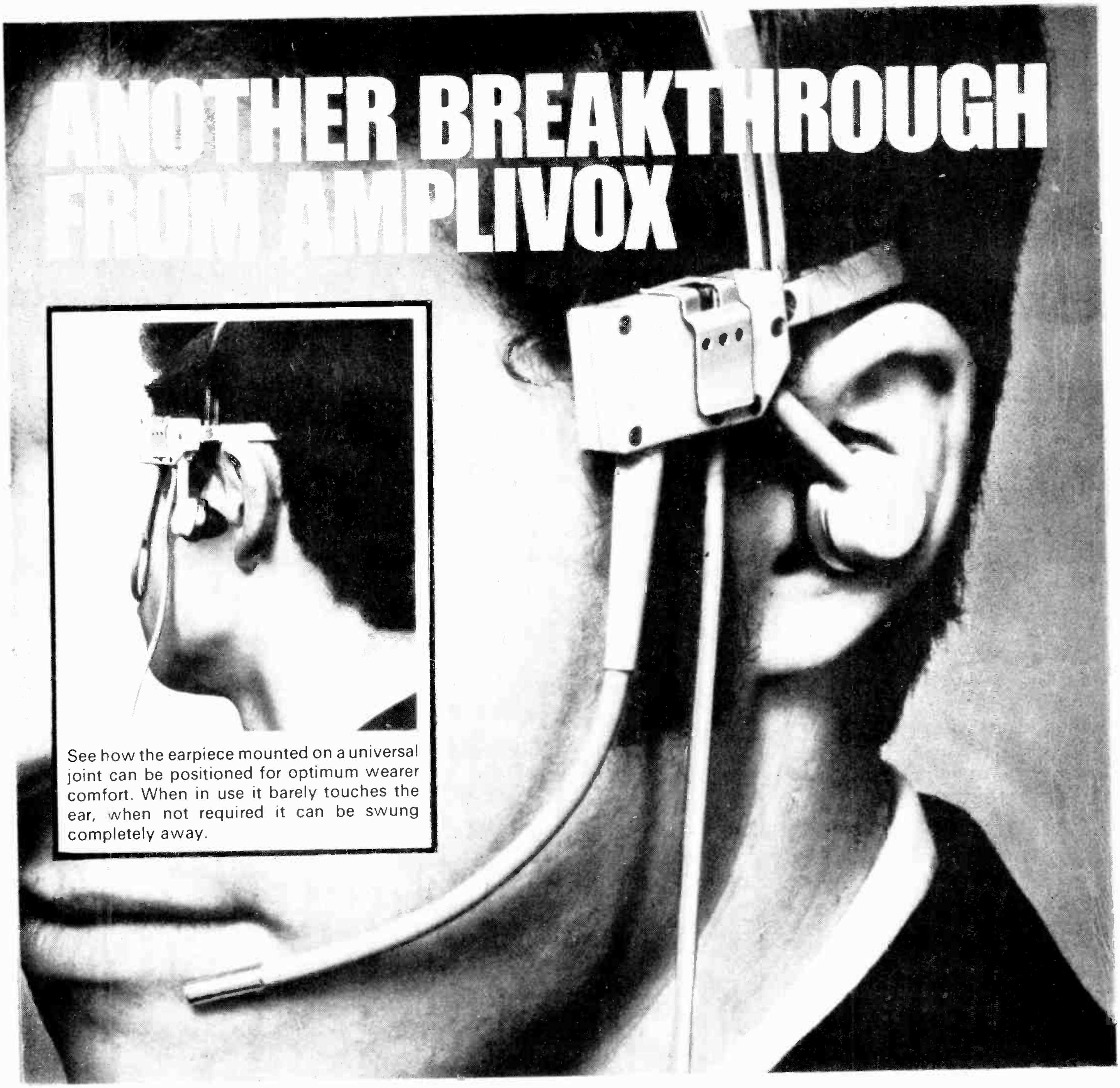

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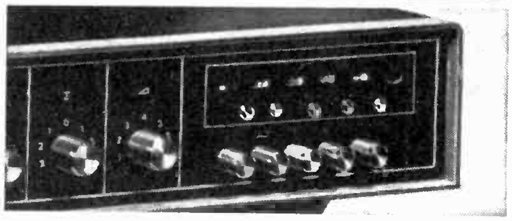

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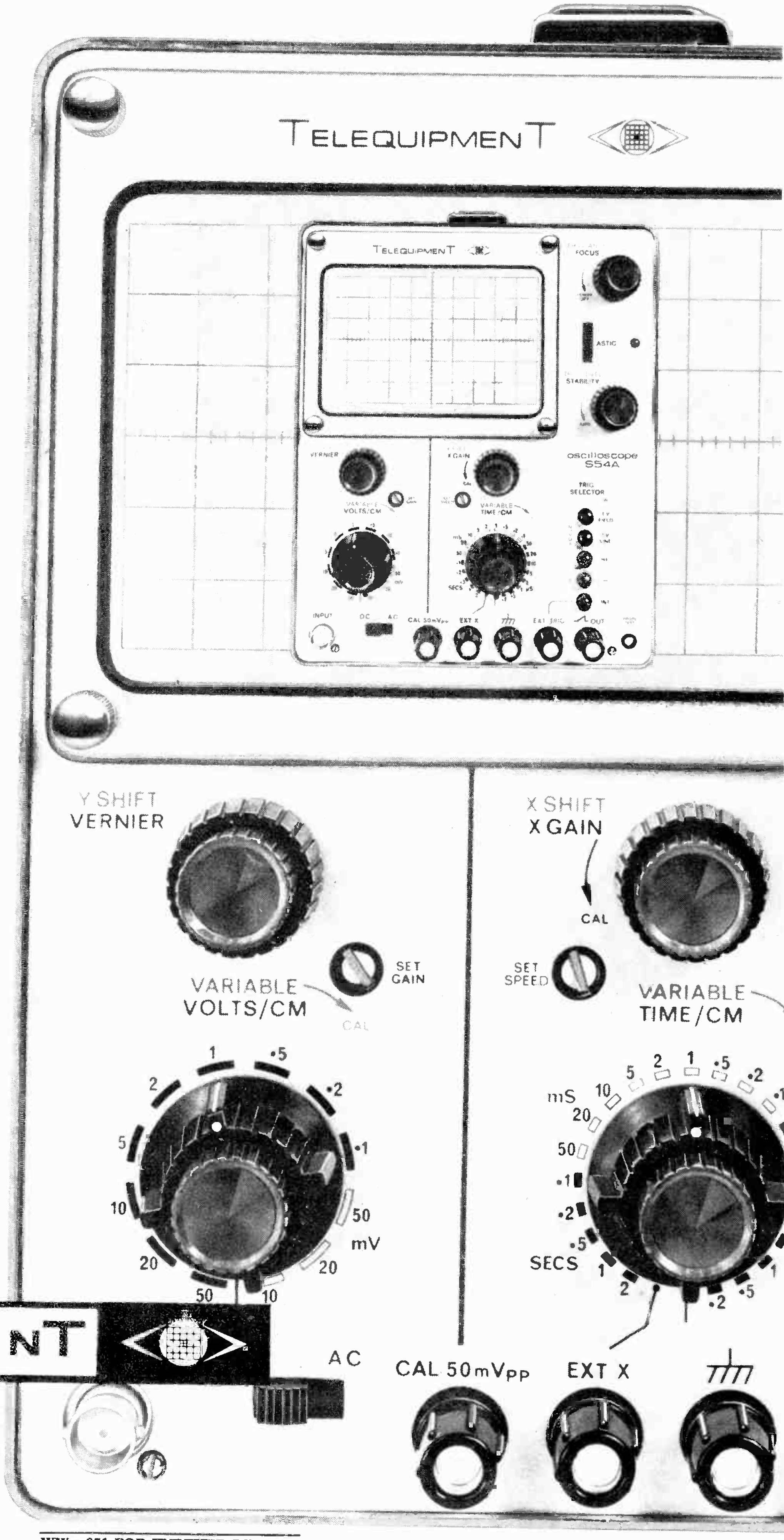

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Wireless World

Electronics, Television, Radio, Audio

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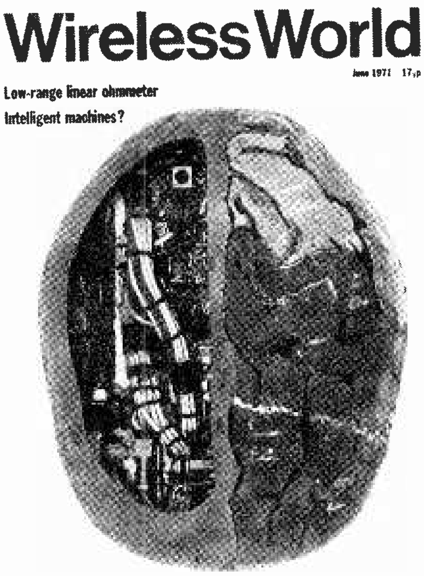

This month's cover. Not a design engineer who has let his work go to his head but our artist's design to illustrate the article in this issue 'In Search of Intelligent Machines'. The original cast (lent to us by the Royal College of Surgeons) shows the Broca areas of the brain.

IN OUR NEXT ISSUE

A high-performance s.s.b. receiver can be built by adding an aerial tuned circuit and a local oscillator to the **s.s.b. receiver module** using i.cs which will be described next month. A circuit for an oscillator for operation on 20m is included.

Audio sweep generator. A low-cost design using voltage-controlled f.e.ts in a Wien bridge oscillator. Sweep times of 0.1s, 4s or 40s can be selected.

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Elements of Linear Microcircuits *by T. D. Towers.* We regret that part 9 of this series has been held over until next month.

A99 APPOINTMENTS VACANT

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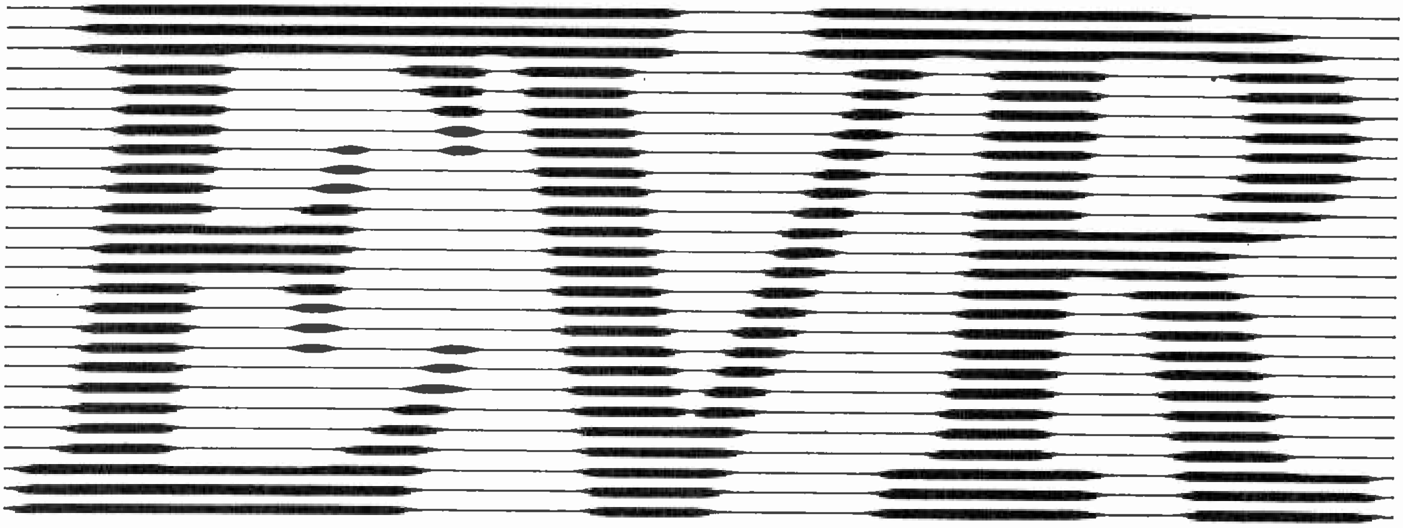

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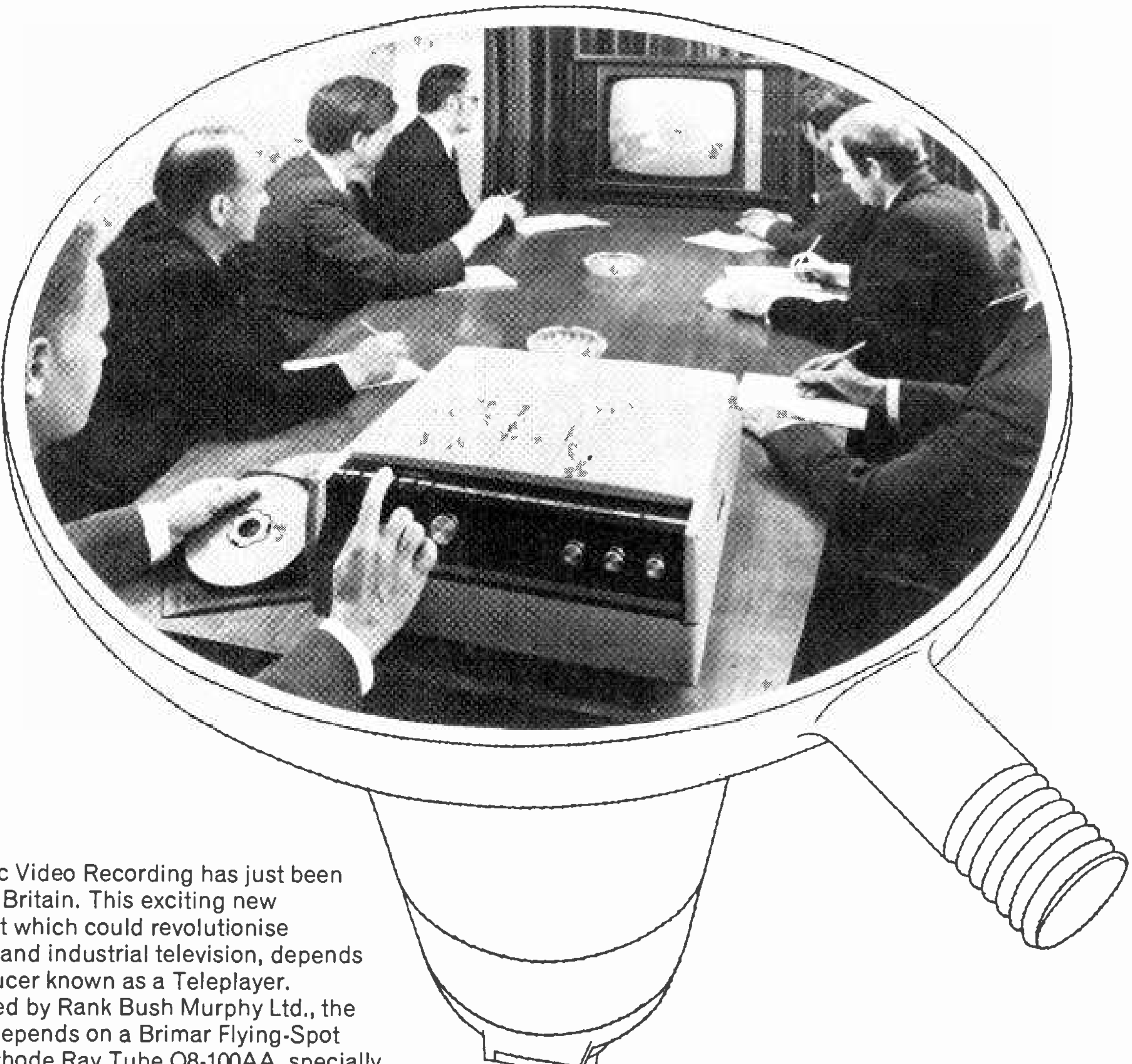

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Wireless World

Value for money in R & D

It has been suggested by Dr. F. E. Jones, managing director of Mullard, that the electron—discovered by J. J. Thomson 74 years ago—is an ageing particle and that although there is still tremendous momentum in the world's electronics industries we are now very much in an era when the chances of major technological advances are becoming much reduced. Despite this outlook there is still a vast sum of money being spent both by industry and the Government on electronics research. The big question is, are we getting value for money?

At a conference* in Liverpool a few months ago on the subject of value for money in R & D it was stated that "the rate of economic growth of Great Britain is quite out of keeping with the amount spent on R & D". Many figures have been published showing how unfavourably the U;K. compares with other countries in this respect. In terms of gross national product, for instance, the U.S.A. and the U.K. spend roughly the same proportion on R & D, but a forecast g.n.p. per head for 1975 is greater for the U.S.A. by a factor of 2.6. For Japan, which spends proportionately less than a half of the amount we in the U.K. spend, the forecast shows Japan will by then overtake us by a factor of 1.6. Even Italy, spending proportionately one ninth of our R & D expenditure will approximately equal the U.K. figure by 1975.

There are two areas concerned—curiosity-oriented R & D and economically-oriented R & D. The two are quite different and there is a tendency to write off the 'basic' research as a necessary investment for the future, mainly because it is difficult, if not impossible, to measure its effect, and to make the other economic in the sense that some measurable return is expected. Some argue that technology—in the sense of applied R & D, design, production—depends on science, that the one follows the other as part of a logical sequence.

Some of Britain's shortcomings in R & D are often put down to qualified manpower difficulties—loss of personnel to other countries, inadequate training and education, and a general shortage of the right kind of people. Some say this shortage arises because the system is not turning out what industry needs, others that many bright people tend to stay at university on curiosity research which means there are fewer available for applied R & D. Professor J. E. Flood, of Aston University, notes a lack of enthusiasm in industry for higher degree holders. He comments "if the enthusiasm of most of industry for M.Sc. courses is lukewarm the attitude to Ph. D. research in universities is almost hostile. Many firms place no value on Ph.D training and some even consider it positively harmful". This is in complete contrast to the U.S.A. where staff for R & D jobs usually have higher degrees, and Bell Telephone for instance recruit only physicists and chemists with Ph.D. degrees. They recruit engineers with first degrees only if they agree to take a master's degree course. There is a widespread feeling that university courses do not relate to the problems of the real world. And there does seem a good case for equipping people with the necessary abilities to handle real problems, to communicate and to work with others. Many feel there is a strong case for a critical look at the Ph.D. mill.

To return to the question of value for money, analysis of a large number of technically based companies producing complex systems showed, according to J. R. Pollard of Plessey Telecommunications, that to spend below 4% of turnover on R & D "is likely to be insufficient to support reasonable company expansion in a technically fairly demanding environment and expenditure in excess of 12% is likely to be unremunerative in the sense of producing comparable profits in the future".

But whatever proportion is spent, it can be argued that a company should be *increasing* R & D expenditure when earnings per employee fall, and not the converse. It does seem reasonable to suppose that when efficiency falls, something must be increased to maintain the situation. Taking this argument to its logical conclusion suggests that because Britain is less efficient than other countries, spending on R & D should be proportionately greater to offset this. So how do we square this with expected future cuts in R & D spending?

* 'Research and Development in Electronics—Value for Money', I.E.E.

The Search for Intelligent Machines

Do we want them, and can we build them?

by R. Baker, B.Sc., M.Sc.*

The basic ideas of logic circuits have by now diffused throughout the electrical engineering world. An ever-increasing number of digital systems, made up from these logic circuits, are finding applications in almost every aspect of modern life. Sometimes special-purpose digital machines are adequate; in other cases the versatility of the digital computer is needed. But, tremendously useful as these machines are, they do have some very distinct limitations. These arise out of the fact that everything that a digital machine can do must be carefully worked out beforehand, and this must be built into the machine by the designer or fed in by computer programmers. Because everything must be planned in this way the data which are to be processed must be presented to the machine in a very well-organized manner. In practice this means that if a machine is to be connected 'on-line', then it must be connected only to very 'tidy', well organized systems. Unfortunately that rules out the majority of real-life problems, because in these the data are more-or-less disorganized. Problems of this kind are still solved (or more often, left unsolved) by human operators. Alternatively the data can be carefully sifted by data-preparation staff. And in any case human designers and programmers are still needed to tell the machine how to solve each kind of problem. With the ever-increasing demand for data-processing, and new faster computer circuits, the human operators are rapidly becoming the weak links in the system. To help improve this situation work is in progress towards getting better man/machine communication; for example, by using programming languages which are more like everyday language, and by using interactive computer graphics. At the same time as this work has been going on, various research workers have been playing a very long shot, in the same general direction. They are assuming that at some time in the future it may be possible to build machines that act intelligently. This will be in distinct contrast with today's generation of machines.

Deep waters

The reader may have noticed that we have got into very deep waters, almost without noticing. Just how deep will be apparent when we remember that the description 'intelligent' has traditionally been reserved for human beings, and more recently to some animals. We are making a complete break with tradition when we take the description over to non-living systems. We shall have to produce a good case for doing so, and we shall have to be very careful how we do it. Even when applied only to humans, the term 'intelligence' is embarrassingly hard to define or describe, as educationists are acutely aware.

If we want to carry over the idea of intelligence from man to machine, we shall do best to define human intelligence in terms of what a person *does* in a difficult situation —how he reacts to problems. By considering intelligence in this active way, we can take the idea over to machines quite easily, because we can talk about how machines would *react* to problems. If we can design a machine to react to a range of problems in the same way that an intelligent person would, we should not say the machine is unintelligent (at least not if it's listening). So far as human intelligence is measured, we generally try to disregard routine skills, however impressive; we are more looking for things like the ability to spot regularities in apparently confused situations, to learn from experience, and generally to take on a wide range of problems even if we have not been taught how to deal with them. Presumably we are looking for the same capabilities from intelligent machines, and that rules out machines such as fixed programme computers with their routine skills, but leads towards pattern recognizing and other adaptive machines.

The hope is that 'intelligent' machines would be able to organize their own input data, and be able to look for their own solutions to problems. If such machines can ever be produced, not only will they be able to take over a whole new range of practical tasks, but they may also give us a clearer idea of our own mental processes. One hopes, too, that they would be able to attempt some of the problems which still baffle human beings. On the other hand we must not overlook the fact that (as has happened with many other worthwhile discoveries) they may be used for anti-social purposes. Nor can we completely disregard those who claim that we are wasting our time trying to make intelligent machines. 'Intelligence' they say 'is the prerogative of the human brain; and that has capabilities which go beyond anything a machine could do'. Of course they may be right, but we are not going to find out by giving up before we start. Although we are not even within sight of making intelligent machines, a modest start has been made, and research is continuing. The name of studies leading in this direction is 'artificial intelligence' or 'machine intelligence'.

Which way to intelligent machines?

There are two schools of thought on how we ought to set about making intelligent machines. Both of them are based on the idea that we should try to get as much information as we can from the working of real brains. We could call the first approach the *software* approach; the idea is to use conventional computers with programmes which make them act intelligently. The proponents of this method point out that we know little of the precise operation of brain cells, or of how they are actually connected to make a working system. So instead of trying to copy something we don't understand anyway, we will do better to use conventional computers, which we do understand; then try to programme them to act intelligently, using any observations we can of our own and other people's mental processes. On this basis a start has been made in getting computers to reproduce some simple aspects of intelligent behaviour. The sort of things computers are doing is controlling a robot vehicle which learns to find its way around in an obstacle-filled room, and being able to recognize and manipulate objects when seen from different angles and distances. More formal tasks include proving theorems in logic and mathematics, and of course playing a good game of chess.

The other approach, which is going to receive more attention in this article, is through the use of so-called adaptive logic. According to the proponents of this approach we have a better chance of getting a 'brainlike' machine if we make at least some attempt to build it with circuits copied from brain cells. In particular, if an intelligent machine is to operate in real-life situations it will have to get visual information about them through TV cameras or the like. Now these visual signals are

*Twickenham College of Technology.

characterized by large amounts of parallel data, much of it redundant or even downright misleading. This will demand parallel arrays of logic circuits acting as pattern-recognizers. Being able to respond to spoken and written information will also be a big help, and these are also recognition tasks. (Digital computers approach jobs in an essentially step-by-step method, and this serial working is going to be slow and inefficient).

What are we trying to copy?

The human brain appears to be made up from about 10^{10} inter-connected nerve cells or neurons. These neurons come in many shapes and sizes, and Fig. 1 shows some of the main features of a typical example. On the left are the input branches, of which there may be many thousands; these are called dendrites. These merge into the central body (or soma) of the cell. From this comes the relatively long axon. Very complex chemical and electrical processes take place within the neuron, and these are not yet fully understood. Streams of low-level electrical pulses can be detected passing through the neurons. These pulses appear to convey pulse-rate-modulated information. It is presumed that the neurons are acting as data-processing elements (virtually logic elements) to this information. The dendrites collect pulses from previous stages, and after some attenuation these arrive at the soma. Here they are summed up (across the inputs and over short periods of time). If this combined sum exceeds a certain threshold value, the soma generates a pulse which travels down the axon, which distributes it to following stages. The neuron is ready to fire again after a short recovery period. Connections between stages are made through small structures called synapses which form junctions between axons and dendrites. It is thought that these synapses might be modifying the performance of the neurons by acting as variable-gain devices. Some of the neuron inputs are actually inhibitory, and signals on these reduce the neuron's sensitivity. Quite a lot of effort has been devoted in the past to designing circuits which exactly reproduce the electrical characteristics of neurons. But so much hardware is taken up reproducing just one neuron like this that it is hardly practical to test large networks, which is really the aim of the operation.

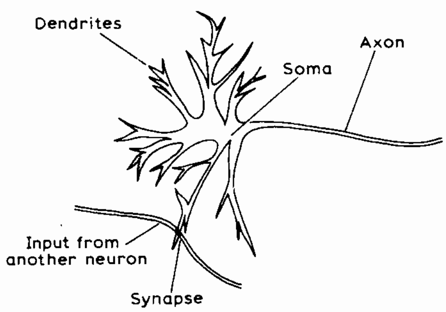

Fig. 1. A typical neuron showing connection with another neuron at a synapse.

Simplified models

What must be done is to produce a very much simplified electronic model of the neuron, and hope that even after this simplification some of the neuron's essential data processing properties will remain. If we conveniently forget the time-factor in the summing process, and replace the modulated pulses with binary signals, we find ourselves with an ordinary threshold logic gate. Such a gate is shown in Fig. 2; for the sake of symmetry the logic levels are set at +1 and −1. The performance of the gate can be adjusted by altering the amplifier gains a_1, a_2 etc. through the range $x(+1)$ to $x(-1)$. The threshold level T can also be altered. The output switches if:

$$a_1.I_1 + a_2.I_2 + \ldots . \geqslant T$$

Because the gate performance can be changed or adapted just by altering certain parameters, it is an example of adaptive logic.

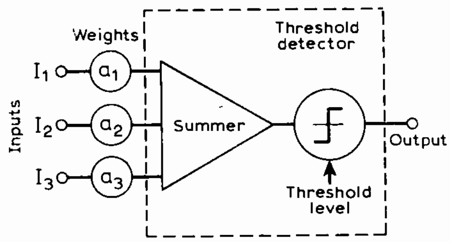

Fig. 2. Threshold gate.

The first breakthrough in this direction was made in 1943 by McCulloch and Pitts. They were able to prove theoretically that virtually any logical or mathematical function could be produced by a suitable network of simple threshold gates. Their classic paper marked the beginning of an era. But it left unsolved the problems of actually designing and constructing networks to carry out useful tasks.

One of the early attempts to build a useful system was the Perceptron, described in 1958 by Frank Rosenblatt. This was a pattern-recognizing device based on the supposed nerve connections coming from the eye. An input pattern was projected onto an array of photocells. Each photocell had the output +1 or −1, depending on whether or not it is illuminated. This matrix fed a 'preprocessor', consisting of a parallel array of threshold gates with fixed weights of +1 or −1. This array fed a single, adaptive output gate, consisting of a threshold gate with variable weights. The idea will be explained by a simple Perceptron which is shown in Fig. 3. This simple Perceptron is to be taught to distinguish between two patterns. Each preprocessor gate sees a small random portion of the matrix. The two patterns are shown alternately. Some of the gates will switch over when the patterns change; we could call these 'useful' gates. Others will remain in one state; these are 'useless' in discriminating between the patterns. The Perceptron is now trained to distinguish the patterns by adapting the gains (weights) of the output gate. The gains in the paths from 'useful' gates are turned up; the 'useless' gates are shut out by turning the corresponding gains towards zero. The gains are adjusted automatically during this training phase. After training, the Perceptron is able to respond also to patterns which are slightly different from the training patterns. This valuable property is called generalization. (This is essential, if distorted or 'noisy' versions of the pattern are to be recognized.) Much more complicated Perceptrons are possible, and they give correspondingly more sophisticated performance. But there are two basic weaknesses in the Perceptron concept. The fixed preprocessing layer may actually tend to disorganize the input data. Also it is quite possible that for a given problem, all the preprocessor gates might happen to be 'useless'. Since the preprocessor logic is fixed, the Perceptron will fail in this case.

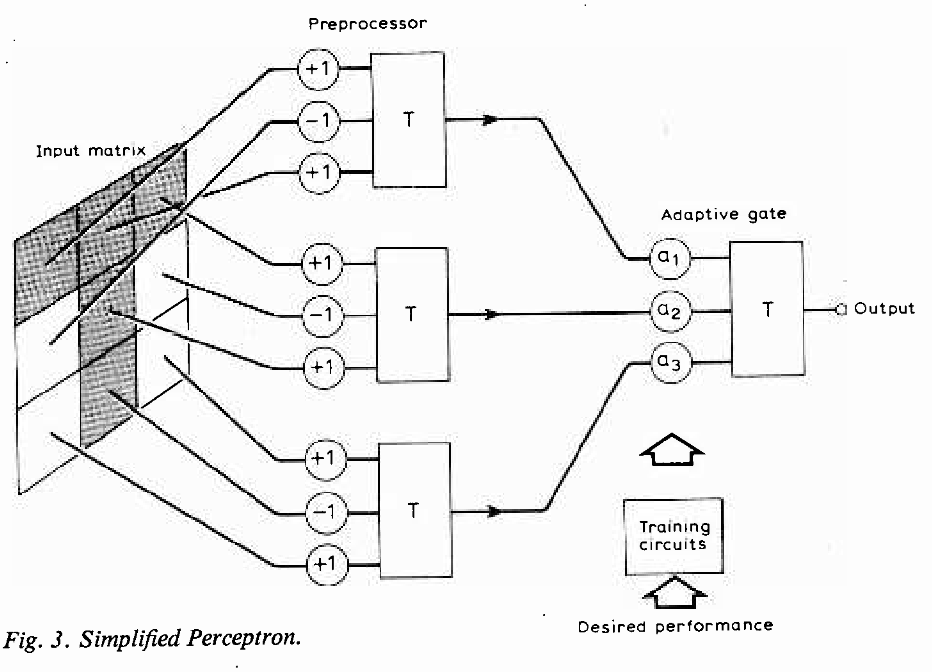

Fig. 3. Simplified Perceptron.

Adeline and Madeline

The problems of the preprocessor were solved by drastic surgery. The fixed logic was eliminated, and the adaptive gate was connected directly to the input pattern. Even the threshold level was made adaptive. Adeline (adaptive linear neuron), devised by Bernard Widrow, works this way. And to obtain better performance, parallel arrays of Adelines were set up, giving Madelines (multiple Adelines). Madeline arrays have been tested, with some degree of success, on a range of problems including speech recognition, weather forecasting, electrocardiogram analysis, and dynamic control.

Having got this far, we should look at the circuit problems involved in actually building an adaptive threshold gate. The logic is straightforward; it is the weights which pose an unpleasant problem. We need either a variable-gain amplifier or else an electronically variable resistor; the snag is that the gain or resistance-value must be stored between adjustments. The first solution, used in the Perceptrons and similar systems, was a motor-driven potentiometer. But this of course gives a bulky, unreliable and expensive system. More recent devices have employed magnetic components. The signal is modulated at r.f. and put through a transformer. The transformer output is adjusted by varying the magnetization of the core, using control windings. Another useful device is the Memistor. This consists of a metal film resistor immersed in electrolyte. Its resistance is varied by plating on or off it, via a third electrode. But to simulate large nerve networks we need a reliable, compact and cheap adaptive circuit. And systems containing vast numbers of analogue storage devices do not look too promising at present. If only we could use purely digital circuits we could take full advantage of modern micro-electronics techniques.

Breaking away from threshold circuits

To get clear of these rather unsatisfactory analogue storage devices, Igor Aleksander decided to make a clean break with the threshold gate model of the neuron. Instead, in 1966 he proposed a completely digital model, based on a 'universal gate'. Now any logic circuit can be specified by its truth table. An ordinary logic circuit has just one truth table. But a universal gate can be adjusted to have *any* truth table. By supplying extra circuitry to set up a truth table to suit the task in hand we get an adaptive universal gate. Although universal gates are farther away from the observed performance of neurons than are threshold gates, this is compensated by the fact that universal gates are much more general. (A universal gate can give any Boolean function of its inputs, but a threshold gate can give only a small fraction of all those possible.) Fig. 4 shows a universal element with two inputs. An AND gate is provided corresponding with each possible entry in the truth table. Connecting the AND gate gives a '1' in the corresponding line of the truth table; disconnecting it gives a '0'. For simplicity, links are shown for these connections. In practice electronic switching circuits are used. In Aleksander's SLAM (stored logic adaptive module), the AND gates are switched in or out of service according to the states of storage bistables. The states of these bistables are actually set up during a training session. This consists of showing the SLAM some typical examples of the patterns it is to recognize, at the same time energizing a 'teach' terminal. Afterwards it responds to the training patterns, even without the 'teach' signal. In practice parallel arrays of SLAMs were used, and these have generalizing properties. For example, after being trained with some typical examples of a handwritten letter, SLAM arrays can recognize slightly different versions of the letter, which they have not seen before.

Feedback of data is known to be a feature of brain activity. Now Dr. Aleksander has incorporated it into SLAM arrays. Binary patterns are shown to SLAM arrays and the resulting transformed patterns are delayed and fed back to the input. This has led to improved recognition. Some quite new properties have also come out. These include a short-term memory of patterns seen previously, the ability to recognize sequences of patterns, and the ability to give attention to certain situations. SLAM circuits are in fact available from Integrated Photomatrix Ltd.

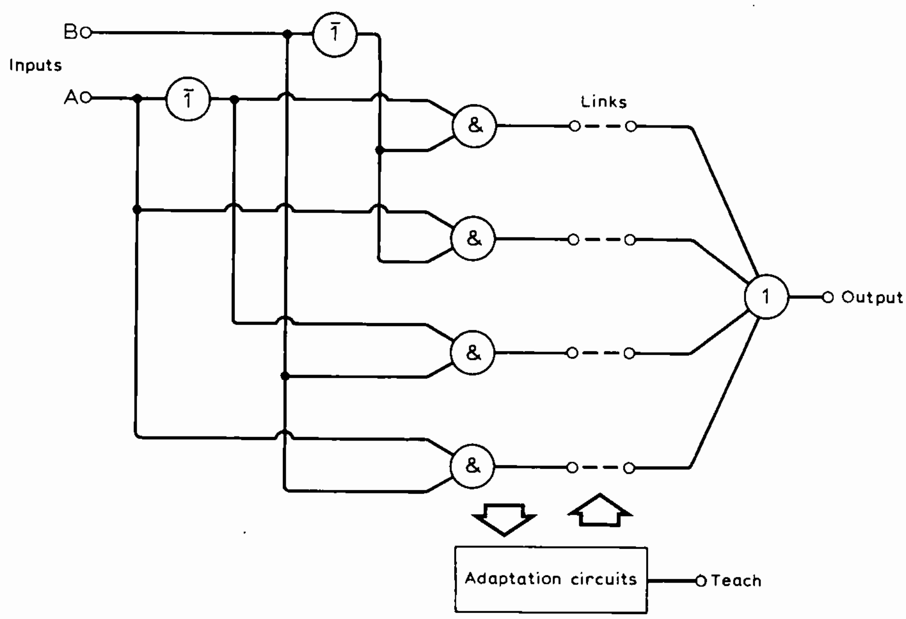

Fig. 4. Universal gate with adaptation circuits.

Improved performance through evolution?

The work described so far concerns attempts to model brain activity using special computer programmes, or by arrays of adaptive logic circuits. The design of these models is obtained by a combination of analysis, experimentation and intuition. But nature, using none of these methods, has achieved vastly more spectacular results. Nature's method has led from simple one-celled organisms right through to that sophisticated specimen, *homo sapiens*. This method is evolution, and its essential features are supposed to be the generation of random variations in offspring, together with a process described as 'survival of the fittest'. It is obviously a very powerful method, but equally clearly it is very slow. Could we simulate evolution electronically, so as to get some of the advantages, but within a reasonable time-scale? According to Laurence Fogel and his colleagues the answer is 'yes'. According to Fogel, the mark of an intelligent being is the ability to look at the past states of a real-life system and from that to predict a future state. If we code these states into a sequence of numbers, we are looking for a machine which after being shown a number-sequence will output a predicted future term in the series. Fogel used computer-simulated sequential logic machines to attempt these predictions. (Sequential machines are made up from logic gates and delay elements.) The states and connections of the machines were randomly modified, one at a time, simulating mutation. The modified machines were either retained or destroyed, depending on whether the modification gave improved prediction. Presumably the effectiveness of the method on real systems will depend on just how successfully a system can be modelled by a sequential machine.

The author has also proposed an evolutionary machine, but this time using an array of universal gates made up in hardware. It was tested on a simulated vehicle-routeing problem. The idea was to simulate in a simple way the two-fold adaptation which goes on in nature. Learning processes in an individual correspond to short-term adaptation. The evolution of a species is a long-term adaptive process. In the author's system short-term adaptation was simulated by systematically modifying the universal gates. Evolution was simulated by randomly inserting extra gates into the array, retaining only those which gave improved system performance.

The future

This brief guided tour will indicate that 'artificial intelligence' is still in its infancy. A number of quite different approaches have been investigated, and in some of these useful progress has been made. And research continues. The results are certainly not spectacular. The search for intelligent machines will be long and difficult, but it presents a unique and fascinating challenge.

Finally, in fairness to the researchers past and present in this field, the author points out that the work of only a few has been described, and that only briefly. For those who want to read further, the first book listed below is a very digestible text covering the work on Perceptrons, Madelines and much else and the second a good introduction to SLAM circuits.

Further reading

A. J. Cote Jr. "The search for the robots". Basic Books Inc. 1967.

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W. S. McCulloch & W. Pitts: "A logical calculus of the ideas immanent in nervous activity", *Bulletin of Mathematics and Biophysics*, 1943, 5, pp.115-134.

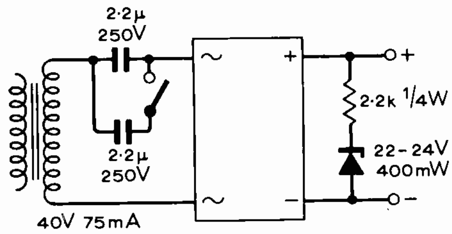
F. Rosenblatt: "A comparison of several Perceptron models in self organising systems", ed. M. C. Yovitz, (Spartan Books, 1962).

B. Widrow & others: "Practical applications for adaptive data-processing systems", *Revue A*, 1968, X, pp.27-38.

Circuit Ideas

Dry cell charger

The circuit shown has proved suitable for charging dry cells. It is pointless (and dangerous) to attempt to charge cells



22mA into 18V } (HP7, VT4 etc.)
27mA " 6V

or

44mA into 18V } (SP11, VT9 etc.)
54mA " 6V

which have discharged over several months. The charge lost (+10%) should ideally be replaced immediately, but weekly topping up is satisfactory. The necessary conditions for recharge are thus like those for lead-acid accumulators. The 2.2μF polyester capacitors act as current limiters. This charger can be used for batteries up to 18V.

K. W. MAWSON,
Bradford.

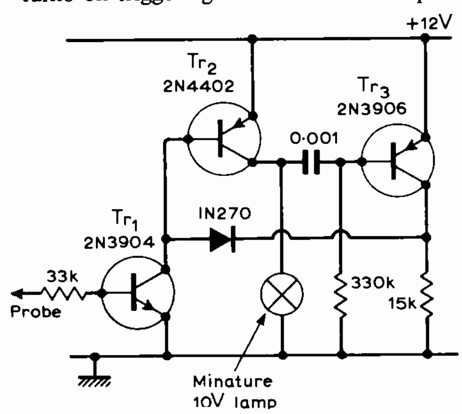
Multivibrator with switched mark ratios

The circuit shown below was devised to provide a multivibrator which can have its mark period varied in fixed ratios (here 1:3:5:7:9) by a switch S_1, whilst allowing for variation of the absolute periods (by R_2) without upsetting these ratios. This idea has been used in a multivibrator also incorporating a previous circuit idea ('Large space-mark ratio multivibrator', K. D. Cliff, April 1969), and in which the 'space' periods are also variable. The circuit formed the heart of a windscreen wiper control. Intermittent operation of 1, 2, 3, 4 or 5 wipes can be selected by S_1. The 100μF capacitor C_1 was added to provide the unbalance needed to start the multivibrator at switch-on.

J. H. J. DAWSON,
Sheffield.

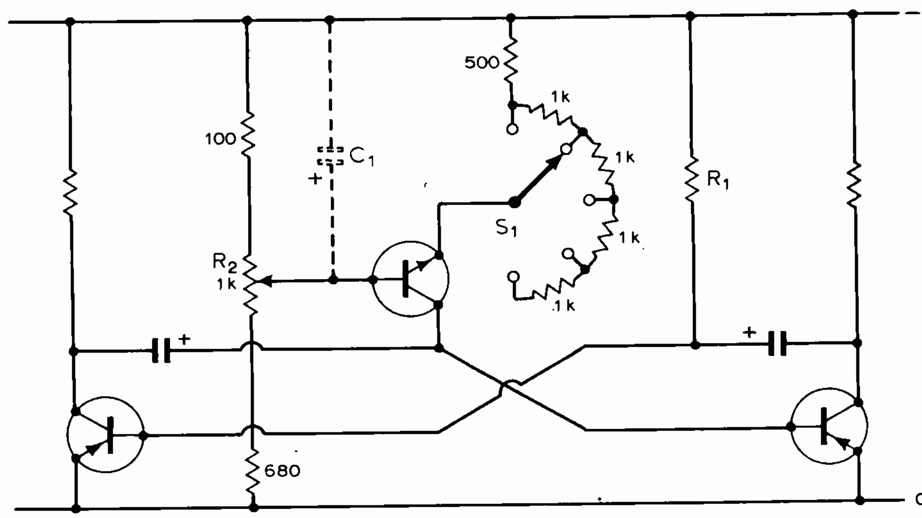
Pulse and voltage level indicator

Trouble-shooting a board holding many digital i.cs is tedious when using a 'scope and probe. The simple circuit shown here lights up a bulb when a pulse or a level above 0.7V is found. The input impedance is high and there is no significant loading of normal digital circuits. A level detector Tr_1 has the same threshold (0.7V) as r.t.l. logic 1. If this level is exceeded Tr_1 turns on triggering a 1 ms monostable pair



(Tr_2 and Tr_3) lighting the lamp momentarily. Steady inputs above 0.7V hold the lamp on. The circuit can be housed in ⅜in diameter plastic tube with a probe attached.

J. M. FIRTH,
Ottawa.



Alternatives to the Teleprinter

A survey of noiseless high-speed methods

by D. A. Paynter, M.I.E.E., M.I.E.R.E.*

The teleprinter has been a familiar device as a communication terminal for a long time. It is an electrical typewriter in which a pulse code decides which character should be printed. Decoding and type actuation is electro-mechanical, giving rise to considerable noise in operation. A typical operating speed is 10 characters per second although machines operating at higher speeds are available.

Recently 'electronic' teleprinters have appeared. In these decoding is performed by solid-state electronic circuits in place of moving parts. The printing process however still involves impacting a type face against paper with its attendant limitations of speed and noisy operation.

In addition to its use as a communication terminal, the teleprinter is finding an increasing application as a computer peripheral and the conventional teleprinter is now commonplace as a man-machine interface connected over a telephone line to a central processor. When used as a print-out connected directly to a computer, the machine takes the form of a line printer in which a number of characters can be printed simultaneously at speeds approaching 1,000 lines per minute. This is slow compared with the capability of the computer, resulting in the total processing time being limited by the printer speed.

The teleprinter used for communication purposes is also slow compared with the information rate which could be transmitted over telephone lines, so there is a potential need for a machine with greater speed capability. If this can be achieved together with an improvement in reliability and reduction in noise level so much the better. If the mechanical printing action could be replaced by some non-mechanical process, higher speeds and quieter operation become a possibility and it is interesting to consider how printing can be performed without a mechanical printing process.

Photographic methods

If an image of a character is projected onto a light-sensitive emulsion, subsequent development results in a permanent visual record of the character. This is exploited in photo-typesetting machines in which the 'fount' consists of a disc containing within its periphery transparent images of the characters required. The required character is selected by rotating the disc until the character is positioned behind a projection system which produces the image on the photo-sensitive emulsion.†

The disc can be replaced by a cathode-ray tube on which visual images can be formed. The use of silver halide photographic material for teleprinter copy would however be prohibitively expensive and a more economic solution is to use xerography[1] which has a familiar application in office copying-machines. In this process a selenium-coated drum is electrostatically charged in darkness by corona discharge. A visual image is projected onto the drum. The resistivity of selenium varies with the amount of light falling upon it and in consequence the charge leaks away in the bright portions of the image. A latent electrostatic image is accordingly formed on the surface of the drum. An electrostatically charged toner powder is then applied to the drum adhering to the charge areas and making the image visible. The powder image is next transferred to paper and fixed by melting a resin contained in the toner powder.

A variation of this process uses paper coated by zinc oxide[2]. The zinc oxide functions in a similar way to the selenium drum and enables the image to be formed directly on the paper and eliminates the transfer process between the drum and the paper. A simpler machine is therefore possible but with the penalty of a requirement for special paper.

Printers in which the characters are formed on the surface of a cathode-ray tube and printed by the photographic methods described are too elaborate and expensive to be seriously considered as an alternative to the teleprinter.

Electrostatics

The examples considered so far entail creation of a visual image before the electrostatic image can be produced. Processes have been invented in which the intermediate light stage has been eliminated. In one case the screen of a cathode-ray tube is replaced by a line or matrix of closely spaced pins which conduct the electrons from the beams through the glass onto the surface of paper bearing an insulating coating. If characters are formed on the face of the tube in a conventional way an electrostatic image is formed on the coated paper and this can be made visible with powder as before. Although the optics of the previous system have been eliminated the tube is expensive and machines using this system have found only limited application.

If a high voltage is applied between two electrodes separated by an air gap, one of which is pointed, a steam of ions will pass across the gap (Fig. 1). If dielectric coated paper is now placed between the electrodes a charge will be deposited on the dielectric. This phenomena can be used to create an electrostatic image of a character on paper. The paper can be arranged to travel under a row of closely spaced pins situated at right-angles to the direction of paper travel. The incoming message in the form of a pulse code is first stored line-by-line in a memory. From this stored information the necessary pulses are derived to produce lines of electrostatic characters which are subsequently processed to become visible.

Machines are available based on this principle but with the variation of a print head actually contacting the paper coating. The voltages needed to print are lower than those required with ionization printing.

The memory can be eliminated if the characters are actually printed character-by-character. This can be achieved by

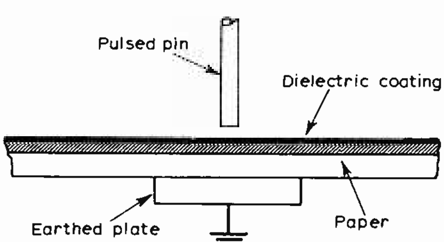


Fig. 1. Electrostatic printing can be achieved by applying an electric field across dielectric coated paper.

† See for instance 'Electronics in typesetting' by R. F. Southall *Wireless World*, March 1968 pp. 34-7.

* Research Division, Marconi Co. Ltd.

using a matrix of pins situated above the paper at each character position. The incoming code is processed by a translator which energizes appropriate pins of each matrix in turn to form the character. Fig. 2 shows a stack of four such heads each consisting of a matrix of 5 × 7 pins of 25-μm diameter on 25-μm centres.

Fig. 3 shows a message printed at the rate of 500 characters a second on an experimental electrostatic tape printer. The paper tape is transported at 125cm a second in contact with a backing electrode and separated from the printing head by 25 to 50μm. The voltage is applied to the appropriate pins in the form of 30-μs pulses, which means that printing can take place on continuously moving paper. In the page-printer form 60 heads similar to that illustrated would be situated across the width of the paper, each head being energized in turn to print sequentially across the paper.

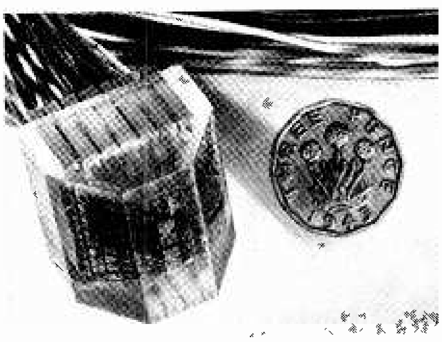


Fig. 2. In the electrostatic method, a matrix of pins can be used to print character by character. The matrix head shown has 5 × 7 matrices with 25 um dia. pins spaced at 25-μm intervals. A page printer might comprise 60 such heads across the width of paper.

The quality of print produced by a 5 × 7 matrix of dots is adequate for most purposes. If a greater variety or higher quality of character is required a 7 × 10 matrix can be used.

Electromagnetism

By using magnetic recording techniques it is possible to 'write' a magnetic image onto suitable material and this image can subsequently be made visible by the application of ferrous powder. As in the case of the electrostatic printer, a magnetic image of the character can be formed by means of a matrix of magnetic recording heads packed into the areas occupied by one character. In place of the voltage pulse demanded by the electrostatic system a current pulse through the appropriate heads is needed and as the coating of paper with a magnetic medium is an expensive procedure, recording takes place on a magnetic drum. Powder is then applied to the drum and subsequently transferred by pressure to paper. An experimental machine using this principle has been demonstrated[4] but such a device has not yet been marketed.

Steered ink jet

If one considers ink issuing from a very small jet physically vibrated along its axis, the liquid will break up into a series of droplets. If these droplets carry an electrostatic charge and are made to traverse an electric field they will be deflected in a similar manner to electrons in a cathode-ray tube. This principle was applied to the design of an oscillograph recorder[3] in 1964 (Fig. 4). In this case droplets of ink are formed by a 25-μm diameter nozzle, vibrated by a crystal transducer operating in the region of 45kHz. Each droplet passes through a hole in a charging electrode to which the voltage waveform to be recorded is applied. Each droplet leaves the charging electrode with a charge proportional to the voltage applied at that instant and then passes through a transverse electrostatic field producing a deflection proportional to the droplet charge. The paper moves continuously at right angles to the deflection of the droplets, producing the other axis of the deflection.

Fig. 5 shows an experimental rig in which droplets of water issuing from a jet are deflected in this way. A pulse voltage waveform is applied to a ring electrode causing the stream of droplets to be deflected in sympathy. The deflection of the droplets is too fast to be seen by the naked eye so the photograph was taken under stroboscopic light synchronized with the droplet frequency. To make the deflection assembly visible a second exposure under steady illumination was made resulting in the solid line from the jet superimposed on the photograph of the droplets.

It is not convenient to turn the ink stream on and off so the same effect is achieved by arranging for the ink to be intercepted by a device which returns the ink to the reservoir at zero voltage; at other voltages the ink is deposited on the paper. If the deflection of the jet and the movement of the paper is used to form a raster scan, a matrix of dots is deposited on the paper. This matrix can be arranged to fill the area occupied by one character in which case any character can be printed by suppressing the appropriate dots. This is achieved in the electronic character translator by arranging that when the stream is at the appropriate position zero voltage is momentarily applied to the charging electrode to ensure that the droplet is intercepted.

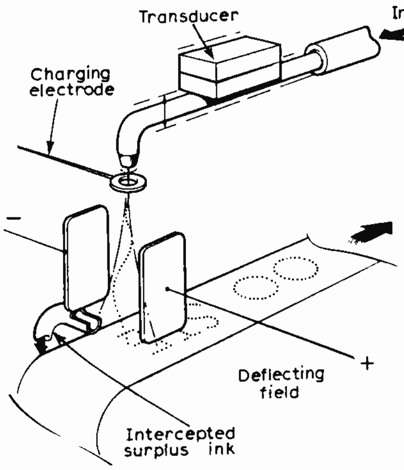


Fig. 4. To avoid using special paper a charged ink jet can be used, deflected electrostatically. Pulsed operation is achieved by attaching a transducer to the ink feed pipe.

This type of printer can operate on wide range of uncoated paper and has the advantage that the characters become visible the moment they are printed. The jet has to be very small (typically 25-μm dia.) and precautions have to be taken to avoid blockage in operation.

Two printers operating on this principle are now available from U.S. sources.

The printing methods described so far constitute the major candidates for supremacy at the present time. There are other methods, for example thermal printing, which offer advantages over impact printing but require relatively expensive paper and lack the speed potential of electrostatic or electromagnetic printing.

Costs

It has not been demonstrated that it is possible to market a machine at a price which will compete with teleprinters currently available. The results of

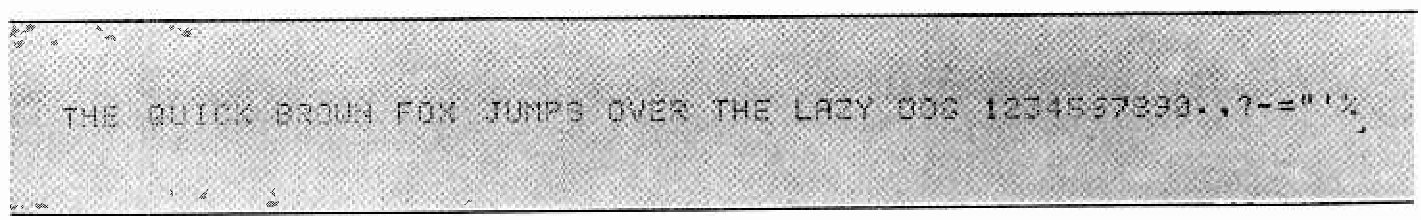


Fig. 3. To print electrostatically on continuously moving paper, the voltage to the printing heads is in the form of 30-μs pulses. In this example the paper speed was 125cm/s giving a printing rate of 500 characters a second.

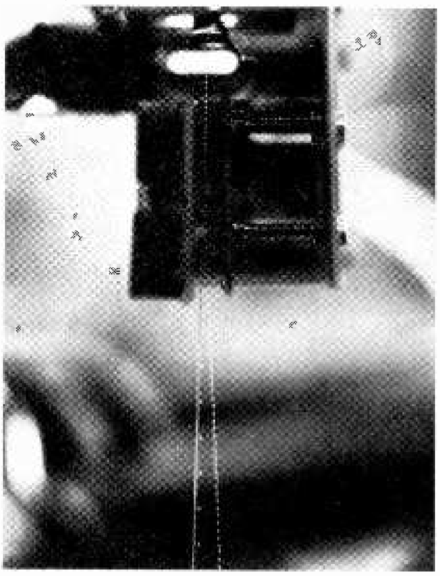


Fig. 5. Ink jet photographed under stoboscopic illumination. A second exposure under steady illumination was made to show the deflection assembly, which accounts for the continuous ink stream.

increased operating speed must be judged in relation to increased capital cost and such disadvantages as the inability to print simultaneous copies.

The cost of paper becomes significant when dealing with high-speed machines. A 300-character-per-second machine operating for three hours per day for a five-day week will cost £200 p.a. for paper. If the machine requires specially coated paper this cost could at least double implying an additional running cost of £200 p.a. or more. The choice could well arise between a relatively simple and reliable machine using special papers and a more complicated machine in which a wide range of papers can be used.

There is at the moment a tremendous world growth in communications. The transmission of the written word is placing an ever increasing demand on available systems. Postal services are finding difficulty in coping with an ever increasing volume of paper. In what sphere the high-speed printer will find its greatest application is not yet clear but without doubt such devices will become an integral part of the communication network of the future.

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2. Young, C. J. & Greig, H. C. 'Electrofax direct electrophotographic printing on paper'. *RCA Review*, vol.15, 1954, p.469.

3. Sweet, R. G. 'High-frequency recording with electrostatically deflected ink jet.' *Rev.Sci.Inst.* vol.36, 1965, p.131.

4. Brewster, A. E. 'A high-speed magnetic printout system.' *Electronics and Power*, vol.62. 1968.

Announcements

The I.E.E. Vacation School at University College, Bangor, **on electric circuit theory,** which was to have taken place from 22 March to 2 April 1971 will now be held from 5 to 10 July.

STC are negotiating with Chelton (Electrostatics) Ltd of Marlow, Bucks, for the acquisition by Chelton of the technical information and know-how needed for the manufacture and exclusive world-wide marketing of all STC **aircraft aerials** (excluding only h.f. notch aerials) and engineering services.

J. Grant and Taylor Ltd are to take over STC's **closed-circuit television** business which includes Grundig and Conrac agencies. STC will continue to market low light level cameras.

Telemotive U.K. Ltd, Albany House, 32 Southfields, East Molesey, Surrey, has acquired from STC their business in 'Telemotive' **radio remote control** of cranes and other industrial machines.

Pye Unicam Ltd, of Cambridge, are to start **leasing scientific equipment.** All the financial arrangements for this service will be carried out by Communication Services Ltd, a company jointly owned by Pye and Philips.

An agreement to grant manufacturing rights on an **instrument landing system** has been concluded between Thomson-CSF (France) and Texas Instruments (U.S.A.).

Cossor Electronics Ltd, Harlow, Essex, have received a large order from the Australian Department of Civil Aviation to supply **secondary surveillance radar** equipment to be installed throughout Australia.

An exclusive U.K. marketing agreement has recently been negotiated between the Tokyo based NF Instrument Co. and Takmar Electronics Ltd for the **NF range of test instruments.** Their test instruments include function generators, an auto-ranging a.c. voltmeter, low-distortion oscillator and distortion analysers.

Wilmex Ltd have undertaken distribution of **Stax Audio Products** in the U.K.

ITT Semiconductors U.K. and Intermetall Hableiter Der Deutsche ITT Industries GmBh Germany, who together form ITT-SC-Europe, have signed a contract with American Micro-Systems Inc. appointing ITT-SC-E as exclusive sales representative and distributor for AMI products in Europe.

Radiatron Components Ltd have taken over as sole U.K. representatives for the complete Irion & Vosseler IVO range of **impulse counters** and associated equipment.

Seatronics (U.K.) Ltd, a new second source of supply of electronic components, becomes the first organization to exclusively market own-brand components, initially **resistors, capacitors and electro mechanical parts** manufactured in Asia. Headed by Peter Webber, previously marketing manager of Morganite Resistors, Seatronics will specialize in standard passive components manufactured in such areas as Singapore and Japan.

Radiall Microwave Components Ltd are now sole U.K. agents for the Cable Division of Thomson Houston, France.

Onkyo, of Osaka, japan, who manufacture **audio equipment,** have appointed J. Parkar & Company (London) Ltd, Parkar House, I Paul Street, London E.C.2, sole distributors for their products.

Redifon Ltd have purchased the **marine radio** interests of Cosalt Ltd.

Industrial Control Systems have recently introduced a **semiconductor burn-in service** at their Northampton factory, for major semiconductor manufacturers, equipment manufacturers and other large volume users of semiconductor components.

Standard Telephones and Cables Ltd has won an order worth over £180,000 from British Rail for a 960-circuit, 4MHZ, **coaxial cable telephone link** between British Rail Marylebone headquarters and four London stations. The stations involved are Euston, Liverpool Street, Waterloo and Paddington.

Radiatron Components Ltd are now sole U.K. representatives for the range of **electromechanical and electronic components** manufactured by ERNI & Co., Zurich.

Under the name, **Raytheon-TAG Components Ltd** a U.K. office, which will operate frm 1st June at Shelley House, Noble Street, London E.C.2, is being opened by Transistor AG, Zurich.

A range of **function generators** made by Interstate Electronics Corporation, of Anaheim, California, is now available in the U.K. through Euro Electronic Instruments Ltd, Shirley House, 27 Camden Road, London N.W.1.

Pye Ether Ltd and Georg C. K. Withof GmbH have concluded an agreement to cover development, production and marketing of their combined ranges of **process control instrumentation.**

Harlech Television are buying three Marconi Mk.8 automatic **colour television cameras** as part of their re-equipment programme in an order worth £80.000 placed with Marconi Communication Systems Ltd.

Dage (Great Britain) Ltd, Haywood House, High Street, Pinner, Middx, have been appointed sole U.K. distributors for the range of glass-sealed flat **packages for integrated circuits** manufactured by Philco-Ford of Pennsylvania, U.S.A.

Books Received

Electronic Measurement Techniques by D. F. A. Edwards. The author's preface states that 'the main object of this book is to provide in one volume practical information concerning the latest techniques in electronic measurements. Another justification for the present work is the fact that many people take up electronic or communication engineering as a career with a good working knowledge of the theory involved but with little idea of how to adapt and use the appropriate measuring instruments'. The chapters, averaging twenty pages each, cover basic electronic measurement (resistance, current, voltage, etc.), the general use of various instruments (including meters, oscillographs and oscilloscopes), and many techniques of measurement (resonance methods for *L, C, R,* and *Q;* various methods for power, frequency etc; null procedures). The last two chapters describe standards and the measurement of non-electrical quantities with reference to electronically linked servo-mechanisms. The author uses SI units throughout and the book includes worked examples and questions from B.Sc., I.E.E. and City and Guilds examination papers, for which the answers are also given. Pp. 377 including index. Price £4.20 cased, and £2.80 limp. Butterworth & Co (Publishers) Ltd, 88 Kingsway, London WC2B 6AB.

Field-Effect Electronics by W. Gosling, W. G. Townsend, and J. Watson. The opening historical review, referring back to 1925, is followed by an up-to-date introduction to junction and insulated gain f.e.t. operation including that relevant to III-V compound semiconductors and Schottky and silicon gate fabrication. A chapter is devoted to noise and the remainder of the book to the applications of f.e.t. devices. Pp. 364 including index. Price £8. Butterworth & Co (Publishers) Ltd, 88 Kingsway, London WC2B 6AB.

200-W Linear Amplifier

*by G. R. Jessop**

An amplifier is described which will provide 200W at frequencies between 3.5 and 28MHz. The article also describes the construction of the high-power valve employed and briefly mentions how it can be used as a 200W a.f. output stage.

Before describing the actual amplifier a few words on the valve employed would not go amiss. The valve is type TT100 and was originally developed from the earlier type TT21 for use in shipborne s.s.b. equipment. It has an anode overload dissipation of 2.7 times the maximum anode dissipation for five minutes allowing for the effect of a possible large aerial mismatch when, for instance, the aerial is broken or 'down on the deck'. The high thermal capacity of the anode is achieved without the use of an expensive carbon block anode. The valve uses a B12F cathode-ray tube base which allows multiple leads to the electrodes resulting in a low electrode lead impedance. To meet the electrical demands, and at the same time to keep the cost down to a reasonable level, two cathode assemblies, complete with grids and screen grids, are employed and surrounded by a massive anode. This means that standard large electrode structures are used and there was no need to design a special electrode assembly for the valve. This dual-electrode construction leads to easy connection of anti-parasitic components.

When using the valve it is essential to ensure that the glass bulb does not exceed 270°C by using some sort of cooling system. Two methods come to mind. The first, and more obvious, is to ventilate the enclosure in which the valve is installed and then to use either a simple fan to stir the air adequately (this method is illustrated in the amplifier described), or a small extractor fan.

Alternatively, a more elegant method is to use a close fitting heat shield having good contact with the bulb allowing the heat to be transferred from it to the chassis. The heat can then be conducted to a suitable heat sink attached to the back of the equipment.

* M-O Valve Company Ltd.

Component details

R_1	1kΩ, 3W, carbon	$C_{1\,2}$	10nF, 500V, disc ceramic
R_2	10Ω (two off)	C_3	30nF, three 10nF capacitors in parallel
R_3	100Ω over-wound with a single turn of 18 s.w.g. enamelled copper wire	$C_{4\,5\,6\,10}$	2.5nF, 2.5kV, mica
		C_7	9-300pF, variable (Jackson)
		C_8	500pF, 2.5kV, mica
r.f.c.$_1$	2.5mH pi-wound choke	C_9	40-500pF variable (Jackson)
r.f.c.$_2$	see text		500mA f.s.d. meter
r.f.c.$_3$	2.5mH pi-wound choke	$L_{1,2}$	see text

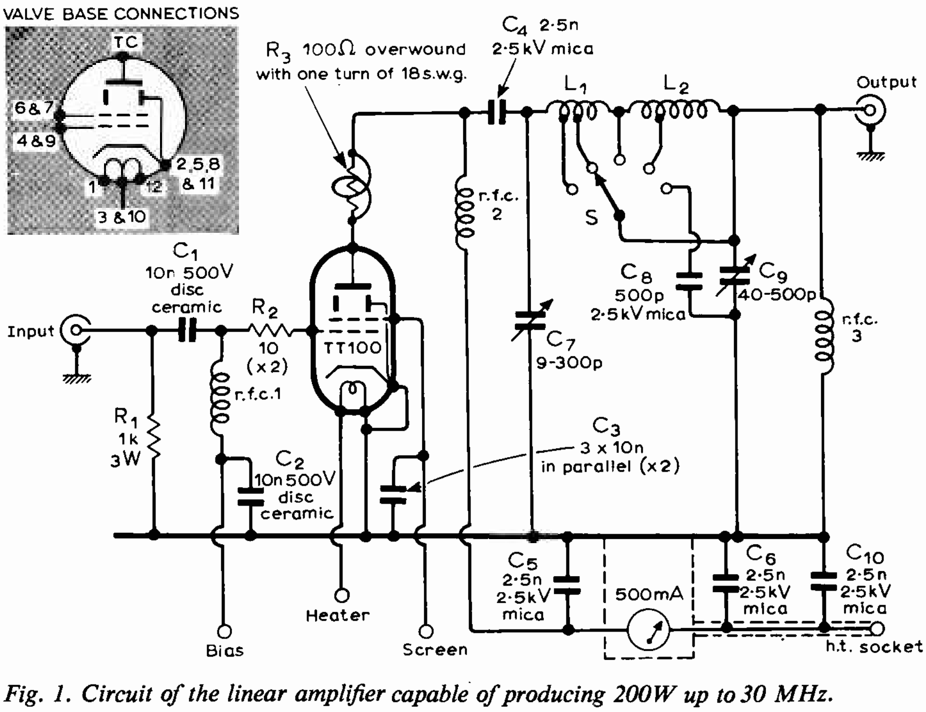


Fig. 1. Circuit of the linear amplifier capable of producing 200W up to 30 MHz.

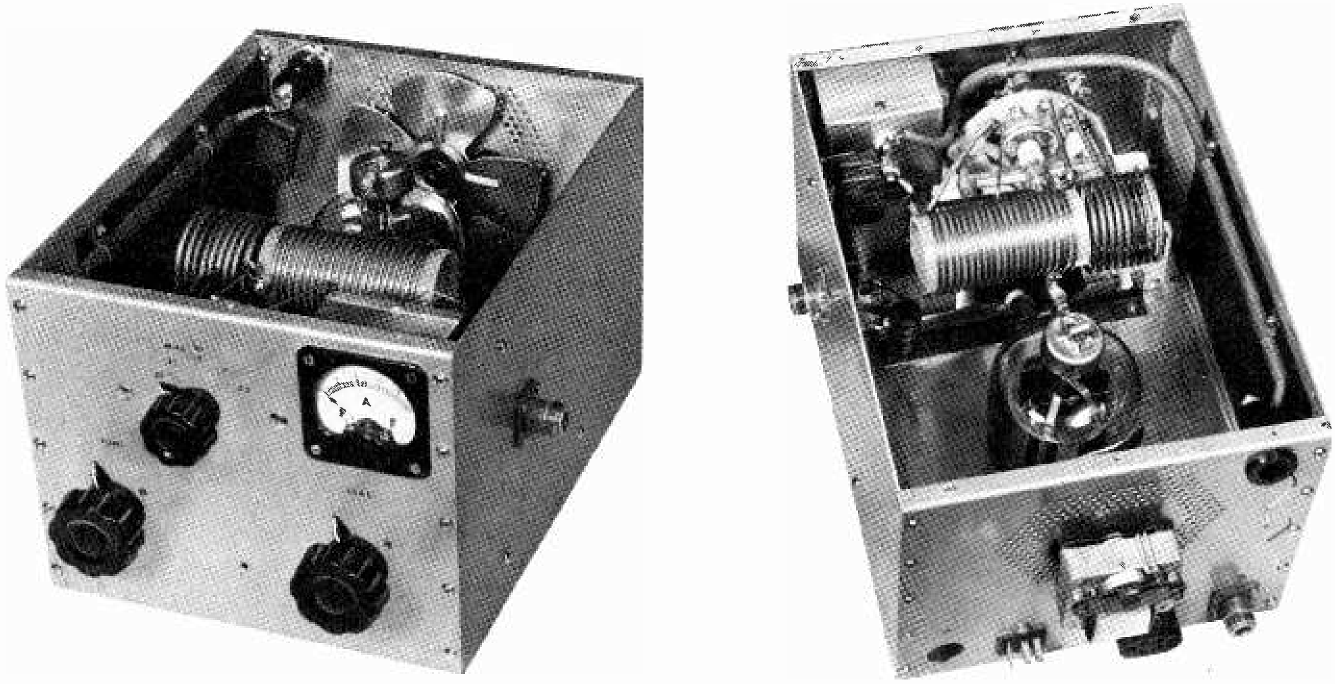
The amplifier

Of the various anode circuits which may be used for linear amplifiers to cover a wide range of frequencies, none is more convenient than the standard 'pi-coupling' where with suitable components a relatively wide range can be matched into the load.

In the grid circuit, the passive arrangement is probably the most satisfactory, provided that a reasonably high value of loading resistor, such as 1kΩ, is used. With this circuit feedback is unlikely if the socket wiring is properly arranged; it does, however, call for somewhat higher drive power than would be the case using a tuned-grid circuit. At the same time a more constant load is provided into which to operate the drive.

The circuit of the amplifier is given in Fig. 1. R_1 is the grid loading resistor and R_2 the anti-parasitic resistor (in fact there are two of them, one being connected to each control grid, pins four and nine). The screen grids are decoupled by the use of three 10nF disc ceramic capacitors in parallel connected from pins six and seven to earth.

All the input and socket connections are made below the chassis; the arrangement of the various components is shown in the lay-out diagram Fig. 2. It is important to note that all the earth connections are made to a common point to reduce chassis circulating currents. The connections of the



Two views of the completed prototype. In the left-hand photograph the h.t. decoupling capacitor can be seen in the top left-hand corner

four cathode pins should be as short as possible and made from thick wire or copper strip.

The anode circuit is a conventional shunt-fed pi-coupling, the variable components being the anode tuning capacitor C_7, the tapped inductor L_1, L_2 and the output matching capacitor C_9.

These main components should be built effectively as a unit using capacitors with insulated end plates and the earth connections to their rotors made by a single piece L-section copper strip (75×50mm) bolted to the chassis (this can be clearly seen in the internal view of the amplifier). A copper strip connection from the output socket should also be returned directly to the common earth strip of the tuned circuit. This arrangement will reduce the chassis circulating currents to a minimum.

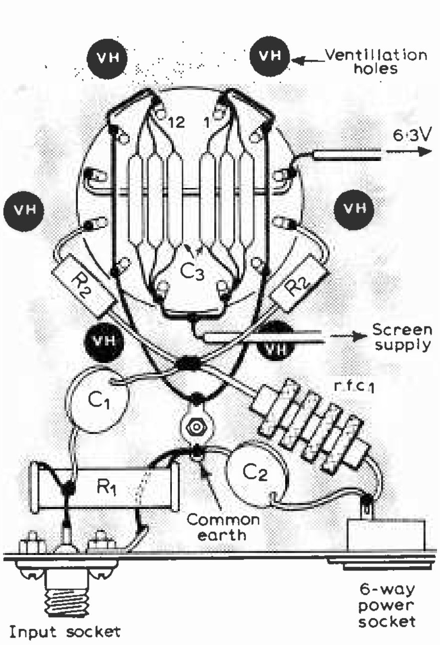


Fig. 2. Under-chassis layout of components.

Coil winding

The anode inductor comprises two parts, L_1 for the higher frequencies connected in series with L_2 to make the complete coil.

L_1: 9 turns of 3mm diameter copper wire, the turn spacing being 1.5mm. The internal diameter of the coil is 38mm. Taps are made at 3 and 5 turns from the anode end for the 28 and 21MHz amateur bands respectively. The whole coil is used for the 14MHz band.

L_2: 21 turns of 2.5mm diameter copper wire wound on an epoxy resin former 38mm in diameter, turns are spaced to occupy a winding length of 70mm. A tap is made at 9 turns from the connection to L_1 for operation at 7MHz. Selection of the taps on the inductor is by the high voltage ceramic switch.

Anode feed r.f. choke: This choke (r.f.c.$_2$) has to have high impedance over the whole frequency range at which the amplifier is to operate, since it is effectively in parallel with the tuned circuit. In this case a simple single-layer coil is used consisting of 100 turns of 24 s.w.g. enamelled wire close wound on a 12.5mm diameter ceramic former (winding length 64mm). The choke is mounted horizontally below and at right-angles to the anode inductance to minimize inductive coupling.

Construction

This may be of any convenient form to suit individual requirements. The unit illustrated is a small amplifier contained in a cabinet 260×200×165mm. A simple fan to provide adequate air circulation is fitted to the rear panel. No detailed drawing is needed for a unit of this type; all the relevant data can be obtained from the photographs.

One point that needs mentioning is that the meter, being close to the considerable r.f. field, must be shielded and its connections by-passed to chassis. The h.t. feed line should also be screened as near as possible to the actual supply socket. It is also by-passed at the h.t. supply socket as can be seen in the front view photograph (top left-hand corner of the rear panel).

Performance

The performance of the amplifier illustrated is summarized in the table of results and the curve, Fig. 3. The power output is substantially constant over the frequency range 3.5 to 28MHz.

Tests carried out at a very much lower frequency give similar results; the operating conditions and performance quoted may

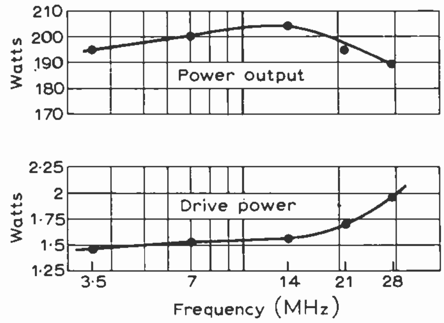


Fig. 3. Performance in terms of output and input power against frequency.

TABLE 1 Amplifier performance

frequency	3.5	7	14	21	28	MHz
anode voltage	850	850	850	850	850	V
screen voltage†	216	216	216	216	216	V
grid voltage	−50	−50	−50	−50	−50	V
anode current (no sig.)	100	100	100	100	100	mA
anode current (max. sig.)	375	375	375	375	375	mA
screen current (max. sig.)	35	20	26	17	33	mA
grid current (max. sig.)	2	2	2	2	2	mA
Power output (in load)	195	200	205	195	190	W
power input (drive)	1.5	1.5	1.6	1.7	2	W

†voltage stabilized using two QS1206 glow discharge stabilizers in series.

Valve data: type TT100
single tone

anode voltage	V_a	600	800	850	V
screen voltage†	V_{g2}	216	216	216	V
grid voltage*	$-V_{g1}$	42	48	50	V
anode current (no sig.)	$I_{a(o)}$	150	110	100	mA
anode current (max. sig.)	I_a	300	350	375	mA
screen current (no sig.)	$I_{g2(o)}$	5	3	2.5	mA
screen current (max. sig.)	I_{g2}	25	28	30	mA
grid current (max. sig.)	I_{g1}	—	1	2	mA
grid voltage (pk crest)	$\hat{V}_{g1}$	42	49	52	V
power output (load)	P_L	100	180	200	W
anode impedance	Z_a	1100	1400	1400	Ω

two tone#

anode current (max. sig.)	I_a	225	245	250	mA
screen current (max. sig.)	I_{g2}	15	15	16	mA
grid current (max. sig.)	I_{g1}	—	0.1	0.25	mA
power output (p.e.p.)	$\hat{P}_L$	100	180	200	W
power output (mean)	P_L	50	90	100	W
intermodulation‡	IM	42	28	26	dB

†Voltage stabilized using two QS1206 discharge stabilizers in series.
*Adjusted to set anode current at no signal.
Two signals of equal amplitude spaced 2kHz in frequency.
‡Intermodulation distortion products at any level of the drive voltage relative to either tone.

therefore be applied to audio amplifier applications as well.

For audio amplifiers (push-pull pair) anode-to-anode load impedance should be 2460Ω. The 400-W output can be obtained with an anode supply of 850V and a grid current of 2mA or at 1kV with no grid current (class AB1).

It will also be seen that the drive power rises with increasing frequency. This is largely due to circulating current through the valve's input capacitance (37.5 pF) dissipated in the anti-parasitic resistors.

The drive can be computed from the following formula:

$a=$ power in load resistor
$= V_{in\,(peak)}/(R \times 2)$ where R is the anti-parasitic resistor R_2.
$b=$ power in anti-parasitic resistors. See Table 2.
$c=$ power in valve = peak drive voltage times peak fundamental grid current.

Total drive power is equal to $a+b+c$.

The amplifier as described is suitable for operation with an input that can be matched to the effective input impedance but if the amplifier is to be driven by an exciter/driver designed itself to feed into a 50-75Ω output with only a limited range of loading capacitance, it will be necessary to provide a suitable matching coupling to step up the impedance to a suitable value or a tuned input circuit.

200-W LINEAR AMPLIFIER
TABLE 2

f MHz	XC_m Ω	I_{in} (peak) A	Input power W
3.5	1200	0.046	0.005
7	580	0.095	0.02
14	306	0.186	0.08
21	200	0.28	0.18
28	120	0.46	0.5

The input current is that flowing in the input capacitance via the two anti-parasitic resistors in parallel.

Books Received

Measuring Oscilloscopes edited by J. F. Golding. This compilation of contributions by Marconi Instruments engineers has been made primarily for oscilloscope users. The accent is laid on methods and principles—circuits are only included to illustrate this approach. The discussion is limited to general purpose real-time oscilloscopes, and does not deal with techniques for measuring very fast transients (or very high frequencies) such as are employed in sampling and travelling-wave oscilloscopes. Chapter titles are—construction and operation, getting the signal to the oscilloscope, the *Y* co-ordinate, the *X* co-ordinate, the display, the complete oscilloscope, and oscilloscope applications. Pp 236 including index. Price £4.20. Iliffe Books, Butterworth & Co. (Publishers) Ltd, 88 Kingsway, London WC2B 6AB.

Transistor Audio Amplifiers by P. Tharma. This book is based on work done at the Mullard Central Application Laboratory. The first nine chapters are analytical, describing transfer characteristics for large and small signals in junction transistors, small signal stages and output stages, noise, thermal stability, negative feedback, and distortion. The remainder of the book, chapters ten to seventeen, describes practical circuits for high- and low-power audio amplifiers, tape recorder circuits and power supplies. An extensive index is provided. Pp. 413. Price £6. Iliffe Books, Butterworth & Co (Publishers) Ltd, 88 Kingsway, London WC2B 6AB.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

June 7 & 8 Royal Lancaster Hotel
Materials Control & Economics
(B.C.E., Mercury House, Waterloo Road, London S.E.1.)

June 8-10 Savoy Place
Aerospace Antennas
(I.E.E., Savoy Place, London WC2R OBL)

June 21-25 Royal Lancaster Hotel
Film '71
(B.K.S.T.S., 110-112 Victoria House, Vernon Pl., London WC1B 4DJ)

SUNBURY

June 1 & 2 Holbrook Hall
Acoustic Testing Facilities
(Sound Research Labs., Holbrook Hall, Sudbury, Suffolk)

OVERSEAS

June 1-3 Ottawa
Electrical & Electronic Measurement & Test Instruments
(I.E.E.E., P.O. Box 252, Richmond, Ontario)

June 2-4 Genoa
Satellite Communications
(Instituto Internazionale delle Comunicazioni, 18 Viale Brigate Partigiane, 16129, Genoa)

June 2-4 Washington
Laser Engineering & Applications
(D. R. Herriott, Bell Telephone Laboratories, Murray Hill, N.J. 07974)

June 2-12 Vancouver
British Columbia International Trade Fair
(D. Kenneth Brown, British Columbia International Trade Fair 1971, Suite 1100, 475 Howe St., Vancouver, B.C.)

June 7 & 8 White Plains
Applications of Ferroelectrics
(Dr. A. W. Smith, IBM Watson Research Center, Yorktown Heights, N.Y. 10598)

June 7 & 8 Chicago
Broadcast & TV Receivers
(D. Ruby, Zenith Radio Corp., 6001 W. Dickens Ave., Chicago, Ill. 60639)

June 12-17 Paris
Automatic Control—I.F.A.C. Congress
(Intl. Fed. of Automatic Control, Graf-Recke-Str. 84, P.O.B. 1139, Düsseldorf, Germany)

June 14-16 Montreal
World Communications Conference
(I.C.C., P.O. Box 201, Station H, Montreal 107)

June 14-19 Lille
International Electronics Week
(Soc. pour la Diffusion des Sciences et des Arts, 14 Rue de Presles, 75—Paris 15ème)

June 17-27 Geneva
Telecom 71 Exhibition
(I.T.U., Place des Nations, Geneva)

June 21 & 22 Baden Baden
Properties of Electric-conductive Magnetic Materials
(Int. Electrotechnical Commission, 1 Rue de Varembe, Geneva)

News of the Month

change over will take place on January 1972.

The change will affect only users of precise frequency generators and time keeping equipment, who probably will have to adjust their equipment or operations. These users include radio and television stations, scientific laboratories, electric-power companies, manufacturers of electronic equipment and perhaps the makers of navigation and radar equipment. Groups which use precise timing instruments for the sole purpose of synchronizing their activities will not necessarily be affected.

1971 Queen's Awards for technical innovation

Six companies in the electronics field received the Queen's Award for technical innovation. AEI Scientific Apparatus received the honour for their EM7 million-volt microscope which is the only electron microscope with a resolution of 0.0005 μm. The microscope is about 6m high and to date ten have either been installed or are being manufactured to order. Decca Radar received the award for their type 71 doppler radar for helicoptors and for the type 72 for fixed-wing aircraft and for their solid-state marine radar. This latter item contains a step recovery diode local oscillator that took three years to develop, an all-semiconductor modulator and auto-follow tuning. Transmitter power is only 3kW. Decca Survey received the award 'for technical innovation in the radio position fixing system Hi-Fix'. Hi-Fix is a portable h.f. position fixing system. This employs three shore-based transmitters working on the same frequency and can determine a ship's position 200 miles away to within a few metres. Hi-Fix was used to find the hydrogen bomb which was lost when a U.S. aircraft crashed near Palomares in Spain some time ago. There are now well over 100 Hi-Fix chains in operation.

International Computers were granted the award for technical innovation in a computer integrated design and production system for the ICL 1906A computer.

Marconi Instruments manufactured a range of r.f. power meters which are the first to be commercially available using thin film techniques. For this range they received the Queen's Award.

In the semiconductor field one cannot get very far without very high quality raw materials. In this field the Queen's technical innovation Award was conferred on Metals Research, for a crystal pulling system for the production of single gallium phosphide crystals. The company also received the award for an image analysing computer.

Colour TV deliveries increase

Television deliveries for the first quarter of 1971 (542,000) were 9% up on the same period of 1970 (496,000), according to the Economic and Statistical Division of the British Radio Equipment Manufacturers' Association. This was due to the continued increase in deliveries of colour sets which reached 146,000 for the three months this year, compared with 86,000 in 1970, whilst monochrome fell slightly from 410,000 in 1970 to 396,000 for the first quarter this year.

During March itself 53,000 colour sets and 134,000 monochrome sets were delivered, as compared with 31,000 and 138,000 respectively in March 1970.

A slight fall in record players from 115,000 for January-March 1970 to 109,000 this year is seen as an indication more of a swing towards the growing audio separates market, rather than a decline in deliveries of record playing equipment. During March itself 39,000 players were delivered compared with 40,000 in March 1970.

Change to bring G.M.T. in line with atomic time

Greenwich Mean Time (G.M.T. or U.T.C.—Co-ordinated Universal Time) will be slightly altered soon to eliminate the present offset from atomic time. This offset consists of a continuous retardation of 30 parts in 10^7 plus step adjustments of 0.1 seconds to keep U.T.C. or G.M.T. within 0.1 second of a time scale based on the rotation of the earth.

The need for the change arises from the fact that today's atomic clocks are very constant and provide a time reference that is much more uniform than the scale provided by the earth's rotation. In fact, a time scale based on the earth's rotation will vary almost a second per year. That much variation cannot be tolerated by many technical and scientific projects, and so atomic clocks are used today.

With the new system the atomic clock rate will not be slowed down at all, and instead of adding or subtracting a whole second every few months, everyone will add or subtract a whole second once in 12 to 18 months. Naturally, if your clocks lose or gain more than one second in a year, you won't have to worry about these tiny adjustments.

The one-second adjustment, or leap-second, is very similar in concept to adding an extra day during leap-years. The standard time and frequency radio stations maintained by various countries will co-operate with the International Time Bureau in broadcasting the new time scale and in making the adjustments simultaneously, preferably on January 1st or July 1st. To provide a traditional service to navigators and astronomers, who need earth related time these stations will broadcast information concerning the difference between the transmitted time and the astronomical time. The difference will not be more than 0.7 second, and will probably be broadcast with a resolution of 0.1 second. The

U.H.F. radio-telephone service

Christopher Chataway, Minister for Posts and Telecommunications, recently inaugurated a new u.h.f. radio-telephone service, called 'Readycall'. Subscribers to the service, operated by Burndept Electronics (ER) Ltd, will have a u.h.f. radio-telephone installed in their cars. They will then be able to make calls, via the Readycall operator and the public telephone network, to anyone they wish; in a like manner they can also receive calls. Although the equipment could be linked directly to the telephone network this is not the case at present and the operator acts as a go-between to relay information.

Burndept have been granted two licences by the Minpostel for the system. The first allows them to use the frequency band 450 to 470MHz and the second covers the break in the Post Office's monopoly.

The system employs 5W transmitters, 25kHz channel spacing and phase modulation with a peak deviation of 5kHz. A selective call method is employed to ensure privacy. Each vehicle installation has an individual 'address' set by a plug-in decoder and can be switched to the receive mode only if the correct sequence of tones is transmitted. A three-tone sequential system is used. the tones being between 540 and 3180Hz. As soon as the correct tone sequence for a particular radio-telephone is received a lamp on the instruments' front panel illuminates. This warns the subscriber he has been called (should he be away from his car) so that he can call the operator on his return.

At present the system is in use only in London which is served by two transmitters covering an area bounded by Enfield, London Airport, Croydon and Dartford. At the inauguration *Wireless World* heard the system operating in a coach driving round London and in spite of the built-up area and dense traffic the freedom of fading and noise was quite remarkable.

Subscribers to the system pay a rental charge of £16 per month and the system is in operation between 8 a.m. and 6 p.m. on weekdays only.

Another Japanese PAL receiver

An imported colour television receiver which claims to avoid infringement of Telefunken PAL patents is announced by Teleton, European marketing organization for the Japanese Mitsubishi combine. First rumoured in these pages in 1969, the set follows introduction of PAL receivers by Hitachi—by agreement with Telefunken—and by Sony, who also claim to avoid patent infringement. Unlike the Sony 33cm set using the single-gun Trinitron c.r.t., the Teleton set uses a shadow mask tube scaled down to 30cm and works on the simple PAL basis. It uses a patented subcarrier switching technique first used in an NTSC set—described in *Electronics*, 31st May 1965—and modified for 180° switching. The set is a single-standard u.h.f. receiver priced at £179.50.

Heart monitoring by 'phone

Patients with heart complaints recovering at home can be monitored for cardiac irregularities over regular telephone lines. A portable, wireless monitor that permits a patient to move around freely has been tested at Beth Israel Medical Centre in New York City. In the test 19 patients were monitored for total of 194 hours. The combined system consists of a small, low-power, radio transmitter carried by the patient; a receiver in the patient's room tuned to the portable transmitter; and a unit linking the radio receiver to the patient's telephone. All the equipment required for remote monitoring can be carried in an attache case.

Heart performance data collected by electrodes on the patient's body is sent by the transmitting unit to the nearby receiver. Bell Labs have co-operated with the Beth Israel Medical Centre in the project.

Stereo radio network extension

Work is being carried out to adapt the v.h.f. Radio-3 transmitter at Rowridge, Isle of Wight, to stereophonic broadcasting. Programme material will be received direct from the transmitter at Wrotham, Kent, and will be retransmitted. It is expected that Hampshire, Dorset, South Wiltshire, South Berkshire, South-west Surrey and West Sussex will have sufficient signal strength for stereo reception from the Rowridge transmitter aerial. Many listeners will have to fit improved aerial systems if they are to benefit fully from the new service, as a good aerial is essential for good stereo reception.

U.S.-Canada satellite agreement

The National Aeronautics and Space Administration of America and the Canadian Department of Communications today signed an agreement for a co-operative experimental communications technology satellite. The agreement provides for the launch of the Canadian satellite in a geostationary orbit by N.A.S.A. in 1974. It will be designated Co-operative Applications Satellite C (CAS-C).

Specific objectives of the project are to conduct communications experiments with ground terminals operating at extremely high frequencies (12 GHz) and to develop and flight test a high efficiency power source (more than 50% efficiency at a minimum output of 200W. The satellite will also test solar power cell arrays which will have an initial power output of over 1kW.

These experiments are intended to develop techniques for providing services to small villages, including TV two-way voice communications, data links and facsimile, which would have potential in the outlying northern areas of Canada. The 12 GHz experiments will help to open the frequency spectrum above 10 GHz which is urgently needed for communications, broadcasting, and educational television.

STAR Aerosat contract

The British Aircraft Corporation Space Systems Group, Bristol, have been appointed prime contractors by the European Space Research Organization in a definition study contract awarded to the STAR (Satellites for Telecommunications, Applications and Research) Consortium. The contract is for an aeronautical communications and surveillance satellite (Aerosat), which will monitor and control aircraft over long distance routes and entails the study of suitable satellites and launch vehicles, as well as the characteristics of aircraft and ground stations.

The work will be concerned with frequencies in the u.h.f. L-Band (1540 to 1660MHz). Thomson-CSF of France have been appointed prime sub-contractors for the communications and surveillance aspects of the system.

This is the second contract gained by the STAR consortium since it was formed in December last year. The first, which was mentioned last month in this section, was to define a European telecommunication satellite system.

How to present a technical lecture

A discussion meeting on how to present a technical lecture will be held on Wednesday, 2nd June 1971, at the Institution of Electrical Engineers, Savoy Place, London, at 5.30 p.m.

An introduction, in the form of a playlet, will illustrate the right and wrong ways of verbal and visual presentation. There will then be an opportunity for the audience to put views to a panel chaired by Mr. J. A. Lawrence, telecommunication consultant with the Plessey Telecommunications Group, together with Dr A. V. M. Coombs, Senior principal scientific officer, P.O. Research Department, Mr. G. Eric Evans, consultant designer and Mr. Aubrey Singer, Head of Features, B.B.C.

The meeting is organized by the Engineering Writing and Speech Chapter of the U.K. and Republic of Ireland Section of the Institute of Electrical and Electronics Engineers.

More Birthday Celebrations

The *Wireless World* '60th birthday' amateur station GB3WW, operating from Dorset House during the month of April, made nearly one thousand contacts with stations in more than 50 countries and in all continents. Contacts were made on the 3.5, 7, 14, 21 and 28 MHz bands, though most were on 3.5, 14 and 21 MHz. Because of the limited operating times (evenings and Saturdays), few stations in Oceania were worked—but an exception was KR6IX in Okinawa; all other continents were well represented. Despite severe ionospheric disturbances around the Easter period, the call signs of many long-distance stations found their way into the GB3WW log: FG7AB (Guadaloupe); MP4TDA (Trucial Oman); MP4BHL and MP4BHM in Bahrein; 9Y4CR (Trinidad); 5Z4LW and 5Z4LI in Kenya; TI2LA (Costa Rica); CR6MK (Angola); VP2EEL (Anguilla); 9M2WM (Malaysia), several ZS stations in South Africa and JA. JH and JR stations in Japan—and many, many others. Distance seemed annihilated during such 'openings' as a 20-minute spell on 14 MHz s.s.b. when four Californian amateurs were contacted in succession.

On 3.5 MHz, considerable numbers of British stations were worked—one was that of Ken Alford (G2DX) whose 1914 station TXK was illustrated in our April 'birthday' issue. Another pioneer station was F8DR in the South of France who was licensed in 1923. DA2XX/P concealed the identity of J. Cooper, G3DPS, and until recently general secretary of the Royal Signals Amateur Radio Society. One of the GB3WW operators made contact with an amateur with whom he had shared his first Army billet in 1941 and whom he had neither seen nor contacted since!

Many British and Overseas amateurs sent birthday greetings to *W.W.*, with large numbers of Americans showing familiarity with the journal. 60th birthday greetings were mutually exchanged with GB3ERD operating during the opening of the 60-year anniversary exhibition of the Derby and District Amateur Radio Society.

A number of American 'novice' stations were worked cross-mode (s.s.b. out, c.w. in) on 21 MHz. Operation was divided between s.s.b. and c.w. At least one American station was using only an indoor dipole—another 40 watts of a.m.

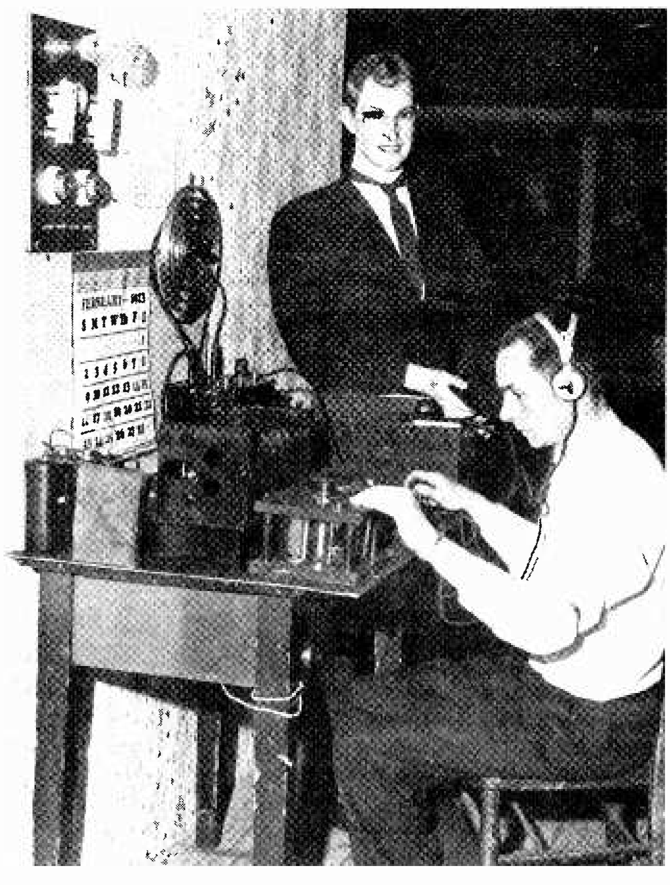
Bulk of the work-load fell on the KW2000B transceiver used in conjunction with the KW linear, though the high performance of the 'first reserve' receiver—one of the new Eddystone 1830/1 all-semiconductor receivers—was fully explored by most operators. Despite one or two minor problems, the equipment showed clearly that extremely effective world-wide communication can be achieved today with a minimum of installation time and even without the use of beam aerials (a KW trap dipole was used throughout, though it had the advantage of the height of Dorset House).

Our thanks to all the hundreds of amateurs whose co-operation made operating GB3WW an event to remember—also to Minpostel for the licence, and to KW Electronics, Eddystone, Shure and D. R. Bowman (G3LUB) for the loan of equipment.

In the event, the team of operators included F. C. Ward, G2CVV; D. A. Findlay, G3BZG, R. S. Roberts, G6NR; B. M. Johnson, G3LOX; D. R. Bowman, G3LUB; G. M. C. Stone, G3FZL; S. H. Andrews, G3OGY; and Pat Hawker, G3VA.

Mullard, who recently celebrated their Golden Jubilee, presented us with a magnificent birthday cake at a luncheon held in honour of Wireless World's *60th birthday. The photograph shows Harold Barnard, the editor, and Charles Marshall (right), of Mullard, who made the presentation. The cake carried a reproduction of the front cover of our April birthday issue.*

The photograph shows a mock-up of a 1911 to 1913 amateur radio station set-up at the Derby and District Amateur Radio Society's exhibition to celebrate their Diamond Jubilee. The Wireless World *birthday station, GB3WW, was pleased to exchange greetings with the Derby Society's Jubilee station GB3ERD*



Physics Exhibition

Items of interest seen at Alexandra Palace

Helical linear motor

A prototype helical reluctance linear motor, demonstrated by University College North Wales, allows accurate control on open loop. Developed at Bangor this new linear actuator is based on the principle that components of a magnetic circuit attempt to move so that a condition of minimum reluctance is attained where there is maximum magneto-motive force. The geometric construction of the motor is such that rotation of the magnetic field in the stator is converted directly into linear motion of the armature. The motor assembly has no racks, pinions or screw threads, and may be used either in a stepping or continuous mode. In the stepping mode it becomes particularly appropriate to use direct digital control. Step sizes are typically 0.2mm and in continuous mode the resolution is typically 0.2mm. The available force depends on machine size and has been recorded at 30kg. Stiffness has been recorded as high as 600kg/mm, and a speed of 100mm/s has been achieved.

Pseudo-random quantization for p.c.m. television

One of the early applications of p.c.m. television may be for transmitting Viewphone signals between towns and cities. An exhibit comprising a 6 megabits/second system constructed as part of the Post Office research programme into methods of minimizing the digital data rate required to transmit television was shown.

A 319-line television system with a bandwidth of 1MHz was used to demonstrate the subjective aspects of transmission by p.c.m. At the input to the p.c.m. system the signal is sampled at 2MHz and each sample is quantized into one of eight levels. The value of each level is coded into three binary digits and the p.c.m. signal is transmitted to the decoder unit at a rate of 6Mb/s. Here, the eight level signal is reconstituted, passed through a low-pass filter and displayed on the picture monitor.

Because of the three bits/sample coding the displayed picture can have only eight levels of brightness. However, instead of keeping these fixed, which would cause severe 'contour' distortion of the image, the coder and decoder are 'dithered' by a pseudo-random signal which causes the brightness represented by each coding level to change frame by frame and point by point within each frame.

The quantizing distortion therefore appears as random noise. Adding the pseudo-random signal to the video signal before coding disperses the quantizing contours as random noise but the total noise power in the displayed image is now equal to that of the inherent quantizing noise plus that of the dither. The signal-to-noise ratio of the image is maximized if the dither is subtracted again after the contours have dispersed. Identical, synchronized pseudo-random dither generators are therefore provided at each end of the digital link. the dither signal itself has been designed to minimize the visibility of the pseudo-random quantizing error by exploiting the way in which the subjective visibility of noise falls with frequency.

Flat display

A flat gas discharge display is under development by Mullard Research Labs. The cathode-ray tube is not necessarily the cheapest form of display when only a few lines of characters are needed, and the device shown had a capacity of four lines of 14 characters. Each device is formed by a 5 × 7 cell matrix, 0.75-mm square and spaced at 1.5-mm centres. Cells in each of 83 columns have their cathodes connected together to form one set of cross bars; anodes connect to an orthogonal set of 34 cross bars.

In the demonstration of this 'tube', rows were addressed sequentially and columns addressed in parallel from a row store. A buffer store recirculated data via a 64-character generator to the row store to refresh the panel at 500Hz. Generator was a standard 2240-bit m.o.s. read-only memory and the buffer store used six recirculating 64-bit m.o.s. shift registers. The display demonstrated is shown in Fig.1.

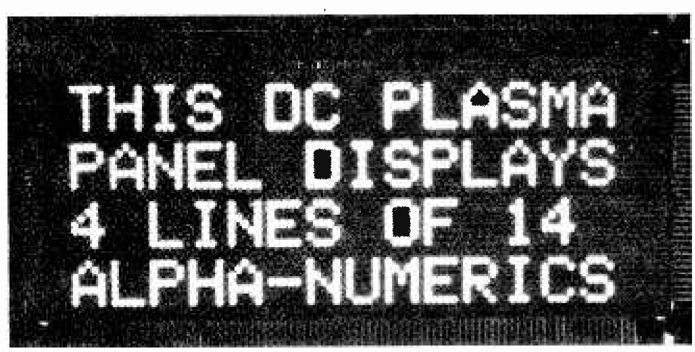


Fig. 1. The flat gas-discharge alpha-numeric display shown by Mullard.

Self-aligned molybdenum-gate m.o.s. transistors

Using the conventional m.o.s.t. technology, source/drain and gate areas, and gate conductors are defined by successive photo-mechanical masking steps, where essentially photographic images are aligned visually onto the pattern produced at the previous stage of processing. The alignment obtainable from this system is limited by the accuracy of the aligning equipment; for a typical system sequential patterns can be aligned to within $\pm 3\mu$m. Thus for a high frequency device of channel length say 3μm the gate conductor must be made 9μm wide to ensure that the gate covers the channel completely. The resultant gate overlap onto source and drain regions gives rise to parasitic input capacitance, which degrades high frequency performance.

With the advent of l.s.i. m.o.s., several techniques to produce auto-registered structures have been investigated to give better performance and higher packing densities. The most commonly used systems are the silicon gate m.o.s. and the ion implanted m.o.s. both of which require quite complex processing.

An attractive alternative, the molyb-

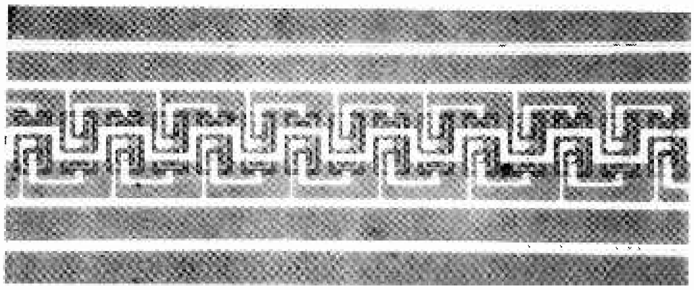


Fig. 2. Molybdenum gate m.o.s. shift register.

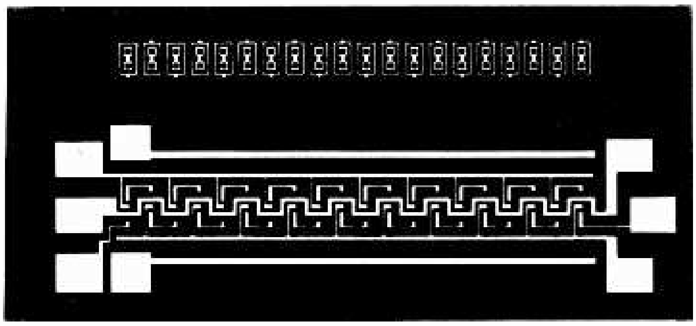


Fig. 3. Mask used for shift register.

denum gate m.o.s. has been investigated in the Electronics Department of Southampton University. This maintains the advantages of self alignment, but also results in simpler processing.

In this technique a layer of molybdenum is deposited onto the oxidized slice, and the metal and underlying oxide removed in the required diffusion areas to define gate conductors and source/drain regions. The slice is then diffused, the gate conductor acting as a diffusion mask, to produce source and drain areas that register exactly with the gate conductor. Gate overlap is now defined solely by diffusion depth. For the devices made at the University the diffusion depth is of the order of 0.4μm, giving gate overlap of around 0.2 to 0.3μm, an order of magnitude reduction over conventional processing.

Fig. 2 shows a shift register produced by this process which has a propagation delay of 10 ns per stage, and is t.t.l. compatible.

The mask used, shown in Fig. 3, was cut by a computer controlled laser-beam machine, also developed in the Electronics Department.

Matrix for addressing displays

A different way of coding information for solid-state displays uses a programmed coding matrix. Normally, character generation is done with m.o.s. read-only memories. The coding matrix shown by STL is simple to manufacture and its current handling capacity is compatible with GaAsP light emitters.

A matrix can be made with conducting rows and columns on a silicon slice, p-n junctions being diffused at appropriate intersections. Thus the matrix distributes current from input lines or terminals to a certain combination of output connections. Normal thickness silicon slices—250μm—are inconvenient because to minimize cross-talk between adjacent diodes they must be well separated, resulting in a large matrix area. Also input and output connections have to be on the same side. But with very thin slices—20μm—input and output conductors can be put on opposite sides and the diode-to-diode distances can be reduced. The slices, 2.5-cm diameter, are lapped and polished conventionally. Thickness monitoring below 25μm is made easy because the slices become transparent to red light. Diodes are produced by diffusing boron to a depth of 10μm into an n-type slice. Metal contacts 50-μm wide and spaced at 75-μm intervals are deposited and wired using the beam lead technique. A matrix with 40 top and bottom contacts measures 5×5mm.

Locked demodulator for Gunn devices

A new technique for frequency demodulation may lead to a simple Gunn oscillator-demodulator for short-range radio links at X-band. Experiments at the University of Sheffield by G. S. Hobson have shown that controlled variation of frequency in a c.w. X-band Gunn oscillator causes variations in bias current, which can be used to directly demodulate f.m. signals when the oscillator is locked to an incoming signal. When the oscillator is locked, detected current and frequency deviation show a linear relation. An efficiency in the range 0.1 to 1mA/MHz is achieved—constant up to 1MHz—with a lock-in bandwidth of 1MHz. In the experiments the Gunn diode was mounted in a coaxial cavity and connected to a constant-voltage bias circuit so that current could be monitored (see Fig. 4). Outputs between 1 and 10mV pk-pk have been obtained with a 50Ω current-sensing resistor, with very little dependence on incoming power. For a 1-MHz bandwidth, detector sensitivity is comparable with junction diode detectors. The trouble is the sensitivity to ambient temperature changes—it is not possible at present to get drift down to less than the 1MHz required under all temperature conditions.

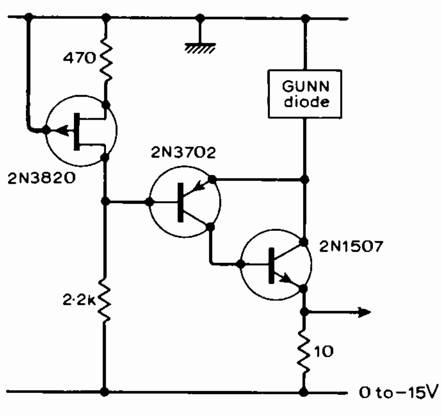


Fig. 4. The constant voltage bias circuit used so that the current could be monitored.

Scanning doppler guidance system

The phenomenon known as doppler shift has been used for many years in navigational systems. Basically, an aircraft can transmit a pulse of r.f. at some known frequency and receive the resulting reflection from the ground. The received signal will differ slightly from the transmitted signal by an amount proportional to the speed of the aircraft. By measuring this doppler, or frequency, shift it is possible to compute the aircraft's ground speed—not to be confused with air speed which can be very different. Several transmitters and receivers are often fitted to one aircraft so that drift can be calculated. Drift is the 'sideways' movement of the aircraft over the ground relative to its heading caused by wind. Doppler ground speed and drift measuring systems are often used as a reference for inertial navigation equipment. The outputs of the inertial equipment being compared with the doppler outputs so that error signals can be computed.

Standard Telecommunications Laboratories Ltd announced work they had been doing on a new way of harnessing the doppler effect to provide an aircraft with positional, instead of speed and drift, information which employs equipment both on the ground and in the aircraft.

On the ground a transmitter transmits a continuous signal (at the moment in the L-band) which is made to physically move at a known rate. A receiver in the aircraft measures the doppler shift of the signal due to the movement of the transmitted signal. This shift is proportional to the sine of the aircraft's bearing on the transmitter relative to the aircraft's heading, or more correctly track.

To make the transmitted signal move STL employ a multiple aerial array. The output of the transmitter is switched to each aerial in turn and the result, as far as the receiver is concerned, is very similar to a continuously moving aerial.

The doppler shift that would be extracted by the receiver from the equipment just described would be very small indeed and would be masked by receiver and transmitter drift. To overcome this problem a second r.f. signal is also radiated to provide a steady reference locked to the moving signal. Both signals are received by the aircraft and both contain the same error components but only one is subjected to the doppler shift due to the movement of the signal source. Comparison of the two signals yields only the doppler shift proportional to the bearing of the transmitter and the error components are eliminated.

In practice the frequency of the reference signal is slightly offset from the bearing signal although they are both ultimately derived from the same r.f. oscillator. The output of the receiver is the beat note between the two signals. This is of fairly low frequency so the doppler shift, which is contained in the beat note becomes relatively large and easy to measure very accurately using digital counting methods.

This basic arrangement can be used to solve a number of navigational problems. A single horizontal array of aerials will provide the aircraft with azimuth (track) information, a vertical aerial array will give information on the aircraft's elevation. Two such arrays mounted at right angles will form an omni-range beacon. Three arrays mounted orthogonally will give a three dimensional service anywhere in a straight line from the transmitter. If two such orthogonal systems (six aerial arrays) are employed at different sites the aircraft equipment can display position over the earth's surface in three dimensions.

Applications do not end with navigation; the scanning doppler system can be used to replace the airfield localizer and glide path transmitters, used for instrument approaches and automatic landing, with advantage. This would be particularly valuable for vertical and short take-off aircraft.

STL say that although they have been working in the L-band they are now extending operations into the C-band. They have calculated that a C-band system would be accurate to about 0.02 degree r.m.s.

Measuring the tides

A printed circuit digital tide gauge, capable of accurately recording mean wave height in open water was demonstrated by the Institute of Coastal Oceanography and Tides. The sensor is a 13m long plastic-covered multi-layer printed circuit which stands vertically in the water. Elements are spaced at 2cm intervals and capacitance changes produced by the fluctuating water level are measured. The associated electronic circuitry provides Gray code binary information, and finally a pulse train is developed in which a pulse rate is proportional to the instantaneous water level. In the presence of waves the sampling procedure provides an accuracy of 1mm in the total range of 13m.

Adaptive delta modulator system

Shown by Southampton University, the exhibit concerned an adaptive version* of the basic delta modulator employing full-width pulses and RC integration. A digital technique is used to sense the level of the input signal and to control the amplitude of the pulses applied to the RC network in the feedback loop. Subjective testing with speech signals and a modulator clock rate of 56 kilobits/s has shown that a useful volume range of 40 dB is available with commercial telephony-grade performance. At a clock rate of 19.2 kilobits/s which is common in military communications, a signal-to-quantization noise ratio of 16 dB has been obtained over a dynamic input range of 20 dB for an 800 Hz sine wave.

The level sensor consists of a J–K bistable, a combination of NOR gates as shown in Fig. 5 and an averaging circuit having a 20 ms time constant. The output from the exclusive NOR circuit is high whenever adjacent pulses in the output from the delta modulator are of the same polarity, and the averaged value is approximately a constant level V_{so} for any sine wave input. $E_{max} \sin \omega_{mt}$ satisfying the limiting condition of nonoverloading of the basic delta modulator

$$E_{max} = \frac{V}{\sqrt{1+\omega m^2T^2}}$$

where T is the time constant of the feedback network and V is the amplitude of the digital output. That is to say,

$$V_{so} \approx kE_{max}\sqrt{1+\omega m^2T^2}$$

$$\approx k\omega mE_{max}, \text{ where } \omega m > 1/T$$

For sine wave inputs having peak amplitudes $E < E_{max}$ the level sensor output V_s, is given by

$$V_s \approx k\omega mTE.$$

These characteristics form the basis of the adaptive system. The feedback loop is arranged to keep the output from the level sensor at V_{so}, i.e. the modulator is

*Betts, J. A. and Ghani, N., 'Adaptive delta modulator for telephony', *I.E.E. Electronics Letters*, Vol. 6, No. 11, 28th May, 1970, pp. 336-338.

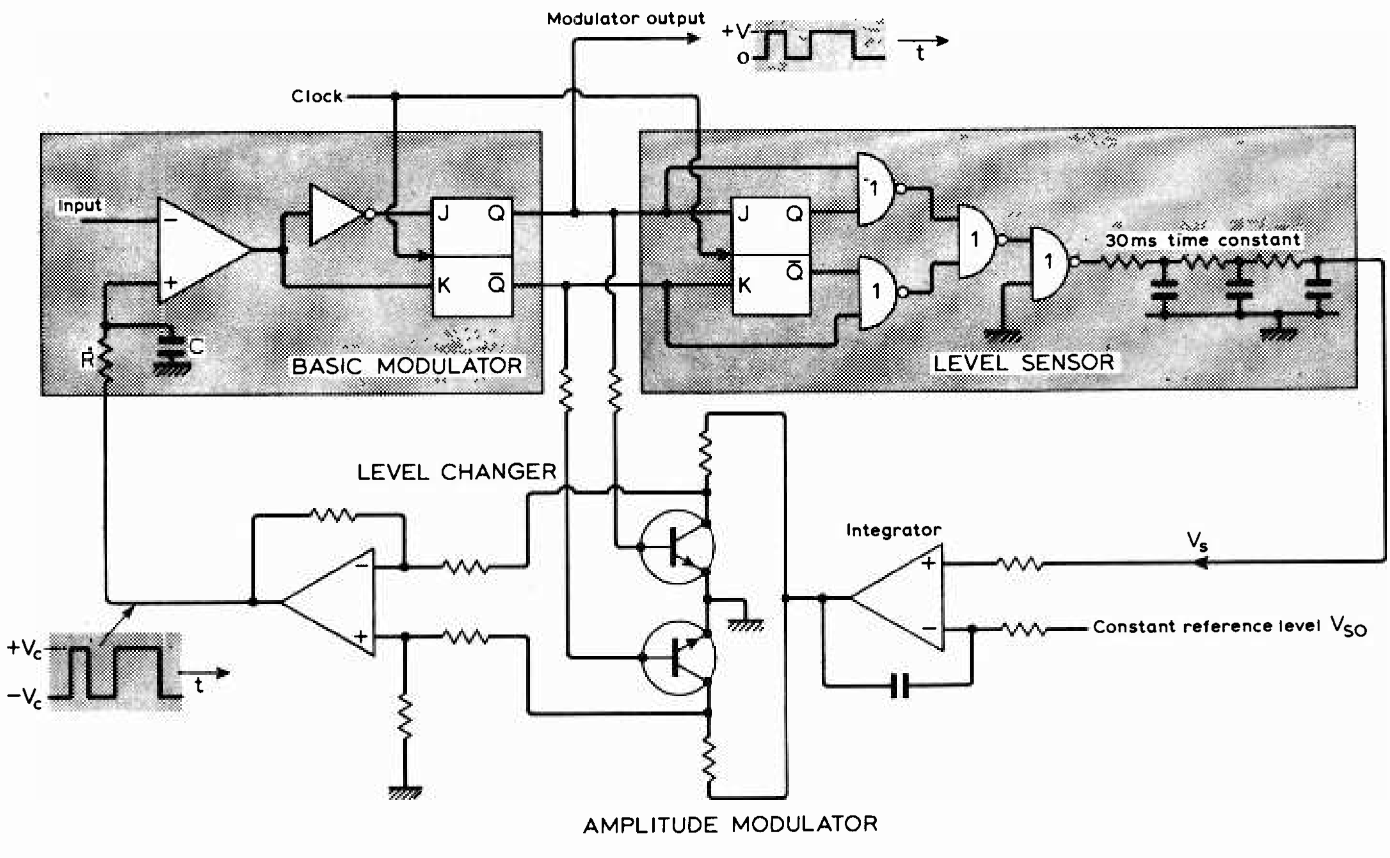


Fig. 5. Adaptive delta modulator using full width pulses.

made to function at the limit of nonoverloading over a wide range of input conditions.

A novel application of the adaptive delta modulator known as the Adaptifon† system has also been developed in which the compression and expansion circuits of Lincompex are realized by the delta modulation technique. Speech is transmitted in analogue form at constant amplitude which together with an f.m. syllable-rate channel occupies the conventional 3kHz bandwidth. The receiving system has the capability of removing fading from signals transmitted over an h.f. path. The system has two advantages over Lincompex, namely the use of a digital shift register for delay equalization and its compact lightweight size which makes it suitable for mobile applications.

Fire detection by laser beam

The Fire Research Station, at Boreham Wood, has found a good use for a low-power laser. The outbreak of fire in a closed room results in a mushroom of hot gas. If a laser beam is passed through the gas layer just below the ceiling the refractive index gradient due to the temperature gradient causes the beam to be deflected downwards. For a temperature gradient of 4°C/m deflection of the beam is about 3mm for a 40m path through the hot gas. Turbulence in the gas flow moves the spot about irregularly. The detector is a photocell with a chequer-board mask. The holes in the mask are roughly equal in area to the laser-beam spot. Capacitatively coupling the photocell to an amplifier results in a signal whenever the spot moves quickly, but there is no output for the slow drive that might result from building movements or changing ambient temperature. Optimum discrimination between fire and normal sources of heat is achieved by amplifying the photocell's output in the range 40 to 70Hz.

Reducing noise in photodiode arrays

With a rectangular array of silicon photodiodes additional noise over a single diode or a linear array is produced which is greater than the random noise generated by the elements themselves. Called spatial noise, it results from the element-to-element differences in output level due to variations in quantum efficiency, cell dimensions, leakage current, and output off-set of associated m.o.s. amplifiers. A signal processing system which can improve signal-to-noise ratio has been developed at the Allen Clark Research Centre. With no illumination, output from each of 100 photodetector elements in the array is stored in a shift register. When an image is focused on to the array, the stored information is subtracted from its output so that the variations causing the spatial noise are eliminated. To obtain sufficient accuracy, the output from each detector element is converted into a 10-bit code. Although the system demonstrated used a small 10 × 10 photodiode array, it had sufficient bandwidth for use with an array of 10^4 detector elements scanned at 16 frames per second. By expanding the digital store it is possible to generate flicker-free displays even when the detector array is scanned at very low rates.

†Betts, J. A., 'Adaptifon system of telephony', I.E.E. Electronic Letters, Vol. 6, No. 17, 20th August, 1970, pp. 542-543.

Measuring distortion using an oscilloscope

The University of Sheffield laid on a simple oscilloscope demonstration of the effect of negative feedback. Of particular interest was a discussion of an oscilloscope technique for estimating the amount of second harmonic distortion present in a sine wave. The procedure is to estimate the upper and lower turning points for a line making equal intercepts with the waveform—as shown in Fig. 6.

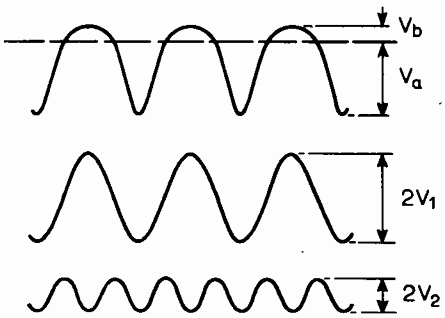


Fig. 6. Demonstrating the effect of negative feedback.

It is easily shown that:

$$\frac{V_2}{V_1} = \frac{V_a - V_b}{2\,(V_a + V_b)}$$

and

$$2V_1 = V_a + V_b$$

This last point illustrates that the amplitude of the distorted signal is the same as that of its fundamental component.

Microwave biased photoconductor

A fast response photoconductor operated with a high-frequency bias provided by a microwave field, gives a photodetector with a large gain-bandwidth product. The system, which was shown at the exhibition, is at present under development at Plessey's Allen Clark Research Centre (for the Ministry of Aviation Supply) and is designed to work at 1.06μm and uses germanium as the photo-conductor. The noise equivalent power is 5 × 10^{-9}W in a 10MHz electrical bandwidth and the 10-90% rise time is 80 nanoseconds. The 10GHz bias is applied to the photoconductor by mounting it in the high-field region of a re-entrant microwave cavity. The change in conductivity of the photoconductor, which is caused by the absorption of amplitude modulated light, results in a change in the reflection coefficient of the microwave cavity. The resultant change in microwave power reflected by the cavity is detected, amplified and displayed. The amplitude fluctuations of the output are a reproduction of the amplitude fluctuations in the incident light beam. The bandwidth of the system is limited by the bandpass of the microwave cavity.

This detector will be suitable for use in optical communications systems, laser radar and imaging systems. It is worth noting that once the microwave system has been developed, operation at any desired wavelength can be obtained by insertion of an appropriate semiconductor sample in the photoconductor cavity. The system under development has been operated with silicon, germanium and indium arsenide and work is in progress to extend the operating wavelength to 10.6 microns.

Safety for miners

The presence of gas in mines is one of the greatest hazards of the mining profession as events of not too long ago have emphasized. The Safety in Mines Research Establishment have been doing work to find ways of detecting the presence of dangerous gases and have come up with a solution employing a semiconductor sensing element. An example shown at the exhibition was designed to detect methane. It consists of a bead of zinc oxide which is doped with platinum and is formed on two 25μm platinum wires held 50μm apart. A current is passed through the bead to heat it up to a temperature of 600°C and a voltmeter is used to register the voltage drop across the sensing element so formed.

If methane is present it is absorbed by the zinc oxide and results in a change in the electrical characteristics of the bead and a change in the reading on the voltmeter.

The sensing element will measure methane concentrations in air over the entire range (0 to 100%) and up to 5% methane concentration it is accurate to ±0.1%.

Short items

● Class D amplifiers with power output up to 2.5kW are being made by E. M. Wareham (Measuring Systems) Ltd. Designed in conjunction with U.K.A.E.A., Culham, they can be paralleled to give powers up to 20kW. Model shown had an output power of 500W from d.c. to 1kHz. Working from two 24-volt batteries, energy is returned to the battery when used with inductive loads.

● *RC* oscillator type TG200 made by Levell Electronics Ltd, uses single-track potentiometer for frequency control in a two-integrator circuit. It is designed so that varying the gain of an amplifier varies frequency. Instrument covers 1Hz to 1MHz with an amplitude of 0.2mV to 7V.

● By illuminating an S1 photocathode with an infra-red gallium arsenide emitter through a light guide, 20th Century Electronics aim to develop an electron emitter as an alternative to the thermionic cathode. Photocathode has a current density of 5mA/cm².

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

M.W. broadcasting

It would seem that around 1955, the B.B.C. gave up trying to provide a decent a.m. service to its listeners on the grounds that an adequate v.h.f. service would be provided. The results are that in the evening Radio 1 suffers from appalling distortions which presumably arise from operating too many transmitters on the same wavelength. Radio 2 is virtually unobtainable in many areas (particularly Scotland) and Radio 4 appears to have ceded its officially allocated 330m and 434m wavelengths to unauthorized, but well muscled, East German transmitters.

Now that the B.B.C. monopoly has been breached and a wavelength re-shuffle is imminent I would like to make a plea that the B.B.C. Engineering Dept. face up to the realities of life in the 70s. First, to accept that 15 years of poor service and propaganda have failed to drive the average listener from the medium and long waves. Secondly to acknowledge that future commercial competition means that some priority will have to be given to the bulk audience i.e. Radios 1 and 2. Thirdly to come to terms with the fact that the Copenhagen Plan died when the two Germanys recovered strength in the early 1950s. Let us have a determined attempt to provide a good, truly national, three channel, day and night a.m. service. If frequencies are the trouble why not take some. What, for example, is wrong with 155 kHz and 254 kHz as reinforcements for Radio 2? Similarly, if interference is the trouble, why not follow the trail blazed by the Foreign Office at Crowborough and turn up the wick? To achieve parity with the noisy Continentals requires 1MW on 200kHz.

C. HIGHAM,
South Croydon,
Surrey.

Loud and clear

Having been engaged in the audio field during what Mr. Devereux, in his evocative article 'Loud and Clear' (April p.156), calls 'the first golden age of high-quality sound', I feel it would be right to couple with the name of P. G. A. H. Voigt those of H. A. Hartley and P. K. Turner. They too produced equipment that was unusual, for those days, in being good enough to disclose transmission defects and to allow enjoyment of the 'good things which for years the B.B.C. had been wasting on the desert air'.

Perhaps Hartley-Turner also rate a mention in an anniversary issue of *Wireless World* on the strength of Hartley's mordant advertising copy, which was for a few years a regular feature of the journal; in its way it was as far ahead of its time as certain of the firm's products and I well remember people saying that the H-T advertisement was the first thing they turned to.

CLAUD POWELL,
New Malden,
Surrey.

C-D ignition

I have recently built the C-D ignition system described by R. M. Marston, (*W. W.* Jan. '70) and incorporating all the modifications later recommended.

On installation in my six cylinder car it was found that severe misfiring occurred from mid-range r.p.m. onwards, a problem that other constructors have experienced (*W.W.* May '70).

Investigation showed this was due to a rapid fall in the 400-volt supply to C_1, which in turn was due to a large difference in peak current through Tr_1 and Tr_2. In my case it was 1.4 amps and 2.5 amps respectively and results from the spread of h_{fe} between transistors.

Unless matched pairs of 2N3055 transistors are purchased it would seem that some form of setting-up procedure should be adopted.

In my case it was as follows:—

(1) After initial wiring and functional checks, short-circuit Tr_1 emitter/base. Connect 250μF capacitor between emitter and collector.

(2) Monitor the voltage across R_6 and adjust the value of R_7 until 2.5 volts are read.

(3) Remove the short-circuit and capacitor from Tr_1. Short Tr_2 emitter/base and connect the 250μF capacitor between the emitter and collector. Adjust the value of R_8 until, again, the voltage across R_6 is 2.5 volts.

(4) Remove the short-circuit and capacitor.

After this setting-up procedure the unit worked perfectly.

I apologize for writing on an article published 18 months ago but feel these comments may be of use to other constructors in similar trouble.

R. C. LOCKWOOD,
Harlow,
Essex.

Stereo decoder using sampling

In his letter in the May issue about the performance of the sample and hold network of his decoder, Mr Waddington has contradicted himself—by charging me with 'relying entirely on theory' on the one hand, while producing 'excellent spectrum photography' on the other, in spite of the spectrum photograph using the sample and hold network of *his* decoder.

I thought my letter made it clear that the results obtained *in practice* closely followed *predicted* theoretical performance—i.e. a (sin x)/x response for a narrow sampling interval. The photograph clearly shows a loss of about 2.4dB at 15kHz, this being supported by theory.

I therefore do not agree with Mr Waddington's estimate of the −3dB frequency of close to 15MHz, rather than the predicted 17kHz.

I also do not agree with his terminology of the sample and hold network as a 'gated peak detector', because it does not detect peaks but merely samples—and therefore multiplies—and holds, a random input signal for a fixed interval.

I must stress again that audible noise reduction may be effectively accomplished only by either pre-filtering or reducing the sampling signal mark-to-space ratio.

T. PORTUS,
Derby.

Pickup self-capacitance

While musing on the design of the rumble filters included in two pre-amplifiers of Mr. J. L. Linsley Hood intended for use with ceramic pickup cartridges (Fig. 5 page 308 *Wireless World* July 69 and Fig. 4 page 208 May 1970) it became obvious that the design as published would not be satisfactory with all pick-ups owing to the effect of the pickup self-capacitance. Each of the two pre-amplifier designs uses the same basic design system for its rumble reduction—a 12dB/oct. active filter circuit giving a slight hump near the cut-off frequency together with an input circuit *C-R* combination to flatten the hump, and to provide a further 6dB/oct.

In the case of the July 1969 design this *CR* circuit is shown as a capacitance of 680pF (C_1) and a resistance of 4.3MΩ (R_1) in Fig. 5. Likewise in the May 1970 design the *CR* circuit is placed at the input of the pre-amplifier and consists of 1500pF (C_1) and 2MΩ (VR_2). These circuit values would give −3dB frequencies of 54 Hz and 53 Hz respectively, if, and only if, the

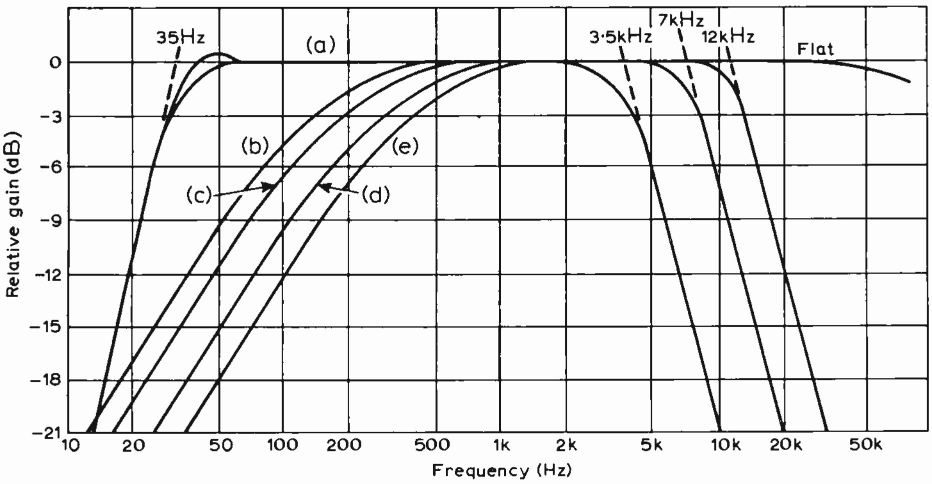


Fig. 1 Performance of unmodified pre-amplifier with three different ceramic cartridges. (a) pre-amplifier alone; (b) Sonotone 9TAHC; (c) Decca Deram; (d) Connoisseur SCU1 plus 100pF strays; and (e) Connoisseur SCU1, no strays.

pickup cartridge can be considered as a zero impedance generator. Since all pickups are capacitive sources, the pickup self-capacitance would have to be at least 10 times the capacitance of C_1 in each case not to interfere appreciably. Of the pickup cartridges likely to be used with these pre-amplifiers, none has a capacitance higher than 1000 pF, and one pickup—the Connoisseur SCU1—is only 200 pF! Thus the pickup capacitance will interfere with the design −3dB point very considerably.

This effect would cause considerable attenuation of the bass, which therefore destroys the advantage of a high load impedance generally required to obtain good bass. The golden rule here is, never put capacitance in *series* with the pickup connection to the load resistor. Series capacitance means that the load resistor must be *raised* to obtain reasonable bass.

As an example of this effect, the actual bass response with three well known pickups is shown in Fig. 1, which is redrawn from Fig. 3 in the May 1970 article. Owing to the large attenuation at rumble frequencies given by having the −3dB frequency so high, no further active filter circuit is necessary. E.g., with a Deram, −3dB freq.= 195 Hz, attenuation at 25 Hz = 18dB.

This is clearly unsatisfactory and does not produce a performance which could be labelled 'high quality'.

Very simple modifications will alleviate the trouble and will restore the actual performance to approximately the designer's intentions. The changes needed in the Fig. 5 July 1969 design, with several popular ceramic pickups, are as Table I, and Table II gives the circuit and component alterations for the May 1970 design.

With these modifications incorporated, the response will be approximately flat down to 50 Hz and then drop off at 18dB/oct. at lower frequencies.

One further point; the circuit given for curve 3 in Fig. 5 of the modular pre-amplifier design of July 1969 is claimed to give a 12dB lift. The circuit shown gives only 9.5dB. However should the full 12dB be needed, the revised values of 1MΩ, 3.3MΩ and 100 pF should be used instead of 1.5MΩ, 3MΩ and 68 pF respectively, as shown in the example circuit beneath Table I. Using these revised values the actual circuit performance is:– lift 12.5dB, turnover frequencies, 500 Hz and 2.1 kHz (as for R.I.A.A. equalization).

B. J. C. BURROWS,
Ewelme,
Oxon.

TABLE II. Modifications to Linsley Hood pre-amplifier May 1970

Pickup cartridge	C_x
C1 (or SC5M)	390pF
CS 90/91E	470pF
9TA HC	560pF
KS 40A	820pF
Deram	820pF
SCU1	Not suitable

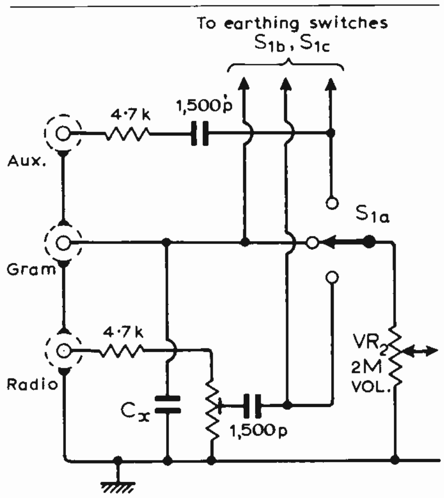
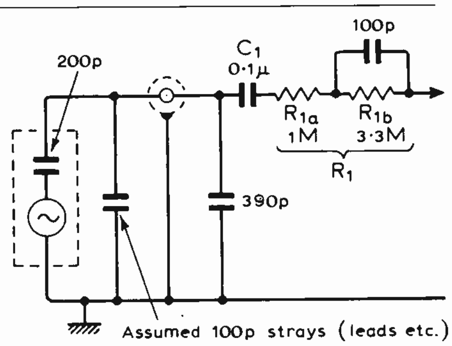


TABLE I. Modifications to Linsley Hood pre-amplifier July 1969, Fig. 5

Pickup	Modification	Comments
Sonotone 9TAHC	Raise C_1 to 0.1μF	Use circuit 2
BSR C1 (or SC5M)	Raise C_1 to 0.1μF	Use circuit 1
Goldring CS 90/91E	Raise C_1 to 0.1μF	Use circuit 1 or 2 according to preference
Decca Deram	Raise C_1 to 0.1μF	Use circuit 1 or 2 according to preference
Garrard KS40A	Raise C_1 to 0.1μF	Use circuit 1 or 2 according to preference
Connoisseur SCU1	Raise C_1 to 0.1μF and shunt pickup input terminal with 390pF	Use circuit below



As an example of the suggested modifications the pickup input circuit for each channel of a Connoisseur SCU1 will be as shown here.

Ganged potentiometers

Your correspondent K. J. Young (March issue) refers to the "Addashaft" scheme for supplying potentiometers and shafts separately. As the sole U.K. distributors of Addashaft controls—this was our trade name for the patented system employed—our marketing experience may be of interest.

Initial interest was high in the context of single ganged potentiometers alone. We were offering a range of nine different shafts together with log. or linear law potentiometers, with or without mains switch. The stock reduction principle expounded by Mr. Young was thus valid. However, in time, industry usage standardized largely on 0.25in. plastic spindles with flat, thus negating the practical effect of this principle. It is true that damage during shaft cutting was diminished. Against this, the combined cost of separate shaft and potentiometer unit was significantly higher than that of a factory assembled unit. Material savings, though offering a wider choice of shaft lengths, would have been marginal and largely offset by the smaller batch sizes of the greater variety manufactured. In the event, market interest declined to a point where the range was discontinued.

During the life of this range, prototypes were produced of dual concentric and tandem forms. The mechanical problems were more complex and aggravated, in the case of dual concentric types, by the different knob fittings and relative shaft lengths. Cost differentials and quality assessment problems would have been greater. Market research indicated a lower level of interest than for single ganged types. For these reasons no serious work was undertaken and all work abandoned at the time the single ganged range was discontinued.

While still recognizing the value to some users of this approach, we do not believe that the overall market situation has since changed to the extent that this idea could usefully be revived as an economically attractive proposition.

ROY S. GIBBONS,
Radiospares,
London E.C.2.

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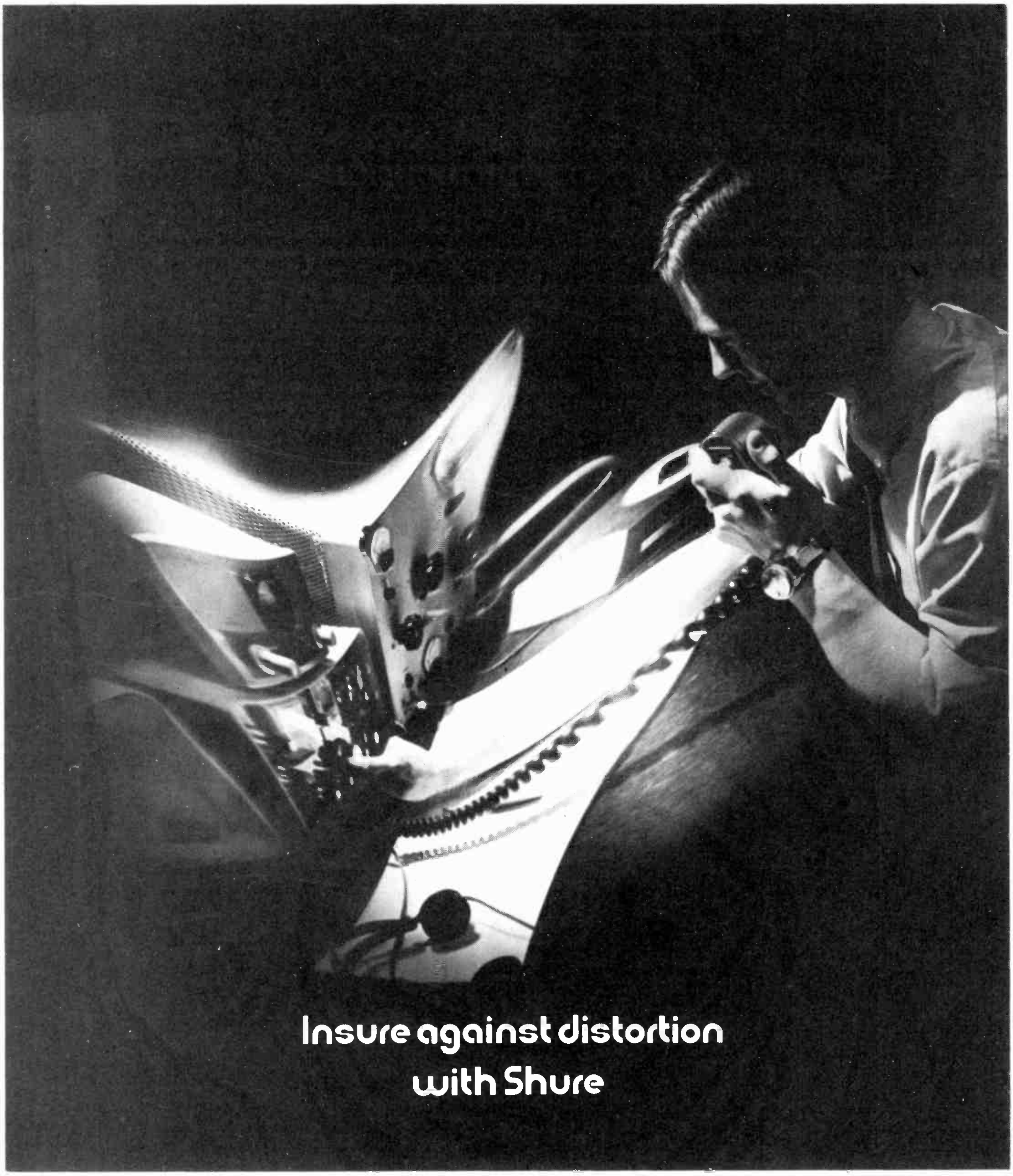

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Transformer Phase Reversal?

by 'Cathode Ray'

Here, in Fig. 1, is a simple practical problem. The transformer has identical primary and secondary windings, with 100% coupling and negligible losses. The secondary is wound around the core from c to d in the same rotation as the primary from a to b (indicated by the conventional dots as well as by the way the coils are drawn). What is the polarity from c to d relative to that from a to b?

I said it was a practical problem. In an amplifier circuit the answer would make all the difference between negative feedback and positive feedback. And in an oscillator circuit it would make all the difference between oscillation and non-oscillation. I have heard of a batch of 200 units having to be scrapped because someone got it wrong. Yet when a certain teacher put it to a class of electrical engineering students, 11 of them said the polarity would be the same and 12 said the opposite!

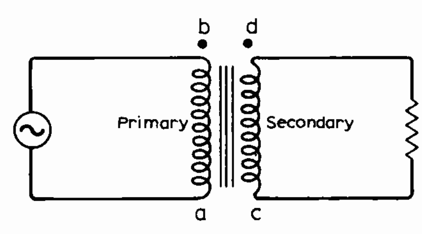


Fig. 1. An ideal transformer. Is the secondary voltage in phase with the primary voltage, or phase-reversed?

Victor Mayes, of Gloucester Technical College, has made a special study of the current state of education on this point, and it seems that it is a very poor state indeed. In the circumstances the class as a whole can be congratulated for nearly half of them getting the answer right, when less than one in ten of the available textbooks was quite clear on this elementary matter. Mr Mayes looked up nearly 60 relevant books of the last 20 years, and found only five he could recommend on it, and he had reservations about some of them. The great majority used double-headed voltage arrows or in some other way failed to show which way they were jumping, but most of them spoke of a voltage phase reversal between primary and secondary and indicated it by a phasor diagram basically as in Fig. 2. Even among the few authors whose symbolism clearly specified the directions of the windings and the relative polarities of the voltages across them, most showed a phasor diagram like this, implying a phase reversal.

What were *you* taught?

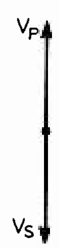


Fig. 2. The usual phasor diagram for Fig. 1 is basically like this.

Mr Mayes was so disturbed by this state of affairs that he sent a circular letter to all the transformer manufacturers he could trace, asking them their answers to the question. I have seen the replies, which reveal a corresponding confusion. One or two said there was supposed to be a phase reversal but for certain purposes it was more convenient to assume there wasn't! (This is matched by at least one author who says there is no phase reversal, but because examination questions are marked on the basis that there is, he would go along with that idea!) The best way of proving that electrical (and electronic) education is an ass is, according to Mr Mayes, to try it and see, using an oscilloscope or other unambiguous indicator. Quite so, but I'm afraid I can't persuade the *Wireless World* management to supply such equipment to each reader with this month's issue, so I'll just have to try to make the thing irrefutably clear on paper.

Being so old, I've completely forgotten what I was taught, but I do know that because of inattention or otherwise I carried away a very hazy impression of a lot of things. In a college course there is really no time to question every little bit of information one is given, orally or by reading; the task of absorbing enough to pass the exams is sufficient. The questioning came later; often much later. Nothing would do but to think it out for myself. The results of this cogitation were sometimes additional to—occasionally even contrary to—the usual teaching. To impress them on my mind I wrote them out and sent them along to the Editor for the time being of *Wireless World,* and he has been publishing them since 1934 (even earlier under another name).

One advantage of this procedure was that when called upon by a correspondent to clarify the phase relationships of transformers I was in no way affected by the regrettable state of things described by Mr Mayes. Until 1968, when he drew my attention to it, I was quite ignorant of it. The possibility of any—let alone a majority of—people clever enough to write a textbook falling into such an elementary error had just not occurred to me. I still find it hard to believe. On the other hand, as long ago as 1954, when this transformer question was put to me, I was already aware of the double-headed voltage arrows and all the other ambiguous and confusing notations and conventions applied to circuit diagrams and still more confusingly to phasor diagrams (then usually called vector diagrams) and had discarded the lot and begun again from scratch, arriving at the system used in the *Wireless World* article on transformers (Sept. 1954, p. 454) and described in more detail in the book *Phasor Diagrams* (Iliffe, 1966). This system, being unambiguous, is incapable of giving a confusing answer over a matter like this of phase relationship. *Any* voltage between two points can be regarded as in one phase or its opposite, depending on which is taken as the reference or zero point. So the points have to be labelled (say a and b) and the voltages labelled to correspond, either V_{ab} or V_{ba} depending on direction (or more simply *ab* or *ba* if such letters are known to be used for voltages, in contrast to *AB* and *BA* for currents). *Finally the phasors have to be labelled to correspond.* Arrows are superfluous, and indeed only tend to confuse.

For example, Fig. 3 shows the voltage phasors corresponding to Fig. 1. The fact that they are parallel signifies that the voltage *cd* is in phase with the voltage *ab.* And equally, it is opposite in phase to *ba.* There are no double-headed arrows, like

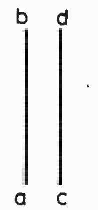


Fig. 3. Recommended phasor diagram for Fig. 1, leaving no uncertainties.

Mr Facing-both-ways in *Pilgrim's Progress,* nor single-headed arrows to tell you that you must face one particular way.

Yes, you may say, but how does one *know* that cd must be drawn that way, and not the opposite as the textbooks say? Well, I went into that in a good deal of detail in the September 1954 *Wireless World* and in Sec. 7.7 of *Phasor Diagrams.* This time only the voltage phase relationship is in question, so we shall cut out most of the detail and confine ourselves to that one point.

We begin with a primary winding only, as in Fig. 4. The generator is giving a sine-wave voltage, which is set up between the two points a and b. It drives a current around the winding, and this current causes a corresponding alternating magnetization of the core. This in turn generates a voltage in the winding. This voltage also occurs between points a and b. And as there cannot be more than one potential difference between two points at the same time, these voltages must be equal. They are in effect one and the same voltage and can therefore be represented by the one phasor ab. What makes them equal? This condition is automatically fulfilled by just enough magnetizing current flowing to make it so.

Here now is the first place where the ordinary phasors with arrow heads can get people confused. Most books call the generator voltage E and the voltage generated in the coil V_1, or some such symbols. Then if they are thinking of the two terminals a and b they may show E and V_1 in phase, as in Fig. 5(a). Much more likely they will be thinking of voltages acting around the circuit, E (say) clockwise at some instant, and V_1 anticlockwise, and will represent them as in Fig. 5(b). Fig. 4 is not only simpler; it corresponds to the undoubted fact, which can be demonstrated with a voltmeter, that only one voltage at a time exists between a and b. So voltages *ab* due to the generator and *ab* due to the coil cannot be anything but in phase. Of course if you prefer to compare voltages *ab* and *ba,* you are

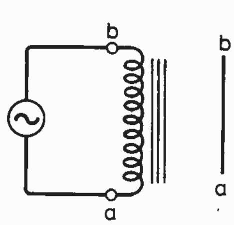


Fig. 4. Fig. 1 can be developed from this basic circuit.

entitled to say they are opposite in phase. Please yourself. All are right. There can be no argument or doubts as in Fig. 5.

Next, no difference in principle is involved if the winding is made of stranded wire. All the strands are in parallel and all have the same voltage induced in them by the alternating magnetic flux. For simplicity let us suppose there are only two strands. There can be a very thin layer of insulation between them, not enough to upset the condition that both windings embrace the same amount of flux so have the same voltage induced in them. These two strands, if they are now disconnected at their ends, can be

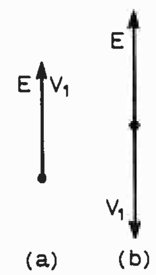


Fig. 5. Voltage phasor diagram (a) is sometimes seen for Fig. 4, but (b) is much commoner.

regarded as the two separate windings in Fig. 1, except that the winding connected to the terminals c and d is open-circuited. The phasor diagram, as in Fig. 6 while the strands were paralleled by connection at their ends, now becomes as in Fig. 3. This diagram shows that there is indeed a phase reversal between voltages *ab* and *dc.* But I think most people would want to compare *ab* and *cd,* which are undoubtedly in phase. It is confusing to say, without precise indication of winding directions and an unambiguous voltage notation, that the secondary voltage is reversed in phase compared with the primary.

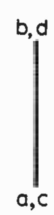


Fig. 6. This phasor diagram applies to Fig. 4 when the winding consists of two strands (ab and cd) in parallel, and Fig. 3. applies when they are disconnected to yield Fig. 1.

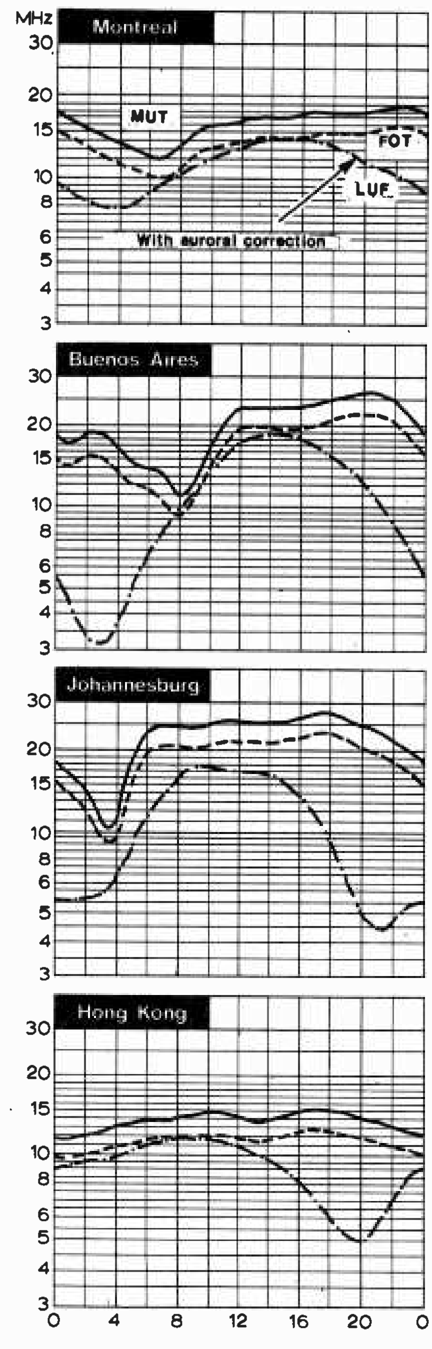
Of course the arrowy situation of Fig. 5 is now complicated by the secondary voltage, which might be called V_2. I will spare you the varieties of 'vector' diagrams you will be able to find when there are three arrows to play about with!

Just before signing off I would however remind you that our transformer was an ideal one, with 100% coupling and negligible losses. Having got the basic action straight, one can then go on to introduce elaborations to represent winding resistances, core losses and leakage inductance.

H.F. Predictions—June

Effects of summer season and steadily decreasing solar activity are particularly evident on the East/West route charts. Poor working or loss of communication on low power systems can be expected when LUF is close to FOT and it can be seen that this condition exists for 8 to 12 hour periods on three of the routes.

LUFs shown are for reception in the U.K. Those for the reciprocal routes will be roughly the same shape but shifted along the time axis. This prolongs the poor working periods for two-way communication.



New Approach to Transistor Circuit Analysis

by A. J. Blundell, M.I.E.E.*

In this two-part article – which forms a complete introduction to transistor amplifier theory – A. J. Blundell describes a simple "voltage-control" transistor model bridging the gap between an earlier simple model and the hybrid-π equivalent circuit. It can be applied to small-signal, large-signal and d.c. conditions and has the advantage that the ordinary circuit diagram can be turned into its own equivalent circuit by introducing a simple circuit concept called a "beta barrier". Part 1 starts with amplifier basics, and introduces the small-signal model and applies it to a common-emitter stage. A correction term used in evaluating internal emitter resistance is proposed by the author who also gives a method of optimizing voltage gain. Part 2 will apply the model to an emitter-follower stage, discuss its accuracy compared to the hybrid-π circuit and give a d.c. and large-signal version of the model applicable to Darlington and complementary pairs. It concludes by applying this model to the well-known Lin output stage and shows how simple modifications balance the circuit.

The theory of transistor amplifiers seems to be in a bewildering state. Although accepted transistor models were laid down and their equations solved many years ago, they do not appear to be entirely satisfactory.

There are several reasons for this, perhaps the most significant being that manufacturers quote only *h* parameters for their transistors, indeed sometimes only h_{fe} is provided. Consequently only the two-generator *h*-parameter model can be used without considerable pre-calculation.

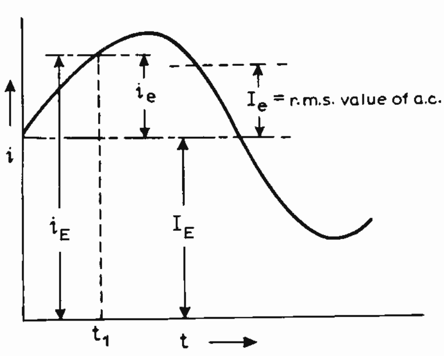
The *h*-parameter model is not easy to handle without approximation, except for the most elementary circuits, as anyone will realize who has attempted an exact solution for the common-emitter amplifier with an external emitter resistor. Also it is not suitable when reactive circuit elements, such as transistor capacitances, become important.

Further, *h* parameters are liable to misinterpretation because of the correlations which exist between them. The result of this is that many engineers have come to regard the transistor as a wide tolerance device and many have adopted the attitude that the only course of action is to apply plenty of feedback so that the open-loop characteristics do not matter very much. In fact the situation is not nearly so bad as this.

I have been concerned with semiconductor power devices since their early days so that when called upon to teach transistor circuit fundamentals it was assumed that I must be an expert on transistors.

Smiling cheerfully to maintain the illusion I hurried to the library to do some hard reading. The wide range of textbooks available only justified fears when, as luck would have it, I saw the article "Simplified transistor amplifier calculations" by C. H. Banthorpe.[1] This immediately rang the proverbial bell because it appeared to have a desirable attribute of any theory—its suitability for back-of-the-envelope calculations in the laboratory. In addition it was a "voltage control" rather than a "current control" approach.

The last point seems very important. From the physical point of view the transistor in its usual common-emitter connection is voltage controlled; the base current being (except for a negligible component) a parasitic effect which would be absent in an ideal transistor. (If anyone would like a fight over this one I'm game!) Further, there are influential engineers who prefer the voltage control point of view. For example P. J. Baxandall says[2]: For many years I have felt that the almost universal tendency to regard transistors as "basically current operated devices" has exerted a major retarding influence on progress in good transistor circuit design.



Explanation of symbols. Average or r.m.s. values are indicated by capital letters; instantaneous values by lower-case letters. Capital letter subscripts indicate the total or d.c. value of a quantity; lower-case subscripts indicate the a.c. or time-varying component, taken from its average value.

There are also very down-to-earth reasons for preferring a voltage description of a circuit. Most transducers are specified in terms of voltage generated or required and, because the oscilloscope is the universally used test instrument, a voltage signal is easier to measure than a current signal.

It is important to point out that the real object of amplification is to increase the power transmitted rather than to increase the signal voltage or current level. To illustrate the distinction consider the transformer which is not an amplifier but can give a voltage gain proportional to the turns ratio. The current gain however, will be the reciprocal of the turns ratio so that the power gain is unity, ignoring losses.

The essential property of an amplifier is that the output power plus the internal loss is greater than the input power. To be able to do this an amplifier needs an active element and an auxiliary power source which it can use to provide the extra signal power. The transistor is such an active element and the auxiliary power source is its d.c. supply.

Unfortunately power is not easy to measure directly so that engineers usually think in terms of a combination of source or load impedance and a voltage or current gain; which amounts to the same thing.

Having put forward arguments intended to explain motivation rather than to convince a sceptic, the following exposition presents a theory of transistor amplifiers which bridges the gap between C. H. Banthorpe's treatment and the hybrid-π equivalent circuit, the latter being the one which allows transistor capacitances to be incorporated most easily. The starting point does not concern transistors, but amplifier theory itself, because it is often misunderstood.

Taking voltage as the main variable for measuring the signal it is necessary to examine the general problem of transferring a signal from a source through an amplifier to a load, starting first with a direct source-to-load transfer with no amplifier.

Coupling gain

Suppose a source feeds a load as in Fig. 1(a). To aid visualization let the source be a microphone and the load a pair of head-

*Lanchester Polytechnic, Rugby

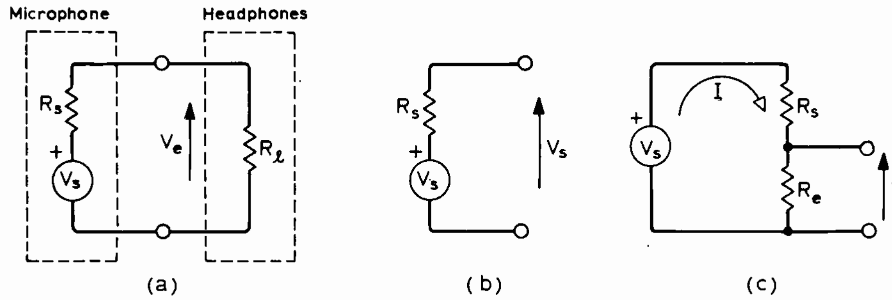


Fig. 1. To introduce transistor amplifier theory an understanding of voltage transfer is necessary—often misunderstood. Simplest way to find signal transfer from source to load (a) under no-load conditions (b), is to treat the two resistances as a potential divider (c).

phones. The specification for the microphone will give the voltage output for a certain sound power *on no load* which is V_s, under the conditions of Fig. 1(b). The output (or internal) resistance R_s will also be given. The resistance of the headphones, R_l, will be given together with some reference to the signal voltage necessary to provide a comfortable level of sound.

Now the simplest way to find the signal transfer is to realize that the two resistances form a potential divider across V_s as shown in Fig. 1(c). Then $I = V_s/(R_s+R_l)$ so that the usual potential divider equation $V_l = IR_l = V_sR_l/(R_s+R_l)$ results. Then

$$G_V = \frac{V_l}{V_s} = \frac{R_l}{(R_s+R_l)}$$

This equation acts as the defining equation for G_V which is the overall voltage gain from specified source voltage V_s to the load voltage V_l.

The amplifier

Often the load voltage will not be sufficient and an amplifier is needed. The linear integrated-circuit amplifier is both the simplest to deal with and the most complicated in construction. A number of parameters are usually specified for it but only three concern the low-frequency a.c. operation—input resistance, output resistance and voltage gain.

Voltage gain is specified *with no load* so that it is the open-circuit voltage gain. Let μ represent a gain of this type which occurs in an unconnected amplifier.

Fig. 2 shows the equivalent circuit. The microphone feeds the input of the amplifier which behaves as a simple resistor r_1. The voltage V_1 appearing across r_1 is amplified

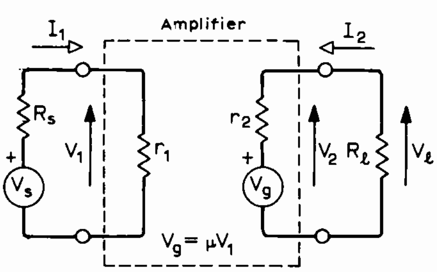


Fig. 2. Equivalent circuit of a source-amplifier-load enables overall gain to be expressed as a product of input coupling gain (from Fig. 1), internal amplifier gain μ and output coupling gain.

by the factor μ and appears as a source V_g which has an output resistance r_2 and is connected to the output terminals. These in turn are connected to the headphones which form the final load R_l. (Capitals represent component resistances while lower-case letters indicate the effective resistance of an amplifying device or circuit.)

This discussion is limited to a unilateral amplifier, i.e. V_1 affects V_2 but V_2 does not affect V_1.

The overall gain comprises three terms: the input coupling gain—this, as for Fig. 1, is a potential divider so that $V_1/V_s = r_1/(R_s+r_1)$; the internal gain of the amplifier $V_g/V_1 = \mu$; and the output coupling gain which is another potential divider $V_l/V_g = R_l/(r_2+R_l)$. Then

$$G_V = \frac{V_l}{V_s} = \frac{V_1}{V_s}\cdot\frac{V_g}{V_1}\cdot\frac{V_l}{V_g}$$

$$= \frac{r_1}{(R_s+r_1)}\cdot\mu\cdot\frac{R_l}{(r_2+R_l)} \quad (1)$$

This equation is the basic expression for the overall voltage gain of an amplifying system in which R_s and R_l are known from the input and output device specifications. Of course R_s or R_l might be the output or input resistance of another amplifier. Equation 1 can easily be extended to multistage amplifiers, the output resistance of one stage becoming the source of the next. For two stages there will be three coupling gains and two μs.

When working out amplifier designs the reader is strongly advised to calculate and record the three items of equation 1 separately and then multiply them together. This is because they each give information about the state of one of the three sections of the circuit not otherwise available as will be shown later.

Before going on to the transistor there is one more gain to be considered. Although G_V is the basic quantity required, it cannot be measured directly when the system is working because the only voltages accessible are V_1 and V_2. The *measured* voltage gain between terminals on load is the loaded stage gain defined by

$$A_V = \frac{V_2}{V_1} = \frac{V_g}{V_1}\cdot\frac{V_2}{V_g} = \frac{\mu R_l}{(r_2+R_l)}$$

It is the product of the open-circuit gain and the output coupling gain; the input coupling does not affect it. It is useful because it is needed when checking and making measurements on the circuit and in the past has been regarded by many writers as the final goal of amplifier calculations (or at least this has been implied). That this is a mistaken notion is easily shown by pointing out that of two amplifiers the one with the highest G_V may have the lowest A_V.

The next section is concerned with finding r_1, μ and r_2 for transistor amplifiers.

Bipolar transistor

Fig. 3(a) shows a transistor, such as the general-purpose n-p-n BC108, with voltages applied to give normal working conditions. If $v_{BE} = V_{BB}$ is varied, i_E will change and a plot of the resulting characteristic is shown in Fig. 3(b), this curve being similar in shape to that for a forward-biased p-n junction diode. Of course the base-emitter junction is a p-n junction but it may seem surprising that the presence of the collector does not alter the relationship. Variations in v_{CE} move the curve slightly, but they do not affect its slope so long as v_{CE} is greater than about one volt.

Under small signal conditions, where a low-value a.c. signal is superposed on the d.c. quantities, it is the slope of the characteristic which is important as demonstrated in Fig. 3(c). This shows an alternating voltage superposed on a 0·6-V steady bias which produces an alternating current superposed on a 1-mA direct current. The amplitude of the alternating current is equal to the alternating voltage divided by the

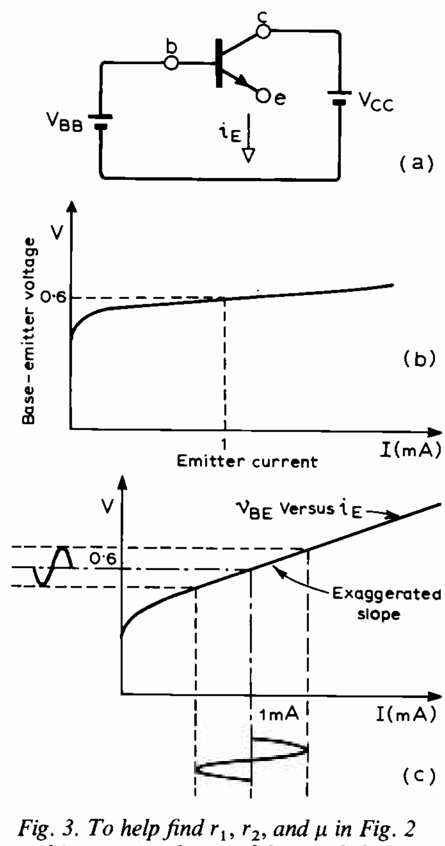


Fig. 3. To help find r_1, r_2, and μ in Fig. 2 and in equation 1, a model is needed in terms of simple components. To provide this the bipolar transistor (a) must be understood, in particular the i_E-v_{BE} relationship (b) whose slope is the important thing (c), and which is approximately constant if v_{CE} is greater than 1 V.

slope of the curve, if the level of the a.c. quantities is low enough so that the curve can be considered straight over the portion used.

When connected as an amplifier v_{CE} varies and the resulting movement of the curve changes the v-i relationship. With most transistors the error introduced in μ is only 3 to 5% if A_V is 200; so that in most circuits it will be less than this. When it is realized that auxiliary component values are usually less precise—most people use 5 or 10% tolerance resistors—the error is negligible in a general-purpose analysis. Equations given in this article assume that v_{CE} does not affect the base-emitter quantities.

Now the key base-emitter relationship is given, under restricted conditions, by the Shockley equation

$$i_E = I_S[\exp(qV_{BE}/kT)-1] \qquad (2)$$

where k is Boltzmann's constant ($1{\cdot}3805\times10^{-23}$ joule/°K) q the electron charge ($1{\cdot}602\times10^{-19}$ coulomb) and T the absolute temperature in °K. At 30°C, a good typical working temperature for a low-level amplifier transistor, $kT/q = 0{\cdot}026$ V.

Because we are only interested in forward bias above 0·1 V where $\exp(qV_{BE}/kT)\gg 1$ equation (2) can be rearranged to give $v_{BE} = (kT/q)\ln(i_E/I_S)$. The slope of the curve, which has the dimensions of V/I, is the differential resistance r_t where t indicates the theoretical value. It is found by differentiating the equation for v giving

$$r_t = \frac{kT}{qi_E} = \frac{0{\cdot}026}{i_E} = \frac{26}{i_E(\text{mA})}\Omega \quad \text{at } 30°\text{C}$$

Resistance r_t is current-dependant but if the swing of i_E is kept small then r_t will not change much and for many purposes the steady d.c. value I_E can be substituted giving

$$r_t = \frac{kT}{qI_E} = \frac{26}{I_E(\text{mA})}\Omega$$

This theoretical emitter resistance is given by many writers and it illustrates a virtue of the bipolar transistor: that its major characteristic should be the same for all transistors and is not a production-dependent parameter. This contrasts sharply with the situation with valves and field-effect transistors.

Unfortunately transistors are not so ideal although the difference is not large at low currents. One cause of deviation is the failure of Shockley's equation at the current values normally used; the term kT/q tending towards $2kT/q$ as the current rises. In addition there are more or less pure resistances present such as the transverse resistance of the thin base layer between emitter and collector regions. Both these effects depend on the size of the device and on manufacturing techniques.

In spite of the complexity of the situation it is possible to provide a satisfactory correction whose accuracy is acceptable as long as the correction itself is not too large a proportion of the total emitter resistance. The correction was found by making measurements of the emitter resistance on a number of groups of various types of transistor. Measurements were done for a range of values of I_E and it was found that the values of emitter resistance fell into two groups

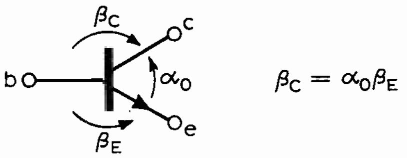


Fig. 4. Summary of transistor parameters are contained in the symbol. Numerical values are added in some positions in following circuit diagrams.

with modern low-level general-purpose transistors in the lower and older types in the higher group. The emitter resistances were plotted against I_E and a curve drawn through at the upper ten percentile. This indicated a deviation from r_t depending on the inverse square root of I_E so that the true emitter resistance is

$$r_e = r_t + \text{correction}$$
$$= \frac{26}{I_E(\text{mA})} + \frac{a}{\sqrt{I_E(\text{mA})}}\Omega$$

where $a = 3$ for modern silicon planar types and 4 for the others. This appears to hold well up to about 10 mA and with decreasing accuracy to a maximum of about 40 mA.

This range of validity is quite good because h parameters are often given for only one current in the 1 to 5 mA range—taking for granted that at higher current the less accurate characteristic curves would be used.

Note that the term given here concerns base-emitter terminal voltage and emitter current. It therefore includes both the input potential divider of Banthorpe and the 2 to 5-Ω emitter-lead resistance used to correct his r_m to his r_t.

The $v_{BE}-i_E$ characteristic is the most important feature of the transistor in linear amplifiers and is basic to the voltage control approach. The other major feature is, of course, that nearly all (a fraction, α_O) of the current in the emitter is deflected to the collector. If the collector current to base current ratio $\beta_C = \alpha_O/(1-\alpha_O)$ is not less than 50, the collector current will differ from the emitter current by less than 2% (for the high-beta BC108 by less than 0·8%), so that for most purposes i_C can be taken equal to i_E.

In the present treatment the base-to-emitter current gain is more important than the usual base-to-collector current gain β_C. To save space I shall write

$$\frac{i_E}{i_B} = \frac{i_C+i_B}{i_B} = \frac{i_C}{i_B}+1 = \beta_C+1 = \beta_E$$

Incidentally, the h parameter corresponding to β_C is h_{FE}, thus $\beta_E = h_{FE}+1$.

The base-to-emitter current gain will have two forms, the direct current gain, $\beta_E = I_E/I_B$, and the alternating current gain, $\beta_e = I_e/I_b$. The a.c. gain is defined mathematically as di_E/di_B but in practice it is measured by applying a small alternating emitter current I_e in addition to the standing current I_E and dividing I_e by the resulting a.c. component of base current I_b. The current must be small enough to avoid the effect of non-linearities.

As an aid to memory the parameters can be written into the transistor symbol as indicated in Fig. 4. This shows at a glance that $\beta_C = \alpha_O\beta_E$. Numerical values will normally be added in some or all of these positions in the circuit diagrams.

The action of a transistor can be summarized as follows

(a) a voltage V_{BE} is applied between base and emitter
(b) a current then flows in the emitter given by the diode curve or, for small a.c. signals superposed on the d.c. level, an alternating current V_{be}/r_e
(c) nearly all the emitter current flows to the collector
(d) a small current flows through the base due to the deflection mechanism being imperfect
(e) the collector voltage hardly affects the process.

Transistor model

When analysing the behaviour of a complicated device a wise thing to do is to try to set up a circuit consisting of simple well-understood components which will do the same job.

The first attempt to do this for the above conditions results in nonsense but it is useful because it shows a reason for the current control philosophy in linear transistor amplifiers.

Items (a) and (b) lead to the circuit of Fig. 5(a), which is satisfactory for all positive values of v_{BE} and i_E except perhaps for very small currents of the order of the collector saturation current. Linear circuit elements cannot deal with the non-linear diode

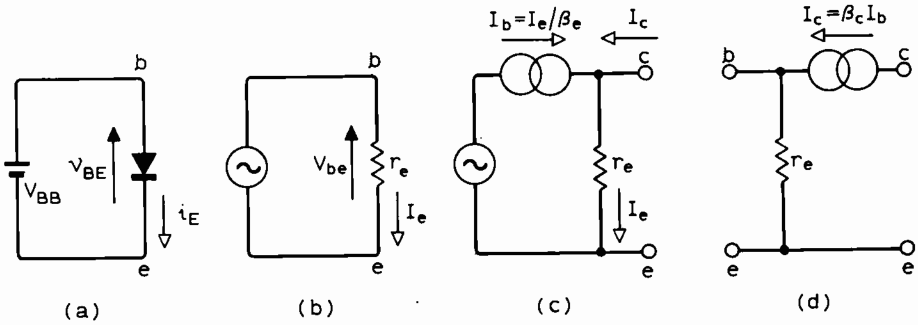


Fig. 5. Partial transistor model (a) can use r_e in place of base-emitter diode for small signals (b). Adding current generator with I_e as control variable (c) is invalid because it prevents input voltage appearing across r_e and allows V_{ce} to appear across r_e. It is avoided by making I_b the control variable (d).

characteristic so the argument is limited to small-signal calculations for which the diode can be replaced by the resistor r_e as in Fig. 5(b). This means that we are making a straight-line approximation to the diode characteristic and ignoring the d.c. offset.

The value of β_e is usually reasonably constant for a useful range of current values and this suggests addition of a current-controlled generator to handle items (c) and (d), Fig. 5(c). Physically I_b depends I_e so that I_e is the control variable and the current generator goes in the base circuit.

Unfortunately this equivalent circuit is invalid: the current generator prevents the input voltage from appearing across r_e because the voltage across a current generator need not be zero. Also it does not account for (e) as it allows V_{ce} to appear across r_e.

The usual way of getting round the difficulty is to put the current generator in the collector circuit and make I_b the control variable, Fig. 5(d). This is correct because the only requirement is a relation between the currents and, mathematically, it does not matter which really controls which. The result is a very neat solution indeed because it fulfils all the requirements (a) to (e) using only two elements. It is the basis for one of the two equivalent T networks widely quoted in the past.

Unfortunately the model immediately introduces the idea that base current controls collector current and that current gain is the major parameter. An alternative solution on which this work is based is to invent new elements.

To add to the already large list of basic circuit elements seems at first sight to be rash but the benefit in ease of circuit analysis is considerable. In fact the proposed elements are similar to two already existing in advanced circuit theory.

The new elements allow d.c. and large-signal analysis as well as small-signal analysis so that we can return to total instantaneous values.

Beta barrier

The starting point is Fig. 5(a) which is valid for the relationship between i_{BE} and v_{BE}. A vertical line is placed across the upper connection to the diode, Fig. 6(a). This is the "beta barrier"* which acts as a semi-permeable membrane to the emitter current. It ensures that $i_B = i_E/\beta_E$ but is itself all at the same potential so that the top of the diode is at base potential. For an n-p-n transistor it is convenient to think of deflecting the flow of electrons which is in the opposite direction to conventional current flow.

One more thing is required. The collector terminal is to take the deflected current but its voltage must not influence the voltage at the beta barrier. This is not difficult to remember but for the time being a single double-zero symbol is used—it is omitted later. Its characteristic is that any voltage may exist across it and any current may flow through it—the current not being influenced by the voltage.

Fig. 6(b) shows the complete equivalent slightly rearranged. Remember that all of

*I cannot recall whether this term is original.

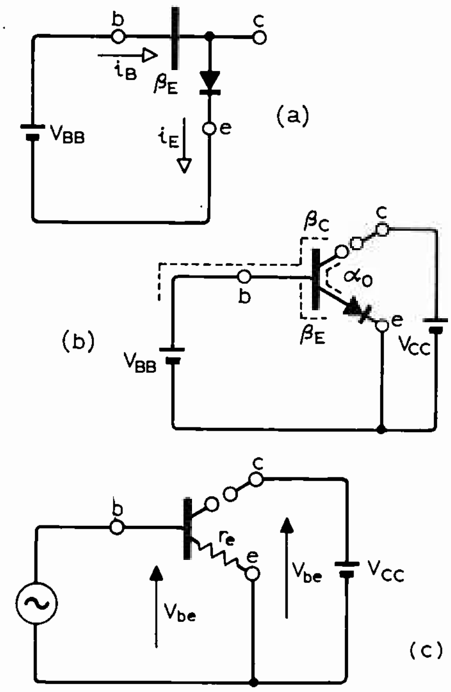


Fig. 6. Because the circuit of Fig. 5 suggests that base current controls collector current, a new equivalent circuit is proposed. This involves two new circuit symbols: a 'beta barrier' shown at (a) which allows $i_b = i_E/\beta_E$ but which itself is at base potential and not influenced by the collector voltage—indicated by the 'double-zero' symbol shown in the new equivalent circuit (b) (omitted in later circuits). Similarity with standard diagram allows an ordinary circuit diagram to act as its own equivalent circuit. New circuit holds for d.c. and large signals as well as for small signals, but small-signal analysis is simplified by replacing diode by r_e (c).

the symbol indicated by the dotted line is at the base potential, the double-0 symbol holding off the collector voltage while allowing the current deflected by the beta barrier to flow round the collector circuit. Choice of the new elements has been made with the standard transistor symbol in mind, and the similarity is essential to the method because the aim is *to turn the ordinary circuit diagram into its own, equivalent circuit.* This means that calculations can be done straight from the conventional circuit diagram.

The equivalent in Fig. 6(b) is a large-signal model suitable for both signal and bias calculations. In the next section it is restricted to small-signal a.c. analysis by replacing the diode by a resistance r_e as shown in Fig. 6(c). For clarity the d.c. collector supply is retained—an example of the need in transistor circuits to be able to mix a.c. and d.c. quantities. It is clear that the model in Fig. 6 faithfully simulates conditions (a) to (e).

Common-emitter amplifier

The common-emitter circuit is the most important connection for voltage amplification. The signal is applied at the base and the amplified voltage appears at the collector. Of course the collector supply would prevent the collector voltage from varying and so a collector feed resistor R_c is added in series with the supply. This component is sometimes called the d.c. load but this term is avoided here partly to avoid confusion with the real load R_l and partly because R_c has a more important significance. Fig. 7(a) shows the circuit in its usual form while Fig. 7(b) gives a "transatlantic" re-arrangement, better suited to analysis. The resistance r_e has been added in the emitter as recommended for small-signal analysis.

Calculation of μ is now as follows. The input alternating signal voltage V_{be} is applied at the base and appears across r_e giving $I_e = V_{be}/r_e$. A fraction α_o of this current is deflected by the beta barrier and flows through the collector and through the resistor R_c to the collector supply. The alternating output voltage will be $V_{ce} = I_c R_c = -\alpha_o I_e R_c$. Thus the open-circuit voltage gain is

$$\mu = \frac{V_{ce}}{V_{be}} = -\frac{\alpha_o I_e R_c}{I_e r_e} = -\frac{\alpha_o R_c}{r_e} \approx -\frac{R_c}{r_e} \qquad (3)$$

where in the last term α_o is taken equal to unity. The equation gives the open-circuit gain needed in the expression for G_V in equation (1).

In case the simplicity of the present model is misunderstood the calculation is repeated for the simpler diagram of Fig. 8, where the d.c. source, which does not affect μ, is omitted and the approximation $\alpha_o = 1$ has been made so that $I_c = I_e$. The major effect of applying a voltage at the base is to cause a current I_e to circulate round the collector-emitter circuit. As the output voltage is the drop across one resistor while the input voltage is the drop across the other, μ is obviously the ratio of the two resistors. Further, the current flows up

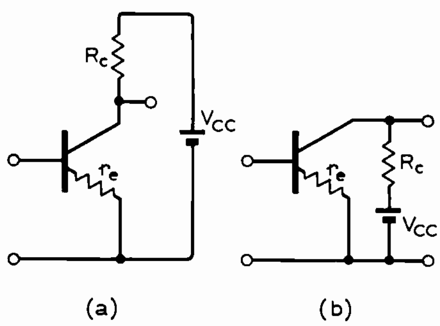


Fig. 7. Common-emitter amplifier circuit used to calculate open-circuit voltage gain μ ($\approx R_c/r_e$).

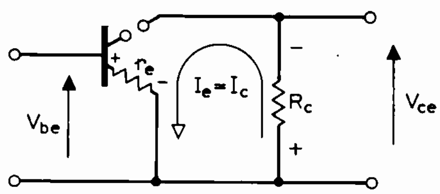


Fig. 8. Simpler circuit of common-emitter amplifier with d.c. source omitted and the approximation $I_e = I_c$ made so that it can be immediately seen that μ is the ratio of the two resistors, and that there is a change of polarity.

one and down the other so that there will be a change of polarity for a.c.

This is all that there is to the calculation of voltage gain, but the idea underlies all further work.

Common-emitter stage with external emitter resistor

Fig. 9(a) shows the normal circuit and Fig. 9(b) the new a.c. equivalent. Voltage gain is easily calculated because R_e is merely in series with r_e so that

$$\mu = -\frac{\alpha_o R_c}{(r_e+R_e)} \approx -\frac{R_c}{(r_e+R_e)} \qquad (4)$$

It must be confessed at this point that the choice of the present model which concentrates attention on the base-emitter characteristic was greatly influenced by the simplicity with which impedances in the emitter lead can be handled. It is gained however at the expense of having to multiply any quantity involving base-emitter to collector transfer by α_o if the current gain is poor enough for it to matter; a small price to pay for the advantages gained.

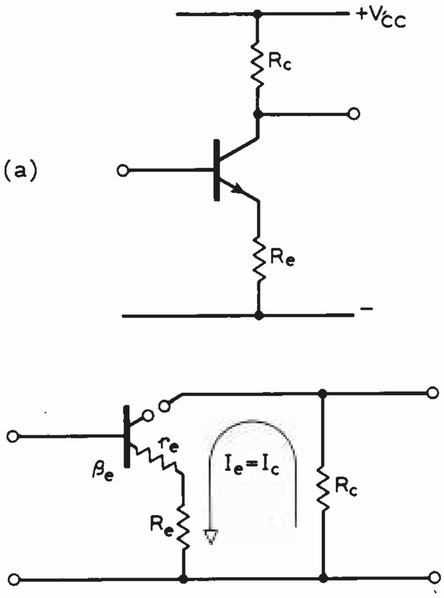


Fig. 9. Calculation of open-circuit voltage gain with addition of an external emitter resistor is easily done as R_e is merely added to r_e.

Input and output resistances

Having calculated μ, then r_1 and r_2 are needed before G_V can be found. These are not difficult to obtain because so far as the input is concerned the base current is proportional to the emitter current. So the transistor behaves as if the resistors r_e and R_e (if present) were across the input, except that the current is only $1/\beta_e$ times as large as it should be, that is it behaves as if the resistances were β_e times larger, so that

$$r_1 = \beta_e(r_e+R_e). \qquad (5)$$

If an alternating voltage is applied to the collector it will produce a current only in R_c as we have agreed that the "double zero" prevents V_{ce} from effecting I_b or I_e and hence I_c, thus

$$r_2 = R_c. \qquad (6)$$

These parameters refer to the circuit including R_c and not just to the transistor. Also, in a practical circuit there may be bias resistors across the input, in which case the effective total input resistance is simply the parallel combination of r_1 as above with the total external parallel resistance. The parameters needed to calculate G_V are now available.

Example

The circuit of Fig. 10 shows a BC108 transistor in the common-emitter connection between a 600-Ω source representing a microphone and a 600-Ω load representing headphones; d.c. bias components are ignored. What is G_V?

From the data sheet β_c is in the range 125 to 500, so that taking the minimum value to give a conservative result, β_e = 126 (correction hardly necessary!). Collector current is 1 mA so that r_e can be calculated using a constant of three as the transistor is a silicon planar of the low-level type.

$$r_e = \frac{26}{1}+\frac{3}{\sqrt{1}} = 29\,\Omega$$

$$\mu = \frac{5000}{29} = -173$$

$$r_1 = 126\times 29 = 3650\,\Omega$$

$$r_2 = 5000\,\Omega$$

$$\therefore\ G_V = \frac{3650}{600\times 3650}\times(-173)\times\frac{600}{5000\times 600}$$

$$= -0{\cdot}859\times 173\times 0{\cdot}107 = -15{\cdot}9$$

The value of working out each term of G_V separately becomes apparent. Of the available gain of 173 the major loss is at the output coupling where only 10·7% gets through. The condition at the input is better; 85·9% being transmitted.

Notice that as only r_1 depends on β_e, the effect of a transistor with maximum β_e is just to change the input coupling loss to 0·96; an increase in G_V of only 12%. *Measured* voltage gain A_V does not of course depend on β_e. It is merely

$$A_V = -173\times 0{\cdot}107 = -18{\cdot}5$$

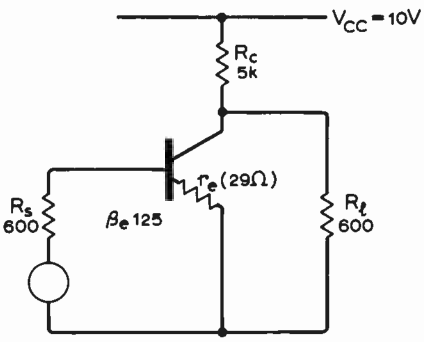


Fig. 10. Example used to illustrate calculation of voltage gain according to equation 1. This method of calculation shows that of the available gain of 173, 85·9% is transmitted by the input coupling and only 0·7% by the output coupling. It also shows that effect of using a transistor of four times the gain is an increase in voltage gain of only 12%.

It is my firm opinion that drawing in the resistor r_e to replace the arrow in the symbol is an important part of the technique; analysis is done by human beings who are invariably helped by such visual aids. The addition of r_e, together with the beta barrier idea, turns the circuit diagram into an equivalent circuit which is made suitable for large signal or d.c. analysis by replacing the resistor with a diode.

Now try adding a 50-Ω emitter resistor to Fig. 10 and see if G_V is 6·4!

Checking the value of r_e

So far the only item outside the scope of previous models, if suitable approximations are made, is the value of r_e. The correction term given is necessarily based on the small range of types and quantities available for measurement and its validity may well be questioned. If any reader has the time and opportunity to extend the measurements it would be a valuable contribution.

The value of r_e can be checked, however, at any current for which h parameters are available. To show this let us give the h parameters for the beta barrier model. We consider the transistor only and not R_c.

h_{ie} is input resistance with output short-circuited = $\beta_e r_e$
h_{fe} is base-to-collector current gain with output short-circuited = β_c
h_{re} is collector-to-base (or reverse) voltage gain with input open-circuited = 0
h_{oe} is output admittance with input open-circuited = 0

Parameters h_{re} and h_{oe} are zero because V_{ce} does not affect V_{be} or I_c. The beta-barrier model therefore is one in which $h_{re} = h_{oe} = 0$, $\beta_e = h_{fe}+1$ and $r_e = h_{ie}/(h_{fe}+1)$.

As an example let us use the data published by the makers of the BC108 to find r_e. For I_E = 2mA, θ = 25°C, this is

	min.	typ.	max.	units
h_{ie}	1600	3600	8500	Ω
h_{fe}	125	280	500	—
$\therefore\ h_{ie}/(h_{fe}+1)$	12·8	12·86	17	Ω

For 25 °C = 298°K, $r_t = kT/qI_E$ = 12·84 and $3/\sqrt{I_E(\text{mA})}$ = 2·1 so that r_e = 14·94 Ω.

Unfortunately the measurements made to obtain the empirical correction factor did not include BC108s, but with those transistors measured no value of r_e was found to be less than r_t, although a few were very near to it, while 90% were covered by the correction factor. Thus, from the measurements, the spread of r_e might be expected to be from 12·84 to about 16Ω; a range which corresponds well with the values calculated from the h parameters.

Voltage gain of transistors

Returning to voltage gain, a very interesting deduction can be made from equation (3).

The collector feed resistor R_c cannot be freely chosen because it must carry the direct collector current and the resulting voltage drop must be less than the collector supply voltage V_{CC}. For a number of reasons a good choice of collector working voltage is half the supply voltage; any other choice merely changes the resulting constant slightly. Assuming that the correction can be neglected at low currents then $r_e = 0{\cdot}026/I_E$ (amps) and the drop across R_c is $V_{CC}/2$ so that $V_{CC}/2 = I_C R_c \approx I_E R_c$ then $R_c = V_{CC}/2I_E$ and

$$\mu = -\frac{R_c}{r_e} = -\frac{V_{CC}I_E}{2I_E 0{\cdot}026} = -\frac{V_{CC}}{0{\cdot}052} \approx -20\,V_{CC} \qquad (7)$$

Thus the open-circuit voltage gain of a transistor ampfier designed in the standard way is about 20 times the supply voltage! For example the usual 9-V radio battery gives $\mu = -180$.

If the half-supply-voltage principle is not adhered to, the result will not change much even if maximum output swing is not required, because there is rarely the need to drop less than $V_{CC}/2$ across R_c and the maximum permissible would be about $3V_{CC}/4$ due to the need to ensure that drift in I_E does not saturate the transistor, i.e. does not reduce $V_{CE} \approx 0$.

At higher currents the correction factor becomes significant and the gain drops below $20V_{CC}$ giving a reduction of 5% at 0·5 mA, 10% at 1 mA and 20% at 5 mA. Equation (7) can therefore be regarded as the maximum gain of the transistor. The only way to increase the voltage gain is to increase the supply voltage!

Optimum gain

The results of the previous section can be used to provide a basis for the selection of the direct emitter current; a subject incompletely dealt with in most text books. First we find that the four parameters of an amplifier are not independent. (Four, because to μ, r_1 and r_2 we must add the current gain $\beta = I_2/I_1$.) For a transistor the amplifier current gain is identical to β_c so that from equations (3) and (5) assuming $R_e = 0$

$$\frac{-\mu}{\beta_c} = \frac{\alpha_o R_c}{\beta_c r_e} = \frac{R_c}{\beta_e r_e} = \frac{r_2}{r_1} \qquad (8)$$

Although proved for the transistor amplifier this relation is true for any amplifying system and only requires the assumption that the amplifier is unilateral.

Because μ and β_c are approximately constant for changes in I_E while both r_1 and r_2 are inversely proportional to it, the transistor turns out to be a unique device in which the input and output resistances can be varied together while their ratio remains constant. This provides an opportunity to maximize the overall voltage gain by adjusting the emitter current to give the maximum coupling gain. It can be shown* that for maximum G_V

$$\frac{r_1}{R_s} = \frac{R_l}{r_2} \qquad (9)$$

*Substitute for r_2 from equation 8 in G_V, differentiate with respect to r_1 and equate to zero.

i.e. the ratio of input resistance to source resistance should be equal to the ratio of load resistance to output resistance. Substituting for r_1 in equation (9) from equation (8) gives

$$\frac{r_2\beta_c}{-\mu R_s} = \frac{R_l}{r_2} \quad \text{or } r_2^2 = \frac{-\mu R_l R_s}{\beta_c}$$

$$\text{Then} \quad R_c = r_2 = \sqrt{\frac{-\mu R_l R_s}{\beta_c}} \qquad (10)$$

For a system R_l and R_s are known and β_c is given for the transistor. Using the approximate value $\mu = 20V_{CC}$, a value can be found for R_c which in turn gives $I_E \approx I_C = V_{CC}/2R_c$. This value for I_E will give the maximum overall voltage gain.

Perhaps the most important relation in this section can now be derived, for equation (9) implies that the coupling gains are equal for the maximum gain condition. Substituting for r_1 from equation (9) into the input coupling gain gives

$$\frac{r_1}{R_s+r_1} = \frac{R_sR_l/r_2}{R_s+R_sR_l/r_2} = \frac{R_sR_l}{R_sr_2+R_sR_l} = \frac{R_l}{r_2+R_l}$$

Thus the optimization can be checked by examining the coupling gains for equality: a powerful reason for working them out separately.

This leads to a very practical design procedure which does not require memorizing equation (10). One merely tries a few current values, calculating r_1 and r_2 and checking the ratios in equation (9). When the current appears to be approximately right G_V is calculated and as a final check the coupling gains are compared.

For an example of the use of equation (10) the circuit of Fig. 10 will be optimized. The working is as follows. $\mu \approx 20V_{CC} = -20\times10 = -200$, $\beta_c = 125$, $R_l = 600$, $R_s = 600$. Then $R_c^2 = 200\times600\times600/125 = 676{,}000\Omega^2$, so $R_c = 760\Omega$. $I_E = 10/2\times760) = 6{\cdot}6$ mA.

$r_e = 26/6{\cdot}6 + 3/\sqrt{6{\cdot}6} = 5{\cdot}1\Omega$.

$\mu = -R_c/r_e = -760/5{\cdot}1 = -148$ (accurately).

$r_1 = 126\times5{\cdot}1 = 640\Omega$. Finally

$G_V = -640/1240\times148\times600/1360 = -0{\cdot}515\times148\times0{\cdot}44 = 34$.

The optimized gain is over twice the gain previously obtained. This is because the increase in output coupling gain has more than compensated for the decrease in input coupling gain. The coupling gain terms in G_V are still not quite equal, but the maximum in the gain-versus-I_E relation is very flat and if the coupling gains are within about 20% of each other the gain is negligably less than maximum.

With the current at its new value the current gain will have a greater effect on G_V. This is because the input coupling term is now more dependent on r_1 which is the only thing that current gain affects. The change to $\beta_c = 500$ will increase G_V to 53 which is a 55% increase to be compared with the previous increase of 12%. If freedom from changes in β_e are required then it is better to work at a lower current than optimum where the input coupling gain approaches unity. There are many reasons for choosing a particular value of I_E—β_e must not have fallen away from its best value, power dissipation must be within limits, frequency response and noise level must be satisfactory etc—but in the absence of such considerations optimization of I_E will give the greatest voltage gain.

To be concluded

References

1. Banthorpe, C. H., 'Simplified transistor amplifier calculations' *Wireless World*, vol. 72 August 1966 pp. 382–4.
2. Baxandall, P. J., 'Symmetry in a class B amplifier' *Wireless World*, vol. 75 September 1969 pp. 416/7.

Sixty Years Ago

June 1911. Fleming in an article 'High-frequency Alternators for Wireless Telegraphy' in the *Marconigraph* looked at the various ways being tried to produce high-frequency alternating current so that these waves could be used instead of spark transmitters. But he said '. . . it will be well to suspend enthusiasm for the new method until it has won its spurs by actual contest with the old established and reliable spark method in the field of everyday radio telegraphic work.' The efforts of a Dr. Goldschmidt, who was a lecturer at Darmstadt Technical College, to produce high frequency waves using an induction motor as a frequency multiplying device were described as follows:

'If a continuous current is passed through the stator of an induction motor, and if the rotor is caused to revolve by some means, the rotor circuits will be traversed by an alternating current, the frequency of which will depend on the number of poles of the stator and speed of the rotor. If the alternating current produced in the rotor is led through the stator it will produce a revolving field, which can be used to create in the rotor current of still higher frequency. These, again can be led through the stator, and in turn induce higher frequencies still in the rotor. In this manner the frequency can be multiplied up. The currents of intermediate frequency can be taken up in condenser circuits tuned to them, and the final high-frequency current be made to circulate up and down an antenna or aerial, and so create persistent electromagnetic waves of, say 10,000 or 20,000 feet in wave length. This process is scientifically and practically possible, and its success, so far as tried has resulted in a company being formed in Germany to exploit it.'

Fleming pointed out that it would take a rotor speed change of only half a per cent to throw the output of the rotor out of tune with 'the various fundamental and harmonic condenser circuits.'

1984

-whatever happened to you-know-who?

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PT383/3b

Electronic Building Bricks

13. Uses of oscillations

by James Franklin

In Part 5 we studied the oscillator and the nature of oscillations. We saw that an oscillation is a cycle of events which repeats itself indefinitely. The time taken to generate one complete cycle is called the period of the oscillation, while the number of periods that occur in a given time is called the frequency of the oscillation.

Of what use are oscillations? Their main function is to act as carriers of information in those parts of electronic systems where several sets of information—different signals—have to be transmitted through a common medium without getting mixed up. One such common medium is space (for which the oscillations are converted into radio waves) and another is the trunk cable, as used for inter-city telecommunications. Within electronic equipment we sometimes have to transmit several signals simultaneously from one 'building brick' to another by means of a single electrical circuit (Part 11 April) without the signals interfering with each other and so destroying the information.

To understand how this is done we need to look at two aspects of oscillations: (1) how they can act as carriers of information; and (2) the properties that enable oscillations to be distinguished from each other.

Since an oscillation is an electrical

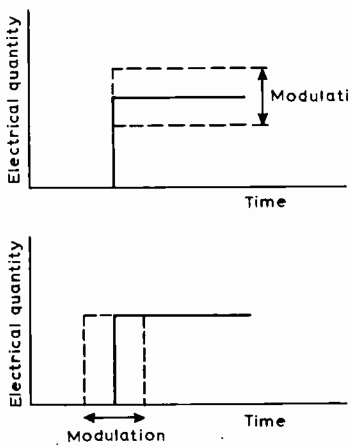


Fig. 1 How a periodic change can be used to carry information: (a) by modulation of amplitude; (b) by modulation in time.

quantity periodically changing with time it offers two possibilities for carrying information: we can vary the *extent* by which the electrical quantity is periodically changing; and we can vary the *time* at which a periodic change takes place. This is illustrated in Fig. 1. At (a) the broken lines show how the extent, or amplitude, of the change could be varied; at (b) the broken lines show how the time of the change could be varied. In both (a) and (b) the process of varying a property in accordance with the information is known as *modulation.*

The general principle of being able to vary the timing of a periodic change can be used in several ways, to give oscillations with distinct properties. Some examples can be seen in Fig. 2. We can control the instants at which the current rises and falls in such a way that the whole current/time graph is displaced, as shown in (a). This is known as a *phase* difference—the broken-line square wave has a different phase from the full-line square wave. Or we can control the instants at which the rises and falls occur in such a way that the time intervals between them, the periods, are different from in (a). This is shown in (b), which has shorter periods, and (c), which has longer periods. As a result, oscillations (b) and (c) differ in frequency from those in (a).

Fig. 2 shows us two things. First, it shows us practical methods of modulation derived from the Fig. 1(b) principle, that is, phase modulation (a) and frequency modulation, (b) (c). Thus, with the amplitude modulation in Fig. 1(a), we have three methods altogether. (There are others, but all are based on the fundamental processes illustrated in Fig. 1.) Secondly Fig. 2 shows us properties by which several oscillations travelling through a common medium may be distinguished from each other, notably the properties of frequency and phase. Of these frequency is the most widely used, for example, tuning a radio receiver to stations with different radio-wave frequencies. The property of phase distinction is utilized, for example, in colour television to enable two different colour information signals to be transmitted simultaneously, with the same carrier frequency, and yet be separated in the receiver. It is also used for trunk telecommunications in which different signals are sent as trains of pulses—each train being identified by its 'position' in time relative to the others*.

What we have discussed so far has been illustrated by square-wave oscillations. Fig. 3 shows how the principles apply to sine waves (Part 10). Oscillations (d) and (e) differ in phase although they have the same frequency. Oscillation (f) differs in frequency from (d) and (e). (Note that a difference in frequency inevitably means a difference in timing as well, but that a phase difference can exist without a frequency difference.) A sine-wave oscillation modulated in amplitude, on the Fig. 1(a) principle, is shown at (g)—the modulating information in this case being part of a signal from a microphone.

* known as time division multiplex

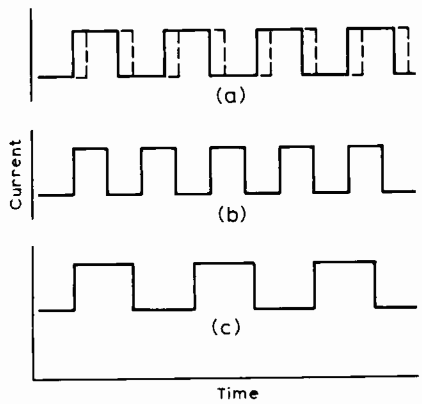


Fig. 2 Square-wave oscillations illustrating (a) phase difference, and frequency difference between (a), (b) and (c).

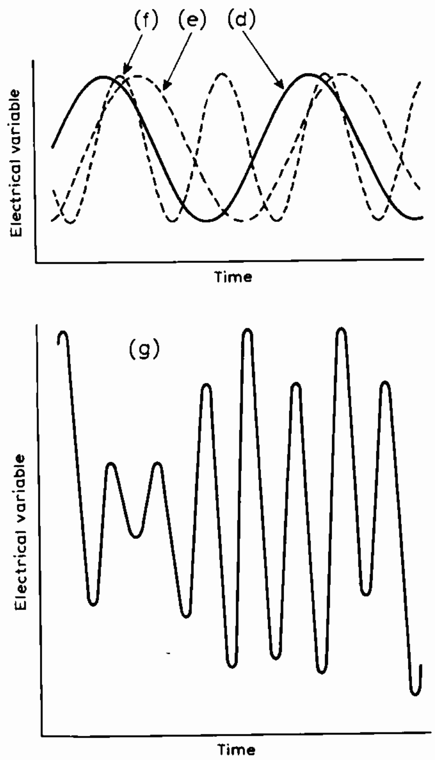


Fig. 3 Sine-wave oscillations differing in phase, (d) and (e), and in frequency, (d) and (f); also a sine-wave oscillation modulated in amplitude (g).

Low-range Ohmmeter

Linear-scaled instrument for measuring resistance of contacts and soldered joints

J. Johnstone

Originally intended for matching the resistance of small wound components, this ohmmeter has since proved to be of general use in the laboratory, typical applications being measuring switch contact resistance and testing printed circuit boards for dry joints. A constant current is applied to the resistance under test, and the resultant potential difference is indicated on a meter. Output voltage is limited to less than one volt to protect the meter and any active devices in the circuit under test. Test current is 250 milliamps for 500 milliohms f.s.d. and 25 milliamps at 5 ohms f.s.d.

Under constant-current conditions, the series pair Tr_1 and Tr_2 are controlled by the current error amplifier, Tr_4 and Tr_5. (Transistor Tr_1 should be fitted to a heatsink of 16-gauge aluminium sheet, 7.5 × 5cm.) Transistor Tr_3 together with R_2 and R_3 form a constant-current source for Tr_4. When the amplifier is balanced—i.e. when the voltage across R_9 and R_5 equals the reference voltage of D_2—the current through R_1 is provided equally by Tr_4 and Tr_5. An error signal at Tr_4 base causes a collector current change of ΔI with a resulting change of $-\Delta I$ in Tr_5 collector current. This changes the bias of Tr_3 by $-\Delta I \times R_3$, altering its collector current by $-(\Delta I \times R_3)/R_2 = -\Delta I$, thus doubling the overall gain of the error amplifier.

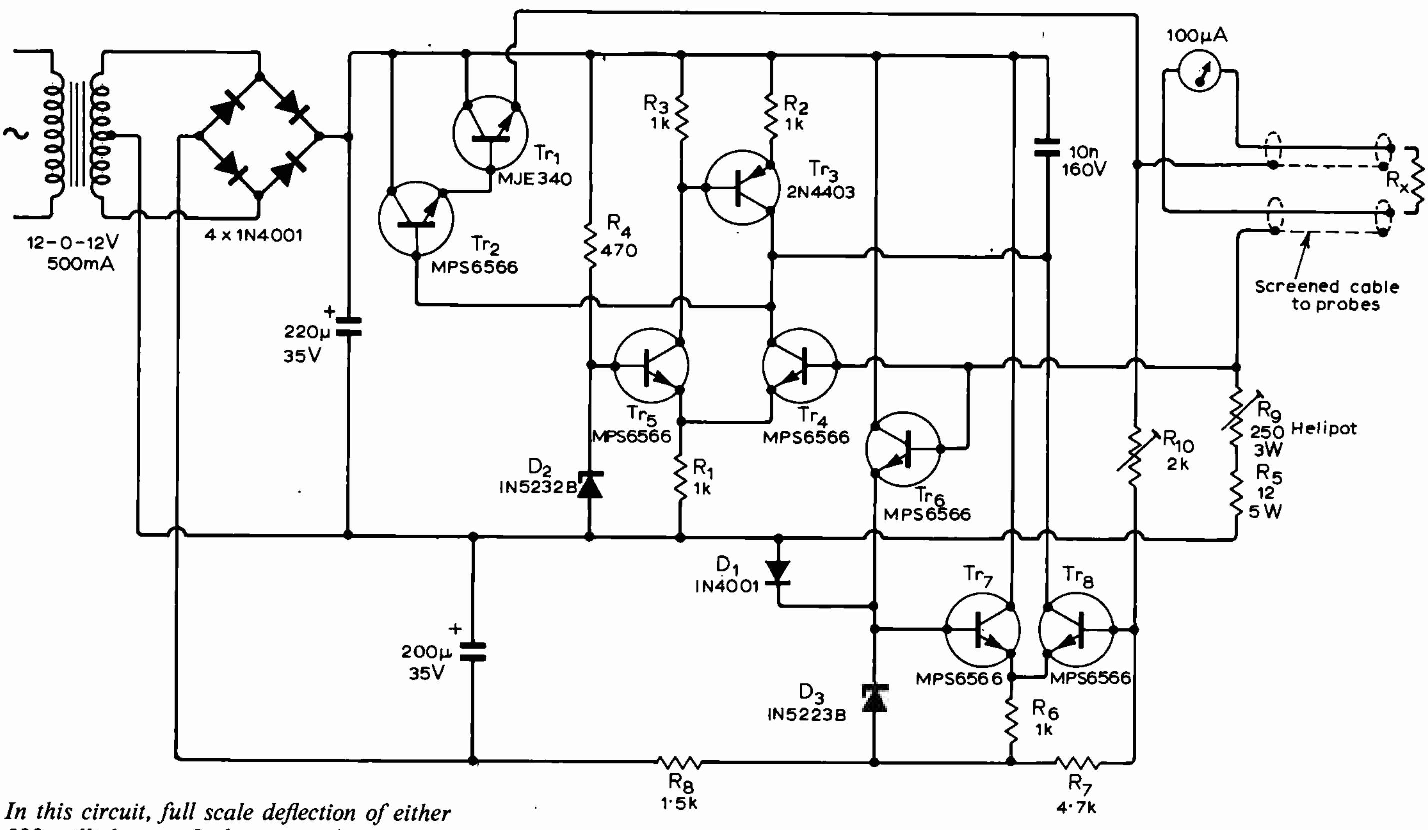
A further advantage of this circuit is that any variation in the amplifier supply rail will have a similar effect on R_2 and R_3, and its effect is nullified. When the voltage between the output rails rises to approximately 500 millivolts, control passes to the voltage limiting amplifier.

The reference and error sensing sides of the voltage limiting amplifier must be referred to the two output rails. This presents a problem in that any load on the negative rail will result in inaccurate current regulation. The emitter follower Tr_6 buffers this point from the current demands of D_3. As voltage limiting occurs the voltage across R_9 and R_5 falls toward the zero volts rail, and Tr_6 ceases to conduct. Diode D_1 then becomes forward-biased and supplies the current required by D_3. The maximum output voltage is preset by adjusting R_{10}.

If the meter is connected across the output rails the impedance of the lead between the instrument and R_X could give rise to errors, particularly at 500 milliohms f.s.d. This is avoided by using screened wire between the instrument and the test probes. The screen carries the test current, while the inner lead is connected to the meter. The screen and inner lead are connected together at the test probe. With suitable probe tips this method gives errors of less than 1% f.s.d.

This instrument is intended for measuring resistances and not monitoring. No attempt has been made to compensate for the drift caused by temperature rise in R_9 and R_5. Prolonged application of the current may also cause temperature drift in R_X. Input voltage variations will result in some drift in both the current and voltage amplifiers. If this proves troublesome R_4 and R_8 should be replaced with constant-current sources.

The range may be adjusted by connecting a resistor of between 20% and 100% of full scale between the test probes. Resistor R_9 is then set to give the required reading. When testing for dry joints, the f.s.d. should be set to 500 milliohms. A good soldered joint will normally have a resistance of less than 50 milliohms, and a dry joint will normally exceed 500 milliohms.



In this circuit, full scale deflection of either 500 milliohms or 5 ohms is set by R_9. Resistors should be $\frac{1}{2}$-watt types with ±5% tolerance unless shown otherwise.

Stereo Mixer

2—Further circuits and construction notes

by H. P. Walker, B.A.

Post-mixing circuits

In the prototype, the signal from the virtual-earth mixer is taken to the tone-control circuit via a switchable rumble filter and the main gain fader and stereo balance controls. The signal is fed at low impedance from the tone-controls directly to external equipment or passed on to the line and metering amplifiers.

Tone-control and filter circuits. The circuit shown in Fig. 11 can conveniently be divided into two by the main gain and stereo balance controls. These controls are similar to those described for the pre-mixing amplifiers except that the balance control does not fade either channel to zero. The author chose a 10kΩ potentiometer for the main gain fader after finding that a 50kΩ potentiometer caused an audible deterioration in the residual noise level when the control was set at about half full output.

Filter circuits. Prior to the stereo balance control, a switchable rumble filter attenuates frequencies below 25Hz at about 24dB/octave in conjunction with the built-in low-frequency turnover, as shown in the tone-control characteristics, Fig. 12. The high-pass filter is synthesized using emitter-follower sections which are cheap to construct and give a gain of unity in the pass-band. Low-pass filters may also be synthesized in a similar manner to give various turnover characteristics (e.g. maximally flat amplitude or linear phase) and various rates of attenuation.

Although no high-frequency filter is included in the present design, its use is definitely advantageous when gramophone records are being reproduced. The omission is partly due to the prejudice of the author who feels that only a comprehensive h.f. filter system, in which the slope and turnover-frequency are variable, is really useful: the best known is that on the Quad 22 and 33 control units*. The subjective affect of Butterworth (or maximally flat magnitude) low-pass filters is often to increase the noise and distortion they are intended to reduce, while the signal assumes an unpleasant 'nasal' quality due to the transient distortion. This is caused by the abrupt turnover in the amplitude response followed by a steep roll-off at 18dB/octave or more, and is easily demonstrated by examining the theoretical response of such a circuit when excited by a step function[7] (e.g. a square wave).

As a result, the author has never found this type of filter very useful and frequently prefers the original noise and distortion to the coloration caused by the transient

*A useful passive circuit having a fixed turnover frequency and variable slope was described by R. Williamson in *Hi-Fi News*[5] and reproduced in a later article by B. Grossmith[6].

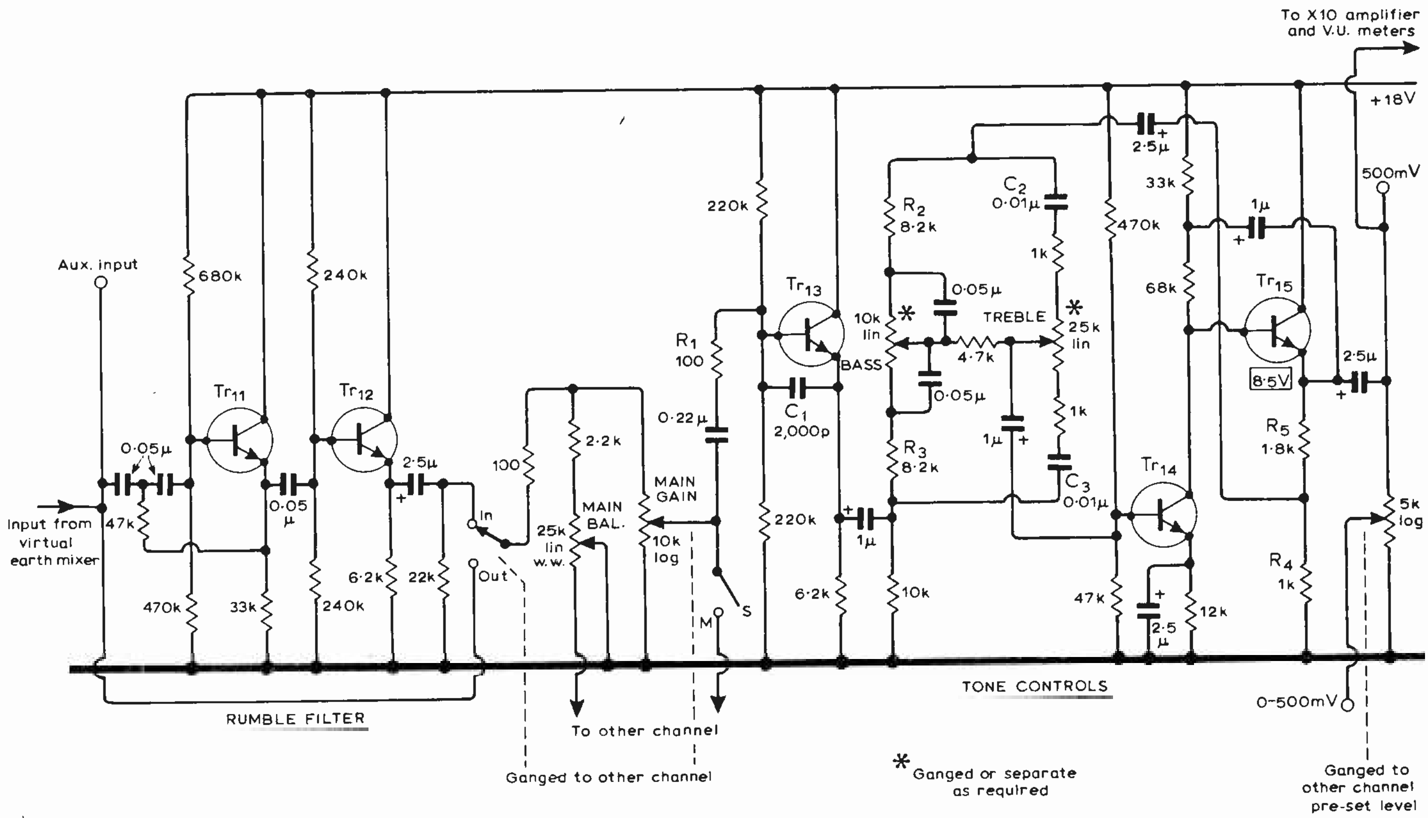


Fig. 11. Tone-control and filter circuit. Residual noise −98dB. Tr_{11}-Tr_{15} BC109 etc.

ringing. However, if the rate of attenuation is reduced to 12dB/octave this transient distortion is aurally less noticeable while tests using a Bessel (linear phase or maximally flat time delay) filter[7] gave, subjectively, a quite pleasing effect even with an 18dB/octave roll-off. This is to be expected from the improved transient response resulting from the more gradual turnover characteristics. A practical circuit, realizing this filter, is shown in Fig. 13 and the frequency response curve for the values shown, in Fig. 14. Changing the turnover frequency involves scaling the values of C_1, C_2 and C_3, but simply halving C_2 to 220pF gives curve 2, which, although not maintaining the true Bessel characteristics, does not seem to cause audible transient distortion.

Tone-control circuit. The shape of the tone-control characteristics, like those of the h.f. filter, are a somewhat subjective problem, though there are some important specifications which must be met by any proposed system:

(i) low interaction between bass and treble controls;

(ii) low distortion even at maximum boost; and

(iii)a truly flat amplitude characteristic and a good transient (i.e. square wave) response when the controls are in the 'flat' position.

The tone-control circuit of Fig. 11 is basically a virtual-earth feedback configuration in which the bass control is of the variable turnover frequency type and the treble control has a fixed turnover frequency, approximately determined by the time constant R_2C_2, and effectively lifts and cuts the whole of the frequency range above 2kHz. The gain/frequency characteristics are shown in Fig. 12. The component values used in the tone control network are the result of experimental measurements and listening tests. In particular the treble control components were carefully chosen so that the control can alter the musical 'brilliance', and it gives a variation which is related to rotation, i.e. there is no 'dead band'.

The nominal signal level of 360mV, leaving the virtual-earth mixer, is attenuated by 6dB in the stereo balance control so that the maximum signal level entering the

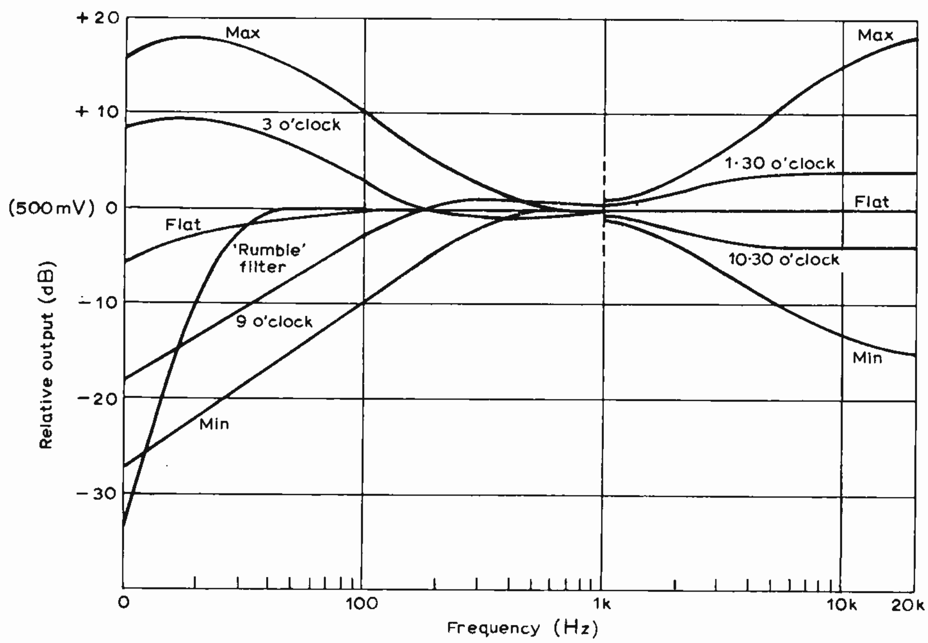


Fig. 12. Characteristics of filter and tone controls.

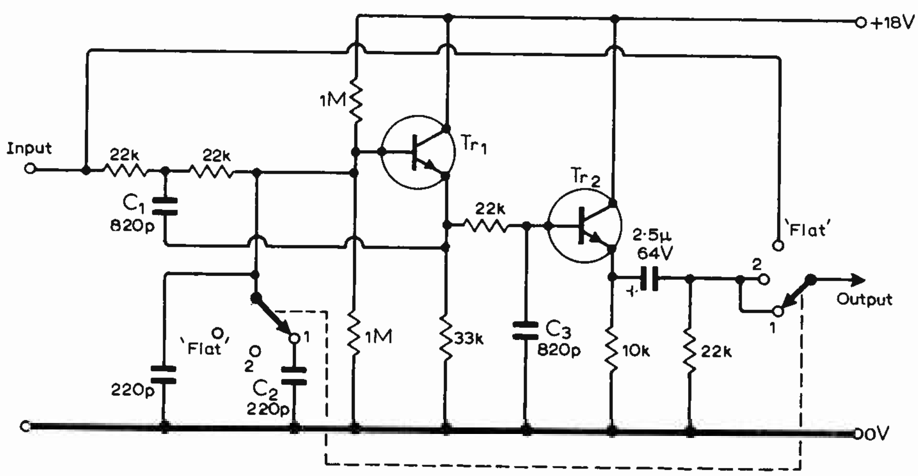


Fig. 13. High-frequency filter. Tr_1 Tr_2 BC109 etc.

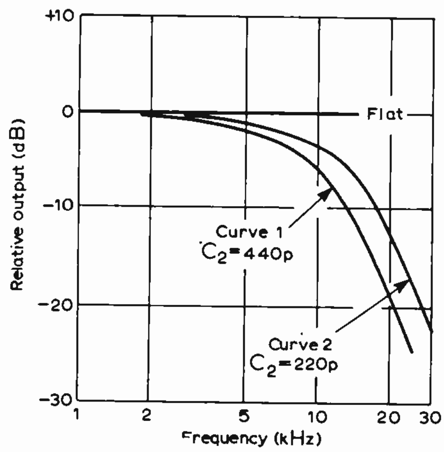


Fig. 14. Characteristics of Fig. 13.

tone-control stage is about 180mV. As the tone-control network is symmetrical, to obtain a gain of greater than one the feedback connection must be made to a tapping in the output load resistor. The gain is then given by $(R_5+R_4)/R_4$. For a nominal output of 500MVr.m.s. a gain of 2.8 is required; for higher or lower outputs R_4 should be altered (e.g. to 390Ω for 1Vr.m.s. output), remembering of course that the circuit is not designed for outputs much greater than 2Vr.m.s.

Turning to the amplifier itself, the bootstrapping circuit is used which gives a gain without feedback of 2000 and a distortion level of less than 1%. This enables very low distortion to be obtained even at maximum boost. Although the effective source resistance presented by the tone-control network varies with frequency, a suitable average value for design purposes is 5kΩ, which sets the collector current at 100μA in Tr_{14} for a low noise figure. Tr_{13} provides a low impedance drive to the tone-control network, R_1 and C_1 being included to prevent h.f. instability.

The complete circuit has low interaction between the controls and in the 'nominally flat' position the overall response is flat to within 1dB over the audio range and the square-wave performance shows rise and fall times of about 0.5μs with no overshoot. Harmonic distortion for an output of 500mV r.m.s. is less than 0.02% rising to 0.05% at 2V r.m.s. The level of residual noise at the output with the main gain control turned down is approximately −93dB w.r.t. 500mV when measured on a bandwidth of −20kHz.

Line amplifiers: The mixer may often be required to feed into a 600Ω termination at a power level of several milliwatts. The line amplifiers have been designed for this purpose and single-ended and push-pull versions are shown in Fig. 15 and Fig. 16 respectively.

Both circuits have a gain of about ten, determined by the feedback components, but the single-ended stage, operating in class A, has a limited output voltage swing (at low distortion) of 2V r.m.s. into a 600Ω load. When feeding high impedance loads (> 10kΩ), such as insensitive power amplifiers, the maximum output voltage is in excess of 5V r.m.s. at less than 0.05%

distortion. Residual noise is −82dB w.r.t. 500mV output (20kHz bandwidth). The single-ended circuit has the merit of simplicity compared with the more sophisticated design of Fig. 16.

The complementary emitter-follower, Fig. 16, operating in class B, can supply more than +20dBm to a 600Ω load (8-9V r.m.s.) at very low distortion (<0.05%). A quiescent current of 2-3mA in the output circuit, set by R_1, reduces the crossover distortion to a low level (none is detectable on the oscilloscope trace of the residual). The circuit configuration is that commonly used in power amplifiers, the a.c. and d.c. feedback loop being combined as they also are in the single-ended design. Residual noise is less than −95dB measured as above.

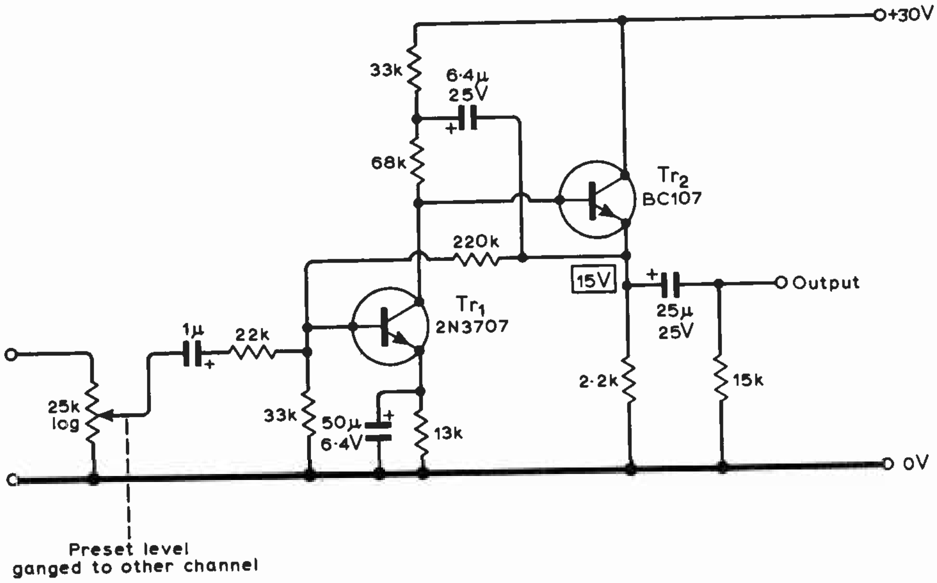


Fig. 15. Single-ended line amplifier. Distortion 0.1% at 2V r.m.s. into 600Ω; 0.05% at 5V into high impedance. Residual noise −82dB w.r.t. 500mV output (20kHz bandwidth).

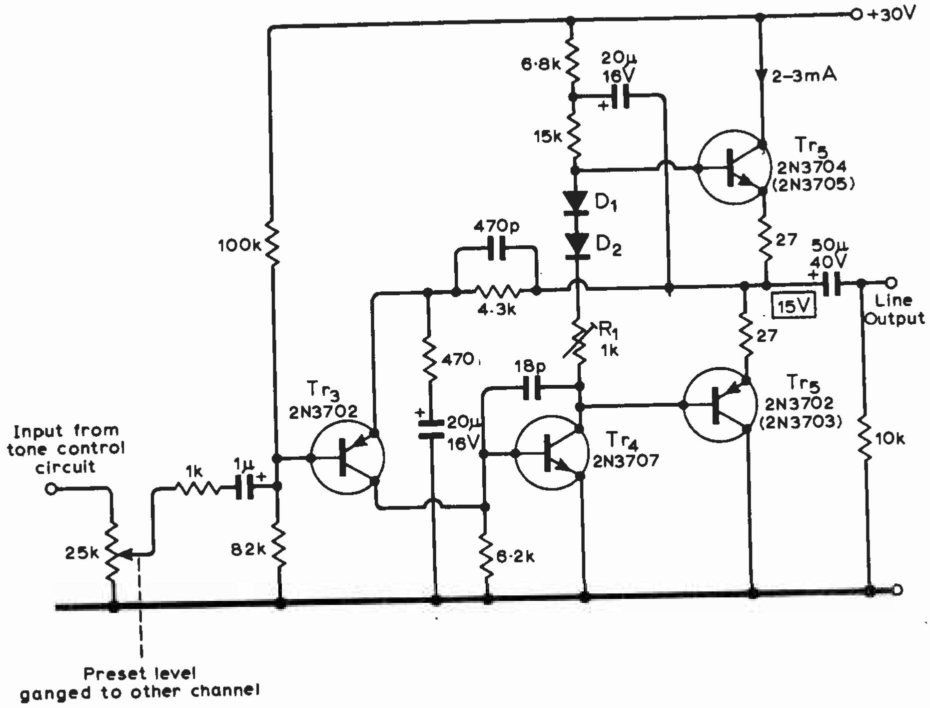


Fig. 16. Push-pull line amplifier. Distortion 0.03% at +20dBm (8V into 600Ω) at 1kHz and 10kHz, and at lower powers (20kHz bandwidth). D_1 D_2 1N914.

Monitor amplifier: The complete circuit is shown in Fig. 17. The clean feeds and mixed output are selected by the two-pole, six-way switch and a 50kΩ log. potentiometer is used as a monitor level control to prevent loading when the individual channels are selected. The monitor amplifier is basically the same configuration as that used in the line amplifier, Fig. 16, except that a higher standing current of 10mA is used in the second transistor and a complementary pair of power transistors, Tr_3 and Tr_4, make the circuit suitable for driving a loudspeaker up to about 2W. The amplifier is, however, primarily meant for headphone monitoring and under these conditions its performance is very good, but the possibility of l.s. operation could be useful for a talk-back facility in live recording. Needless to say the output transistors should have some form of heat sink for continuous loudspeaker operation.

The components R_1, C_1 and C_2 improve the high-frequency stability. The preset, R_4, is adjusted for symmetrical clipping at the output (a centre-line voltage of 10V d.c.) and R_5 is used to set the quiescent current of 10mA in Tr_3 and Tr_4. The diode, D_1, across which the bias voltage is developed, should be mounted close to the power transistors to aid thermal stability. A gain of approximately 20, determined by $(R_2+R_3)/R_3$, is sufficient to cause overload when the amplifier is driven from the clean feeds at a nominal signal level of 240mV. Normally some resistance (e.g. 15Ω) must be connected in series with low-impedance headphones to protect the phones—and also the operator's ears!

Signal-level meters: Some form of metering is essential in a mixer of this complexity if maximum signal-to-noise ratio and low distortion are to be obtained. Apart from the obvious value in setting-up procedures and in monitoring output levels, a properly calibrated built-in meter is very useful for checking pickup cartridges, tone control characteristics, channel balance and so on.

The relative merits of peak programme and VU meters are a controversial subject![8] The use of VU meters in this design does not presume any general preference for this type of metering. In the author's opinion peak programme meters are better as recording level indicators, whereas VU meters seem to give a more realistic indication of sound or signal level. In either case, though, the interpretation placed on meter readings depends on the experience of the user.

In the prototype the metering circuit was connected directly to the output of the tone-control stage, Fig. 11, but naturally it could be switched to read other data in the equipment. The simple one-transistor amplifier of Fig. 18 provides the required gain and any frequency compensation and isolates the meter (and its non-linear loading) from the signal circuit. The meter is the heart of the system and while it is possible to obtain satisfactory results without spending vast sums of money, the constructor should avoid 'cheap' meters which are often poorly damped and inaccurately calibrated and give quite meaningless readings on transient signals. The meters used in the prototype were SEW MR45P, from G. W. Smith & Co. (Radio) Ltd., which give adequate performance for the author's requirements; more expensive models would give more consistent readings. The values of R_c and C_c given in Fig. 18 relate to this particular meter and give a calibration accurate to within 0.5dB at high frequencies.

Power supply

The advantages of a regulated power supply are—

(i) rail voltages independent of mains supply fluctuations,
(ii) mains-borne interference partially suppressed, and
(iii) low-impedance power supply rails,

avoiding possible low-frequency instability due to interaction between circuits.

This last point is particularly relevant in circuits where emitter-follower outputs draw currents of several milliamps. Although the author included an a.c. decoupling network (100—200Ω and 100μF) in series with the power supply rail to most of the individual circuits, this was avoided with the tone-control circuit because the bass-boost control would make the circuit rather sensitive to l.f. crosstalk and instability if maximum boost were used. Electronic overload protection can be built into such a supply and can prevent excessive damage under fault conditions.

The complete power supply circuit shown in Fig. 19(a) is the one used by the author for the prototype but there are several variations possible to suit different requirements. These are mainly determined by the desired output facilities. If it is intended to use the low-power loudspeaker monitoring facility (described in connection with Fig. 17) then the separate 20V regulated supply (Fig. 19(a)) should be used since this provides isolation from the supply rails to the rest of the mixer and incorporates a peak overcurrent protection circuit, R_2 and Tr_6. The moderate current swings required for headphone monitoring allow the monitor amplifier to use the same supply rails as other circuits in the mixer. For this application the series transistor regulator, shown in Fig. 19(b), should be substituted for the shunt zener stabilized circuit.

The series regulators are of conventional design. Transistors Tr_1 and Tr_4 are mounted on heatsinks (the metal chassis is satisfactory) and Tr_8 (Fig. 19(b)) should be fitted with a clip-on, finned, heatsink though currents of more than 50mA are better handled by a chassis-mounted 2N3054 (with R_4 reduced to 2.2kΩ). When the current drawn from the supply is sufficient to develop about 0.6V across R_1 (or R_2), Tr_2 (or Tr_6) begins to conduct and removes a proportion of the current drive from the series regulator to maintain a constant current limit which is set by Vbc_2/R_1.

It may have occurred to readers that, because the 0V rails of the regulator outputs will be a common signal earth, the same control voltage will appear across both R_1 and R_2 and consequently the current limits cannot be set independently. In passing, it should be noted that common power supply rails must be paralleled at the actual supply and *not* by devious routes in the mixer.

Under working conditions R_1 is between 2.7Ω and 1.2Ω and R_2, which will dominate the current limit, should not be less than 0.3Ω thus setting the peak-current limit at 2A. When testing the mixer circuits during construction, the author found it expedient to disconnect the 20V regulated supply and increase R_1 to a much larger value (say 10Ω) as a safeguard against wiring mistakes. The maximum current which can be drawn from the zener-stabilized 20V supply is determined by the value of R_3, such that $I_{max} = 10/R_3$.

If, however, there is likely to be a large variation in the current required from this supply, allowance must be made for the dissipation in the zener diode and the alternative circuit, Fig. 19(b), is preferable.

Little need be said of the rest of the circuit; any type of rectifying diodes and

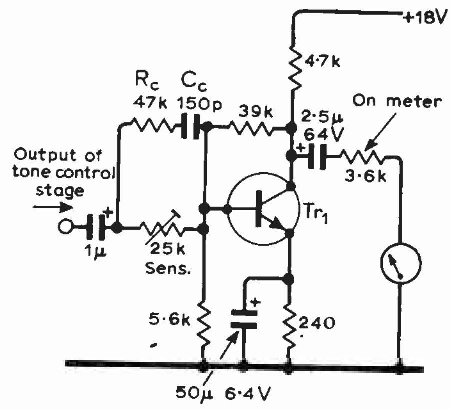


Fig. 18. VU-metering amplifier. Tr_1 BC109 etc.

transformer can be used so long as they meet the specifications.

Earthing

Care must be taken that earth loops do not arise within the mixer or when it is connected to other equipment. When a low-resistance closed loop is formed (e.g. by a multiple earth return of busbar and chassis) a relatively large current can flow for only a small induced voltage. If this current happens to pass through the earth return to the input of a sensitive amplifier, the potential difference developed across this earth return is in series with the signal source and a background hum is produced.

The presence of both power supply and signal earth returns is a potential source of trouble and to prevent it, low-value resistors (1.2—4.7Ω) should be included at suitable points. Fig. 20 shows the method used by the author for earthing the sensitive input circuits and no earth-loop problems were experienced with the prototype. Note that the only low-resistance path is between the input sockets; also that 'dry-joints' in the earthing system can create low-value resistances in the signal-earth return path.

Much the same kind of arguments apply to the interconnection of equipment, namely, the mixer should not be connected to amplifiers, tape machines, etc., via both the mains and signal earths.

To facilitate 'setting-up' procedures the author fitted a switchable mixer earth return (Fig. 20) and also optional turntable earthing switches in case some strange earthing arrangement is encountered with ancillary equipment.

It is very difficult to generalize on earthing problems and although one can become quite speedy at this kind of trouble shooting, it can also be very perplexing at times. However, an intelligent and logical approach from the beginning helps enormously if trouble does occur and one should not tempt providence by placing mains transformers close to input circuits and microphone transformers. Earth loops can usually be identified by the 'edgy' character of the hum they produce (more of a 'buzz' in fact).

Constructional details

The photographs, Fig. 21, show the front and back of unit 1, which contains

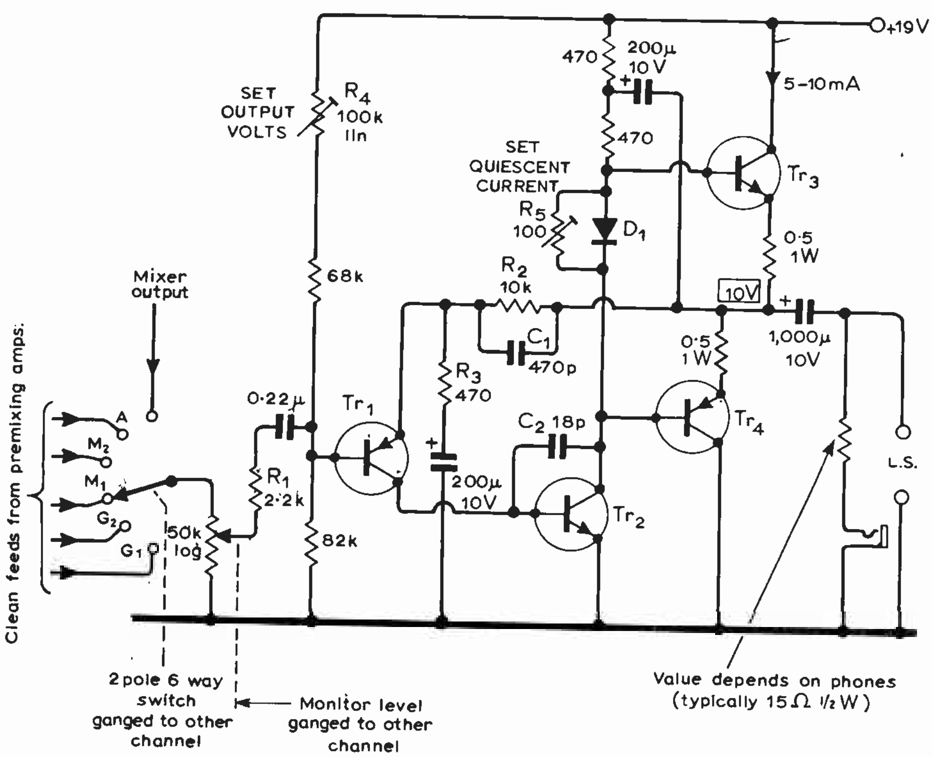


Fig. 17. Monitor amplifier. Tr_1 2N4058, 2N3702 etc; Tr_2 BC109 etc, Tr_3 Tr_4 AD161/162 (matched), D_1 OA95.

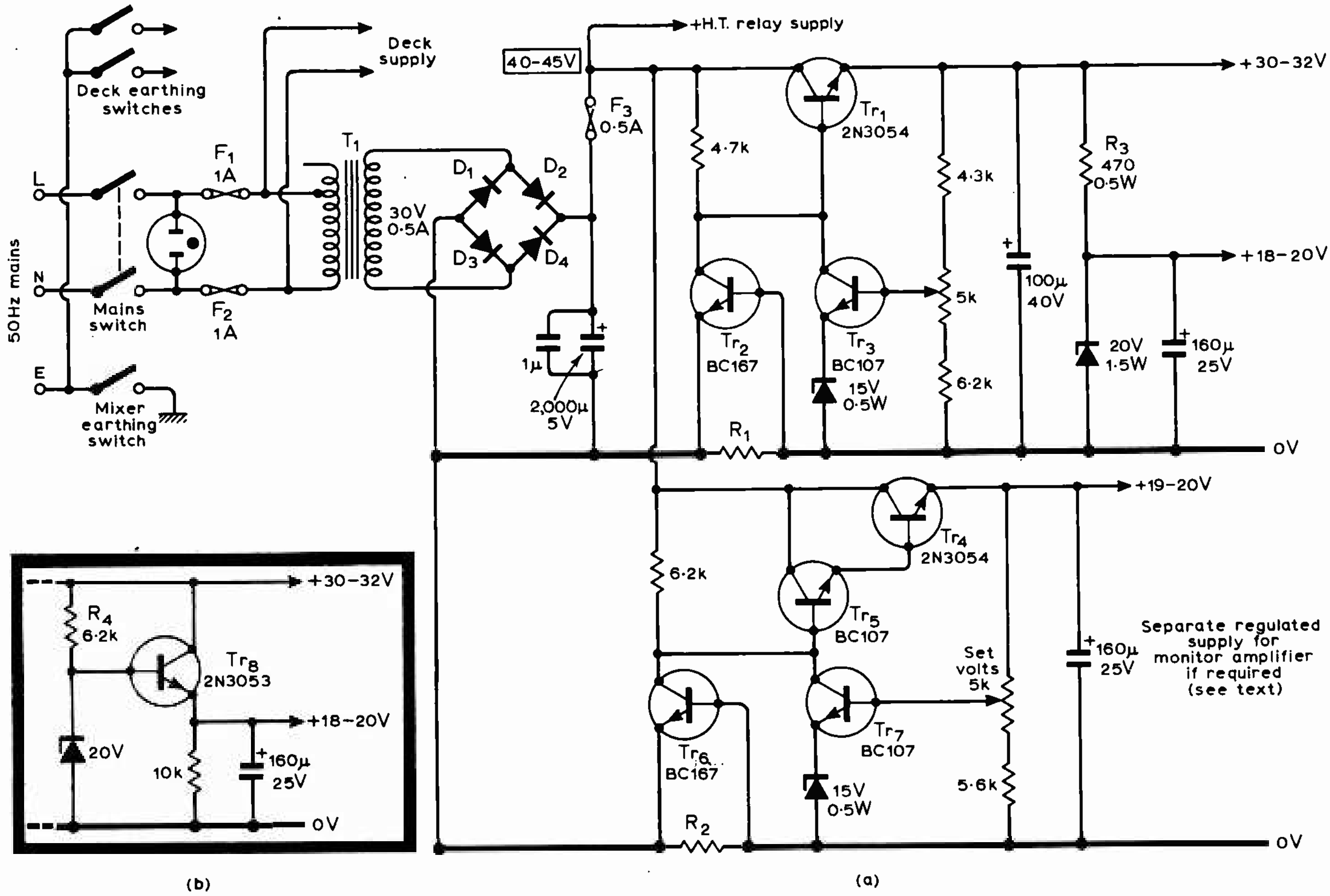


Fig. 19. (a) Comprehensive power supply. D_1-D_4 100V 0.5A. T_1 30V 0.5A. (b) Alternative to zener diode stabilized 18V rail.

the premixing amplifiers, channel faders and virtual-earth mixer. Interconnection between units is by one 8-way cable carrying signal and power supplies and one 12-way cable for clean-feed monitoring signals. Unit 2 contains tone-controls, output and monitor amplifiers, metering facilities and regulated power supply. The advantages of using two units instead of one are, first, that the sensitive input circuits can be isolated physically and electrically from the a.c. mains wiring; secondly, the greater flexibility compared with the rather cumbersome single unit; and thirdly, that if one wished to use completely different mixing facilities, unit 1 could be changed while still maintaining the facilities of unit 2 in its present form.

All the individual circuits, with the exception of the power supply, were constructed on plug-in printed circuit boards made by the author from $\frac{1}{16}$in copper-clad laminated board. Input facilities of the mixer can then be changed simply by removing one board and plugging-in another. As all connections to a board must be made in close proximity to each other, care must be taken to keep input and output as far apart as possible particularly on high gain, 'wideband' circuits (e.g. microphone amplifiers).

It is logical to layout a stereo pair of circuits as mirror images of one another and then the circuits will still operate if the boards are accidently inserted back to front. The outermost tabs on the edge connector for any board are the power-supply earths, and they connect via the low-value resistors to the signal earth busbar round the perimeter of the board. The positive rail enters on the innermost tabs; the different supply voltages are standardized to enter on different sets of tabs (18V on the middle two and 30V on adjacent tabs) so that even if an 18V board were accidently plugged

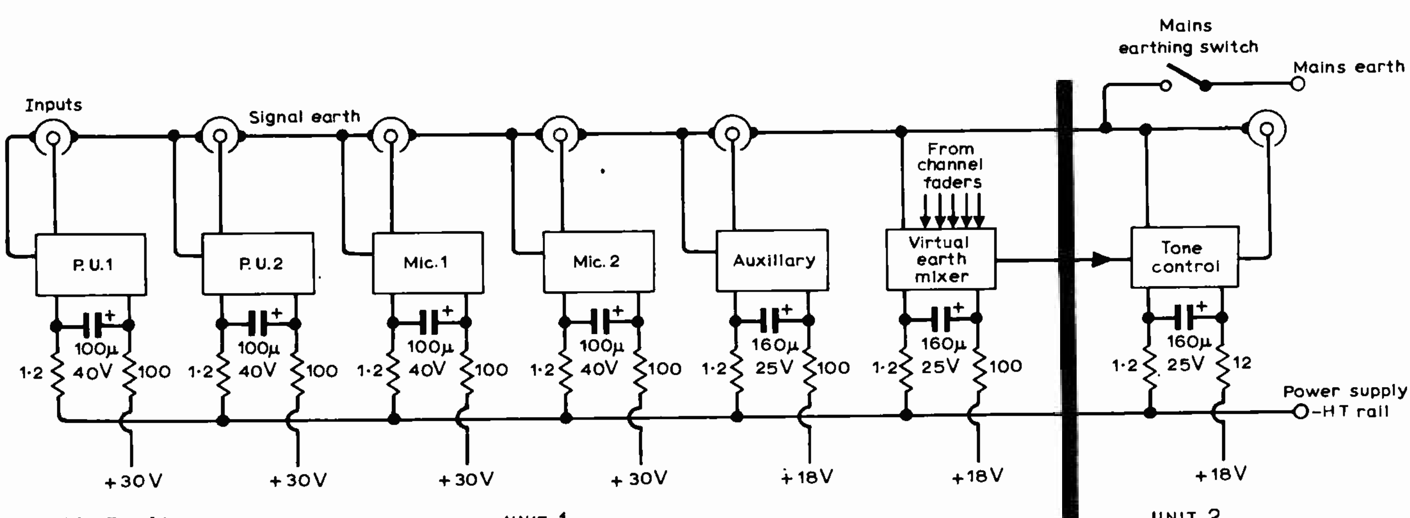


Fig. 20. Earthing arrangements.

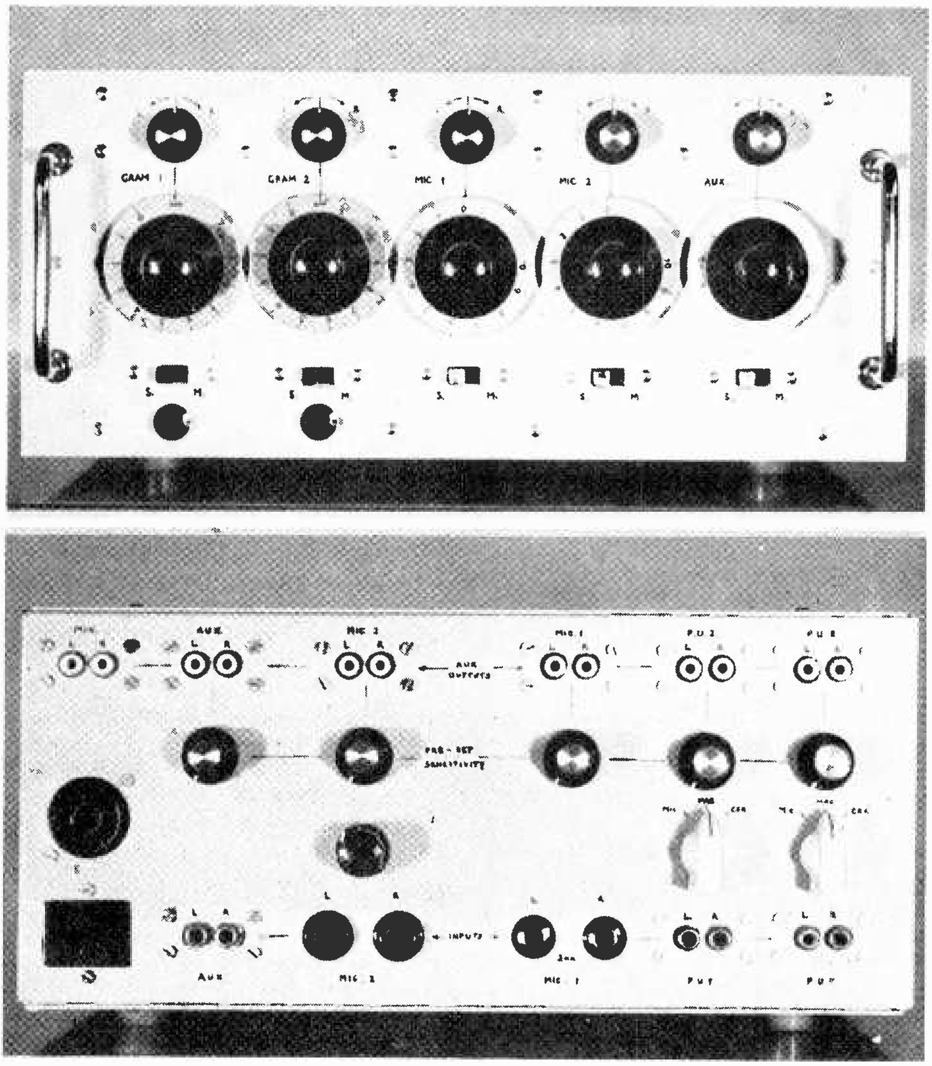


Fig. 21. Front and rear views of unit 1.

into a 30V socket, no damage could result. Signal outputs were normally placed near the edge of the board and inputs near the middle.

For obvious reasons the connections between input sockets and edge connectors should be as short as possible and properly screened. The circuits themselves are sufficiently stable for reasonable lengths of screened wire to be used in connecting them to controls and no great care was exercised in this respect when building the prototype.

So far in this article we have not mentioned the subject of crosstalk because it is a function only of layout, provided that the circuits have been designed with low output impedances to prevent electrostatic induction. For the circuitry from the virtual-earth mixer input to the output, the author obtained readings of −75dB and −66dB (ref. 500mV r.m.s. output) at 1kHz and 10kHz respectively. Crosstalk in the input circuits is very dependent on how the input of the other channel is loaded but typically the electronics will have a cross-talk 30dB better than that of pickup cartridges and tape machines. The worst cross-talk is likely to occur with sensitive microphone inputs though here the measured values for the prototype were considerably better than −40dB even at 10kHz.

Testing

If the constructor does not own the necessary equipment to test the specification of the completed circuits, simply checking the d.c. voltage at the amplifier output (shown on the circuit diagrams) is correct can be taken as an indication that the circuit is functioning properly. This is because the direct coupling between stages requires all d.c. conditions to be right.

Using the mixer

To obtain the highest signal-to-noise ratio at low distortion, some attention must be given to the adjustment of preset sensitivity controls and it is here that the metering facility comes into its own. The steps are as follows:—

(i) Turn-up the main gain fader to 0.75 full output and leave the main balance control at the central position.

(ii) Turn-up the channel fader to the desired working point (e.g. 0.75 full output) and then adjust the preset sensitivity and channel stereo balance controls for maximum outputs of 0 VU when a monophonic tape or record is being played stereophonically. Repeat this procedure for all channels to be used.

The important point is to use full signal level after the channel faders without going to the other extreme of overloading the virtual-earth mixer and obtaining the maximum output of 0 VU with the main gain control turned down to low levels. Conversely if low outputs are required from the mixer (e.g. for tape recorders or sensitive amplifiers) these should be achieved by turning down the main gain fader or preferably the preset output level control and *not* by using a low mixing level with the main gain control turned fully up. The main stereo balance control is intended to compensate for imbalance in output equipment such as loud speakers.

Some readers may think this is stating the obvious, but the author has sometimes found a logical approach the only way of ensuring full use of the mixer when connected to a variety of input and output equipment which may also have gain controls.

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7. Kuo, F.F., 'Network Analysis and Synthesis', second edition Chapter 13, J. Wiley (1966).
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Correction Note

'Stereo Mixer' Part 1, May 1971

The auxiliary input sensitivity given as 230 mV in Table 1 should be 30 mV. R_3 in Fig. 8(a) should be 220Ω. R_2 and R_5 in Fig. 10 should be 22k and 33k respectively, and C_4 should be rated at 64V not 6.4V. In Figs. 7 and 8(a) and (b), the signal-to-noise ratio is given without reference to an input signal level. For Fig. 7 a 66dB s/u ratio is obtained for 200Ω source resistance with respect to 45μV at 1kHz. For Figs. 8(a) and (b), 63.5 dB s/u ratio refers to a signal level of 100μV on 30Ω. All measurements were made on a noise bandwidth of about 20kHz.

June Meetings

8th. AES—Discussion on "Audio assessments and measurements" at 19.15 at Mechanical Eng. Dept., Imperial College, Exhibition Rd., London S.W.7.

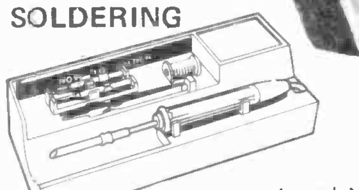
10th. RTS—Lecture/demonstration on I.T.A. digital standards converter at 19.00 at the I.T.A., 70 Brompton Rd., London S.W.3.

30th. Brit. Acous. Soc.—"Acoustic atmospheric propagation and applications" at 14.30 at University College, London W.C.1.

SK2 Soldering kit

In polystyrene pack, containing 15 watt miniature soldering iron, 240 volts fitted with $\frac{3}{16}$" bit, 2 spare bits $\frac{5}{32}$" and $\frac{3}{32}$". Coil of resin-cored solder, heat sink, 1A fuse and booklet "How to Solder".

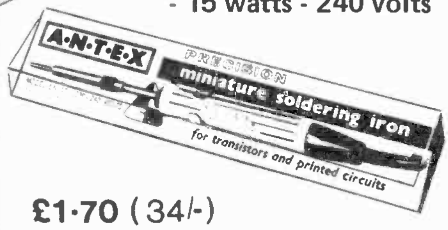
SK1 SOLDERING KIT



£2·75 (55/-)

In rigid plastic "tool box" containing Model CN - 15 watts - 240 volts miniature iron fitted $\frac{3}{16}$" bit. Spare bits $\frac{5}{32}$" and $\frac{3}{32}$". Reel of resin-cored solder, heat sink, cleaning pad, stand and booklet "How to Solder"

Model CN 240/2 - 15 watts - 240 volts



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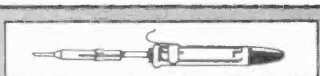

Model G - 18 watts. Fitted $\frac{3}{32}$" bit. Spare bits $\frac{1}{8}$", $\frac{3}{16}$" and $\frac{1}{4}$" available. For 240 or 220 volts. £1.80 (36/-).

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Model ES - 25 watts. Fitted $\frac{1}{8}$" bit. Spare bits $\frac{3}{32}$", $\frac{3}{16}$" and $\frac{1}{4}$" available. For 240, 220 or 110 volts. From £1·80 (36/-).

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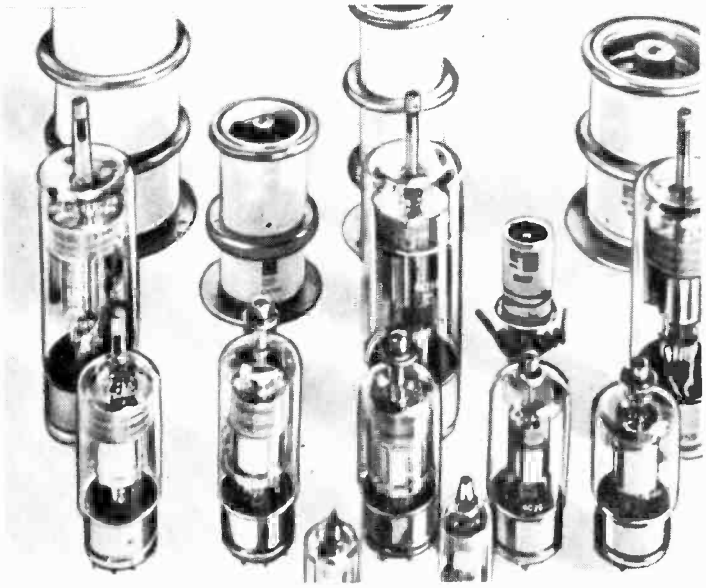

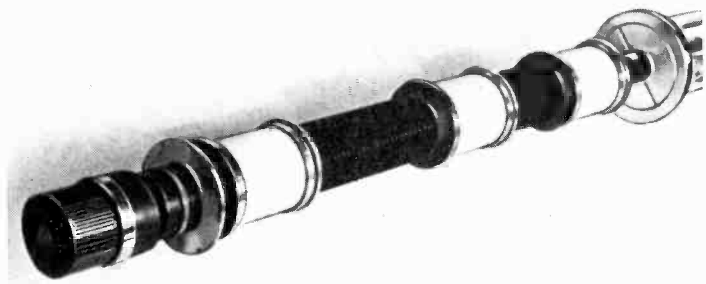

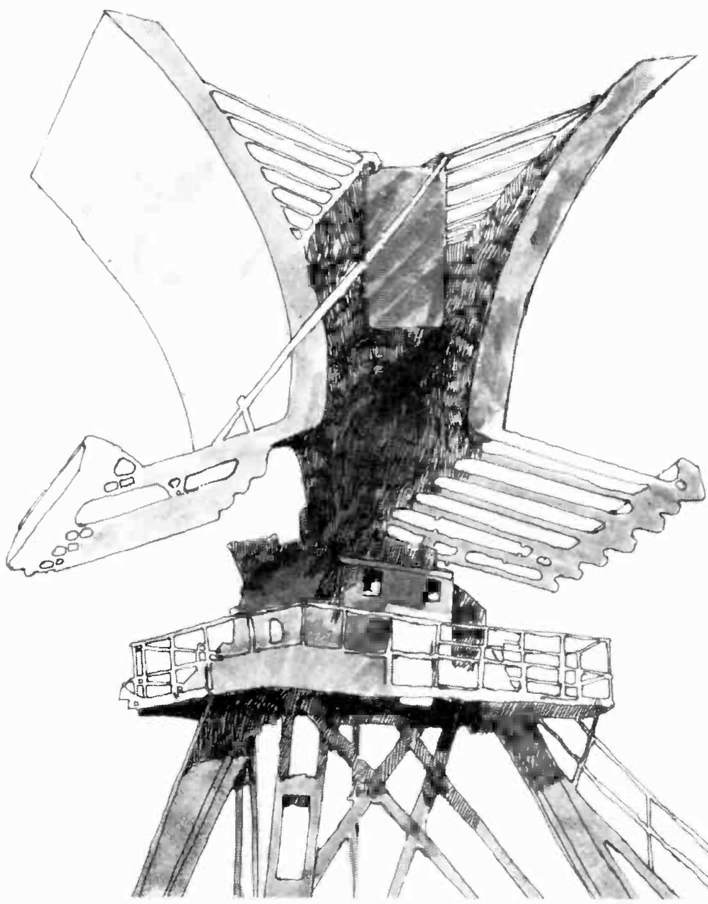

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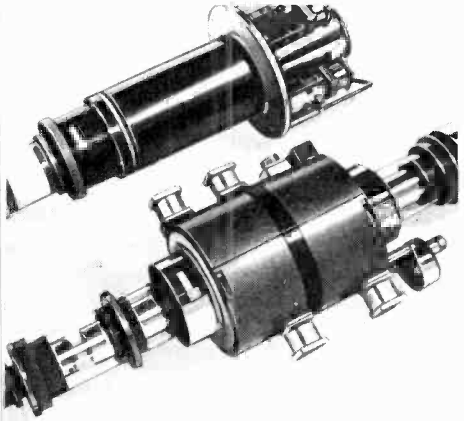

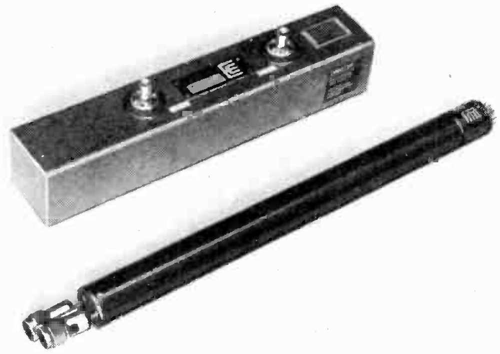

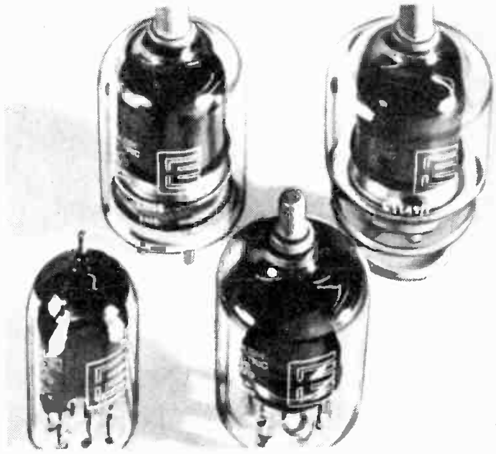

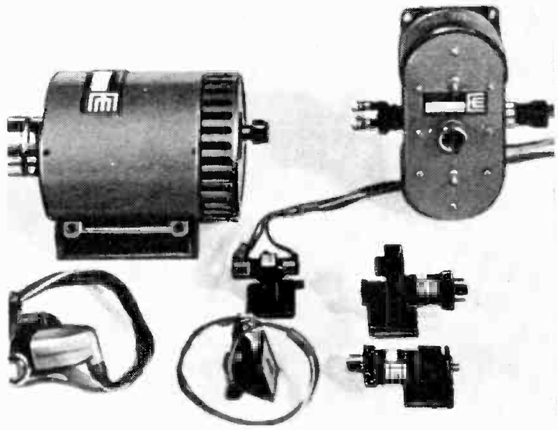

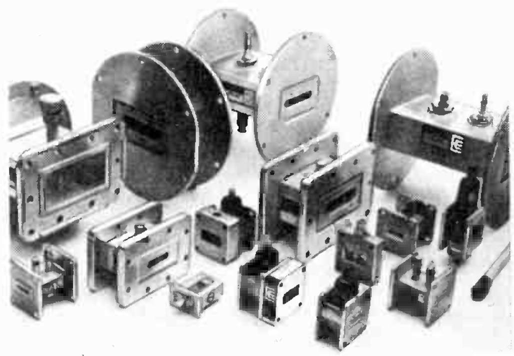

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T.T.L. Monostable Cascade

by H. A. Cole, M.I.E.R.E.*

The circuit uses t.t.l. quad two-input gates to produce a cascade of monostables in a very economic way. A trigger pulse causes a chain of any number of pulses to be produced. Each pulse can have a different duration as set by a single resistor and capacitor. The cascade can be arranged so that it is self sustaining after the initial triggering. An auxiliary output provides a pulse with a duration equal to the sum of the durations of all other pulses in the cascade.

The principles of the circuit may be understood by looking at Fig. 1. Application of a start pulse to the AND gate (&1) sends a trigger pulse to the first monostable m.s.1, which produces a negative going pulse for a period t_1. At the end of this period, the output waveform from m.s.1 returns to its quiescent level and, in doing so, it provides a trigger for m.s.2 and so on down the chain until the last monostable (m.s.n) is triggered. When this happens, the circuit either returns to the quiescent state at the end of the period t_n, or it is made to start the sequence all over again; depending upon the setting of the switch S_1.

With S_1 in the 'single-shot' mode, only one cascade is produced for the application of each start pulse. With S_1 in the 'repetitive' mode, the circuit is automatically re-triggered at the end of each cascade by the pulse produced by the last monostable.

The second AND gate (&2) produces an output waveform $\overline{t_1 + t_2 + t_3 + tn}$ which is a negative going pulse with a duration equal to the sum of all the other pulses in the chain.

Circuit description

The circuit diagram, and the waveforms are shown in Fig. 2. The monostables are formed from 74-series NAND-gate elements, connected in such a way that any one gate (except the first) is shared by two adjacent monostables. In this way, only half the number of gates is required compared with usual circuits of this type in which two gates are required to form each monostable.

The first monostable (m.s.1) is formed from gates G_3 and G_4, its operating period (t_1) being determined by the time-constant of the coupling components C_1, R_1. The second monostable (m.s.2) is formed from gates G_4, G_5, and its operating period (t_2) is determined by C_2, R_2. The remaining monostables are connected in exactly the same way. To a first approximation, the operating period of each monostable is given by 1.3 CR seconds, where C and R are the coupling components expressed in farads and ohms. To reduce the need for large-value coupling capacitors it is desirable to keep the value of R as large as possible. However, the maximum value which may be used for normal-power t.t.l. (SN7400) is of the order of 500Ω; the corresponding value for low-power t.t.i (SN74L00) is 5kΩ. These values are dictated by the maximum permissible input voltage to a gate which will be accepted as a logical '0' level (approx. 0.8V max), and the corresponding maximum input current requirements (1.6mA for normal-power t.t.l. and 0.18mA for low-power t.t.l.). In the circuits described here, low-power t.t.l. is used throughout and the value of R used is 4.7kΩ with a tolerance of ±5%.

In the quiescent state, the output levels of gates G_4, G_5 ... G_n are held at a logical '1' (about 4V) by the resistors R_1, R_2 ... R_n; the capacitors C_2, C_3 ... C_n are therefore fully charged. The output level of G_3 is at a logical '0' (≈4V) since both inputs are at a logical '1'; the capacitor C_1 is therefore uncharged.

When a 'start' pulse is applied to the circuit, G_2 supplies a logical '0' pulse to G_3 and causes its output to change to a logical '1'. This level is transferred to G_4 via C_1, R_1, and causes its output to fall to the '0' level. This is fed back to G_3 to reinforce the trigger pulse, which may now be removed. The fall in level at G_4 output also causes C_2 to discharge, the discharge path being via the output and input impedances of G_4 and G_5, respectively. The circuit remains in this unstable state as C_1 charges towards the '1' level produced by G_3; the charging path being via R_1 and the output impedance of G_3.

When the voltage developed across R_1 (due to the charging current of C_1) falls below about 2V (the minimum acceptable '1' level for G_4 input), the output produced by G_4 once more reverts to a '1' level and the first monostable returns to its quiescent state; the waveform produced by this monostable is shown as $\overline{T_1}$ in Fig. 2(b).

The return of G_4 output to the quiescent '1' state causes a logical '1' to appear (by way of C_2, R_2) at G_5 input, and hence a '0' to appear at its output. This output is fed back to the input of G_4 to reinforce the '0' level transition which occurs across R_1 during the operation of the first monostable; it also causes the discharge of

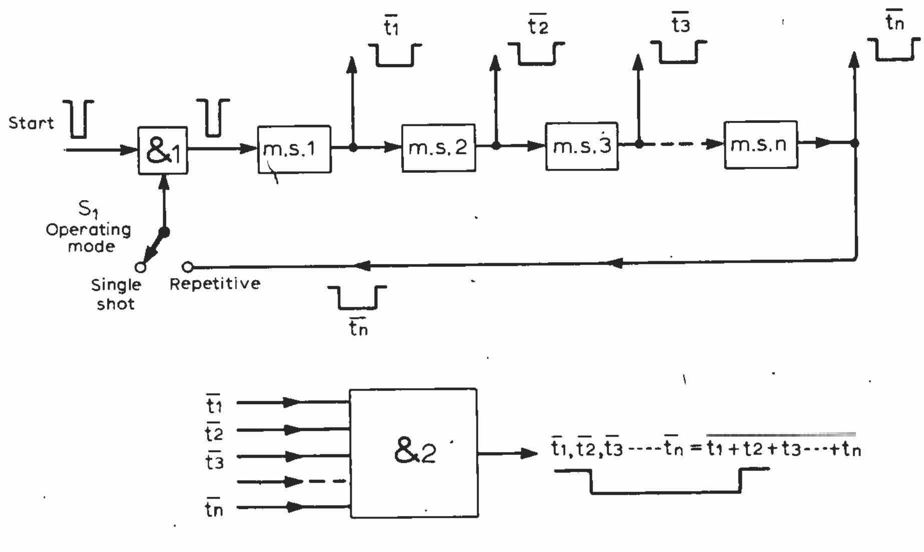
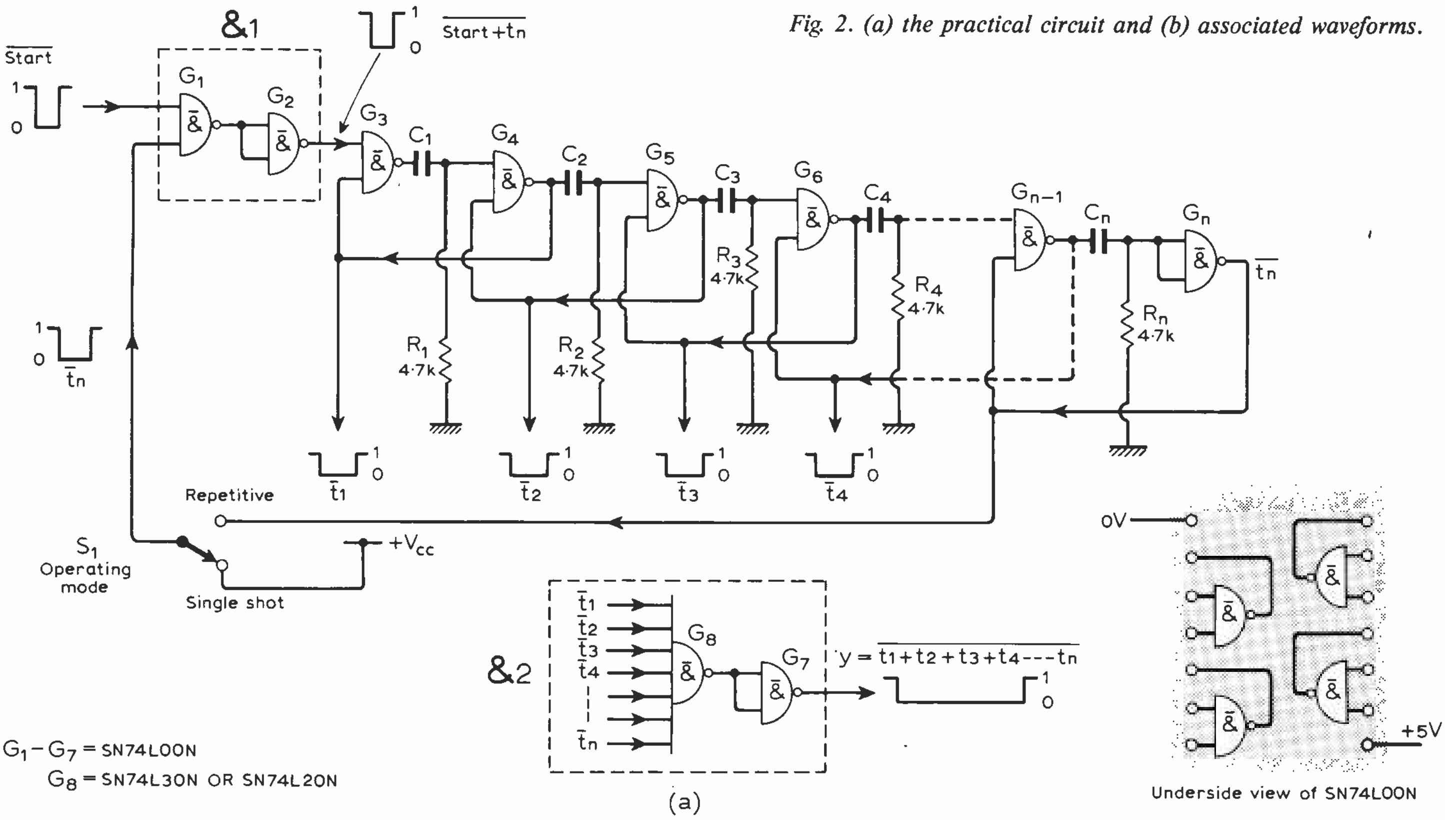


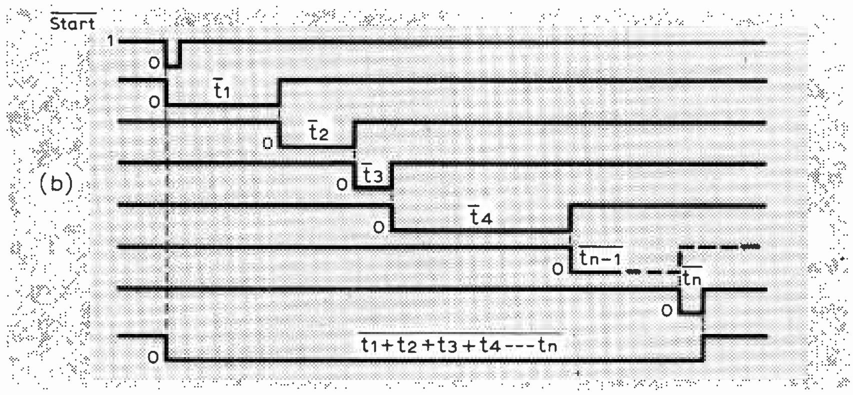
Fig. 1. Block diagram. With S_1 in the repetitive position the cascade is self sustaining.

*A.E.R.E., Harwell

Fig. 2. (a) the practical circuit and (b) associated waveforms.



Underside view of SN74LOON



C_3 via the output and input impedances of G_5 and G_6, respectively. The second monostable remains in this unstable state until the charging current of C_2 causes insufficient voltage to be developed across R_2 to maintain a logical '1' at G_5 input. At this point, the second monostable reverts to its quiescent state and the output from G_5 returns to a logical '1'; the output waveform produced by this monostable is shown as $\bar{t}_2$ in Fig. 2(b).

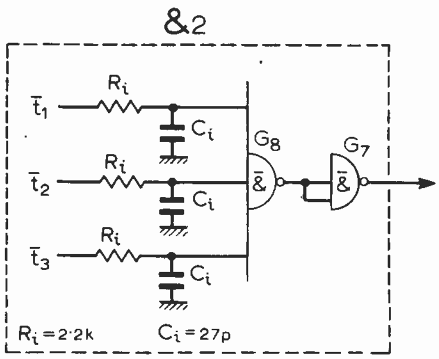


Fig. 3. It may be necessary to connect the sum output gate like this.

The remainder of the circuit continues to operate in the same way as the second monostable, each monostable being triggered by its predecessor.

When the circuit is set to operate in the single-shot mode, the cascade of waveform generation ends with the completion of the waveform produced by the last monostable. It is then necessary to apply another 'start' pulse to the circuit to initiate another cascade. When the circuit is set to the repetitive mode of operation, the cascade is automatically re-started by pulse $\bar{t}_n$.

Experimental results

It may be found necessary to delay the recovery of the waveforms at the inputs of &2 in order to allow sufficient time for the leading edges of successive input waveforms to reach the logical '0' state required by the gate G_8. This may be done by means of the method of coupling shown in Fig. 3. The maximum permissible value of the resistor R_i, for low-power t.t.l. is about 2.5kΩ. Values of 2.2kΩ for R_i and 27pF for C_i have been found quite satisfactory.

Start-pulse duration

The duration of the 'start' pulse required to initiate the monostable cascade, is determined largely by the value of the timing capacitor (C_2) used in the second monostable. This is because of the slowing-up effect which this capacitor has on the regenerative feedback connection between the two gates (G_3, G_4) which form the first monostable. For values of C_2 less than about 1000 pF, the 'start' pulse duration need not exceed 50 ns. Above this value, however, the required duration increases almost linearly with C_2, being about 10μs for a C_2 value of 1 μF.

To a first approximation, the necessary 'start' pulse duration is given by: 13*C us* where *C* is the value of the capacitor C_2, in μF, and *R* is assumed to be 4.7kΩ.

No attempt has been made to find out the maximum timing period, although consistently reliable operation has been observed with timing periods as high as 2.5 seconds.

Integrated Circuit Stereo Pre-amplifier

Adding an active rumble filter

by L. Nelson-Jones

In the original design of this pre-amplifier[1] the low-frequency response was flat to below 20 Hz, the first limiting factor being in practice the l.f. cut-off of the power amplifier with which it was designed to work[2]. In use the unit has given excellent service, with the exception of occasional rumble. Some discs seem to have rumble recorded on them.

The original pre-amplifier design aimed at simplicity and this was kept in mind in trying to establish a suitable circuit modification. The first obvious thought was to reduce the size of the coupling capacitors, but this was not pursued, since the cut of 12dB per octave obtained in this manner leads to a very gradual roll-off, and thus a serious loss of bass if adequate rumble attenuation is to be achieved. A parallel-T notch filter was also considered, but rejected on the grounds of complexity and the tight matching of components required. The solution eventually settled upon was to use a Sallen & Key active filter which results in the addition of only two extra components. The filter can be added in one of two places: (a) at the input to the first stage, which has the advantage of affecting only the pickup cartridge input; or (b) between the output of the volume control and the input to the second stage, where it will also serve to attenuate $1/f$ noise, which comes almost entirely from the R.I.A.A. compensated first stage and is the major noise component in the amplifier. On balance the author prefers the latter position.

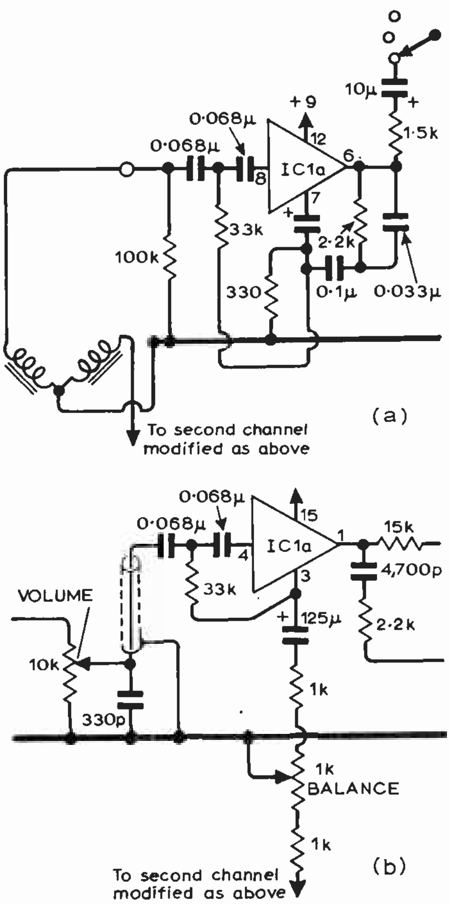


Fig. 1. Alternatives for incorporating the filter network: (a) in gram' input and (b) in second stage where it is effective on all inputs and reduces the 1/f noise of the first stage. The 0.068µF capacitors are 10% polyester and each should be matched with its corresponding number in the other channel. The 33kΩ resistor should be 5%, or better, 0.25W high stability carbon film or metal oxide.

Fig. 1 shows the way to connect the filter in these two positions, together with the extra components used. Fig. 2 shows the effect of this filter on the response curves of the pre-amplifier. The Sallen & Key filter has the great merit of having little effect on the circuit at frequencies appreciably above the cut-off, so that it is very easily incorporated into an existing design. At frequencies above the cut-off, the resistor between the centre point of the two capacitors and the feedback point of the amplifier is effectively 'bootstrapped' since, in accordance with normal feedback theory, the feedback point closely follows the input voltage waveform in level and phase. Only near and below the cut-off does the feedback point differ from the input in amplitude and phase, and it is this shift in the feedback point relative to the input at the cut-off that gives the filter its very sharp cut-off. The effective damping factor, or Q, of the circuit can be adjusted by changing the values of the time constants of the filter. The values chosen give the sharpest roll-off without appreciable lift prior to this roll-off. If for instance the 33kΩ resistor is reduced to say 27kΩ then there will be a slight lift at the cut-off point relative to the higher frequencies, while a value of say 39kΩ will result in a more gradual cut.

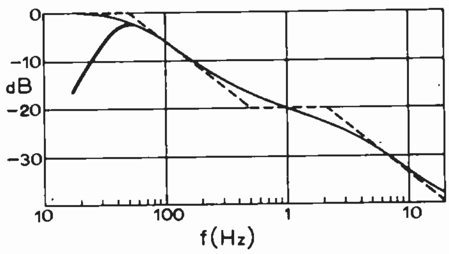
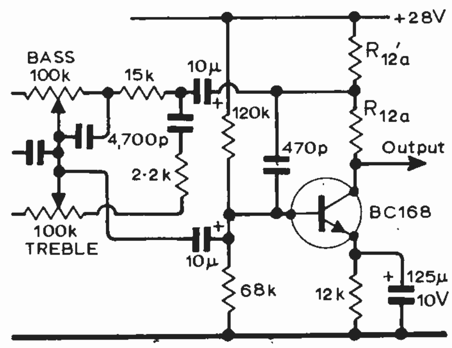


Fig. 2. Overall R.I.A.A. equalization with and without the rumble filter (either circuit).



Gain	R_{12a}	R'_{12a}
1	0	12k (As original circuit)
2	6·2k	6·2k
3	8·2k	3·9k

Fig. 3. Simple modifications for different output stage gain.

Note on gain modification to tone control stage

Some users requiring to drive valve amplifiers which need a larger swing have asked if the gain and output rating can be raised to make it possible to drive these amplifiers. The load resistor of the tone control stage may be modified very simply as shown in Fig. 3 to give up to about 2V r.m.s. and a gain of up to 3.

References

1. Nelson-Jones, L., 'Integrated Circuit Stereo Pre-amplifier', *Wireless World*, July 1970.
2. Nelson-Jones, L., 'Ultra-low Distortion Class-A Amplifier', *Wireless World*, March 1970.

Personalities

Alan Cormack, B.Sc., M.I.E.E., has been appointed general manager, Communications Division, of Redifon Ltd. He joined the company last November from Racal-B.C.C. Ltd, where he had been technical director since 1967. Before joining Racal he was technical director with B.C.C. Ltd, where he was responsible for all engineering and production activities. Mr. Cormack, who is 44, served in R.E.M.E. after graduating from Manchester University at the early age of 19. Commissioned as captain, he was put in charge of basic electronic training at the R.E.M.E. Training Centre. Upon leaving the Army, he joined G.E.C., and was chief engineer, Radio Communications Division, when he left to join B.C.C. in 1965.

T. D. Towers, M.B.E., M.I.E.E., M.I.E.R.E., who is well known to readers for his contributions on semiconductors and i.cs (part 9 of his current series will be in the next issue) was recently appointed marketing director of Newmarket Transistors Ltd. He joined the company in 1958 as a circuit applications engineer. He had previously served for 18 years in the Colonial Audit Service and it was not until joining Newmarket that he took up electronics professionally. An honours graduate of the universities of Glasgow (M.A.), Cambridge (B.A.) and London (B.Sc.) Mr. Towers has successively been chief development engineer and marketing manager of Newmarket.

R. P. Henegan, Assoc. I.E.R.E., has been appointed managing director of Gardners Transformers Ltd in succession to **C. J. Gardner** who becomes executive-chairman. Mr. Henegan, who is 45, joined the company as general manager in 1964 from Technograph and Telegraph Ltd, with whom he was a director and general manager. His career includes nearly 10 years with Gresham Transformers, where he was commercial manager. Mr Gardner started the business with his brother, Harold, as a small wireless shop in 1928. Four years later the manufacture of transformers and other wound components began. The appointment of **Dennis E. Wheatley,** M.I.E.E., as general sales manager is also announced by Gardners. Mr. Wheatley, 42, was sales manager with Cannon Electric (GB) Ltd, and before that marketing manager in the connectors and wiring divisions of the Plessey Company.

LTH Electronics Ltd, of Luton, have announced the appointment of **Ken Brown** as joint managing director, and **N. W. A. Le Gros** (previously managing director) becomes chairman and joint managing director. Prior to joining LTH, Mr. Brown was sales director of Pye-Ether Ltd, of Stevenage, manufacturers of control instruments, formerly known as Ether Controls. He was also on the board of other Ether Group companies.

The British Electrical and Allied Manufacturers Association has announced the appointment of **S. L. H. Clarke,** B.A., F.I.E.R.E., as chairman of the Industrial Control and Electronics Board. Mr. Clarke is a director of GEC-Elliott Automation Ltd., GEC-Elliott Process Automation Ltd., Marconi Elliott Computer Systems Ltd., and GEC-Elliott Computer Software Ltd. He is also chairman of the Instrumentation and Control Groups of the I.E.R.E. and vice-president of the Institute of Measurement and Control.

G. Ivor Thomas has been appointed director, design and development, of A.B. Electronic Components Ltd, of Abercynon, Glamorgan. Mr. Thomas, who is 48, has been with the company for 17 years as chief development engineer, and latterly as chief product engineer. The company also announced the appointment of **Alan Sutton** as sales director. An honours graduate of Bristol University in electrical engineering, Mr. Sutton was formerly product planning manager of Solartron Electronic Group Computer Division at Farnborough. He was also at one time project manager, missile systems, at B.A.C., Stevenage. The following members of the executive staff have also been appointed associate directors: **D. J. Evans,** finance director; **H. R. Heaven,** company secretary; **Lloyd C. Burton,** supplies director; and **R. J. Gent,** production director.

P. David Glasspole, the former sales manager, has been appointed sales director, and **R. J. (Dick) Virgoe,** previously chief development engineer, technical director of Transducers (CEL) Ltd, of Reading, Berks. Mr. Glasspole, aged 37, joined the company towards the end of 1968 as marketing manager, before which he was on the sales staff of Leeds and Northrup where he was concerned with all aspects of the manufacturing and marketing of their instruments. Prior to this he spent three years in R.E.M.E., having previously been for eight years with the British Aircraft Corporation. Mr. Virgoe, who is 33, joined Transducers (CEL) in 1963 as a development engineer. He was previously a project leader in the Transducer Division of Ether Langham Thompson, where he was responsible for developing bonded foil-strain-gauge and semiconductor load cells and pressure transducers, strain and piezo-electric accelerometers, variable-reluctance pressure transducers and related products.

Portescap (UK) Ltd, the newly-formed subsidiary of Portescap, Swiss manufacturers of d.c. micromotors, has announced the appointment of **G. Roger Swainston,** B.Sc., as managing director. Prior to joining Portescap, he was marketing director of IDM Electronics and before that was sales manager (control and instrumentation division) for Ultra Electronics. He graduated in physics from London University, was commissioned in R.E.M.E. and was an instructor in servomechanisms and control equipment at the Army School of Electronics.

Bob Wise has been promoted to sales manager of the Commercial Products Division of Ultra Electronics Ltd. Previously regional sales manager, he will now be responsible for the United Kingdom sales and service operations of the division's products, with particular emphasis on the Lion radiotelephone range. Previously with Multitone, Mr. Wise has been with UEL for nearly four years. **John Wood** has joined the company as product manager and will be responsible for product planning and overseas operations for the Lion range. For the past 18 years he has been with Pye Telecommunications Ltd, where he was manager, spares division. **Lance Horne,** southern area sales manager has been appointed field sales co-ordinator. Mr. Horne has been with UEL for three years, having previously been with Storno Ltd. **Jack Moseley** has joined UEL as service manager, Commercial Products Division, after 16 years with Pye Telecommunications Ltd, where he was a regional service manager. Mr. Moseley is now responsible for all home and overseas service of the Lion radiotelephone range.

M. A. Stuart, B.Sc., M.I.E.E., was recently appointed managing director of the Belclere Company. **F. B. Day,** the retiring managing director, continues as chairman of the Board. Mr. Stuart, who joined the company as director and general manager last November, was previously general manager of the Electro-component Division of English Numbering Machines Ltd, a division of the Rank Organisation.

L. E. Q. Walker, who has edited the *Marconi Review* for over 30 years, has retired from the Marconi Company. He joined the company after graduating at the Imperial College of Science & Technology in 1926. He was at one time the company's deputy chief engineer (works) but has been at the Great Baddow Research Laboratories since 1958 where, at the time of his retirement, he was special process consultant.

A. E. Bowyer-Lowe, who has been in the radio and electronics industry since 1922, has retired. After working as an apprentice in the family business making components and receivers, he joined Pye Radio in 1930 and was at one time manager of the group's Test Engineering Department. Latterly he has been senior electronics engineer in Ling Dynamic Systems, previously known as Pye-Ling Ltd.

OBITUARY

Brigadier Sir Lionel Harris, K.B.E., M.Sc., F.I.E.E., engineer-in-chief of the Post Office from 1954 to 1960, died on 18th March aged 73. He joined the Post Office research branch at Dollis Hill in 1922 having previously spent four years with signals in the Australian Imperial Forces. During the 1939-45 war he successively commanded G.H.Q. Signals; was Chief Signal Officer, Lines of Communication; and for two years chief of General Eisenhower's Telecommunications Section. From 1949 until his appointment in 1954 as engineer-in-chief he was controller of research.

World of Amateur Radio

The Swedish way

For several years amateurs have been convinced that some television chassis are significantly more prone to suffer interference from nearby radio transmitters than others. But few serious attempts to make objective assessments of receiver immunity characteristics over a full range of models have ever been reported. However the current issue of *Radio Communication* (May) describes how the Swedish amateur society S.S.A., in conjunction with the Swedish government institute S.I.F.U., recently tested 16 different colour TV receivers on sale in Sweden (no British models). These were operated on moderately weak TV signals using an aerial only 2 metres away from a 14 MHz dipole. The sets were tuned to C.C.I.R. channel 4 (not in direct harmonic relationship with the transmitter powering the dipole). The power of the transmitter could then be increased from zero to a maximum of 100 W output.

Three of the TV receivers (Blaupunkt, Radionette and Telefunken) showed no noticeable interference on sound or vision even when the transmitter was at maximum power. Yet several models showed interference effects when the transmitter output was only 0.5 W; still others were affected by 2, 2.5, 4.4, 8.3, 12.5 and 14.5 W. Generally, it required significantly more transmitter output to interfere with sound compared with vision (but one chassis was affected on sound by 8.3 W, yet coped with up to 72 W on vision). This cross-section of Continental chassis thus showed differences in immunity to high r.f. fields amounting to over 17 dB.

It would be extremely interesting if similar tests could be carried out on British TV chassis—many of us would be extremely surprised if these did not show a very wide spread of results. Yet it is extremely difficult to convince viewers that an amateur may cause TVI through no fault of his own but as a direct result of receiver design practices. The general adoption of bipolar transistors in TV front-ends has made the performance in the presence of local transmitters a very real problem.

Could not the R.S.G.B., B.R.E.M.A., Minpostel, B.B.C. and I.T.A. co-operate in carrying out similar tests—and publishing the results? In 1969, the B.B.C. Research Department published a report on a few sample v.h.f./f.m. radio receivers which emphasized the wide differences in performance near to unwanted local transmitters and have since demonstrated this to official organizations. But the public is left without guidance.

Upsurge in American activity?

After several 'stand still' years, A.R.R.L. has recently reported a marked upsurge of interest by newcomers in amateur radio: membership is up by 1600; there has been increased sales of 'beginner publications'; a record number of visitors to the League's headquarters; an increase of 50% in the number of 'advanced class' licences. About half the newcomers are aged 20 or younger.

Fifty-eight stations have now gained the 'five-band DXCC' award, with J. Bazley, G3HCT (No 35), and Dr E. J. Allaway, G3FKM (No 42), as British representatives—but Europe's strongest entry is seven West German amateurs.

Body-blow to 70 cm TV?

Only a decade ago, British amateurs, including the amateur TV enthusiasts, had the use of a full 40-MHz-wide band between 420 and 460 MHz. Today they are restricted to a split 22 MHz. Soon, as became explicit at the recent R.S.G.B. v.h.f. convention, Minpostel propose to reduce the allocation to 8 MHz (432 to 440 MHz). Thus, in a few years, the band will have become a mere one-fifth of its former size. This outcome to the constant pressure exerted in recent years by the business mobile radio interests is not unexpected—and few responsible amateurs would deny that two-way radio has strong claims to more frequencies. But it represents, unless some special provisions are made, a body blow at amateur TV transmission. If the band is rigorously enforced, it will in future become impossible to transmit 625-line d.s.b. signals. And even if v.s.b. can be achieved by amateurs, a single amateur TV signal would occupy virtually the entire band, rendering it unusable for organized communication based on zonal band planning.

Unfortunately, this is only the latest example of the unfavourable restrictions imposed on amateurs in Region 1 when compared with the other regions. Consider h.f., North Americans (Region 2) have 3.5-4 MHz (British only 3.5-3.8) and 7 to 7.3 MHz (British 7-7.1); or, on v.h.f., the substantial American allocations at 50 and 220 MHz, and their 144 MHz band twice the size of that in Region 1. Comparisons are odious—in this case they are also extremely depressing. Why are British and European amateurs so less deserving of frequencies than those in the States and Canada and South America?

It is much to be hoped that some provision can be made for amateur TV in the 430 MHz region. The numbers of TV amateurs may be small, but they should surely be encouraged.

In Brief

Will Badman, G2ZG, of Bath, one of Britain's oldest active amateurs, has died at the age of 91. In 1922 he put out several local broadcast programmes on 160 and 1000 metres—but even as a youth he had charged the batteries used by Marconi during his historic Bristol Channel experiments in 1897 . . . . 'Trans-equatorial tests' on 1.8 MHz are being organized this year by Rolf Rasp, daily during June from 00.00 to 00.30 g.m.t. European stations should transmit between 1825-1830 kHz and stations in the southern hemisphere will use 1.8-1.81 MHz. Europeans are allotted the first five and then alternate five-minute periods. Last year, during similar tests, a number of 'firsts' were made by European amateurs with Brazil—this year PY1MGF and PY2BJH have increased their power to 1 kW . . . . June R.S.G.B. events include National Field Day (June 5-6), a microwave contest (June 20) for bands from 1GHz up; 70 MHz portable contest (June 27) . . . . The Midland V.H.F. Assembly and Dinner is on June 19 at Oldbury and application forms for tickets are available from Graham Badger, G3OHC, 50 Essex Road, Four Oaks, Sutton Coldfield . . . . Pembroke 'Bucket and Spade' party at Saundersfoot on June 13 (J. Hogg, GW8DMD, 2 Pembroke Road, Pembroke Dock) . . . . Anglian Mobile Rally at the Suffolk Show Ground on June 27 (D. W. Thomas, G3ZLN, 9 Burlington Road, Ipswich) . . . . Longleat Park Mobile Rally on June 27, organized by Bristol R.S.G.B. Group (details G3PQE, G8AGT or G3ULD) . . . . 9H1BL in Malta has successfully received 50 MHz TV pictures from Rhodesia by means of transequatorial-mode propagation . . . . German and Austrian amateurs have been heard on 145.41 MHz in the U.K. while they were using a balloon-borne translator . . . . An Oscar Australis prototype translator carried in a balloon resulted in a 500-mile 144/420 MHz contact in Australia recently.

PAT HAWKER, G3VA

New Products

Oscilloscope amplifier

An oscilloscope *Y*-amplifier plug-in module, type EM505, is announced by S.E. Laboratories for the 102 series a.c./d.c. main frames. The module is a high-gain differential amplifier, plus an additional high-bandwidth channel, with input sensitivity extending from 50μV/cm to 20μV/cm; bandwidth in all positions is greater than 0.5MHz. The EM505 display-noise is less than 3μV/cm measured tangentially. Since noise is related to bandwidth, the display noise can be reduced with a 3dB point filter switch at 50kHz, 5kHz, 500Hz, or 50Hz. Drift has been reduced to 50μV/°C, but d.c. off-set can be applied. The range covered by this front panel control is $\pm$150mV c.m.r. at 1kHz, 94dB at 100kHz. The front panel provides an output to drive a u.v. galvanometer recorder. An additional *Y* amplifier channel provides a bandwidth d.c. to 150MHz at 10mV/cm, and 1mV at 6MHz. Price of the module is under £150. S.E. Laboratories (Engineering) Ltd, North Feltham Trading Estate, Feltham, Middx.
WW330 for further details

Wide bandwidth oscilloscope

New Philips oscilloscope type PM3370 has a plug-in amplifier with a sensitivity of 1mV/cm extending up to 150MHz. Previous instruments with bandwidths of this order had a sensitivity of 5 or

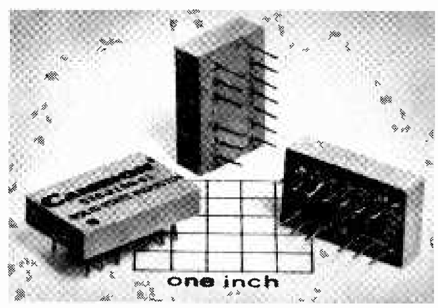
10mV/cm. Noise is kept to a low level by using two amplifiers in parallel for high and low frequencies, giving open-circuit noise of 200μV and short-circuit noise of 100μV. There are five vertical-channel plug-in units, two new–one is the PM3372, a dual-trace 150-MHz, 1mV/cm amplifier and the other is the PM3379, a 10MHz to 6.5GHz spectrum analyser. The other three are 50-MHz units originally made for model PM3330 oscilloscope. A 70-ns signal delay is incorporated in the Y-signal path to allow examination of leading edges of pulses. Timebase includes a 'display' switch associated with the main and delayed timebase, so that both the original trace and the intensified portion can be viewed at the same time. Sweep times cover the range 50ns/cm to 1s/cm and a $\times$10 magnifier extends time to 5ns/cm. The c.r.t., with distributed deflection plates, has a display area of 6 $\times$ 10cm. Pye Unicam Ltd, York Street, Cambridge.
WW303 for further details

Wattmeter

The Wattavi wattmeter, available from Hartmann and Braun (UK), has a sensitive iron-cored electrodynamic movement. It has three separate field coils arranged in adjacent compartments and constructed for rated currents of 1, 5 and 25A. There are five connecting terminals on the front of the case—two for the current path and three for the voltage path. Below the scale are three switches, by means of which three current and three voltage ranges (1, 5, 25A and 100, 200 and 500V) can be selected. The circuit used is that of a three-phase three-wire system, i.e. there is a single-phase movement with an artificial star point created by three star-connected resistances. A current selector permits measurements to be made with single phase a.c. on all the ranges. A wide variety of applications is possible. For instance current transformers with a secondary current of 1A or 5A can be inserted in the 1A and 5A ranges. Similarly the 100V range of the voltage path facilitates the use of voltage transformers, the secondary voltages of which are 100V or 110V. Two scales marked in 50 divisions are provided, one numbered 0-100 the other 0-250, from which the results can be calculated by use of a few simple constants, of which a table is included on the front of the instrument. Hartmann & Braun (UK) Ltd, 967 Harrow Road, Wembley, Middx.
WW319 for further details

Solid-state inductor

A solid-state inductor weighing less than 3g and housed in a 14-pin dual-in-line package, is available from Cambion Electronic Products. The inductance can be externally varied from 1H to greater than



100H. Usable below 100kHz, *Q* values in the order of 15 are obtainable at 1Hz and below. Cambion Electronic Products Ltd, Sales Department B-02, Cambion Works, Castleton, Nr. Sheffield S30 2WR.
WW325 for further details

Instrument for comparing micro circuits

A new version of the Vision Engineering Comparascope extends its application to the comparison of integrated-circuit photo-masks and thick- and thin-film circuits against a master sample. Pairs of objectives for magnification of 10, 25, 50 and 100 are fitted so that any two

WW250 for further details

magnifications can be used. Images from the specimen circuit and its master are combined through polarizers in the microscope head and then passed through a rotating analyser. When viewed through the binocular eyepiece the master and sample are repetitively superimposed with an approximately constant light intensity, and any points of discrepancy between the two show as a periodic change. A micrometer eyepiece allows measurements to be made down to 2.5um. Inspection tables are motorized with automatic centralizing. Price is about £5,000. Vision Engineering Ltd, Send Road, Woking, Surrey.
WW308 for further details

Switching transistors

High voltage n-p-n silicon planar switching transistors, types 2N3724, 2N3725, 2N4013, and 2N4014, are now available from Sprague Electric Co. (U.S.A.). Types 2N3724 and 2N4013 feature a 30-volt BV_{CEO}, a 50-volt BV_{CBO}, and a current gain of 30 at a collector current of 1 amp. BV_{CBO} and BV_{CEO} for 2N3725 and 2N4014 are 80V and 50V respectively, with a minimum current gain of 25 for a collector current of 1 amp. The devices have a gain-bandwidth product greater than 300MHz and turn-on and turn-off times of 35ns and 60ns respectively at a collector current of 0.5 amp. Types 2N3724 and 2N3725 are available in a TO-5 package and types 2N4013 and 2N1014 in a TO-18 case. Available in the U.K. from Sprague distributors—Quarndon Electronics Ltd, W.E.L. Components Ltd, and S.D.S. (Portsmouth) Ltd. Sprague Electric Co. North Adams, Mass. 01247, U.S.A.
WW328 for further details

V.H.F. transceivers

The v.h.f. airmobile band ground-to-air transceivers, models 25/SS and 25A/SS from Park Air Electronics may be powered from internal batteries, from an external a.c. supply or from an external

d.c. supply. An output power of 2.5W 85% modulated a.m. is sufficient for ranges of up to 45 miles to aircraft at 2000ft or above, using the built-in telescopic aerial. Up to 24 channels are available on the 25A/SS (four on the 25/SS, which may lie anywhere in the band 118/126MHz). A full range of accessories is available as optional extras. The complete equipment including batteries and internal charger and a.c. supply weighs only 4.6g and measures 36 × 12 × 19cm. Prices: £295 for 25/SS and £320 for 25A/SS (U.K.). Park Air Electronics, Red Lion Square, Stamford, Lincs.
WW320 for further details

200pF to 33nF variable capacitor

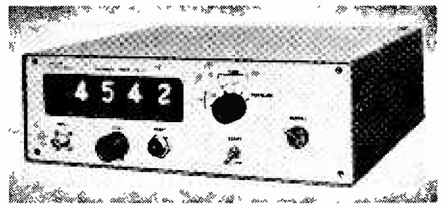
A variable capacitor with a 1:165 range of capacitance has been developed recently by J. Briechle in Germany. It is made with a minimum capacitance of 200pF and maximum value is 33nF. This wide range is achieved by winding metal foil onto a reel fed by two adjacent reels.

self-time constant	600s at 20nF
tan δ	9.5×10^{-3} at 800Hz
insulation	$3 \times 10^{10}\Omega$ at 20nF
temp. coefficient	10^{-3}/deg C

The main application is in the construction of variable-frequency *RC* filters. J. Briechle, 7731 Kappel über Villingen, Schwarzwald, Federal Republic of Germany.
WW307 for further details

Counter timer

A four-decade counter timer, type 72C-1, from Orbit Controls provides facilities for frequency measurement, interval timing, and counting. The timebase is derived from the 50Hz mains supply and its accuracy is therefore dependent on the supply frequency, which is normally within ±0.1%. Two ranges of frequency measurement are provided, having gate times of 0.1s and 1s respectively. The measurement capacity therefore is 100kHz. The display time is arranged to be 1s on both frequency ranges. Three timing ranges are provided, with timing increments of 0.01, 0.1 and 1s respectively. Start and stop is by means of a front panel switch,



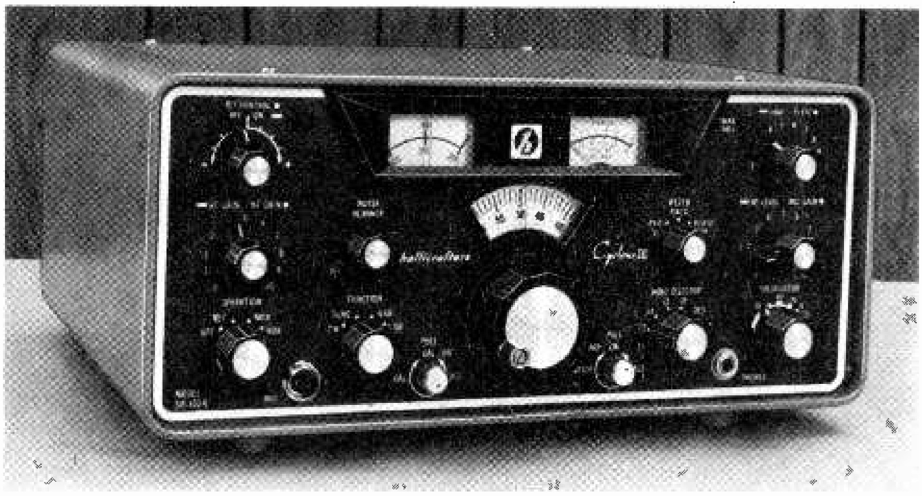
or by the opening and closing of remote contacts, for which terminals are provided on the rear panel. Facilities for 2-line operation are also provided on the rear panel. The instrument provides a single counting range to 9999. The same start/stop switch or parallel rear panel contacts are used as in the single-line timing mode. On both single-line timing and counting, successive counts can either accumulate on the display, or restart from zero. A reset button on the front panel, again paralleled with contacts on the rear panel for remote operation, is provided to enable each successive count to restart from zero. On two-line timing, successive counts always start from zero. While the instrument has a maximum frequency indication of 100kHz, its counting capability is in excess of 1MHz, offering pulse discrimination better than 1μs. Input is via a b.n.c. connector on the front panel, or a parallel pair of terminals on the rear panel. Input sensitivity is 100mV and a continuously variable input attenuator is provided. Also appearing on rear panel terminals is a +5V d.c. supply for energizing external transducers. Price £95 in U.K. Orbit Controls Ltd, Alstone Lane Industrial Estate, Cheltenham, Glos. GL51 8JQ.
WW327 for further details

Fast thyristor

The D1162 thyristor from Westinghouse Brake English Electric Semiconductors is a 55A I_T r.m.s. (35A I_T av.) device capable of turning off in 8 to 10μs at 100°C. Shorter turn-off time can be achieved if the current is reduced. The D1162 TB1 (100V) costs £9.41 and the TB6 (600V) costs £29.41. Intermediate voltage versions are available. Westinghouse Brake English Electric Semiconductors Ltd, Avon House, Upper Cocklebury, Chippenham, Wilts.
WW329 for further details

Transmitter-receiver for amateurs

An improved version of the SR-400 Cyclone 2 transmitter-receiver has been introduced by Hallicrafters Co., of Illinois. Designated SR-400A and called Cyclone 3 it has increased power for single-sideband operation–550 watts peak envelope. Features of the new set include a built-in crystal calibrator, *calibrated* fine receiver tuning, circuit obviating need for matched power amplifier valve, six-pole crystal i.f. filter, and audio notch filter. Optional extras include an air blower for the output valves, and an 11 to 16-volt power supply



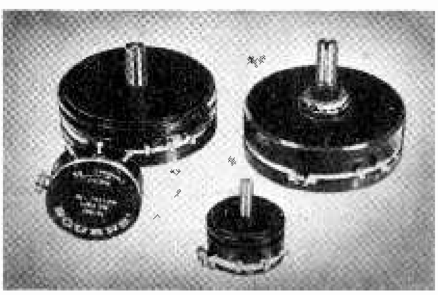
for mobile and field operation. Price is \$995 in the U.S. Hallicrafters Co, 600 Hicks Road, Rolling Meadows, Illinois 60008.
WW302 for further details

Precision potentiometers

The Bourns 'B-line' range of single-turn wirewound precision potentiometers for servo or bush mounting is available in $\frac{7}{8}$in, $1\frac{1}{16}$in or 2in diameters. The thin profile (0.6in housing length) is claimed to fit wherever another potentiometer has been used and facilitates smaller packaging sizes and modifications.

Standard specification:

resistance tolerance	±3%
linearity for $\frac{7}{8}$in and $1\frac{1}{16}$in	±0.5%
linearity for 2in	±0.3%
track angle	350° ±2°
absolute minimum setting	1Ω or 0.1% total resistance
power rating at 70°C	$\frac{7}{8}$in, 1.0W
	$1\frac{1}{16}$in, 1.5W
	2in, 4.0W
insulation resistance	1,000MΩ
temperature range	−65 to +150°C
maximum no. of gangs	10



Additional gangs are easily fitted; these add only 0.2in to the housing length. Bourns (Trimpot) Ltd, Hodford House, 17-27 High Street, Hounslow, Middx.
WW324 for further details

F.M. tuner

An f.m. tuner for sound distribution systems is made by Millbank Electronics. Tuning is by one pre-set multi-turn potentiometer. For other applications a push-button station selector is available. The normal tuning range is 80-110MHz with absolute limits of 65 and 130MHz. Dual-gate f.e.ts are used at v.h.f., together with i.c. voltage regulators, two i.cs in the 10.7-MHz i.f. amplifier and a ceramic filter unit, and a 'quadrature' demodulator—a line-up quickly becoming standard. In addition, a two-stage audio amplifier gives low output impedance at up to 3.5V for ±75kHz deviation. Sensitivity is 5μV for 30dB signal-to-noise ratio. T.H.D. is 0.2% at 1kHz and 2 V output. Millbank Electronics, The Square, Forest Row, Sussex.
WW312 for further details

High-power audio amplifier

Crown (U.S.A.) amplifier type D150 with a continuous output of 140 watts per channel into four ohms is sold by Carston Electronics Ltd in the U.K. The amplifier gives 90W r.m.s. into an 8Ω load.

noise	100dB below 75 watts
damping factor	200
intermodulation	0.1%, 10mW to max. power
power response	5Hz-20kHz, 75 watts ±1dB
price	£200

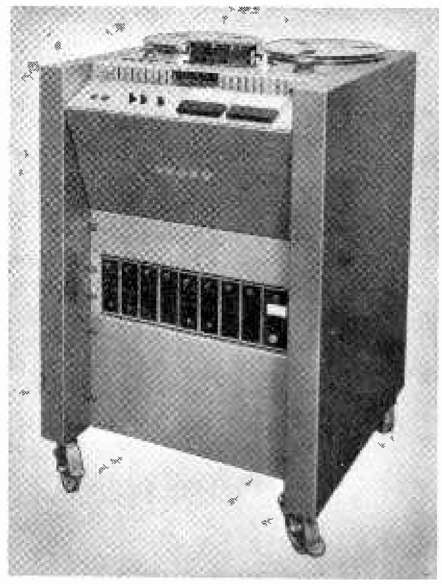
Carston Electronics Ltd, 71 Oakley Road, Chinnor, Oxfordshire.
WW306 for further details

I.Cs for f.m. stereo receivers

Standard stereo processing circuits, including a 19kHz amplifier, frequency doubler, stereo indicator lamp, and stereo demodulator, are contained in each of four new integrated circuits for f.m. stereo receivers now in production at the Semiconductor Division of the Sprague Electric Co. The four new devices are types ULN-2120A, ULN-2121A, ULN-2122A, and ULN-2128A. In addition, type ULN-2121A is provided with an emitter follower output. Both the ULN-2120A and ULN-2122A have provision for audio muting and stereo/mono switching. The type ULN-2122A also provides for adjustable stereo channel separation. The ULN-2120A, ULN-2122A, and ULN-2128A may be used as direct electrical pin-for-pin replacements for Motorola types MC1304, MC1305, and MC1307, respectively. All four circuits are housed in 14-lead dual-in-line moulded plastic packages and are specified to operate over the ambient temperature range of −30 to +85°C. Stockists are Quarndon Electronics, WEL Components, and SDS (Portsmouth). Sprague Electric Company, North Adams, Mass. 01247, U.S.A.
WW318 for further details

Professional tape recorder

Leevers-Rich Equipment have replaced their E5 machine with a new $\frac{1}{4}$-inch console recorder, model E200. The machine is available in full-track, twin-track and half-track versions. All the principal sub-assemblies are readily interchangeable, even down to spool pot assemblies and deck-control switch banks. The standard model offers speeds of 38 and 19cm/sec (15 and $7\frac{1}{2}$ i.p.s.). Other speed ranges are readily obtained by interchanging plug-in



units. The equipment is housed in a console which occupies only four square feet of floor area. Tape speed and direction are continuously variable, and there is provision for 'inching' whilst maintaining tape contact with the replay head. Leevers-Rich Equipment Ltd, 319 Trinity Road, Wandsworth, London S.W.18.
WW313 for further details

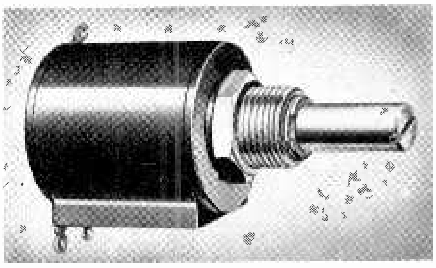
Silicone adhesive sealant

'Silcoset' 153 silicone adhesive from I.C.I. cures in air, with little shrinkage, to give a silicone rubber that is flexible from −60°C to +225°C. It has good electrical insulation properties, resists corona and ozone and bonds to unprimed surfaces. It resists ageing and weathering, as well as oxidation, and stands up to many oils,

chemicals and solvents. Easily applied, it gives protection against dust, moisture, vibration and shock. 'Silcoset' 153 is supplied in a 75cc tube; ⅓-litre cartridge; 5-litre drum and 20-litre drum. I.C.I. Nobel Division, Nobel House, Stevenston, Ayrshire.
WW315 for further details

Helical potentiometer

A high resolution wirewound helical potentiometer, HEL.09, is available from Reliance Controls in 3, 5 or 10 turn versions. Resistance ranges are 10 turn—25Ω to 150kΩ; 5 turn—25Ω to 100kΩ; 3 turn—25Ω to 50kΩ. Higher values are available. Body diameter is 22.4mm and length 24mm. It is available in sealed or unsealed versions. Performance data:



linearity	±0.1% or ±0.2%
power rating	2W at 70°C (0 at 125°C)
temperature range	−55°C to +125°C
noise	100Ω e.n.r. Max.
spindle diameter	6mm or ¼in

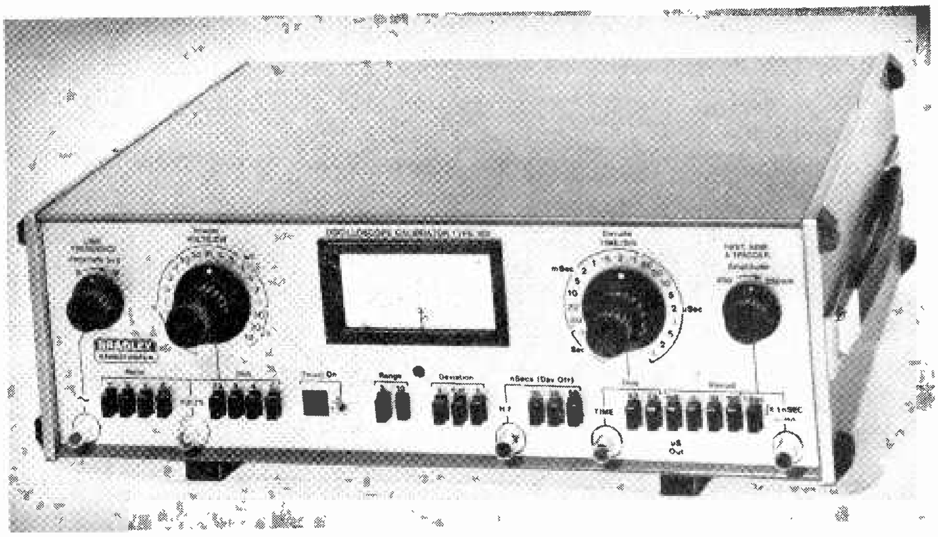
Spindle lengths from 16 to 35mm are available. Mounting is metric bush or imperial bush. The case is diallyl pthalate and the former enamel-coated copper. The nominal weight is 28g (1oz). Sales Department, Reliance Controls Ltd, Drakes Way, Swindon, Wilts.
WW316 for further details

High-output op-amp

The Ancom 15A-11 op-amp is unusual in providing an output of ±100mA at ±10V. Overdrive recovery time is 2μs. Input current offset is ±10mA and input voltage offset 8μV/°C. The common-mode rejection ratio is 10,000. The amplifier measures 32 × 32 × 16mm. Price £10 (1-9), £8.50 (10-24). Ancom Ltd, Devonshire Street, Cheltenham GL50 3LT.
WW326 for further details

Oscilloscope calibrator

An up-dated version of model 156 oscilloscope calibrator is announced by G. & E. Bradley. The new calibrator–type 192–provides a 1-ms edge at variable repetition frequencies (1s to 1μs) for testing *Y*-amplifier response. For *Y*-amplifier calibration, a 1-MHz square-wave train, together with direct voltage levels accurate to ±0.25%, cover the range 30μV to 200V. A time mark generator giving one pulse every five



seconds to every 10ms allowing timebase calibration. G. & E. Bradley Ltd, Electral House, Neasden Lane, London N.W.10.
WW305 for further details

Audio transistors

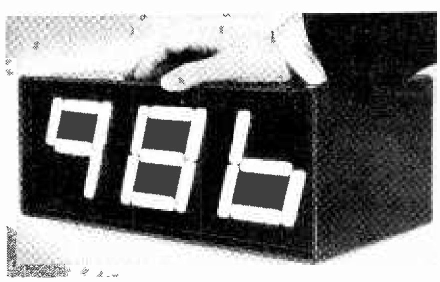
Four new audio transistors are announced by Mullard. Designed for 'driver' stages in amplifiers, they are plastic types with TO-92 cases. Types BC327 and BC328 are p-n-p devices and BC337 and BC338 are n-p-n. They have a dissipation of 500mW at 25°C ambient with an h_{FE} range of 100 to 600. Maximum V_{CEO} is 45V for BC327 and BC337 and 25V for BC328 and BC338. I_{CM} is 800mA. Mullard Ltd, Torrington Place, London W.C.1.
WW311 for further details

Ten-watt p.a. amplifier

A low-cost 10W amplifier made by Trusound for public address, gives a regulated 100-volt output from two low-impedance microphone inputs (100μV) and a high-impedance input (500mV). Amplitude response is 100Hz to 12kHz ±3dB. Price £32. Trusound Manufacturing Ltd, Crittall Road, Witham, Essex.
WW310 for further details

Large digital display

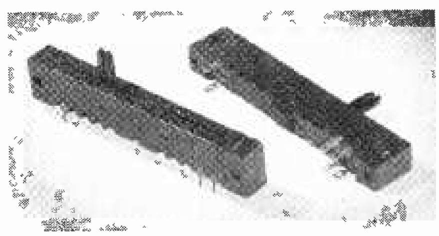
A recent addition to the range of apparatus by Unilab Science Teaching Equipment, for use in schools and colleges, is a t.t.l.-compatible digital readout unit with 4in-high characters. The readout can be used



up to 10MHz. Two or more digital readouts may be linked together. Input modules available include a 1, 10 and 100kHz clock oscillator, single and dual gates and output for a frequency meter. There is also a ×10, ×100 and ×1,000 multiplier. Unilab Science Teaching Equipment, Clarendon Road, Blackburn, Lancs.
WW322 for further details

Slider potentiometers

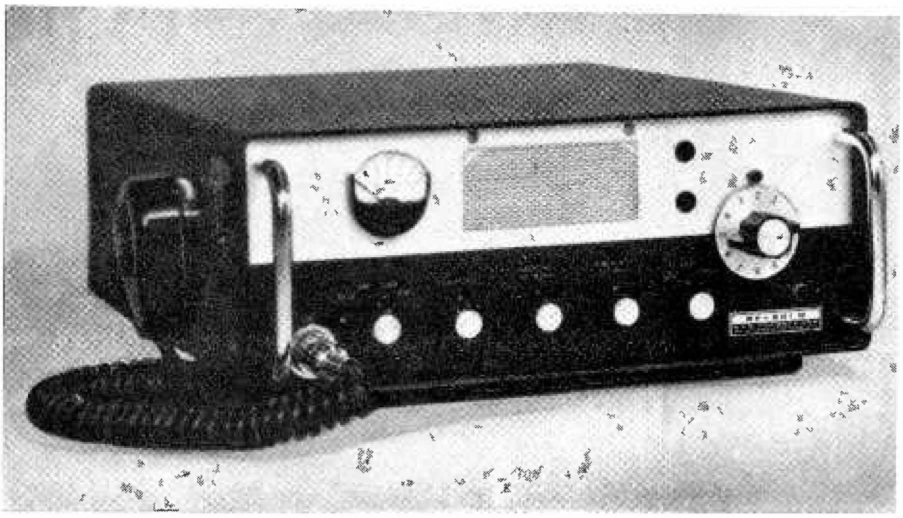
A range of carbon-track slider potentiometers is available from A.B. Electronic Components. The resistance range for linear tracks is 100Ω to 10MΩ and for log tracks 1kΩ to 10MΩ. The power rating at 40°C ambient temperature is



0.4W for linear controls and 0.2W for log. The body material is glass-filled nylon. Slider travel is 58mm. For quantities 1-9 single units cost £1.60 and dual units £2.40 each, and for quantities of 100-249 the cost falls to 40p and 60p respectively. The minimum invoice charge is £3. A.B. Electronic Components Ltd, Abercynon, Glam.
WW317 for further details

Marine s.s.b. radiotelephone

Covering 2 to 24MHz, a single-sideband radiotelephone made by RF Communications Inc., of Rochester, N.Y., has six variants for on-board and coastal station use. The models, type RF-201M, differ in the number of channels (between 6 and 60) and in the simplex/duplex facility. Modes available are upper sideband suppressed carrier, upper sideband reduced carrier and double sideband. Rated power output is 150 watts (peak envelope) but this can be increased to 1kW with an optional linear amplifier. In common with



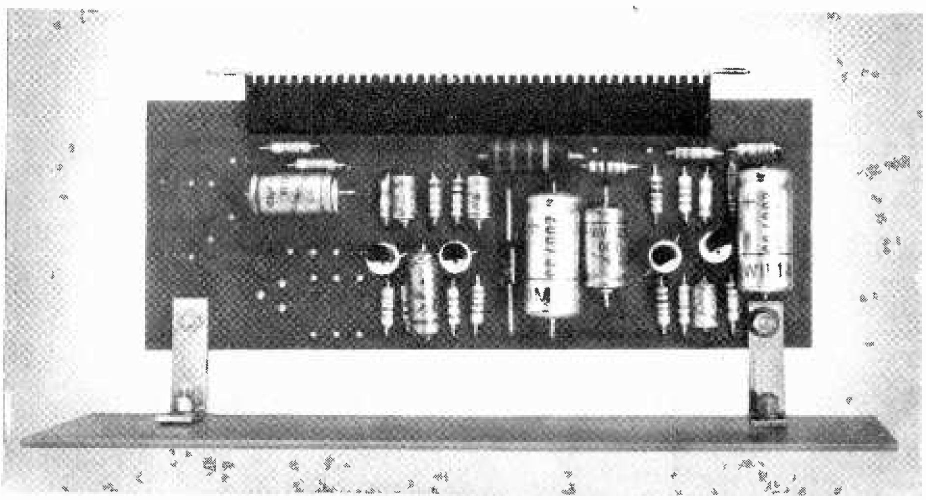
other radiotelephones of this type transistors are used in all but the power amplifier circuits. Receiver sensitivity is 0.5μV for 10dB signal-to-noise ratio. Available for 12, 24 or 32-volt direct supplies, or 115 and 230-volt alternating supplies, from RF Communications Inc, 1680 University Avenue, Rochester, N.Y. 14610.
WW301 for further details

Low-power heatsinks

A range of lightweight clip-on coolers, designated the NF200 series, is available from Jermyn for TO-5, TO-8 and TO-18 size transistors and i.cs. Each size is available with a choice of fin height and overall diameter and the unique fin design assures excellent natural air convection in both horizontal and vertical positions. Prices start at £0.13 (1-99 off) for the smallest (TO-18) size. Jermyn Industries, Manufacturing Division, Vestry Estate, Sevenoaks, Kent.
WW331 for further details

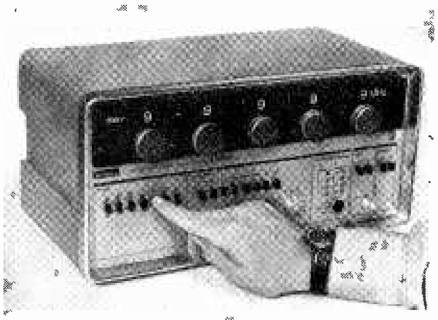
P.A. acoustic 'equalizer'

A filter module designed to avoid howl or acoustic feedback in p.a. systems is made by Astronic Ltd. The module is available with up to eight plug-in *LC* filters for frequencies between 160Hz and 5kHz and with a control range of $\pm$12dB. The filters can be used for either cut or lift in response depending on which way each filter 'card' is plugged in. The module is also useful in music reproduction systems where acoustic properties of the environment alter tonal balance. Astronic Ltd, Dalston Gardens, Stanmore, Middx HA7 1BL.
WW309 for further details



Signal generator synthesizer

An accurate wide-range oscillator, made by Green ECE Ltd, allows frequency selection by five decade switches giving a resolution between 1 in 10^4 and 1 in 10^5. Frequency

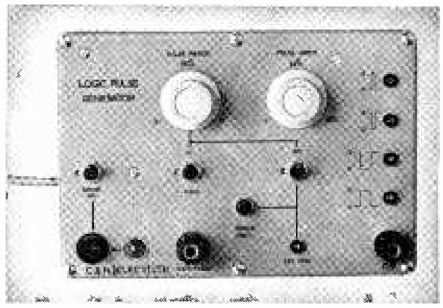


of the output extends from 1Hz to 10MHZ with an harmonic distortion of less than 1% for the range 10Hz to 100kHz. Square-wave output is available with a rise time of less than 20ns. Outputs are also available at the fixed frequencies of 10, 50, 100, and 500Hz and 1, 5 and 10kHz. Lock-on time is three seconds. Green ECE Ltd, 5 Thorold Road, London N22 4YE; marketed by Echometrix Ltd, 113 The Broadway, Leigh-on-Sea, Essex.
WW332 for further details

Logic pulse generator

A small mains-operated logic pulse generator has been produced by C. & N. (Electrical). It is designed for testing and checking integrated circuit systems and its outputs—fully compatible with d.t.l./t.t.l. levels—include simultaneous positive and negative pulses and delayed pulses. Performance characteristics are:

pulse repetition frequency	1Hz to 10kHz
pulse duration	1μs to 500μs
delayed pulse duration	150ns
rise/fall time	20ns
output	typically 4V into 200Ω



The unit comes in a die-cast alloy case and costs £30. C. & N. (Electrical) Ltd, The Green, Mumby Road, Gosport, Hants.
WW321 for further details

High-power static switch

The Transipack high-power static switch from Industrial Instruments is claimed to be capable of switching the output of a static inverter over to the mains supply without any interruption of power flow —the waveform of the inverter being locked to that of the mains. Thus the failure of the inverter supplying smooth a.c. to a computer system need not cause immediate shut down. Industrial Instruments Ltd, Stanley Road, Bromley BR2 9JF, Kent.
WW314 for further details

Flash tube

A spiral zenon-filled flash tube, type XL630, from E.E.V. is intended for use in stroboscopic applications. It is capable of producing up to 300 flashes per second. Four or five of these tubes running at a mean level of 40W each, will provide the equivalent to several kilowatts of tungsten lighting. Anode voltage is 1400V max. and 800V min. Required trigger energy 4mW. Ignition voltage (minimum) 6kV. Overall height is 110mm. English Electric Valve Co. Ltd, Chelmsford, Essex.
WW323 for further details

Wireless World, June 1971

Literature ...eceived

For further ir ... item include the appropriate ... WW numb ... ly card

... listened to and ... e physicists ... on and the ... xplanation ... n (in a ... these ... 'enter ... n or ... the ... h

... outlines the ... making inte... show a typical ... anufacture. The ... ard Educational ... n WC1E 7HD .... price 25p

...ullard semiconductors ...td, 37/39 Loverock Road, ... has been produced ... WW401

...oup, 126 Hamilton Road, London ... ecently appointed distributors for the ...ork company Sensitron Semiconductors, have ... data sheets on Sensitron power transistors WW402

We have received the following literature from LST Electronic Components Ltd, 7 Coptfold Rd, Brentwood, Essex.

Retail semiconductor catalogue ...... postage 5p

RCA, HM91 Hobby circuits manual; includes equivalents chart for the transistors mentioned which are not available in the U.K. price £1.55

A publication from AEG-Telefunken, D71 Heilbronn, Postfach 1042, West Germany, lists new semiconductor devices manufactured by them WW403

Amendment sheet No. 10 is available for the technical handbook 'Semiconductors' published by Ferranti Ltd, Gem Mill, Chadderton, Oldham, Lancs. WW404

The following literature is available from AEI Semiconductors Ltd, Carholme Rd, Lincoln:

BS9000 scheme for semiconductors: explanation WW405

'Thyristors and their applications' ..... price 25p

'Voltage regulator diodes' .... price 25p

'Power semiconductors—quick reference data' WW406

Semiconductor price list WW407

The National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051, U.S.A., have sent us the following literature:

'Tri-state logic' (TTL-5); characteristics and uses WW408

Data sheet, LM114/115 transistor pairs. WW409

A retail semiconductor price list (No. 36) is available from Henry's Radio Ltd, Edgware Road, London, W.2.

A data sheet gives details of the type UHP-004 quad high-current core driver from the Sprague Electric Company. The sheet may be obtained from W.E.L. Components Ltd, 5 Loverock Rd, Reading, Berks. WW410

Wall chart giving details of the new 10,000 range of emitter coupled logic from Motorola Semiconductors Ltd, York House, Empire Way, Middlesex . WW411

Brochure describing the logic design services and logic card products of Jasmin Electronics Ltd, Station Rd, Quorn, Leics LE12 8BP WW412

We have received a microwave semiconductor catalogue (SF-4006) from Microwave Associates Ltd., Craddock Rd, Luton, Beds. WW413

Also available from the same company is a list of the semiconductor literature produced by them WW414

PASSIVE COMPONENTS

Publication TD: 2-70 gives details of a range of encapsulated *LC* filters. Cambridge Thermionic Corp., 445 Concord Ave, Cambridge, Massachusetts 02138, U.S.A. WW415

The NC range of glass-tin-oxide resistors is the subject of a data sheet from Electrosil Ltd, Pallion, Sunderland, Co. Durham WW416

A short-form catalogue from A.B. Electronic Components Ltd, Sutherland House, 5/6 Argyll Street, London W1V 1AD, lists thick film microcircuits, cermet controls, connectors, switches, potentiometers, tuners, c.c.tv. equipment, amongst other things WW417

Manual GT23 from Gardners Transformers Ltd, Christchurch, Hampshire BH23 3PN, describes a range of inductors and gives full data WW418

We have received a copy of a 'stock catalogue' giving details of the capacitors, potentiometers and resistors available through the distributor division of Erie Electronics Ltd, South Denes, Gt. Yarmouth, Norfolk WW419

Miniature, metal sensing, switches (25 x 10mm) are described in a leaflet from Digitation Ltd, 117 Church Lane, Rickmansworth, Herts. WW421

Catalogue 102 from Cambion Electric Products Ltd, Cambion Works, Castleton, Nr. Sheffield, Yorks S30 2WR, deals with solder terminals, r.f. chokes and connectors WW422

Integrated circuits, connectors and thermistors are described, with data and prices, in the April 1971 edition of *Sasco Electronic News*. SASCO Ltd, P.O. Box 2000, Crawley, Sussex WW423

Also available from SASCO is a leaflet giving data on precision thermistors manufactured by the Yellow Springs Instrument Company of the U.S.A. WW424

The DTV Group 126 Hamilton Rd, West Norwood, London S.E.27, have published a catalogue giving details of the range of products manufactured by Omron Precision Controls of Edgware. Included are timers, switches, variable transformers and the like WW425

APPLICATION NOTES

Application report No. 10 from Brookdeal Electronics Ltd, Market St, Bracknell, Berks, describes the use of the boxcar detector in acoustic paramagnetic resonance measurements WW426

We have received three application notes from SGS (U.K.) Ltd, Planar House, Walton St, Aylesbury, Bucks, which show how some of their complex consumer equipment microcircuits can be employed:

No. 101. TAA661, i.f./f.m. amplifier and detector WW427

No. 105. TAA621, audio frequency amplifier WW428

No. 106. TBA261, i.f./f.m. limiter-amplifier, f.m. detector, d.c. volume control WW429

Technical Bulletin 116, 'Aquisition of shaft-angle data' discusses the three main approaches, digital shaft encoders, resolvers and synchros, and precision potentiometers. North Atlantic Industries Inc., Terminal Drive, Plainview, New York 11803, U.S.A. WW430

Application notes from Hewlett Packard (224 Bath Rd, Slough, Bucks) show how their equipment can be used for solving particular problems. The two latest examples we have received are:

125. 'Data acquisition' WW431

120. 'A new technique for pulsed r.f. measurements' WW432

EQUIPMENT

Hewlett Packard Ltd (224 Bath Rd, Slough, Bucks) instruments and accessories price list WW451

Also available from the same address, data on the HP9500 series of automatic test systems ... WW452

A logic probe (LP500/1), manufactured by EMI, is the subject of a leaflet from SASCO Ltd, P.O. Box 2000, Crawley, Sussex WW446

Designed for use in small boats a 25W radio telephone is described in a leaflet from RF Communications Inc., Marine Marketing Dept, 1680 University Ave, Rochester, New York 14610, U.S.A. . WW449

A simulated three-dimensional c.r.t. display using isometric presentation is achieved on the automatic display generator from Federal Scientific Corp., 615 West 131st Street, New York 10027, U.S.A. The equipment is intended for use with the company's spectrum analyzer WW450

Tempatron Ltd, 65 Milford Rd, Reading, Berks RG1 8LZ, have available literature on a range of electronic timers WW458

Dynamic Technology Ltd, Station House, Harrow Rd, Wembley, Middlesex, have sent us the following literature:

'Equalizing video distribution amplifier 1-6'. One input, six equalized outputs, gain 0dB . WW459

'Equalizing video amplifier 1-1'. As above with one output WW460

'Colour error corrector' WW461

GENERAL INFORMATION

The Electrical Research Association (Cleeve Rd, Leatherhead, Surrey) have set-up a vacuum technology consultation service which is described in a brochure WW462

Magyar Kereskedelmi Kamara, Hungarian Chamber of Commerce, Budapest 62, P.O.B. 106, have available a directory of Hungarian trade companies WW463

The following British Standards publications are available from BSI Sales Branch, 101 Pentonville Rd, London N1 9ND:

BS4665: Part 1: 1971. 'Specification for enamelled copper conductors temperature index 180 (modified polyester base)' .... price £1

BS4663: Part 1: 1971. 'Specification for enamelled copper conductors temperature index 220 (aromatic polymide base)' .... price £1.60

The following publications are in the BS9000 series and contain generic data and methods of test for parts of assessed quality:

BS9010: 1971. Transmitter tubes .... price £1

BS9030: 1971. Magnetrons .... price £1.80

BS9050: 1971. Cathode-ray tubes ...... price £2

BS9070: Section 4: 1971. Fixed capacitors polystyrene dielectric .... price 60p

BS9070: Section 5: 1971. Fixed capacitors ceramic dielectric .... price 60p

BS9070: Section 6: 1971. Fixed capacitors polycarbonate dielectric and polythene terephthalate dielectric for d.c. use .... price 60p

BS9070: Section 7: 1971. Fixed capacitors mica dielectric .... price 60p

BS9070: Section 8: 1971. Fixed capacitors aluminium electrolytic .... price 60p

The following publications in the BS9000 series are rules for the preparation of specifications for semiconductor devices of assessed quality:

BS9321: 1971. Microwave mixer diodes, pulse operation .... price 60p

BS9322: 1971. Microwave detector diodes .... price 60p

BS9365: 1971. Transistors (general) ... price 60p

International Aeradio Ltd, Aeradio House, Hayes Rd, Southall, Middlesex, have produced a 32-page glossy brochure which describes their activities round the world WW464

The Mullard Educational Service, Mullard House, Torrington Place, London WC1E 7HD, have published a list of the literature available from them which can be obtained by applying to the above address. Mullard also have available a 16mm film, which can be borrowed free of charge, called 'The Electrons Tale'. It tells, in a light-hearted way, using cartoons, how the electron has revolutionized life.

Real & Imaginary

by "Vector"

Electronic Communication with the Dead?

I don't often deal with technical matters on this page. The way I figure it is that you, having digested the *hors d'oeuvre* of editorial thunderings and survived the main dish of electronics theory and practice, would have to be a masochist to demand another helping of the mixture as before.

However, every rule has its exception. Free Grid's comments on metamorphosed ψ waves (see page 212, April issue) reminded me of a curious incident which happened to me some years ago and for which I have never been able to find a rational explanation. When I was about fourteen years old I discovered, lying in a loft, an ancient radio of the type which I believe was known in the 1920s as a 'det-2 l.f.' This used a leaky-grid detector (a triode) with reaction applied by the old swinging-coil principle, the coils being of the plug-in type. I refurbished this museum piece and, being curious as to its DX capabilities, it became my practice during school holidays to set the alarm for 2 a.m. and to search, using headphones, for American stations.

But now we come to the curious bit. On two or three occasions over several weeks, at times when I had removed the aerial plug-in coil to change wavelength (which meant that the aerial was virtually open-circuited) a raucous voice burst the silence with a few words; it was clearly speech but so distorted as to be unidentifiable as to content. Only a few words occurred at a time, although I remember waiting for about an hour hoping to hear more, but without success. Most of the European stations had long since closed down and I was remote from any high-power commercial transmitters, neither were any amateurs operating in the area.

I'd all but forgotten about it until reminded by Free Grid's hypothesis. Then, in the curious way things happen, I came across a newly-published book called 'Breakthrough'* which I strongly commend to your attention. The author claims that an ordinary common-or-garden tape recorder, if switched on and left to its own devices can, on playback, be found to reproduce voices originating from the dead.

Now there are few words which are more emotive than 'spiritualism', with vehement pro- and anti-camps arising at the mere mention of it. So if you are anti- and feel the hackles rising and find yourself muttering 'More mumbo-jumbo about vibrations and ectoplasm!', just hold your horses and bear with me for a few minutes more.

Personally, at the moment, I stand uncommitted. I only know what I have read. The author, Dr. Raudive, is not an electronics man, but he has apparently recorded some 72,000 of these voices and a selection of these has been put on to a gramophone record which is on general sale. What is even more important from our standpoint is that he has called in a host of independent opinions, including those from highly qualified physicists and electronics engineers, all of whom verify the claim that voices do appear on the tape, although not all are convinced that they originate from the dead. No one can offer any theory which reconciles known natural laws with the phenomena. The electronics engineers have experienced this mysterious voice production using their own equipment and have weighed in with various circuits of their own devising (this book gives diagrams) which offer improvements on the original Raudive apparatus. Incidentally, it is suggested that videotape might provide a medium for further development work.

There are, the book says, four main approaches to the recording process which have been investigated. They are:

(a) *The microphone method.* For this, the microphone is connected to the tape recorder in the conventional way. The tape is run in the presence of witnesses, who may talk, providing that gaps are left for the 'x-voices'.

(b) *The diode method.* A simple circuit is given. This consists of an 'aerial' wire 6-7 cm long, connected to one recorder input terminal via an inductance of about 0.5 mH. One side of a solid-state diode connects to the 'aerial'/inductance junction; its other side goes to the second input terminal; the input terminals are shunted with a 100kΩ resistor. The diode ci...

(c) ... radio ... screened. the rec... The ge... radio method. Here a standard spot bet... to the tape recorder, weak unm...

(d) *The* ... a few cm of wire. For this a ... conjunction ... select a blank receiver) for the ... preferably, a

As for the e... described as "v... themselves, call our... that make sense (or so... these voices do not or... and the names they give we know to have left this e... are on a tape which can be heard by everybody. Th... cannot explain the phenomen... psychologists cannot offer an e... either. Scientific tests have show... Faraday cage, for example) tha... voices originate outside the experi... and are not subject to auto-suggestio... telepathy. Philologists have examined phenomenon and testified that, althoug... audible and understandable, *the voices are not formed by acoustic means; they are twice the speed of human speech and of a peculiar rhythm which is identical in the 72,000 examples so far examined.*" (My italics.)

It seems also that the sentences are telegraphese in character and, when the experimenter is multilingual the language may be polyglot—one word perhaps in Swedish, the next in German, the next in English, and so on. Like the messages purporting to emanate from conventional psychic sources, the accent seems to be on identification of friends and relatives who have passed over.

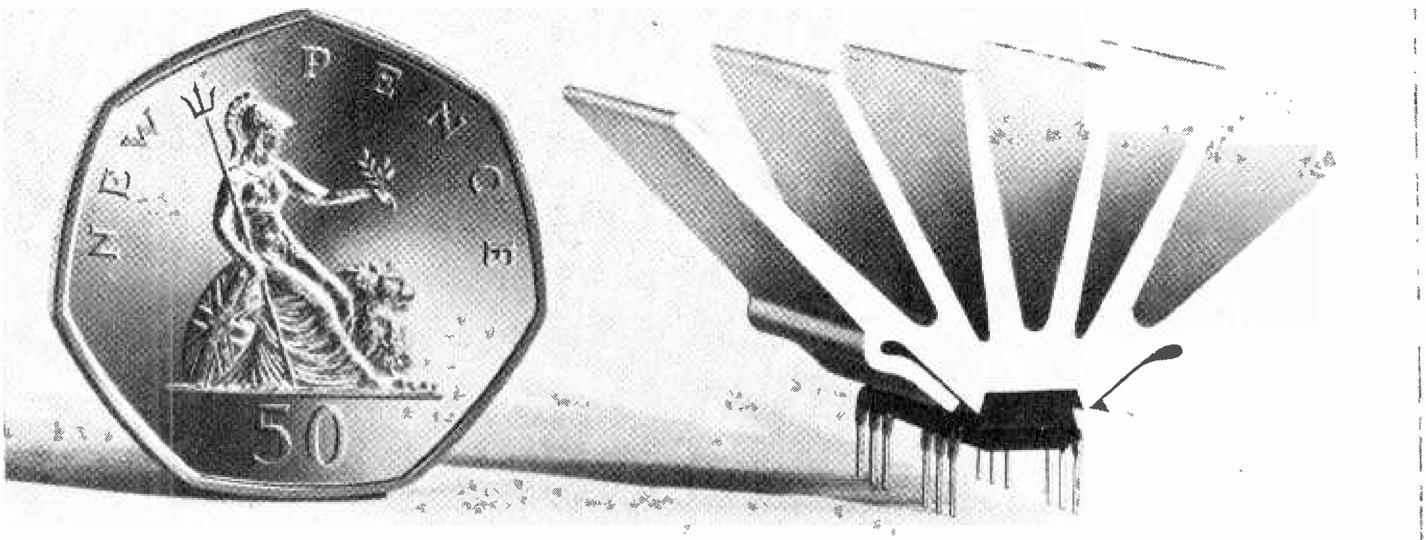
The sincerity of the book seems beyond question and the near one hundred pages of appendices give much technical detail of the apparatus used, as well as hypotheses regarding the cause of the phenomenon, although the translation seems to fall down in places (but not so badly as to cloud the gist). Theories involving relativity and anti-matter are among those present. One, however, which (unless I have missed it) does not seem to have been advanced is that fortuitous irregularities in the formation of the magnetic tape itself might, if put through a high gain amplifier, sound like words to anyone who (perhaps unconsciously) wanted words to be there. I put this forward with diffidence, particularly in view of the overwhelming evidence. I should be only too pleased to be proved wrong.

One thing is sure, and that is that the problem of the origin of these 'voices' cries out for investigation. I know, as well as you, that the whole thing sounds impossible. How can words be derived from a silent microphone? But don't forget that in 1901 it was theoretically impossible for radio waves to cross the Atlantic, because no-one knew of the existence of the ionosphere. By the same token there are no doubt a lot of things about electronics which so far we know nothing.

* By Dr. Konstantin Raudive; published by Colin Smythe Ltd £3.50.

new

Super IC-12



High fidelity Monolithic Integrated Circuit Amplifier

Two years ago Sinclair Radionics announced the World's first monolithic integrated circuit Hi-Fi amplifier, the IC.10. Now we are delighted to be able to introduce its successor the Super IC.12. This 22 transistor unit has all the virtues of the original IC.10 plus the following advantages:

1. Higher power.
2. Fewer external components.
3. Lower quiescent consumption.
4. Compatible with Project 60 modules.
5. Specially designed built-in heat sink. No other heat sink needed.
6. Full output into 3, 4, 5 or 8 ohms.
7. Works on any voltage from 6 to 28 volts without adjustment.
8. NEW 22 transistor circuit.

Output power 6 watts RMS continuous (12 watts peak).
Frequency Response 5 Hz to 100KHz ± 1dB.
Total Harmonic Distortion Less than 1% (Typical 0.1%) at all output powers and all frequencies in the audio band.
Load Impedance 3 to 15 ohms.
Power Gain 90dB (1,000,000,000 times) after feedback.
Supply Voltage 6 to 28 volts (Sinclair PZ-5 or PZ-6 power supplies ideal).
Size 22 x 45 x 28 mm including pins and heat sink.
Input Impedance 250 Kohms nominal.
Quiescent current 8mA at 28 volts.
Price: including FREE printed circuit board for mounting. **£2.98** Post free

With the addition of only a very few external resistors and capacitors the Super IC.12 makes a complete high fidelity audio amplifier suitable for use with pick-up, F.M. tuner etc. Alternatively, for more elaborate systems, modules in the Project 60 range such as the Stereo 60 and A.F.U. may be added. The comprehensive manual supplied with each unit gives full circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include car radios, oscillators etc. The very low quiescent consumption makes the Super IC.12 ideal for battery operation.

Sinclair Radionics Ltd., London Rd, St. Ives
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Telephone St Ives (048 06) 4311

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Sinclair Project 60 presents high fidelity in such a way that it meets every requirement of performance, design, quality and value and now that the remarkable phase lock loop stereo FM tuner is available, it becomes the most versatile of high fidelity systems. With Project 60, it is possible to start with a modest mono record reproducer and expand it to a sophisticated stereophonic radio and record reproducing system of fantastically good quality to hold its own with any other equipment, no matter how expensive. Project 60 is a unique high fidelity module system where compactness and ease of assembly are combined with circuitry that is far in advance of any other manufacturer in the world. Thus it is extraordinarily easy to assemble any combination of modules using nothing more complicated than the simplest of tools, and you certainly do not have to be experienced to build with complete confidence. The 48 page manual free with Project 60 equipment makes everything easy and you can house your assembly in an existing cabinet, motor plinth, free standing cabinet or virtually any arrangement you wish. Once you have completed your assembly you will have superlatively good equipment to give you years of service and enjoyment. You will have obtained superb value for money because Project 60 is the best selling modular system in Europe and can therefore be produced at extremely competitive prices and with excellent quality control.

	System	The Units to use	together with	Cost of Units
A	Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control	**£4.48**
B	Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control etc.	**£9.45**
C	20+20 W. R.M.S. stereo amplifier for most needs	**2 x Z.30s, Stereo 60, PZ.5**	Crystal, ceramic or mag. P.U., most dynamic speakers, F.M. tuner etc.	**£23.90**
D	20+20 W. R.M.S. stereo amplifier with high performance spkrs.	**2 x Z.30s, Stereo 60, PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
E	40+40W. R.M.S. de-luxe stereo amplifier	**2 x Z.50s, Stereo 60 PZ.8, mains trsfrmr**	As for D	**£34.88**
F	Outdoor P.A. system	**Z.50**	Mic., up to 4 P.A. speakers controls, etc.	**£5.48**
G	Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**
H	High pass and low pass filters	**A.F.U.**	C, D or E	**£5.98**
J	Radio	**Stereo F.M. Tuner**	C, D or E	**£25.00**

WW—081 FOR FURTHER DETAILS

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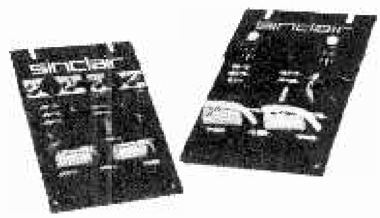
Sinclair Project 60

Z.30 & Z.50 power amplifiers



The Z.30 and Z.50 are 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 Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

SPECIFICATIONS ***(Z50 units are interchangeable with Z.30s in all applications).***
Power Outputs
Z.30 15 watts R.M.S. into 8 ohms using 35 volts: 20 watts R.M S. into 3 ohms using 30 volts.
Z.50 40 watts R.M S. into 3 ohms using 40 volts: 30 watts R.M.S. into 8 ohms, using 50 volts.
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 Kohms.
For speakers from 3 to 15 ohms impedance.
Size $3\frac{1}{2} \times 2\frac{1}{4} \times \frac{1}{2}$ in.

Z.30
Built tested and guaranteed with circuits and instructions manual **£4.48**

Z.50
Built, tested and guaranteed with circuits and instructions manual. **£5.48**

Power Supply Units

Designed specially for use with the Project 60 system of your choice.
Illustration shows PZ.5 to left and PZ.8 (for use with Z.50s) to the right. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stablised supply is essential.
PZ-5 *30 volts unstabilised* **£4.98**
PZ-6 *35 volts stabilised* **£7.98**
PZ-8 *45 volts stabilised (less mains transformer)* **£7.98**
PZ-8 *mains transformer* **£5.98**

Guarantee

If within 3 months of purchasing Project 60 modules directly from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.

Stereo 60 pre-amp/control unit

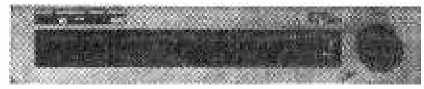
Designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

SPECIFICATIONS
Input sensitivities: Radio–up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ± 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 10KHz: BASS + 15 to—15dB at 100Hz.
Front panel: brushed aluminium with black knobs and controls.
Size: $8\frac{1}{4} \times 1\frac{1}{2} \times 4$ ins.
Built, tested and guaranteed. **£9.98**

Active Filter Unit

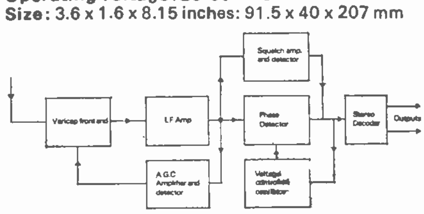
For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two stages of filtering are incorporated – rumble (high pass) and scratch (low pass). Supply voltage – 15 to 35V. Current – 3mA. H.F. cut-off (–3dB) variable from 28kHz to 5kHz. L.F cut-off (–3dB) variable from 25Hz to 100Hz. Distortion at 1kHz (35V. supply) 0.02% at rated output.
Built, tested and guaranteed **£5.98**

Stereo FM Tuner



first in the world to use the phase lock loop principle
Before production of this tuner, the phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio over other systems. Now, for the first time, the principle has been applied to an FM tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. Sensitivity is such that good reception becomes possible in difficult areas. Foreign stations can be tuned in suitable conditions and often a few inches of wire are enough for an aerial. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with any other high fidelity system.

SPECIFICATIONS:
Number of transistors: 16 plus 20 in I.C.
Tuning range: 87.5 to 108 MHz
Capture ratio: 1.5dB
Sensitivity: 2μV for 30dB quieting: 7μV for full limiting.
Squelch level: 20μV.
A.F.C. range: ±200 KHz
Signal to noise ratio: >65dB
Audio frequency response: 10Hz—15KHz (±1dB)
Total harmonic distortion: 0.15% for 30% modulation
Stereo decoder operating level: 2μV
Pilot tone suppression: 30dB
Cross talk: 40dB
I.F. frequency: 10.7 MHz
Output voltage: 2 x 150mV R.M.S.
Aerial Impedance: 75 Ohms
Indicators: Mains on: Stereo on; tuning indicator
Operating voltage: 25-30 VDC
Size: 3.6 x 1.6 x 8.15 inches: 91.5 x 40 x 207 mm



Price: £25 built and tested. Post free

To: SINCLAIR RADIONICS LTD LONDON ROAD ST. IVES HUNTINGDONSHIRE PE17 4HJ

Please send ______________________

Name ______________________

Address ______________________

for which I enclose cash/cheque/money order. WW6/71

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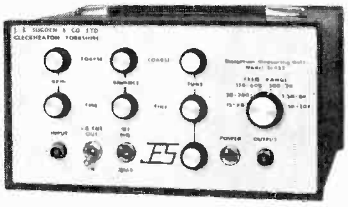
J E S AUDIO INSTRUMENTATION



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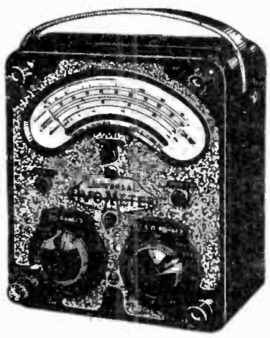

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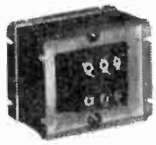

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
61	100	5	12	10·2 × 8·9 × 8·3	2·28	2·13	52
62	250	12	4	9·5 × 12·7 × 11·4	5·05	4·66	67
63	500	27	0	17·1 × 11·4 × 15·9	9·74	9·01	*
92	1000	40	0	17·8 × 17·1 × 21·6	17·94	16·59	*
128	2000	63	0	24·1 × 21·6 × 15·2	29·66	27·43	*
129	3000	84	0	21·6 × 21·6 × 20·3	46·38	42·90	*
190	6000	178	0	31·1 × 35·6 × 17·1	76·11	70·48	*

AUTO SERIES (NOT ISOLATED)

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
113	20		11	7·3 × 4·3 × 4·4	0-115-210-240	0·74	0·69	20
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	1·44	1·33	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	1·74	1·61	36
66	300	6	0	10·2 × 10·2 × 9·5	,, ,,	3·38	3·13	52
67	500	12	8	14·0 × 10·2 × 11·4	,, ,,	5·03	4·65	67
84	1000	16	0	11·4 × 14·0 × 14·0	,, ,,	9·12	8·84	82
93	1500	28	9	13·5 × 14·9 × 16·5	,, ,,	13·22	12·23	*
95	2000	40	0	17·8 × 16·5 × 21·6	,, ,,	17·26	15·96	*
73	3000	45	8	17·4 × 18·1 × 21·3	,, ,,	23·47	21·73	*

LOW VOLTAGE SERIES (ISOLATED)
PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps 12V	Amps 24V	Weight lb	oz	Size cm.	Secondary Windings	Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
111	0·5	0·25		12	7·6 × 5·7 × 4·4	0-12V at 0·25A × 2	0·74	0·69	22
213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	0·88	0·81	22
71	2	1	1	0	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·16	1·07	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	1·62	1·50	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	1·95	1·81	42
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	2·56	2·37	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	3·95	3·16	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	5·03	4·70	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	9·28	8·58	82

30 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz.	Size cm.	Secondary Taps	Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
112	0·5	1	4	8·3 × 3·7 × 4·9	0-12-15-24-30V	0·88	0·81	22
79	1·0	2	0	7·0 × 6·4 × 6·0	,, ,,	1·18	1·10	36
3	2·0	3	2	8·9 × 7·0 × 7·6	,, ,,	1·75	1·63	36
20	3·0	4	6	10·2 × 8·9 × 8·6	,, ,,	2·16	1·95	42
21	4·0	6	0	10·2 × 9·5 × 8·6	,, ,,	2·56	2·37	52
117	6·0	7	8	12·1 × 9·5 × 10·2	,, ,,	3·79	3·51	52
89	10·0	12	2	14·0 × 10·2 × 11·4	,, ,,	6·21	5·74	67

50 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.		Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
102	0·5	1	11	7·0 × 7·0 × 5·7	0-19-25-33-40-50V	1·16	1·07	30
103	1·0	2	10	8·3 × 7·3 × 7·0	,, ,,	1·69	1·57	36
104	2·0	5	0	10·2 × 8·9 × 8·6	,, ,,	2·34	2·16	42
105	3·0	6	0	10·2 × 10·2 × 8·3	,, ,,	3·18	2·94	52
106	4·0	9	4	12·1 × 11·4 × 10·2	,, ,,	4·20	3·89	52
107	6·0	12	4	12·1 × 11·1 × 13·3	,, ,,	6·21	5·74	67
118	8·0	18	9	13·3 × 13·3 × 12·1	,, ,,	8·10	7·49	97
119	10·0	19	12	16·5 × 11·4 × 15·9	,, ,,	10·15	9·39	97

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.		Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
124	0·5	2	4	8·3 × 9·5 × 6·7	0-24-30-40-48-60V	1·18	1·09	36
126	1·0	3	0	8·9 × 7·6 × 7·6	,, ,,	1·64	1·52	36
127	2·0	5	6	10·2 × 8·9 × 8·6	,, ,,	2·56	2·37	42
123	4·0	10	6	11·4 × 9·5 × 11·4	,, ,,	5·03	4·65	67
120	6·0	16	12	13·3 × 12·1 × 12·1	,, ,,	7·28	6·73	82
122	10·0	23	2	16·5 × 12·7 × 16·5	,, ,,	12·05	11·15	*

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45	1·5	1	9	7·0 × 6·0 × 6·0	Please note, these units do not include rectifiers	1·17	1·08	30
5	4·0	3	11	10·2 × 7·0 × 8·3		1·77	1·64	42
86	6·0	5	12	10·2 × 8·9 × 8·3		2·67	2·47	52
146	8·0	6	4	8·9 × 10·2 × 10·2		3·04	2·82	52
50	12·5	11	14	13·3 × 10·8 × 12·1		4·52	4·18	67

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R20	75p
SU2150A	75p
TT21	£2·40
TT22	£2·50
U18/20	67½p
U20	67½p
U25	75p
U26	75p
U31	45p
U37	£1·50
U50	30p
U52	30p
U76	25p
U78	25p
U191	75p
U201	35p
U281	40p
U282	40p
U301	57½p
U403	50p
U404	37½p
U801	£1·00
UABC80	52½p
UBF89	40p
UBC41	49p
UCC85	46p
UCH42	66p
UCH81	54p
UCL82	51p
UCL83	61p
UF41/2	55p
UF80/5	37½p
UF89	41p
UL41	57½p

UL84	55p
UM80/4	45p
UY41	40p
UY85	34p
U25	75p
U26	75p
U191	72½p
U193	41p
U301	85p
W729	55p
Z759	£1·22½
OA2	32½p
OA3	45p
OB2	32½p
OB3	50p
OC3	35p
OD3	32½p
3Q4	40p
3S4	35p
3V4	40p
5R4GY	55p
5U4G	30p
5U4GB	37½p
5V4G	40p
5Y3GT	30p
5Z3	45p
5Z4GT	40p
6/30L2	75p
6AB4	32½p
6AF4A	47½p
6AG7	37½p
6AH6	50p
6AJ8	29p
6AK5	30p
6AK6	57½p
6AL3	42½p
6AL5	16p
6AM5	25p
6AM6	22½p
6AQ5	32½p
6AQ6	50p
6AR5	32½p

6AR6	32½p
6AS5	35p
6AS7G	80p
6AT6	45p
6AU6	30p
6BA6	47½p
6BE6	60p
6BH6	42½p
6BJ6	42½p
6BK7A	50p
6BL8	35p
6BN5	42½p
6BN6	40p
6BQ5	25p
6BR7	75p
6BR8	95p
6BW6	82½p
6BW7	60p
6BX6	25p
6BZ6	32½p
6C4	30p
6C5GT	35p
6CD6G	£1·40
6CA4	27½p
6CA7	52½p
6CB6	27½p
6CD6GA	£1·15
6CG7	45p
6CH6	55p
6CL6	50p
6CW4	62½p
6CY5	40p
6CY7	60p
6D3	40p
6DC6	67½p
6CK6	42½p
6DQ6B	60p
6DS4	75p
6EA8	55p
6EH7	32½p
6EJ7	35p

6EW6	60p
6F1	70p
6F8	40p
6F6G	25p
6F11	32½p
6F12	22½p
6F13	35p
6F14	60p
6F15	55p
6F18	40p
6F22	32½p
6F23	77½p
6F24	67½p
6F25	75p
6F26	35p
6F28	70p
6F29	32½p
6F30	35p
6J4	47½p
6J5GT	30p
6J7	42½p
6K6GT	50p
6K7	32½p
6K8G	30p
6K23	50p
6K25	75p
6L6GT	45p
6L7	32½p
6L18	30p
6LD20	33½p
6N7GT	35p
6P1	60p
6P25	£1·05
6P28	61½p
6Q7	37½p
6R7G	35p
682	40p
6S4A	55p
6SA7	37½p
6SG7	32½p
6SJ7	37½p
6SK7	32½p

6SL7GT	32½p
6SN7GT	30p
6SQ7	40p
6SR7	37½p
6T8	32½p
6U4GT	62½p
6U8	35p
6V6GT	32½p
6X4	25p
6X5GT	27½p
6X8	55p
6Y6G	60p
7Y4	60p
9BW6	42½p
10C2	50p
10D1	40p
10D2	40p
10F1	90p
10F9	50p
10F18	40p
10L1	40p
10LD11	55p
10P13	55p
10P14	£1·00
12AB5	50p
12AC6	37½p
12AD6	37½p
12AL5	40p
12AQ5	40p
12AT6	25p
12AU6	75p
12AV6	30p
12AV7	45p
12AX7	30p
12AY7	67½p
12B4A	50p
12BA6	32½p
12BA7	32½p
12BE6	32½p
12BH7	32½p
12BY7	50p
12K5	50p

12K7GT	35p
12Q7G	25p
12SC7	25p
12SG7	35p
12SH7	25p
12SJ7	25p
12SK7	40p
12SL7GT	40p
12SN7GT	40p
12SQ7	40p
12SR7	32½p
14S7	30p
20D1	45p
20L1	£1·00
20P1	50p
20P3	60p
20P4	£1·00
20P5	£1·00
25C5	45p
25L6GT	37½p
25Z4G	30p
25Z6GT	50p
30A5	40p
30AE3	40p
30C15	75p
30C17	80p
30C18	75p
30F5	65p
30FL1	75p
30FL2	92½p
30FL13	50p
30FL14	77½p
30L1	45p
30L15	85p
30L17	85p
30P12	80p
30P18	35p
30P19	75p
30PL1	77½p
30PL13	90p
30PL14	85p
35A3	50p

35A5	55p
35B5	65p
35C5	35p
35D5	65p
35L6GT	47½p
35W4	25p
35Z3	55p
35Z4G	25p
35Z5GT	37½p
50A5	65p
50B5	35p
50C5	35p
50L6GT	40p
83A1	90p
85A2	37½p
90AUY	£2·40
90C1	60p
90CU	£1·25
807	47½p
811A	£1·50
612A	£2·25
813	£3·75
866A	70p
5642	60p
6080	£1·37½
6146	£1·50
6146B	£2·37½
6267	32½p
6360	£1·25
6939	£2·10
7199	75p
7360	£1·80
7586	£1·25
9002	32½p
9003	50p

CATHODE RAY TUBES

New and Budget tubes made by the leading manufacturers. Guaranteed for 2 years. In the event of failure under guarantee, replacement is made without the usual time wasting forms.

Type		New £	Budget £
MW36—20			£4·50
MW36—21			£4·50
MW43—69Z	CRM171		
	CRM172	£6·60	£4·62½
MW43—80Z	CRM173	£6·60	£4·62½
AW43—80Z	CME1702	£6·60	£4·62½
	CME1703	£6·60	£4·62½
	CME1706	£6·60	£4·62½
	C17AA	£6·60	£4·62½
	C17AF	£6·60	£4·62½
AW43—88	CME1705	£6·60	£4·62½
AW47—90			
AW47—91	A47 14W	£5·95	£4·87
A47 14W	CME1901	£5·95	£4·87
	CME1902	£5·95	£4·87
	CME1903	£5·95	£4·87
	C19AH	£5·95	£4·87
147 13W	CME1906	£10·27½	£8·50
A47—11W	CME1905	£8·86½	£7·00
A47—26W	CME1905	£8·86½	£7·75
A47—26W/R	CME1913R	£9·33½	

Type		New £	Budget £
A50—120W/R	CME2013	£10·35	
AW53—80		£8·93½	£6·25
AW53—88	CME2101	£8·93½	£6·25
AW59—90			
AW59—91	CME2303	£9·58½	£7·20
A59—15W	CME2301		
	CME2303		
	CME2303	£9·58½	£7·20
A59—11W	CME2305		
A59—13W	CME2306	£13·65	£10·97½
A59—16W	CME2306	£13·65	£10·97½
A59—23W	CME2305	£12·60	£10·50
A59—23W/R		£12·60	£10·50
A61—120W/R	CME2413	£13·50	£11·50
A65—11W	CME2501	£16·50	£14·50

COLOUR TUBES

A49—191X	19 inch	£52·50
A56—120X	22 inch	£57·50
A63—11X	25 inch	£62·50

PORTABLE SET TUBES

TSD217	£11·50	
TSD282	£11·50	
A28—14W	£9·16½	
		Not supplied
CME1601		£7·75
CME1602		£8·00

TRANSISTORISED UHF TUNER UNITS NEW AND GUARANTEED FOR 3 MONTHS

Complete with Aerial Socket and wires for Radio and Allied TV sets but can be used for most makes.
Continuous Tuning, £4·50; Push Button, £5·00.

SERVICE AIDS

Switch Cleaner, 55p; Switch Cleaner with Lubricant, 55p; Freeza 62½p. P. & P. 7½p per item.

PLUGS

Jack Plugs and Sockets		Co-Axial Plugs	
Standard Plugs	19p	Belling Lee (or similar type)	6½p
Standard Sockets	12½p	Add 2p per doz. p. & p.	

LINE OUTPUT TRANSFORMERS

G.E.C.	BT454	£4·75	G.E.C.	2028	£4·75
G.E.C.	BT456	£4·75	G.E.C.	2041	£4·75
G.E.C.	2010	£4·75	G.E.C.	2000 Series	
G.E.C.	2013	£4·75	Philips	19TG	£4·75
G.E.C.	2014	£4·75	Pye	Mod. 36	£4·75
G.E.C.	2018	£4·75	Pye	Mod. 40	£4·75
G.E.C.	2043	£4·75	Thorn	800—850	£4·75
G.E.C.	2048	£4·75			

STYLII—BRITISH MANUFACTURED

All types in stock.		Double Tip "S"	33p
Single Tip "S"	13p	Double Tip "D"	47p
Single Tip "D"	37p		
"S" = Sapphire		"D" = Diamond	

A discount of 10% is also given for the purchase of 3 or more tubes at any one time. All types of tubes in stock. Carriage and insurance 75p anywhere in Britain.

SEMICONDUCTORS BRAND NEW MANUFACTURERS MARKINGS NO REMARKED DEVICES

2N388A	62½p
2N614	30p
2N697	20p
2N698	25p
2N706	12½p
2N706A	12½p
2N930	27½p
2N1132	32½p
2N1303	17½p
2N1305	22½p
2N1306	25p
2N1307	25p
2N1711	25p
2N2147	72½p
2N2160	57½p
2N2614	30p
2N2646	57½p
2N2905	40p
2N2926	
Green	14p
Yellow	12½p
Orange	12½p
2N3053	27½p
2N3055	75p
2N3391	20p
2N3392	20p
2N3702	17½p
2N3704	22½p
2N3705	20p
2N3711	20p
2N3819	35p
2N3826	30p
2N3905	37p
2N3914	P.A.

R.C.A.	
40253	P.A.
40398	P.A.
40458	P.A.
2N4061	22½p
2N4062	22½p
2N4286	17½p
2N4291	17½p
AC107	30p
AC117	60p
AC126	20p
AC127	25p
AC128	20p
AC154	22½p
AC176	25p
AC187	62½p
AC188	37½p
ACY17	27½p
ACY18	25p
ACY19	25p
ACY20	25p
ACY21	25p
ACY22	20p
ACY28	20p
ACY40	20p
ACY41	25p
ACY44	40p
AD140	40p
AD142	58p
AD149	57½p
AD150	62½p
AD161	37½p
AD162	37½p
AF102	58p

AF106	42½p
AF114	25p
AF115	30p
AF116	25p
AF117	25p
AF118	60p
AF119	20p
AF124	22½p
AF125	20p
AF126	20p
AF127	17½p
AF139	37½p
AF178	45p
AF179	45p
AF180	52½p
AF181	42½p
AF186	66½p
AF239	42½p
ASY28	28p
BC107	15p
BC108	15p
BC109	15p
BC113	27½p
BC114	37½p
BC115	32½p
BC116	62½p
BC116A	37½p
BC117	39p
BC118	32½p
BC134	57½p
BC135	P.A.
BC136	P.A.
BC137	P.A.
BC138	P.A.

BC142	30p
BC143	P.A.
BC147	17½p
BC148	15p
BC149	17½p
BC152	17½p
BC157	20p
BC158	17½p
BC169B	14p
BC169C	15p
BC171	17½p
BC175	27½p
BC183	22½p
BC184	22½p
BC187	28½p
BC213L	26½p
BCY32	37½p
BCY58	22½p
BCY70	20p
BD115	78p
BD121	65p
BD123	82½p
BD124	62½p
BD131	97½p
BD132	97½p
BF115	25p
BF117	47½p
BF160	P.A.
BF162	P.A.
BF163	35p
BF167	25p
BF173	32½p
BF178	35p
BF179	72½p
BF180	35p
BF181	32½p
BF184	25p
BF194	22½p
BF195	27½p
BF196	42½p
BF197	31½p
BF198	42½p
BF200	36½p

BF224	30p
BF225	30p
BF257	47½p
BFX84	30p
BFY19	33p
BFY50	22½p
BFY51	22½p
BFY52	22½p
BSX21	37½p
OC25	50p
OC26	32½p
OC28	62½p
OC29	75p
OC35	40p
OC36	62½p
OC42	25p
OC44	20p
OC45	12½p
OC46	15p
OC70	15p
OC71	12½p
OC72	12½p
OC74	32½p
OC75	22½p
OC76	22½p
OC77	27½p
OC78	25p
OC81	20p
OC81D	20p
OC83	25p
OC84	25p
OC139	32½p
OC140	32½p
OC170	30p
OC171	30p
OC200	32½p
OC202	47½p
OCP71	42½p
P346A	25p
TI843	40p

P.A. Price on application

DIODES & RECTIFIERS

IN914	7½p	BOY88 (Series)	32½p	OA91	7½p
AA119	10p	O15	12½p	OA91	7½p
BA102	22½p	OA47	7½p	OA202	10p
BA115	7½p	OA70	7½p	BA144	12½p
BA114	12½p	OA79	9p	BA145	20p
BY100	22½p	OA81	7½p	BA148	23p
BY126	20p	OA90	7½p	BA155	P.A.
BY127	22½p			BA156	P.A.

CARTRIDGES

		Inc. P. T. each
ACOS		
GP79		63p
GP91—1Sc		£1·05
GP91—2Sc		£1·05
GP91—3Sc (TC8)		£1·05
GP92		£1·32
GP93—1		£1·24
GP94—1		£1·55
GP94—5		£1·80
GP95		£1·24
GP96		£1·57
Acos 104 1—10		£2·09
B.S.R.		
X3M	S/S	£1·39
X3H	S/S	£1·39
X5M	S/S	£1·39
X5H	S/S	£1·39
SX5M	S/S	£1·81
SX5H	S/S	£1·81
SX5M	D/S	£2·00

		Inc. P.T. each
SX5H	D/S	£2·00
X4N	D/S	£1·36
GOLDRING		
850		£5·25
G800		£7·35
G800E		£15·00
G800 Super E		£19·50
RONETTE		
105	S/S	99p
106	S/S	99p
DC400	S/S	70p
DC400SC	S/S	70p
105	D/S	£1·12
106	D/S	£1·12
DC400	D/S	84p
DC400SC	D/S	84p
SONOTONE		
8TA	D/S	£1·25
9TA	D/S	£1·79
9TAHC	D/S	£1·79

MAGNETIC RECORDING TAPES by a leading manufacturer

POLYESTER Length	Spool Size in.	Price	POLYESTER Length	Spool Size in.	Price
Standard Play			900ft	5	70p
600ft	5	50p	1200ft	5¾	85p
850ft	5¾	63p	1800ft	7	£1·00
1200ft	7	70p	Double Play		
Long Play			1200ft	5	87p
210ft	3	27p	1800ft	5¾	£1·10
450ft	4	43p	2400ft	7	£1·30

EMPTY TAPE REELS

3in	7p
4in	9p
5in	11p
5¾in	13p
7in	13p

CASSETTES
Boxed in Plastic Library Packs

C60	53p
C90	63p
C120	87p

P. & P. 7p on all orders.

ADD 3p PER ITEM FOR POST AND PACKING FOR ORDERS UNDER 24 PIECES.

TERMS, CASH WITH ORDER ONLY. POST AND PACKING PAYABLE ON ORDERS UP TO £6, AFTER THAT, FREE EXCEPT C.R.T.'s.

CHOICE OF 1000'S OF ITEMS LARGEST SELECTION LOW PRICES AND RETURN OF POST SERVICE

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	0·20	2N3393	0·15	3N128	0·70	BC122	0·20	BFY25	0·25	NKT214	0·22½
2G302	0·20	2N3394	0·15	3N140	0·77½	BC125	0·35	BFY26	0·20	NKT215	0·22½
2G303	0·20	2N3402	0·22½	3N141	0·72½	BC126	0·35	BFY29	0·50	NKT216	0·37½
2G306	0·42½	2N3403	0·22½	3N142	0·55	BC140	0·37½	BFY30	0·50	NKT217	0·42½
2G308	0·30	2N3404	0·32½	3N143	0·67½	BC147	0·17½	BFY41	0·50	NKT219	0·30
2G309	0·30	2N3405	0·45	3N152	0·87½	BC148	0·12½	BFY43	0·62½	NKT223	0·27½
2G371	0·15	2N3414	0·22½	R.C.A.	0·52½	BC149	0·17½	BFY50	0·22½	NKT224	0·25
2G374	0·20	2N3415	0·22½	40050	0·55	BC152	0·17½	BFY51	0·22½	NKT225	0·22½
2G381	0·22½	2N3416	0·37½	40250	0·87½	BC157	0·20	BFY52	0·22½	NKT229	0·30
2N388A	0·62½	2N3417	0·37½	40251	0·32½	BC158	0·17½	BFY53	0·17½	NKT237	0·35
2N404	0·22½	2N3439	1·30	40309	0·32½	BC159	0·20	BFY56A	0·57½	NKT238	0·25
2N696	0·20	2N3440	0·97½	40310	0·45	BC160	0·62½	BFY75	0·30	NKT240	0·27½
2N697	0·20	2N3570	1·25	40311	0·35	BC167	0·15	BFY76	0·42½	NKT241	0·27½
2N698	0·25	2N3572	0·97½	40312	0·47½	BC168B	0·14	BFY77	0·57½	NKT242	0·20
2N699	0·62½	2N3605	0·27½	40314	0·37½	BC168C	0·15	BFY90	0·67½	NKT243	0·62½
2N706	0·12½	2N3606	0·27½	40315	0·37½	BC169B	0·14	BFW58	0·27½	NKT244	0·17½
2N706A	0·12½	2N3607	0·22½	40316	0·47½	BC169C	0·15	BFW59	0·25	NKT245	0·20
2N708	0·15	2N3702	0·12½	40317	0·37½	BC170	0·12½	BFW60	0·25	NKT261	0·20
2N709	0·62½	2N3703	0·12½	40319	0·55	BC171	0·15	BPX25	1·85	NKT262	0·30
2N718	0·25	2N3704	0·17½	40320	0·47½	BC172	0·15	BPX29	1·80	NKT264	0·20
2N718A	0·30	2N3705	0·15	40323	0·32½	BC175	0·22½	BPY10	1·45	NKT271	0·20
2N726	0·30	2N3706	0·12½	40324	0·47½	BC182	0·12½	BRY29	0·47½	NKT272	0·20
2N727	0·30	2N3707	0·15	40326	0·37½	BC183	0·12½	BSX19	0·17½	NKT274	0·20
2N914	0·17½	2N3708	0·09	40329	0·30	BC184	0·15	BSX20	0·17½	NKT275	0·20
2N916	0·17½	2N3709	0·10	40344	0·27½	BC182L	0·10	BSX21	0·37½	NKT281	0·27½
2N918	0·30	2N3710	0·11	40347	0·57½	BC183L	0·10	BSX26	0·45½	NKT401	0·87½
2N929	0·22½	2N3711	0·12	40348	0·52½	BC184L	0·15	BSX27	0·47½	NKT402	0·90
2N930	0·27½	2N3713	1·87½	40360	0·42½	BC212L	0·12½	BSX28	0·32½	NKT403	0·75
2N987	0·52½	2N3714	2·00	40361	0·47½	BCY10	0·27½	BSX60	0·82½	NKT404	0·62½
2N1090	0·22½	2N3715	2·22½	40362	0·57½	BCY12	0·27½	BSX61	0·62½	NKT405	0·75
2N1091	0·22½	2N3716	2·90	40370	0·32½	BCY30	0·27½	BSX76	0·22½	NKT406	0·62½
2N1131	0·25	2N3773	2·40	40406	0·57½	BCY31	0·30	BSX77	0·27½	NKT451	0·62½
2N1132	0·25	2N3791	2·75	40407	0·40	BCY32	0·50	BSX78	0·27½	NKT452	0·62½
2N1302	0·17½	2N3819	0·35	40408	0·52½	BCY33	0·25	BSY10	0·27½	NKT453	0·47½
2N1303	0·17½	2N3823	0·97½	40409	0·55	BCY34	0·30	BSY11	0·27½	NKT603F	0·32½
2N1304	0·22½	2N3854	0·27½	40410	0·62½	BCY38	0·40	BSY24	0·15	NKT613F	0·32½
2N1305	0·22½	2N2754A	0·27½	40412	0·50	BCY39	0·60	BSY25	0·15	NKT674F	0·30
2N1306	0·25	2N3855	0·27½	40467A	0·57½	BCY40	0·50	BSY26	0·17½	NKT677F	0·30
2N1307	0·25	2N3855A	0·30	40468A	0·35	BCY42	0·15	BSY27	0·17½	NKT713	0·25
2N1308	0·30	2N3856	0·30	40528	0·72½	BCY43	0·15	BSY28	0·17½	NKT717	0·42½
2N1309	0·30	2N3856A	0·35	40600	0·57½	BCY54	0·32½	BSY29	0·17½	NKT734	0·27½
2N1507	0·17½	2N3858	0·25	40603	0·50	BCY58	0·22½	BSY32	0·25	NKT736	0·35
2N1613	0·25	2N3858A	0·30	AC107	0·30	BCY59	0·22½	BSY36	0·25	NKT773	0·25
2N1631	0·35	2N3859	0·27½	AC126	0·20	BCY60	0·97½	BSY37	0·25	NKT781	0·30
2N1632	0·30	2N3859A	0·32½	AC127	0·25	BCY70	0·20	BSY38	0·22½	NKT10339	0·32½
2N1637	0·30	2N3860	0·30	AC128	0·20	BCY71	0·42½	BSY39	0·22½	NKT10419	0·30
2N1638	0·27½	2N3866	1·50	AC154	0·22½	BCY72	0·17½	BSY40	0·32½	NKT10439	0·37½
2N1639	0·27½	2N3877	0·40	AC176	0·25	BCZ10	0·27½	BSY51	0·32½	NKT10519	0·32½
2N1701	1·62½	2N3877A	0·40	AC187	0·62½	BCZ11	0·42½	BSY52	0·32½	NKT20329	0·47½
2N1711	0·25	2N3900	0·37½	AC188	0·37½	BD116	1·12½	BSY53	0·37½	NKT20339	0·37½
2N1889	0·32½	2N3900A	0·40	ACY17	0·27½	BD121	0·65	BSY54	0·40	NKT80111	0·77½
2N1893	0·37½	2N3901	0·97½	ACY18	0·25	BD123	0·82½	BSY56	0·90	NKT80112	0·97½
2N2147	0·82½	2N3903	0·35			BD124	0·82½	BSY78	0·47½	NKT80113	1·12½
2N2148	0·57½	2N3904	0·35	ACY19	0·25	BD131	0·75	BSY79	0·45	NKT80211	0·92½
2N2160	0·57½	2N3905	0·37½	ACY20	0·25	BD132	0·85	BSY82	0·52½	NKT80212	0·92½
2N2193	0·40	2N3906	0·37½	ACY21	0·25	BDY10	1·37½	BSY90	0·57½	NKT80213	0·92½
2N2193A	0·42½	2N4058	0·17	ACY22	0·20	BDY11	1·62½	BSY95A	0·12½	NKT80214	0·92½
2N2194A	0·30	2N4059	0·10½	ACY28	0·20	BDY17	1·50	BSW41	0·42½	NKT80215	0·92½
2N2217	0·27½	2N4060	0·12½	ACY40	0·20	BDY18	1·75	BSW70	0·27½	NKT80216	0·92½
2N2218	0·32½	2N4061	0·12½	ACY41	0·25	BDY19	1·97½	C111	0·75	OC20	0·75
2N2219	0·32½	2N4062	0·12½	ACY44	0·40	BDY20	1·12½	C424	0·27½	OC22	0·50
2N2220	0·25	2N4244	0·47½	AD140	0·52½	BDY38	0·97½	C425	0·55	OC23	0·60
2N2221	0·25	2N4245	0·42½	AD149	0·57½	BDY60	1·25	C426	0·40	OC24	0·60
2N2222	0·30	2N4254	0·42½	AD150	0·62½	BDY61	1·25	C428	0·37½	OC25	0·50
2N2287	1·07½	2N4255	0·42½	AD161	0·37½	BDY62	1·00	C744	0·30	OC26	0·27½
2N2297	0·30	2N4284	0·17½	AD162	0·37½	BF115	0·25	D16P1	0·37½	OC28	0·62½
2N2368	0·17½	2N4285	0·17½	AF106	0·42½	BF117	0·47½	D16P2	0·40	OC29	0·62½
2N2369	0·17½	2N4286	0·17½	AF114	0·25	BF163	0·37½	D16P3	0·37½	OC35	0·50
2N2369A	0·17½	2N4287	0·17½	AF115	0·25	BF167	0·25½	D16P4	0·40	OC36	0·62½
2N2410	0·42½	2N4288	0·17½	AF116	0·25	BF173	0·32½	GET102	0·30	OC41	0·22½
2N2483	0·27½	2N4289	0·17½	AF117	0·25	BF177	0·30	GET113	0·20	OC42	0·25
2N2484	0·32½	2N4290	0·17½	AF118	0·62½	BF178	0·30	GET114	0·20	OC44	0·20
2N2539	0·22½	2N4291	0·17½	AF119	0·20	BF179	0·30	GET118	0·20	OC45	0·12½
2N2540	0·22½	2N4292	0·12½	AF124	0·22½	BF180	0·35½	GET119	0·20	OC46	0·15
2N2613	0·35	2N4303	0·47½	AF125	0·20	BF181	0·32½	GET120	0·52½	OC70	0·15
2N2614	0·30	2N5027	0·52½	AF126	0·20	BF184	0·25	GET873	0·12½	OC71	0·12½
2N2646	0·52½	2N5028	0·57½	AF127	0·17½	BF185	0·42½	GET880	0·30	OC72	0·12½
2N2696	0·32½	2N5029	0·47½	AF139	0·37½	BE194	0·17½	GET887	0·20	OC74	0·32½
2N2711	0·25	2N5030	0·42½	AF178	0·42½	BF195	0·20	GET889	0·22½	OC75	0·22½
2N2712	0·25	2N5172	0·12½	AF179	0·72½	BF196	0·42½	GET890	0·22½	OC76	0·22½
2N2713	0·27½	2N5174	0·52½	AF180	0·52½	BF197	0·42½	GET896	0·22½	OC77	0·30
2N2714	0·30	2N5175	0·52½	AF181	0·42½	BF198	0·42½	GET897	0·22½	OC81	0·20
2N2865	0·62½	2N5176	0·45	AD239	0·42½	BF200	0·52½	GET898	0·22½	OC81D	0·22½
2N2904	0·30	2N5232A	0·30	AF279	0·47½	BF224	0·20	MJ400	1·07½	OC83	0·25
2N2904A	0·32½	2N5245	0·45	AF280	0·62½	BF225	0·20	MJ420	1·12½	OC84	0·25
2N2905	0·37½	2N5246	0·42½	AF211	0·32½	BF237	0·22½	MJ421	1·12½	OC139	0·32½
2N2905A	0·40	2N5249	0·67½	ASY26	0·25	BF238	0·22½	MJ430	1·02½	OC140	0·32½
2N2906	0·25	2N5265	3·25	ASY27	0·37½	BF244	0·32½	MJ440	0·95	OC170	0·30
2N2906A	0·27½	2N5266	2·75	ASY28	0·27½	BFW61	0·47½	MJ480	0·97½	OC171	0·30
2N2907	0·30	2N5267	2·62½	ASY29	0·27½	BFX12	0·22½	MJ481	1·25	OC200	0·40
2N2923	0·15	2N5305	0·37½	ASY26	0·25	BFX13	0·22½	MJ490	1·00	OC201	0·60
2N2924	0·15	2N5306	0·40	ASY50	0·25	BFX29	0·30	MJ491	1·37½	OC202	0·75
2N2925	0·15	2N5307	0·37½	ASY51	0·32½	BFX30	0·30	MJ1800	2·17½	OC203	0·42½
2N2926		2N5308	0·37½	ASY53	0·25	BFX43	0·37½	MJE340	0·62½	OC204	0·42½
Green	0·14	2N5309	0·62½	ASY54	0·25	BFX44	0·37½	MJE520	0·87½	OC205	0·90
Yellow	0·12½	2N5310	0·42½	ASY62	0·25	BFX51	0·20	MJE521	0·87½	OC207	0·75
Orange	0·12½	2N5354	0·27½	ASY63	0·17½	BFX68	0·67½	MPF102	0·42½	OCP71	0·42½
2N3011	0·30	2N5355	0·27½	ASY72	0·25	BFX84	0·25	MPF103	0·37½	ORP12	0·62½
2N3014	0·32½	2N5356	0·32½	ASY83	0·25	BFX85	0·32½	MPF104	0·37½	ORP61	0·50½
2N3053	0·25	2N5365	0·47½	ASY86	0·32½	BFX86	0·25	MPF105	0·37½	P346A	0·22½
2N3054	0·50	2N5366	0·32½	ASZ21	0·42½	BFX87	0·27½	MPS3638	0·32½	TIS34	0·62½
2N3055	0·75	2N5367	0·57½	AU103	1·25	BFX88	0·25	NKT0013	0·47½	TIS43	0·40½
2N3133	0·30	2N5457	0·37½	BC107	0·12½	BFX89	0·62½	NKT124	0·42½	TIS44	0·12½
2N3134	0·30	2S005	0·75	BC108	0·12½	BFX93A	0·70	NKT125	0·27½	TIS45	0·12½
2N3135	0·25	2S020	2·00	BC109	0·12½	BFY10	0·32½	NKT126	0·27½	TIS46	0·12½
2N3136	0·25	2S102	0·50	BC113	0·20	BFY11	0·42½	NKT128	0·27½	TIS47	0·12½
2N3340	0·97½	2S103	0·25	BC114	0·25	BFY17	0·22½	NKT135	0·27½	TIS48	0·12½
2N3349	1·30	2S104	0·25	BC115	0·27½	BFY18	0·32½	NKT137	0·32½	TIS49	0·12½
2N3390	0·25	2S501	0·32½	BC116	0·27½	BFY19	0·32½	NKT210	0·30	TIS50	0·17½
2N3391	0·20	2S502	0·35	BC116A	0·27½	BFY20	1·60	NKT211	0·30	TIS51	0·12½
2N3391A	0·30	2S503	0·27½	BC118	0·32½	BFY21	0·42½	NKT212	0·30	TIS52	0·12½
2N3392	0·17½	3N83	0·40	BC121	0·20	BFY24	0·45	NKT213	0·30	TIS53	0·22½

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38 Series—FACE SIZE 42 × 42 mm. All prices for 1-9 pieces. All meters D.C.

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50	Microamp	1·87½	5	,,	1·25
100	,,	1·75	10	,,	1·25
200	,,	1·62½	50	,,	1·25
500	,,	1·37½	100	,,	1·25
50-0-50	,,	1·75	500	,,	1·25
100-0-100	,,	1·62½	1	Amp	1·25
500-0-500	,,	1·25	5	,,	1·25
1	Milliamp	1·25	10	Volts	1·25
			20	,,	1·25
			50	,,	1·25
			300	,,	1·25
			500	,,	1·25

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	£		£
10″ × 6″	2·37½	3″	0·62½
9″ × 4″	1·27½	5″	0·72½
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5″ × 3″	0·62½	*Post and packing*	0·15

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COMMONWEALTH (AIR) .. .. 0·65 (minimum)

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PIV	50	100	200	400	600	800	1000	1200	1400
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1A	0·10	0·12½	0·15	0·16	0·17½	0·19	0·20	—	—
3A	0·15	0·17	0.20	0·22½	—	0·30	—	—	—
6A	—	—	0·25	0·30	0·32½	0·35	0·50	—	—
10A	—	0·52½	0·57½	0·65	0·77½	0·87½	0·97½	1·25	1·60
17A	—	0·57½	0·62½	0·77½	0·90	0·97½	1·20	1·57½	1·87½
35A	—	1·37½	1·60	1·97½	2·37½	2·70	3·10	3·50	4·50

1 amp and 3 amp are plastic encapsulation.

DIODES AND RECTIFIERS

IN914	0·07½	AAZ17	0·12½	BAY31	0·07½	OA5	0·17½
IN916	0·07½	BA100	0·15	BAY38	0·25	OA10	0·22½
IN4007	0·22½	BA102	0·22½	BY100	0·17½	OA9	0·10
IS44	0·10	BA110	0·32½	BY103	0·22½	OA47	0·07½
IS113	0·15	BA115	0·07½	BY122	0·37½	OA70	0·07½
IS120	0·15	BA141	0·32½	BY124	0·15	OA73	0·10
IS121	0·17½	BA142	0·32½	BY126	0·15	OA79	0·09
IS130	0·12½	BA144	0·12½	BY127	0·17½	OA81	0·07½
IS131	0·12½	BA145	0·20	BY164	0·57½	OA85	0·07½
IS132	0·15	BA154	0·12½	BYX10	0·22½	OA90	0·07½
IS940	0·07½	BA156	0·22½	BYZ10	0·35	OA91	0·07½
AA119	0·10	BAX13	0·12½	BYZ11	0·32½	OA95	0·07½
AA129	0·10	BAX16	0·12½	BYZ12	0·30	OA200	0·10
AAZ13	0·10	BAY18	0·17½	BYZ13	0·25	OA202	0·10
AAZ15	0·12½						

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5 amp (Douglas) MT107 Sec. tappings from 6v to 50v .. 5·50
Post and packing 0·37½.
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				DIACS	
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SC40D	1·50	40486	0·95	MPT28	0·37½
SC41D	1·20	40528	0·72½	MPT32	0·37½
SC45D	1·62½	40430	1·30	MPT36	0·37½
SC46D	1·42½	40432	1·37½	ST2	0·21
SC50D	2·05	40512	1·45	40583	0·27½

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4	10	0·07½	50	12	0·07½	640	16	0·17½
4	40	0·07½	50	25	0·07½	1000	16	0·18
4	350	0·11	50	50	0·10	1000	25	0·25
5	18	0·07½	64	25	0·07½	1000	50	0·37½
5	50	0·07½	80	16	0·07½	2000	25	0·37½
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8	40	0·07½	100	6·4	0·07½	2500	12	0·25
8	450	0·15	100	12	0·07½	2500	25	0·42½
10	12	0·07½	100	25	0·10	2500	50	0·57½
10	25	0·07½	100	50	0·12½	2500	64	0·80
12·5	25	0·07½	125	10	0·07½	3000	25	0·45
16	10	0·07½	200	10	0·07½	4000	100	2·37½
16	15	0·07½	250	25	0·14	4500	64	2·25
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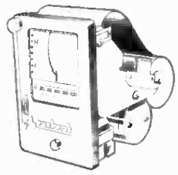

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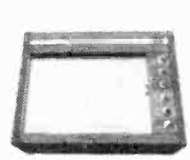
Fully overhauled. Calibrated (Certified) and Guaranteed.

Specification: Scale: 109999. D.C. Accuracy: 0·001% F.S.D. Range: 10 micro V-1·1 kV; I/P Z greater than 25,000 M ohm; C.M.R. D.C. 160 dB. 50 Hz 130 dB O/P. Parallel B.C.D. Inductive potentiometric system for excellent stability. Price: **£850** (new price over £2,000).

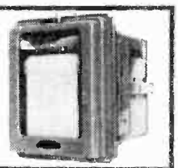


ELECTRONIC ASSOCIATES VARIPLOTTER 1100E

X-Y plotter, suitable for recording analogue information. Table size 15 in. × 10 in.; slew speed 20 in./sec: i/p sensitivity for F.S.D. 0·05-20V in 9 ranges: Basic i/p sensitivity: Arm 10m V/in; Pen 1 v/in. Fully overhauled, tested, guaranteed and in new condition. Price: **£350**.

FACSIMILE RECORDERS

D649 K 18 in. Chart Recorder. Helix speed: 60, 90, 120 rev./min. Transmission speed: ⅝ in.; 15/16 in.; 1⅛ in. per min. Scanning rate 96 lines/in.
Ref. C.3........ Price **£350**. Completely overhauled + carriage



SINGLE PEN RECORDER By Record Electrical (R3)

3 in. chart, sensitivity 1 mA. Coil resistance 1·53k. Fully interchangeable gears available to make a wide range of chart speeds. 200/250V. Size: 8×11×6 in. List over £100.
Our price .... **£49·50**

MULTIMETER TYPE CT471B

Fully transistorized multi-range instrument for measurement of voltage up to 1000 MHz (1500 MHz with reduced accuracy) and current up 2 kHz and D.C. Resistance A.C. and D.C. voltage and current divided into 11 ranges.
A.C./D.C. Volts 12mV-1200V.
A.C./D.C. Current 12 micro A-1·2A.
D.C. Resistance 5 ranges 0·1 ohm-1000 M ohm.
R.F. Voltages 5 range 40mV to 4V.
Battery powered. Offered in excellent condition. Tested before despatch. Complete with handbook. **£54**. Carriage 10/-.

WELDING POWER SUPPLY—Hughes Model

MCW 550. Constant voltage. Weld voltage and duration controls. Mains input. Price **£125**.

NEW LOW INERTIA INTEGRATING MOTORS

Electro-Methods Model. 901 and 906 PL. Permanent magnet D.C. Motor. High sensitivity. Ideal for instrument-type servo mechanisms, light loads driving mechanical counters performing integration, or as small power generators. Will operate directly off a photo-cell or thermo couple, etc. 6V. Nominal. Typical parameters. Starting voltage (no load) 15 mV at 0·375 mA. Full load speed 1845 r.p.m. (approx.). Moment of Inertia of Armature 1·8 gr. cm/cm. Weight of Motor 300 gms (approx.). **£15**. P. & P. included.

E.H.T. GENERATOR, BRAND NEW D.C. CONVERTER MULLARD TYPE 1049

Input 12V D.C. 0·3A. Output 1800V (Min) at 1 mA, 2500V (Min) on No Load. Full spec. and circuit provided. Encapsulated module L. 5in., W. 2⅛in., H. 1⅞in. **£5·50**. P. & P. included.

MIDGET POWER RELAY Type Mk 1 (OMRON)

230V 50 Hz Coil, 1 pole double throw. Unused. Faulty plating on frame.
5 for **£1·50**. P. & P. included.

R.F. ATTENUATOR MARCONI TF 1073A

DC—150 MHz 1dB steps 75 Ohms. Double Screened construction. Tested and in VG condition. **£25**.

ACTUATOR

By English Electric. Type 4519 Mk. 1 D.C. Motor AE 1560 Mk. 1 28V 3A. 500 r.p.m. Intermittent rating. **£16**. P. & P. inclusive.

ACCELEROMETERS Model LA23C Potentiometric

± 10g. operating voltage 30V nominal resistance 17·5K. Price: **£26**. P. & P. 25p.
± 100g. operating voltage 34V nominal resistance 20K. Price: **£26**. P. & P. 25p.
Type SE55/A ± 1g. Price: **£26**. P. & P. 25p.
Type F. Ceramic type manufactured by G.E.C. up to 1000g. o/p 23mV. c.w. Technical leaflet 2BA stud mounting. Price: **£3·75**. P. & P. 25p.

SPLIT-FIELD D.C. SERVO MOTOR

Evershed and Vignoles Type. FAE 2/C/B, FB5A/A1/B, FEX25/CG/30, FB6A/P1/B, FAD6/G4/BD, FB5/A1, FE16/C. **£13·50**. P. & P. included.

NEW D.C. STEPPING MOTOR

"Slo-Syn." 14V 0·53A 50 oz in torque.
BIFILAR Synchronous Motor. Stepping duty 200 steps/shaft revolution. Each step 1·8 degrees + 3% accuracy. Non-cumulative. Made by Superior Electric Co., U.S.A. **£16·50**. P. & P. included.

TRANSDUCER OSCILLATOR-AMPLIFIER-DEMODULATOR.

An encapsulated unit. Suitable where space or adverse environmental conditions prevail. Supplied with a matching transducer a typical o/p is ± 3V into 50KOhms. Supply voltage 12v. D.C. Range of transducers available 0-50: 0-750: 0-1000: 0-4000 psi. Price **£65**

TRANSDUCERS

New K.D. Instruments Model TD 216. Resistive Bourdon Tube pressure transducer range 0-2000 p.s.i. Price: **£15**.

New Displacement Bonded Resistant Strain Gauge

Range ±⅛ mechanical displacement produces 0·3% resistive change. Nominal resistance 3·5 + 3·5 Kohm. Ex-Government Model No. 1T-2-31-35. Price: **£10**.

MARCONI T.F. 1168 HIGH DISCRIMINATION OSCILLATOR

Suitable for H.F. Communication applications. The 2 Hz discrimination makes this instrument ideally suitable for crystal filter response in Tx and Rx drive units in the frequency range 90-110 KHz. Crystal and standardised centre frequency. Calibration accuracy ±1%. Price: **£135**.

PEN RECORDERS Southern Instruments M.942C

4 channel fitted with 4 speed gearbox giving 1, 5, 25 and 100 mm/sec. Frequency response 0-55 Hz with a sensitivity of 25mA Price: **£150**.

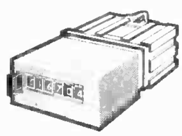
2 Pen Southern Instruments MR 450

2 channel wtih same spec. as 4 channel above. Price: **£90**.

E.M.I. INSTRUMENT L.F. TAPE RECORDER

Portable equipment consisting of 3 units (Deck, Amplifier and P.S.U.) in transit cases. Four speeds using standard ¼ in. tape. Exceptional value, two only available. Price: **£75**.

BRAND NEW ELECTRO-MAGNETIC COUNTER



A high precision counter offered at a fractional cost of other manufacturers of similar type. High counting speed. 25 impulse/sec. 6 digit display. 24 volt D.C. supply. 2·75 watts. 840 ohms. Size: 100mm × 50mm × 26mm. Immediate delivery. **£4·50**. (Carriage extra.) Other various voltage and impulse rates available. Phone or write for details.
110v D.C. version available **£2·98** (Ex equip.)

NUMICATORS

End Reading		Quantity	Price Each (Less Base)	Price
GRIOM/U (Clear)		1– 3	£1·40	Bases
		4– 10	£1·35	20p
		11– 25	£1·30	Each
		26–100	£1·20	
Side Reading				
XN3/FA	38 m/m lead	(Amber) ..		Less Bases
XN3/F	38 m/m lead	(Red) ..	1– 3	£1·15
XN3A/F	6 m/m lead	(Red) ..	4– 10	£1·10
XN3A	6 m/m lead	(Clear) ..	11– 25	£1·05
XN11/F	38 m/m lead	(Red) ..	26–100	£0·95
XN23/FA	38 m/m lead	(Amber) ..		
		Post Free		

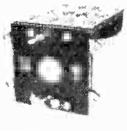
TELETYPE 8 HOLE PAPER PUNCH BRPE11 £260.

Also available 5 hole punch BRPE2 as above. This model has interchangeable heads. Complete with spooler. Price **£75**.

5/7 HOLE OPTICAL READER BY FERRANTI

20 characters per second. **£20**.

SINE COSINE POTENTIOMETER 47K

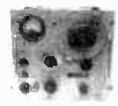


Precision component by Pye. Model 2002. Manufactured to rigid Ministry specification. The assembly consists of three units mounted in one frame. Each unit contains two sine and two cosine potentiometer sections, the sliders being ganged together. Electrical connections, 2 end taps, slider and centre tap. Mechanical I/P: 30 r.p.m. Max torque: 3½ oz./in. Dimensions: W. 6½ in., H. 5 in., D. 7½ in. Wt. 7½ lb. Very good condition. **£10·00** each. Carriage extra.

VHF ADMITTANCE BRIDGE

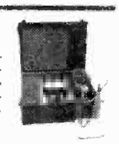
Wayne Kerr B801A. 1-100 MHz. Conductance 0-100 millimhos. Capacitance 0-230 pF and 0 to —230 pF. **£120** (40% of new price). Also **B901**. Indicates parallel components of conductance and positive or negative capacitance for lines, antennas and feeders. 0-100mMho. 0, to ± 75 pF and — 75 pF. Accuracy 2% up to 250 MHz. **£115** (40% of new price).

SIGNAL GENERATOR Advance D1/D



Advance D1/D. 10 MHz-300 MHz in 6 ranges. Modulation at 1 KHz 30Ω. Square Ware 1 KHz 100Ω Modulation. Attenuator 1 micro v.-10 mV in 5 steps. Fine attenuator. 0-10 db. I/P 80-240 v. 40/2000 Hz. W. 13½ in., H. 7⅞ in., D. 12½ in. Tested and in very good condition. **£45.00**. Carriage extra.

PH METER



Pye Model 11071. Portable battery operated. Rugged wooden case construction. Range 2-12 pH. Min. Scale Division: 0·2 pH. Temp. compensation, Manual 0-100 deg. C. Dimensions: W. 12 in., D. 9 in., H. 5 in. Wt. 9 lb. Very good condition, **£42.00**. P. & p. £1·00.

Industrial & Scientific Instruments Ltd.

Model 6A. Mains I/P. Very good condition. Can also be used as Millivoltmeter. Supplied in wooden carrying case. Complete with Electrode Stand. W. 23 in., H. 13½ in. D. 11 in. **£30.00**. Carriage extra.

PORTABLE FREQUENCY METERS

TF1026/1. A direct reading absorption meter, employing a concentric line closed at one end and turned by variable capacitor at the other end of the line, giving a frequency range: 250 MHz-500 MHz, on an almost linear scale approx. 9in. in length. Complete in polished wooden case. Price **£17·50**. Carriage extra.

DIGITAL INDICATORS KGM Type M3

A neat compact indicator providing selective display 0-9. Fig. height 18 mm. panel mounting. 6 mm. tubular midget flange lamps. Supplied with 28 v. bulbs. Finished matt black anodized. W. 1 in., H. 2 in. Wt. 4 ozs. Price **£3·25**. P. & p. Free.

MODEL 1706 VISICORDER

In almost new condition. This direct reading U/V Recorder can record up to 6 channels simultaneously from D.C. 5000 Hz at writing speed of 30000 in ohs/sec.

Recording range:	D.C.—5000 Hz.
Paper width:	4⅞ ins. wide.
Optical Arm:	19 cm.
Paper Speeds:	Eight speeds from 0·25—32 in./sec. and 6—800 mm/sec.
Dimensions:	H. 10½ in., W. 12 in., Depth 14 in.

Complete with 4 3k Hz Galvos. **£400**

BRAND NEW CAPACITOR REVERSIBLE SINGLE PHASE PARVALUX MOTORS

230/250 v. 50 Hz 2,800 r.p.m. 1/30 h.p. Cont. rated. $\frac{5}{16}$ in. shaft dia. × 3½ in. long. Foot mounting. Weight 6 lb. **£3·50** post free.

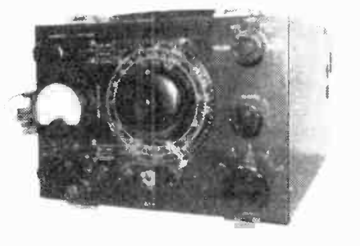
COAXIAL LINE OSCILLATOR

By Saunders. Type CLC 7-12. The Oscillator is adjustable from 7-12 MHz. A high reset accuracy with no backlash having ± ·1%. The instrument is supplied with a calibration chart and valve, and is suitable to be coupled to any waveguide size by using a coaxial to waveguide transformer. Price: **£55**.

3 PHASE VARIAC TYPE 50 BM

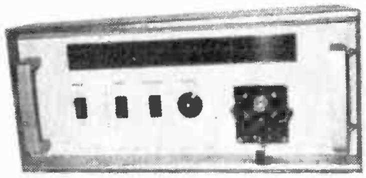
I/P 230 v. 50 Hz. O/P 0-270 v. 20A. per unit 60A in parallel (5·7 kVA). Mounted on trolley. H. 38 in., Dia. 15 in. **£80.00**. Carriage extra.

FIELD STRENGTH MEASURING SET RI NO. I



Manufactured to highest specification by Union Radio Company. Complete with Mains/Battery Power Unit, 5 Section Telescopic Aerial. Very good working condition. £75 (carriage extra).

ELLIOTT CONSTANT SPEED DRIVE UNIT TYPE 64D 2595



This unit can be used for the calibration of tacho-generators, testing and calibration of potentiometers or any test where an input in the form of a shaft rotation at a selected speed. Accuracy: Transistorised Crystal Oscillator (Temperature Controlled) 1 part in 100,000. Self-Checking: is provided by Stroboscope and illuminated displays. Shaft Speeds: 450-3,000 RPM. O/P Torque: 30 gm/cm. Power Supplies: 220-240V 50 Hz 1 phase or 115/200V, 400 Hz 3 phase. Size: W. 19¾ in., H. 8¾ in., D. 13 5/16 in. P.O.A.

PERKINS ELMER MODEL 240 ELEMENTAL ANALYZER

This precision instrument accurately determines the carbon, hydrogen and nitrogen content of organic compounds by detecting and measuring their products of combustion. This equipment has only had one user and is offered c/w a Leeds and Northrup Speedomax Recorder. Excellent condition. Manufacturers overhaul. 6 month guarantee. £3,000 (representing a saving of £1,000).

BARGAIN D.C. STABILISED POWER SUPPLY UNIT Price £9·50

Brand new solid state modular unit. I/P 110 v.-240 v. 50 Hz. O/P + 12 v. D.C.-12 v. D.C.- 24 v. D.C. w.r.t. common. All at 500 mA. I/P on/off switch. Fuse and warning light. Stabilisation 100/1 for + 10%-15% mains charge. Equivalent O/P resistance less than 50 M ohms. Ripple and noise less than 10 mV. Ambient Temp. Range 0-50°C. Dimensions: L. 9¾ in., H. 4¾ in., D. 4¾ in. Wt. 8½ lbs.

CONSTANT VOLTAGE TRANSFORMERS

Advance CVH 1500 A. Harmonic Filtered. I/P 190-260 v. 50 Hz., 1 phase. O/P 230 v. 1500 w. Unity PF. £50.00. Carriage extra.

ADVANCE MT 285ZA

I/P 190-260 v. 50 Hz., 1 phase. C/P 230v. 2 kW. Unity P.F. £35.00. Carriage extra.

X Y PLOTTERS

We are now able to offer the following Recorders in an overhauled and tested condition:

1. MOSELEY AUTOGRAF MODEL 2A
Table size: 11 in. × 17 in. Dimensions: W. 24 in., H. 9 in., D. 16 in. Wt. 55 lbs. Power I/P: 115 v. 1 phase 100 w. Signal I/P: X Axis 0-7½, 15, 75, 150, 750 mV; 0-1½, 7½, 15, 75, 150 v. Y Axis 0-5, 10, 50, 100, 500 mV; 0-1, 5, 10, 50, 100 v. Sensitivity not less than 200 k ohms/V. Accuracy: 0·25% FS on all ranges. Response speeds: 1 sec. for full scale. Supplied complete with copy of handbook. £310.00. Carriage extra.

2. HOUSTON INSTRUMENTS MODEL HR 934
Table size: 8½ in. × 10½ in. Dimensions: W. 14 in., H. 8 in., D. 16 in., Wt. 30 lb. Power I/P: 115 v. 1 phase. Signal I/P: "X" and "Y" Axis. 0-7, 7-8, 10, 19, 68 mV and 0-5 v. Switched Attenuators on both Axes. Response speeds: 2 sec. for full scale. £250.00. Carriage extra.

PRECISION POTENTIOMETERS

TEN TURN 3600° ROTATION (Ref. C5)
BRAND NEW

Res. Ohms	Linearity Per cent	Manufacturers	Model	Price
100/100/100		Beckman	A	£8·00
100	0·5	Beckman	A.S.	£3·00
200	0·5	Beckman	A	£3·00
500	0·1	Beckman	S	£3·50
500		Colvern	2501	£2·25
500		Foxes	PX4	£2·00
500		Colvern	2610	£2·50
500		Colvern	26/1000/11	£3·00
500	1·0	Relcon	HEL107-10	£2·25
1K		Relcon	HEL0710	£2·25
2K	0·5	Beckman	SA1101	£3·00
2K	0·25	Beckman	7216	£3·00
2K		Reliance	GPM15	£2·00
2K		General Controls	GPA15/4	£2·00
5K		Relcon	07-10	£2·50
5K		Colvern	CLR2503	£3·00
10K	0·5	Beckman	A	£3·00
10K	0·1	Beckman X	A	£3·50
10K	0·1	Colvern	CLR26/1001	£3·50
15K		Colvern	CLR2402	£3·00
18K		Beckman	A	£3·00
25K	0·5	Helipot	SA1337	£3·00
29K	0·05	Beckman	SA1244	£4·50
30K		Colvern	2402	£1·50
30K		Beckman	SA95C	£3·00
30K	0·1	Beckman	A.88	£3·50
30K	0·5	Beckman	SA1692	£3·00
30K	0·25	Beckman	SA1679	£3·25
30K	1·0	Colvern	2402/1	£1·50
50K		Reliance	07·10	£2·25
50K			07·5	£2·25
50K		Colvern	2503	£2·25
50K	X	Foxes	PX4	£2·25
50K	0·5	Beckman	A	£3·00
50K	0·1	Beckman	A	£3·50
100K/100K		Ford	A	£5·00
100K	0·1	Beckman	A	£3·50
100K	0·5	Beckman	A	£3·00
100K		Colvern	2501	£2·25
100K		Colvern	2610	£2·50
298K	0·1	Beckman	SA3902	£3·50
300K	0·1	Beckman	A	£3·50

THREE TURN 780° ROTATION

100/100	0·5	Beckman	C	£3·00
100/100		Beckman	Type C	£3·00
300		Beckman	9303	£2·25
1K		Fox	PX2/H3	£2·25
10K	0·5	Beckman	C.88	£2·25
20K/20K	0·1	Beckman	C.S.	£3·00
10K/10K	0·1	Beckman	C	£3·00
50K	0·5	Beckman	C.S.	£1·75

FIVE-AND-A-HALF TURN

500		Colvern	2405	£2·00

TWENTY TURN 7200° ROTATION

1 Meg	General Controls	PXM130	£4·00
50K	Reliance		£2·00

FIFTEEN TURN 5400° ROTATION

25K/25K	Beckman B	10 watts	£6·50
46K/46K	Beckman B	10 watts	£6·50

TRIM POTENTIOMETERS (Ref. C7)

Manufacturer	Value	Connection	Price
PAIGNTON	5 ohms	P.C.	50p
AMPHENOL	5 ohms	P.C.	50p
PAIGNTON	10 ohms	P.C.	50p
AMPHENOL	20 ohms	—	50p
AMPHENOL	50 ohms	—	50p
AMPHENOL	70 ohms	T.C. Turret Lugs	50p
AMPHENOL	75 ohms	P.C.	50p
MICROPOT	100 ohms	—	50p
AMPHENOL	200 ohms	P.C.	50p
AMPHENOL	250 ohms	P.C.	50p
AMPHENOL	300 ohms	P.C.	50p
PAIGNTON	500 ohms	T.C.	50p
AMPHENOL	600 ohms	P.C.	50p
PAIGNTON	1 Kohms	P.C.	75p
AMPHENOL	2 Kohms	P.C.	75p
PAIGNTON	2·5 Kohms	P.C.	75p
AMPHENOL	2·5 Kohms	T.C.	75p
AMPHENOL	3 Kohms	T.C.	75p
BOURNES	5 Kohms	Stud Connection	75p
BOURNES	5 Kohms	Flying lead	75p
AMPHENOL	10 Kohms	P.C.	£1
AMPHENOL	25 Kohms	P.C.	£1
AMPHENOL	30 Kohms	T.C.	£1

MONOCHROMATIC LIGHT "LAPMASTER"

110/220V. 1-ph. 50 Hz. Light area: 11in. × 8½in. £15·00. Carriage £2·00.

SOUND ANALYSER

General Radio Co. Type 760-A. Portable. Battery powered. Designed for use with Type 759 sound level meters, but can be used with any other microphone or vibration pick-up and amplifier with suitable characteristics. Supplied less microphone. £50. Carriage extra.

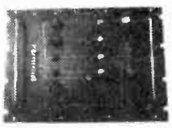
MARCONI TF899

20mV-2V A.C., 3 ranges. 50Hz-100MHz. Detected O/p for modulation monitoring RF probe. Mains P.S.U. Overhauled. £25. P. & P. £0·50.

PHILLIPS GM6020

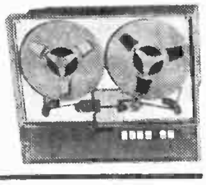
100 micro V-10V, input 1. 10mV-1000V input 2. 100 pA-10 micro A. Accuracy ± 3%. Input Z 1 M ohm, input 1, 100 M ohm, input 2. Recorder output. Working order £65. P. & P. £1.

ADVANCE STABILISED POWER SUPPLY Model D.C. 207A 24v 8A



Built to the highest specifications for continuous use in computor installations. 19 in. rack mounting; 200/250v. 50 Hz I/P: o/p 24v 8 amp floating; —20v 2 amp; —10v 3 amp; +10v 5 amp; + 20v 9 amp w.r.t. common. Price: £69.

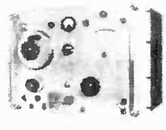
HONEYWELL MODEL 6200 INCREMENTAL DIGITAL RECORDER



Records digital (binary) data on 7 track ½ in. tape in steps of 0·005 in. with a packing density of 200 bits/inch. Almost new and in excellent condition. This recorder offers excellent value for many applications involving date, logging. One only available. Price: £750.

SIGNAL GENERATOR "X" BAND

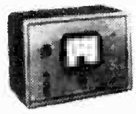
SANDERS MODEL CT 480 (SG 480) and CT 478 (SG 478). Specifications: CT 480 8-11·5 KMHz; CT 478 1·3-4·2 KMHz. O/P of 1mW from 8·0-11·0 KMHz (CT 480) and 1·5-4·0 KMHz (CT 478). These high grade generators comprise a klystron oscillator in a co-axial cavity fed from a stable power source. Provision for application of square ware or pulse modulation internal or external sources. Attenuator calibrated from 0-100 db below 1 mW. I/P 110-250 v. 50-500 Hz. 200 w. Rack mounting. W. 19 in., H. 14 in., D. 15 in. Wt. 74 lb. Supplied complete with copy of handbook. Tested before despatch. £275. Carriage extra.



DEVIATION METER Marconi TF 928

20-100 MHz. Can be used to 500 MHz. Measurement of deviation up to 400 KHz. Crystal Standard. Used in setting up deviation in VHF Wide Band Multi Channel FM Systems and Radar. I/P 100-150 v. and 200-250 v. 40-100 Hz 120 w. H. 14", W. 20½", D. 17" Wt. 70 lb. £95·00. Carriage extra.

VIBRON ELECTROMETER MODEL 33B



An exceptionally stable laboratory instrument for the measurement of very small d.c. voltages and currents derived from a high impedance source. The Vibron Electrometer has input ranges of 10 mV, 30 mV, 100 mV, 300 mV and 1 V and the output is 1 mA full scale on all ranges. The zero drift does not exceed 100 microvolts in 12 hours and the input resistance is 10 to the power of 13 ohms. £75 (carriage extra).

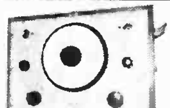
SOLARTRON OSCILLATOR CO546

25Hz-500kHz. Attenuator and O/P meter. Very good condition. £55 (carriage extra).

RCA U.H.F. SIGNAL GENERATOR Type 710A

Frequency range 370-560 MHz. Modulation facility. I/P 117V 50/60 Hz 50w. Overhauled and supplied complete with auto transformer for 230/250 V i/p. £85 (carriage extra).

FREQUENCY & DISTORTION MEASURING BRIDGE TYPE 1607



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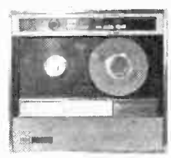

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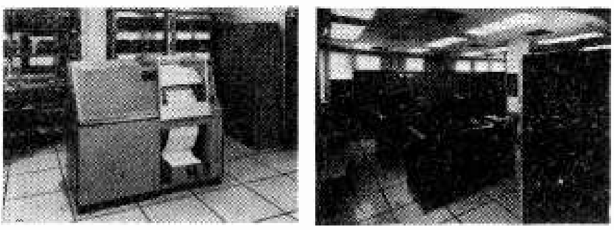

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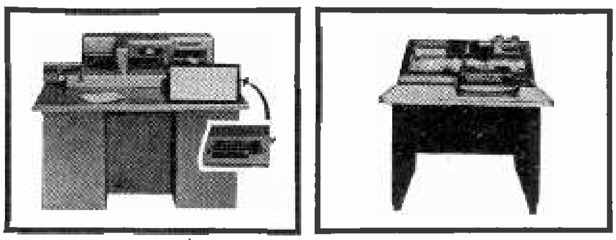

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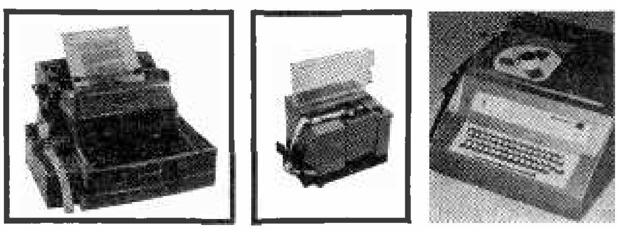

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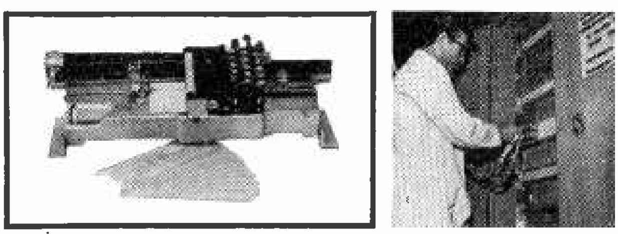

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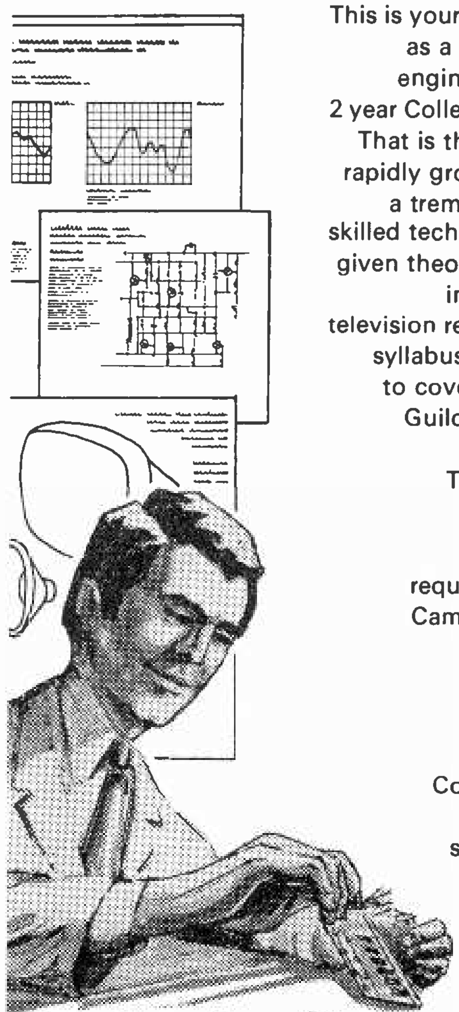

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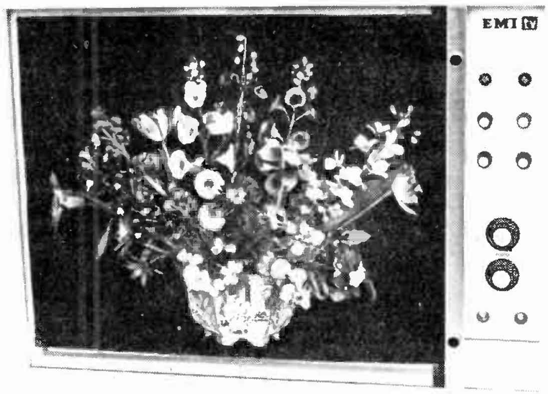

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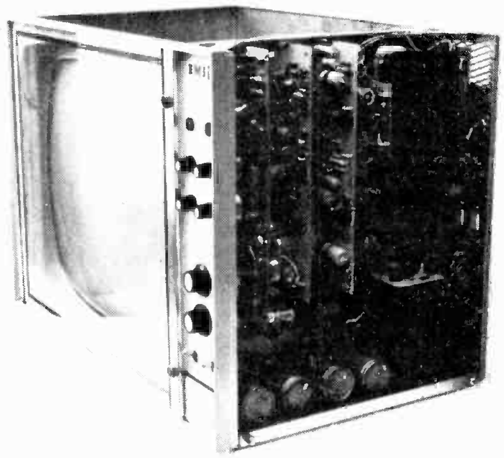

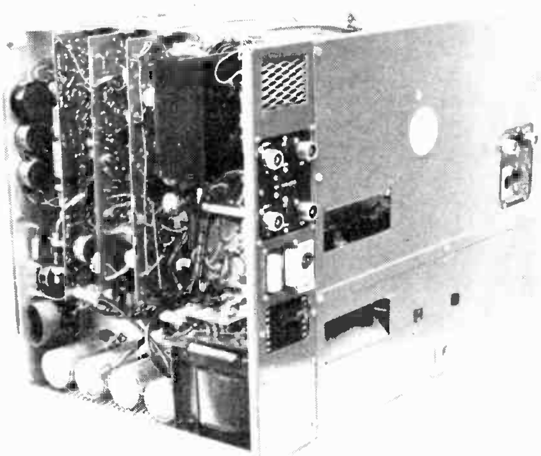

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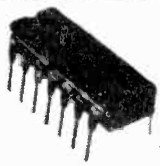

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uL900	40p	35p	32p
uL914	40p	35p	32p
uL923	53p	50p	47p

Devices may be mixed to qualify for quantity price.

G.E. (U.S.A.)

PA230	Pre-amp	£1·10
PA234	1 watt Amp	£1·00
PA237	2 watt Amp	£1·87
PA246	5 watt Amp	£2·63
PA424	Zero Volt Switch	£2·45

MISC

TH9013P	Toshiba 20 watt Hybrid IC Amp	£4·47
IC10	Sinclair	£2·75
SL403A	Plessey New Design	£2·12

Mullard

TAA263	Linear Amp	75p
TAA293	Gen. Purp. Amp	£1·00
TAA310	Record/Playback Amp	£1·50
TAA320	MOS LF Amp	65p
TAD100	IC Receiver	£1·97
TAD110	AM/FM Receiver	£1·97

ULTRASONIC TRANSDUCERS

Operate at 40 kc/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 .. .. £5·90
(Sold only in pairs)

NEW! "SONALERT"

Solid state alarm device as used in many American alarm circuits 70-80 DB of noise—operates on 6-28v. 3-14mA.

£5·50 each

IOR

DD119	Heat sink compound—Silicone grease	30p
DD170	Bargain pack of 5 1-watt Zener diodes	97p
DD175	4 pieces 100 PRV Rectifiers 500mA	50p
DD176	2 pieces 200 PRV Rectifiers 500mA	30p
DD177	2 pieces 400 PRV Rectifiers 500mA	50p
DD180	Bargain Transistor pack 2 AF+RF	57p
DD184	Assortment of RF, audio and power transistor solar cell and diode	£1·67
DD190	Pack of 4 assorted solar cells	50p
EP50A	Solar motor (operates from S4M)	£1·97
S1M	Silicon Solar cell 10-16mA	95p
S4M	Silicon Solar cell 25-40mA	£1·67
B2M	Low cost Selenium solar cell	63p
B3M	Selenium cell in protective case	75p
CS120	Cadmium Sulphide photoconductive cell	98p

Only part of the International Rectifier "Diamond Line" range are listed. Send for free catalogue or ask your local component stockist.

ENCAPSULATED BRIDGES

Type No.	Current	RMS Volts	Price
W005	1 Amp	50	50p
W06	1 Amp	600	65p

ELECTROVALUE

EVERYTHING BRAND NEW TO SPEC • LARGE STOCKS • NO SURPLUS

BARGAINS IN NEW SEMI-CONDUCTORS

MANY AT NEW REDUCED PRICES • ALL POWER TYPES WITH FREE INSULATING SETS

40361	55p	2N2905	44p	2N4291	15p	BC148	9p	BFX87	29p
40362	68p	2N2905A	47p	2N4292	15p	BC149	10p	BFX88	26p
2N696	20p	2N2924	20p	AC107	46p	BC153	19p	BFY50	23p
2N697	22p	2N2925	22p	AC126	20p	BC154	20p	BFY51	20p
2N706	12p	2N2926	11p	AC127	20p	BC157	12p	BFY52	23p
2N930	29p	2N3053	27p	AC128	20p	BC158	11p	BSX20	16p
2N1131	36p	2N3055	65p	AC153K	22p	BC159	12p	C407	17p
2N1132	40p	2N3702	13p	AC176	16p	BC167	11p	MC140	25p
2N1302	19p	2N3703	13p	ACY20	20p	BC168	10p	MPS6531	35p
2N1303	19p	2N3704	13p	ACY22	16p	BC169	10p	MPS6534	30p
2N1304	23p	2N3705	13p	AD140	56p	BC177	11p	NKT211	25p
2N1305	23p	2N3706	13p	AD142	50p	BC178	14p	NKT212	25p
2N1306	33p	2N3707	13p	AD149	60p	BC179	13p	NKT214	23p
2N1307	33p	2N3708	13p	AD161	33p	BC182L	14p	NKT274	18p
2N1308	36p	2N3709	13p	AD162	36p	BC183L	10p	NKT403	65p
2N1309	36p	2N3710	13p	AF114	30p	BC184L	10p	NKT405	79p
2N1613	23p	2N3711	13p	AF115	30p	BC212L	16p	OC71	29p
2N1711	26p	2N3819	35p	AF117	28p	BC213L	16p	OC81	25p
2N1893	54p	2N3904	35p	AF124	30p	BC214L	16p	OC83	20p
2N2147	95p	2N3906	35p	AF127	28p	BCY70	19p	ZTX300	12p
2N2218	34p	2N4058	13p	AF139	33p	BCY71	33p	ZTX301	16p
2N2218A	43p	2N4059	10p	AF239	36p	BCY72	15p	ZTX302	22p
2N2219	33p	2N4060	11p	ASY26	27p	BF115	23p	ZTX303	22p
2N2219A	53p	2N4061	11p	ASY28	27p	BF167	18p	ZTX304	27p
2N2270	62p	2N4062	12p	BC107	12p	BF173	19p	ZTX500	18p
2N2369A	19p	2N4124	18p	BC108	11p	BF194	14p	ZTX501	21p
2N2483	35p	2N4126	27p	BC109	12p	BF195	15p	ZTX502	25p
2N2484	42p	2N4284	15p	BC125	15p	BFX29	31p	ZTX503	22p
2N2646	54p	2N4286	15p	BC126	22p	BFX84	25p	ZTX504	52p
2N2904A	42p	2N4289	15p	BC147	10p	BFX85	34p		

RESISTORS

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99	100 up
C	1/20W	5%	82Ω–220KΩ	E12	9	8	7·5
C	1/8W	5%	4·7Ω–330KΩ	E24	1	0·8	0·7
C	1/4W	10%	4·7Ω–10MΩ	E12	1	0·8	0·7
C	1/2W	5%	4·7Ω–10MΩ	E24	1·2	1	0·9
C	1W	10%	4·7Ω–10MΩ	E12	2·5	2	1·8
MO	1/2W	2%	10Ω–1MΩ	E24	4	3·5	3
WW	1W	10% ± 1/20Ω	0·22Ω–3·9Ω	E12	7	7	6
WW	3W	5%	12Ω–10KΩ	E12	7	7	6
WW	7W	5%	12Ω–10KΩ	E12	9	9	8

(see note below).

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW= wire wound, Plessey.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions on total value of resistor order.)

Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

ZENER DIODES 5% full range E24 values: 400mW: 2·7V to 30V, **15p each**; 1W: 6·8V. to 82V, **27p each**; 1·5W: 4·7V to 75V, **60p each.**
Clip to increase 1·5W rating to 3 watts (type 266F), **4p.**

CARBON TRACK POTENTIOMETERS, long spindles. Double wiper ensures minimum noise level.
Single gang linear 100Ω to 2·2MΩ, **12p**; Single gang log, 4·7KΩ to 2·2MΩ, **12p; Dual gang** linear 4·7kΩ to 2·2MΩ, **42p**; Dual gang log, 4·7KΩ to 2·2MΩ, **42p**; Log/antilog, 10K, 47K, 1MΩ only **42p**; Dual antilog, 10K only, **42p.** Any type with ½A D.P. mains switch, **12p** extra.
Only decades of 10, 22 & 47 available in ranges quoted.

CARBON SKELETON PRE-SETS
Small high quality, type PR, linear only: 100Ω, 220Ω, 470Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M2, 5M, 10MΩ. Vertical or horizontal mounting, **5p each.**

COLVERN 3 watt Wire-wound Potentiometers. 10Ω, 15Ω, 25Ω, 50Ω, 100Ω, 250Ω, 500Ω, 1K, 1·5K, 2·5K, 5K, 10K, 15K, 25K, 50K, **32p each.**

ENAMELLED COPPER WIRE even No. SWG only: 2 oz. reels: 16-22 SWG **25p**; 24-30 SWG **30p**; 32, 34 SWG, **33p**; 36-40 SWG, **35p.**
4 oz. reels: 16-22 SWG only **42p.**

TYGAN SPEAKER MATERIAL
7 designs, 36 × 27 in. sheets, **£1·57** sheet.

MULLARD polyester C280 series
250V 20%: 0·01, 0·022, 0·033, 0·047 **3p each;** 0·068, 0·1, **4p each;** 0·15, **4p;** 0·22, **5p.** 10%: 0·33, **7p;** 0·47, **8p;** 0·68, **11p;** 1μF, **14p;** 1·5μF, **21p;** 2·2μF, **24p.**

MULLARD SUB-MIN ELECTROLYTICS
C426 range, axial lead .. .. .. 6p each
Values (μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·5/64; 4/10; 4/40; 5/64; 6·4/6·4; 6·4/25; 8/4; 8/40; 10/2·5; 10/16; 10/64; 12·5/25; 16/40; 20/16; 20/64; 25/6·4; 25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2·5; 50/6·4; 50/25; 50/40; 64/4; 64/10; 80/2·5; 80/16; 80/25; 100/6·4; 125/4; 125/10; 125/16; 160/2·5; 200/6·4; 200/10; 250/4; 320/2·5; 320/6·4; 400/4; 500/2·5.

LARGE CAPACITORS
High ripple current types: 1000/25, **28p**; 1000/50, **41p**; 1000/100, **82p**; 2000/25, **37p**; 2000/50, **57p**; 2000/100, **£1·44**; 2500/64, **77p**; 2500/70, **98p**; 5000/25, **62p**; 5000/50, **£1·10**; 5000/100, **£2·91**; 10000/25, **£1·40**; 10000/50, **£2·40.**

COMPONENT DISCOUNTS
10% on orders for components for £5 or more.
15% on orders for components for £15 or more.
(No discount on nett items.)

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Free on orders over £2. Please add 10p if orders under £2.
Overseas orders welcome: carriage and insurance charged at cost.
Send S.A.E. for latest list. Prices subject to alteration without notice.

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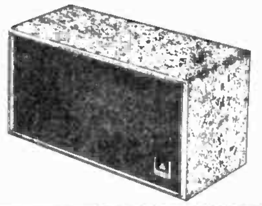
NEWMARKET TRANSISTORS.

PEAK SOUND



BAXANDALL SPEAKER SYSTEM

Designed by Peter Baxandall. Superb reproduction for its size. Handles 10 watts with ease. Uses ELAC 15Ω 59RM109 speaker unit. Kit **£13·90** nett; built **£19·42** nett.

MAINLINE AMPLIFIER KITS

RCA/SGS designed main amplifier kits. Input sensitivity 500–700mV for full output into 8Ω.

Power	Kit price including components	Suitable unreg. power supply kit
12W	£8·40 nett	£4·82
25W	£9·75 nett	£5·92
40W	£10·50 nett	£6·03
70W	£12·60 nett	£6·87

30 WATT BAILEY AMPLIFIER PARTS

Sensitivity 1·2V for full output into 8Ω.
Transistors and PCB for one channel **£6·30**
Transistors and PCBs for two channels **£12·72**
Capacitors and resistors (metal oxide), **£1·95** per channel
Complete unregulated power supply pack, **£4·75**
Suitable heat sink 10DN space 400c, **55p**

INTEGRATED CIRCUITS

PLESSEY SL403A 3 watts into 7·5 ohms. **£2·10** nett Application data **10p**
SINCLAIR IC.10 as advertised, complete with instructions and applications manual **£2·95** nett. Components pack for stereo inc. transformer, controls, etc., **£4·75** nett.

S-DECS PUT AN END TO BIRDS NESTING
Components just plug in—saves time—allows re-use of components. S-Dec (70 points), **£1·00**
Complete T-Dec, may be temperature-cycled (208 points), **£2·50**
Also μ-Decs and IC carriers.

INDICATOR LAMPS
NEON chrome bezel, round red NR/R, **24p**; chrome bezel, round amber NR/A, **24p**; chrome bezel, round clear NR/C, **24p.** Neon, square red type LS5C/R, **17p**; amber type LS5C/A, **17p**; clear type LS5C/C, **17p.** All above are for 240v. mains operation. **Filament types:** 6v. 0·04A square red type LS5C/R-6v., **20p**; 6v. 0·04A amber type LS5C/A-6v., **20p**; 6v. 0·04A clear type LS5C/C-6v., **20p**; 6v. 0·04A green type LS5C/G-6v., **20p**; 12v. 0·04A LS5C/R-12v., **23p**; 28v. 0·04A LS5C/R-28v., **28p.**

DIN CONNECTORS

		plug	socket
Loudspeaker	2-pole	12p	10p
Audio	3-pole	13p	10p
Audio	4-pole	14p	12p
Audio	5-pole 180deg.	15p	12p
Audio	5-pole 240deg.	15p	12p
Audio	6-pole	15p	13p

TOGGLE SWITCHES, 250V a.c. 1·5A.
chrome dolly and chrome milled nut S.P.S.T. **19p**, S.P.D.T. **25p** D.P.D.T. **29p**; S.P.D.T. centre off **22p**
WAVECHANGE SWITCHES
LONG SPINDLES
1P 12W; 2P 6W; 3P 4W; 4P 3W **24p each**
SLIDER SWITCHES D.P.D.T. **15p each**
CORED SOLDER—64/40 alloy, 20 s.w.g. 8oz. reel, **65p**, 1lb. reel, **£1·20.**

HANDBOOK OF TRANSISTOR EQUIVALENTS & SUBSTITUTES 40p. (Post 3p if ordered alone.)

ELECTROVALUE

DEPT. WW.671, 28 ST. JUDES ROAD, ENGLEFIELD GREEN, EGHAM, SURREY,
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Complete Stereo System £43

This superb stereo system is a real price breakthrough. It comprises the VISCOUNT F.E.T. Mk I amplifier on which full details are given below, the famous Garrard SP 25 Mk III (including teak veneer base and transparent cover) with diamond cartridge or 2025 TC and the very successful DUO type 2 speakers.

Measuring 17½" x 10¾" x 6¾" the Duo type 2 speakers are teak finished with matching Vynair grills. They incorporate a 3 ohm, 13" x 8" drive unit and Parasitic tweeter. Max. power handling 10 watts. Price £14 per pair plus p&p £2.

WITH MK II amplifier and magnetic cartridge £48 plus £2.50 P&P.

The Viscount **F.E.T.** Mk I **£14.25** plus 50p P. & P.

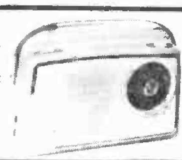
High fidelity transistor stereo amplifier employing field effect transistors. With this feature & accompanying guaranteed specifications below, the Viscount F.E.T. vastly surpasses amplifiers costing far more. *Size: 12½" × 6" × 2¾" in simulated teak case.*

Specification: Output per channel 10 watts r.m.s. into 3 ohms. Frequency bandwidth 20 Hz to 20 kHz ± 1 dB @ 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 26 dB.
Signal to noise ratio: 70 dB on all inputs (with vol. max).
Controls: 6 position selector switch (3 pos. stereo & 3 pos. mono). Separate Vol. controls for left & right channels. Bass ± 14 dB @ 60 Hz. Treble (with D.P.S. on/off) ± 12 dB @ 10 kHz. Tape Recording output sockets on each channel.

BUILT & TESTED.
Mk II (MAG. P.U.) £15.75 *plus 50p p&p*
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 ± 1 dB RIAA. Signal to noise ratio—65 dB (vol. max).

Elegant Seven Mk 3 (350mW)
7 transistor fully-tunable M.W.-L.W. superhet portable Set of parts. Complete with all components, including ready etched and drilled printed circuit board—back printed for foolproof construction.
MAINS POWER PACK KIT 75p extra
Price **£5.25** plus 50p P. & P.
Circuit 13p FREE WITH PARTS



The Dorset (600 mW)
7-transistor fully tunable M.W.-L.W. superhet portable—with baby alarm facility. Set of parts. The latest modulised and pre-alignment techniques makes this simple to build. Sizes: 12 x 8 x 3in.
MAINS POWER PACK KIT 75p extra.
Price **£5.25** plus 50p P. & P.
Circuit 13p FREE WITH PARTS

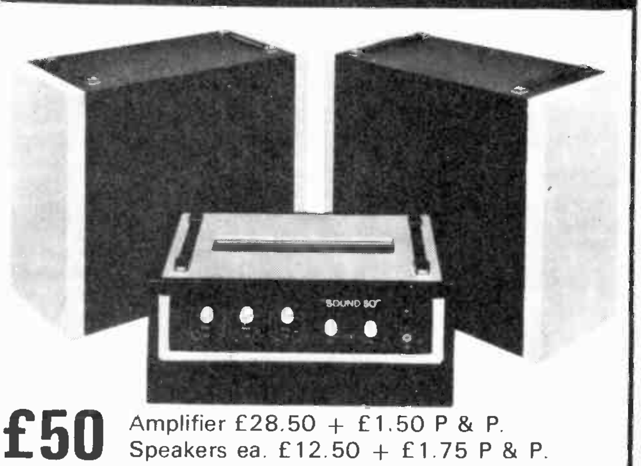
SOUND 50

SOUND 50 AMPLIFIER AND SPEAKER SYSTEM

The Sound Fifty valve amplifier and speakers are sturdily constructed with smart housings and thoroughly tested electronics. They are designed to last—to withstand the knocks and bumps of life on the road. Built for the small and medium sized gig, they are easy to handle and quick to set up and can be relied upon to come over with all the quality and power you need.

Output Power: 45 watts R.M.S. (Sine wave drive). *Frequency response:* –3 db points 30 Hz at 18 KHz. *Total distortion:* less than 2% at rated output. *Signal to noise ratio:* better than 60 db. *Speaker Impedance:* 3, 8 or 15 ohms. *Bass Control Range:* ±13 db at 60 Hz. *Treble Control Range:* ±12 db at 10 KHz. *Inputs:* 4 inputs at 5 mV into 470 K. Each pair of inputs controlled by separate volume control. 2 inputs at 200 mV into 470 K.

To protect the output valves, the incorporated fail safe circuit will enable the amplifier to be used at half power. *SPEAKERS:* Size 20" x 20" x 10" incorporating Baker's 12" heavy duty 25 watt high flux, quality loudspeaker with cast frame. Cabinets attractively finished in two tone colour scheme—Black and grey.



COMPLETE SYSTEM **£50** plus £4 P & P

Amplifier £28.50 + £1.50 P & P.
Speakers ea. £12.50 + £1.75 P & P.

LIQUIDATED STOCK

DANSETTE

TOURISTE MK3
CAR RADIO
ALL TRANSISTOR

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" x 2" x 4½" deep.

Originally sold completely built for £15.23

SET OF PARTS £6.30 Plus 50p P. & P.

Circuit diagram 13p. Free with parts. Speaker, baffle and fixing kit £1.25 extra plus 20p P & P.

Postage on speaker free when ordered with parts.

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2N1307	25p
2N1308	30p
2N1309	25p
2N1613	22p
2N1711	25p
2N2147	75p
2N2160	65p
2N2218	30p
2N2219	32p
2N2222	30p
2N2222A	37p
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2N3819	35p
2N3820	60p
2N4058	17p
2N4061	15p
2N5457	35p
2N5458	37p
2N5459	50p
28301	50p
2S302	50p
2S303	60p
2S304	75p
40250	50p
40361	55p
40362	60p
AAY30	10p
AAY42	15p
AAZ13	12p
AAZ17	10p
AC107	37p
AC126	25p
AC127	25p
AC128	25p
AC176	25p
AC187	30p
AC188	30p
ACY17	30p
ACY18	25p
ACY19	25p
ACY20	22p
ACY21	22p
ACY22	17p
ACY39	50p
ACY40	15p
AD140	50p
AD149	50p
AD161	37p
AD162	37p
AF114	25p
AF115	25p
AF116	25p
AF117	25p
AF118	62p
AF124	25p
AF125	20p
AF126	17p
AF127	17p
AF139	30p
AF178	47p
AF179	47p
AF180	52p
AF181	42p
AF186	40p
AF239	42p
ASY26	25p
ASY27	32p
ASY28	25p
ASY29	30p
ASY67	47p
ASZ21	42p
BA115	7p
BA164	10p
BAX13	6p
BAX16	7p
BAY31	7p

BAY38	17p
BC107	12p
BC108	12p
BC109	12p
BC113	25p
BC114	35p
BC115	32p
BC116	40p
BC116A	45p
BC118	37p
BC119	50p
BC134	37p
BC135	30p
BC136	35p
BC137	40p
BC138	40p
BC147	17p
BC148	12p
BC149	20p
BC154	37p
BC157	20p
BC158	17p
BC159	20p
BC177	25p
BC178	25p
BC179	27p
BCY30	25p
BCY31	30p
BCY32	50p
BCY33	25p
BCY34	30p
BCY38	40p
BCY39	60p
BCY40	50p
BCY41	15p
BCY42	15p
BCY43	20p
BCY58	25p
BCY59	25p
BCY70	20p
BCY71	30p
BCY72	15p
BCY78	30p
BCY79	30p
BCZ10	35p
BCZ11	40p
BD112	50p
BD121	65p
BD123	80p
BD124	80p
BD125	50p
BD131	75p
BD132	85p
BD153	62p
BD156	57p
BD131	75p
BDY10	£1·25
BDY11	£1·62
BDY17	£1·50
BDY18	£1·75
BDY19	£1·97
BDY61	£1·25
BDY62	£1·00
BF115	25p
BF152	30p
BF154	40p
BF158	30p
BF159	60p
BF167	25p
BF170	35p
BF173	30p
BF177	40p
BF178	25p
BF179	40p
BF180	37p
BF181	37p
BF182	32p
BF184	25p
BF185	25p
BF194	17p
BF195	15p
BF196	15p
BF197	15p
BF200	37p
BF274	37p
BFW87	25p
BFW88	23p
BFW89	20p
BFW90	22p
BFW91	20p
BFX13	25p
BFX29	30p
BFX30	32p
BFX37	32p
BFX84	30p
BFX85	40p
BFX86	32p
BFX87	32p
BFX88	30p
BFY18	30p
BFY50	22p
BFY51	20p
BFY52	22p
BFY53	17p
BFY64	42p
BFY90	65p

BSX20	17p
BSX21	37p
BSX76	15p
BSY95	15p
BSY95A	15p
BY100	15p
BY126	15p
BY127	20p
BY182	85p
BYZ10	40p
BYZ11	35p
BYZ12	30p
BYZ13	25p
BYZ15	£1·00
GET102	30p
GET111	40p
GET880	37p
GET882	25p
MAT100	25p
MAT101	30p
MAT120	25p
MAT121	30p
MJ2801	£1·37
MJ2901	£2·25
MJE370	97p
MJE520	87p
MJE2955	£1·37
MJE3055	87p
MPF102	42p
MPF103	35p
MPF104	37p
MPF105	40p
NKT213	25p
NKT214	15p
NKT216	37p
NKT217	40p
NKT277	20p
NKT403	75p
NKT404	62p
OA5	20p
OA9	10p
OA10	25p
OA47	10p
OA70	10p
OA73	10p
OA79	10p
OA81	10p
OA85	12p
OA90	10p
OA91	7p
OA95	7p
OA200	7p
OA202	10p
OC16	50p
OC20	97p
OC22	50p
OC23	60p
OC24	60p
OC25	37p
OC26	25p
OC28	62p
OC29	62p
OC35	50p
OC36	62p
OC41	25p
OC42	30p
OC43	40p
OC44	17p
OC45	15p
OC70	12p
OC71	15p
OC72	25p
OC73	30p
OC74	30p
OC75	25p
OC76	25p
OC77	40p
OC81	25p
OC82	25p
OC83	25p
OC84	25p
OC139	25p
OC140	37p
OC141	62p
OC170	25p
OC171	30p
OC200	40p
OC201	60p
OC202	75p
OC203	40p
OC204	40p
OC205	75p
OC206	90p
OC207	90p
OCP71	97p
ORP12	50p
ORP60	40p
ORP61	42p
ZTX107	15p
ZTX300	12p
ZTX500	20p
ZTX503	20p
ZTX531	30p

Discounts
10% 12+
15% 25+
20% 100+
Any one type

HENRY'S LOW COST INTEGRATED CIRCUITS

WE OFFER FROM STOCK AN EXCLUSIVE RANGE OF BRAND NEW CERAMIC FULL SPECIFICATION LOW COST TTL 7400 RANGE OF INTEGRATED CIRCUITS

Part No.	Description	Price 1-49	Price 50-99	Price 100-499	Price 500+
7400	Quad 2—Input Nand Gate	25p	20p	18p	15p
7401	Quad 2—Input Nand Gate Open Collector	25p	20p	18p	15p
7402	Quad 2—Input Positive Nor Gate	25p	20p	18p	15p
7404	Hex Inverter	25p	20p	18p	15p
7405	Hex Inverter with Open Collector	25p	20p	18p	15p
7410	Triple 3-Input Nand Gate	250	20p	18p	15p
7430	Single 8-Input Nand Gate	25p	20p	18p	15p
7440	Dual 4-Input Buffer Gate	25p	20p	18p	15p
7441	BCD to Decimal Decoder and N1X Driver	£1·00	90p	80p	75p
7442	BCD to Decimal Decoder (TTL)	£1·00	90p	80p	75p
7450	Dual 2-Input and/or/not Gate—Expandable	25p	20p	18p	15p
7453	Single 8-Input and/or/not Gate—Expandable	25p	20p	18p	15p
7460	Dual 4-Input—Expandable	25p	20p	18p	15p
7470	Single JK Flip Flop—Edge Triggered	40p	35p	30p	25p
7472	Single Master Slave JK Flip Flop	40p	35p	30p	25p
7473	Dual Master Slave JK Flip Flop	45p	40p	35p	30p
7474	Dual D Flip Flop	45p	40p	35p	30p
7475	Quad Bistable Latch	£1·00	90p	80p	75p
7476	Dual Master Slave Flip Flop with Preset	50p	45p	40p	35p
7483	Four Bit Binary Counter	£1·00	90p	80p	75p
7490	BCD Decade Counter	£1·00	90p	80p	75p
7492	Divide by 12. 4 Bit Binary Counter	£1·00	90p	80p	75p
7493	Divide by 16. 4 Bit Binary Counter	£1·00	90p	80p	75p
7494	Dual Entry 4 Bit Shift Register	£1·00	90p	80p	75p
7495	4 Bit Up Down Shift Register	£1·00	90p	80p	75p
7496	5 Bit Shift Register	£1·00	90p	80p	75p

Data available for above series in booklet form, price **10p**. *(Ref. No. 30) Larger quantity prices Extn. 4* Dual Inline 14 Pin Sockets **30p** each. 16 Pin **35p** each.

TRIACS GENERAL ELECTRIC

(All stud mounting)

Type	P.I. Volts	Current	1-49	50+	100+	500+
SC35A	100	3 amps	90p	75p	65p	60p
SC35B	200	3 amps	95p	80p	70p	65p
SC35D	400	3 amps	£1·00	85p	75p	70p
SC40A	100	6 amps	£1·00	85p	75p	70p
SC40B	200	6 amps	£1·20	£1·00	85p	80p
SC40D	400	6 amps	£1·25	£1·10	£1·00	90p
SC45A	100	10 amps	£1·25	£1·10	£1·00	90p
SC45B	200	10 amps	£1·35	£1·20	£1·10	£1·00
SC45D	400	10 amps	£1·50	£1·35	£1·20	£1·10
SC50A	100	15 amps	£1·65	£1·50	£1·35	£1·20
SC50B	200	15 amps	£1·75	£1·60	£1·45	£1·30
SC50D	400	15 amps	£2·00	£1·75	£1·60	£1·40
SC40E	500	6 amps	£1·50	£1·25	£1·10	£1·00
SC45E	500	10 amps	£1·75	£1·50	£1·35	£1·25
SC50E	500	15 amps	£2·25	£2·00	£1·75	£1·55

DIAC ST2 **20p**

Larger quantity prices on application Extn. 4

SILICON RECTIFIERS

1 AMP MINIATURE WIRE ENDED PLASTIC

Type	P.I.V.	1-49	50+	100+	500+	1000+
IN4001	50	8p	7p	6p	5p	4p
IN4002	100	9p	8p	7p	5½p	4½p
IN4003	200	10p	9p	7½p	6p	5p
IN4004	400	10p	9p	8p	7p	6p
IN4005	600	12p	10p	9p	7p	7p
IN4006	800	15p	14p	12p	11p	9p
IN4007	1000	20p	16p	13p	12p	10p

1·5 AMP MINIATURE WIRE ENDED PLASTIC

Type	P.I.V.	1-49	50+	100+	500+	1000+
PL4001	50	10p	9p	8p	7p	6p
PL4002	100	11p	10p	9p	8p	7p
PL4003	200	12p	11p	10p	9p	8p
PL4004	400	12p	11p	10p	9p	8p
PL4005	600	15p	13p	11p	10p	9p
PL4006	800	17p	15p	13p	12p	10p
PL4007	1000	20p	17p	15p	13p	11p

3 AMP PLASTIC WIRE ENDED RECTIFIERS

Type	P.I.V.	1-49	50+	100+	500+	1000+
PL7001	50	20p	18p	17p	16p	14p
PL7002	100	20p	19p	18p	17p	15p
PL7003	200	22p	20p	19p	18p	16p
PL7004	400	25p	23p	21p	20p	18p
PL7005	600	26p	24p	23p	22p	20p
PL7006	800	27p	25p	24p	23p	21p
PL7007	1000	30p	28p	26p	24p	22p

MINIATURE POTTED BRIDGE RECTIFIERS
(Silicon) Size ¼ in. × ½ in. × ⅜ in.

Type	P.I.V.	Current	1-49	50+	100+	500+
1002	100	2 amps	60p	55p	50p	45p
2002	200	2 amps	70p	65p	60p	55p
4002	400	2 amps	80p	75p	70p	65p
6002	600	2 amps	90p	80p	75p	70p
1004	100	4 amps	70p	60p	55p	50p
2004	200	4 amps	75p	70p	65p	60p
4004	400	4 amps	80p	75p	70p	65p
6004	600	4 amps	90p	80p	75p	70p
1006	100	6 amps	75p	70p	65p	60p
2006	200	6 amps	80p	75p	70p	65p
4006	400	6 amps	£1·10	£1·00	90p	80p
6006	600	6 amps	£1·25	£1·10	£1·00	90p

R.C.A. INTEGRATED CIRCUITS

Linear Types

CA3005	£1·20	CA3035	£1·25
CA3011	75p	CA3036	90p
CA3012	90p	CA3039	85p
CA3014	£1·45	CA3041	£1·10
CA3018	£1·10	CA3043	£1·40
CA3020	£1·25	CA3044	£1·25
CA3021	£1·55	CA3046	85p
CA3023	£1·25	CA3048	£2·25
CA3026	£1·00	CA3051	£1·35
CA3028A	£1·20		

Data Notes 10p *(Ref. No. 30)*

INTEGRATED CIRCUITS

MFC 4000P	Motorola	£1·12
I.C.10	Sinclair	£2·75
PA246	5 Watt	£2·45
TAA263	Mullard	75p
TAD100	Mullard	£1·97
TAD110	Mullard	£1·97
MC1303	Motorola	£2·60
UL900	Fairchild	40p
UL914	Fairchild	40p
UL923	Fairchild	60p
LA709C	Fairchild	75p
MC1304	Motorola	£2·75
PA230	G. Electric	£1·10
PA234	G. Electric	£1·00

Zener Diodes 400 M/W 5% Miniature
BZY 88 Range
All voltages 3·3 Volt-33 Volt.
15p each.
25 + ... 12p
100 + ... 10p
500 + ... 9p
1000 + ... 8p
Any one type.

Zener Diodes 1 Watt 5% Plastic Wire Ends
6·8 Volt all voltages to 100 Volts
25p each.
25 + ... 20p
100 + ... 18p
500 + ... 16p
1000 + ... 15p
Any one type.

Zener Diodes 3 Watt Plastic Wire Ends 5%
All voltages 6·8 -100 Volts. **30p** each.
25 + ... 27p
100 + ... 25p
500 + ... 23p
1000 + ... 21p
Any one type.

Zener Diodes 7 Watt Stud Mounting 5%
All voltages 5·1-100 Volts. **40p** each.
25 + ... 35p
100 + ... 30p
Any one type.

POWER RECTIFIERS

Stud Mounting 6 amp Range

	P.I.V.	1-49	50+	100+
BYZ10	800	40p	35p	30p
BYZ11	600	35p	30p	25p
BYZ12	400	30p	25p	20p
BYZ13	200	25p	20p	17p

10 amp Rectifiers

	P.I.V.	1-49	50+	100+
SK103	100	45p	40p	37p
SK203	200	50p	45p	42p
SK403	400	55p	50p	45p
SK603	600	60p	55p	50p
SK803	800	75p	70p	65p

SEMI-CONDUCTORS

LOOK AT THESE PRICES FOR QUANTITIES FROM STOCK

AF114 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p

AF116 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p

2N3055 **75p**
Mullard 115 watt Silicon Power
25 + 65p
100 + 55p
500 + 50p

BFY90 **65p**
1000 MC/S
25 + 60p
100 + 55p
500 + 50p
1000 + 45p

AF139 **30p**
Siemens V.H.F.
25 + 25p
100 + 22p..
500 + 19p
1000 + 17p

OC170 Mullard **25p**
25 + 21p
100 + 17p
500 + 15p

OC171 Mullard **30p**
25 + 27p
100 + 22p
500 + 20p

BY127 Mullard **20p**
1000v 1 amp Plastic
25 + 17p
100 + 15p
500 + 13p

BC113 **25p**
SGS
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OA202 **10p**
SILICON Diodes
25 + 8p
100 + 6p
500 + 5p
1000 + 4p

OC42 Mullard **30p**
25 + 25p
100 + 23p
500 + 21p
1000 + 18p

OC45 Mullard **15p**
25 + 13p
100 + 12p
500 + 10p
1000 + 8p

OC75 Mullard **25p**
25 + 21p
100 + 17p
500 + 15p
1000 + 13p

OC20 **97p**
Mullard 100v
25 + 85p
100 + 80p
500 + 75p

OC44 Mullard **17p**
25 + 15p
100 + 13p
500 + 11p
1000 + 10p

OC139 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC81 Mullard **25p**
25 20p
100 + 17p
500 + 15p
1000 + 13p

AF115 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p

AF117 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p

2N3819 Texas **35p**
25 + 30p
100 + 25p
500 + 23p
1000 + 20p

2N2646 **50p**
Motorola Unijunction
25 + 44p
100 + 37p
500 + 33p
1000 + 30p

AF186 **40p**
Mullard V.H.F.
25 + 35p
100 + 30p
500 + 25p
1000 + 23p

BYZ13 **25p**
Mullard 6a 200v
25 + 20p
100 + 17p
500 + 5p
1000 + 13p

BC107, BC108, BC109 **12p each**
I.T.T. Planars
25 + 11p
100 + 10p
500 + 8p
1000 + 6p

OCP71 **97p**
Mullard Photo
25 + 85p
100 + 80p
500 + 75p

OC28 **62p**
Mullard Power
25 + 55p
100 + 50p
500 + 42p
1000 + 40p

OC71 Mullard **15p**
25 + 12p
100 + 10p
500 + 8p
1000 + 7p

ORP12 Mullard **50p**
25 + 45p
100 + 42p
500 + 40p
1000 + 37p

2N930 **25p**
25 + 23p
100 + 20p
500 + 17p
1000 + 15p

OC72 Mullard **25p**
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC83 **25p**
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC84 **25p**
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

AF239 **42p**
25 + 35p
100 + 30p
500 + 25p
1000 + 20p

HENRY'S RADIO LTD. SEMI-CONDUCTOR DEPARTMENT
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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.** T.T.L. Digital SN 74N Series fully coded, brand new to Manufacturers' Specifications. Dual In-Line plastic 14 & 16 pin packages.

BI-PAK Order No.	Description	Price and Qty. 1-24	25-99	Prices 100 up
BP 00 = 7400	Quadruple 2-input NAND Gate	23p	20p	15p
BP 01 = 7401	Quadruple 2-input Positive NAND Gate (with open collector output)	23p	20p	15p
BP 02 = 7402	Quadruple 2-input Positive NOR Gates	23p	20p	15p
BP 03 = 7403	Quadruple 2-input Positive NAND Gates (with Open-Collector Output)	23p	20p	15p
BP 04 = 7404	Hex Inverters	23p	20p	15p
BP 10 = 7410	Triple 3-input Positive NAND Gates	23p	20p	15p
BP 13 = 7413	Dual 4-input Schmitt Trigger	35p	32p	29p
BP 20 = 7420	Dual 4-input Positive NAND Gates	23p	20p	15p
BP 30 = 7430	8-input Positive NAND Gates	23p	20p	15p
BP 40 = 7440	Dual 4-input Positive NAND Buffers	23p	20p	15p
BP 41 = 7441	BCD to decimal nixie driver	87p	77p	67p
BP 42 = 7442	BCD to decimal decoder (4-10 lines, 1 of 10)	87p	77p	67p
BP 47 = 7447	BCD-Seven-Segment Decoder/Drivers (15-V Outputs)	£1·40	£1·30	£1·20
BP 50 = 7450	Expandable dual 2-input AND-OR-INVERT	23p	20p	15p
BP 51 = 7451	Dual 2-wide 2-input AND-OR-INVERT GATES	23p	20p	15p
BP 53 = 7453	Quad 2-input Expandable AND-OR-INVERT	23p	20p	15p
BP 54 = 7454	4-wide 2-input AND-OR-INVERT Gates	23p	20p	15p
BP 60 = 7460	Dual 4-input Expander	23p	20p	15p
BP 70 = 7470	Single-phase J-K Flip-Flop	35p	32p	29p
BP 72 = 7472	Master-slave J-K Flip-Flop	35p	32p	29p
BP 73 = 7473	Dual Master slave J-K Flip-Flop	43p	40p	37p
BP 74 = 7474	Dual D type Flip-Flop	43p	40p	37p
BP 75 = 7475	Quad latch	47p	45p	43p
BP 76 = 7476	Dual J-K with pre-set and clear	47p	45p	43p
BP 80 = 7480	Gated Full Adders	87p	77p	67p
BP 81 = 7481	16-bit read/write memory	£1·35	£1·25	£1·15
BP 82 = 7482	2-bit Binary Full Adders	£1·30	£1·20	£1·00
BP 83 = 7483	Quad Full Adder	87p	77p	67p
BP 86 = 7486	Quad 2 Input Exclusive OR Gates	80p	70p	60p
BP 90 = 7490	BCD decade counter	87p	77p	67p
BP 91 = 7491	8-bit Shift Registers	£1·21	£1·00	87p
BP 92 = 7492	Divide-by-Twelve Counters	87p	77p	67p
BP 93 = 7493	4-bit Binary Counters	87p	77p	67p
BP 94 = 7494	Dual entry 4-bit shift register	87p	77p	67p
BP 95 = 7495	4-bit up-down shift register	87p	77p	67p
BP 96 = 7496	5-bit Parallel in parallel out Shift-Register	£1·10	£1·00	90p
BP100 = 74100	8-bit Bistable Latches	£1·75	£1·65	£1·55
BP118 = 74118	Hex Set-Reset Latches	£1·30	£1·20	£1·00
BP121 = 74121	Monostable Multivibrators	87p	77p	67p
BP141 = 74141	BCD-to-Decimal Decoder/Driver	87p	77p	67p
BP145 = 74145	BCD-to-Decimal Decoder/Drivers	£1·80	£1·70	£1·60
BP151 = 74151	8-bit Data Selectors (with Strobe)	£1·40	£1·30	£1·20
BP153 = 74153	Dual 4-Line-to-1-Line Data Selectors/Multiplexers	£1·40	£1·30	£1·20
BP191 = 74191	Binary Counter reversible	£3·50	£3·25	£3·00

Devices may be mixed to qualify for quantity price. Larger quantities—prices on application. (TTL 74 Series only.)

Data is available for the above series of I.C's in booklet form. PRICE 13p.

TTL INTEGRATED CIRCUITS

Manufacturers' "Full outs"—out of spec. devices including functional units and part function but classed as out of spec. from the manufacturers' very rigid specifications. Ideal for learning about I.C's and experimental work.

PAK No.		PAK No.		PAK No.	
UIC00 = 12 × 7400N	50p	UIC42 = 5 × 7450N	50p	UIC80 = 5 × 7480N	50p
UIC01 = 12 × 7401N	50p	UIC50 = 12 × 7450N	50p	UIC82 = 5 × 7482N	50p
UIC02 = 12 × 7402N	50p	UIC51 = 12 × 7451N	50p	UIC83 = 5 × 7483N	50p
UIC03 = 12 × 7403N	50p	UIC60 = 12 × 7460N	50p	UIC86 = 5 × 7486N	50p
UIC04 = 12 × 7404N	50p	UIC70 = 8 × 7470N	50p	UIC90 = 5 × 7490N	50p
UIC05 = 12 × 7495N	50p	UIC72 = 8 × 7472N	50p	UIC92 = 5 × 7492N	50p
UIC10 = 12 × 7410N	50p	UIC73 = 8 × 7473N	50p	UIC93 = 5 × 7493N	50p
UIC20 = 12 × 7420N	50p	UIC74 = 8 × 7474N	50p	UIC94 = 5 × 7494N	50p
UIC40 = 12 × 7440N	50p	UIC75 = 8 × 7475N	50p	UIC95 = 5 × 7495N	50p
UIC41 = 5 × 7441AN	50p	UIC76 = 8 × 7476N	50p	UIC96 = 5 × 7496N	50p

UICX1 = 25 × Asst'd 74's £1·50

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.

DTL 930 SERIES

Type No.	Function	Price 1-24	25-99	100 up
BP930	Expandable dual 4-input NAND	23p	20p	15p
BP932	Expandable dual 4-input NAND buffer	25p	23p	20p
BP933	Dual 4-input expander	25p	23p	20p
BP935	Expandable Hex Inverter	25p	23p	20p
BP936	Hex Inverter	25p	23p	20p
BP944	Dual 4-input NAND expandable buffer without pull-up	25p	23p	20p
BP945	Master-slave JK or RS	35p	32p	29p
BP946	Quad, 2-input NAND	23p	20p	15p
BP948	Master-slave JK or RS	35p	32p	29p
BP951	Monostable	90p	85p	80p
BP962	Triple 3-input NAND	23p	20p	15p
BP9093	Dual Master-slave JK with separate clock	80p	75p	70p
BP9094	Dual Master-slave JK with separate clock	80p	75p	70p
BP9097	Dual Master-slave JK with Common Clock	80p	75p	70p
BP9099	Dual Master-slave JK Common Clock	80p	75p	70p

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only.)

DTL (Diode Transistor Logic) INTEGRATED CIRCUITS manufacturers "Full 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.

Pak No.		Pak No.	
UIC930 = 12 × μA 930	50p	UIC948 = 8 × μA 948	50p
UIC932 = 12 × μA 932	50p	UIC951 = 5 × μA 951	50p
UIC933 = 12 × μA 933	50p	UIC961 = 12 × μA 961	50p
UIC935 = 12 × μA 935	50p	UIC9093 = 5 × μA 9093	50p
UIC936 = 12 × μA 936	50p	UIC9094 = 5 × μA 9094	50p
UIC944 = 12 × μA 944	50p	UIC9097 = 5 × μA 9097	50p
UIC945 = 8 × μA 945	50p	UIC9099 = 5 × μA 9099	50p
UIC946 = 12 × μA 946	50p	UIC × 9 25 Assorted 930 Series	£1·50

Packs cannot be split but 25 Assorted Pieces (our mix) is available as Pack UICX9. Every Pak carries our BI-PAK Satisfaction or money back guarantee. **Data Booklet available for the BP930 Series, PRICE 13p**

LINEAR I.C's

Type No.	Case	Leads	Description	Price 1-24	25-99	100
BP201C—SL201C	TO-5	8	G.P. Amp	63p	53p	45p
BP701C—SL701C	TO-5	8	OP Amp.	63p	50p	45p
BP702C—SL702C	TO-5	8	OP Amp Direct O/P	63p	50p	45p
BP702—72702	D.I.L.	14	G.P. O.P. Amp (Wide Band)	53p	45p	40p
BP709—72709	D.I.L.	14	High Gain OP Amp	53p	45p	40p
BP709P—μA709C	TO-5	8	High Gain OP Amp	53p	45p	40p
BP741—72741	D.I.L.	14	High Gain OP. Amp (Protected)	75p	60p	50p
μA703C—μA703C	TP-5	6	R.F.—IF Amp	43p	35p	27p
TAA263	TO-72	4	A.F. Amp	70p	60p	55p
TAAA293	TO-74	10	G.P. Amp	90p	75p	70p

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Pack No.	Qty. per pack	Description	Price
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Q 2	16	White spot R.F. trans. P.N.P	50p
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Q 5	4	OC 75 transistors	50p
Q 6	4	OC 72 transistors	50p
Q 7	4	AC 128 trans. P.N.P. high gain	50p
Q 8	4	AC 126 trans. P.N.P.	50p
Q 9	7	OC 81 type trans.	50p
Q10	7	OC 71 type trans.	50p
Q11	2	AC 127/128 Comp. pairs PNP/NPN	50p
Q12	3	AF 116 type trans.	50p
Q13	3	AF 117 type trans.	50p
Q14	3	OC 171 H.F. type trans.	50p
Q15	5	2N2926 Sil. Epoxy trans.	50p
Q16	2	GET880 low noise Germ. trans.	50p
Q17	3	NPN 1 ST141 & 2 ST140	50p
Q18	4	Madt's 2 MAT 100 & 2 MAT 120	50p
Q19	3	Madt's 2 MAT 101 & 1 MAT 121	50p
Q20	4	OC 44 Germ. trans. A.F.	50p
Q21	3	AC 127 NPN Germ. trans.	50p
Q22	20	NKT trans. A.F. R.F. coded	50p
Q23	10	OA202 Sil. diodes sub-min.	50p
Q24	8	OA 81 diodes	50p
Q25	6	IN914 Sil. diodes 75PIV 75mA	50p
Q26	8	OA95 Germ. diodes sub-min. IN69	50p
Q27	2	10A 600PIV Sil. Rects. 1S425R	50p
Q28	2	Sil. power rects. BYZ 13	50p
Q29	4	Sil. trans. 2 × 2N696, 1 × 2N697, 1 × 2N698	50p
Q30	7	Sil. switch trans. 2N706 NPN	50p
Q31	6	Sil. switch trans. 2N708 NPN	50p
Q32	3	PNP Sil. trans. 2 × 2N1131, 1 × 2N1132	50p
Q33	3	Sil. NPN trans. 2N1711	50p
Q34	7	Sil. NPN trans. 2N2369, 500MHZ	50p
Q35	3	Sil. NPP TO-5 2 × 2N2904 & 1 × 2N295	50p
Q36	7	2N3646 TO-18 plastic 300MHZ NPN	50p
Q37	3	2N3053 NPN Sil. trans.	50p
Q38	7	PNP trans. 4 × 2N3703, 3 × 2N3702	50p
Q39	7	NPN trans. 4 × 2N3704, 3 × 2N3705	50p
Q40	7	NPN amp. 4 × 2N3707, 3 × 2N3708	50p
Q41	3	Plastic NPN TO-18 2N3904	50p
Q42	6	NPN trans. 2N5172	50p
Q43	7	BC 107 NPN trans.	50p
Q44	7	NPN trans. 4 × BC108, 3 × BC109	50p
Q45	3	BC 113 NPN TO-18 trans.	50p
Q46	3	BC 115 NPN TO-5 trans.	50p
Q47	6	NPN high gain 3 × BC167, 3 × BC168	50p
Q48	4	BCY70 PNP trans. TO-18	50p
Q49	4	NPN trans. 2 × BFY51, 2 × BFY52	50p
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CANNON. 50 way DDM50P **75p** ea.; DDM50S **50p** ea. **£1** per pair.
As above but 25 way **50p** ea. plug; **35p** ea. socket; **75p** per pair; 9 way **33p** ea. plug and socket, **50p** per pair.
U.H.F. Plugs fit UR57, 59, 65 etc., **40p** ea.
B.N.C. to U.H.F. Adaptor **£1·37** ea.; Min. B.N.C. to U.H.F. **£1·50** ea.; 'T' junction B.N.C. **£1** ea.; B.N.C. plug to B.N.C. plug **£1** ea.; B.N.C. Right angle **£1** ea.; Min. B.N.C. right angle **£1·25** ea.; Min. socket round **50p** ea.
Standard B.N.C. round **35p** ea. Many others too numerous to list. All prices quoted for 'one off.'

TRANSFORMERS. All standard inputs.
STEP DOWN ISOLATING trans. Standard 240v AC to 120V tapped 60-0-60 700W. Brand new. **£5** ea.
Neptune series 460-435-0 etc. 230 MA and 600-570-540-0 etc. 250 MA. **£3·50** incl. post.
Multi 6.3Volts to give 48V 3.5Amps etc. **£3·50** incl. post.
Transformer 0-215-250 120 MA; 6.3V 4A CT×2; 2×6.3v 0.5A and separate 90v 100 MA **£1·25** ea. P. & P. 20p.
Matching contact cooled bridge rectifier **37p** ea.
4.5V 40 amp (180Va) **£1·75** ea. incl. postage or 3 for **£4·50** incl. postage. Designed to be Series paralleled.
Parmeko 6.3v 2 amp×4—**£1·13** ea.
Gard/Parm/Part. 450-400-0-400-450. 180 MA. 2×6.3v. **£3** ea.
Transformer 250-80MA; 13V-1.2A and 6.3V 5A. **£1·50.** P. & P. 25p.
CHOKES. 5H; 10H; 15H; up to 120mA. **42p** ea. P. & P. 17p. Up to 250mA **63p.** P. & P. 35p.
Large quantity LT, HT, EHT transformers. Your requirements, please.
GROUND PLANE ANTENNA. Ex-admiralty. Brand new boxed. Adjustable 90-160 megs. (Like umbrella) **£6·50.** Carr. £1.

NUCLEONIC INSTRUMENTS
Pulse analyser N101; Scaler 1009E; Coincidence unit 1036C; Anti coincidence unit Panax AU460; Amplifier N567; A/B/G Radiation Monitor 1257A; complete 1339A system A/B/G; EHT Potentiometer unit 1007; 1430 amplifier CF and head; Some scintillation castles; radiation monitor 1320C and 1320X (X-ray); survey meters no. 2 and 3; Ratemeter scintillation 1368A; Fast neutron 1262C; Fluori-meter 1080A and many others. Also 2000 SERIES. Amp 2002A; Low level amp 2024; PU's 2004; 2005B; nanosec time amplitude convertor 2011A; pulse amplitude analyser 2010B; discriminator 2007B; high level amp 2025 and others. Information available.

MARCONI Wide Range Oscillator TF1370's and TF1370A's. 10c/s—10mc/s from **£140.**

TEST GEAR

OSCILLOSCOPES
E.M.I. WM 2 DC—13 mc/s **£25**
SOLARTRON CD1014 DB. DC—6 megs. **£55.**
SOLARTRON 711S.2 D.B. DC—9 mc/s. In fine condition **£50.**
SOLARTRON 643 DC—15 mc/s Brand new **£85** Good condition **£50.**
SOLARTRON DC—10 mc/s. CD513—**£40.** CD513.2—**£42·50.** CD523S—**£45.**
SOLARTRON CT316 (D300 range) DC—6 megs. **£17·50.**
SOLARTRON Storage scope QD910 **£150.**
COSSOR 1049 Mk. 3. DB. **£25**
HARTLEY 13A DB. **£25.**
CT52 Min. scope. **£17·50.**
All carefully checked and tested. Carriage £1·50 extra.

MARCONI
Noise gen. TF1301, **£40.** Carr. £1·50.
Vacuum tube Voltmeter TF1041A, **£35**; 1041B, **£45.**
Deviation Meter TF934/2, **£50** ea. Carr. £1·50.
Deviation type 719, **£30** ea. Carr. 75p.
AM/FM Portable VHF Test sets. As new. A must at **£60.** Carr. £1·25.
TF 1026 Frequency Meter **£12·50.** Carr. 75p.
TF 329 Magnification Meter. As new condition **£60.**
TF 195 Audio Generator **£10.** Carr. £1·50.
TF 801A Signal generator **£35.** Carr. £1·50.
TF801B Sig Gen 10-500 mc/s from **£150.**
Better grade **£55** ea. Carr. £1·50.
TF 886 Magnification Meter **£45.** Carr. £1.
TF 369 N. 5 Impedance Bridge from **£50** ea. Carr. £1·50.
TF 144G Signal Generator. Serviceable. Clean **£15.** In exceptional condition **£25.** Carr. £1·50.
Valve voltmeter type CT208, **£17·50** ea. Carr. 75p.
TF 885 Video Oscillator Sine/Square **£35** Carr. £1·50.
TF885/1 **£55.** Carr. £1·54.
TF 1343/2 'X' Band gen. **£35.** Carr. £1·50.

SOLARTRON
Laboratory amplifier AWS51A. 15c/s—350kc/s **£35** Carr. £1
Stabilised P.U. SRS 151A **£20.** Carr. £1·50.
Stabilised P.U. SRS 152 **£15.** Carr. £1·50.
Precision Millivoltmeter VP252. **£25.** Carr. £1.
Process Response Analyser. Fine Condition **£250**
Oscillator type OS 101. **£30.** Carr. £1·50.
D.C. Amplifier type AA900. **£30.** Carr £1.

AVO
Testmeter No. 1 **£12** ea. Carr. 75p.
Electronic Testmeter CT 38. Complete **£20** Carr. £1

CINTEL
Square and Pulse gen. PW 0·05 to 0·3 micro secs. 15mV to 50V; rep rate 5 hz to 250 kz **£20.** Carr. £1.

AIRMEC
Signal Generator type 701. **£25.** Carr. £1·50.
AIRMEC Generator type 210 **£120.** Carr. £1·50.

MARCONI TF 1277. Colour studio scope, will line select. In superb condition. **£120.**

E.M.I. Oscilloscope type WM16. Main frame **£125.** Choice of Plug in 7/2 DC—24 mc/s x 2 **£35**; 7/1 DC—40 megs **£25.** Differential unit available from **£40.**
E.M.I. WM8. DC to 15 mc/s. Complete with plug in pre-amp, from **£40.**

BRADLEY ATTENUATORS 0/500 meg cycles. 0/12 db and 0/120 db—**£20** per pair.

BECKMAN MODEL A. Ten turn pot complete with dial. 100k 3% Tol.0.25%—only **£2·13** ea.

E.H.T. Base B9A in Polystyrene holder with cover. Brand new. **13p** ea.
DVM's BIE 2114 **£50** ea.; BIE 2116 **£50** ea. Carr. £1·50.
BC221—Brand new **£35** ea. Carr. £1.
NAGARD Double pulse gen type 5002 **£50.** Carr. £1·50.

MARCONI SPECTRUM ANALYSERS type OA 1094, from **£325.**

FIBRE GLASS PRINTED CIRCUIT BOARD. Brand new. Single side ½p per sq. in. Double sided **1p** per sq. in. Cut to size (Max. 2½"×15"). Postage 5p per order.
BERCO miniature variac type 31C. 0-250V 1 amp. 2 5/16th" depth. 3" diameter. Complete with dial and pointer. As new **£3.** P. & P. 37p.
SEQUENTIAL TIMERS 240V synchronous motor ½ rpm. 12 cam operated 2 pole micro switches. Individually adjustable from 0° to 180°. **£6** ea.
Standard **240V MOTORS** with reduction gearbox 14 lbs. inch. **£3** ea.
Modern replacement for VCR 138 tube. Flat face 3 in. **£1·63.** P. & P. 25p. Bases 17p.
FERRITE rods complete with LW, MW and coupling coils. Brand new. **25p** ea. P. & P. 7p.
FIREBALL TURRETS. Brand new **£1·50** ea. P. & P. 25p
Sub-miniature IF's 465/470 kcs. Size ½ × ½ × ½" high. Set of 3—**63p.**
Sub-min. Vitality bulbs 8V 1.2W 5 mm Clear L.E.S. **7p** ea. 100 off **6p** ea.
DUNFOSS—solenoid valves. 240V 50 c/s. Type EVJ 2. Brand new boxed **£5**; Second hand **£3.** P. & P. 30p.

CLAUDE LYONS Main Stabilizer. Type TS-1L-5S0. Input 119-135 volts 47/65 cs. Output 127+/—0.25% 16 amps. **£35.** Carr. £2.
SERVOMEX. Stab. Transistor P.U. 0-15V 2·5 amps. Volt and Current meters. overload trip. **£15** ea. Carr. £1·50.
E.H.T. Unit by Brandenburg model S.0530/10. **£55.**
SMITHS twin channel recorder. Transistorised. **£65.** Various other single and twin track recorders from **£20.**
EVERSHED & VIGNOLES Recording paper. Brand new boxed. L618H4 7" wide, 1½" dia. **17p** roll; 6" dia. **£1** roll. JL900H4 7" wide, 1½" dia. **25p** roll.
19in. Rack Mounting **CABINETS** 6ft. high 19in. deep. Side and rear doors. Fully tapped, **£12·50.** Carriage at cost.
Double Bay complete with doors. Fine condition. **£25.** Carriage at cost.
ADVANCE Sig. gen type 71. **£15** ea. Carr. £1·50. Calibration unit type CT155. **£6** ea. Carr. 50p.
Signal Generator CT53. Complete with charts **£15.** Carr. £1·50.
TIME CALIBRATOR unit by Cawkell any or all time intervals from 0.5 microsecond to 1,000 microsecond. Internal calibration; gate generation **£50.** Carr. £1·50.
WAYNE Kerr Universal Bridge type CT375 **£45** ea. Carr. £1·50.
MUIRHEAD Swept Audio Oscillator **£50** ea. Carr. £1·50.
EMI Swept Audio Oscillator type SRO2 **£40** ea. Carr. £1·50.
Travelling **WAVE** oscilloscopes—Sweep speed from 10 micr secs to 10 nano secs. **£150** ea.

4 DIGIT RESETTABLE COUNTERS. 1000 ohm. coil. Size 1½ × ⅞ × 4½in. As new, by Sodeco of Geneva. **£2·50** ea.
As above but 350 ohm. **£3·50** ea.

METERS—Model 3705. 25-0-25 micro amp. Scaled. -100-0-+100. 5½" × 4". **£3** ea.
SANGO 50 micro amp 4" round. Brand new boxed. **£1·38.** P. & P. 38p.
SANGO 50 micro amp rectangular meter. Size 2⅞ × 3" with 4 separate scales, lever operated, 0/6 white, 0/60 blue, 0/600 red and set zero. **£1·75.** P. & P. 17p.
SANGO 50 micro amp 3" round meters. Ex brand new radiation equip. **£1** ea. P. & P. 17p.

SEEING IS BELIEVING!
First come, first served
AT LAST. BC221 complete with correct charts, circuit diagrams, in fine condition for **ONLY £13·34.** Carr. £1.
C.R.T.'s 5". Brand new with spec sheet. **63p** ea. P. & P. 25p.
MARCONI Valve Voltmeter 428B/1 **£5** ea. Carr. £1.
AMERICAN oscilloscope type TS34/AP. Size 7 × 6½ × 15½" deep with viewing hood. Tested, good working condition. Ideal general purpose scope. 117 volt mains therefore only **£12·50.** Carr. £1.
COSSOR D.B. Scopes—some models from **£15.**
MARCONI Absorption Wattmeter 1 micro watt to 6 watts. Type TF956. FANTASTIC at **£7** ea.
SOLARTRON Stab. PU AS516 & AS517. Circuits supplied. Fantastic value at **£2** and **£4** each.
SUPERB BUYS. Furzehill V200A Valve millivolt meter 10mv to 1 kv. **£10** ea.
MEGA Ohm Meters—check earths, bonding etc. Ridiculous at **£5** ea.
Genuine **MULLARD** Transistors/Diodes. Tested and guaranteed. OC41, 42, 76, 77, 83; OA5, 10. All at **5p** ea. OC23—**10p** ea.
COMPONENT PACK consisting of 2-2 pole 2 amp push on/off switches; 4 pots 1 double; 1-small double pole vol control; 250 resistors ¼ and ½ watt many high stabs. Fine value at **50p** per pack. P. & P. 17p.
3000 Series relays—15 mixed values (new and as new, no rubbish) **£1·50.** P. & P. 37p.
3000 Type 2 pole c/o assembly. Brand new boxed —will fit any 3000 type relay. **10p** incl. postage.
Carriage extra.

TRANSISTOR EHT INVERTORS. 12 volt in, o/p (+ or —) 1.5 KV 2 MA and 3 KV +100 micro amp. Ideal CRT supply, photomultipliers etc. Full information supplied. Brand new at **£6·50** ea. P. & P. 25p.
Also, as above but 1.5KV AC 20 kc/s. **£3·50.** P. & P. 25p.
Panel switches DPDT ex eq. **13p** ea.; DPST Brand new, **17p** ea.; DPST twice, brand new **25p** ea.
Switches 4 pole 2 way **13p.**
Replacement UHF Transistor Tuners. Brand new. BRC. **£3·50.**
Brand new heads for TR50 and TR51 Tape Recorders **£1.60.**
GYROS Large clear plastic topped. Type A **£5** ea. P. & P. 75p.
ALBRIGHT Heavy Duty Contactor. Single make. 200 amp. 24V coil. Brand new, boxed. **£1** ea. incl. P. & P.
MOTOR DRIVEN SWITCHES. 4 to 24 volt, 6 pole, 24 way. Brand new. **£3** ea. P. & P. 25p.

Official Orders Welcomed, Gov./Educational Depts., Authorities, etc., otherwise Cash with Order

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.

7-9-11 Arthur Road · Reading · Berks · Tel. No. 582605
(rear Tech. College) 300 yds. west of 22 Sun Street · Reading 65916

Push Button Switch, Type 14 D.M.G. A very fine switch made by Honeywell. The switch is intended for mounting on panel through oblong hole. No screws required for fixing, its sprung clips secure it quite firmly. The operating button is approximately 1 in. dia. round and dished for ease of operation. Has 2 sets of 10 amp c/o contacts. Sprung loaded, returns to normal when pressure released. Ideal for instrument or quality gear. Price **40p. £4** per dozen.
12v. Fluorescent Light. This uses 12 in. 8 watt tube, is energised by transistor inverter thus gives maximum light for minimum battery drain. Ideal for caravan, boat or van interior light. Not a kit, but made up on aluminium body and ready to install. Complete with tube **£4**. Post 20p.
Sew-tric Pump Motor. Very powerful series wound so easily controllable from speed point of view, size 3½ in. × 3 in. approx. For mains working. Price **£1·75** plus 30p post and insurance.
Mains Operated Solenoids Model TT2. A small one but has a powerful pull, size approx. 1½ in. × 1¼ in. × 1¼ in. ⅝ in. pull Mains operated, **65p**—model 400/1 medium size 2 in. × 2 in. × ⅞ in. approx. ⅞ in. pull—**80p** plus 20p post.
TT10. A very powerful solenoid with 1¼ in. long pull, as fitted to many automatic washing machines etc. Size 3 in. × 2½ in. × 2½ in. Mains operated, **£1·80** plus 25p post and insurance.
Cold Room or Air-Conditioning Thermostat. This is calibrated from 30 to 60 F. and operates in the reverse way to normal thermostats, i.e. switches on with a rising temperature. In a neat wall mounting case, size 2½ in. × 1½ in. × 1½ in. Made by famous Teddington company. Limited quantity, **£1·75** each.
110 R.P.M. Geared Motors. This is a powerful 2-pole mains operated induction motor similar construction and size as that used in record players, but much more powerful (⅜ in. tack). Gear box is sealed and the final drive shaft is 1 in. long × ¼ in. diameter. **£1·75.** Postage and insurance 25p.
Hearing Aid Amplifiers. 3 transistors and associated condensers and resistors on a little printed circuit board, the whole thing only about half as big as an Oxo cube. If you are making miniature equipment then these may well be just what you are looking for. **£1·75** each.
Mains Solenoid Operated Water Valve. Normally closed opens when activated. Nylon body as used in many automatic washing machines. The mains solenoid is completely embedded in a resin jacket thus making it absolutely waterproof. Many uses include automatic control of plant watering. Model 1 for 2 small hose connectors, Model 2 for one small and one large hose connector. Price **95p. £10** dozen.
Mains Solenoid Operated Water Valve. Normally open, closes when activated. This is made by Asco, their type No. 8030 A2. This is a heavier and somewhat superior water valve with an all-metal body suitable for connecting in line with ¼ in. pipe. The solenoid is not waterproofed but is enclosed in a metal casing with ½ in. conduit entry. To facilitate electrical connection the solenoid casing may be rotated through 360 degs. Well made, should give years of trouble free service. Price **£1·75**, post and insurance 30p.
Amplifier Mains Transformer, 50v 1½ amp. Upright mounting with fixing brackets and metal shrouds to contain magnetic field, 50 c/s primary, tapped 110v, 117v, 210v, 230v and 250v. 2 secondaries, one 50v, 1½ amp, other 6v 1 amp for pilot light etc. **£2·50**, postage 30p.
Mains Transformer. 25-0-25v 2 amps, 50 c.p.s. primary tapped 200/250v, in 10v steps, separate screen. 2 secondaries, one 25-0-25v, at 2 amps and the other 110v, at 10 MA. Open construction with mounting feet. **£2·25**, post 30p.
Multi-Range Test Meter. Handy slip-in-your-pocket size, but angled movement gives wide easily read scale, 8 ranges, D.C. volts 0-15-150-1000 AC volts 0-15-150-1000 OC current 0-150 MA. Resistance 0-100k. A very well made tester, 100-o.p.v. ideal for most jobs. Japanese made, of course, and very robust. Buy one of these and save your expensive instruments for precision jobs. Price **£2.** Post and insurance 20p.
Air Spaced Tuning Condenser. 2 gang with slow motion spindle (standard ¼ size). Exact capacity not known, but estimated at approximately 300 p.f., and 250 p.f. **45p. £5** doz.
Micro Switch, reference RW18. An ultra sensitive switch operated by spring lever only slightest pressure needed to operate. Contacts rated at 10 amps. Price **20p.**
500K. Edgewise Control Pot-Meter. Morganite, approximately 1¼ in. dia. useful size and standard replacement in many T.V. sets, **12p. £1·20** per dozen.
Pre-Set Pot Meters. With integral bakelite control knob, all by Morganite, Welwyn or similar quality makers. Standard size (approximately 1 in. dia.) suitable for pre-set or variable circuits. Low values are wire wound. The following values are in stock. 22ohm, 33ohm, 300 ohm, 1K, 5K, 50K, 100K. **10p** each. **£1** per dozen.
1 Watt Transistor Amplifier. Japanese made, very good quality. Panel size approx. 5½ in. × 2 in. 5 transistors, 3-8 ohm output, operated from 9v battery or from mains with 12v transformer. **£1·25.**
See and be seen with a Thorn Dip Dim unit. Designed to dip headlights, 12v 50/40 watt or 64/45 watt and 6v 45/35 or 36/36 watts. Supplied complete with simple instructions and wiring diagram, not suitable for vehicles with sealed ignition system or a diesel powered vehicle without a master switch. Comprises of relay coil with switch in metal can and limiting resistor mounted on metal chassis with one hole fixing. **75p.**
30 Second Delay Unit. This requires 24v. AC or DC to operate. A higher or lower voltage would decrease or increase the delay time within limits. The switch which is isolated from the operating voltage is normally open and closes after delay. It will remain closed for a period of 30 to 60 seconds depending upon how long the delay voltage is applied and the external condition which delay cool down. Made by A.E.I. these have many uses, i.e. to delay switching on fan of central heating switching until the boiler has properly fired. Price **75p.**
If you wish to delay the switching off instead of the switching on then use a relay. We can supply suitable one at **62p.**
Thermo Gas Valve. Intended for gas refrigerators but obviously adaptable to many other uses, this has an 8 ft. long capillary sensor and a very positive action gas valve. The thermostat is adjustable over the normal refrigeration range. **75p** each.
Panostat. This device is fitted to many electric cookers, it's a thermostat with flat probe and with it the temperature of a pan or liquid bath, vat etc. can be kept at below boiling point or made to boil vigorously. The setting is by normal pointer knob on the spindle. (Pointer knob not supplied.) Price **75p** each.
Remington Mini-Computers. At the time of going to press we haven't very much information about these, but they do look very impressive. With keyboard and numeration controllers, these are mounted on teak finish desks and weigh just over 2 cwts. Size approx. 4 ft. × 2 ft. 6 in. × 2 ft. 6 in. high. We understand these cost several thousand pounds each to make. We have only three. Price **£175** each. Obviously we sell these without guarantee as we have no means of testing them, but they look virtually unused.
16 r.p.m. Motors. Small mains operated motor made by Smiths, with gear box attached. Final drive shaft 1/16th in. Good quantity of these available. **50p** each or 12 for **£5.**
Micro-Sonic Radios for Repair. Guaranteed to contain all parts and to be in repairable condition. 4 for **£3·50.** Post paid.
10 Minute Timer Switch. Made by the famous Smiths company. This has a control shaft which rotates through approximately 120 deg. Turn the shaft and the circuit switch closes and will remain closed for up to 10 minutes depending on arc through which the switch has been turned.
Time and Temperature Controller. This is a mains driven normal 12 hour clock with 20 amp switch which may be set to operate on and off anywhere around the 12 hour dial. Also incorporated is an oven thermometer and thermostatic switch. The thermostatic switch may be set anywhere between 50°C and 90°C. Price **£5** each plus 35p postage and insurance. Oven censor unit on flex lead available as separate item price **£2.**

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 thryristor firing control.

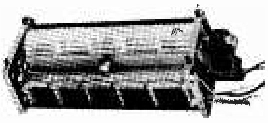
4 models are available—all are brand new in makers cases:

Model 2410	for up to 5 amps	**£17·50**
Model 2411	for up to 10 amps	**£27·50**
Model 2413	for up to 45 amps	**£47·50**
Model 2415	for up to 80 amps	**£95·00**

Note: 2415 is a floor mounting unit.

OUT OF SEASON BARGAIN

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. **£3·50.** 2kW. Model as above except 2 kilowatts **£2·50.** Don't miss this. Control Switch **35p.** P. & P. 40p

DISTRIBUTION PANELS

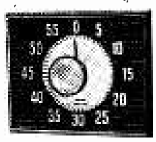
Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work, **£2** less plug; **£2·25** with fitted 13 amp plug; **£2·40** with fitted 15 amp plug, plus 23p P. & I.

THIS MONTH'S SNIP

FIRE ALARM BELL

Mains operated Really loud ring 6 in. gong. Size approx. 12 in. × 6 in. × 4½ in. suitable outside or inside. Heavy cast case with ¾ in. conduit entry. Made by A.F.A. Operates off 200-240V AC. **£3·75** plus 60p.

1 HOUR MINUTE TIMER

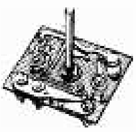


Made by famous Smiths company, these have a large clear dial, size 4¾ in. × 3¾ in., which can be set in minutes up to 1 hour. After preset period the bell rings. Ideal for processing, a memory jogger or, by adding simple lever, would operate micro-switch. **£1·15.**

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. **£2·35.** Post and ins. 23p.

THYRISTOR LIGHT DIMMERS



Will dim incandescent lighting up to 600 watts from full brilliance to out. Suitable to mount on M.K. switch plate, same size and fixing as standard wall switch, so may be fitted in place of this, or mount on surface. Price complete with control knob **£3.**

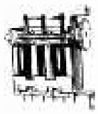
RESETTABLE FUSE

How long does it take you to renew a fuse? Time yourself when next one blows. Then reckoning your time at £1 per hour see how quickly our resettable fuse (auto circuit breaker) will pay for itself. Price only £1 each or £11 per dozen, specify 5, 10 or 15 amp—*simply fit in place of switch.*

19 PIECE SOCKET SETS

Complete with wall or bench rack. Most useful sizes from ¼ in. to 15/16 in. **80p** plus 23p post and insurance.

3 STAGE PERMEABILITY TUNER



This Tuner is a precision instrument made for the famous Radiomobile Car Radio. It is a medium wave tuner (but set of long wave coils available as an extra if required) with a frequency coverage 1620 Kc/s-525 Kc/s and intended to operate with an I.F. value of 470 Kc/s. Extremely compact (size only 2¾ × 2 × ½ in. thick) with reduction gear for fine tuning. **65p,** with circuit of front end suitable for car radio or as a general purpose tuner for use with Amplifier.

INSTRUMENT SWITCHES

Miniature ¾ in. dia. wafers—silver plated 5 amp std. ¼ in. spindle.

No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	9 way	10 way	12 way
1 pole	60p	60p	60p	60p	60p	33p	33p	33p	33p
2 poles	60p	60p	60p	60p	60p	33p	33p	55p	55p
3 poles	60p	60p	60p	60p	£1	55p	55p	75p	75p
4 poles	60p	60p	60p	£1	£1	55p	55p	95p	95p
5 poles	60p	60p	£1	£1	£1·40	75p	75p	£1·15	£1·15
6 poles	60p	£1	£1	£1	£1·40	75p	75p	£1·35	£1·35
7 poles	60p	£1	£1	£1·40	£1·80	95p	95p		
8 poles	£1	£1	£1	£1·40	£1·80	95p	95p		
9 poles	£1	£1	£1·40	£1·40	£2·20	£1·15	£1·15		
10 poles	£1	£1	£1·40	£1·80	£2·20	£1·15	£1·15		
11 poles	£1	£1·40	£1·40	£1·80	£2·60	£1·35	£1·35		
12 poles	£1	£1·40	£1·40	£1·80	£2·60	£1·35	£1·35		

COMPUTER TAPES

2,400 ft. of the best magnetic tape money can buy. Made by E.M.I., 1 in. wide, almost unbreakable and on a 10½ in. metal computer spool. Users have claimed successful results with video as well as sound recordings. **£1** plus 33p post. Cassette to hold spool **50p** extra.

MICRO SWITCH

5 amp. changeover contacts, **9p** each, **90p** doz. 15 amp. on/off **10p** each or **£1·05** doz.

Where postage is not stated then orders over £5 are post free. Below £5 add 20p. S.A.E. with enquiries please.

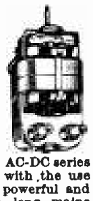
DRILL CONTROLLER

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 **£1,** plus 13p post and insurance. Made up model also available **£1·85** plus 13p p. & p. **New 1kW model.**

BALANCED ARMATURE UNIT

500 ohm, operates speaker or microphone, so useful in intercom or similar circuits, **33p** each, **£3·50** doz. 80 ohm model **28p.**

MULTI-SPEED MOTOR

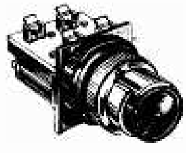


Replacement in many well-known food mixers. Six speeds are available 500, 850 and 1,100 r.p.m. from either or both of the nylon sockets (where the beaters of the food mixers normally go) and 8,000, 12,000 & 15,500 r.p.m. (ideal polishing speeds) from the main drive shaft. This drive shaft is ¼ in. diameter and approximately 1 in. long. A further point about this motor is that being 230/240v. AC-DC series wound its speed may be further controlled with the use of our Thyrister controller. This is a very powerful and useful motor size approx. 2 in. dia. × 5 in. long, mains 230/240v. Price **88p** plus 23p postage and insurance. 12 or more post free.

MAINS OPERATED CONTACTOR

220/240v. 50 cycle solenoid with laminated core so very silent in operation. Closes 4 circuits each rated at 10 amps. Extremely well made by a German Electrical Company. Overall size 2½ × 2 × 2 in. **£1** each.

EMERGENCY SWITCH

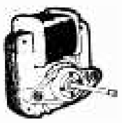


A heavy duty switch, ideal as an emergency stop switch, machine flow-line, etc. To operate the switch you simply push the centre, but this is protected against accidental switching by an extended metal flange. 2 pair contacts, one pair open other pair close as switch pressed. **65p.**

MAINS TRANSFORMER

Output variable 24/38v. 50 c.p.c. primary 230/240v. Voltage from secondary depends upon the setting of a plug connector and may be varied from 24v. to 38v. approximately in 4 stops. Secondary rated at 40 watts. Price **95p.** Post 20p.

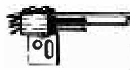
MAINS MOTOR



Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at **50p.** Postage 15p for first one then 5p for each one ordered. 12 and over post free.

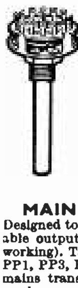
NEED A SPECIAL SWITCH?

Double Leaf Contact



Very slight pressure closes both contacts. **6p** each. **60p** doz. Plastic push-rod suitable for operating, **5p** each, **45p** doz.

MINIATURE WAFER SWITCHES



2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way 1 pole, 12 way. All at **18p** each, **£1·80** dozen, your assortment.

WATERPROOF HEATING ELEMENT
26 yards length 70W. Self-regulating temperature control. **50p** post free.

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 **83p,** plus 18p postage.

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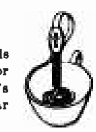
QUICK CUPPA



Mini immersion heater, 250w., 200/240v. Boils full cup in about 2 mins. Use any socket or lamp holder. Have at bedside, for tea, baby's food, etc., **£1·23,** post & ins. 14p. 12v. car battery model also available at **98p.**

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SUGDEN CLASS A AMPLIFIER. A Hi-Fi News design. All parts are in stock except the Metalwork.
WADDINGTON STEREO DECODER. Printed circuits now available in fibreglass and paxolin material.
J. R. STUART TAPE CIRCUITS. We will be designing Printed Circuit Boards and supplying parts for this interesting design.
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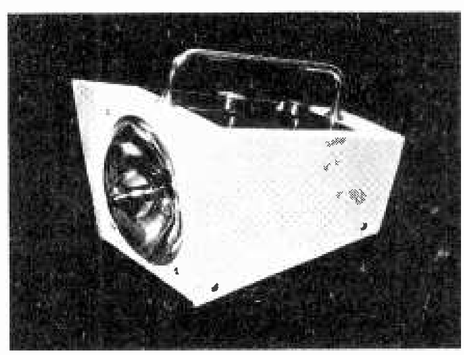
WW—098 FOR FURTHER DETAILS

XENON STROBOSCOPE



A Stroboscope designed primarily for laboratory, industrial and educational applications where the elaboration and expense of more complex equipment may not be required. Features include simplicity of operation, robust construction, exceptionally low price and built in reliability.

The instrument is of modern appearance, small, light in weight, convenient to use and portable. A wide range of flashing rates is covered by the large accurately calibrated dial, allowing operation at low frequencies for strobo photographic experiments and at high speeds for observation of rapidly rotating or reciprocating phenomena.

The external triggering facility permits single shot operation by an external closing contact and also provides a synchronising input for high and low speed repetitive phenomena which might otherwise be difficult to maintain in exact phase.

Light source.	High intensity Xenon tube mounted in a parabolic reflector.
Flashing rate.	1-250 flashes/second in 3 ranges.
Frequency accuracy.	Typically ± 2% of each full scale.
Triggering.	(a) by internal oscillator (b) by external closing contacts.

Price: £38.50

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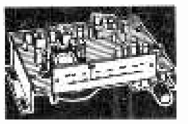
Knowle Road, Mirfield, Yorkshire. Tel: 092484 4242

WW—099 FOR FURTHER DETAILS

TRANSISTOR FM TUNER



6 TRANSISTOR HIGH QUALITY TUNER SIZE ONLY 6in. × 4in. × 2½in. 3 I.F. stages. Double tuned discriminator, ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money, £6·37½. P. & P. 12½p.

STEREO MULTIPLEX ADAPTORS, £4·97½.

GOODMANS SPECIAL OFFERS!
MAXAMP 30 Stereo Amplifier 15 + 15 watt r.m.s. with matching STEREO-MAX AM/FM Tuner. Total list price £136·52 OUR PRICE £89 THE PAIR Carriage £1.

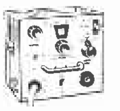
CRYSTAL CALIBRATORS NO. 10

Small portable crystal controlled wavemeter. Size 7in. × 7½in. × 4in. Frequency range 500 Kc/s—10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. £4·47½. Carr. 87½p.

LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

0-20 Kc/s. Output 5K or 500 ohms. 200/250 v. A.C. Offered in excellent condition, £12·50. Carriage 50p.

CLASS D. WAVEMETERS

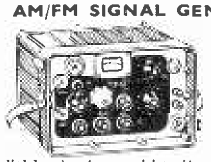


A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition £5·97½. Carr. 37½p. or Brand New £7·97½. Carr. 37½p.

B.C. 221 FREQUENCY METERS

Latest release 125 KHz-20 MHz. Excellent condition. Fully tested and checked and complete with calibrator charts. £27·50 each. Carr. 50p.

AM/FM SIGNAL GENERATORS

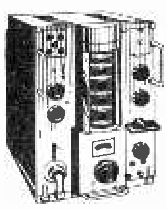


Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1μV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 8½ x 9in. Supplied in brand new condition complete with all connectors, fully tested, £45. Carr. £1.

AVO CT.38 ELECTRONIC MULTIMETERS

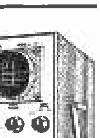
High quality 97 range instrument which measures A.C. and D.C. Voltage, Current, Resistance and Power Output Ranges D.C. volts 250 mV-10,000v. (10 meg Ω-110 meg Ω input). D.C. current 10μA-25 amps. Ohms. 0-1,000 meg Ω A.C. volt 100mv.-250V (with R.F. measuring head up to 250 Mc/s) A.C. current 10μA-25 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. 75p.

ADMIRALTY 62B RECEIVERS



High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 150-300 Kc/s, 560 Kc/s-1.5Mc/s, 3.9-30.5 Mc/s. I.F. 500 Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½ × 13½ × 16in. Weight 114lb. Offered in good working condition. £22·50, carr. £1·50. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. £17·50. Carr. £1·50.

TO-2 PORTABLE OSCILLOSCOPE



A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS—1 MHZ. Input imp. 2 meg Ω. 25 PF. Illuminated scale. 2" tube. 115 × 180 × 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. £22·50. Carr. 50p.

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Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps—1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook £37·50. Carr. 50p.

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CLEAR PLASTIC METERS

TYPE SW. 100
100 x 80 mm.

50μA	£3·47½	20V. D.C.	£2·97½
50-0-50μA	£3·37½	50V. D.C.	£2·97½
100μA ..	£3·37½	300V. D.C.	£2·97½
100-0-100μA	£3·25	1 amp. D.C.	£2·97½
500μA ..	£3·12½	5 amp. D.C.	£2·97½
1mA	£2·97½	300V. A.C.	£2·97½
		VU Meter	£3·75

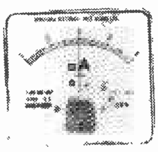
BAKELITE PANEL METERS

TYPE S-80
80 mm.
square fronts

50μA	£3·12½	50V. D.C. ..	£2·47½
50-0-50μA ..	£2·97½	300V. D.C...	£2·47½
100μA	£2·97½	1 amp. D.C.	£2·47½
100-0-100μA	£2·87½	5 amp. D.C.	£2·47½
500μA	£2·62½	300V. A.C...	£2·62½
1mA	£2·47½	VU Meter ..	£3·37½
20V. D.C. ..	£2·47½		

"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4½in. × 4¼in. fronts.



50μA	£3·60	10mA	£2·60
50-0-50μA ..	£3·10	50mA	£2·60
100μA	£3·10	100mA	£2·60
100-0-100μA	£3·10	500mA	£2·60
200μA	£2·87½	1 amp.	£2·60
500μA	£2·75	5 amp.	£2·60
500-0-500μA	£2·60	15 amp.	£2·60
1mA	£2·60	30 amp.	£2·60
1-0-1mA	£2·60	20V. D.C. ..	£2·60
5mA	£2·60	50V. D.C. ..	£2·60
		150V. D.C...	£2·60
		300V. D.C...	£2·60
		15V. A.C. ..	£2·60
		300V. A.C...	£2·60
		S Meter 1mA	£2·87½
		VU Meter ..	£3·60
		1 amp. A.C.*	£2·60
		5 amp. A.C.*	£2·60
		10 amp. A.C.*	£2·60
		20 amp. A.C.*	£2·60
		30 amp. A.C.*	£2·60

Type MR.52P. 2½in. square fronts.

50μA	£3·10	10V. D.C. ..	£2·00
50-0-50μA ..	£2·60	20V. D.C. ..	£2·00
100μA	£2·60	50V. D.C. ..	£2·00
100-0-100μA	£2·37½	300V. D.C...	£2·00
500μA	£2·25	15V. A.C. ..	£2·00
1mA	£2·00	300V. A.C...	£2·00
5mA	£2·00	S Meter 1mA	£2·10
10mA	£2·00	VU Meter ..	£3·10
50mA	£2·00	1 amp. A.C.*	£2·00
100mA	£2·00	5 amp. A.C.*	£2·00
500mA	£2·00	10 amp. A.C.*	£2·00
1 amp.	£2·00	20 amp. A.C.*	£2·00
5 amp.	£2·00	30 amp. A.C.*	£2·00

Type MR.65P. 3½in. × 3¼in. fronts

50μA	£3·37½	10V. D.C. ..	£2·10
50-0-50μA ..	£2·75	20V. D.C. ..	£2·10
100μA	£2·75	50V. D.C. ..	£2·10
100-0-100μA	£2·60	150V. D.C...	£2·10
200μA	£2·60	100V. D.C...	£2·10
500μA	£2·37½	15V. A.C. ..	£2·10
500-0-500μA	£2·10	50V. A.C. ..	£2·10
1mA	£2·10	150V. A.C...	£2·10
5mA	£2·10	300V. A.C...	£2·10
10mA	£2·10	500V. A.C...	£2·10
50mA	£2·10	S Meter 1mA	£2·37½
100mA	£2·10	VU Meter ..	£3·37½
500mA	£2·10	50mA A.C.‡	£2·10
1 amp.	£2·10	100mA A.C.*	£2·10
5 amp.	£2·10	200mA A.C.*	£2·10
10 amp.	£2·10	500mA A.C.*	£2·10
15 amp.	£2·10	1 amp. A.C.*	£2·10
20 amp.	£2·10	5 amp. A.C.*	£2·10
30 amp.	£2·10	10 amp. A.C.*	£2·10
50 amp.	£2·37½	20 amp. A.C.*	£2·10
5V. D.C.....	£2·10	30 amp. A.C.*	£2·10

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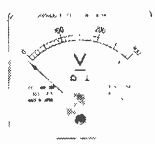
Type MR.38P. 1 21/32in. square fronts.



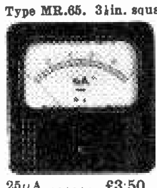
50μA	£2·00	200mA	£1·37½
50-0-50μA ..	£1·87½	300mA	£1·37½
100μA	£1·87½	500mA	£1·37½
100-0-100μA	£1·75	750mA	£1·37½
200μA	£1·75	1 amp.	£1·37½
500μA	£1·50	2 amp.	£1·37½
500-0-500μA	£1·37½	5 amp.	£1·37½
1mA	£1·37½	10 amp.	£1·37½
1-0-1mA	£1·37½	3V. D.C.....	£1·37½
2mA	£1·37½	10V. D.C. ..	£1·37½
5mA	£1·37½	15V. D.C. ..	£1·37½
10mA	£1·37½	20V. D.C. ..	£1·37½
20mA	£1·37½	100V. D.C...	£1·37½
50mA	£1·37½	150V. D.C...	£1·37½
100mA	£1·37½	300V. D.C...	£1·37½
150mA	£1·37½	500V. D.C...	£1·37½
		750V. D.C...	£1·37½
		15V. A.C. ..	£1·37½
		50V. A.C. ..	£1·37½
		150V. A.C...	£1·37½
		300V. A.C...	£1·37½
		500V. A.C...	£1·37½
		S Meter 1mA	£1·60
		VU Meter ..	£2·10

Type MR.45P. 2in. square fronts.

50μA	£2·25	5 amp.	£1·50
50-0-50μA ..	£2·10	10V. D.C. ..	£1·50
100μA	£2·10	20V. D.C. ..	£1·50
100-0-100μA	£1·87½	50V. D.C. ..	£1·50
200μA	£1·87½	300V. D.C...	£1·50
500μA	£1·60	15V. A.C. ..	£1·50
500-0-500μA	£1·50	300V. A.C...	£1·50
1mA	£1·50	S Meter 1mA	£1·87½
5mA	£1·50	VU Meter ..	£2·25
10mA	£1·50	1 amp. A.C.‡	£1·50
50mA	£1·50	5 amp. A.C.‡	£1·50
100mA	£1·50	10 amp. A.C.‡	£1·50
500mA	£1·50	20 amp. A.C.‡	£1·50
1 amp.	£1·50	30 amp. A.C.‡	£1·50

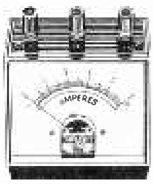
"SEW" BAKELITE PANEL METERS

Type MR.65. 3½in. square fronts.



25μA	£3·50	500mA	£1·75
50μA	£2·37½	1 amp.	£1·75
50-0-50μA ..	£2·25	5 amp.	£1·75
100μA	£2·25	15 amp.	£1·75
100-0-100μA	£2·25	30 amp.	£1·75
500μA	£2·10	50 amp.	£1·75
1mA	£1·75	5V. D.C.....	£1·75
1-0-1mA	£1·75	10V. D.C. ..	£1·75
5mA	£1·75	20V. D.C. ..	£1·75
10mA	£1·75	50V. D.C. ..	£1·75
50mA	£1·75	150V. D.C...	£1·75
100mA	£1·75	300V. D.C...	£1·75
		30V. A.C.* ..	£1·75
		50V. A.C.* ..	£1·75
		150V. A.C.*	£1·75
		300V. A.C.*	£1·75
		500mA A.C.*	£1·75
		1 amp. A.C.*	£1·75
		5 amp. A.C.*	£1·75
		10 amp. A.C.*	£1·75
		20 amp. A.C.*	£1·75
		30 amp. A.C.*	£1·75
		50 amp. A.C.*	£1·75
		VU Meter ..	£3·10

SEW EDUCATIONAL METERS



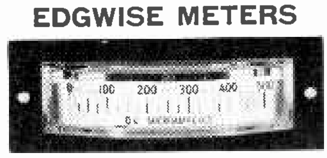
Type ED 107
Size overall 100mm × 90mm × 108mm

A new range of high quality moving coil instruments ideal for school experiments and other bench applications. 3in. mirror scale. The meter movement is easily accessible to demonstrate internal working.

Available in the following ranges:—

50μA	£4·50	10V d.c.	£3·97
100μA	£4·25	20V d.c.	£3·97
1mA	£3·97	50V d.c.	£3·97
50-0-50μA ..	£4·25	300V d.c.	£3·97
1-0-1mA	£3·97	Dual range	
1A d.c.	£3·97	500mA/5A d.c.	£4·25
5A d.c.	£3·97	5V/50V d.c. ..	£4·25

EDGWISE METERS

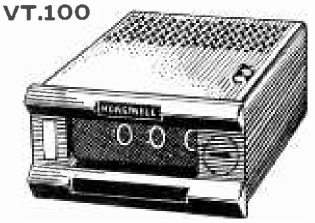


Type P.E.70. 3 17/32in. × 1 15/32in. × 2½ in. deep.

50μA	£3·00	500μA	£2·60
50-0-50μA ..	£2·87½	1mA	£2·37½
100μA	£2·87½	300V. A.C...	£2·37½
100-0-100μA	£2·75	VU Meter ..	£3·25
200μA	£2·75		

Send for illustrated brochure and further details on all Sew Panel Meters—Discounts for quantities

HONEYWELL
DIGITAL VOLTMETER VT.100

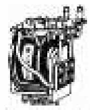


Can be panel or bench mounted. Basic meter measures 1 volt D.C. but can be used to measure a wide range of AC and DC volt, current and ohms with optional plug in cards.

Specification:
Accuracy: ± 0·2, ± 1 digit.
Resolution: 1mV.
Number of digits: 3 plus fourth overrange digit.
Overrange: 100% (up to 1·999)
Input impedance: 1000 Meg ohm.
Measuring cycle: 1 per second.
Adjustment: Automatic zeroing, full scale adjustment against an internal reference voltage.
Overload: to 100v. D.C.
Input: Fully floating (3 poles).
Input power: 110-230v. A.C. 50/60 cycles.
Overall size: 5½in. × 2 13/16in. × 8 3/16in.
AVAILABLE BRAND NEW AND FULLY GUARANTEED AT APPROX. HALF PRICE

£49·97½ Carr. 50p

230 VOLT A.C. 50 CYCLES RELAYS



Brand new, 3 sets of changeover contacts at 5 amp rating. 50p each P. & P. 10p (100 lots £40) Quantities available.

MARCONI TF.142E DISTORTION FACTOR METERS

Excellent condition. Fully tested £20. Carr. 75p.

TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.

A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1 Ω—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" × 5" × 2". £20. P. & P. 25p.

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. 37½p. S.A.E. for details.

COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

D.C. coupled. Band width 1 Kc/s. Perfect order. £25. Carr. £1·50.

MARCONI TF885 VIDEO OSCILLATORS

0-5 mc/s Sine Square Wave £45. Carr. £1.

ADVANCE TEST EQUIPMENT

Brand new and boxed in original sealed cartons.

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.

TT1S. TRANSISTOR TESTER
Full range of facilities for testing PNP or NPN transistors in or out of circuit. £37·50.
Carriage 50p. per item.

MARCONI TF195M BEAT FREQUENCY OSCILLATORS

0-40 kc/s. £20. Carr. £1·50.

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. £6·97½ pair. P. & P. 17½p.

G. W. SMITH & Co. (Radio) Ltd.
ALSO SEE NEXT TWO PAGES

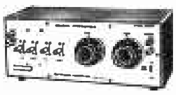
RUSSIAN C1-16 DOUBLE BEAM OSCILLOSCOPE

mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5 in. × 4 in. C.R.T. Calibrated triggered sweep from .2 μ/sec. to 100 milli-sec. per cm. Free running time base 50 c/s-1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. **£87** Carr. paid.

MARCONI CT44 TF956 AF ABSORPTION WATTMETER

1 μ/watt to 6 watts. **£20.** Carr. £1.

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. Brand new **£27·50** P. & P. 25p.

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR

Sine 18-200,000 Hz; Square 18-50,000 Hz. Output max. +10 dB (10 K ohms). Operation internal batteries. Attractive 2-tone case 7½ in. × 5in. × 2in. Price **£17·50** Carr. 17½p.

TE-16A TRANSISTORISED SIGNAL GENERATOR

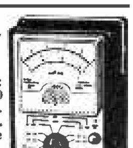
5 Ranges 400 kHz-30 mHz. An inexpensive instrument for the handyman. Operates on 9 v. battery. Wide easy to read scale. 800 kHz modulation. 5½ in. × 5½ in. × 3½ in. Complete with instructions and leads. **£7·97½** P. & P. 20p.

BELCO DA-20 SOLID STATE DECADE AUDIO OSCILLATOR

New high-quality portable instrument Sine 1 Hz to 100 KHz. Square 20 Hz to 20 KHz. Output max. +10 db (10 K ohms). Operation 220/240 v. A.C. Size 215 mm × 150 mm × 120 mm.

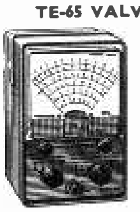
Price **£27·50** Carr. 25p.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER



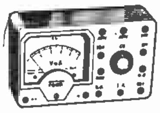
10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels −40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. **£17·50** Carr. 25p.

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 **£17·50**. P. & P. 30p. Additional Probes available: R.F. **£1·75** H.V. **£2·12½**.

MULTIMETERS *for EVERY purpose!*



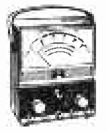
TECH PT-34. 1,000 O.P.V. 0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K. **£1·97½** P. & P. 12½p.

MODEL TE-200 20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000 V. D.C. 0/10/50/250/1,000 V. A.C. 0/50 μA/250 MA. 0/60K/6 meg. + 20 to + 62 db. **£3·75** P. & P. 15p

MODEL PL436. 20k Ω/Volt D.C. 8k Ω/Volt A.C. Mirror scale. ·6/3/12/30/120/600V D.C. 3/30/120/600V A.C. 50/600μA/6/600 mA. 10/100K/1 Meg/10 meg Ω. —20 to +46db. **£6·97½**. P. & P. 12½p.

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. **£5·50** P. & P. 15p

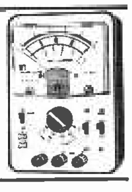
TMK MODEL TW-50K 46 ranges, mirror scale. 50K /Volt D.C. 5K /Volt A.C. D.C. Volts: .125, .25, 1.25, 2.5, 5, 10, 25, 50, 125, 250, 500, 1000V. A.C. Volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500, 1000V. D.C. Current: 25, 50μA, 2.5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance 10K, 100K, 1 MEG, 10 MEG. Decibels: -20 to +81.5 dB. **£8·87½** P. & P. 17½p



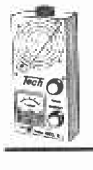
TE-900 20,000 Ω/VOLT GIANT MULTIMETER. Mirror scale and overload protection. 6 in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0/25/12.5/10/50/250/1,000/5,000 v. D.C. 0/50μA/0/10/100/500mA/10 amp. D.C. 02K/200K/20 MEG. OHM. **£15** P. & P. 25p

MODEL 5025 57 Ranges, Giant 5½ in. Meter, Polarity Reverse Switch. Sensitivity: 50K /Volt D.C. 5K /Volt A.C. D.C. Volts: .125, .25, 1.25, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.C. Volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.C. Current: 25, 50μA, 2.5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance: 2K, 10K, 100K, 1MEG, 10 MEG. Decibels: —20 to +85 dB **£12·50** P. & P. 17½p.

FTC-401 TRANSISTOR TESTER



Full capabilities for measuring A, B and ICO. NPN or PNP. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads. **£6·97½**. P. & P. 15p.

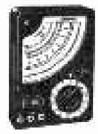


TE15 TRANSISTORISED GRID DIP METERS

Six ranges. 440 Kc/s.-280 Mc/s Operates on 9v. battery. Full instructions **£12·00**. P.P. 17½p.

270° WIDE ANGLE 1mA METERS

MW1-6 60mm. square **£3·97½**
MW1-8 80mm. square **£4·97½**
P. & P. extra

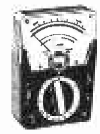


HONOR TE.10A. 20 kΩ/Volt 5/25/50/250/500/2,500 v. D.C. 10/50/100/500/1,000 v. A.C. 0/50μA/2.5 mA/250 mA D.C. 0/6K/6 meg. ohm. -20 to + 22 dB. 10-0, 100 mfd. 0.100-0.1 mfd. **£3·47½**. P. & P. 15p.

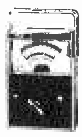
MODEL TE-300 30,000 O.P.V. Mirror scale, overload protection 0/.6/3/15/60/300/1,200 V.D.C. 0/6/30/120/600/1,200 V.A.C. 0/30μA/6mA/60mA/300mA/600mA. 0/8K/80K/800K/8 meg. -20 to + 63 db. **£5·97½**. P. & P. 15p.

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/6/60/600 mA. 0/6K/600K/6Meg./60 Meg. Ω. 50 PF. .2 MFD. **£5·97½**. P. & P. 17½p.

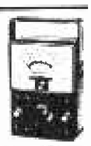
MODEL 500 30,000 O.P.V. with overload protection, mirror scale. 0/.5/2.5/10/25/100/250/500/1,000 v. D.C. 0/2.5/10/25/100/250/500/1,000 v. A.C. 0/50μA/5/50/500 mA. 12 amp. D.C. 0/60/K/6 meg/60 meg Ω. **£8·87½**. Post paid.



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. —20 to +63 dB. **£7·50**. P. & P. 15p.



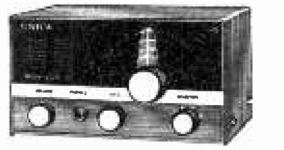
TMK MODEL TW-20CB FEATURES RESETTABLE OVERLOAD BUTTON. Sensitivity: 20K Ω/Volt D.C. 5K Ω/Volt A.C. D.C. Volts: 0-0.5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 0-2.5, 10, 50, 250, 1,000V. D.C. Currents: 0-0.05, 0.5, 5, 50, 500mA. - 10 amp. Resistance: 0-5K, 50K, 0-500K, 5 MEG. Decibels: -20 to + 52db. **£11·50**. P. & P. 17½p.



MODEL AS-100D. 100K Ω/Volt 5 in., 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/200M. -20 to + 17 dB. **£12·50**. P. & P. 17½p.

TMK LAB TESTER 100,000 O.P.V. 6½ in. Scale Buzzer Short Circuit Check. Sensitivity: 100,000 OPV D.C. 5 /Volt A.C. D.C. Volts: .5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 3, 10, 50, 250, 500, 1,000V. D.C. Current: 10, 100μA, 10, 100, 500mA, 2.5, 10 amp. Resistance: 1K, 10K, 100K, 10MEG, 100MEG. Decibels: —10 to +49 db. Plastic Case with carrying handle. Size 7½ × 6½ × 3½. **£18·90**. P. & P. 25p.

SKYWOOD SW-500 50 K Ω/Volt. Mirror scale D.C. volts: 0.6/3/12/30/300/600. A.C. volts: 3/30/300/600. D.C. current: 20μA/6/60/600mA. Resistance: 10K/100K/1 Meg. Decibels: —20 to + 57 dB. **£7·50**. P. & P. 15p.



UNR 30 RECEIVER

4 Bands covering 550kc/s - 30mc/s. B.F.O. Built in Speaker 220/240v AC. Brand new with instructions. **£15·75**. Carr. 37½p.

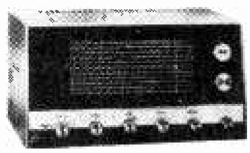
WS62 TRANSCEIVERS

Large quantity available for EXPORT! Excellent condition. Enquiries invited

UR-1A SOLID STATE COMMUNICATION RECEIVER

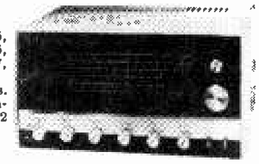
4 Bands covering 550kc/s - 30mc/s. FET, S Meter, Variable BFO for SSB, Built in Speaker. Bandspread, Sensitivity Control. 220/240v AC or 12v DC. 12½" × 4½" × 7". Brand new with instructions. **£25**. Carr. 37½p.

LAFAYETTE HA-600 RECEIVER



General coverage 150-400 kc/s, 550kc/s-30 mc/s. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, S Meter, Bandspread. RF Gain. 15" × 9½" × 8½". 18 lb. 220/240v AC or 12v DC. Brand new with instructions. **£45** Carriage 50p.

LAFAYETTE HA-800 SOLID STATE AMATEUR COMMUNICATION RECEIVER



3.5 - 4, 7 - 7.3, 14 - 14.35, 21 - 21.45, 28 - 29.7, 50 - 54 mc/s. Dual conversion, 2 mech. filters, product detector, variable BFO, S Meter, 100kc/s calibrator. 220/240v AC or 12v DC. 15" × 9½" × 8½". 18 lb. Brand new with instructions. **£57·50**. Carr. Paid. (100kc/s Crystal £1·97½p extra).

FULL RANGE TRIOEQUIPMENT

EDDYSTONE V.H.F. RECEIVERS

770R. 19-165 Mc/s. excellent condition. **£150**.

SOLID STATE VARIABLE A.C. VOLTAGE REGULATORS

Compact and panel mounting. Ideal for control of lamps, drills, electrical appliances etc. Input 230/240 v. A.C. Output continuously variable from 20 v.-230 v. Model MR 2305 5 amp 68 × 46 × 43 mm. **£8·37½**. Model MR 2310 10 amp 90 × 68 × 60 mm. **£11·97½**. Postage 12½p.

AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded.
150 W. **£2·37½**. P. & P. 17½p
300 W. **£3·25**. P. & P. 22½p
500 W. **£4·97½**. P. & P. 32½p
1,000 W. **£7·25**. P. & P. 37½p
1,500 W. **£8·97½**. P. & P. 42½p
5,000 W. **£36·00** P. & P. £1.

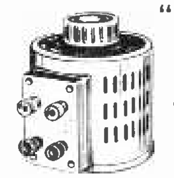
VOLTAGE STABILISER TRANSFORMERS. 180-260v. input. Output 230v. Available 150w or 225w. **£12·50**. Carr. 25p.

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, ⅜in. dia. shafts. Bulk quantities available.
25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. **72½p**. P. & P. 7½p
50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. **£1·05**. P. & P. 7½p
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. **£1·37½**. P. & P. 7½p.

"YAMABISHI" VARIABLE VOLTAGE TRANSFORMERS

Excellent quality • Low price • Immediate delivery



MODEL S-260 General Purpose Bench Mounting
1 Amp .. **£5·50**
2.5 Amp .. **£6·75**
5 Amp .. **£9·75**
8 Amp .. **£14·50**
10 Amp .. **£18·50**
12 Amp .. **£21·00**
20 Amp .. **£37·00**

MODEL S-260 B Panel Mounting
1 Amp .. .. **£5·50**
2.5 Amp .. .. **£6·62½**
Please add postage
ALL MODELS
INPUT 230 VOLTS, 50/60 CYCLES
OUTPUT VARIABLE 0-260 VOLTS
Special discounts for quantity

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50 AMP

I AMP

INPUT 230 v. A.C. 50/60
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BRAND NEW. Keenest prices in the country. All types (and spares) from ½ to 50 amp. available from stock.

0-260 v. at 1 amp.	£5·50
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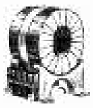
20 Different types available for immediate delivery.

OPEN TYPE (Panel mounting). ½ amp. £3·93 1 amp £5·50. 2½ amp. £6·63. P. & P. 40p.

RING TRANSFORMERS



Functional Versatile Educational

These multi-purpose Auto Transformers, 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,	£2·25+28p p. and p.
RT.300VA	2.27 turns per volt,	£4·20+38p p. and p.
RT.1KVA	1.82 turns per volt,	£6.50+58p p. and p.
RT.2KVA	1.5 turns per volt,	£10·50+80p p. and p.
RT.3KVA	1.5 turns per volt,	£14·00+80p p. and p.

L.T. TRANSFORMERS

All primaries 220-240 volts.

Type No.	Sec. Taps	Price	Carr.
1	12 v. at 5A	£1·88	28p
2	30, 32, 34, 36 v. at 5 amps.	£4·68	45p
3	30, 40, 50 v. at 5 amps.	£6·88	45p
4	10, 17, 18 v. at 10 amps.	£4·95	45p
5	6, 12 v. at 20 amps.	£6·43	45p
6	17, 18, 20 v. at 20 amps.	£7·28	55p
7	6, 12, 20 v. at 20 amps.	£6·88	55p
8	24 v. at 10 amps.	£5·23	35p
9	4, 6, 24, 32 v. at 12 amps.	£7·15	45p

AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3·63 each. P. & P. 35p. 500 watt type £5·13 each. P. & P. 45p. 1,000 watt type £7·13 each. P. & P. 55p.

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 **£2·75** plus 18p. P. & P.

LIGHT SENSITIVE SWITCHES

Kit of parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. **Price £1·25**, plus 12p P. & P. **ORP. 12 and Circuit 63p post paid.**

220/240 A.C. MAINS MODEL incorporates mains transformer rectifier and special relay with 1 make, 1 break, H.D. contacts. Price inc. circuit £2·38, plus 20p P. & P.

INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 10p each. Post paid.

SANWA MULTI RANGE TESTERS LATEST TYPE

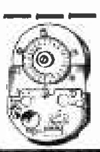
MODEL K-30. THD has thermal scales provided which directly reads temperature. With thermometer probe attached. The Meter checks from —50° C up to 200° C.

Technical Data
DC volts: 0·25 ~ 1000V in 6 ranges (10k Ω/V)
AC volts: 10 ~ 1000V in 5 ranges (5k Ω/V)
DC milliamperes: 0·25 ~ 250ma in 4 ranges
DC ohms: R×1 ~ R×1000 in 4 ranges (min 2 Ω & max 10mg Ω). Decibels:—20 ~ + 62 db.
Temperature: —50° C ~ 100° C & 0±200° C —50°—200° F & 30°—400° F
Size: 5¾ × 3¾ × 1¾ in. Weight 1·2 lb. PRICE £12·60. Post paid.

TEN OTHER MODELS FROM STOCK. LEAFLET ON REQUEST.

RUNNING HOUR METER. 240 volt, 50 cycle, 2·2 watt. Calibrated in minutes. Six figure. PRICE; £3·00 including Post & Packing.

VENNER ELECTRIC TIME SWITCH



200/250 volt. Ex-GPO. Tested, perfect condition. Two ON, two OFF, every 24 hrs. at any manually pre-set time. Price: 10amp. £2·75. 15amp. £3·25. 20amp. £3·75. P. & P. 20p. Also available with Solar Dial ON at dusk. OFF at dawn. Prices as above.

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 ¾in. dia. 15/64 in., **£1·50.** P. & P. 15p.
50 WATT 1·12/10/25/50/100/250/500/1K/1·5K/2·5K/5K ohm. All at £1·12. P. & P. 11p.
25 WATT 10/25/50/100/250/500/1K/1·5K/2·5K ohm. All at 78p, P. & P. 5p.

Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia. brass bush. Ideal for above Theostats, 18p ea.

UNISELECTOR SWITCHES NEW 4 BANK 25 WAY FULL WIPER

25 ohm coil, 24 v. D.C. operation £5·88, plus 22p P. & P.

6 BANK 25 WAY FULL WIPER
25 ohm coil, 24 v. D.C. operation. £6·50, plus 22p P. & P.

8 BANK 25 WAY FULL WIPER
24 v. D.C. operation. £7·63, plus 22p P. & P.

12-28 VOLT D.C. BLOWER UNIT

Powerful, smooth running, precision made Blower Unit. 5,000 RPM, ·54 amps. Size 3" diameter × 3¾" long over all. Price £2·00 post paid.

VERY SPECIAL OFFER

Cannot be repeated. 500 v. 50 Meg Record insulation testers. Excellent condition, fully tested. Complete with leather carrying case. **£12.** P. & P. 50p.

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. Uniiunction Xenon Tube + instructions **£5·25** plus 25p 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 **£9·45.** 50p P. & P.

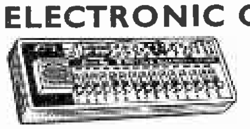
HY-LYGHT STROBE
This strobe has been designed for use in large rooms, halls and the photographic field, and utilizes a silica tube for longer life expectancy, printed circuit for easy assembly, also a special trigger coil and output capacitor. Speed adjustable 1-30 f.p.s. Light output approx. 4 ioules. Price **£10·88.** P. & P. 50p.

7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price **53p** and 13p P. & P. or post paid with kits.

MOTOROLA MAC11/6 PLASTIC TRIAC 400 PIV 8 AMP

Now available EX STOCK supplied complete with full data and applications sheet. Price £1·05 plus 7p P. & P. Suitable diac 30p (RCA40583)

ELECTRONIC ORGAN KIT



Easy to build, solid state. Two full octaves (less sharps and flats). Fitted hardwood case, powered by two penlite 1½v. batteries.

Complete set of parts including speaker, etc., together with full instructions and 10 tunes. £3·00. P. & P. 25p.

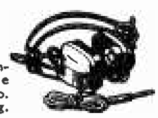
50 in 1 ELECTRONIC PROJECT KIT

50 easy to build Projects. No soldering, no special tools required. The Kit includes Speaker, meter, Relay, Transformer, plus a host of other components and a 56-page instruction leaflet. Some examples of the 50 possible Projects are: Sound level Meter, 2 Transistor Radio, Amplifier etc., etc. Price **£7·75.** P. & P. 30p.

CRYSTAL RADIO KIT

Complete set of parts including: crystal diode, ferrite aerial, drilled chassis and personal ear-piece. No soldering, easy to build, full step-by-step instructions. £1·75 inc. post.

HOSIDEN DH-02-S Stereo Headphones



Outstanding performance. 8 ohm impedance and 20-12,000 cps. Adjustable head band. Price only **£2·38.** P. & P. 12p. Complete with lead and stereo jack plug.

RELAYS NEW SIEMENS PLESSEY, etc.

MINITURE RELAYS AT COMPETITIVE PRICES.

1	2	3	4	1	2	3	4
45	6-9	2 HD M	50p	700	12-24	2 c/o	63p*
185	6-12	2 c/o	63p*	700	15-35	2 c/o HD	73p*
185	6-12	4 c/o	73p*	700	16-24	6 M	63p*
230	9-18	2 c/o HD	63p*	1250	24-36	4 c/o	63p*
230	9-12	4 c/o	78p*	2500	36-45	6 M	63p*
280	9-12	2 c/o	73p*	2400	30-48	4 c/o	50p
600	18-32	4 c/o	78p*	5800	40-70	4 c/o	63p*
700	16-24	4 M 2 B	63p*	9000	40-70	2 c/o	50p*
700	16-24	4 c/o	78p*	15k	85-110	6 M	50p*

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD = Heavy Duty. All Post Paid. *including Base.

MAINS RELAY
230 v. A.C. coil 3 c/o, 10 amp. A.C. contacts. **50p** + 8p p. & p. Similar to above illustration.

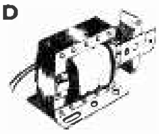
RECHARGEABLE NICKEL CAD. BUTTON CELLS.

2 × 1.2 v. 250 MA/HR Nickel Cad. Cells, connected to give 2.4 v., at 25 milliamp/10 hour rate, complete with 200/250 v. A.C. charger, unused. Price **48p** each plus 8p p. & p. or 2 units for £1·00 post paid.

NICKEL CADMIUM BATTERY

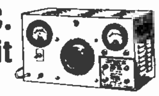
1.2 v. 35 AH. Size 80 high × 3 × 10. **£1·50** each, plus 20p P. & P.
Sintered Cadmium Type **1.2 v. 7AH.** Size: height 3½ in., width 2½in. × 1 3/16in. Weight: approx. 13 ozs. Ex-R.A.F. Tested **63p.** P. & P. 15p.

230 VOLT AC SOLENOID



EXTREMELY POWERFUL SOLENOID with approximately 14lb. pull, 1 inch travel. Fitted with mounting feet. Size 4 inches long, 2⅜ inches wide and 3 inches high. Price **£2·00** including post & pkg.

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit



Input 220/240 v. A.C. **Output** Continuously variable 0-36 v. Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. **£58** plus £2 p. & c.

230V/240V COMPACT SYNCHRONOUS GEARED MOTORS

Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox.
1 rev. per hour. Clockwise rotation.
1 rev. per hour. Anti-clockwise rotation.
2 revs. per hour. Clockwise rotation.
3 revs. per hour. Anti-clockwise rotation.
5 revs. per hour. Anti-clockwise rotation.
15 revs. per hour. Anti-clockwise rotation.
60 revs. per hour. Clockwise rotation.
Fraction of makers' price. All at **75p** incl. P. & P.

12 VOLT DC MOTOR

Powerful 12 volt 1 amp REVERSIBLE motor. Speed 3,750 rpm. Complete with external gear train (removable) giving final speed of 125 RPM. Size 4½in. × 2½in. dia. Price inc. post **95p.**

PARVALUX TYPES D19 230/250 VOLT AC REVERSIBLE GEARED MOTORS

30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. **Mounted on substantial cast aluminium base.** Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. **£6·30,** P. & P. 50p.

BODINE TYPE N.C.1 GEARED MOTOR

(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. 50 cycle .38 amp. **(Type 2) 28 r.p.m.** torque 20 lb. in. **Reversible** 1/80th h.p. 50 cycle .28 amp.
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for **230/240v A.C. input**
Price, either type **£3·15** plus 35p P. & P. or less transformer **£2·13** plus 27p P. & P.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines etc. etc.

ALL MAIL ORDERS. ALSO CALLERS AT:
57 BRIDGMAN ROAD. LONDON. W4 5BB. Phone: 01-995 1560
Closed Saturdays.

SERVICE TRADING CO.
SHOWROOMS NOW OPEN
AMPLE PARKING

PERSONAL CALLERS ONLY
9 LITTLE NEWPORT STREET. LONDON, WC2H 7JJ. Tel.: 01-437 0576

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DISPLAYED SITUATIONS VACANT AND WANTED: £8 per single col. inch.
LINE advertisements (run-on): 45p 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 25p.
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No responsibility accepted for errors.

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jump! to computers

Join us now as a Computer Service Engineer, and after six months' paid specialist training, you will be responsible for ensuring that our computers are in peak condition.

We are Britain's leading computer manufacturer; we give men who want a rewarding career an excellent basic salary while we train them in every aspect of customer engineering in the computer industry. You'll learn to deal with operational problems, and to use the most intricate machinery.

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To add to your basic salary, you can get generous overtime and shift rates. There is a special allowance for working in central London. You will be operating in a computer environment on customers' premises in conditions well above the average for industry.

Age: 21/35.

Locations: Middlesex, Hertfordshire, Surrey, Central London, Manchester, Kidsgrove, Reading, Bracknell, and Dublin.

Write giving brief details of your career, and quoting ref. WW756C to: A. E. Turner, International Computers Limited, 85/91 Upper Richmond Road, Putney, London SW15.

International Computers ICL

1168

TECHNICAL AUTHORS

The Data Systems Divisions of Redifon Ltd engaged in design and manufacture of computer-based systems, requires two additional experienced Technical Authors to meet its demand of expansion programme. If you possess HNC electronics or equivalent knowledge and can meet the challenge of producing original drafts from engineering drawings of electronics and digital equipment telephone immediately for further details and interview appointment. A secure career with attractive salaries and removal expenses will be offered to suitable applicants.

Apply to:
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Tel: Crawley 30511, Ext. 47

REDIFON
A Member Company of the Rediffusion Organisation

1167

Senior Engineer

Audio Systems £2,000 p.a. +

Rank Bush Murphy are acknowledged leaders in the field of high quality domestic radio, television and audio products. To strengthen our present team we want to recruit a Senior Engineer to work on Audio systems.

He will be responsible for the design and development of complete systems from initiation of the project to production stage. For such a level of responsibility the right man will have at least 3 years' direct experience in design and development of audio, tape and radio equipment. Membership of I.E.R.E. or I.E.E. would indicate to us the quality of the man.

The salary level and other employee benefits are as generous as one would expect from an organisation of our strength and profitability. Relocation expenses will be paid where appropriate.

Please write quoting reference WW or telephone, giving us brief details of your career to date, to:
David Jux, Rank Bush Murphy Ltd.,
Power Road, Chiswick, London, W.4.
Telephone: 01-994 6491.

RANK BUSH MURPHY

1189

Opportunities with Redifon in Radio Communications

Experienced Test Engineers are invited to write to Redifon with regard to vacancies in our Test Department at Wandsworth.

The salary range for these positions is £1,248–£1,749 plus. The Company is engaged in the design and manufacture of a wide range of radio communications and allied equipment from military pack set to broadcast transmitter, including communications receivers, M.F. beacons, teleprinter terminals, complete radio office installations for the Merchant Marine and mobile H.F. S.S.B. stations. Our Test Engineers have sound technical knowledge coupled with good practical experience in the alignment and test of H.F. and V.H.F. Communications equipment.

The work is varied and interesting and offers excellent opportunity to broaden experience in semiconductors S.S.B. and Frequency Synthesis.

Please write in the first instance to
Norman Manion,
The Recruitment Officer, Redifon Limited
Broomhill Road, Wandsworth, S.W.18

REDIFON
A Member Company of the Rediffusion Organisation 1970

1174

CAR RADIO TECHNICIAN

Bosch Automotive Products, in Watford, are looking for a rather special Car Radio Technician.

You must not only enjoy working on your own with the most modern equipment but also meeting people. We want you to help in training our dealer service personnel and give technical advice to dealers and private customers.

To cope with all this you must be qualified to City & Guilds Standard in Radio and T.V. and have some administrative ability in order to maintain spare parts lists and the like.

This is a real opportunity with a growing company and not to be missed.

Interested? Ring or write: Miss F. Cracknell
Bosch Automotive Products Ltd.,
Rhodes Way,
Watford, Herts.
Tel: Watford 44233

1184

H.M. GOVERNMENT COMMUNICATIONS CENTRE

has vacancies at Hanslope Park for

TELECOMMUNICATION ENGINEER

Posts are available for young men between the ages of 25 to 30 years with 3-5 years post graduate experience in communications or electronic design; knowledge of VHF-UHF systems and digital techniques an advantage. A degree in Telecommunications or Electronics is preferred.

Salaries are up to £2,500 according to age, qualifications and experience.

Applications with details of previous experience etc, to:

Personnel Officer, HMGCC, Hanslope Park, Wolverton, Bucks.

1158

LONDON BOROUGH OF BRENT

WILLESDEN COLLEGE OF TECHNOLOGY

DENZIL ROAD, LONDON, N.W.10

DEPARTMENT OF ELECTRICAL ENGINEERING

LECTURER GRADE II

to teach telephony on the C & G Telecommunications Part I and Part II courses. Excellent opportunities exist for the development of a laboratory for this section of the department's work.

LECTURER GRADE I

to teach Radio/T.V./Electronics theory and practice on C & G Craft and Technician courses.

Commencing salary within the scales according to experience and qualifications:
Lecturer Grade II £2,032—£2,622
Lecturer Grade I £1,315—£2,160
subject to review.
Further particulars from Bursar.

1188

LEICESTERSHIRE EDUCATION COMMITTEE

LOUGHBOROUGH TECHNICAL COLLEGE

Principal: F. Lester, B.Sc., Ph.D., F.R.I.C.

DEPARTMENT OF ELECTRICAL ENGINEERING

Applications are invited for the post of

LECTURER GRADE I

duties to commence on the 1st September, 1971. The person appointed will be required to teach Radio and Television Theory and Practice, Electronics and Electrical Principles to Final Certificate level in Technicians and other courses. Applicants should be suitably qualified and should preferably be members of a Professional or Technician Institution. A thorough knowledge of broadcast receiving equipment is required; previous teaching experience would be an advantage. Salary will be in accordance with the Burnham Scales for teachers in establishments for Further Education (under review), viz: Lecturer Grade I, £1,230—£2,200, with placing on the appropriate scale according to qualifications and experience. Further particulars may be obtained from the Principal, Loughborough Technical College, Radmoor, Loughborough, Leicestershire, to whom completed applications should be returned within fourteen days of the appearance of this advertisement.

1190

DOLBY SYSTEM

NOISE REDUCTION IN RECORDING AND COMMUNICATIONS

Dolby Laboratories manufacture professional noise reduction equipment which has been widely accepted by major recording companies, recording studios and broadcasting authorities throughout the world. New applications for the equipment are now being explored in the film and television industries.
Dolby Laboratories is situated in a modern building south of the river, with excellent communications to the centre of London and main railway stations: the company, 6-years-old, is expanding rapidly and now comprises 100 people. New vacancies arising within the Sales Department are for a Sales Engineer and a Sales Controller.

SALES ENGINEER

The requirement is for an electrical engineer who will be involved in all technical aspects of sales, including installation engineering, field servicing, and visiting and providing demonstrations and technical training for customers and distributors, both in the UK and abroad. He will occasionally be involved in investigations of new applications for the equipment. The successful applicant may well have experience of recording studio or broadcasting practice. He will probably have a degree, and should be aged between 25 and 35.

SALES CONTROLLER

The Sales Controller will have responsibility for the supervision of the sales office, with particular reference to customer and distributor correspondence, sales forecasting, liaison with the Production Department, delivery scheduling, and shipping and exporting. In addition, he will explore new sales outlets for the equipment and seek suitable distributors in new markets. It is possible that the successful applicant will already have worked within the recording industry. He will probably have a degree, and should be aged between 25 and 35.

Salary £2500-£3000 (even higher for exceptional men)

Write with brief details, in the first instance, or telephone:

Ioan Allen, Sales Manager

Dolby Laboratories Inc., 346 Clapham Road, London, S.W.9. Telephone: 01-720 1111

1173

Telecommunications Officer Grade II MALAWI

* *Salary up to £2165*
* *Low taxation*
* *25% gratuity on completion of 30 month tour*
* *Education allowances*
* *Subsidised housing*
* *Appointments Grant £100 or £200 payable in certain circumstances*
* *Contract 24-36 months*

Required by the Department of Civil Aviation for the installation servicing and maintenance of aeronautical telecommunications equipment including MF beacons, low power (up to 1 KW) HF transmitters using SSB, AM and FSK techniques, low power (up to 50 W) VHF transmitters and associated VHF and HF receivers including RTT terminals, VHF multi-channel link and Wilcox VOR/DME equipments, Facsimile equipment and 200 Mc/s DME.
Selected candidates will also be required to assist with the training of local staff.

Candidates, aged 25-55, must have completed a recognised apprenticeship or similar training in aeronautical telecommunications followed by a minimum of five years' relevant experience on at least 50% of the above-mentioned equipment. The possession of the City & Guilds Final Certificate in Telecommunications, H.N.C. or equivalent would be an advantage although applicants lacking formal educational qualifications but with extensive experience may be considered.

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/710342/WF.

1160

OXLEY DEVELOPMENTS

Have a vacancy in their Lake District Factory for a fully qualified

RADIO ENGINEER

The position will be one of potential and responsibility in a Company with 30 years of expansion behind it, and only those with ability and willingness to work hard should apply.

The Engineer chosen must have knowledge and experience in up to date Microwave design and measurement techniques and have a background which qualifies him to conduct a project from inception to manufacture.

The salary will be commensurate with experience; superannuation and other conditions of service are generous.

Applications giving details of education, experience and qualifications, should be forwarded to:

OXLEY

THE PERSONNEL MANAGER,
OXLEY DEVELOPMENTS COMPANY LIMITED,
PRIORY PARK, ULVERSTON, NORTH LANCASHIRE

1176

Engineers

Do you want to get into sales?

We require a development engineer without previous sales training for an internal sales engineer. This position offers excellent scope for personal advancement into the sales field. Salary negotiable plus special bonus and pension schemes.

Please 'phone T. Jermyn or P. Baker at Sevenoaks (0734) 51174.

Jermyn Industries
Vestry Estate Sevenoaks Kent

JERMYN

1100

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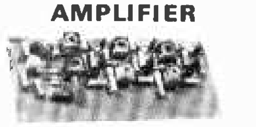

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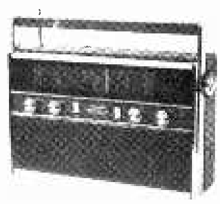

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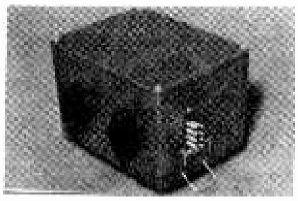

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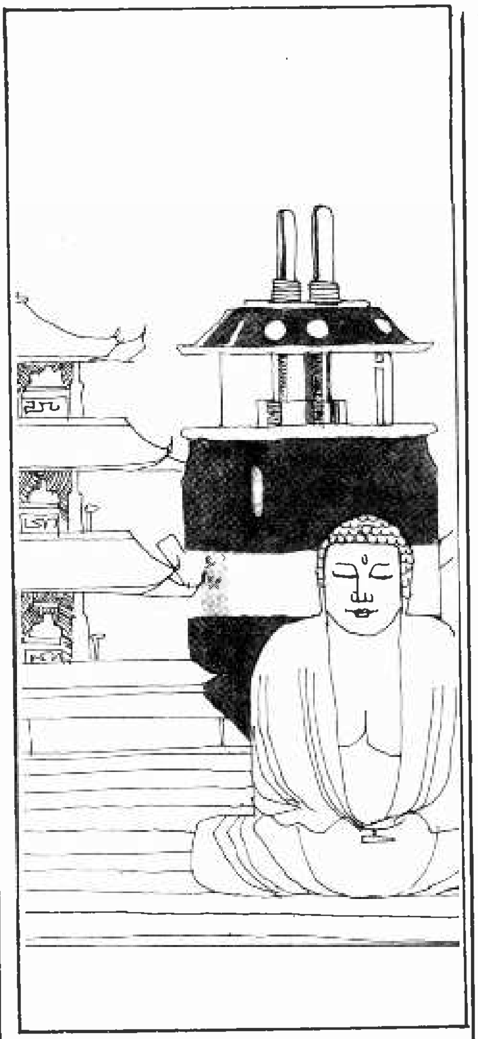

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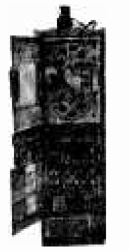

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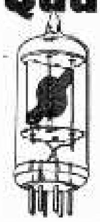

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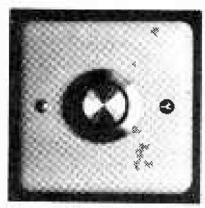

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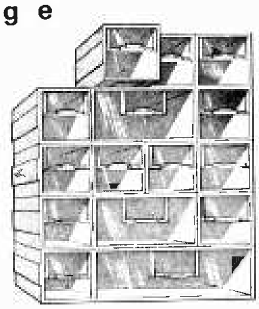

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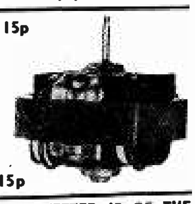

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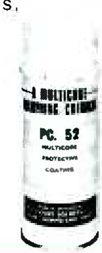

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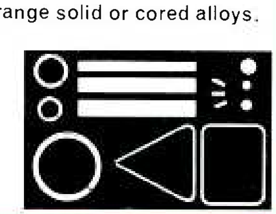

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