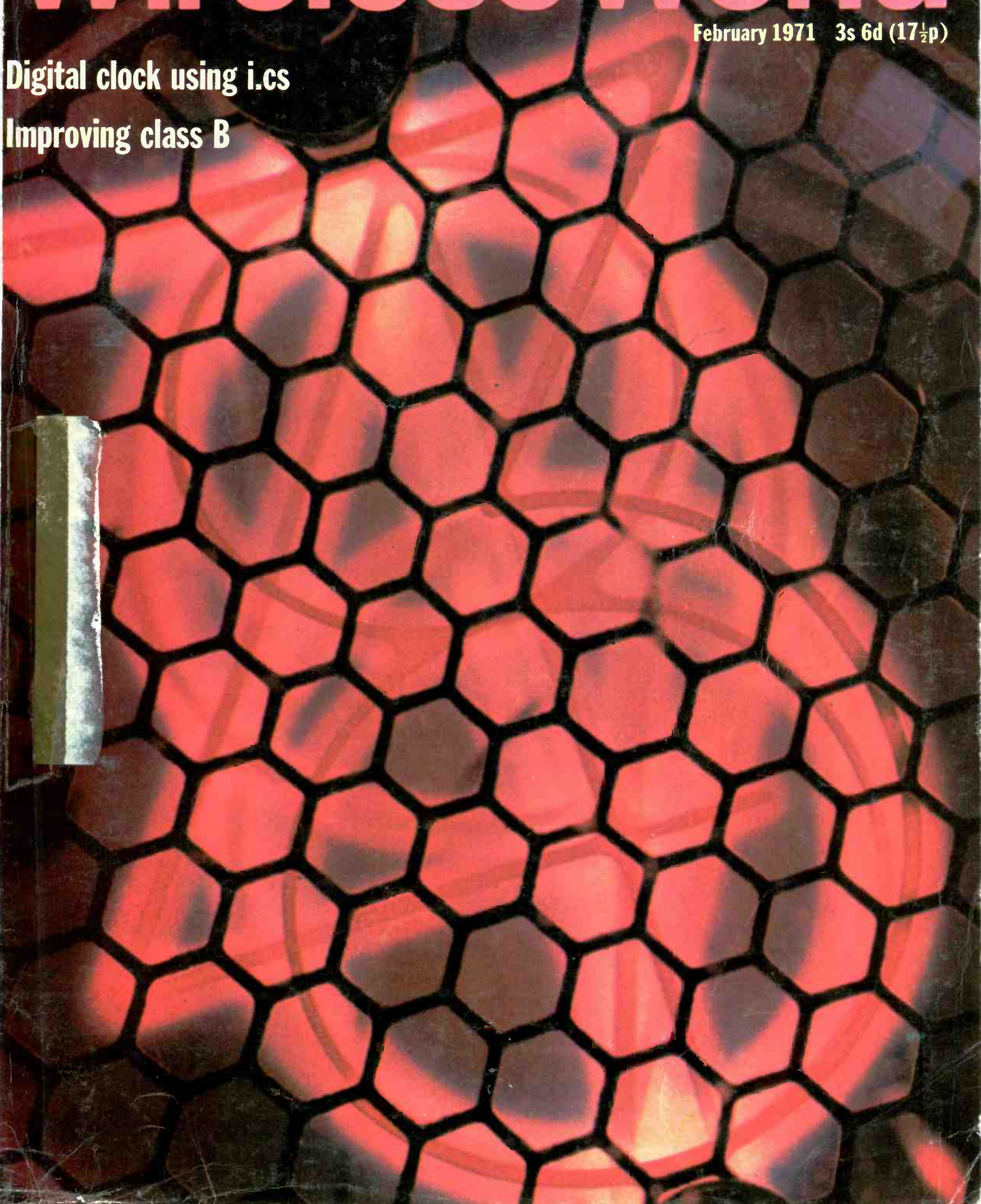
Wireless World

February 1971 3s 6d (17½p)

Digital clock using i.cs

Improving class B



Tektronix Type 576 Curve Tracer

★ Expanded viewing area – combines a 10 cm x 12 cm graticule with fibre-optic readout of scale factors, step amplitude, and Beta/div or gm/div.
★ Swept or DC Collector Supply to 1500 V.
★ Leakage Measurements to 1 nA/div.
★ Multi-function Switching – direct-reading power limits, polarity tracking, auto-positioning, mode changes.
★ Calibrated Display Offset – improved accuracy (±2%) increased resolution.
★ Step Generator Range to 2A or 40V.
★ Calibrated Step Offset – aid or oppose.
★ Pulsed Base Operation.
★ Kelvin Sensing for high-current tests.
★ Interlock Operator Protection.

576............£1,084
576 mod 301W £920
(without character read out)
All prices delivered U.K.

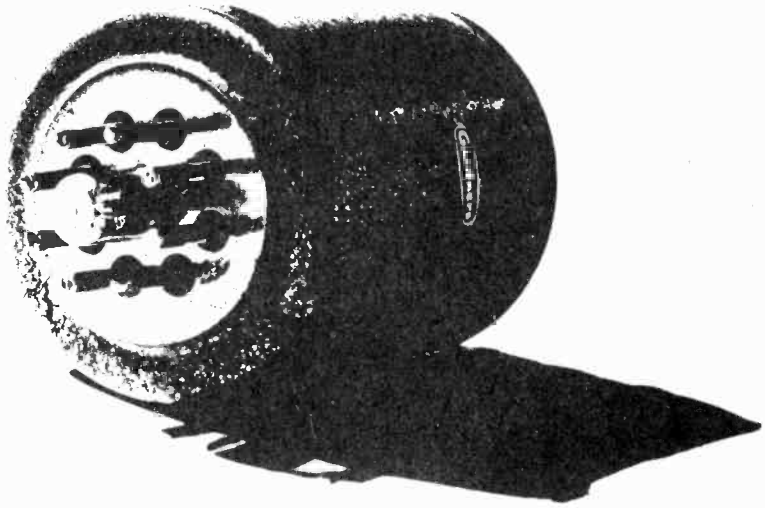
The 176 Pulsed High-Current Fixture extends the capabilities of the 576 Curve Tracer by providing pulsed collector operation to 200 amps peak and pulsed base steps to 20 amps peak. The step offset, when selected, is also pulsed. The pulsed operating mode allows many tests previously impossible. **£664 plus duty £94**

Please fill in Reader Reply Card or write, telephone or telex:

Tektronix U.K. Ltd.
Beaverton House, P.O. Box 69,
Harpenden, Herts.
Tel: Harpenden 61251 Telex: 25559
Northern Region Office:
Beaverton House, 181A Mauldeth Road,
Manchester 19.
Telephone: 061 224 0446 Telex: 668409

TEKTRONIX
committed to progress in waveform measurement

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.

Return the coupon to us.
And we'll send you the GTs by return.

GT.1	POWER CONTROLLING SATURABLE REACTORS 50W. to 1kW. with application notes.
GT.5	AUDIO TRANSFORMERS including Microphone and line matching, Driver, output and impedance matching transformers.
GT.12	LILLIPUT SERIES OF MICROMINIATURE TRANSFORMERS including Inverter, A.F. and wide-band carrier matching A.F. Driver and pulse types, miniature smoothing and A.F. inductors.
GT.16	ALPHA SERIES OF ASSEMBLIES for filters, delay lines, modulators, etc.
GT.17	LOW VOLTAGE, ISOLATING AND AUTO TRANSFORMERS in nearly two hundred ratings, 6v. to 440v. and 5vA to 2kvA in six assembly styles.
GT.21	MANUAL OF INVERTER TRANSFORMERS AND MODULES.
GT.23	INDUCTORS, including heavy current and commutation types.
GT.24	POWER TRANSFORMERS for use with tube type circuits (including obsolescent types) and E.H.T. and Magnetron Supply Transformers.
GT.25	TRANSISTOR POWER SUPPLY TRANSFORMERS.
GT.100	GENERAL REFERENCE CATALOGUE with data sheets of assemblies available for specially designed transformers.

Gardners

GARDNERS TRANSFORMERS LIMITED
Christchurch Hampshire BH23 3PN
Tel: Christchurch 2284 (STD 0201 5 2284)
Telex 41276 GARDNERS XCH

Please indicate your requirement by circling the number/s below

1 5 12 16 17 21 23 24 25 100

NAME ______________________

ADDRESS ______________________

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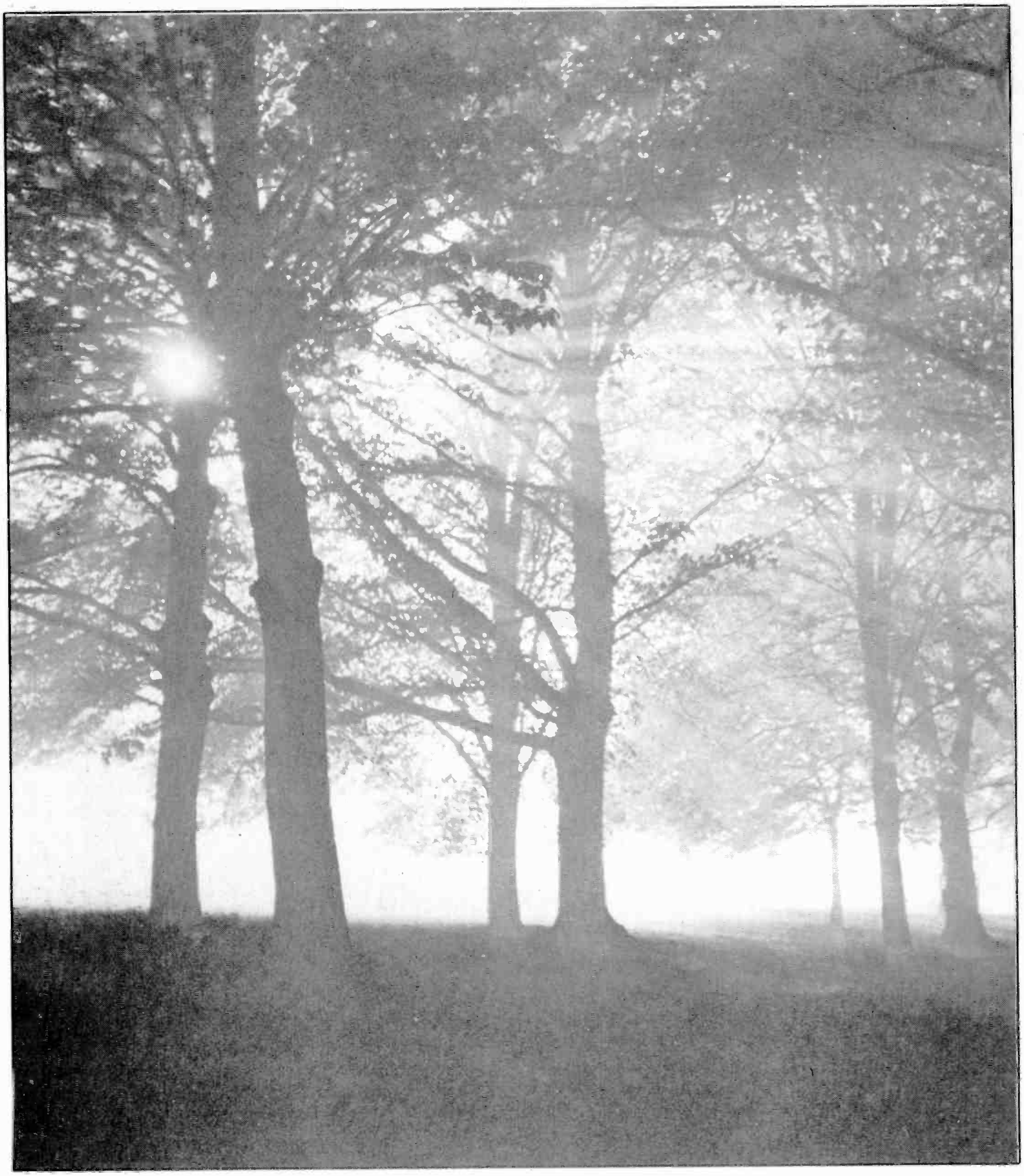
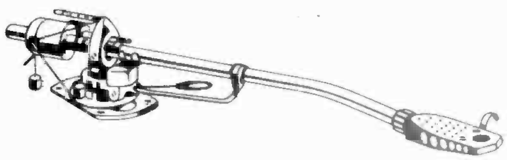
When did you last hear for the first time?





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EEV flash flash flash tubes make light of the toughest jobs

For pumping lasers. For strobing. For photography. For any application in which quality, reliability and performance are vital, that's where you'll find EEV flash tubes.

There's almost certainly a flash tube in the EEV range that has the right characteristics for your application – and if there isn't we can probably make one!

EEV flash tubes have extra heavy-duty electrodes. They give you long life, with up to 10^6 flashes, *and* they give you high conversion efficiency. Our air-cooled xenon flash tubes have a wide range of input energy levels and can operate at high repetition rates.

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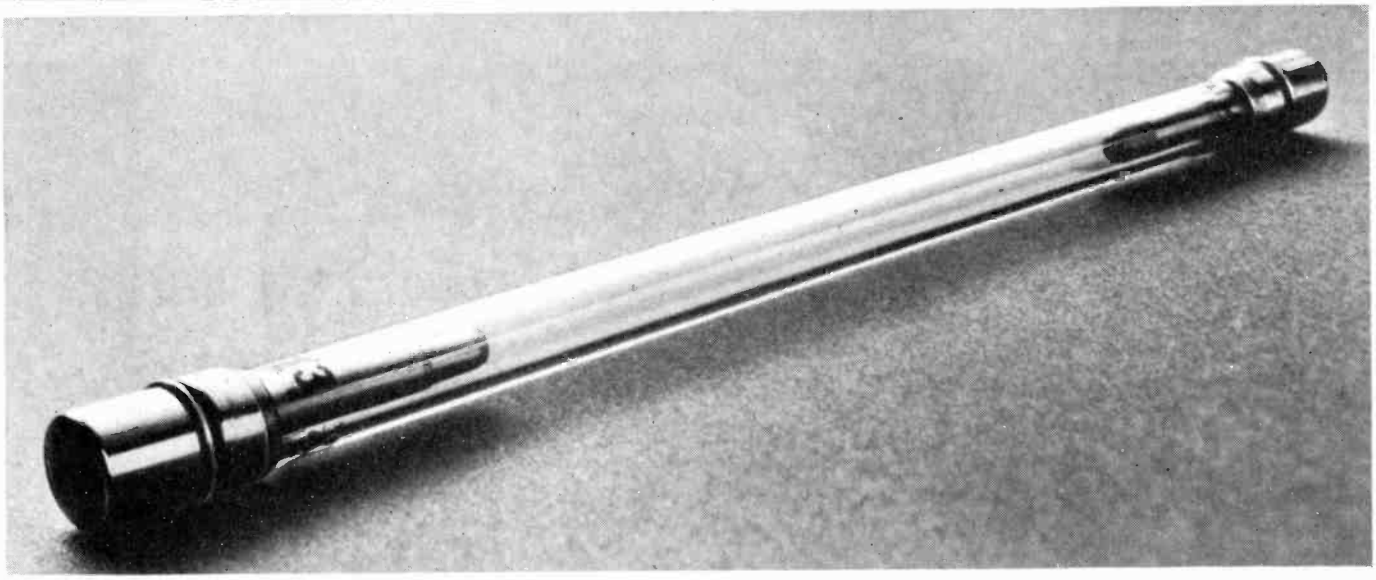
English Electric Valve Co Ltd, Chelmsford, Essex, England. Telephone: 0245 61777 Telex: 99103
Grams: Enelectico Chelmsford



Type	Energy input per flash max. (J)	Arc length (in.)	Bore diameter (mm)	*Typical operating conditions* Voltage (kV)	Series inductance (μH)	*Flash rate	Trigger voltage (kV)
XL615/4/3	400	3	4.0	2.5	400	1 per 30 sec.	12-16
XL615/7/3	600	3	7.0	2.5	400	1 per 15 sec.	12-16
XL615/9/4	1500	4	9.0	2.5	400	1 per 30 sec.	16-20
XL615/10/5.5	3500	5.5	10.0	2.5	400	1 per 60 sec.	16-20
XL615/10/6.5	5000	6.5	10.0	2.5	800	1 per 2 min.	20-25
XL615/10/12	9000	12	10.0	2.5	800	1 per 2 min.	25
XL615/13/6.5	10000	6.5	13.0	2.5	800	1 per 2 min.	25
XL615/13/12	18000	12	13.0	2.5	800	1 per 2 min.	25

**At maximum input levels (air-cooled)*

To: English Electric Valve Co Ltd, Chelmsford, Essex, England
Send for full data on EEV flash tubes.

I am interested in ______________ (application)

Name

Position

Company

Address

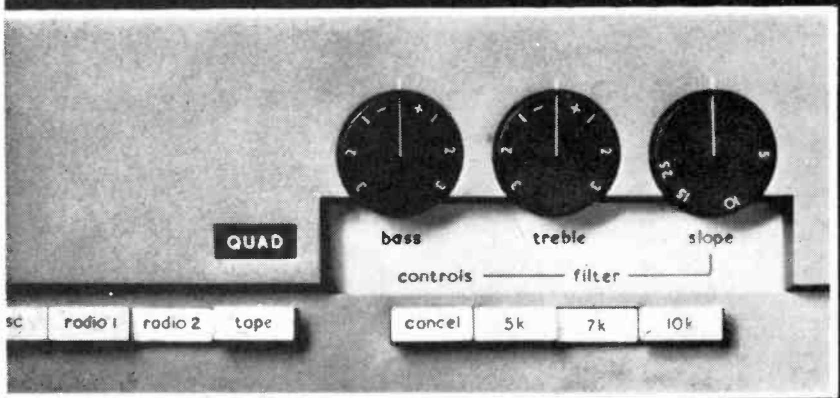
Tel. exchange or code

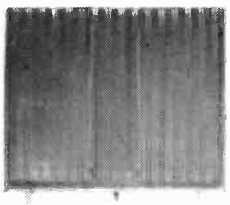
Number Ext.

ENGLISH ELECTRIC VALVE CO LTD

CRC 6

WW—009 FOR FURTHER DETAILS


QUAD
bass
treble
slope
controls
filter
sc
radio 1
radio 2
tape
cancel
5k
7k
10k




QUAD 303

Red Kite (*Milvus milvus*)

Quality and Value

WELWYN ELECTRIC LIMITED

(Founded 33 years ago)

A reputation for producing high quality products, that also offer better value for money, takes a long time to achieve. Such a reputation when achieved can be enjoyed but never taken for granted.

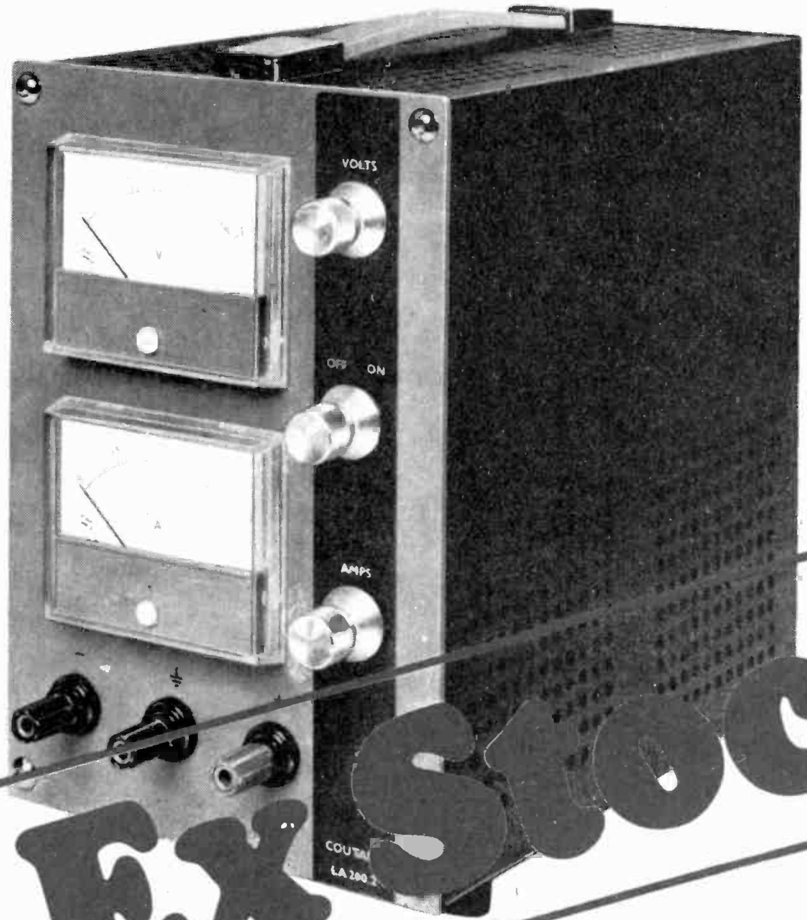
Through our Quality Engineering Department we continuously ensure that consistency of performance parameter and long life is built into everything we make. Constant probing and inspection of every facet of our design and manufacture ensures that every product is at the top of its class.

But how about value for money? This can be related to but should never be confused with price. Our prices are sometimes 'higher than' and sometimes 'lower than', but our value-for-money remains constant i.e. the best. We have achieved, enjoy, and guard our reputation.

Our wing span – a third of a century

WW—012 FOR FURTHER DETAILS

Coutant 'L' series Laboratory power supplies

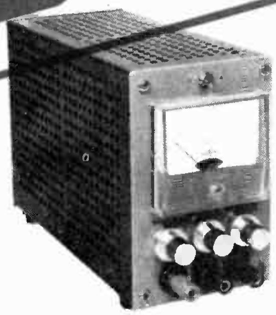


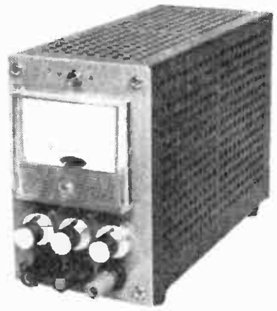
The 'L' Series bench power supplies are ideally suited for the wide range of laboratory and general applications where continuously variable high performance power is essential. The entire range has been designed for trouble-free operation into any type of load, and the compact design takes up very little valuable bench space.

- Mains Regulation: CV 0.01% + 1mV
- Mains Regulation: CC 0.01% + 1mA
- Load Regulation: CV 0.03% + 3mV
- Load Regulation: CC 0.03% + 3mA
- Ripple Voltage: <1mV p-p
- Ripple Current: 0.01% + 1mA p-p
- Transient Response: <10 μS
- Maximum Operating Temperature: +45°C

LA Range
Constant Voltage or Constant Current Operation
LA 100 0-50V 0-1A
LA 200 0-30V 0-2A
LA 400 0-15V 0-4A
£57

LB Range
Constant Voltage or Constant Current Operation
LB 200.2 0-50v 0-2A
LB 500.2 0-30v 0-5A
LB 1000.2 0-15v 0-10A
£89.5





LP Range
Constant Voltage or Constant Current Operation
LP 50/50 0-50v 0-0.5A
LP 100/30 0-30v 0-1A
LP 200/15 0-15v 0-2A
£35

LM Range
Constant Voltage. Variable Current Limiting.
LM 50/30 0-30v 0-0.5A
LM 100/15 0-15v 0-1A
£22.5

LQ Range
Constant Voltage. Variable Current Limiting.
LQ 50 0-50v 0-0.5A
LQ 100 0-30v 0-1A
LQ 200 0-15v 0-2A
£29

LAB Range
Constant Voltage or Constant Current.
LAB 100 0-50v 0-1A
LAB 200 0-30v 0-2A
LAB 400 0-15v 0-4A
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Ask our Sales Office for the complete specification.

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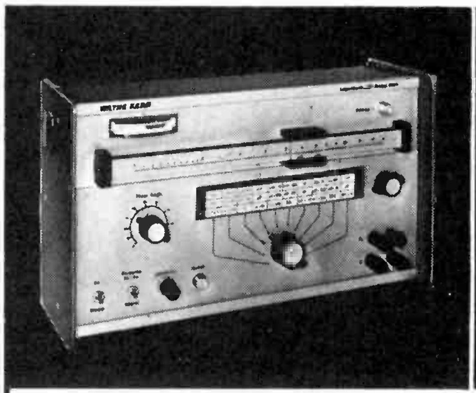
Trafford Road, Reading RG1 8JR Tel: 0734 55391 Telex 84519

Coutant take the initiative in new Technology

WW—014 FOR FURTHER DETAILS


This is a plug for our new tin oxide pluggables
259P
9P2D
259P

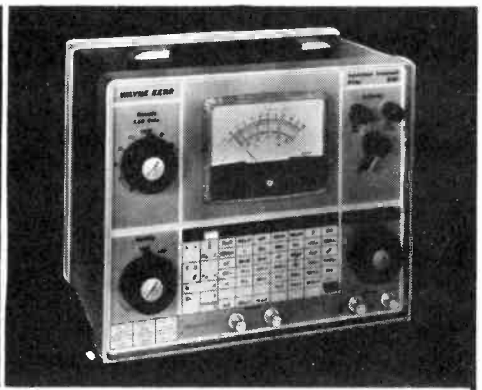


Slide-rule L C R Bridge has ten overlapping ranges for rapid 1% measurements of any component, also tolerance and phase angle. Switch selects 1kHz or 100/120Hz operation. 2, 3 and 4-terminal connections. Adjustable overall sensitivity, special 'search' facility, and automatic increase of detector gain as balance is approached.

B 500

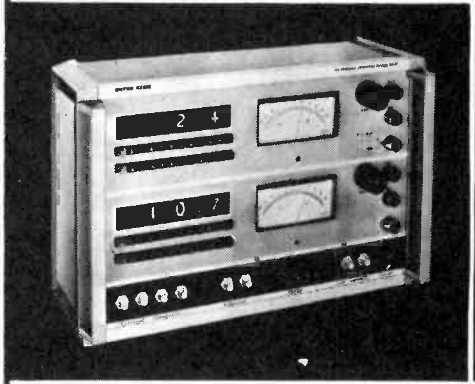
Universal Bridge for 0.1% measurements of any LCR combination from 2 micro-ohms to 500 gigohms. Source/detector (1592Hz) operate from a.c. or internal rechargeable battery. Sockets for external 200Hz – 20kHz. Display gives units, zeroes and decimal point. Four-terminal connections for accurate low impedance measurements.

B 224



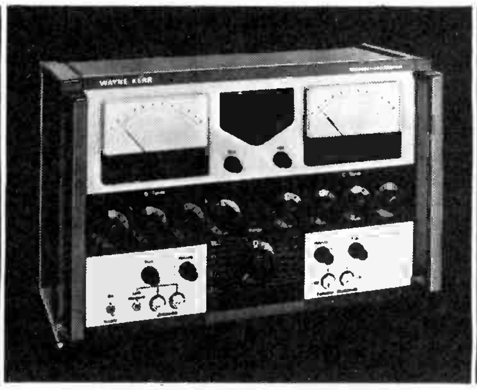
Autobalance Component Bridge for immediate readout of resistance, capacitance and shunt loss, inductance and series loss. C and R comparisons from —25% to +25%. Electrolytics tested with d.c. Accuracy 0.25% (R & C), 2% (L). Internal 1kHz source/detector.

B 421



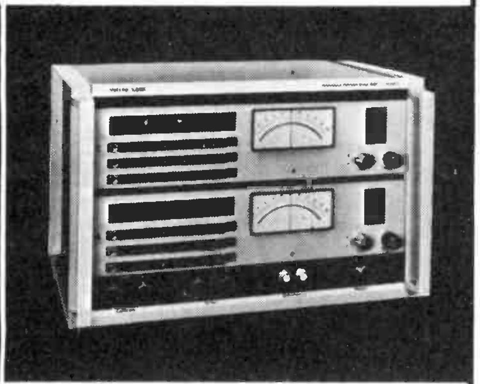
Autobalance Universal Bridge for continuous 0.1% readout of in-phase and quadrature terms, with analog outputs of both. Backing-off facilities, DVM connections, optional BCD outputs. Push-buttons for optimum discrimination up to five figures. Illuminated readout.

B 641



Autobalance Universal Bridge gives four-figure readout on all ten ranges covering every practical value of L, C, R & G. Sensitivity increases automatically when decade back-off controls are used but can be selected manually. External Standards sockets permit comparative measurements and increase discrimination to 5 or 6 figures. Accuracy 0.1%.

B 642



Autobalance Precision Bridge accurate of 0.01% though simple to operate. It measures virtually any meaningful immittance in any quadrant. Automatic compensation for measurement lead impedance. Six-figures discrimination. Analog outputs.

B 331 MkII

Wide range A.F. Bridges

Wayne Kerr Bridges provide accurate measurement of L, C and R values over an unusually wide range. They employ a minimum number of fixed stable Standards in association with precision tapped transformers giving voltage and current ratios. Speed and ease of operation are assured by functional styling.

WAYNE KERR

THE WAYNE KERR COMPANY LIMITED,
Roebuck Road, Chessington, Surrey. Tel: 01-397 1131. Cables: Waynkerr, Chessington. Telex 262333

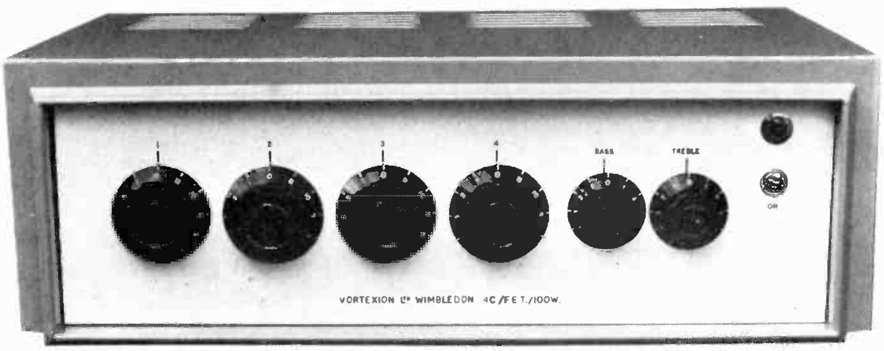
WW—016 FOR FURTHER DETAILS

Vortexion

This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable—100 Watt Amplifier (no failures to date) with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer amplifier, again fully protected against overload and completely free from radio breakthrough. The mixer is arranged for 3-30/60Ω balanced line microphones, and a high impedance line or gram input followed by bass and treble controls. 100 volt balanced line output

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

100 WATT ALL SILICON AMPLIFIER. A high quality amplifier with 8 ohms–15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100K ohms.



THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4 channel F.E.T. mixer, 3 mic. 1 gram with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25% and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms–15 ohms and 100 volt line. Bass and treble controls fitted.

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 Hi Z gram.

ELECTRONIC MIXERS. Various types of mixers available. 3-channel with accuracy within 1 dB Peak Programme Meter. 4-6-8-10 and 12-way mixers. Twin 2, 3, 4 and 5 channel stereo. Built-in screened supplies. Balanced line mic. input. Outputs: 0.5 V at 20K or alternative 1 mW at 600 ohms, balanced, unbalanced or floating.
Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, S.W.19

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

WW—019 FOR FURTHER DETAILS

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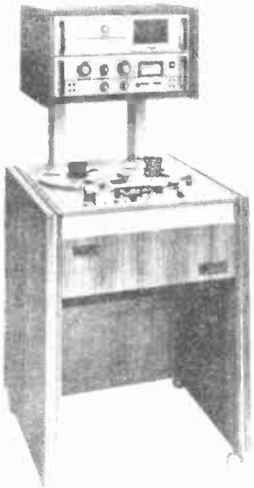
Plessey studio equipment includes reel-to-reel, portable, console and endless-loop cartridge recorders that have been time proven for twenty-two years by broadcasters around the world. This kind of equipment will fit into your system — and give definite operational and cost advantages. Keep us in mind when next you are considering new equipment.



A full range of technical literature is available on request, or better still, a technical representative will call if it's convenient.

Contact us now!

PLESSEY
Electronics

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Westbank Terrace Richmond Australia 3121
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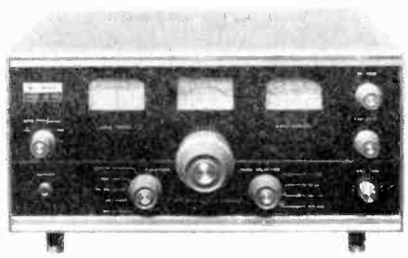
AV27 —E

ALL BAND COMMUNICATIONS RECIVER JR-599 **ALL BAND SSB TRANSMITTER TX-599**

TRIO IS FULLY-EQUIPPED FOR FULL-CYCLE COMMUNICATIONS

TRIO's JR-599 communications receiver brings the highest-type, professional, all-bands potential to amateur bands on an allocated 1.8 to 29.7 MHz frequency range, 50 and 144 MHz bands and WWV's 10 MHz standard signal. A receiver frequency readable to the nearest 500 Hz is guaranteed due to precision type double gear mechanism and variable capacitor with linear characteristic for main tuning dial of a 25 kHz band at one full turn. The all-band SSB TX-599 transmitter matches the JR-599 with its wide-spread IC and FET network. All HF bands are covered with its single switch mode on LSB, USB, AM and CW positions. All of TRIO's equipment—or equipment combinations—is designed to provide entirely full-cycle communications capability.

SP-5D
COMMUNICATIONS SPEAKER
- Communications Speaker which has been designed for use with the 9R-59DS.
- Dimensions: 3-9/16"(W), 7-1/8"(H), 5-3/16"(D).



9R-59DS
BUILT IN MECHANICAL FILTER
8 TUBES COMMUNICATION RECEIVER
- 4 Bands Covering 540 KHz. to 30 MHz.
- Two Mechanical Filters Ensure Maximum selectivity.

the sound approach to quality—

TRIO

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TRIO KENWOOD ELECTRONICS S.A. 160 Ave., Brugman, 1060 Bruxelles Belgium

Sole Agent for the U.K.

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% Deviation
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Amps
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DANGER
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Power
Print
Ohms Zero
Output
Reset
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Off
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MULTIMETER CALIBRATOR 171

ADCOLA

-the handy stripper with precision performance

ADCOLA R 400

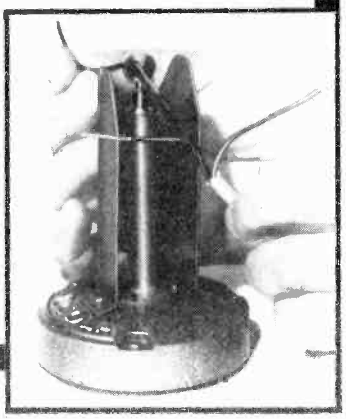
Thermal Cable Stripper

The ideal hand model for the thermal stripping of P.V.C. and Polythene cables up to $\frac{1}{8}$" (3.2mm). Provides just the right temperature. Precision constructed throughout. Closely controlled element. Strong reinforced handle. Neon indicator lamp.

ADCOLA R 310

Bench-Mounted Model

Leaves the operator with both hands free for accurate, rapid cable stripping. Fitted with Neon Indicator Lamp.



ADCOLA offer you a speedy off-the-shelf service with the world's most comprehensive range of modern soldering instruments.

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UNREPEATABLE OFFER!

LIMITED NUMBER ONLY

EMI L4A PROFESSIONAL BATTERY MAINS PORTABLE

Never before and possibly never again will we be able to make an offer such as this!! To coin an old cliche "It's the chance of a lifetime."

We have made the exclusive purchase of these superb battery/mains portable half-track professional recorders.

Not in the recent past available to the domestic user due to its exemption from Purchase Tax being maintained only if sold to professional, scientific and industrial organizations. Had it been placed on the domestic market it would have retailed at approx. £170 for the recorder without any accessories!!

The superb EMI L4A battery mains professional recorder has been sold by the Professional Products Department of the world famous EMI organization to professional, scientific and industrial users throughout the world. Ranking high in esteem with all professionals it has gained an unprecedented reputation for superb quality and utter reliability. Its specification developed over many years from the earlier world famous EMI L2A, used almost exclusively by the BBC and other world wide broadcasting stations, provides facilities only to be found in other professional recorders such as Nagra, etc.

Just look at the unique features contained in its comprehensive specification.

3 Heads (1 Erase, 1 Record, 1 Playback) 2 speeds $3\frac{3}{4}$" and $7\frac{1}{2}$". Unique automatic back tension control to ensure absolute constant speed. Two microphone inputs, with separate mixing controls, plus Remote control facilities through microphone switch. Edge mounted meter can be switched to monitor battery voltage, erase and bias oscillator current, record level and line out output. Recorded signal can be monitored before and after record on 3" internal speaker driven by inbuilt 200mW amplifier or through monitoring headphones. Extremely lightweight. Only $10\frac{3}{4}$lbs. Size 7" x $11\frac{3}{4}$" x $5\frac{3}{4}$". Exceptionally robust. Fully tropicalised. Built to last a lifetime. Minimum running costs. Rechargeable batteries can be used over and over again in conjunction with the Mains Battery charger which also acts as a mains power supply unit. Wow and flutter better than 0.2% RMS. Signal to Noise ratio +50dB (unweighted).

Absolutely ideal for every form of live recording. Orchestral and organ music, wild life recordings, interviews, expeditions, scientific investigations, etc. A recorder never previously available at such a ridiculously low price.

69 GNS. Carr. 50/– Cash or Terms

Every machine brand new, fully guaranteed and supplied complete with superb carrying case (retail value £5.10.0), shoulder strap and comprehensive instruction manual. Recorders can be supplied to European or NAB standards (State which required when ordering). A full range of accessories are available including mains battery charger units, rechargeable battery packs, dynamic and ribbon microphones, monitoring headsets, etc.

EMI L4C Full Track Neopilot Sync. Model

We have a very limited number of these special cine/sync models. An absolute must for any amateur or professional movie maker, providing 100% lip synchronisation. 4 Heads with star indicator for use with sync head telling when camera is in action. Had these been available on the domestic market they would have been approx. £220!!!

89 GNS. Carr 50/– Cash or Terms

We cannot guarantee being able to meet the expected demand for this unrepeatable bargain as we have very limited numbers available and would advise early ordering to avoid disappointment.

HP TERMS FOR PERSONAL CALLERS EXPRESS MAIL ORDER SERVICE

THE DISCOUNT TAPE RECORDER CENTRE

TCR

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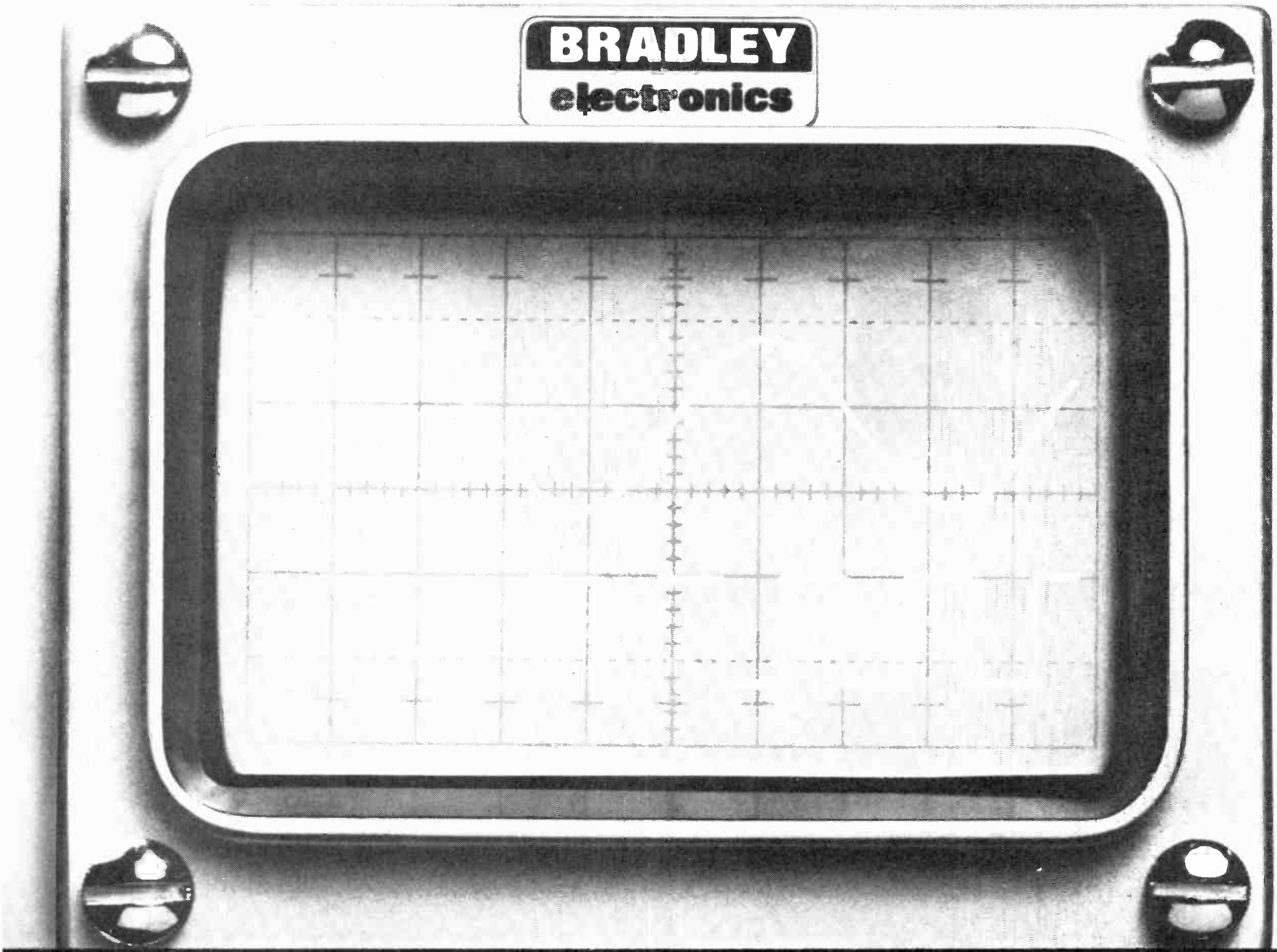
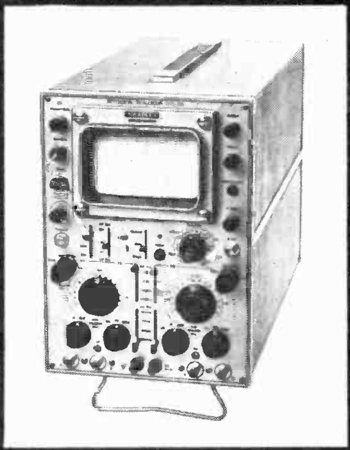
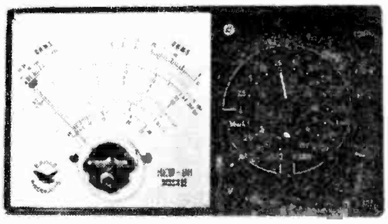
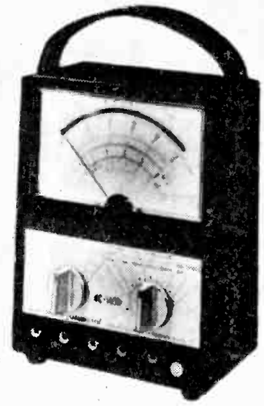

BRADLEY
electronics



How much is your company paying for multimeters?



Eagle multimeters offer top quality, accuracy and years of faithful service but still cost less - ask top companies like NCR or Addressograph - Multigraph. The two dramatic examples below show you what we mean - compare the specifications and performance, then check the price tag!



	KEW 66	BRAND X	K1400	BRAND X
DC OHMS PER VOLT:	20,000	10,000	20,000	20,000
AC OHMS PER VOLT:	10,000	1,000	5,000	1,000
DC VOLTS:	0-1,000 volts in 10 ranges	0-1,000 volts in 7 ranges	0-5,000 volts in 8 ranges	0-2,500 volts in 8 ranges
AC VOLTS:	0-1,000 volts in 10 ranges	0-1,000 volts in 5 ranges	0-5,000 volts in 6 ranges	0-2,500 volts in 7 ranges
DC CURRENT:	0-500mA in 4 ranges	0-1A in 5 ranges	0-10A in 6 ranges	0-10A in 7 ranges
AC CURRENT:	—	—	0-10A in 4 ranges	0-10A in 4 ranges
RESISTANCE:	0-5M OHM in 4 ranges	0-2M OHM in 2 ranges	0-20M OHM in 3 ranges	0-20M OHM in 3 ranges
ACCURACY:				
DC VOLTS & CURRENT	2.5% of FSD	2.25% of FSD	3% of FSD	2% of FSD
AC VOLTS	3% of FSD	2.75% of FSD	3% of FSD	2.25% of FSD
OVERLOAD PROTECTION:	YES	NO	YES	YES
FITTED CASE:	YES	YES	OPTIONAL EXTRA	OPTIONAL EXTRA
SIZE:	185 x 102 x 44mm	197 x 102 x 41mm	203 x 164 x 96mm	204 x 185 x 115mm
LIST PRICE:	£10.4.0.	OVER £12	£23.14.0.	OVER £37

These are just two examples. The wide, wide Eagle range offers a lot more! Ring or write for more information and the 40-page Eagle electronics catalogue.

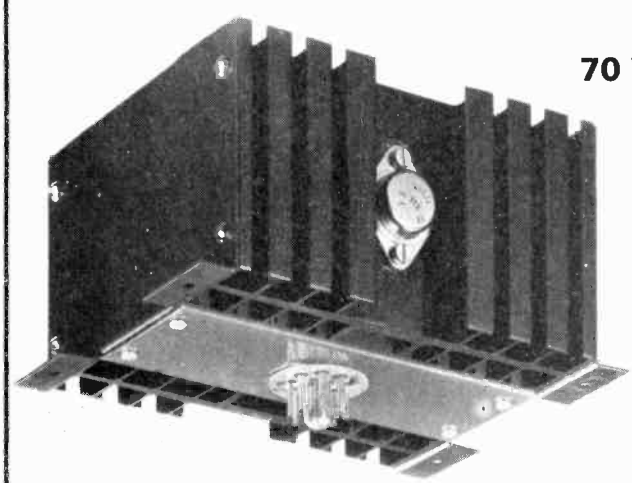
Eagle International
Coptic Street
London, WC1A 1NR.
Tel: 01-636 0961

LOOK UP TO EAGLE FOR VALUE IN ELECTRONICS

EAGLE PRODUCTS

WW—026 FOR FURTHER DETAILS

THE MOD 70
70 WATT R.M.S. PLUG-IN POWER AMPLIFIER



Wherever reliable audio reproduction power is required at better than average bandwidth specification, at lower than average cost, and in an extremely compact, well finished package, the Mod-70 is exceptional.

DESIGNED FOR MAXIMUM FLEXIBILITY, THE MOD-70 POWER AMPLIFIER MODULE WILL PERFORM AT 70 WATTS RMS CONTINUOUSLY IN AMBIENT TEMPERATURES TO 70°C, IS FULLY OUTPUT/INPUT PROTECTED, YET OCCUPIES LITTLE MORE THAN 70 CUBIC INCHES.

ALL I/P, O/P, AND SUPPLY CONNECTIONS ARE THROUGH AN INTERNATIONALLY STANDARD 8-PIN HEADER WHICH PROVIDES EASE OF INSTALLATION, WHILE FOUR CONVENIENT TIE-DOWN POINTS SECURE FIXING AND QUICK RELEASE.

FOR FULL PERFORMANCE AND COMPLETE TECHNICAL SPECIFICATIONS,
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2A LANSDOWNE GARDENS,
LONDON, S.W.8. 01-622 7187

WW—027 FOR FURTHER DETAILS

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Welcome the news that Goldring and Toa can offer you the most advanced range of P.A. systems. Nothing but the best–in high performance products . . . P.A. Amplifiers–microphones–horn speakers–megaphones–power intercoms–meeting amplifiers–background music players, etc.

Goldring

Sole UK distributors of modern P.A. systems by Toa Electric Co., Ltd,
Goldring Manufacturing Co. Ltd. (Great Britain)
10 Bayford St, Hackney, London E8 3SE.
Write or Telephone 01-985 1152 For Full Details

GMS

WW—031 FOR FURTHER DETAILS

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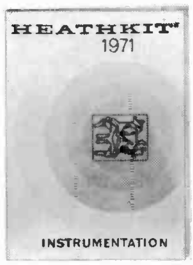
The finest value offered in instruments in the world.

A) Wide Band Gen. Purpose Oscilloscope, IO-18U Kit **£42.80** Carr 80np
B) Gen. Purpose Service Oscilloscope, OS-2 Kit **£32.00** Carr 60np
C) Universal 'VVM', IM-25 Kit **£44.00** Carr 40np
D) Portable Solid State 'VVM', IM-17 Kit **£17.30** Carr 30np
E) Portable Multimeter, MM-1U Kit **£16.00** Carr 30np
F) RF Signal Generator, RF-1U Kit **£17.50** Carr 30np
G) Regulated High Voltage Supply, IP-17 Kit **£39.90** Carr 60np
H) Regulated Low Voltage Supply, IP-27 Kit **£41.40** Carr 50np

These models are also available factory assembled and tested.

For the full range of Heathkit models why not send for the free Catalogue. Yours for only the price of a postage stamp.



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29/2

HEATHKIT HEATH (Gloucester) LTD., GLOUCESTER, GL2 6EE

a Schlumberger Company

WW—035 FOR FURTHER DETAILS

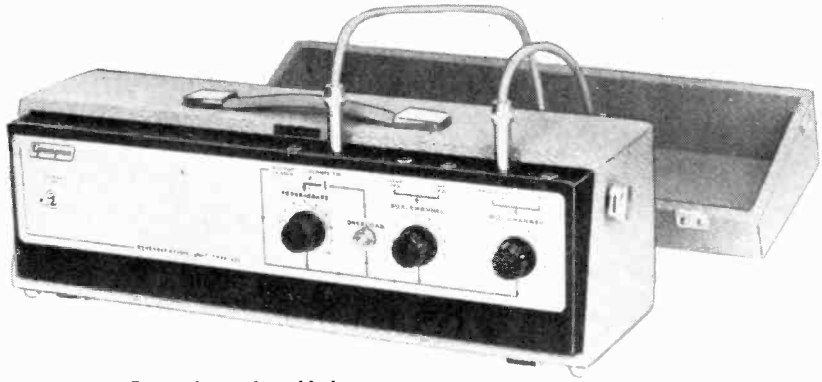
A NEW PORTABLE OSCILLOSCOPE

- * £56 Ex STOCK DELIVERY
- * DC-4.5 MHz BANDWIDTH
- * 100 mV/cm
- * 8x6x4¾in.
- * 5LB
- * BRIGHT LINE TRACE
- * AUTOMATIC SYNCHRONISATION
- * SOLID STATE
- * RUGGED CONSTRUCTION

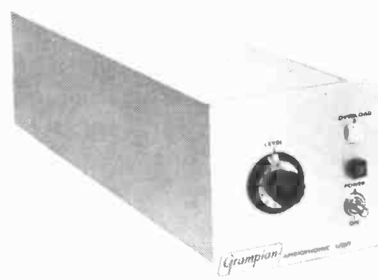
CALL!

**meteronic: BIRCHEN NAPPS PLATT: BOROUGH GREEN, Nr. SEVENOAKS, KENT.
BOROUGH GREEN 2797**

WW—036 FOR FURTHER DETAILS



Reverberation Unit
Type 636



Ambiophonic Unit
Type 666

After the fun of the Audio Fair then whatever amplifier equipment you have chosen you will no doubt be interested in the added advantages of incorporating Reverberation or Ambiophonic units. May we advise you on this?

We shall be pleased to supply further details on these two units, and indeed on any Audio equipments, including mixers, microphones and matching units etc.

Let GRAMPIAN know your requirements.

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TELEPHONE: 01 894 9141.

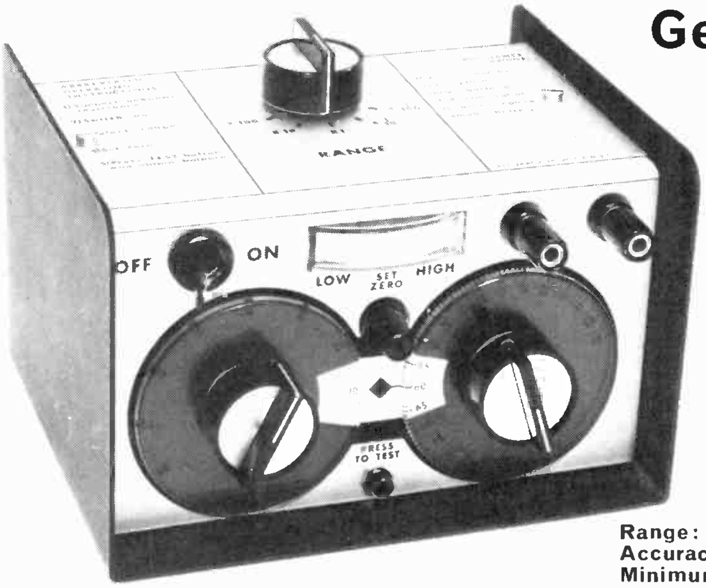
AUD1/JACW/X/86.

WW—037 FOR FURTHER DETAILS

New Bridges from Jay-Jay Instruments

All fitted with High Discrimination Electronic Null Detectors

RESISTANCE BRIDGES



General Purpose Resistance Bridge

(Cat. Ref. BR1 - Accuracy ±0.2%)

A low priced portable battery operated resistance bridge utilising a high discrimination solid state null detector giving overload protection even under severe out of balance conditions.

To facilitate use, the final balance is obtained on a single dial with 100 subdivisions.

Range: 0–1·1 M ohm in 5 ranges.
Accuracy at 20°C ±0·2% ±1 subdivision.
Minimum subdivision 0·1 ohm.
Discrimination ±0·5 scale division.

Price £29-18-0

Portable Workshop Resistance Bridge

(Cat. Ref. BR2 - Accuracy ±0.03%)

A completely portable Wheatstone Bridge utilising a sensitive solid state null detector giving the high discrimination normally associated with more sophisticated laboratory instruments. Automatic current limiting protects the null detector from overloads even under severe out of balance conditions, making the instrument suitable for use by unskilled personnel.

Range: 0–1·111 M ohms in 5 ranges.
Accuracy at 20°C ± 0·03% ±0·5 minimum subdivision.
Discrimination ±0·05 minimum subdivision.

Price £159-0-0

JJ INSTRUMENTS

Write for further details to:-

J.J. Lloyd Instruments Limited

Brook Avenue, Warsash, Southampton SO3 6HP.
Tel: Locks Heath 4221.

WW—038 FOR FURTHER DETAILS

meet our new baby

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

FREQUENCY:	1 Hz to 1MHz 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.

LEVELL
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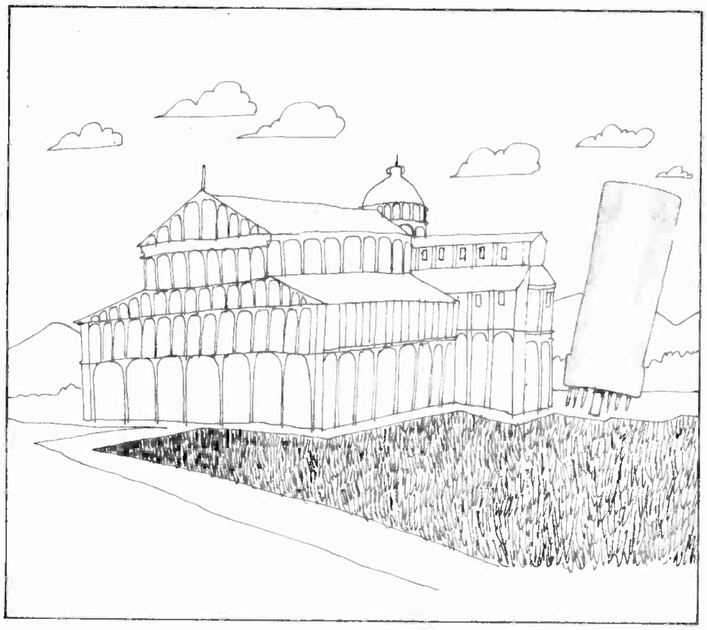
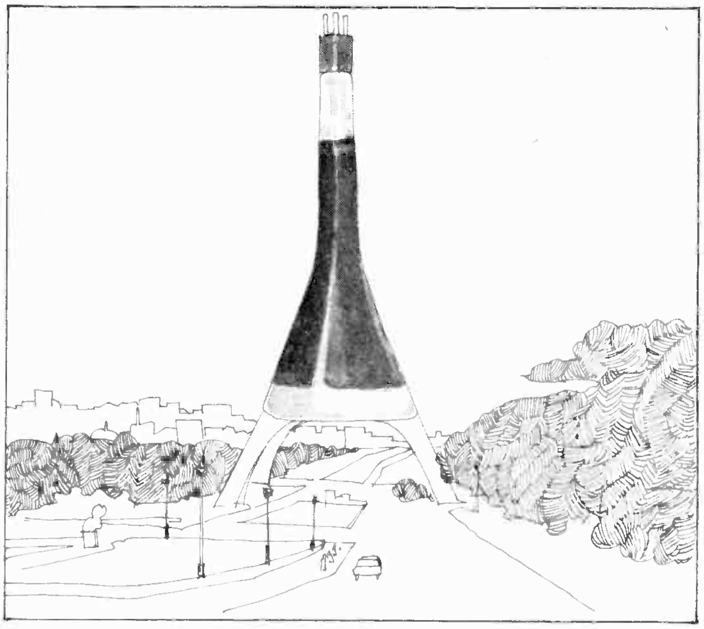
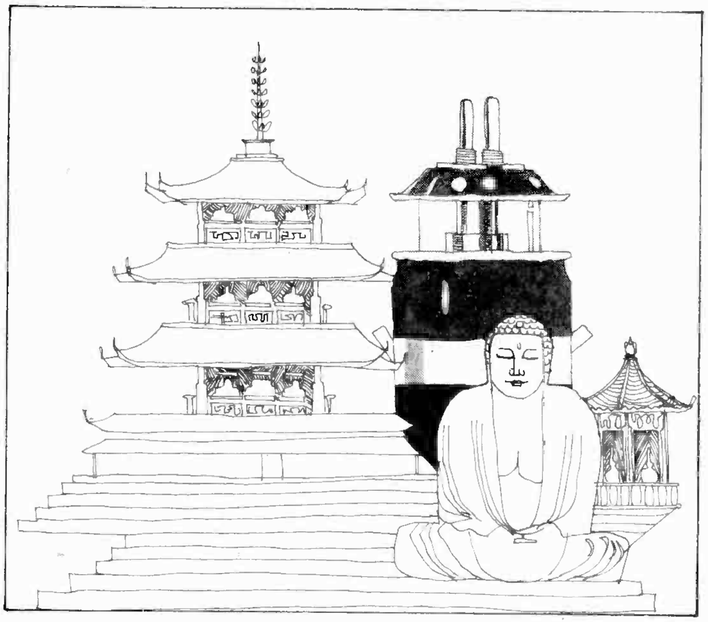
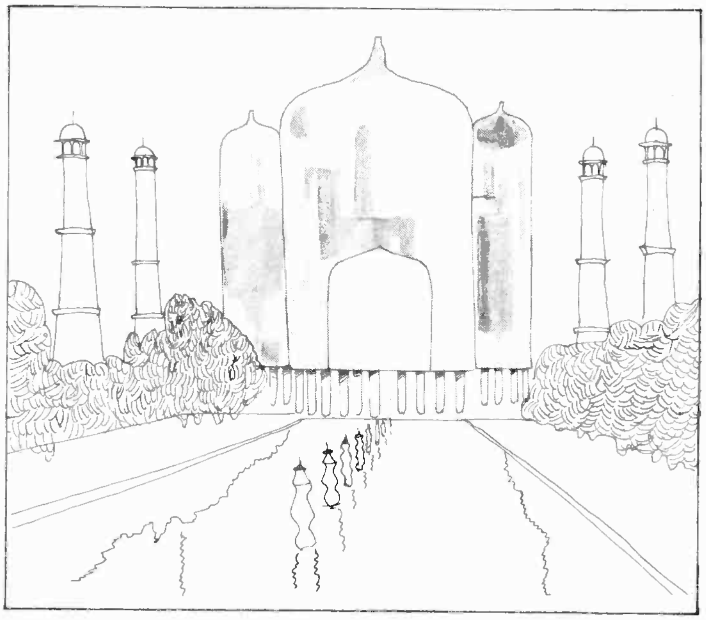
Send for literature covering our full range of portable instruments.

WW—041 FOR FURTHER DETAILS









Wonders of the modern world

Teonex products, of course! Over 3,000 of them, electronic valves, semi-conductors, and now—neons and indicators too... all performing superbly in many climates ... all at prices that are very competitive.

How do Teonex do it? Specialisation in one field. Concentration on export only. Very strict quality control.

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WW—045 FOR FURTHER DETAILS

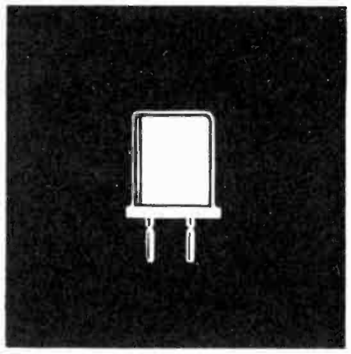
The Crystal Controlled Switched AM or FM Tuners are at the heart of every S.N.S. Radio Distribution System.

You will know that you are installing the best because the crystal ensures drift-free reception and with our rigorously-controlled manufacturing methods, backed by a 72-hour soak test before despatch on all Tuners and Amplifiers, reliability is ensured.

The concept of removing External Controls where possible so that unskilled hands do not create unnecessary Service Calls is now Internationally acceptable.

Since their introduction three and a half years ago, many hundreds of our Tuners and Amplifiers have been providing trouble-free operation in many parts of the world.

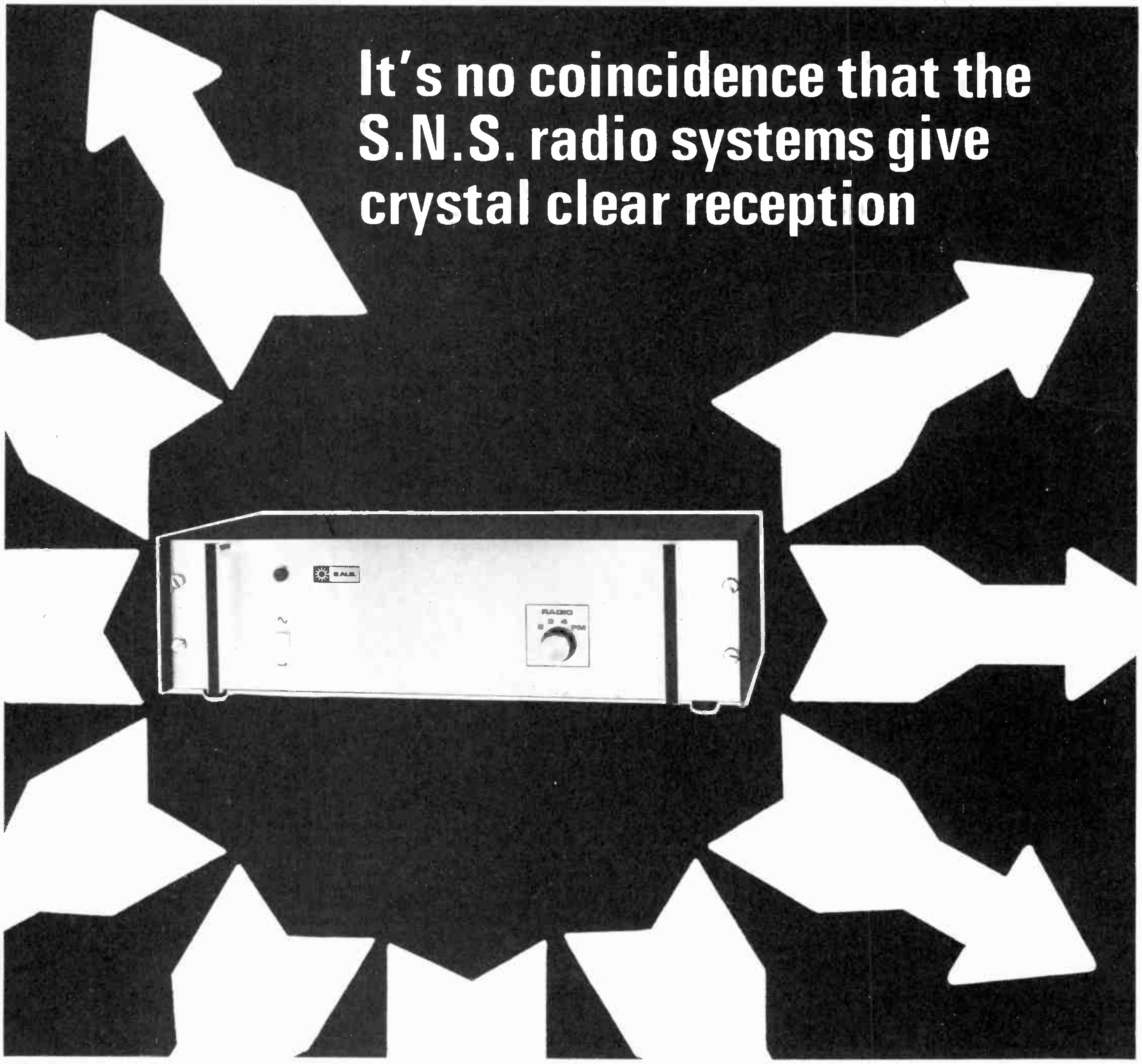
It's no coincidence that S.N.S. equipment has a reputation for quality – it's been designed that way.



S.N.S.

radio distribution systems

S.N.S. Communications Ltd., 851 Ringwood Road, West Howe, Bournemouth, England, BH11 8LN. Tel: Northbourne 5331. Telegrams: Flexicall Bournemouth.



Come and see us at Stand C8 at the Sound 71 Exhibition from March 16th - 19th

WW—051 FOR FURTHER DETAILS

Think professional.

If you're thinking about acquiring a new stereo system, think professional. Think Sansui.

Give yourself the extra professionalism of a control amplifier, with all the extra capability that such a component offers. Sansui lets you choose from among three quality units, each equipped with a Triple Tone Control circuit for more complete control of the entire sound spectrum than was ever before possible, and each the unquestioned leader in its power range. Sansui's control amplifiers are the powerful 180 watt AU-999, the 100 watt AU-666 and the 85 watt AU-555A. One of them is right for you.

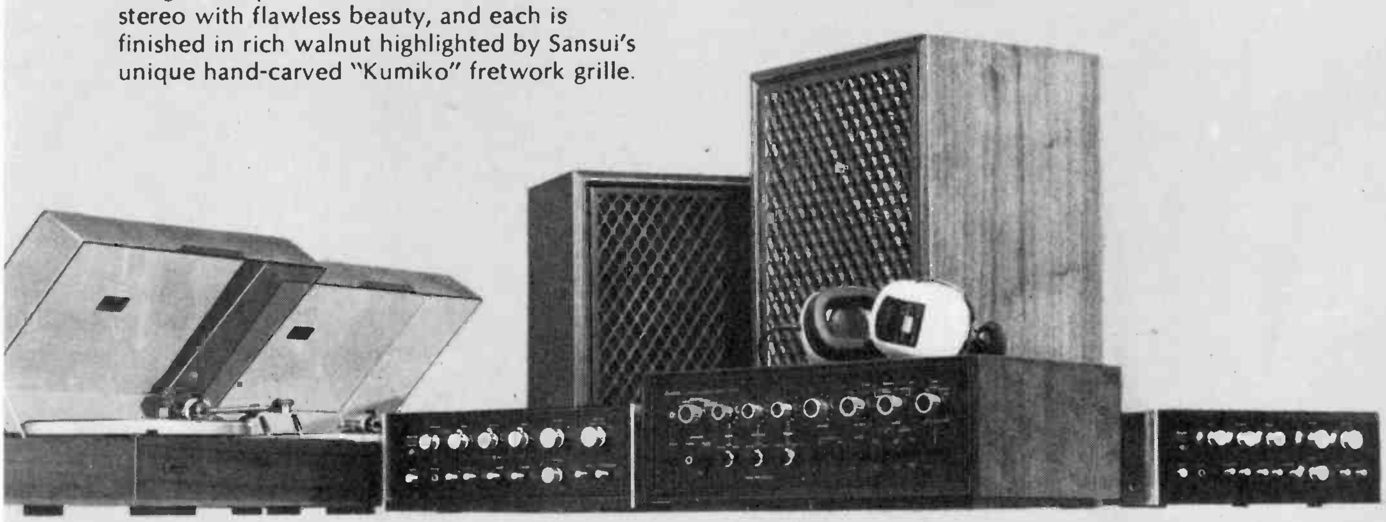
And to more fully enjoy the professionalism of your control amplifier, choose one of these brilliant new high linearity speaker systems—the 3-way 3-speaker SP-150 with a full 40 watts in power, or the 2-way 2-speaker 25 watt SP-50. Each is designed to pour forth the rich sounds of stereo with flawless beauty, and each is finished in rich walnut highlighted by Sansui's unique hand-carved "Kumiko" fretwork grille.

For a turntable, Sansui suggests the elegant new SR-2050C Automanual with exclusive Auto Lift/Stop mechanisms, a highly professional component which unites the convenience of an automatic with the accuracy of a manual. Another very advanced turntable is the SR-1050C, a direct belt-drive manual complete with all the refinements and precision that knowledgeable stereo enthusiasts demand today.

Whichever combination you decide on, you'll get more out of it with Sansui's 2-way 4-speaker SS-20 stereo headphone set, complete with separately adjustable Volume and Tone controls for luxurious private listening.

Think professional, and see your nearest authorized Sansui dealer soon. We think you'll find it rewarding.

Sansui



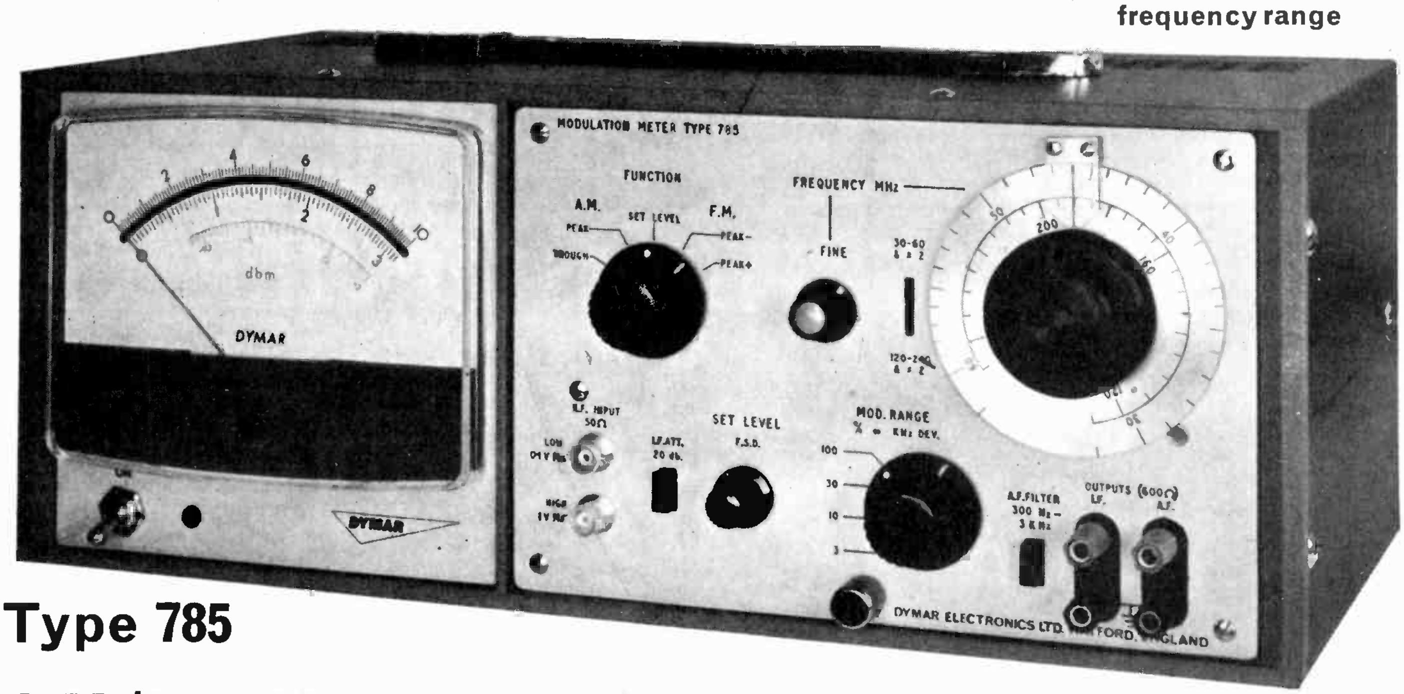
England: **VERNITRON (UK) LTD. Thornhill Southampton S09 5QF Tel: Southampton 44811** / Ireland: RADIO CENTRE 122A, St. Stephen's Green, Dublin 2 /West Germany: COMPO HI-FI G.M.B.H. 6 Frankfurt am Main, Reuterweg 65 / Switzerland & Liechtenstein: EGLI, FISCHER & CO. LTD. ZURICH 8022 Zurich, Gotthardstr. 6, Claridenhof / France: HENRI COTTE & CIE 77, Rue J.-R. Thorelle, 77, 92-Bourg-la-Reine / Luxembourg: LUX HI-Fi 3, rue Glesener, Luxembourg / Austria: THE VIENNA HIGH FIDELITY & STEREO CO. A 1070 Wien 7, Burggasse 114 / Belgium: MATELECTRIC S.P.R.L. Boulevard Léopold II, 199, 1080 Brussels / Netherlands: TEMPOFOON N.V. Tilburg, Kapitein Hatterasstraat 8, Postbus 540 / Greece: ELINA LTD. 59 & 59A Tritis Septemvriou Street, Athens 103 / Italy: GILBERTO GAUDI s.a.s. Piazza Mirabello 1, 20121 Milano / South Africa: GLENS (PTY) LTD. P.O. Box 6406 Johannesburg / Cyprus: ELECTROACOUSTIC SUPPLY CO., LTD., P.O. Box 625, Limassol / Portugal: CENTELEC LDA. Avenida Fontes Pereira de Melo, 47, 4.o dto., Lisboa-1 / Malta: R. BRIZZI 293, Kingsway, Valletta / SANSUI AUDIO EUROPE S.A. Diacem Bldg., Vestingstraat 53-55, 2000 Antwerp, Belgium / SANSUI AUDIO EUROPE S.A. FRANKFURT OFFICE 6 Frankfurt am Main, Reuterweg 93, West Germany / SANSUI ELECTRIC CO., LTD. 14-1, 2-chome, Izumi, Suginami-ku, Tokyo, Japan

WW—052 FOR FURTHER DETAILS

DYMAR FOR R/T MEASUREMENT

DYMAR manufacture a range of very economically priced instruments specifically designed for use in the design, production and servicing of Radio Telephone Equipments.
The Type 785 Modulation Meter is a solid state instrument for the measurement of the Depth of Modulation in Amplitude Transmitters or the Frequency Deviation in the case of F.M. Transmitters. It is specifically designed for narrow deviation transmitters in today's mobile and portable V.H.F. radiotelephones, the most sensitive deviation range being 3kHz f.s.d. A feature of the instrument is the low residual F.M. noise of the local oscillator which with the A.F. "Voice" filter switched in is typically —44db below 3kHz deviation.

Carrier Frequency Range:	**30MHz – 100kHz**
F.M. Deviation:	**3kHz f.s.d. – 100kHz**
A.M. Modulation Depth:	**3% f.s..d – 100%**
Sensitivity:	**Better than 2 millivolts over the whole frequency range**



Type 785

A.M./F.M. Modulation Meter only £260

Other Dymar Instruments

701	Wideband Millivoltmeter	£125	745	Two-Tone Signal Generator	£200
761	Noise Factor Meter	£115	724	Suppressed Zero D.C. Microvoltmeter	£165
711	V.H.F. Millivoltmeter	£250	705	A.F. Microvoltmeter	£140
721	D.C. Microvoltmeter	£130	765A	Distortion Factor Meter	£195
585	A.F. Power Meter with Batteries	£140	771A	A.F. Wave Analyser	£330

DYMAR

DYMAR ELECTRONICS LIMITED,
Colonial Way, Radlett Road, Watford, Herts. WD2 4LA.
Telephone: Watford 21297/8/9.

WW—059 FOR FURTHER DETAILS

CALAN SPEED CHECK

A Service Aid

The Calan Speed-Check monitors the running of tape transport mechanisms or record players by detecting the frequency of a signal played from special test tape or disc. Any deviation from the nominal 3kHz frequency indicates a deviation in running speed from the correct condition.

The Speed-Check is simple to operate. Two controls are provided. A function switch connects power to the equipment and selects three ranges of deviation sensitivity. The second control is a set zero control which enables examination of the speed performance of mechanisms whose nominal running speed is fast or slow by up to 4 per cent. on the 1 per cent range so that such measurements as capstan slip and speed constancy can be examined at maximum sensitivity. A switch position on the set zero control cancels this facility to enable calibrated measurements to take place. Two Test Tapes Provided. 1. Standard ¼" Tape 5" spool. Side A 7½ ips. side B 3¾ ips. 2. C60 cassette records at 1⅞ ips.

TECHNICAL DETAILS

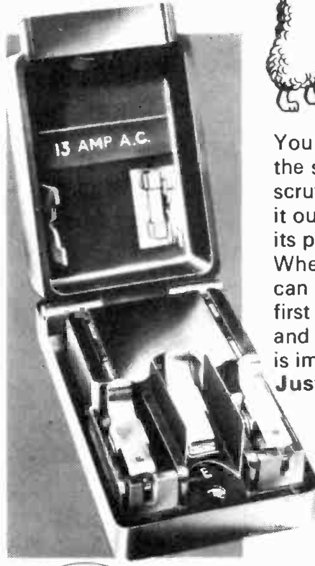
Input sensitivity 100MV MAX. INPUT 50 Volts. Input impedence 10K. Zero Frequency 3KHZ + or −0.1 per cent. Ranges 1 per cent, 3 per cent, 10 per cent deviation. Supply 200-250 50/60HZ.

CALAN ELECTRONICS LTD.,
Crossroads by Ormiston
East Lothian.
Telephone Humbie 242 & 258

calan

WW—060 FOR FURTHER DETAILS

Looking for a safer breed of Connector?



You choose electrical equipment in much the same way you choose a dog: you scrutinise and examine carefully, and take it out for a trial run. And you ask to see its pedigree.

When you handle a Rendar product, you can see at once that it's a better breed: first class materials; precision machinery and assembly; sound design. Its pedigree is impeccable.

Just 1 winner from the Rendar kennel

The Rendar Safebloc saves time and saves life. There's no need to fit a plug for testing — just connect the apparatus direct. And there's no danger of shocks — no current can pass until the lid is closed.

Rendar pioneered this concept, and introduced the "Safebloc" to the British market over 12 years ago. It's indispensable on testing lines, and for all kinds of electrical demonstrations. Double Safebloc available for 3-phase applications.

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STYLII

	Sapphire	Diamond
ACOS		
GP59	2/6	7/6
GP65	2/6	7/6
GP67	2/6	7/6
GP73-1	6/6	9/6
GP73-2	6/6	9/6
GP79	2/6	7/6
GP81-1	2/6	7/6
GP91-1	6/6	9/6
GP91-2	6/6	9/6
GP91-3	6/6	9/6
GP91-1Sc	6/6	9/6
GP91-3Sc	6/6	9/6
HGP37	2/6	7/6
B.S.R.		
BSR C1 (ST3)	6/6	9/6
BSR TC8H	2/6	7/6
BSR TC8M	2/6	7/6
BSR ST8	6/6	9/6
BSR ST9	6/6	9/6
BSR ST10	—	9/–
BSR X1M	6/6	9/6
BSR X1H	6/6	9/6
BSR X3M	6/6	9/6
BSR X3H	6/6	9/6
BSR X5H	6/6	9/6
BSR X4H	6/6	9/6
COLLARO		
Collaro Studio 'O'	2/6	7/6
Collaro-Ronett TX88	2/6	7/6
Collel SK1	2/6	7/6
Dual CDS2/CDS3 (DN2)	6/6	9/6
Dual CDS/320 (DN3)	6/6	9/6
ELAC KST9 (PE10)	6/6	9/6
ELAC KST9 (PE1B)	6/6	9/6
ER5MB	6/6	9/6
ER5MX	2/6	7/6
ER5 SB	6/6	9/6
ER60 Stereo	6/6	9/6
GARRARD		
EV26 Stereo	2/6	7/6
GC2	2/6	7/6
GC8	2/6	7/6
GCE12	2/6	7/6
GCS10/1	2/6	7/6
GCS10/2	2/6	7/6
S 1—2—3	6/6	9/6
TS1	6/6	9/6
TS2	6/6	9/6
TS3	6/6	9/6
GOLDRING		
CM50	2/6	7/6
CM60	2/6	7/6
MX1	2/6	7/6
MX2	2/6	7/6
Stereo CS80	2/6	7/6
PERPETUUM EBNER		
PE188	6/6	9/6
PHILIPS		
AG3016	2/6	7/6
AG3063	2/6	7/6
AG3306	6/6	9/6
AG3310/3306	6/6	9/6
AG3400	2/6	7/6
RONETTE BINOFLUID		
BF40	2/6	7/6
DC284	2/6	7/6
SONOTONE		
2T	6/6	9/6
3T	6/6	9/6
8T4A	6/6	9/6
9TA	6/6	9/6
9TA/HC	6/6	9/6
19T	2/6	7/6
20T	2/6	7/6

The Diamond Tip is .007 in. radius, thus making it compatible to play stereo records on mono equipment without damage to the record; and of course full stereo.
BRITISH MADE
EXPORT ENQUIRIES WELCOMED

CARTRIDGES

		Inc. P.T. each
ACOS		
GP79		12/6
GP91-1SC - 1		21/–
2- 11		17/9
12- 49		15/6
50-500		13/6
GP91-2SC		As above
GP91-3SC		As above
Suitable to replace TC8, etc.		
GP92		26/5
GP93-1		24/9
GP94-1		31/–
GP94-5		36/–
GP95		24/9
GP96		31/6
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SX5M	S/S	36/3
SX5H	S/S	36/3
SX5M	D/S	39/11
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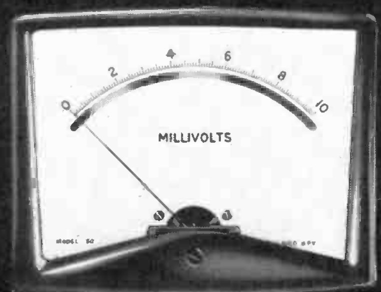

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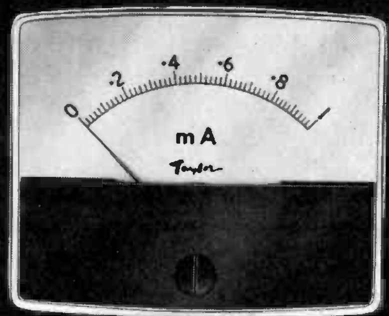

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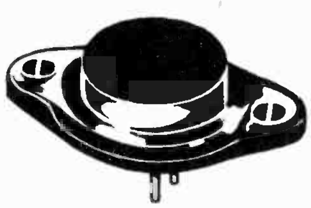

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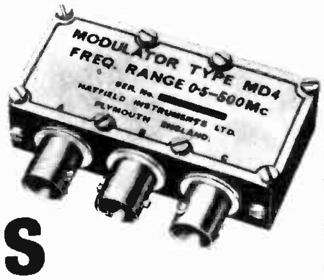

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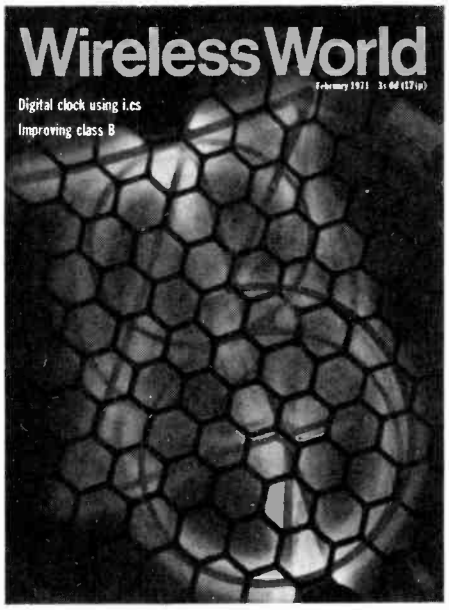

This month's cover. We hope that constructors of the digital clock described in this issue do not obtain the results shown, which might be caused by a molten b.c.d.-to-decimal decoder. Paul Brierley, the photographer, used other means.

IN OUR NEXT ISSUE

Wein Bridge Audio Oscillator: Using a m.o.s.f.e.t. as the input device this oscillator has eight ranges from 10Hz to 100kHz in $\sqrt{10}$ steps, a six-position output attenuator (also in $\sqrt{10}$ steps) which varies the output from 3.16mV to 1V and a built-in frequency meter.

Electronic Voltmeter for 2 to 50kV: This unusual design employs a triode in an inverted form in which the anode voltage is made the independent variable and the grid voltage the dependent variable.

Microcircuit Audio Amplifiers: Continuing his series 'Elements of Linear Microcircuits' T. D. Towers deals exclusively with a.f. amplifiers in part 6.

Contents

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Components industry—dead or alive?

The above title is the theme of one of the debates planned for the Electronic Components Conference to be held* during the Electronic Components Show at Olympia, London, in May. Described as a no-holds-barred conference, it is being organized by the Electronic Components Board and will range over the whole field of development, performance and application of both active and passive devices, with one session devoted to the BS9000 scheme.

It will be interesting to hear what the answer will be to the question posed in the debate. Without wishing to prejudge the outcome, a few comments might not be out of place. First, it must be made perfectly clear that the measure of co-ordination attained in the component sector of the electronics industry is to a large extent due to the work of the E.C.B. It has brought together under one roof, with a common secretariat, the three component industry associations—R.E.C.M.F., B.V.A. and V.A.S.C.A.—and joint meetings of some committees are now being held. However, the success of the administrative organization of the associations must not blind us to the dangers which beset this sector of our industry.

Much has been said, and written, about the situation in the field of microcircuits; suffice it to say now that we in the U.K. are by no means out of the wood. Prices of imported t.t.l. devices have fallen still further, and there seems little likelihood that British manufacturers will be able to match the American prices. How much longer the few British t.t.l. manufacturers will be able to survive is a matter for conjecture.

What may be seen as of even greater significance to the industry is the fact that so many British equipment manufacturers are buying components from overseas. Why is this? Some say it is because prices are lower, others because delivery is faster, while others cite quality as the reason. If this is the situation now, what will happen if, and when, we go into the European Common Market?

When integrated circuits were introduced many Jonahs predicted that their arrival would alter the whole pattern of both the components industry and the function of the circuit designers who would, they said, become systems engineers. It is, of course, true that the i.c. has in many instances reduced the number of discrete components used, but the application of electronics to so many new fields has maintained the volume of components required.

When the Economic Development Committee for Electronics issued its economic assessment for 1972 about a year ago the section devoted to the passive components sector of the industry made encouraing reading so far as exports are concerned: exports £65M, imports £39M giving a trade balance of £26M. If, however, one omitted the 'audio components' i.e. loudspeakers, microphones, gramphone turntable units, tape decks, and pickup cartridges, there is an adverse trade balance of £4M.

The forecast for active components was less clear; in fact the report stresses the "problem in forecasting the total active component output in 1972".

We have not attempted to answer the question posed in the heading but it would certainly seem from our prognosis that the industry is ailing—at least in some limbs.

* Royal Garden Hotel, London W.8, May 18-21.

A Digital Clock

A design which uses medium scale t.t.l. integrated circuits

*by Roger Buckley **

Using m.s.i. (medium scale integration) integrated circuits it is possible to construct a digital clock with relatively few components. In this design the 50Hz mains is used as the timing source. On initially switching on the clock, or after a power failure, it can be set to the correct time by feeding pulses into the counter chain at a rate faster than one per minute. Push switches are provided for this purpose. The block diagram of the clock is given in Fig. 1.

A 5V peak-to-peak 'square wave' is provided by clipping the output of a low-voltage secondary on the mains transformer using a zener diode. These pulses are then divided by 3000 to give a one-pulse-per-minute signal and then counted by a decade counter followed by a modulo-6 counter. These two counters drive numerical readout tubes via decoders to produce a minutes display. From the modulo-6 counter the one-pulse-per-hour output is then fed into another decade counter followed by a single *J-K* flip-flop to drive the hours decoders and display. This arrangement gives the clock a twelve hour readout and the clock recycles to 01.00 at 12.59 plus one minute.

The gating that resets the hours display is not shown but the block diagram does show how the clock may be set to any desired time using a signal of about 1Hz fed into either the minutes or the hours counters.

*Marconi Elliott Microelectronics Ltd.

The logic elements

At this stage a description of the functions carried out by the integrated circuits employed would not be amiss. One of the most interesting is a counter designated type 9316 (type 74161 is a direct equivalent). This counter can be made to divide by any number from two to sixteen. A drawing of the i.c's various inputs and outputs is shown in Fig. 2(a).

Ignoring for a moment the inputs labelled *P*; if the inputs C_{EP} and C_{ET} are held 'high' (+5V), and if clock pulses are applied to input C_P, then the device will behave as a standard four-flip-flop counter and will divide by sixteen. The outputs Q_0 to Q_3 are the outputs of the four flip-flops and will produce the standard binary code. Notice that there is another output called T_C which stands for terminal count. The output goes high when all the flip-flops are set, i.e. they each contain a 1, corresponding to the maximum count of the device which is 15. The waveforms appearing at the various outputs are shown in Fig. 2(b).

Now we come to the section of the device which enables this counting sequence to be modified. The inputs P_E and P_0 to P_3 enable the counter to be synchronously preset to any desired number (in counter jargon *reset* implies set all flip-flops to 0, *set* implies setting all flip-flops to 1 and *preset* means that the counter is set to some intermediate number within the counter's range but out of its normal counting sequence).

With the P_E (parallel enable) input high (+5V) a number can be fed to the inputs P_0 to P_3 without affecting the counter in any way. With the number in position if P_E is taken low and a clock pulse is applied to C_P and then P_E taken high again the counter will contain the number that was applied to the parallel inputs.

With this sequence of operations in mind have a look at Fig. 2(c) which shows how the counter is connected to divide by any number from two to sixteen; a universal counter in fact. At the terminal count, binary 1111 or decimal 15, the T_C output will go high and the output of the external inverter will cause the P_E (parallel enable) input to go low. The next clock pulse will feed the information on the inputs P_0 to P_3 into the counter; the counter is no

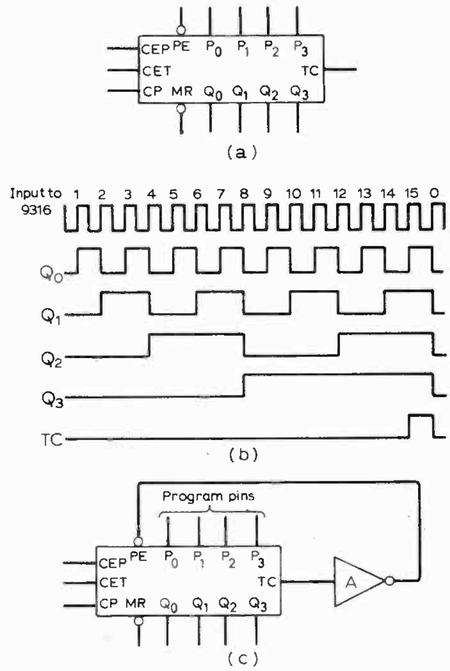

Fig. 2. The 9316 counter. (a) Inputs and outputs; (b) output waveforms; (c) dividing by two to sixteen.

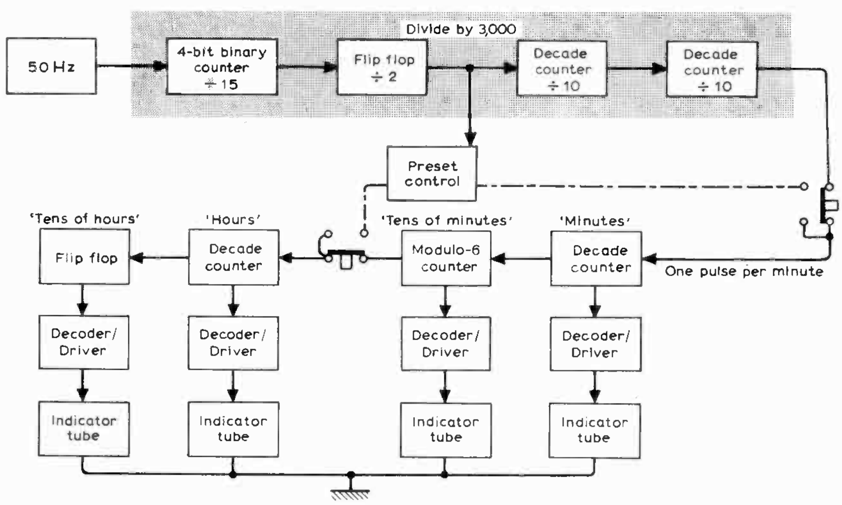

Fig. 1. A block diagram of the clock.

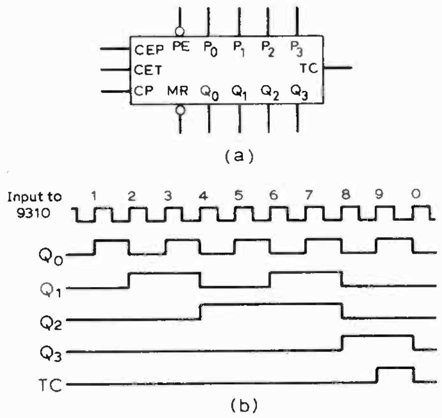

Fig. 3. (a) Inputs and outputs of the 9310 decade counter; (b) output waveforms.

longer at its terminal count so P_E will go high again because of the action of the inverter and the T_C output.

In other words the counter on reaching 1111 instead of being recycled to 0000 on the next clock pulse is forced into a condition between 0000 and 1111, determined by P_0 to P_3, and the counting sequence is shortened. The number can be set on the P_0 to P_3 inputs by connecting these inputs either to +5V (1) via a resistor or directly to earth (0). By the way, the M_R input is the master reset for resetting all the flip-flops to 0.

The other counter used in the clock is the type 9310 (the equivalent type is 74160). This counter is similar to the 9316 except that the counter divides by ten and the T_C output goes high on the count corresponding to decimal nine. Details of the 9310 are given in Fig. 3. There are other integrated circuits in the clock but these are conventional and will be described as they are met.

The circuit

The complete circuit diagram of the clock is given in Fig. 4. A 50Hz waveform provided by the transformer T_1 is clipped by the zener diode D_6 and is fed to the input of a 9316 counter. In the manner discussed earlier this i.c. is made to divide by 15. One gate from an i.c. which contains four two-input gates (7400) is used as the inverter. The parallel inputs cause the counter to recycle from 1111 to 0001 (instead of 0000) subtracting 1 from the overall count making it 15 instead of 16. The next stage of the divide by 3,000 section is one section of a dual J-K flip-flop (7473) which divides by two to make the total division $15 \times 2 = 30$. Two decade counters complete the division of the 50Hz pulses to one pulse per minute. When the first decade counter reaches its terminal count of nine (1001) the T_C output enables the next clock pulse, in addition to resetting the first decade counter to 0000, to cause the second decade counter to advance by one. This is because the C_{EP} input was taken high by the T_C output of the first counter. The total division is therefore $15 \times 2 \times 10 \times 10 = 3{,}000$.

The resulting pulses at a rate of one per minute are counted on the decade counter *A*. The contents of the counter *A* are decoded by a type 9315 (or 7441) decoder driver which converts the binary output of the counter into decimal and drives a numerical indicator directly. The tube is a gas-filled indicator tube which will display the digits 0 to 9.

When counter *A* reaches its terminal count, counter *B* is allowed to advance one on the next clock pulse. Counter *B* is another decade counter and its output is decoded by another 9315 to provide the tens of minutes display. When counter *B* reaches five it will receive its next pulse as counter *A* goes from nine to zero. When this happens counter *B* must also return to zero as we would be breaking the rules if we allowed a six to appear in the tens of minutes display! Now five corresponds to binary 0101 and six to 0110. When counter *A* goes from nine to zero, assuming that counter *B* holds a five, both inputs to the NAND gate *X* will go high as counter *B* tries to go to six. The NAND gate is another section of the four two-input gate i.c. (7400 used in the ÷3,000 counter). With both inputs to gate *X* high the input M_R to counter *B* will go low and counter *B* will be forced to 0000; as this happens both inputs to gate *X* will go low. This happens once per hour, and it is this negative going edge at the Q_2 output of counter *B* which is applied to the hours counting section.

The hours counting section is a little more complex because of the need to recycle the clock from 12.59 to 01.00. The hours counter is another 9310 decade counter (*C*) and the tens of hours counter is a *J-K* flip-flop (D). This flip-

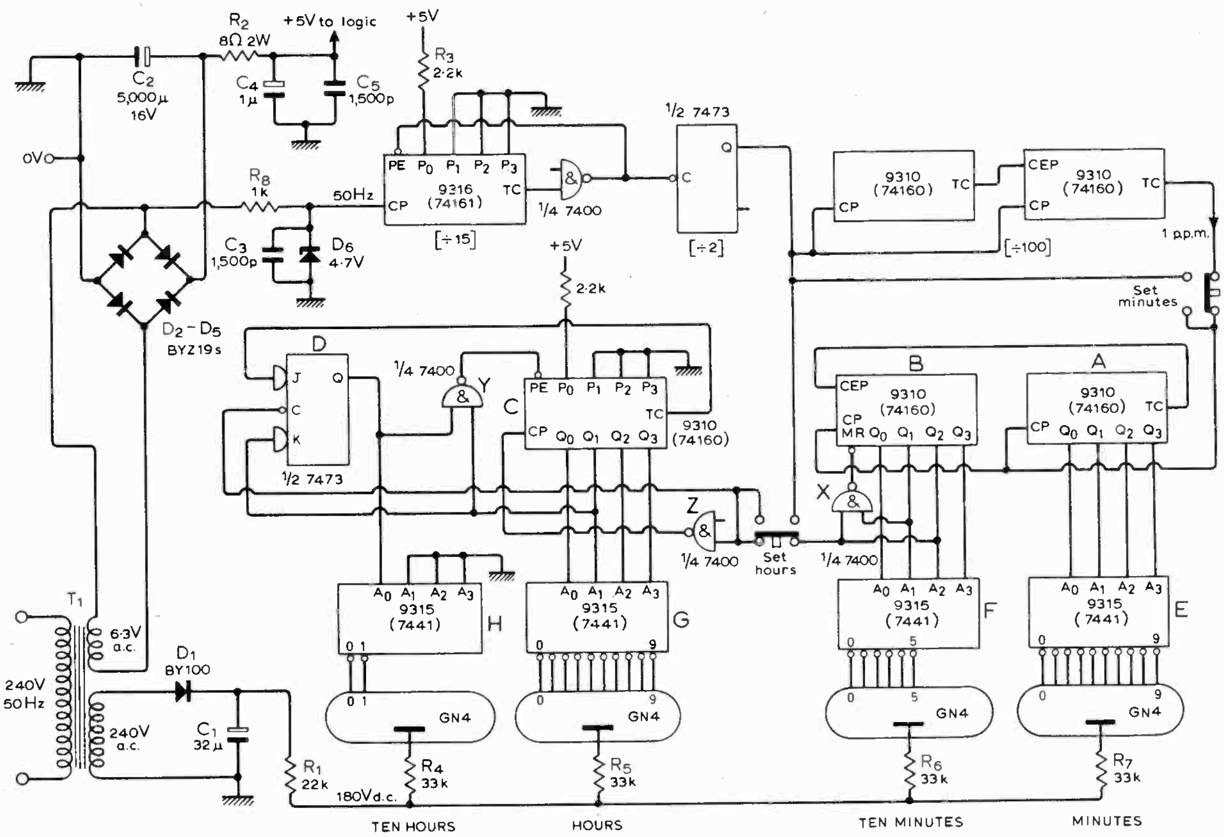

Fig. 4. The circuit diagram of the clock. The integrated circuits are available from Marconi Elliott Microelectronics Ltd, Freebournes Rd, Witham, Essex. The indicator tubes are available from Electroniques, Edinburgh Way, Harlow, Essex.

flop is in the same package (7473) as the one used in the ÷3,000 counter.

The once-per-hour pulse from the input of gate X is fed to counter C after being inverted by gate Z and is also fed straight to flip-flop D. The reason for the inverter is that the 9310 changes state on a positive going edge and the flip-flop changes on a negative going edge.

Consider the situation at 01.00 (o'clock). Each hour's pulse will advance counter C but will not change the state of flip-flop D because of the low on the J input of the flip-flop from the T_C output of counter C. A J-K flip-flop will not change state from 0 to 1 when the J input is low.

When counter C reaches nine its T_C output will go high as will the J input to flip-flop D. The clock now indicates 09.00. After another 59 minutes the clock will hold 09.59 and the next minute pulse will return counters A and B to 00 and will generate a pulse to set the hours counter at 10. The J input to the flip-flop D was high, remember, and counter C recycled from nine to zero as normal.

The next two once-an-hour pulses will advance the hours counter C to two giving a display of 12.00. Although these two pulses are fed to flip-flop D they will not affect its state because once a J-K flip-flop is in the 1 state the input K has to be high before a clock pulse will reset it.

Counter C now holds decimal 2 or binary 0010. Q_1 is at 1 and this is fed to the K input of flip-flop D. Both inputs to gate Y will be high (flip-flop D is set and Q_1 of counter C is high) so the output of gate Y and the P_E (parallel enable) input of counter C is low. Note that the number fed to the parallel inputs of counter C is 0001 which is decimal 1. 59 minutes later the clock will display 12.59. After one minute the minutes counters in recycling to 00 will generate a pulse for the hours counter. Because the P_E input to counter C is low the number at the parallel inputs will be read into the counter, i.e. 1, and because the K input to flip-flop D was high, flip-flop D will reset to 0. The clock will now display 01.00. The sequence of events described goes on for as long as the clock is switched on.

The two push-buttons are for presetting the clock and do so by feeding pulses at a higher frequency than is normal to the counting sections of the circuit. It is possible that, if the arrangement shown in Fig. 4 is used, some trouble may be experienced with contact bounce. To eliminate this trouble the circuit shown in Fig. 5 was

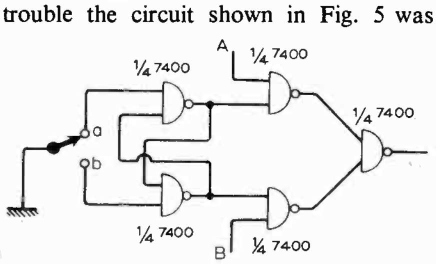

Fig. 5. The anti-bounce circuit. Two of these are required to replace the push-buttons of Fig. 4.

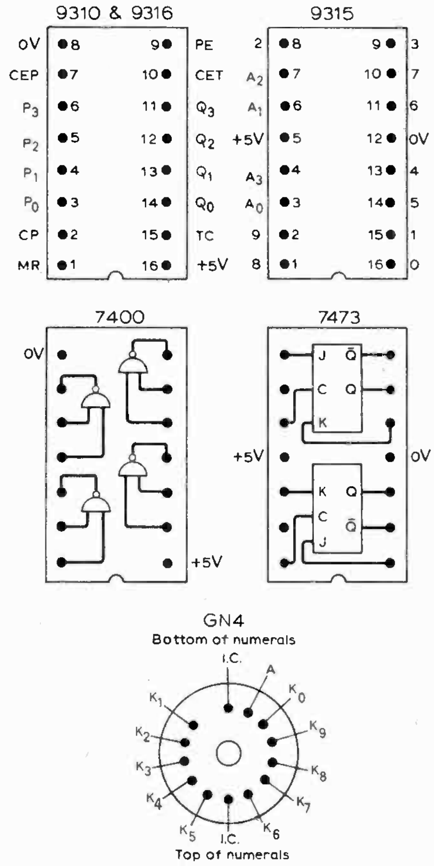

Fig. 6. Connection details of the integrated circuits and indicator tubes used. All pins are as seen from the underside of the package.

used in the prototype. As can be seen two identical circuits are required, one for the minutes and one for the hours. The operation of one only is described.

Two gates are cross-coupled to form a simple flip-flop the state of which is controlled by a single-pole change-over switch. When the switch is in position (a) the input A reaches the output and with the switch in position (b) input B reaches the output.

Construction

The layout is not critical but care should be taken to keep all leads fairly short. It should be borne in mind that t.t.l. integrated circuits switch in a few nano seconds, that is, high in the r.f. region, and lengths of wire can have a sizeable inductance at this sort of frequency. Also take care to minimize stray capacitive coupling between wires. Provided good circuit practice is followed no difficulty should be experienced.

Because of the design of the output stages of t.t.l. integrated circuits they can cause nasty spikes on the supply line. This trouble can be eliminated by connecting 0.01μF ceramic capacitors between +5 and 0V at various points on the circuit board close up to the i.c. supply pins. One every three or four packages should be more than ample.

Pin connection details of all the i.c.s used are given in Fig. 6.

Possible modifications

If it were arranged that the initial division stages gave an output of one pulse per second, a seconds display could be added. This would simply consist of another block made up of units A, B, E, F, X and Z. Such a block would give a one-pulse-per-minute output to feed into the minutes counters.

By using a crystal controlled oscillator instead of 50Hz mains, more accuracy could be obtained. A precision clock could use a 1MHz oscillator and only a few more decades of initial division would be required. This modification is desirable if very precise timing signals were required. As the resolution of the clock is increased it is necessary to increase the frequency and the stability of the timing source.

A continental clock, going from 0 to 24 hours, would be simple to implement. Another flip-flop would be required following flip-flop D, so that the tens of hours display could reach a count of two. Gating could then be simply arranged to reset the hours counters when there is a count of 23 hours plus one hour.

Back issues

We are frequently asked if back issues of the journal are available. Regretably very few are. However, readers who missed one of the following articles during the past year will be glad to know we can supply "tearsheets" (sets of pages).

May
Low-cost Horn Loudspeaker System *by 'Toneburst'*
Simple Audio Pre-amplifier *by Lindsley Hood*

June
Transistor Tester *by Waddington*
Crystal Oven and Frequency Standard *by Nelson Jones*

July
Integrated Circuit Stereo Pre-amplifier *by Nelson Jones*
15-20 Watt Class AB Audio Amplifier *by Linsley Hood*

September
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New Approach to Class B Amplifier Design

*by Peter Blomley**

The class B amplifier has established itself as the most versatile and lowest cost amplifier known. This is mainly due to the excellent work in the field of semiconductor circuit design by H. C. Lin[1], R. C. Bowes[2], R. Tobey and J. Dinsdale[3], A. R. Bailey[4] and P. J. Baxandall[5]. In this article it is hoped to complement the work of these designers by putting forward a new approach† which may solve some of the problems inherent in present designs.

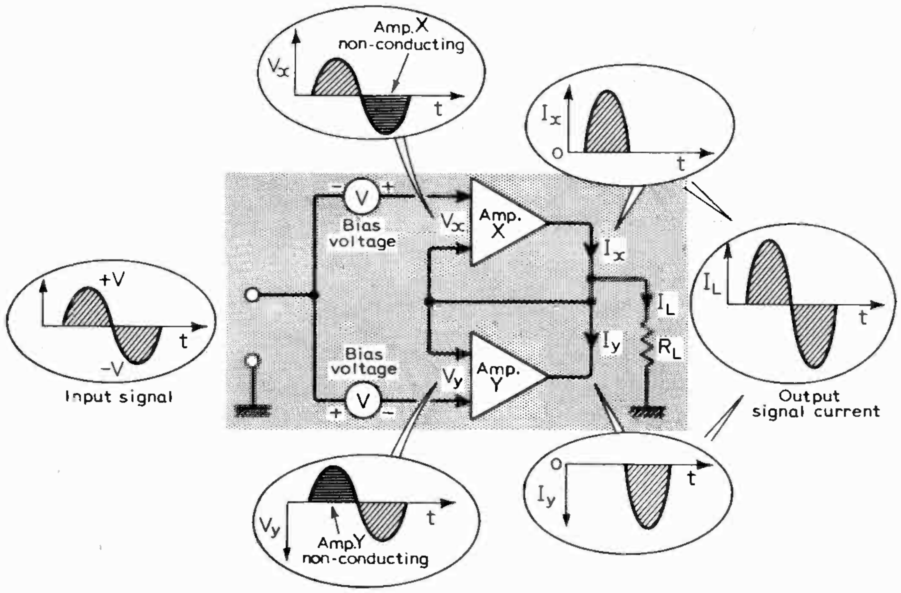


Fig.1. Block diagram of conventional class B amplifier with the two halves of a complementary output stage represented by sub-amplifiers X and Y.

Conventional approach

A definition of a class B amplifier could be 'one in which the operating point of each output device is set at the lower extreme of its transfer characteristic. Hence in a push-pull design, for any symmetrical input signal, each output device conducts only one half of the output waveform'. This method of operation gives the amplifier zero (or nearly zero) quiescent power consumption, high efficiency and excellent peak current drive capability. It is unfortunate that the sacrifice paid for these virtues is the problem of ensuring a linear transfer of signal drive from one output device to the other.

So that the class B system can be analysed it is useful to approach the output circuit as two separate amplifiers (labelled X and Y in Fig. 1 for convenience), the outputs of which combine to give the complete signal. This is shown in diagrammatic form in Fig. 1, where it is assumed that the blocks representing the amplifiers form the equivalent of a complementary output stage.

The transfer characteristic for one of these 'sub-amplifiers' is shown in Fig. 2, where above the bias point A the characteristic is extremely linear and below it becomes a combination of linear and exponential relationships. The designer's task is to define this last region so accurately that when it is combined with that of the other sub-amplifier, the overall gain will remain *constant* (i.e. as the gain of one sub-amplifier decreases, the other increases equally to compensate).

The workings of a class B output circuit can be clarified by the use of g_m diagrams, these being a plot of gain—or in this case

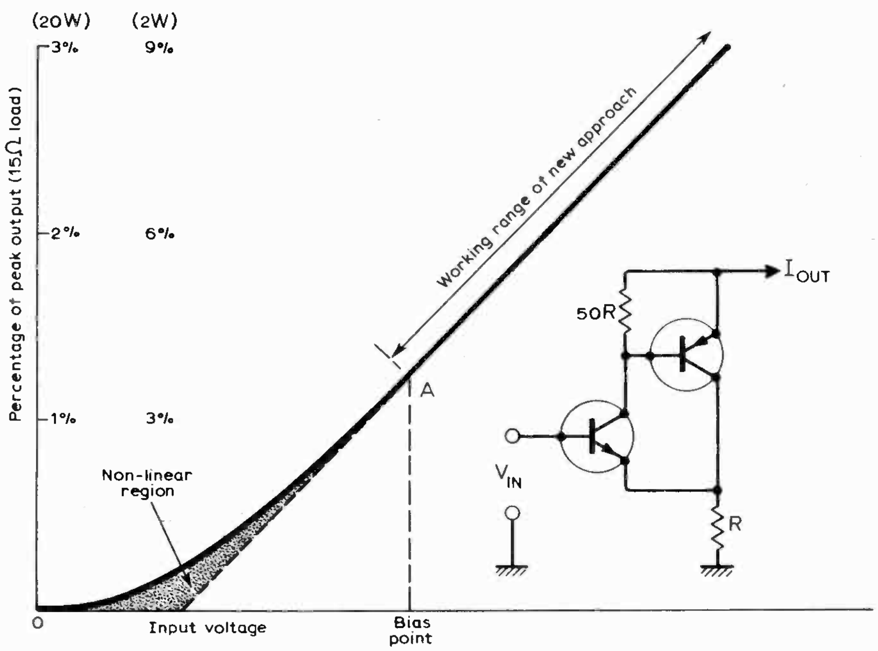


Fig.2. Transfer characteristic of sub-amplifier X which is linear above bias point A and non-linear below. In conventional class B, non-linear regions of X and Y sub-amplifiers have to be accurately matched to give overall linearity.

*Allen Clark Research Centre (Plessey), Caswell, Northants.

†The subject of patent application 53916/69.

mutual conductance—of the complete output circuit against drive voltage. The ideal would, of course, be a straight line parallel to the input voltage axis (indicating there is no change of gain with input swing), but regrettably this is not the case with designs popular at the moment. To provide a comparison of the different types of output circuits, I have prepared gain plots showing the effects of different bias levels, these being illustrated in Figs. 3 and 4. From these it is now easy to see the characteristic change in gain which can occur during the transfer from one sub-amplifier to the other. Referring to Fig. 3 about a 10% gain change occurs during transfer, whatever the bias level is set at.

The output circuit in Fig. 4 is a quasi-complementary type giving most interesting results. The main conclusion is that it is impossible to bias this circuit for symmetrical gain change and in practice it proves very difficult to establish which biasing point would give the best results concerning the *rate* of gain change.

This method of describing a class B amplifier can give an insight into the problems involved with a conventional design. First, each sub-amplifier has to have two regions in its transfer characteristic:

—the constant gain region (above bias point A in Fig. 2)

—the non-linear region (below this point).

Second, the non-linear region of each sub-amplifier has to be complementary to its partner, otherwise the situation shown in the g_m diagrams (Figs. 3 & 4) will occur. An interesting point is that the only reason why the non-linear region of the transfer curve is important is because the input signal normally traverses this region as well as the linear portion. If this was not the case most of the design problems in class B amplifiers would be solved.

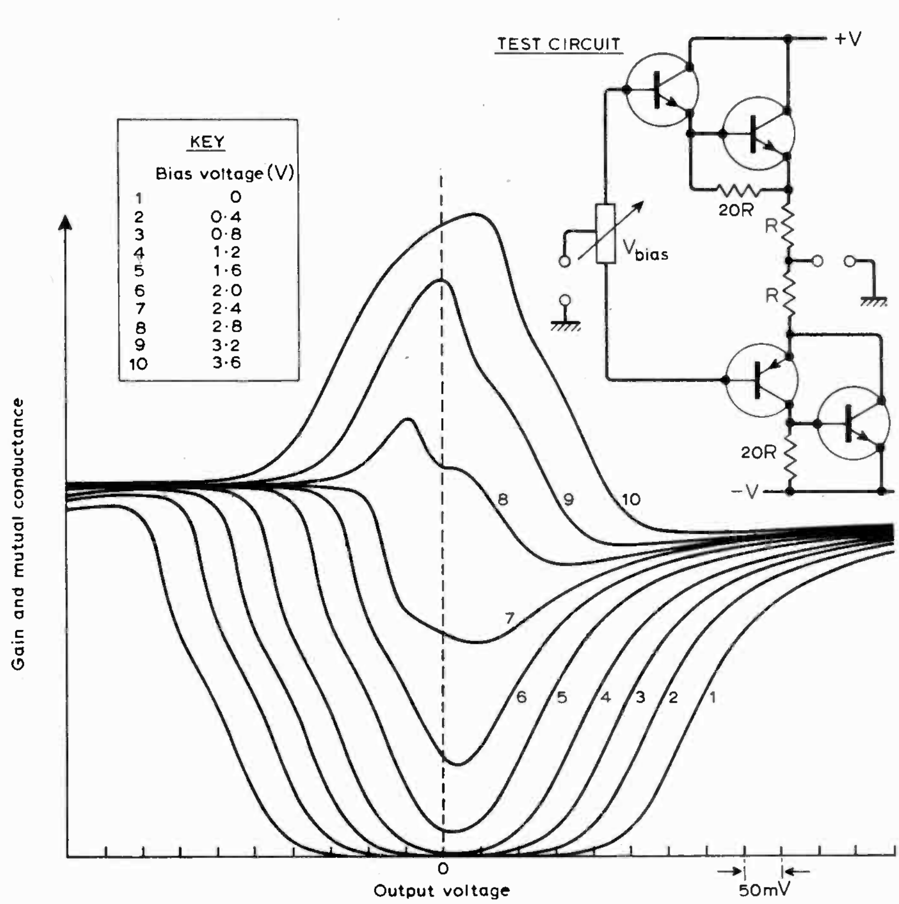


Fig.4. Curves for quasi-complementary output circuit show impossibility of biasing circuit for symmetrical gain change.

It is difficult to realize at first that a class B amplifier has to have this non-linear region in the sub-amplifier characteristic so that the two halves of the waveform can be separated. With conventional designs this is a built-in feature, but it need not be so. Assuming we define class A operation to include any amplifier where the input signal never traverses the non-linear region, the sub-amplifiers of a class B amplifier can operate in class A as long as the input signals are uni-directional. To accomplish this the required non-linear element is placed before the sub-amplifier inputs.

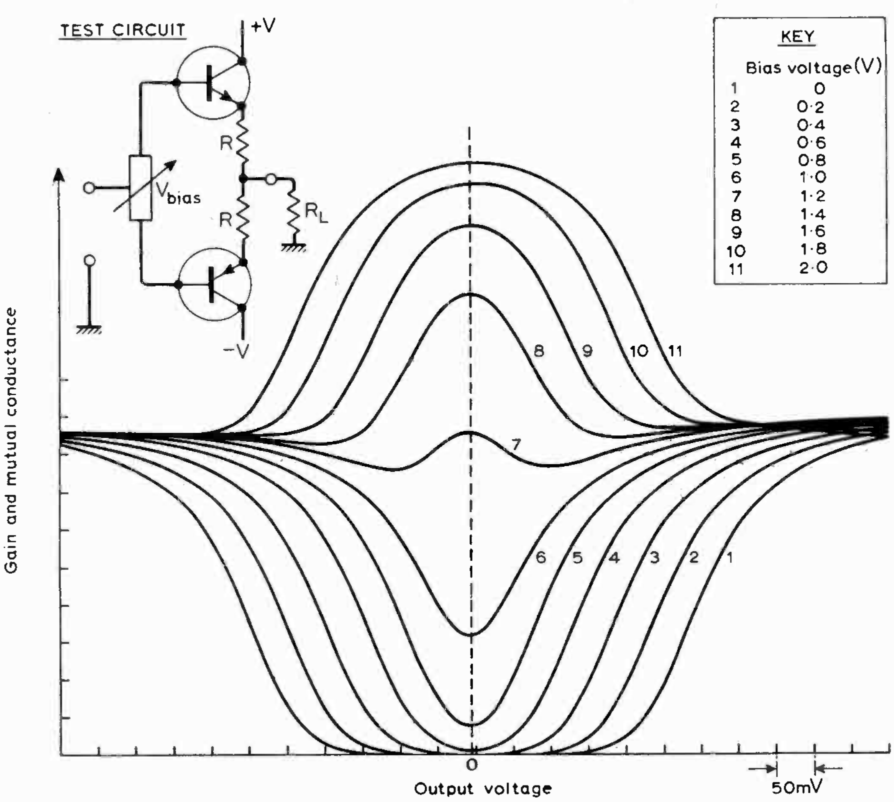


Fig.3. Gain—or mutual conductance—of simple symmetrical output circuit showing change in gain which can occur during transfer from one sub-amplifier to the other. Effect of different bias levels is shown.

New approach

Now the key to the problem is in the proposition that each sub-amplifier should be considered as a separate class A design, hence distortion generated by each of these units can be held to an extremely low level as long as the input signal can be prevented from driving the amplifier into the cut-off region. In the new approach, the output sub-amplifiers are biased *above* the non-linear region and *uni-directional* signals are fed into the input. This arrangement is illustrated in Fig. 5, where the necessary circuit changes are shown by comparison with Fig. 1. The obvious difference is the addition of the two diodes at the input which produce the uni-directional signal to drive the output sub-amplifiers. The linear transfer of signal between the two amplifiers is now dominated by this signal splitter.

Signal splitter. As the name implies the task of the signal splitter in a class B amplifier is to segregate the top and bottom halves of the signal waveform. Normally this is achieved by using the non-linear characteristics of each half of the output stage, but as this particular approach leads to problems, the new approach separates the two functions of amplifying and signal splitting completely.

To explain the problems involved with the design of a signal splitter it is usual to establish the ideal and see how this can be approached practically. As it happens there are two ideal 'half' characteristics which will give a linear cross-over when they are combined. The first, and obvious one, has a conduction path only in one direction and absolutely zero in the other. The other is more complicated and has three regions—linear region (large positive inputs), a non-linear region (transfer coefficient is proportional to signal) and a reverse region (transfer coefficient is zero).

The difficult region is the non-linear one. This will only give a linear crossover when it is combined with another conjugate characteristic. Not only this, but the relationship between the linear and non-linear portion has to be accurately defined. Normally this is achieved by altering the quiescent current in the signal splitter for minimum crossover distortion. Thus using this approach in the signal splitter means that the non-linear region has to be complementary to its partner and also that the linear and non-linear regions have to be accurately related. If additional constraints are imposed—due to device spreads and temperature changes—the situation can become very difficult unless a simple approach is used.

Returning to the first type of signal splitter, the immediate comparison which can be drawn is the simplicity of the characteristic. There are no interactions between each element and only one region has to be accurately defined. Ideally, therefore, this type of characteristic should be easy to control once a suitable device configuration is found.

Ideal element. The simple p-n diode fabricated in silicon can have a forward-to-reverse current ratio of 10^{10}; thus it approaches the ideal almost within the boundaries of measurement. This is however only considering the forward characteristic under conditions of *current drive.* If a voltage source were used the forward transfer would revert to the familiar exponential relationship between input voltage and output current (Fig. 6a). If a signal splitter is now made of two of these diodes and a *current* of changing direction fed into the common point, then from Kirchhoff's second law the current must flow either in diode D_1 or diode D_2 depending on the direction of signal current flow. The transfer coefficient for the diode must be unity, as it is only a two-terminal device, hence this type of signal splitter is extremely linear under the conditions of current drive (Fig. 6b).

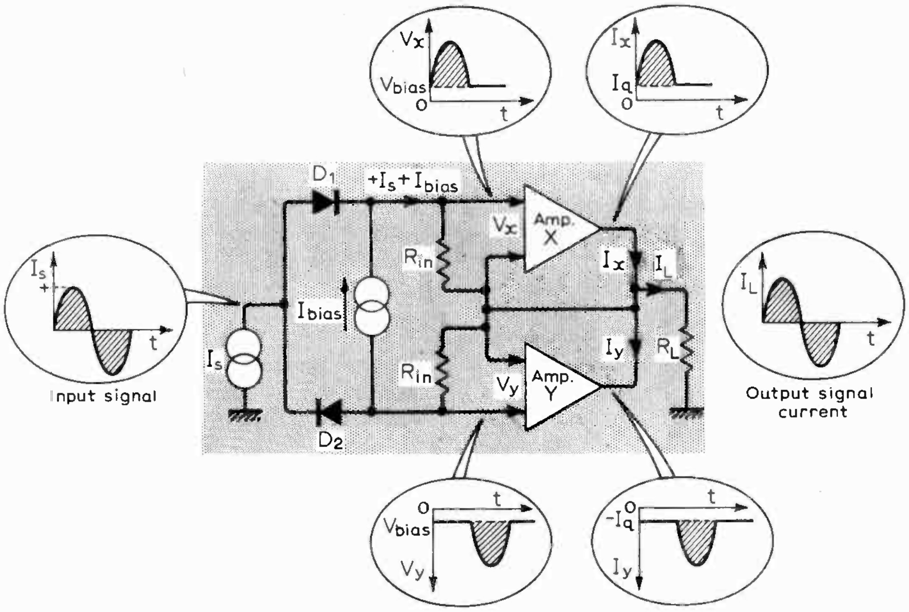


Fig.5. New approach to class B amplifier in which sub-amplifiers are biased above non-linear region and fed with uni-directional signals produced by the diodes. This effectively transfers signal splitting from the sub-amplifiers to a separate part of the circuit.

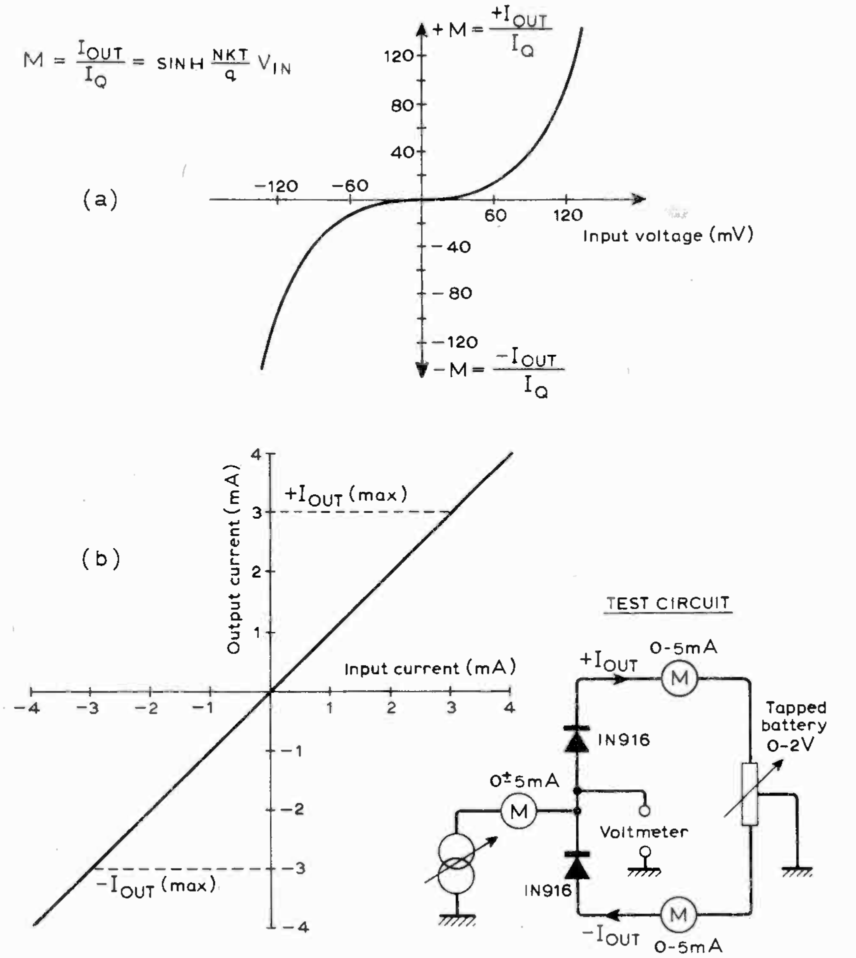


Fig.6(a). Transfer characteristic of voltage driven diode signal splitter.
Fig.6(b). Linear transfer characteristic of current driven diodes.

Transistor signal splitter. The use of a transistor as a signal splitter (Fig. 7) logically follows that of a p-n diode simply because the emitter-base junction has almost identical characteristics to that of a diode. Exactly where the transistor is superior to that of the diode depends on the design approach but in most cases the level-shifting property of a bipolar device is the main reason. This is very useful in a practical design but care has to be taken in the selection of the type of device. There is a problem with the use of transistors as signal splitters due to the emitter-base depletion capacitance. Under conditions of low injection this can add an additional phase lag during the crossover period. The problem can be overcome by using silicon planar devices with very high transition frequency (f_T) or by selecting devices in which the f_T is dominated by the diffusion capacitance as f_T remains constant down to very low emitter currents.

Synchronous signal splitter. There is a limit to the speed at which the diode or transistor signal splitter will transfer the signal path between the sub-amplifiers. If a synchronous signal splitter is used the time taken can be reduced to a few nanoseconds. This makes true class B operation possible at frequencies far higher than the audio spectrum. The system diagram is shown in Fig. 8(a). Instead of using the characteristics of the devices, as in the signal splitter which separates the two halves of the waveform, switches Tr_1 and Tr_2 are turned on and off at the required time by another amplifier labelled ST. This is a high-gain amplifier with a small amount of hysteresis, and as soon as the input exceeds a predetermined level the output from the trigger (amplifier ST) will change its polarity and turn on Tr_1 or Tr_2, depending on the signal direction, Fig. 8(b). This therefore gives almost the ideal signal splitting characteristics but the added complication might spoil its commercial possibilities.

Performance of the new design

The transistor signal splitter and the output stage circuit have a combined characteristic shown in Fig. 9 which demonstrates the excellent gain linearity. It is only when the bias of the sub-amplifiers is decreased below its optimum, allowing the output signal excursions to trace the non-linear region of the characteristic, that distortion begins to rise sharply. Further studies of these curves reveal that increasing the quiescent current through the output devices *does not* degrade, or for that matter improve, the crossover performance of the output circuit. Keeping this in mind it is therefore possible to design a class B amplifier *without any bias adjustment*. This assumes that the designer can guarantee that spreads in active devices and resistance values do not permit the quiescent current to fall below the level where the mutual conductance of the amplifier begins to decrease.

In this discussion about the performance of the design as a whole it would be fitting if the sub-amplifier design is mentioned. With conventional designs this two- or three-transistor element is fraught with compromises, one of the most serious being the decision on the inclusion of a base-emitter 'turn-off' resistance for the power transistor. Such a combination generates what can be called 'dead zone' distortion, mainly due to the change in slope of the transfer characteristic at zero crossing. One example of this is shown in Fig. 10 where, as predicted, the lower the value of resistance the more pronounced is the effect. It is very tempting to exclude this resistance altogether, especially if the current drive approach has been adopted, but the penalty would be a poor high-frequency performance coupled with overload recovery problems. This dilemma is aggravated if the designer decides to use homotaxial base powder devices (chosen for the robust nature of their construction and freedom from secondary breakdown) because the input diffusion and depletion capacitance is very high, hence the gain-bandwidth product of the device is relatively low (e.g. silicon planar $f_T \approx 90$MHz, homotaxial base $f_T \approx 1$MHz). In the latter case it is essential that the resistor is included. However, if the approach suggested in this article is adopted the sub-amplifier will never enter this non-linear region, thus the base-emitter turn off resistance can be included in the circuit to improve the performance without undue complications.

Once the decision has been taken to use the new approach the best circuit configuration has to be found and here again nature's swings and roundabouts create a difficult situation where compromise seems necessary. One of the criteria I used was that of thermal performance, following an initial consideration of the electrical properties of each configuration. The power transistor chip can change its temperature by tens of degrees centigrade during a power cycle, this being reflected by a corresponding change in the base-emitter voltage (V_{BE}) of the device. If the voltage bias to the sub-amplifier is applied directly to the power device (Fig. 11a), any change in the V_{BE} will cause a considerable change in quiescent current and in turn an

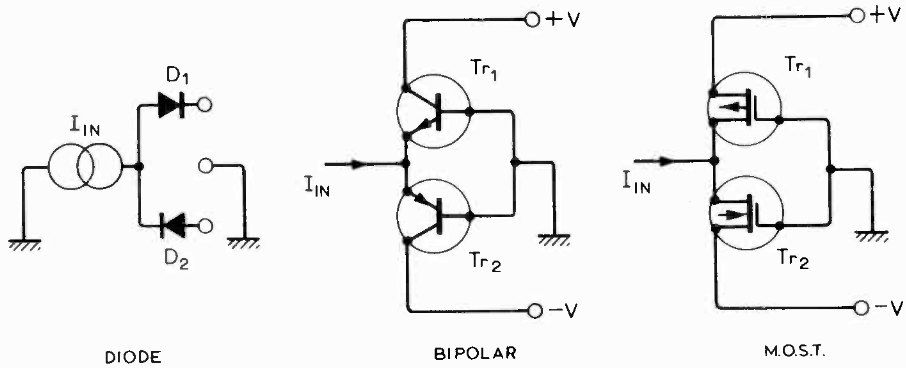
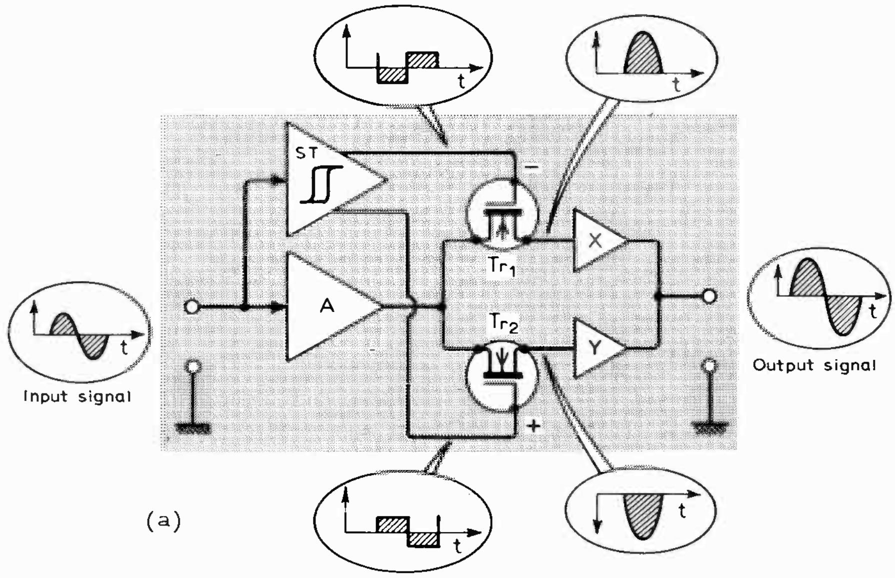


Fig.7. Types of signal splitter. Transistor type has the advantage of level shifting.



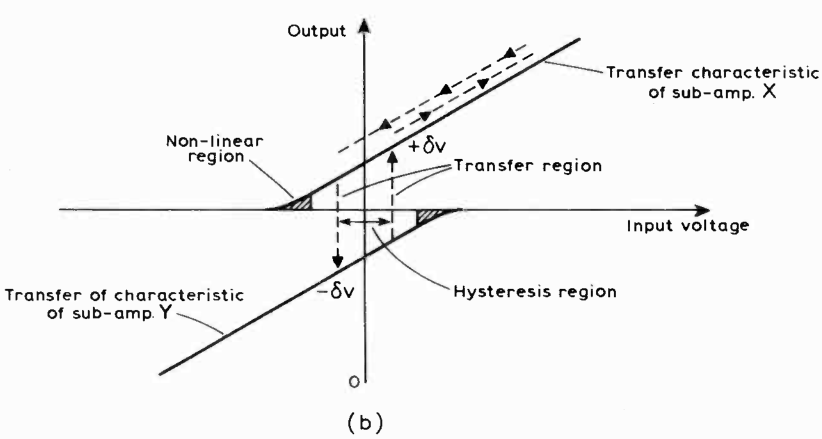


Fig.8(a). Synchronous signal splitter, with fast switching time, allows new approach to be used at frequencies well above audible range.
Fig.8(b). Operation of synchronous splitter of Fig.8(a). When input level exceeds a pre-determined level, output changes polarity and turns on Tr_1 or Tr_2.

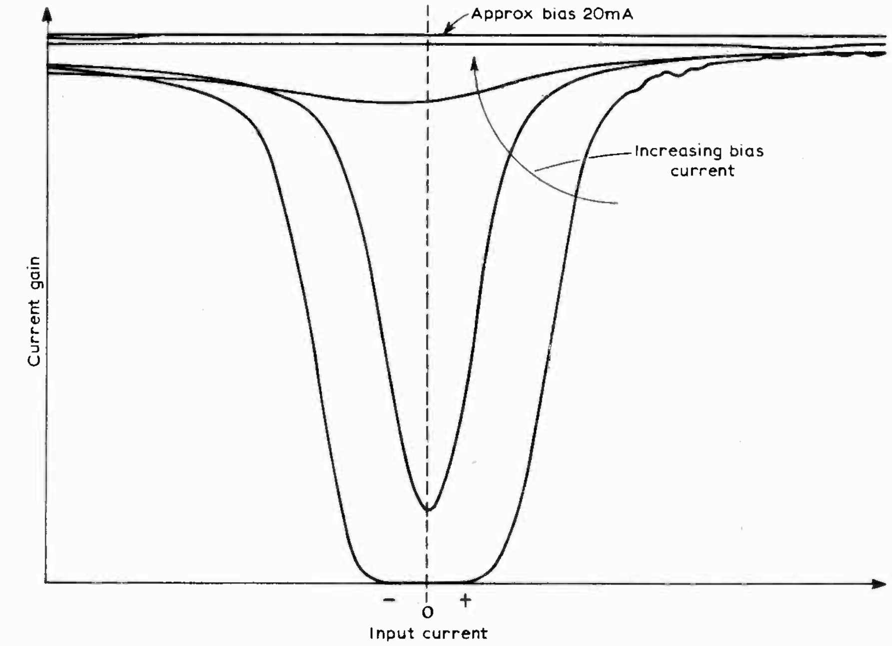


Fig.9. Combined characteristic of transistor splitter and output circuit shows excellent gain linearity.

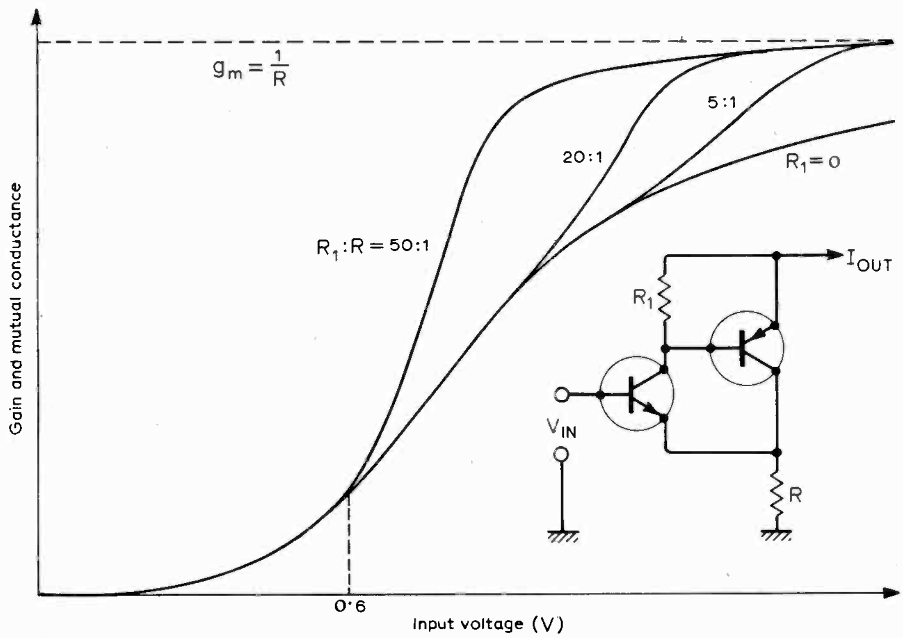


Fig.10. Transfer characteristic for conventional two-transistor sub-amplifier showing worsening effect of reducing the base-emitter 'turn-off' resistance of the power transistor. This normally generates 'dead zone' distortion due to the change in slope at zero crossing but is avoided in the new approach.

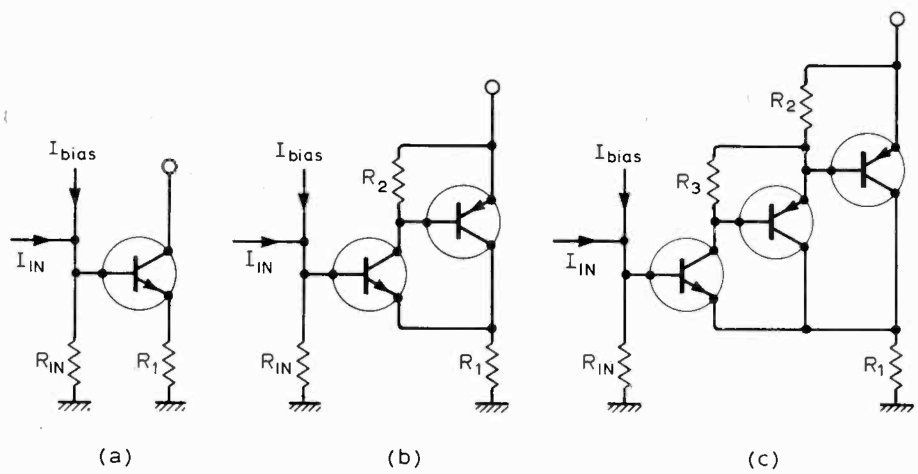


Fig.11. (a) Change in V_{BE} with temperature causes considerable change in bias current which could adversely affect intermodulation distortion. Circuits in (b) and (c) avoid this.

increase in distortion at low frequencies which could adversely affect the intermodulation performance of the amplifier as a whole. An improved design is shown in Fig. 11(b) and a more elegant version similar to that used in the Quad amplifier[6], in Fig. 11(c). It is on this latter example that I have concentrated most design effort, mainly because the performance advantages tend to outweigh the increased cost of pre-driver devices.

Returning now to an examination of the performance of the whole amplifier—the total distortion through the audio range can readily be made less than 0.1% *before applying feedback*, this performance being repeatable at almost any level of quiescent current.

Future designs

The use of class B amplifiers is not, of course, confined to the field of audio and in fact the ideas set out in this article lend themselves to applications in the high-frequency (> 1MHz) spectrum. The poor cross-modulation performance of present designs is usually due to the presence of non-linearities in the crossover region, hence substantial improvements can be expected in this direction.

Other applications where an ultra-low distortion amplifier of low stand-by power and high output capability is needed can be seen, examples of such devices being portable standard oscillators and meter calibration amplifiers. In the next article a practical design for a 30-watt audio amplifier is discussed in detail and future proposals developed in diagrammatic form.

(*To be concluded*)

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Our 60th Birthday

The first issue of this journal, which for two years was entitled *The Marconigraph,* appeared in April 1911 and we therefore celebrate our 60th birthday this year. To mark the occasion we plan to have an enlarged April issue including several contributions reviewing the past 60 years in various fields. Further details will be given in our next issue.

News of the Month

Congratulations Glenrothes

The Glenrothes Development Corporation has embarked on an imaginative plan which was pioneered 100 years ago by Thomas Edison and forgotten. Edison provided work space and facilities for private inventors that they would otherwise not have had. The Corporation are building a £20,000 factory, due for completion in June, which will be divided into small units of something over 400 sq feet. These units will be let to inventors at a nominal rent. The exact rent will depend upon the means of the person involved and will not exceed 60s per week (a house in the area costs about 50s weekly to rent). On top of this the inventor will have to pay rates of around £30 per year.

Advice on setting up in business, business management, accountancy, marketing etc will be freely given by a committee. This committee, made up from prominent local business men, will vet each inventor who wishes to take advantage of the scheme, and will offer factory space to those, who in their opinion, are most likely to succeed.

An inventor, who has successfully developed his idea and has gone into production, would soon outgrow 400 sq.ft and would be offered a factory site in Glenrothes. However there are no strings attached to the offer at all and the successful inventor would be free to go where he chose. A bank has shown interest in the scheme and is willing to advance money for the purchase of plant to individuals who have successfully passed the committee's vetting and set up shop in the factory.

Individuals who would like to apply for factory space under the scheme should write to the Glenrothes Development Corporation, Glenrothes House, Glenrothes, Scotland.

European space consortium

Companies from eight of the ten member states of the European Space Research Organization have formed a consortium to respond to tenders issued by ESRO for both application and scientific satellites.

The new consortium has been named STAR (Satellites for Telecommunications, Applications and Research). The member companies are British Aircraft Corporation; Contraves AG., (Switzerland); CGF-Fiar (Italy); Dornier System, (West Germany); Fokker VFW, (Netherlands); L. M. Ericcson AB., (Sweden); Mondetel, (Italy); SBCA, (Belgium) and Thomson CSF, (France).

The West German company AEG-Telefunken has also joined the STAR consortium but specifically for study and development of telecommunications satellites expected in the European programmes.

Naval trainer

A trainer system is to be designed and built for the Royal Navy by Ferranti Limited in collaboration with the Admiralty Surface Weapons Establishment at Portsdown. The trainer will be commissioned at *H.M.S. Dryad,* the Royal Navy's School of Tactics, Navigation and Action Information Organization during 1975, at a cost approaching £5M.

The function of the new system will be to train staff in using automated action information and weapon control equipment. It will simulate the operations rooms and the weapon control systems of the *Leander* class frigates fitted with the various weapon systems as well as the new type-42 guided-missile destroyer.

The trainer will contain three FM.1600 and eight FM.1600B computers which will generate, process and distribute data to displays in the control and operation rooms of the trainer. The four simulated operations rooms are replicas of the ships' operations rooms they represent. Radar, sonar, electronic warfare and weapon control data are presented on the same displays and in the same form as under operational conditions. Many of the displays, themselves, will be supplied by Plessey Radar Ltd and by Decca Radar Ltd. Instead of live signals being used, the data will be synthetically generated. In general these synthetic signals will be programmed computer outputs, but for one of the more complex radars Marconi Ltd are to supply special equipment.

Exercises will be controlled by the instructional staff in a central control room containing sixteen displays. Each of the simulated ships will be able to exercise independently or as a task force using radio and digital data-links for exchange of information. Communication with the computers is by means of keyboards.

Electronic typesetting

The latest method of high speed typesetting for printing forms the characters on a cathode-ray tube and the resulting images are recorded on photographic film, which is subsequently used for making lithographic plates. Characters are built up from closely spaced vertical or horizontal parallel lines traced by the c.r.t. spot, rather on the principle of television picture synthesis except that the spot intensity is not continuously variable—just full on or full off. The instants of turning on and off the beam current are determined by binary digital data held in magnetic-tape and disc stores under the control of a computer-like system. An interesting feature of the method is that it is not restricted to letters, numbers and other such characters but can also be used for composing diagrams, which can be directly interspersed with the text.

Wireless World's printing has not quite reached this advanced technique though much of the journal's text is composed by an earlier phototypesetting method (see "Electronics in Typesetting", March 1968). But our publishers have an associated printing company, Computaprint Ltd., which has just installed a machine of the fully electronic kind described above, the RCA Videocomp 70/800. This is capable of typesetting at the astonishing speed of 6000 characters (about two columns of this page) per second—which compares with up to 500 characters/second for non-c.r.t. photocomposition, 5 characters/second for conventional "hot metal" mechanical typesetters and 1 character/second for hand setting. Another commercial machine, the Mergenthaler Linotron, is claimed to work at up to 10,000 characters/second.

The Videocomp 70/800 is in fact a room-full of computer-like equipment: c.r.t./photographic unit, two magnetic tape stores, a random-access disc store, a data processor with a core store of its own, and an operator's console with a typewriter. The c.r.t. forms characters from vertical lines with a definition of up to 1800 lines/inch and diagrams up to 450 lines/inch. Type of various founts (styles) can be set with character sizes varying from 4 to 96 points (72 points = 1 inch), and characters can be altered electronically to form roman, oblique (quasi italic), expanded and condensed versions of the basic "face". A piece of text is composed line by line at any width up to 70 picas (11.67in) and to any required length on the film, which is moved past the c.r.t. optical system at speeds up to 40ft/minute. Drawings and diagrams measuring up to 7in × 9in can be composed.

One possible outcome of this general technique is further development in the remote control of newspaper printing, already being done to some extent by facsimile transmission. Now that the visual as well as the verbal content of newspapers can be codified and transmitted electronically as digital data there will be less need to consider news as freight which has to be physically distributed from centralized printing works.

German satellite earth station

AEG-Telefunken are to build a satellite station at Leeheim, near Gross-Gerau, Hesse, West Germany, under a DM3.5M contract awarded by the Central Telecommunications Bureau of the Federal German Post Office. The station will work mainly with the Italian synchronous satellite, Sirio, which is due to be launched in 1972.

The station will mostly be employed in experimental work in the band 10 to 20GHz with the aim of opening up this band for commerical use. Normal communication satellite frequencies are 4 and 6GHz.

American scientific space projects

Below we list the major scientific projects planned by the American National Aeronautics and Space Administration. Some of these projects have been mentioned in earlier issues of *Wireless World*. The cost quoted for each project is the highest estimate of all expenses from project conception to the completion of the programme.

Applications technology satellites (ATS): Synchronous satellites intended to test new satellite systems. Earlier ATS satellites (1 to 5) have carried out photographic and radio propagation experiments and have tested gravity gradient satellite stabilization systems. ATS-F (1973) and ATS-G (1975) will test a 30-ft erectable space aerial with a 0.1° pointing accuracy for TV transmissions to small earth receivers. (See pictures.) Cost, $360M.

Atmosphere explorer: Three 1000lb spacecraft to be launched in 1973, 1974 and 1975 to investigate the earth's atmosphere at altitudes between 75 and 95 miles. Earlier similar explorers have been launched in 1963 and 1966. Cost, $49M.

Earth resources satellite (ERTS): To be launched in 1972 and 1973 to assist in research in agriculture, oceanography, forestry, cartography, etc., and to develop a new data handling system. Cost, $200M.

Geodetic earth orbiting satellite (GEOS): Earlier satellites in the series launched in 1965, 1966 and 1968. New satellite planned for 1972 to study earth's gravity and to precisely define the position of 86 points on the earth's surface (to within ± 10 metres) cost, $31M.

Interplanetary monitoring platform (IMP): To improve knowledge of solar, lunar and terrestrial relationships obtained by studying interplanetary radiation. Earlier satellites launched in 1963, 1964, 1965, 1966, 1967 and 1969. Further launches scheduled for 1971, 1972 and 1973. Cost $75M.

Mariner Mars 1971: Will survey 70% of the surface of Mars to identify landing areas and study seasonal variations. The vehicles will transmit photographs of the planet's surface and data on the Martian atmosphere. Two spacecraft to be launched one month apart in 1971. Cost $125M.

Mariner Mars/Venus 1973: To be launched in the autumn of 1973. Will pass within 3,300 miles of Venus in February 1974 and within 625 miles of Mercury in March of the same year. The pictures to be transmitted of Mercury will have a resolution similar to those of the moon taken by Earth based telescopes. Cost, $120M.

Nimbus: To develop and flight test sensors and instrumentation basic to the study of the atmosphere and to provide data for meteorological research. Earlier launches in 1964, 1966 and 1969. Two more launches to be carried out in 1972 and 1973. Cost $325M.

Orbiting astronomical observatory (OAO): Extremely complex 5,000-lb satellites to study stellar phenomena and the galactic and intergalactic medium. Earlier launches 1966, 1968 and 1970; planned launch in 1971. Cost $360M.

Orbiting solar observatory (OSO): Earth orbiting spacecraft designed to obtain high resolution information on the sun. Earlier launches 1962, 1965, 1967(2), 1969(2); planned launches 1971 and 1973. Cost $185M.

Pioneers F and G: To be launched in 1972 and 1973 on missions that will last about two years each and will culminate in about a 100 hour inspection of Jupiter as the craft swing round this planet. The craft are exploratory in nature and will study space beyond Mars, the asteroid belt and will photograph Jupiter. Cost, $105M.

Radio astronomy explorer (RAE): One placed in earth orbit in 1968 and another to be placed in lunar orbit in 1972. These craft have 750 ft extendable aerials to monitor radio signals from the milky way, other galaxies, the Sun, Jupiter and the Earth. Cost, $22M.

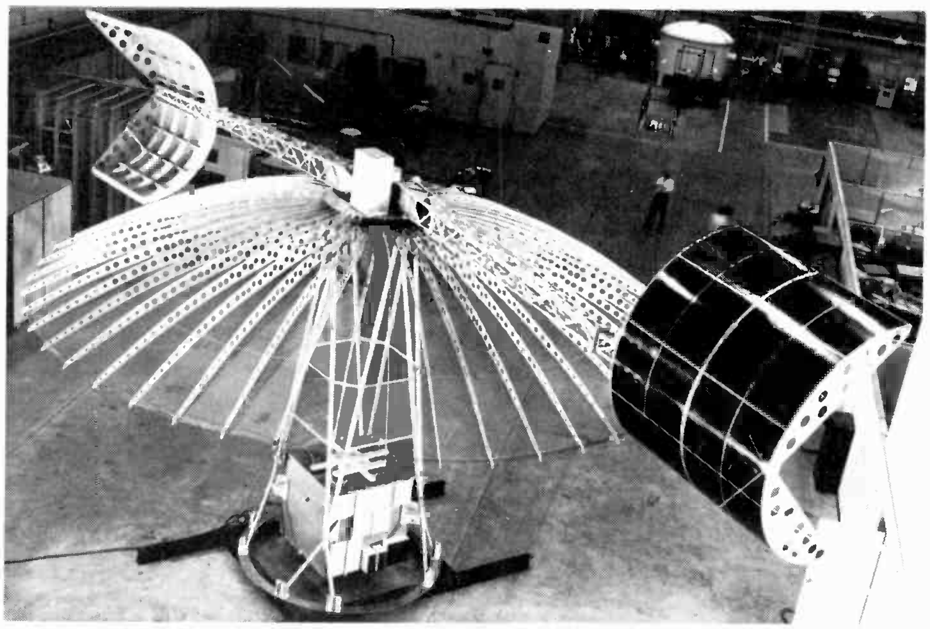
Small astronomy satellite (SAS): 330-lb earth orbiting satellites (1970 and 1971) to search for X-ray, gamma ray and u.v. sources from inside our galaxy. Cost, $37M.

Small scientific satellite: To be placed in earth orbit in 1971 to study magnetic fields, auroral phenomena and charged particles. Cost, $7M.

Synchronous meteorological satellite (SMS): Will continuously observe the atmosphere; launches in 1972 and 1973. Cost, $30M.

Viking: Unmanned Martian landing and orbiting spacecraft. The craft will divide into two when in orbit of Mars and one section will land on the planet. Photographs, as well as biological and chemical data, will be transmitted from the surface of the planet. An attempt will be made to find evidence of life. Launch 1975. Cost $850M.

ATS-F to be launched in 1973 will take on the shape shown in the photograph once out in space. One of its tasks will be to relay educational television programmes to India. In addition the satellite will relay weather data from Nimbus satellites to ground stations and will carry out experiments in air traffic control on congested air routes.



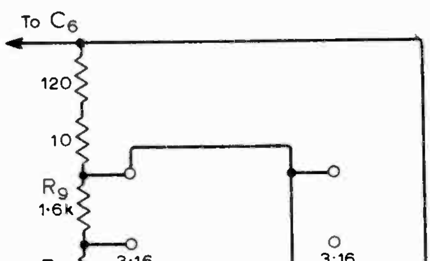
Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

'Linear Scale Millivoltmeter'

I congratulate A. J. Ewins on the design of his linear scale millivoltmeter (*W.W.* Dec. 1970) which represents a very worthwhile improvement over Waddington's original circuit. Even with the circuit modified as described for use with a 100μA meter movement, the improvement in linearity is most valuable.

One useful further modification which may be of interest to other readers is the addition of a decibel range to the instrument. For each range to be $\pm$10dB relative to the adjacent ones, the attenuator requires modifications to obtain 3.162:1 steps. To avoid the need for non-standard resistor values, the arrangement shown in the figure may be used. Resistors R_9 to R_{14} have the same values as in the original circuit, but in the '3.16' decade positions, an extra 130Ω



is switched into the resistor chain. The meter is rescaled to read 0-10 and 0-3.16 on the voltage ranges, the ratio between them now being 10dB. A separate decibel scale is calibrated from −10 to +2dB relative to 1mW into 600Ω, which corresponds to 775mV. This calibration may be achieved indirectly from the 0-10 voltage scale by the use of the following table.

dB	V	dB	V
−10	2·45	−3	5·48
−9	2·75	−2	6·15
−8	3·08	−1	6·90
−7	3·46	0	7·75
−6	3·88	+1	8·69
−5	4·36	+2	9·75
−4	4·89		

In this way a total decibel range of −70 to +50 may be obtained, which is very convenient for plotting frequency response curves.

D. J. FARMAN,
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Durham City.

Compression chambers behind horn drivers

In the article 'Low-cost Horn Loudspeaker System', May 1970 *Wireless World*, 'Toneburst' seems mystified about why adding and tuning a compression chamber behind the driver should make such an improvement in the bass performance. In the absence of his data regarding design flare rate, total horn length and driver, we can only speculate from this side of the Atlantic regarding an explanation for the observed improvement.

Probably the mechanism is that of 'reactance annulling' as described by D. J. Plach and P. B. Williams in the February 1955 *Radio-Electronic Engineering*. A more theoretical treatment is given by D. J. Plach, 'Design Factors in Horn-Type Speakers' *Journal of the Audio Engineering Society*, October, 1953.

The basic mechanism is rather simple to descibe. Within an octave below and above the horn cut-off frequency (determined by the flare rate) the horn presents an 'inductive' mechanical impedance to the driver as well as a 'resistive' portion which falls rapidly as frequency decreases in this region. This inductive portion of the horn load can be 'annulled' or tuned out by proper choice of a 'capacitive' effect which is the compliance of the driver suspension. If the driver is of the 'high compliance' type, the effective compliance is too high and can be lowered by a sealed chamber behind the driver. As a rule of thumb, the resonance of the combined driver and chamber (less horn) should be two to four times the cut-off frequency of the horn. That is, a horn with a 30 Hz cut-off should be driven with a cone having a free air resonance of 60 to 100 Hz. Most 12 to 15 inch loudspeakers have free air resonance below this range and would need a rear compression chamber of several cu. ft. volume to adjust the resonance. Perhaps this is what 'Toneburst' was doing with his compression chamber.

J. ROBERT ASHLEY,
University of Colorado, Colorado Springs, Colorado.

That a finite length acoustic horn in practice delivers appreciable sound output (i.e., it has a non-zero impedance) below its cut-off frequency has been noted by many authors.[1-3] An article by "Toneburst"[3] in the May 1970 issue is one of the most recent ones again noting this fact. However, in that article, "Toneburst" quoted Paul Klipsch[1] as saying "... It must be concluded that the computed horn impedances are only qualitatively correct for frequencies within an octave of the low frequency cut-off." This statement refers to the condition of an acoustic horn having a zero impedance at and below its cut-off frequency. Shortly, after making the above quote, Klipsch[4] showed that this was an erroneous condition and that the theory in fact does predict a non-zero impedance (i.e., finite sound output) at and below cut-off. Here is a short exposition of Klipsch's work.

Theoretical development. The acoustical impedance, Z_{A1} of an exponential horn is given by Olson[5] as

$$Z_{A1} = \frac{pc}{S_1} \times \left\{ \frac{S_2 Z_{A2}[\cos(bL+\theta)] + jpc[\sin(bL)]}{pc[\cos(bL-\theta)] + jS_2 Z_{A2}[\sin(bL)]} \right\} \quad (1)$$

where

S_1 = the area of the throat in cm^2
S_2 = the area of the mouth in cm^2
L = the length of the horn in cm
Z_{A2} = the acoustical impedance of the mouth in acoustical ohms
$\theta = \tan^{-1}(a/b)$
$a = m/2$
m = the flare constant of the horn = $4\pi f_c/c$
f_c = the cut-off frequency in hertz
c = the velocity of sound in the medium—in air it is $3{\cdot}45 \times 10^4$ cm/sec.
$b = \sqrt{4k^2 - m^2}/2 = 2\pi\sqrt{f^2 - f_c^2}/c$
$k = 2\pi/\lambda$
$\lambda = c/f$
p = the density of the medium—for air it is $1{\cdot}18 \times 10^{-3}$ gm/cm^3
$j = \sqrt{-1}$

Performing some mathematical manipulations, a normalized throat impedance can be written as

$$Z_{A1}' = \frac{Z_{A2}'[b - a\tan(bL)] + jk[\tan(bL)]}{[b + a\tan(bL)] + jkZ_{A2}'[\tan(bL)]} \quad (2)$$

where

$$Z_{A1}' = \frac{Z_{A1}}{Z_1} \qquad Z_{A2}' = \frac{Z_{A2}}{Z_2}$$

$$Z_1 = \frac{\rho c}{S_1} \qquad Z_2 = \frac{\rho c}{S_2}.$$

If we take $\lim_{b\to 0} Z_{A1}'$, then equation (2) becomes indeterminate. By applying the well known L'Hospital's Rule of Calculus, the normalized throat impedance at the cut-off frequency ($b = 0$) is

$$Z_{A1}'\Big|_{f_c} = \frac{Z_{A2}'(1-aL)+jkL}{(1+aL)+jkLZ_{A2}'}. \qquad (3)$$

It is immediately apparent that this value of Z_{A1}' is definitely non-zero.

Two further points are that: (a) below cut-off, b becomes imaginary and $\tan(jx) = j\tanh(x)$ in equation (2) and (b) the mouth impedance, Z_{A2}', is that of a piston of equivalent radius R vibrating in a hole in an infinite baffle.[6-7]

A practical example. To illustrate graphically, a horn with an $f_c = 107{\cdot}5$ Hz, $m = 0{\cdot}0392$, $L = 14$ in, $S_1 = 128$ in^2 and $S_2 = 550$ in^2 was investigated. Fig. 1 shows how the resistance (R) and the reactance (X) of Z_{A1}' vary with frequency. The dotted lines

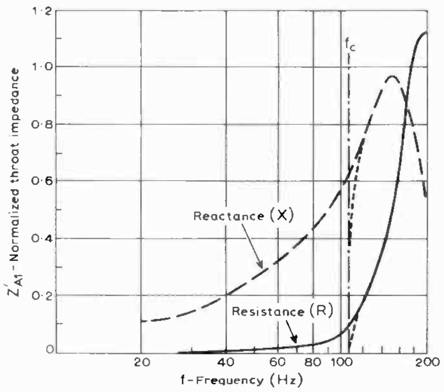

Fig. 1. Throat impedance versus frequency.

represent the erroneous condition of zero impedance at and below cut-off.

Klipsch[8] went on to indicate that the reactance curve, X, of Fig. 1 should be offset by a combination of the diaphragm suspension stiffness and an enclosed air chamber behind the diaphragm. "Toneburst" found that an air chamber reinforced the bass frequencies that were otherwise of small amplitude.

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3. "Toneburst", "Low-Cost Horn Loudspeaker System", *Wireless World*, May 1970, pp. 202–205.
4. Klipsch, Paul W., "A Note on Acoustic Horns", *Proc. I.R.E.*, July 1954, pp. 447–448.
5. Olson, Harry F., "Music, Physics, and Engineering", Dover Publications, New York, 1967, pp. 93–94.
6. Beranek, L. L., "Acoustics", McGraw-Hill, New York, 1954, pp. 116–128.
7. Olson, *op. cit.*, p. 85.
8. Klipsch, *op. cit.*, p. 448.

The author replies:

I have not been in any doubt about the function of the chamber behind the driver. Indeed in the original paper of 1941 Klipsch says quite succinctly "The air chamber behind the diaphragm is designed to offset the main reactance of the throat impedance at low frequencies". My interest and surprise does not lie in this.

Perhaps I should have presented the theoretical foundations of the experimental approach a little more squarely in the article, but I believe that all the necessary clues are provided in the three introductory paragraphs.

We are used to seeing flat response curves for amplifiers. We expect the power output of a good amplifier to be absolutely steady through the whole audio spectrum—say from 20Hz to 20kHz. It is quite wrong, however, to believe that such a flat frequency/sound-power curve should be expected of a loudspeaker.

In a previous article* I reproduced data originally published by Weiner showing sound levels reaching the listener's ears from a level-output source 45° to the left or right of the listener. At 200Hz the sound intensity was the same at both ears but at 3kHz the level was up by 5dB at one ear and down by 10dB at the other. Since (as was also stated) stereophony does not seem to depend on time delays for frequencies above 1kHz, but rather on relative intensities, we can draw three very important conclusions.

1. Absolutely flat response from the loudspeakers at frequencies above 1kHz is ideal, but failing this identical response curves (assuming correct dispersion and nothing worse than falling treble output with rising frequency) will give a completely stable stereophonic image in an ideal listening room.
2. The response curves should be nearly flat from 1kHz down to about 200Hz.
3. As the frequency drops below 200Hz a flat response becomes less and less important and may be judiciously traded for extended bass performance, reduced enclosure size, or both. (Note that the variations described are of amplitude not phase. Extending the bass by phase reversal, i.e. by a transmission line or by bass reflex techniques, audibly adulterates the signal.)

The experimental approach lay in shortening the folded-horn bass enclosure and thus allowing the amplitude variations, due to impedance changes in the horn, to reach a level of ±6dB at the bottom of the range. Variation in the output of the horn driven by the FR4 is less than ±1dB up to about 4kHz where the horn gradually loses its "grip" on the driver cone and the response begins slowly to decay.

I hope this brief account clarifies the matter. How corner placing allows such bass performance is still a mystery.

'TONEBURST'.

* "Towards True Stereophony", *Wireless World*, Sept. 1969.

Audio Fair Report: putting the record straight

I was glad to see the report on the London Audio Fair in the December issue, especially from a very observant technical angle, which after all is what the show is all about.

In the interests of fairness however, I would like to refer to, and possibly clarify, a couple of points made in the item on JBL loudspeakers. The writer says 'the sound level was too high—we were assured this was necessary to prove their superiority'. Unfortunately, all too often, a speaker which has a very even response and clean sound at listening levels, has a hopeless overload factor, and is incapable of following really fast transients at high levels. Conversely, a speaker which does cater for higher listening levels and subsequent high transients, is incapable of maintaining an even response at low listening levels. Had your reporter stayed a little longer, he would have heard an alternating demonstration of low-level choral and orchestral work, and some "clean feed" recordings played at high level, to demonstrate the speakers' efficiency, and ability to maintain linear cone excursions during really sharp transients.

Similarly, your writer states "Bass and treble lift seemed a permanent amplifier setting". Can I assume this to be a compliment to the speakers' performance? I don't think so. I can only assume your reporter glanced at the vertical faders on the JBL Graphic Controller, and seeing them in the 'half way up' position, assumed this to be a permanent bass and treble setting. Perhaps I can clarify this also. The faders, as with all graphic control equalizers, in the midway position, are set at 'flat'.

As a final point, your writer followed up this item with an excellent note on h.f. dispersion—a very much neglected subject in this field. Whereas he mentions the polar diagram in Fig.1(b) belongs to the B&W Model 70, the unnamed polar diagram in Fig.1(a) entitled 'A well designed radial horn', bears a striking resemblance to the polar diagram of the JBL 2350 radial horn*.

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Feldon Recording Ltd,
London, W.1.

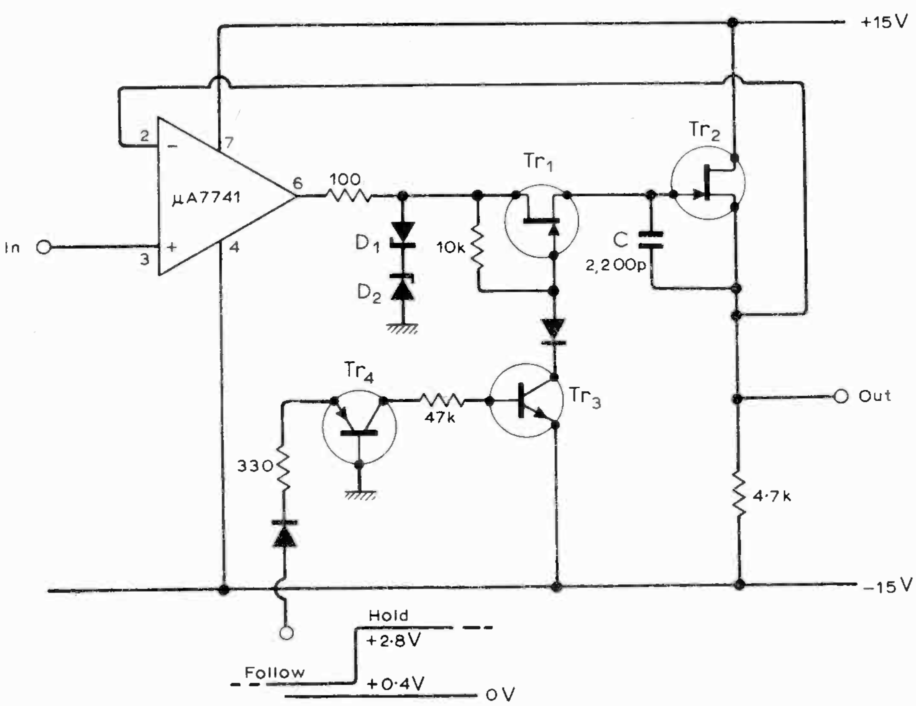
* We should have acknowledged JBL as the source of the diagram although, in fact, there are ways other than that used by JBL of designing a radial horn to provide the correct dispersion.—ED.

Circuit Ideas

Follow-and-hold circuit

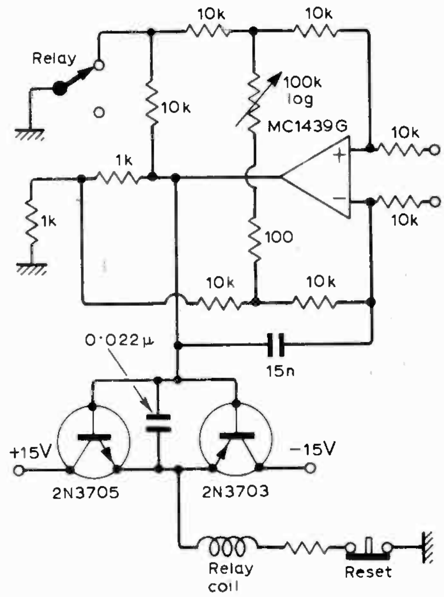
There are certain measurement situations where it is advantageous to have a circuit which follows an input voltage signal until instructed to hold the instantaneous level. In the circuit presented Tr_1 is an f.e.t. switch and Tr_2 a source follower. When Tr_1 is 'on' the very high open-loop gain of the operational amplifier ensures that the output voltage is equal to the input to within the input off-set of 5mV for a 741 or 709 type amplifier. On application of the hold instruction, Tr_1 switches 'off', isolating the source follower and leaving a voltage V_{gs} stored on C such that the output remains at the instantaneous value it occupied when the 'hold' instruction was given. It is necessary to clamp the operational amplifier output by means of zener diodes D_1 and D_2 (each 5.1V) to ensure that Tr_1 cannot be turned on due to the amplifier saturating negatively when open-loop. Transistors Tr_3 and Tr_4 (general purpose types) enable the hold instruction to come from d.t.l. or t.t.l. circuitry. Tr_1 and Tr_2 are n-channel junction f.e.ts, e.g. MPF102. Very long holding times may be achieved by choosing low-leakage f.e.ts for Tr_1 and Tr_2 or increasing the value of C. High-speed operation is possible if the operational amplifier is a high-speed device. With the components shown the output impedance is approximately 2kΩ and input impedance 400kΩ. It is possible to introduce some gain, R_f/R_{in} by having a resistor R_f in the feedback loop and a resistor R_{in} at the non-inverting input, as in standard operational amplifier practice.

J. F. ROULSTON,
Edinburgh.



Sensitive ± voltage trip

The gain of the amplifier can be varied widely by the potentiometer to produce a saturated output for a wide range of input voltages. Once tripped, the amplifier state is held by the feedback circuitry, until reset, providing the over-voltage has been reduced or removed.

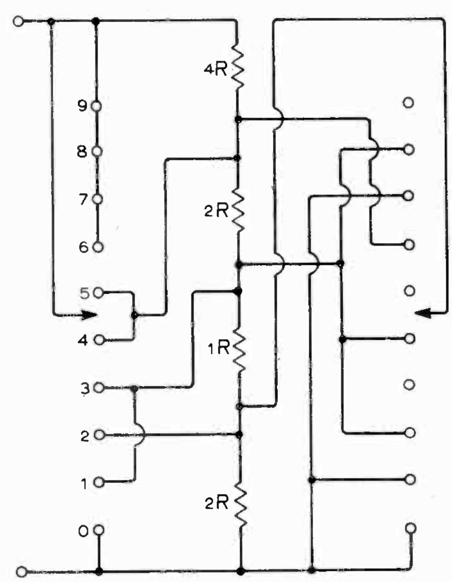


With components shown, the trip voltage ranged between ±50mV and ±5V. The max. and min. trip voltages are directly proportional to the input resistors. Both resistors must have the same value. The transistors may be powered from the same supply as the integrated circuit, and this supply need not be highly stabilized. The resistor in series with the relay coil is for current limiting, if necessary.

N. NICOLA,
Geneva.

Decades of resistance

The figure shows a way of obtaining decade resistance ranges, using only four resistors and a double-pole ten-



position switch. To obtain higher decades, resistors should be increased by powers of 10.

J. JOHNSTONE,
Hanley,
Stoke-on-Trent.

Loudspeaker Stereo Techniques

How to combine left and right signals and get the message from the medium

by E. J. Jordan

I think to start with it is pertinent to ask 'why stereo?'. As is often the case in the design of loudspeaker systems the primary aim may appear somewhat cloudy. One advantage of stereo is that two loudspeakers are sold instead of one, which is very much in the interests of many people. But what are the *performance* advantages of stereo reproduction? It may be suggested that lateral location of the various instruments or voices in music becomes possible, but on this point it is worth noting that one of the difficulties associated with concert hall design is to provide a sound stage which *minimizes* lateral spread, and such spacing as there is only comes about due to the problem of having to accommodate possibly 100 or more instruments (and many of them large) on the sound stage. Obviously they should not be too deeply ranked, otherwise the sounds from the front will mask those from the rear and there may also be a time delay problem. On the other hand it would be equally unsatisfactory to stretch an orchestra out in a horizontal line so that sounds came to us from widely different directions. Orchestral layout must aim to bring out the full quality of each individual instrument whilst maintaining a balanced harmonious whole.

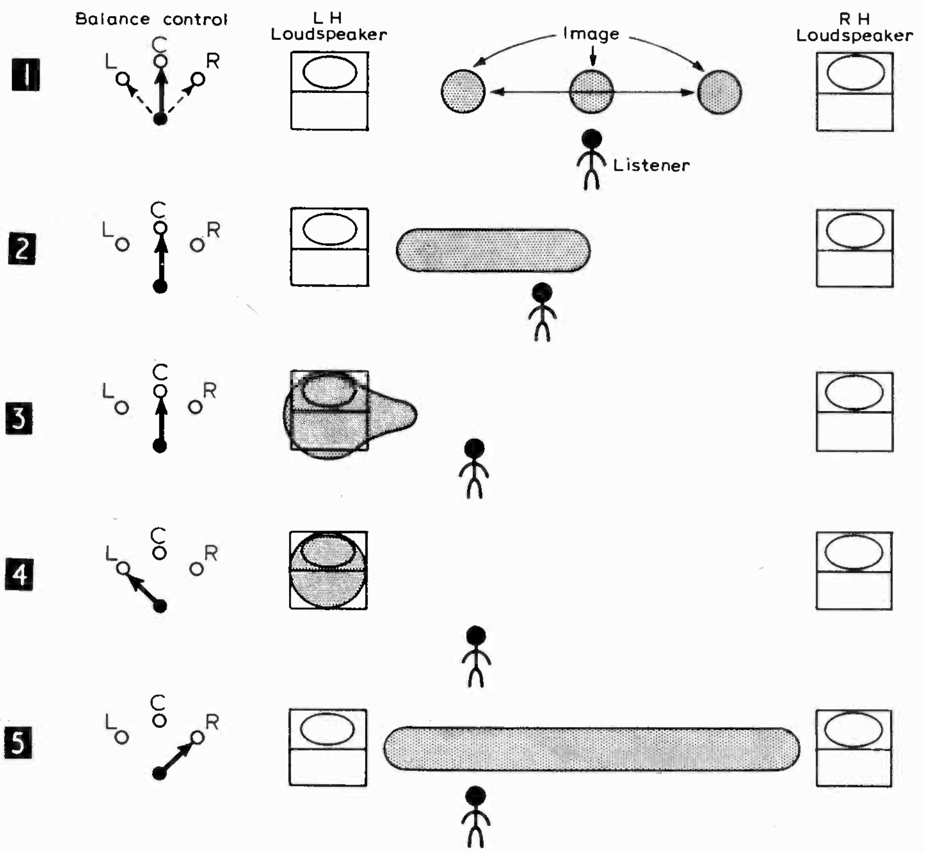
Having said this it is a double paradox that so often in stereo reproduction attempts are made to spread the sound out over the greatest possible width, whilst using conventional loudspeaker arrangements that are intrinsically incapable of doing this. It has become apparent to me that in so many aspects of sound reproduction, considerable time, money and effort are directed towards ends which are neither possible nor even desirable.

Certain types of programme, such as opera, can benefit from a wide sound stage, particularly where movement on the stage is to be portrayed; and this provides us with one advantage of stereo. However, the effective stage width must be appropriate to the programme and to the listening area. I personally do not like to hear a violin solo spread over the same area as the full chorus in *Aida*—or vice versa.

Which leads us to the second and more important performance advantage of stereo, which is to provide an appropriate sound stage: not to squirt sound from the left and right, but to provide a sound area commensurate with the programme. A single loudspeaker can do this adequately for an unaccompanied voice or small instrument provided that there is little reverberation. This situation normally only applies to news bulletins. For all other programme material good stereo provides a considerable enhancement of realism which cannot be secured merely by using two spaced loudspeakers in mono.

The reader will have appreciated by now that the advantages of stereo reproduction are purely subjective; accordingly this article is primarily a description of some of the many experiments that I and my colleagues have conducted over the past few years, and the observations made therefrom.

A third important advantage of stereo reproduction is that it separates the sounds of instruments playing together. Now I am not referring here to apparent physical separation in the sense of spreading apart but to the discrete identity of instruments, even when closely grouped, allowing the individual music lines to be heard more clearly. This is due to the fact that binaural hearing is far more selective than monaural when dealing with a multiplicity of sound sources. The dramatic demonstration of this is to listen to someone speaking in a noisy environment first using both ears normally and then with one ear covered. The immediate impression with one ear covered is that the wanted sound is being masked by the noise whereas the use of both ears results in a far higher degree of separation of the speaking voice and the other sounds, and higher definition.



Figs 1-5. Listening effects produced using two loudspeakers connected to a twin-channel amplifier switched to 'mono'. The positions of listener and balance control are varied.

To sum up then, stereo reproduction can offer the following performance advantages:

(1) the provision of an appropriate sound stage width;

(2) enhanced separation of sound detail; and

(3) the effect of sound source movement.

These are in what I consider to be their order of importance.

Throughout this article I shall only consider two-channel stereo. First, we are normally equipped with only two ears and can therefore deal with only two bits of audio information at any one instant. Secondly, any advantage of multi-channel stereo can be secured with two channels at less cost by improved loudspeaker techniques which will be discussed later. (The use of four channels to give reverberation effects is another matter entirely and will be dealt with in a subsequent article—the editor permitting.)

Basic arrangement

The simplest and almost universally adopted loudspeaker arrangement for stereo is the use of one loudspeaker for each channel positioned to the left and right of the required sound stage. Such a situation is shown in Figs. 1 to 5.

To study how these and other configurations work, two loudspeakers were connected to the left and right outputs of a stereo amplifier which was switched to the mono position. Each loudspeaker thus received the same signal which could be varied in relative intensity between the loudspeakers by varying the balance control from centre to half right and half left. For these tests the loudspeakers were placed face upwards to eliminate polar effects.

In Fig. 1 with the balance control central and the listener on the centre line facing forward, there is a sharply defined image straight in front of the listener. If the listener, however, swivels his head, the sound image will tend to move in the direction he is facing. (By shaking his head vigorously, he can shake the entire orchestra—rather like the effect with headphones. Returning now to the 'eyes front' condition and swinging the balance control, the image will retain its sharpness and move left or right accordingly. So far so good, we have a working stereo system—just so long as your head is held in a clamp.

Setting the balance control back to centre and moving the listener just off axis, has the effect shown in Fig. 2, where we see the centre image replaced by an extended sound area of indeterminate position between the nearest loudspeaker and the centre.

Moving the listener further off axis with the balance control still central gives the situation in Fig. 3 where most of the sound image is centred around the nearest loudspeaker with just a hint of pull to the centre. This is known as the Haas effect and also explains why two spaced loudspeakers in mono will not give an increase in the size of the sound stage. Keeping the listener in this position and moving the balance control half left (in this case) not surprisingly concentrates the image solidly around his nearest loudspeaker as in Fig. 4.

Moving the control half right, however (Fig. 5), produces a completely indeterminate image extending from one loudspeaker to the other.

It is obvious from these experiments that for any listener position other than forward-facing on céntre, the reproduction of a stereo signal by this system is quite unsatisfactory. It is appreciated that by gimmick recording techniques some sounds may emanate from the remote loudspeaker but the image in between the units will remain distorted.

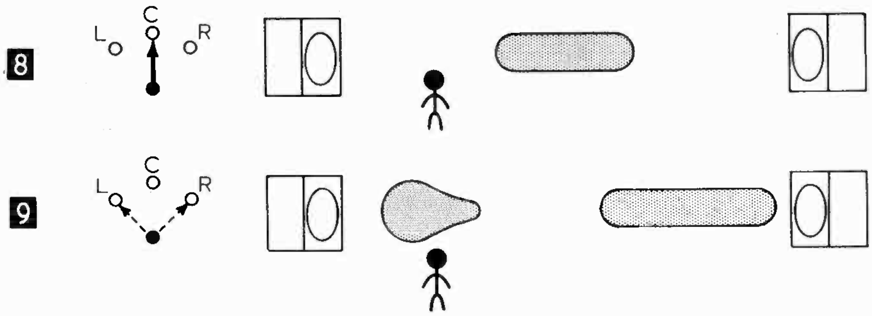
Improved results can be secured by the use of loudspeakers having forward polar lobes. The loudspeakers should not be highly directional and a very suitable characteristic would be to have a difference of about 6dB at 15kHz between the response on axis and 30° off axis. A frequency response curve of the preferred type is shown in Fig. 6. The optimum stereo results are secured when the axis of the polar lobes crosses *in front* of the main listening area (Fig. 7). If we now place our little man back in the centre of the listening area he will experience exactly the same situation as depicted in Fig. 1. In fact, this will be true for any symmetrical arrangement of identical loudspeaker systems. It is when our man moves off centre that the trouble starts, and what we are trying to do is establish a two-channel stereo system which will work for all listening positions.

With the loudspeakers arranged as in Fig. 7, and the balance set centrally, our off-centre man will observe a somewhat extended image but at least it will be situated more or less centrally (Fig. 8). (Compare with Fig. 3.)

If the balance control is swung half left a more sharply defined image will approach the left-hand loudspeaker. If it is swung half right our listener, still to the left, will 'observe' a broad image between centre and the right-hand speaker (Fig. 9). This is still far from ideal but nevertheless it is considerably better than the effects in Figs. 4 and 5.

An additional problem arises in the crossed polar system when broad images occur: there is apparent sound movement within the image which is frequency conscious, but this is usually the least disturbing problem.

A programme source in which there is considerable movement exposes a further drawback of the basic two-loudspeaker



Figs. 8 and 9. Images produced by the arrangement of Fig. 7 for an off-centre listener.

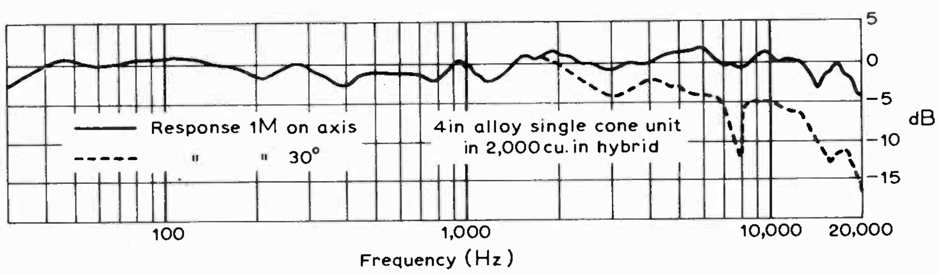


Fig. 6. The type of polar characteristic required for optimum stereo performance.

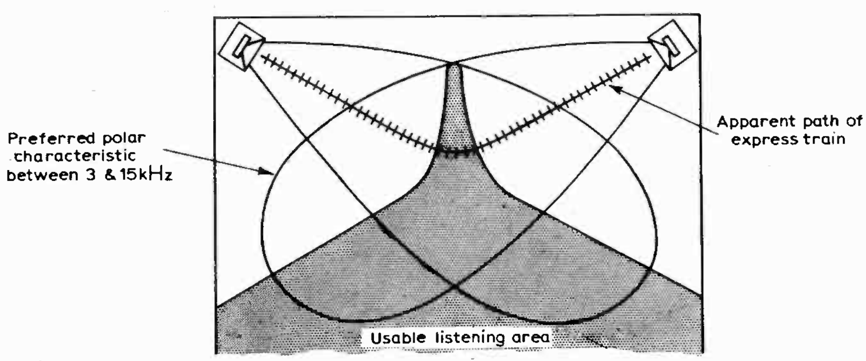


Fig. 7. The optimum stereo condition. The polar lobes cross in front of the main listening area.

arrangement and this can be illustrated by the use of one of the 'passing express train' types of recording. One assumes that the train did in fact go *straight* past the microphones in the first place but all arrangements similar to those described so far give the impression that the train passes on a curved track as indicated in Fig. 7.

It is thus theoretically possible to provide perfectly adequate stereo from two channels. However, the arrangements normally used can provide considerable image distortion. This can be minimized by optimizing the polar characteristics of the loudspeakers. If the loudspeakers tend to be either omni-directional or on the other hand extremely directional, then the image distortion may be so bad as to render the additional cost of stereo over mono quite unjustifiable.

Image distortion is also worsened by trying to achieve too wide a sound stage, i.e. having the loudspeakers too far apart relative to the listening position.

Centre loudspeaker system

I first encountered the use of a centre speaker many years ago demonstrated by Hugh Brittain. He had a large G.E.C. Periphonic system each side of a stage and a small forward-facing system in the middle. The middle speaker was fed with a sum signal from each channel attenuated by 20dB and could be switched in or out. Listening in the centre position it was barely possible to tell whether the middle speaker was on or off. Moving to the side with the centre speaker off produced the usual shift of the entire image to the nearest loudspeaker. Switching in the centre loudspeaker expanded the image right across the full width of the stage with good image location.

Fig. 10 illustrates our experiments on these lines. In this case the two side loudspeakers were turned inwards by an angle of about 30°. The centre unit faced upwards and was fed from both channels at full level. This resulted in an effective gentle top roll-off above about 3kHz. With the listener in his usual off-centre position and the balance at centre, an almost perfect central image was secured. With the control set half left or half right, fairly well defined images were secured in the appropriate positions. It was very refreshing to be able to walk across the full sound stage and find that all the images remain stationary and well formed. It was interesting to note that the passing express on this system went *straight*.

A game that two can play

A very entertaining evening can be spent if you get your hi-fi friend to bring his loudspeakers to your house. (Naturally his equipment is not quite up to your standards so he will only have bookshelf units.) Each of these is then connected, via very long leads, in parallel and in phase with your own systems. You can now play for hours with various juxta-positions of all four loudspeakers and the various effects obtained can be quite startling. You can 'do your thing' and get 'high' on a plasma of sound; and at the culmination you can shake your heads vigorously and splatter the sound all over the walls. (Marijuana has nothing on this.) Having settled down, however, the effects of placing the two 'visiting' loudspeakers in the centre back-to-back will bring about a remarkable improvement in the stereo effects. Quite seriously, these experiments are well worth trying.

An arrangement sometimes used on grounds of economy is a large centre speaker handling the bass of both channels with the middle and high frequencies handled by small left and right 'outrigger' units. But if the crossover frequency is too high or the crossover too sharp, the imagery will be distorted as in the case of the basic two-loudspeaker system and the bass will be disembodied.

Reflected stereo system

A variation of the centre loudspeaker technique which possesses certain additional advantages is the reflected system. The arrangement is shown in Fig. 11 where two loudspeaker systems are placed back-to-back facing two reflectors. It is necessary for the polar characteristics of the loudspeakers to be similar to those described for Fig. 7 and it must be stressed that the arrangement is not satisfactory with polar responses markedly different from these. The reflectors should be inclined inwards at an angle of about 60°. The surface of the reflectors should be as hard as possible, glass or Formica covered timber is ideal, and they must be substantially flat. Any attempt to broaden the coverage by curving the reflectors will destroy the stereo effect. The arrangement as described can provide full room coverage in any case. The spacing of the reflectors and their area is not critical. It can be seen from the diagram that due to the positions of the reflected loudspeaker images, the effective sound stage width is nearly double the actual distance between reflectors. A typical spacing between reflector and loudspeaker might be 3 to 4ft in which case the width of the listening area will be 6 to 8ft and the effective stage width 12 to 16ft. As a guide to reflector area, if the spacing is 3ft then the area should not be less than about 3ft² with the smallest dimension not less than 1ft. These figures are taken pro rata for other spacings.

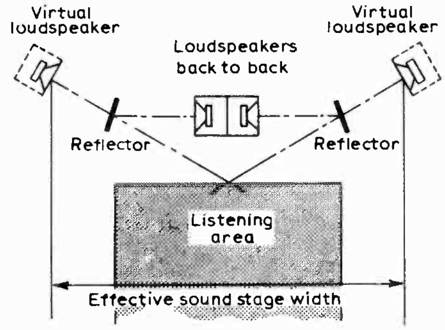


Fig. 11. A reflector system providing a virtual sound stage wider than the spaced reflectors.

The stereo performance of this arrangement is very good, being almost identical with that shown in Fig. 10. It has the additional advantage that only two loudspeakers are required. The cost of the reflectors is low and may be offset by the fact that one double enclosure may be used for the loudspeakers instead of two separate ones. In spite of the fact that all very low frequencies will be coming from the centre, this is not apparent when listening. The reflectors in any case will start to become operative only above about 200Hz. A considerable increase in extreme bass efficiency is provided by the mutual coupling between the units.

All in all this technique provides a neat, practical and economic solution to the problems of stereo reproduction. From the point of view of room décor the reflectors may be made appropriately decorative, fitted on simple stands and put away when not in use. The space between the reflectors and the loudspeakers may be used, provided no large object is placed in line of sight on the loudspeaker axis. A standard lamp, plants, coffee table or a small chair may be accommodated or even a bookcase, provided it does not project into the 'beam' of the system.

An integrated radiogram

Not long ago I conducted an interesting exercise to see if a fully integrated stereo hi-fi radiogram could be successfully made using the reflector technique. The carcass of the system was provided by two back-to-back double loudspeaker systems spaced about four feet apart. The enclosures were of the hybrid type and the tunnel structures extended across the four-foot space and formed 'girders' upon which the equipment was mounted. One of the obvious problems was to prevent feedback from the speakers to the pickup without overloading the excellent bass response. This was achieved by a mechanical filter upon which the entire record-player was mounted.

Full delay-line system

A delay-line system is costly but nevertheless represents, in my opinion, the most advanced loudspeaker system at present possible both in quality of reproduction and in stereo performance. In view of the degree of the design

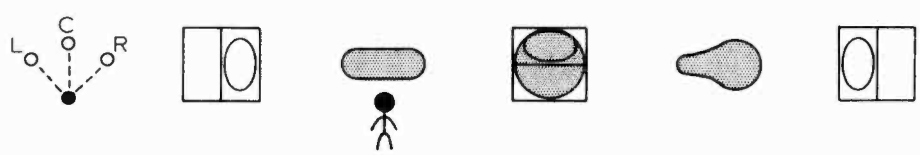


Fig. 10. Adding a centre speaker.

flexibility available, it is very desirable to design these systems individually to match the room in which they are to be used both aesthetically and acoustically. Basically the system comprises a continuous line of loudspeakers extending the full width of the required sound stage and the left and right channels are fed in at each end (Fig. 12). The loudspeakers are interconnected to form a delay line. The simplest arrangement is shown in Fig. 13. In practice, of course, provision has to be made for impedance matching. To make the continuity of the sound source as complete as possible the loudspeaker units should face upwards or downwards so that their axes are at 90° to the listener with the exception of the extreme end units which should face inwards. The effective polar response of these can be controlled by choice of delay components to optimize stereo performance. We naturally wish to avoid the hysteretic distortion normally associated with inductive crossover components and therefore only air cored inductors should be used and resistors if necessary. Development work on purely acoustic delay components is at present under way. Actual component values and the dimensions and layout of these systems are determined by the particular environmental requirements.

The stereo performance of the system is virtually perfect: well-defined images are produced which are precisely located and location remains quite independent of the position of the listener even if he stands at the end looking along the system. (To stand in this position with an express train rushing towards you is frighteningly realistic.) On the score of cost this would be in the region of £400 for a 10ft stage which does not make it the most expensive loudspeaker in the world by any means, especially when it is pointed out that this is only £200 per channel. It is interesting, therefore, to see how this system compares with others in this price bracket. I have already made my stand clear in the first of these articles regarding the advantages of the full-frequency range single-cone moving-coil approach over crossover systems, so we will not cover that ground again. We have just qualified the stereo performance as being vastly superior to basic two-speaker system techniques. So if we are going to pay £200 for a conventional loudspeaker, such as a large horn-loaded system, what in fact are we paying for? The answer and remaining consideration is power bandwidth. On this score it is worth noting that a 10ft delay-line system would have a very high efficiency at low frequencies (approaching 20 times that of a single cone unit) and would handle up to 300 watts input power. The available sound power would therefore be extremely high; of the order of one acoustic watt. This is about 500 times higher than the power required to reproduce a full symphony orchestra in a 2000 ft^3 lounge.

A delay-line system need not take up very much space. A convenient configuration might take the form of a 'shelf' approximately 15in. wide and 8in. deep, running along one wall. The top surface of the shelf would be free for use with most of the loudspeaker units mounted on the underside (Fig. 14). As we have already pointed out, the delay-line system allows great flexibility of design.

Reflector delay-line system

As we have seen, the use of reflectors can produce a very wide sound stage—wider than the room if required—and for this reason reflectors may be used in conjunction with a full delay system. Of more interest, perhaps, is the fact that with the use of reflectors the delay line may be shortened with only a small deterioration in stereo performance and a considerable reduction in cost. An arrangement which has been satisfactorily used is shown diagrammatically in Fig. 15. A system like this would cost basically about £180, or £90 per channel. The total power handling capacity would be 120W and the low-frequency efficiency would be well above average. The available low-frequency power would be 64 times that of a single unit or about 0.13 acoustic watts. Using a system like this in the library of a large country house, an effective sound stage of 40ft was readily achieved with good location throughout this area. It was wonderful for listening to grand opera.

Conclusions

I feel that the loudspeaker industry as a whole has shown insufficient regard for the requirement of stereo, whilst on the other hand some of the record companies have messed things up with multi-channel computerized gimickry. The result is a squirt to the left of us and a squirt to the right, with a muddled hubble bubble in the middle. (Tongue twisters please note.) *Given* an optimized polar characteristic and correct placement, the basic two-loudspeaker system will work sufficiently well to justify the additional cost. With very little additional effort these may be placed back-to-back in conjunction with reflectors to achieve a very marked improvement. If cost is not a primary consideration, then one of the delay line techniques may be used with or without reflectors to provide an ultimate in sound reproduction by today's standards.

A few times I have used the expression 'available sound-stage width', and to avoid confusion I should point out that there is no disadvantage in making this as wide as possible, provided the image location is good. In this case if the programme requires only a restricted stage, then this should be evident in the signal information and the programme material will restrict itself near to the centre of the available sound stage. Some programme material does benefit from a wide stage, in which case it is nice to have it available and to let the programme (by the grace of the recording engineer) determine its own width.

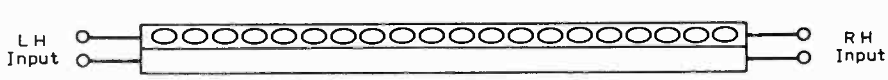


Fig. 12. A continuous line of speakers.

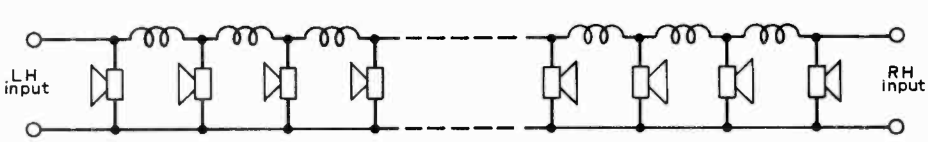


Fig. 13. Introducing delays to blend polar characteristics.

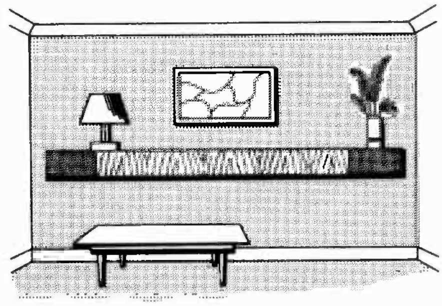


Fig. 14. Impression of how a full delay system might be fitted on a wall.

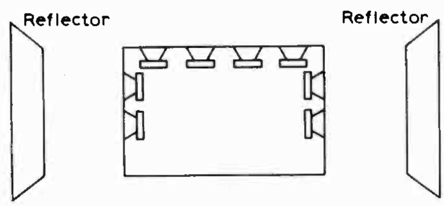


Fig. 15. A shortened delay line system also employing reflectors.

Printed-circuit Boards

Wireless World Colour TV Receiver. We are informed by D-B-S Electronics, The Parade, Cadnam, Hants, that they can supply printed-circuit boards for this receiver. One for part of the colour circuitry measures only 2¾ in. by 9¾ in. The layout is different from the original, but the board is drilled and the *R* and *C* numbers are marked on it.

Capacitor-discharge Ignition System. D. E. Bolton, of 61 Cuckmere Road, Seaford, Sussex, has produced printed-circuit boards for the capacitor-discharge ignition system designed by R. M. Marston and published in January 1970. Boards are available for both negative and positive earth versions at a cost of 25s (£1.25). This price includes postage, circuit diagrams, a list of components and suppliers, and practical construction tips.

Stereo Decoder using Sampling

A design using sample-and-hold techniques to obtain good channel separation, low distortion and low sub-carrier breakthrough

by D. E. O'N. Waddington, M.I.E.R.E.

Inspired by an article, "Synchronous detector uses switching techniques" by R. Glasgal published in *The Electronic Engineer* of April 1968, I have designed a new decoder circuit using sampling. This circuit has several significant advantages over my design of three years ago[1]: the sub-carrier filtering is far more efficient so that the breakthrough is negligible; it is very much easier to set up and far less critical (actually the number of pre-sets has been reduced from five to three); and the gain of the decoder is the same with either mono or stereo. This last is particularly important now that the B.B.C. sometimes broadcasts alternate stereo and mono items in the same programme.

Principle of operation

The starting point for the design lies, naturally enough, in the basic equation for the composite stereo signal. This may be given as

$$\text{instantaneous value } V_i = 0{\cdot}9\left[\frac{A+B}{2}+\frac{A-B}{2}\sin 2\,\omega t\right]+0{\cdot}1\sin\omega t$$

where
$\omega/2\pi$ = 19000 Hz
A = left audio-frequency signal
B = right audio-frequency signal.

For the purpose of this analysis this can be reduced to

$$V_i = \frac{A+B}{2}+\frac{A-B}{2}\sin 2\,\omega t$$
$$= \tfrac{1}{2}[A+B+(A-B)\sin 2\,\omega t].$$

If this equation is solved for the limiting values of $\sin 2\,\omega t$ (i.e. when $\sin 2\,\omega t = +1$ and $\sin 2\,\omega t = -1$ it will be seen that $V_i = A$ for the former and $V_i = B$ for the latter. Thus by sampling at the correct instants, theoretically, the A and B signals can be recovered with no cross-talk at all. This process is illustrated in Fig. 1. In practice it is not possible to take an infinitely narrow sample in exactly the correct phase. In order to estimate the effects of incorrect phasing, the equation can be solved for other values of $\sin 2\,\omega t$. The results of this calculation for values of $\sin 2\,\omega t$ between 60° and 120° is shown in Fig. 2. It will be seen that for a phase error of ±20°, the amount of unwanted signal will rise to 30 dB below the required signal. Thus it is not essential to set the phase exactly in order to obtain adequate channel separation. The effects of sampling period are more difficult to assess accurately but it is safe to assume that if the sample is less than 10°, sufficient channel separation will be obtained.

In order to implement this method of decoding, the following steps are necessary.

1. Extract the 19 kHz pilot tone from the composite signal.
2. Generate sampling pulses synchronized with and having the correct phase relationship to the incoming pilot tone.
3. Sample the multiplex signal.
4. Filter out the unwanted signal components.
5. Apply de-emphasis.

In practice it is necessary to use even more steps as examination of the block diagram, Fig. 3, will show. In particular, the sampling pulses are generated from a continuously running oscillator. This avoids the need to switch any circuits on or off when a stereo signal is

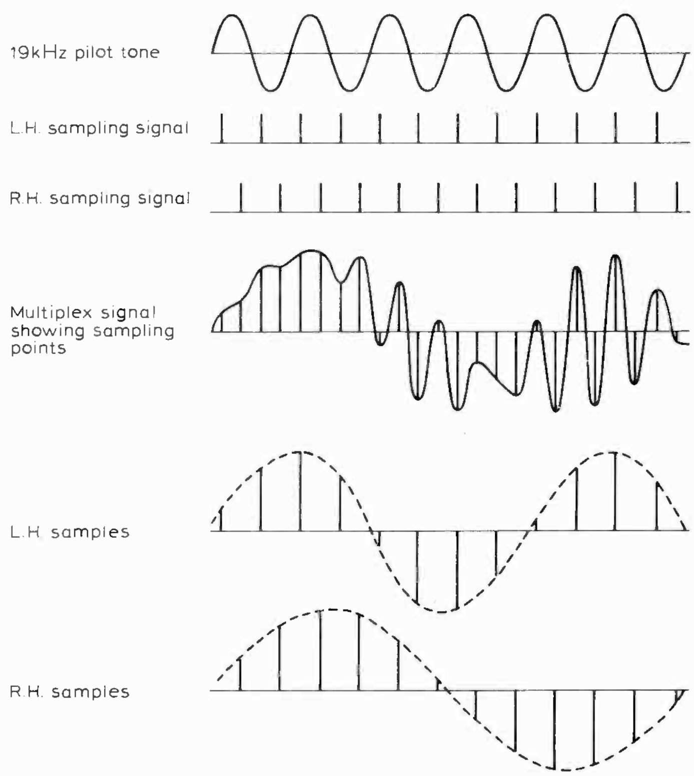


Fig. 1. Method of extracting the left- and right-hand channel information from the multiplex signal by sampling. Note: the pilot tone has been omitted from the multiplex signal for clarity.

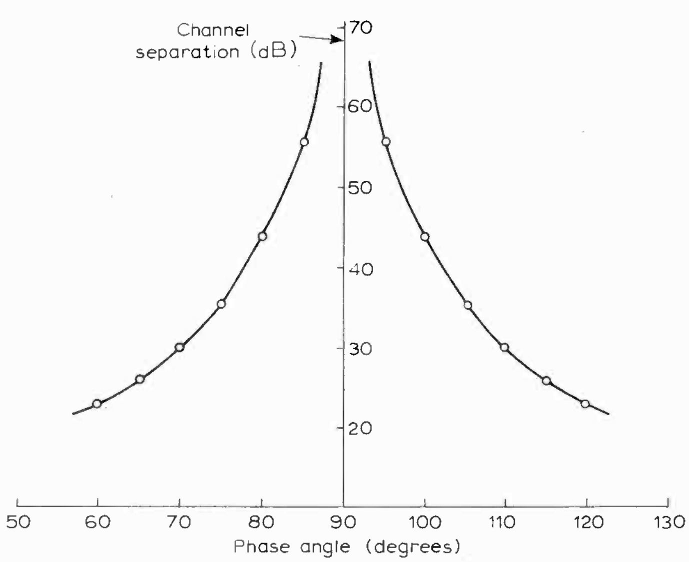


Fig. 2. Plot of channel separation plotted against sampling instant.

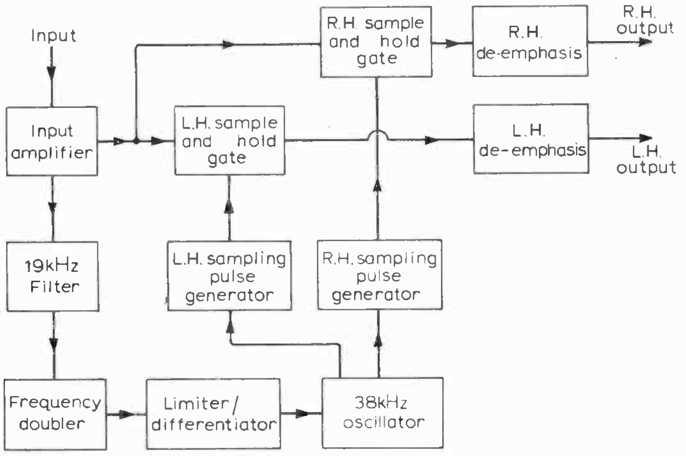


Fig. 3. Sampling decoder block diagram.

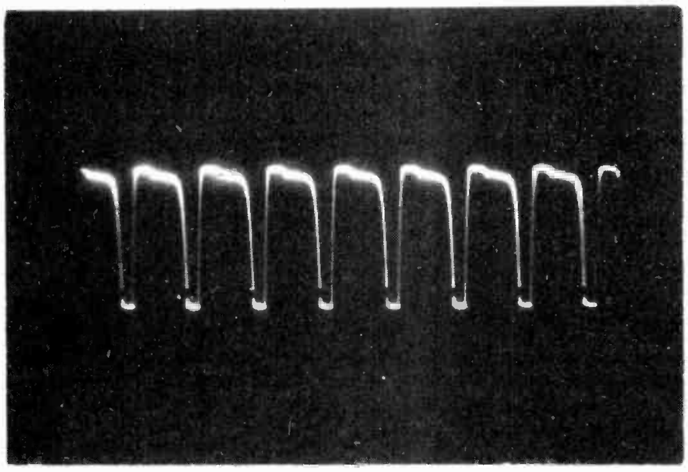


Fig. 4. Limiting amplifier output.

received and, incidentally, ensures that the gain is the same for stereo and mono. Another important change in the basic system is that the sampling gates are actually sample-and-hold gates so that the filtering requirement is satisfied by the de-emphasis networks.

Pilot-tone extractor and frequency doubler

When I started this design I thought that it would be much easier to construct if all coils could be eliminated. I therefore investigated the use of active filter networks with resistance/capacitance tuning. Although I produced working circuits, none of them was simple enough. The main trouble was that each tuned network needed at least two set-up controls, one for frequency adjustment and another for Q. Furthermore, the Q depends on amplifier gain (unless this is negligibly large) so that simple one or two transistor circuits are more or less ruled out. As a result of this investigation I decided to use a Q multiplier again. Thus, in Fig. 7, the signal at the output of the emitter follower Tr_1 is split so that the composite signal is fed to the sampling networks and the high-frequency components only are fed to the transformer T_1 which drives the Q multiplier stage Tr_2. The output from this stage is fed to the primary of the tuned transformer T_2. At the secondary of this transformer the 19 kHz pilot tone is full-wave rectified and applied to the base of Tr_3. As this stage has high gain it limits giving an output as shown in Fig. 4. This limited waveform is differentiated and used to lock the frequency of the free-running multivibrator Tr_5 and Tr_6.

Sampling pulse generation

While an infinitely narrow sampling pulse would be ideal, it is not strictly necessary, which is as well as it is not practical. However, it is quite practical to make the pulse duration 250 ns which is equivalent to 3·42° or approximately 1% of the period of one cycle of the sub-carrier. This gives adequate channel separation.

The method of generation is as follows. Just prior to the generation of a pulse, Tr_4 is bottomed, Tr_5 is switched off and C_{11} is charged to the supply voltage. Now, when Tr_5 bottoms (because of multivibrator action) the base of Tr_4 is taken negative by C_{11} and Tr_4 switches off so that the voltage at its collector goes to the positive line. C_{11} discharges through R_{13} and, when the voltage at the base of Tr_4 is sufficiently positive, Tr_4 bottoms once more and the voltage at its collector goes negative again. The width of this positive going pulse will be approximately 0·7 CR. This process is illustrated in Fig. 5. The sampling pulses for the other channel are generated in a similar way by Tr_6 and Tr_7.

Sampling gate

The simple sampling process shown in Fig. 1 would obviously contain a large proportion of high-frequency components and very little of the wanted signal. A better method is to use a sample-and-hold technique where the value of each sample is stored until the next one. This is shown in Fig. 6. It will be seen that the low-frequency component predominates and that very little high frequency is present.

This is implemented as follows (Fig. 7). The composite signal from the emitter follower Tr_1 is capacitively coupled to the sources of the f.e.ts. Tr_8 and Tr_9 and referenced via R_4 to the positive line. Normally the f.e.ts. are held in the off or high impedance condition as their gates are connected directly to the collectors of the normally bottomed transistors Tr_4 and Tr_7. When a sampling pulse is generated by Tr_4, the voltage at the gate of Tr_8 will go to the positive line switching the f.e.t. to its low impedance condition thus allowing C_{12} to charge to the voltage at the source of the f.e.t. As the $R_{DS_{on}}$ of the f.e.t. will be less than 500 Ω the charging CR will be less than $33 \times 10^{-12} \times 500 = 16{\cdot}5$ ns. That is, it will be less than 10% of the sampling pulse width so that the voltage across C_{12} at the completion of the sampling period will equal that at the source of the f.e.t. to within less than 1%. When the f.e.t. is switched off, C_{12} will start to discharge through R_{24}. The discharge time-constant is $10 \times 33 \times 10^{-6} = 330$ μs. Hence C_{12} will not have discharged by more than 6% before the next sample. Thus the output waveform will consist of a series of steps. In order not to add to the load across the 10 MΩ resistor R_{24}, the output is taken via a source follower Tr_{10} to the de-emphasis network. The sampling action is similar for the other channel.

Setting up

The effectiveness of the decoder in separating the left- and right-hand channels depends, naturally enough, on the accuracy with which it

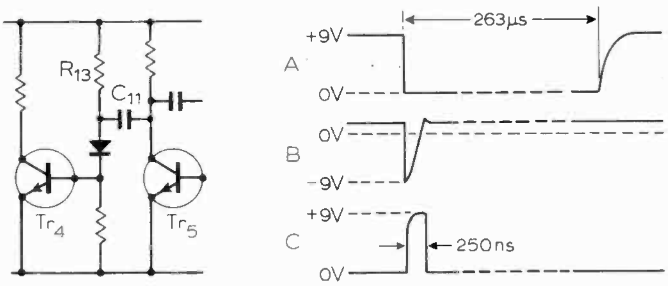


Fig. 5. Formation of sampling pulses.

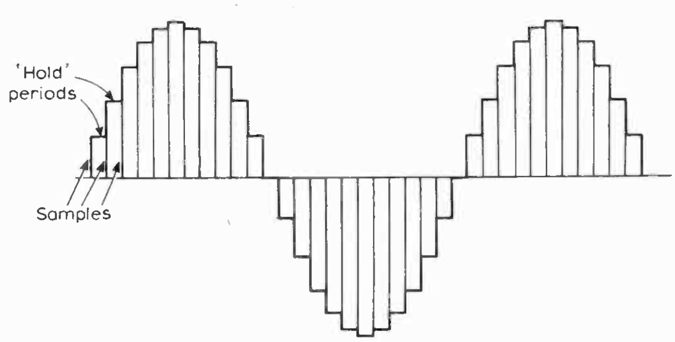


Fig. 6. Sample-and-hold technique. The samples are stored on the capacitors C_{12} and C_{17} which are charged or discharged according to the values of the samples by Tr_8 and Tr_9.

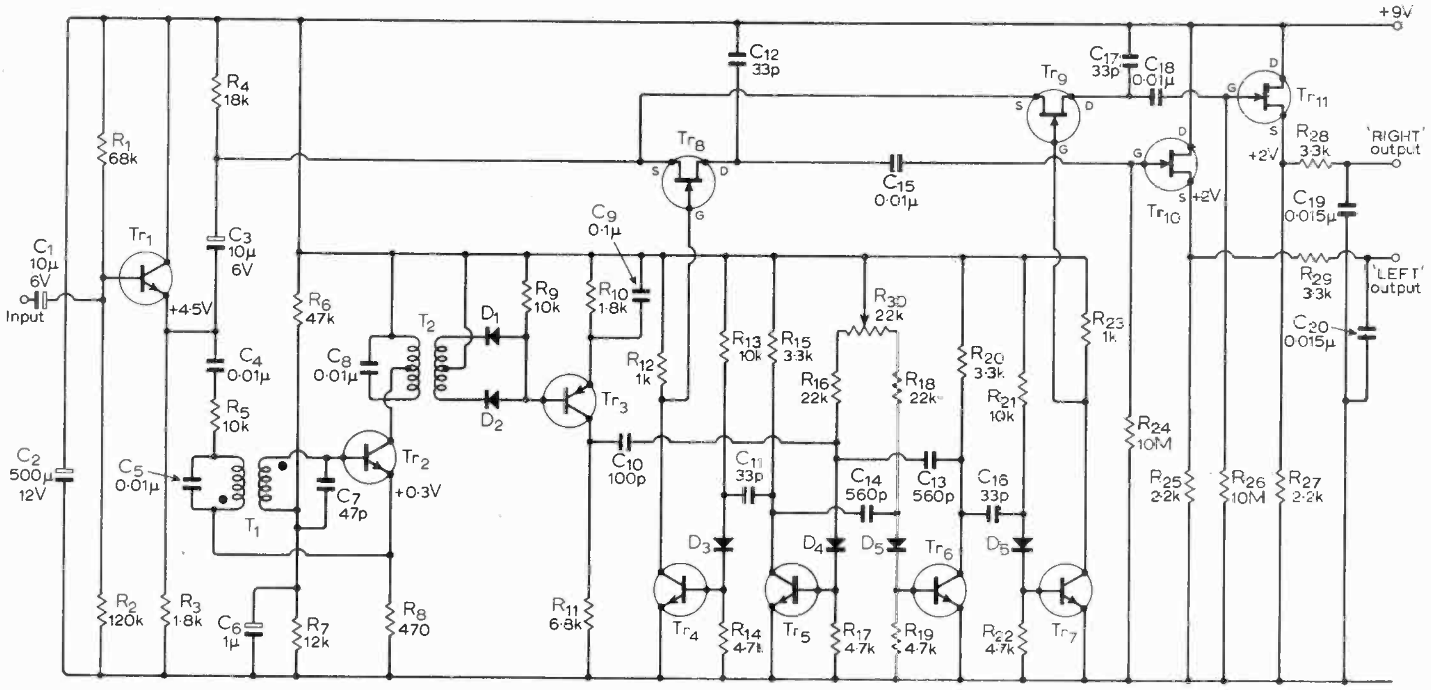


Fig. 7. Circuit diagram of complete decoder. Transistor types: Tr_1 BC108, 2N929; Tr_2 BC109, 2N930; Tr_3 BCY72, 2N3702; Tr_{4-7} BSX20, 2N2369; Tr_{8-11} BF244b, 2N3819, MPF105, UC714, BFW10.

and the receiver with which it is to be used have been set up. The setting up consists of two separate parts—

1. tuning the receiver for correct bandwidth and optimum phase response
2. tuning the pilot tone extraction circuits and adjusting the phase of the sampling circuits for best channel separation.

Receiver adjustment

This has been put first because no decoder can give good performance with a poorly adjusted receiver and also, the stereo signal which will then be available can be used to set up the decoder.

For stereo reception the receiver not only needs adequate bandwidth (360 kHz approximately) but it must also have a reasonable phase response. The bandwidth can be checked using an ordinary signal generator but measurement of the phase response really requires more complicated test gear. Fortunately the effects of poor phase response can easily be seen on an oscilloscope so that the following procedure can be used.

1. Disconnect the de-emphasis network from the output of the discriminator. (This network will not be needed again as de-emphasis is included in the decoder.)
2. Connect the *Y* input of an oscilloscope to the output of the discriminator.
3. Tune in a signal modulated with a stereo signal with information in the left-hand channel only. If the receiver has a.f.c. be sure to switch this off while tuning and to switch it on again only after the signal has been tuned in correctly.
4. Examine the output from the discriminator on the oscilloscope. It should appear as shown in Fig. 8(a). If necessary, adjust the tuning of each i.f. transformer *slightly* to improve the oscillogram. Be careful not to overdo the adjustment as excessive de-tuning will reduce the sensitivity of the receiver.

Note. To date, none of the published circuits for f.m. tuners using untuned intermediate frequency amplifiers and pulse counting discriminators is suitable for stereo reception. Even the circuit using double conversion to give a 300 kHz untuned second i.f.* has its problems. I have found it necessary to decouple the supplies to the discriminator section carefully and to include extra low-pass

*E. D. Frost, "Pulse-counting F.M. Tuner", *Wireless World*, Dec. 1965.

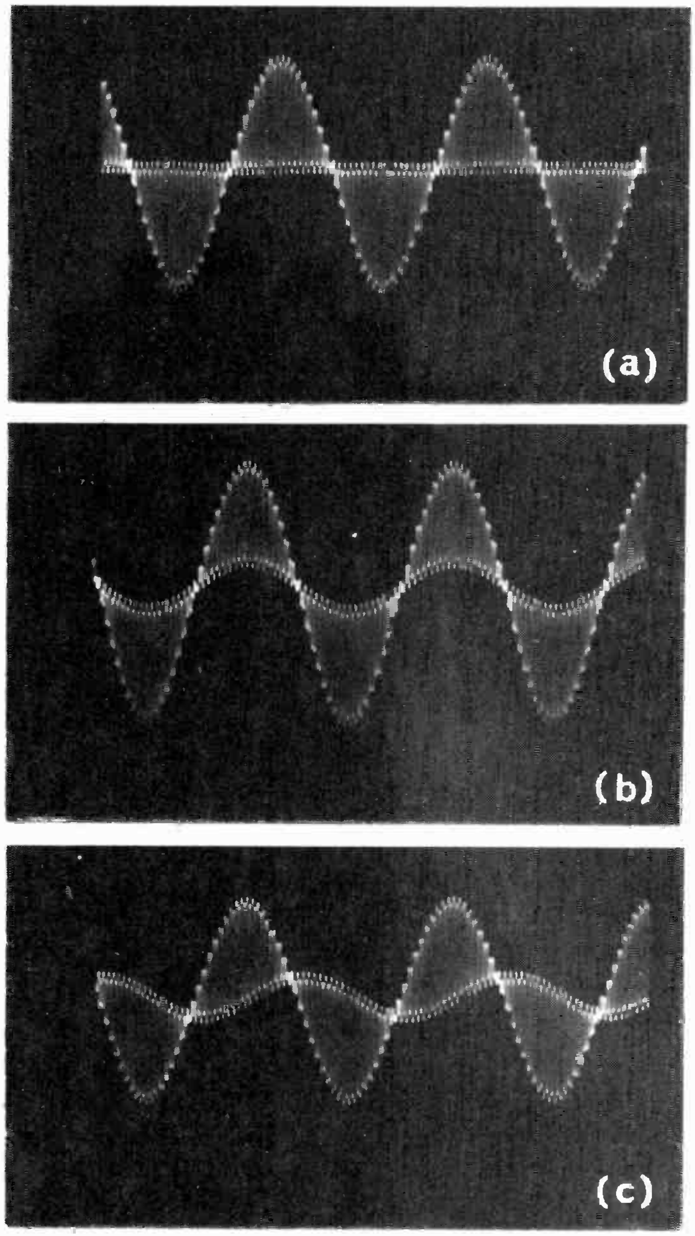


Fig. 8. Output from the discriminator of an f.m. tuner with (a) i.f. amplifier correctly tuned, (b) inadequate bandwidth, and (c) poor phase response.

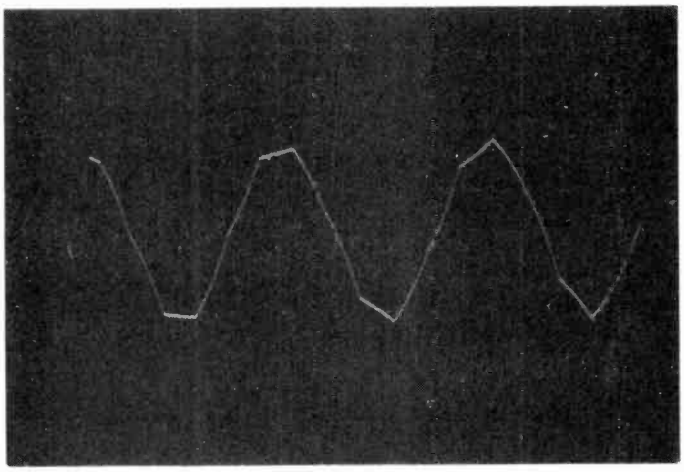


Fig. 9. Output at 5 kHz. This picture is obtained only if the input frequency is coherent with the sub-carrier.

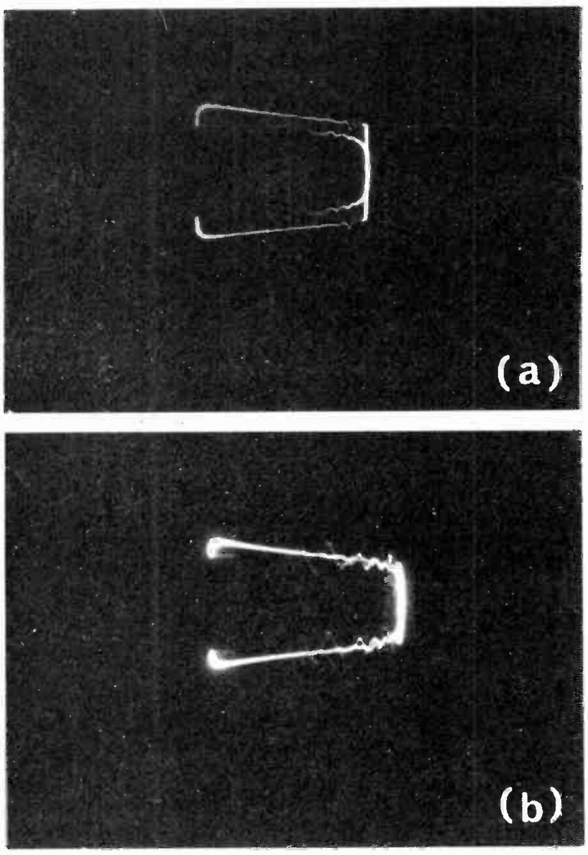


Fig. 10. Phase adjustment Lissajous figures. (a) 40 dB channel separation, (b) 30 dB channel separation.

filtering to prevent residual i.f. components from beating with the 38 kHz sub-carrier giving rise to "birdies" and consequent distortion.

Decoder adjustment

Before starting to set up the decoder it is as well to check if there is a reasonable hope that it will work. This can be done as follows.

Connect the circuit to a 9 V supply. Apply a 5 kHz, or thereabouts, sine-wave having an amplitude of about 100 mV r.m.s. to the input of the decoder. The signals at the two outputs should each be less in amplitude by about 9 dB than the input and should appear as stepped waveforms (see Fig. 9). If this is correct, it indicates that the input-output circuits, the sampling pulse generator, and the sampling gates are working.

Having ascertained that the decoder will pass a mono signal, the next step is to set up the pilot tone extraction circuits. To do this, it is desirable to have an accurate 19 kHz source as well as a stereo signal. However, the decoder can be set up if either is available.

Using an accurate 19 kHz source

1. Connect the 19 kHz source to the input of the decoder and monitor the output of the Q multiplier at the collector of Tr_2 using an oscilloscope.
2. Keeping the 19 kHz input as low as possible consistent with obtaining an adequate picture, adjust the core of T_1 for maximum output.
3. Transfer the oscilloscope input connection to the junction of the secondary of T_2 and D_1.
4. Adjust the core of T_2 for maximum output. Again keep the input level as low as possible.
5. Connect the oscilloscope input to the collector of Tr_6 and note that as the input is increased above about 5 mV, the squarewave 'locks on'.
6. With this 'locked' condition, adjust R_{30} so that this squarewave has a 1:1 mark-to-space ratio.
7. With a 19 kHz input of 10 mV, connect the Y input of the oscilloscope to the input and the X input to the collector of Tr_6.
8. Adjust the core of T_2 to give the Lissajous figureshown in Fig. 10.

A decoder set up in this way should give a channel separation of better than 30 dB.

Using a receiver tuned to a stereo signal

Any stereo signal can be used for steps 1 to 7 as only the 19 kHz pilot tone is used but for setting the channel separation (steps 8 and 9) it is essential that the 'left channel only' signal should be used.

1. Connect the output of the discriminator to the input of the decoder using a potentiometer as shown in Fig. 11.
2. Monitor the output of the Q multiplier at the collector of Tr_2 using an oscilloscope.
3. Keeping the input level as low as possible, consistent with obtaining an adequate picture, adjust the core of T_1 for maximum output.
4. Transfer the oscilloscope input connection to the junction of the secondary of T_2 and D_1.
5. Adjust the core of T_2 for maximum output. Again keep the input level as low as possible.
6. Connect the output of the discriminator directly to the decoder. (Note: The pilot tone level should be between 10 and 30 mV for best results.)
7. Monitor the waveform at the collector of Tr_6 using an oscilloscope and adjust R_{32} so that the waveform seen has a 1:1 mark/space ratio.
8. Tune in the 'left only' signal and monitor the 'right' output on the oscilloscope.
9. Adjust the core of T_2 for minimum signal.

Set up in this way, the decoder should give a channel separation of at least 30 dB.

Performance

Tests were carried out on the decoder to assess its frequency response, distortion, and channel separation.

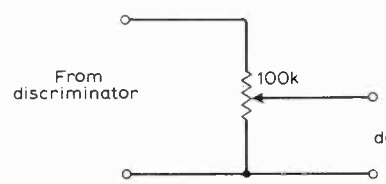


Fig. 11. Method of connecting the discriminator output to the decoder for setting up purposes.

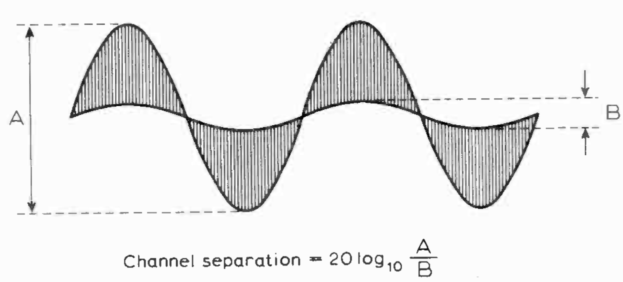


Fig. 12. Oscilloscope method of measuring channel separation.

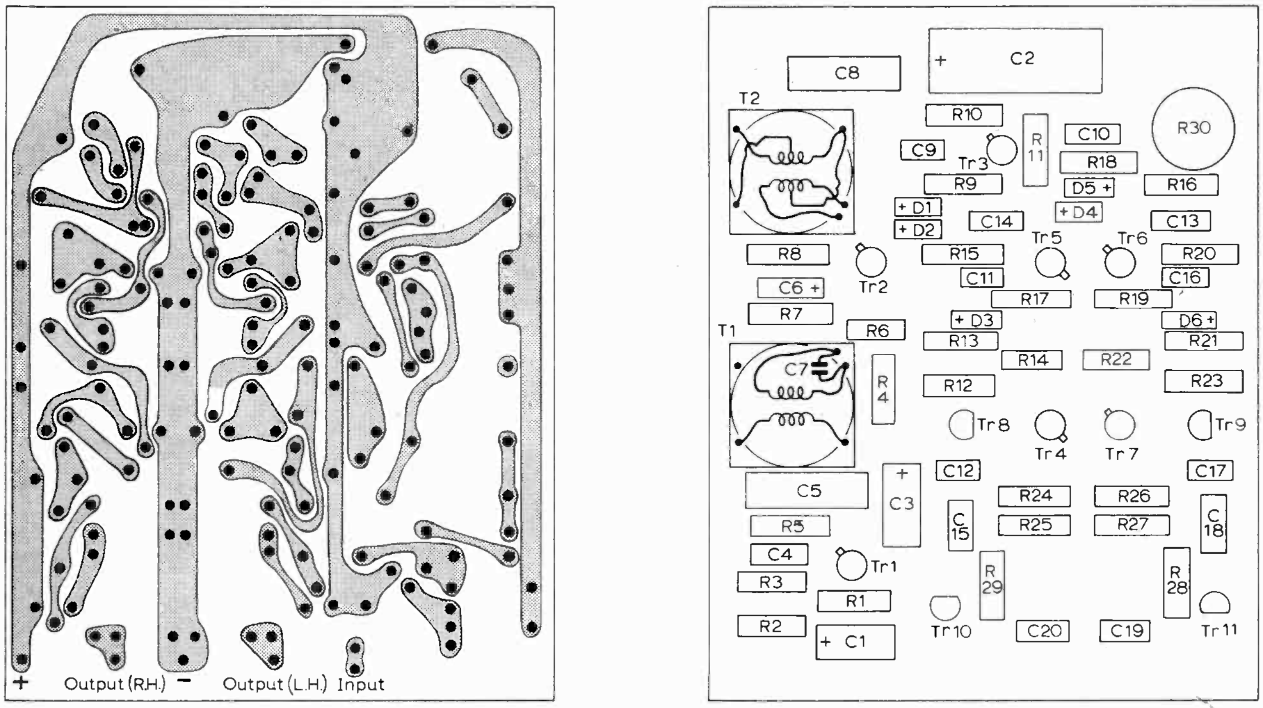


Fig. 13. Printed circuit layout.

No noise measurements were made because the sub-carrier leakage would make them meaningless.

The frequency response follows the standard 50 μs de-emphasis characteristic quite closely. How closely will depend, naturally enough, on the accuracy of the components used.

As no low-distortion stereo generator was available, the tests were done using a simulated signal consisting of 10 mV of 19 kHz, linearly added to the output of a low-distortion oscillator. (Marconi Instruments T.F.2005 was used for this as it adds two low-distortion signals with less than 0·0005% intermodulation.) The results of the tests are summarized in Table 1. As intermodulation between the 19 kHz pilot and the upper audio frequency signal components can occur, some measurements were made to assess their importance. The spurious outputs due to this were less than 0·3% second order from 11 to 15 kHz while the third order components could not be found.

The problem of accurate measurement of channel separation was also aggravated by lack of guaranteed test gear. It was possible to set up the stereo simulator[2] so that it gave a channel separation, measured as shown in Fig. 12, of better than 40 dB. When this signal was used to check the decoder a separation of 46 dB was obtained! While this figure is not completely reliable, it does give an indication of the performance which can be obtained. The sensitivity of channel separation to pilot tone level was also checked and it was found that, with the separation set to 40 dB with a pilot level of 20 mV, the separation deteriorated to 30 dB when the pilot level was halved. The Lissajous figures corresponding to this change are shown in Fig. 10. These results are more than adequate for normal listening.

Practical notes

The layout of this circuit is generally non-critical although the lead lengths in the sampling section should be kept short. A suitable printed circuit layout is shown in Fig. 13.

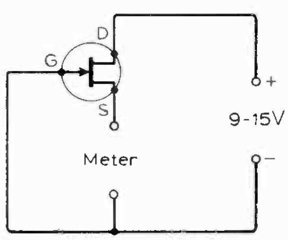


Fig. 14. Test circuit for f.e.t. Note: meter resistance should be greater than 100 kΩ.

Table 1

level (mV)	frequency f	2 f	3 f	4 f	19 kHz	38 kHz
30	1 kHz	0·6%	0·05%	0·04%	0·2%	0·09%
100	1 kHz	0·2%	0·01%	—	0·25%	0·2%
100	10 kHz	0·4%	0·01%	—	0·25%	0·2%

Table 2

Mullard		primary	secondary	wire gauge
LA 2517 LA 2532	T_1 T_2	112 t 112 t tapped at 56 t	116 t 112 t tapped at 56 t	36 s.w.g. enam.
LA 2500 LA 2534	T_1 T_2	139 t 140 t tapped at 70 t	144 t 140 t tapped at 70 t	36/37 s.w.g. enam. 36/37 s.w.g. enam.
LA 2501 LA 2536	T_1 T_2	176 t 176 t tapped at 88 t	182 t 176 t tapped at 88 t	38 s.w.g. enam.
LA 2502	T_1 T_2	222 t 222 t tapped at 111 t	230 t 222 t tapped at 111 t	39 s.w.g. enam.

In general the semiconductors used are readily available types. However, the output f.e.ts. could pose a problem if their V_p is too low. Preferably the V_p should be greater than 2 V so, unless a BF 244 B is used, it is as well to check this parameter. The method is quite simple. Connect the f.e.t. in the circuit shown in Fig. 14. The meter will indicate V_p to a sufficient degree of accuracy for this circuit.

One of the problem areas can be the coils, particularly if they are wound by hand, as there is a possibility that they will not have the exact inductance. This can make tuning difficult. However, the performance of the decoder does not depend critically on the *L/C* ratio, so it is permissible to pad the values of C_5 and C_7 to enable them to tune. Care must be taken that the directions of the windings of T_1 are correct or the *Q* multiplier will not work. Table 2 gives a list of various suitable ferrite cores with the appropriate winding information.

References

1. D. E. O'N. Waddington: "A Stereo Decoder", *Wireless World*, Jan. 1967.
2. D. E. O'N. Waddington: "Stereo Signal Simulator", *Wireless World*, Oct. 1967.

A reprint of these two articles is available, price 3s, from The Publisher, Dorset House, Stamford Street, London S.E.1.

Elements of Linear Microcircuits

5: Everyday uses of monolithic operational amplifiers

by T. D. Towers, M.B.E., M.A.*

By now you should have realised that a monolithic op-amp is really a 'gain block' of electronic amplification that, because of its low cost, is set fair to displace discrete transistors far outside the analogue computer field for which it was originally designed.

In this article we will pass over the use of op-amps for the mathematical operations of addition, subtraction, integration, differentiation, level sensing, etc. that form the basis of analogue computers and instead we will take a look at how designers are using them in more mundane circuits.

D.C. amplifiers

Although most run-of-the-mill circuits tend to be a.c., we will start with d.c. amplifiers, because much d.c. circuitry carries over readily from analogue computers.

Most op-amps have two inputs and at least one output. This is shown in diagrams by the symbol for an op-amp (a triangle on its side) having '−' and '+' inputs on the left and an output on the right (as in Fig.1). The + input signal appears amplified at the output without phase inversion, and this input is therefore known as a 'non-inverting' input. A signal applied to the − input is amplified to the same extent as a signal at the + input, but appears at the output 180° out of phase with the input. Therefore the − input is known as the 'inverting' input.

You will find in Fig.1(a) the basic 'resistance ratio' inverted configuration of the op-amp. In this the voltage gain is the ratio of the feedback resistance R_2 to the input resistance R_1. The op-amp input terminals are at virtual earth. This means that the input resistance of the inverted circuit is equal to the series resistance R_1. This fact can lead to complications where you want high input resistance combined with high gain. If R_1 is large, then for a high gain, A_v, the feedback resistance = $A_v \times R_1$ can become impracticably large. Designers can then adopt the modified circuit of Fig.1 (b). In this, high gain can be achieved along with high input resistance. It uses a lower value of R_2 to get part of the required total gain. The rest arises from the potentiometer, R_4, R_3

* Newmarket Transistors Ltd.

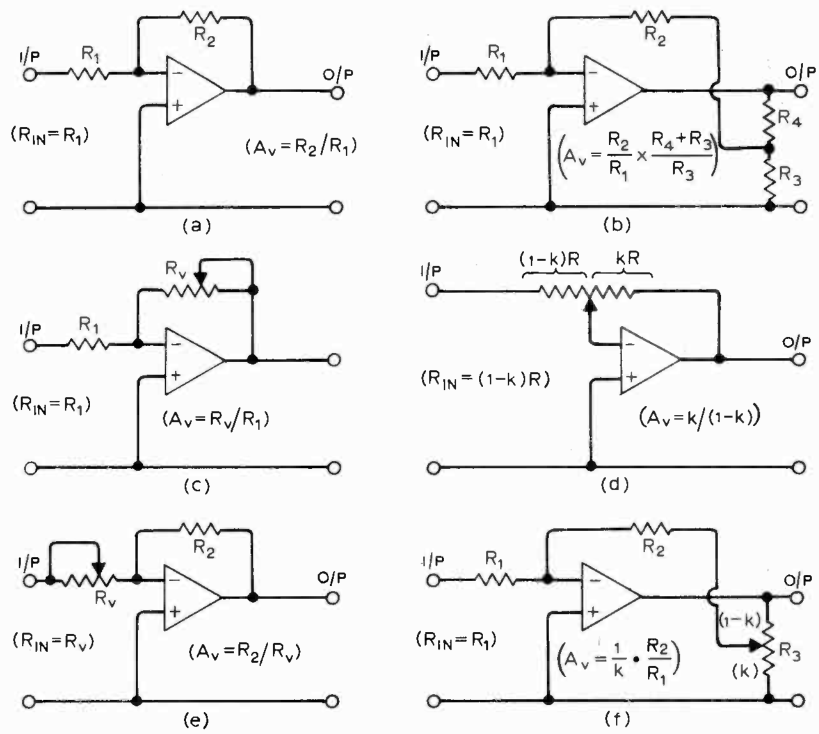


Fig. 1. The op-amp 'inverted' configuration; (a) 'standard' fixed gain arrangement; (b) modification for high gain without unduly low imput resistance; (c) gain control by varying feedback resistance only; (d) varying feedback and input resistance together; (e) varying input resistance only; (f) varying proportion of output applied to feedback network.

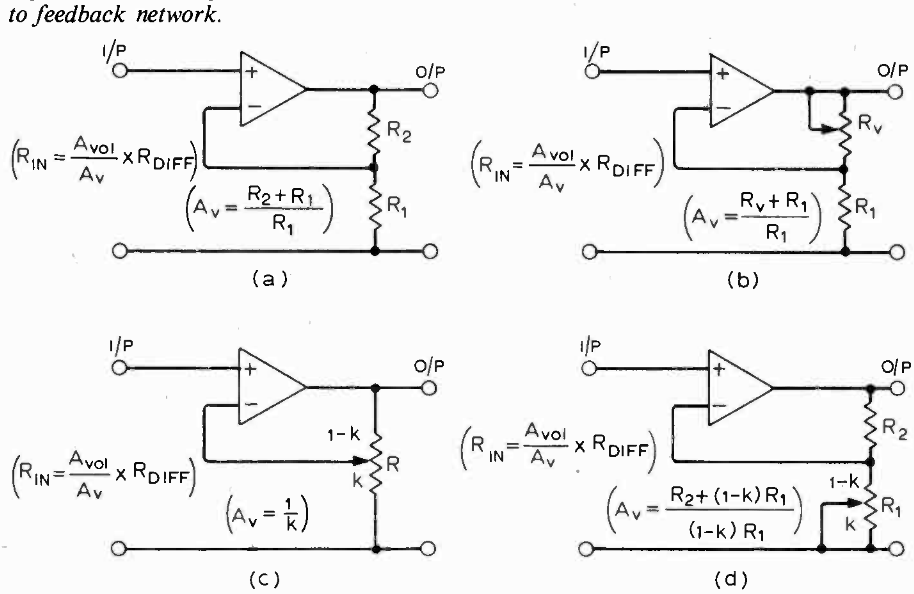


Fig. 2. The op-amp 'non-inverted' configuration; (a) fixed gain 'standard' arrangement; (b) gain control by varying output feedback resistance only; (c) varying feedback and 'fedback' resistance together; (d) varying 'fedback' resistance only.

across the output, which reduces the proportion of the output fed back into the feedback network.

The resistance-ratio inverted configuration gives a very tightly controlled fixed gain. However, many circuits call for adjustable gain, and Figs. 1(c) to (f) show arrangements that can be adopted for variable gain with an inverted op-amp.

In Fig. 1(c) the feedback resistance R_2 of Fig. 1(a) is replaced by a variable resistance R_v. This has the advantage that the input resistance is not affected by the gain setting, but also the disadvantage that the variable resistance is very sensitive to hum and noise pick-up.

Fig. 1(d) shows an arrangement used to give more flexible gain variation. Here the feedback and input resistances are combined in one potentiometer, and the setting of the potentiometer slider adjusts the gain. With an ideal op-amp the gain could be varied in this way from zero to infinity, but of course this is not possible in practice. Fig. 1(d) has the defect that the input resistance of the circuit varies widely with the setting of the gain control. Also the rate of control is highly non-linear.

Fig. 1(e) is another variant sometimes found in which the feedback resistor is kept constant and only the input resistance R_v varied. Here the gain is inversely proportional to the resistance of the variable resistance and the circuit input resistance varies with the gain setting.

A final variable-gain circuit in which the feedback and input resistors are not altered is given in Fig. 1(f). Here, the gain is set by a potentiometer across the output which varies the proportion of the output allowed into the feedback network. It has the big advantage that the variable element is across the output (a low impedance part of the circuit), and is buffered by the feedback resistor from the input virtual earths which are very sensitive to noise and pick-up.

Fig. 2(a) shows the standard fixed gain resistance-ratio non-inverted configuration for the monolithic op-amp. This arrangement has the big advantage compared with the inverted configuration that the input resistance is high, being roughly equal to the op-amp's differential input resistance multiplied by the 'loop gain'. Loop gain being the ratio of the op-amp's intrinsic (open loop) gain to the gain with feedback. This configuration is therefore widely used when high input impedance is important.

Gain variation in the non-inverted configuration can be achieved in a number of ways. Fig. 2(b) shows the 'top' feedback resistor being varied. Fig. 2(c) shows both the feedback and 'fedback' resistors being varied. Fig. 2(d) achieves gain control by varying only the 'fedback' resistor. Each arrangement has its own advantages and disadvantages. The formulae for input resistance and voltage gain appropriate to each arrangement are noted on the circuit diagram. Inspection of these will show which element it is best to vary for your particular problem.

If you want to measure accurately d.c. voltages much below 1V where ordinary meters run out, you will find the inverting configuration of an op-amp widely used. Provided the voltage being measured has a low source impedance, a resistance ratio of up to 100:1 can be used to bring the measured voltage up to the level at which it can be read accurately on a meter. Fig. 3(a) gives a typical practical circuit for measuring 2.5mV d.c. full scale on the 50μ. A range of an Avometer.

The monolithic op-amp also proves very valuable for measuring low d.c. currents. When you want to measure currents substantially less than the 50μ. A full-scale of readily available meters, you can feed the current through a small resistor and measure the resulting d.c. voltage drop. Fig. 3 (b) is just such a practical circuit for measuring 1μ A d.c. full scale with a 50μ A meter.

The monolithic op-amp can readily provide a constant-voltage reference source. Typical of such applications is the circuit of Fig. 3(c) which permits the precise voltage from a zener diode to be adjusted upwards to some other precise voltage.

When you have played around with op-amps for a while, you will discover many useful d.c. circuits. They are, for example, peculiarly suited to such arrangements as the logarithmic amplifier

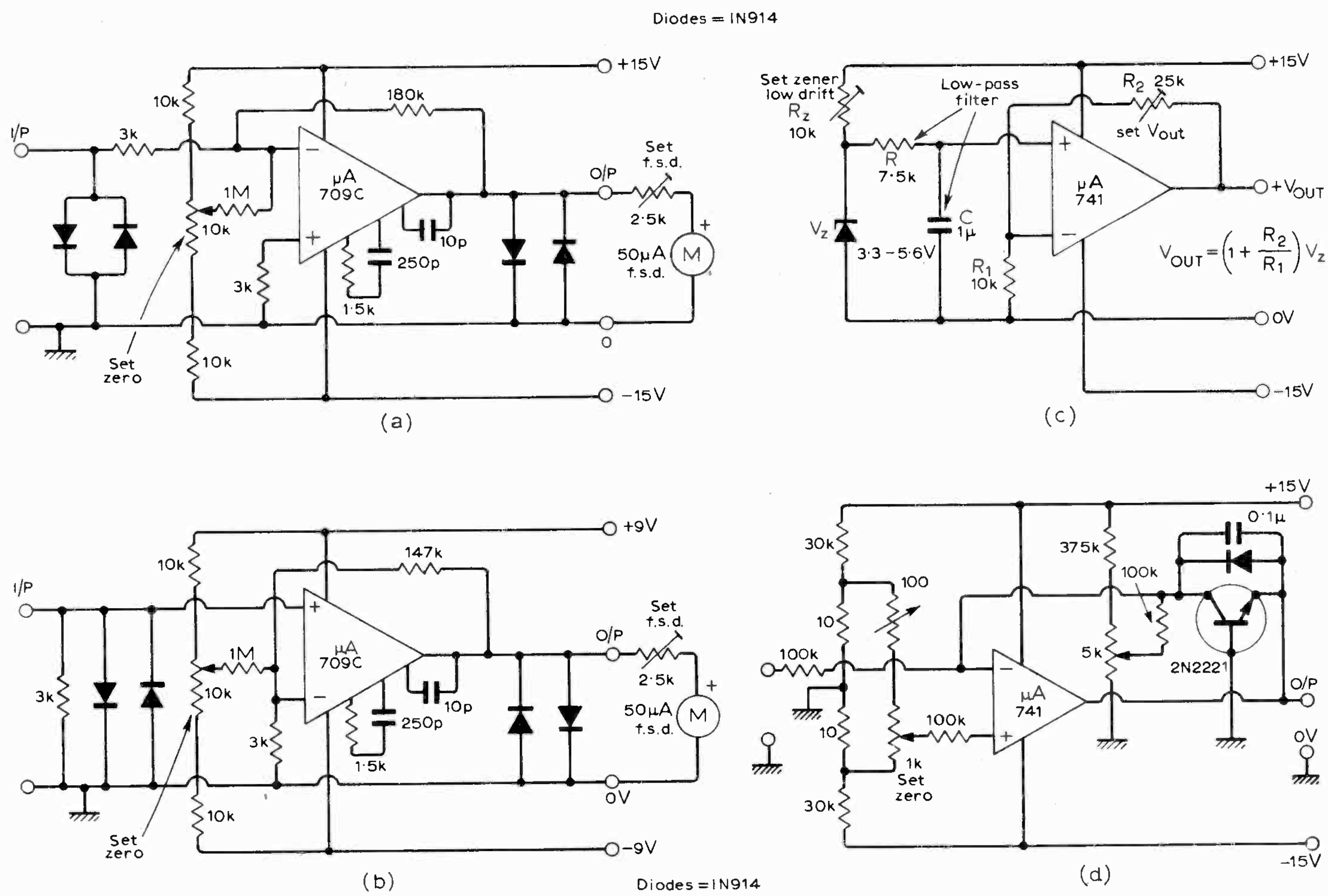


Fig. 3. Some useful op-amp d.c. circuits; (a) amplifier to give 2.5mV d.c. full scale on 50μA range of an Avometer; (b) amplifier for 1μA d.c. full scale with Avometer; (c) adjustable zener reference voltage; (d) logarithmic amplifier.

shown in Fig.3(d). This has the property of rapid variation around zero and logarithmic fall off in gain for higher signal levels. This makes it most useful as a null detector.

Most of the circuitry discussed above is expressed in terms of neat little op-amps with only two input terminals and an output-terminal. Real op-amps have other characteristics needing more components which make practical circuitry much less simple looking.

Firstly it should not be overlooked that the op-amp is not merely a d.c. amplifier but a d.c. to 1MHz amplifier. For d.c. use it is essential that compensation of some sort is applied in the circuit to prevent oscillation. It is impossible to give any simple rules of thumb on applying compensation networks to commercial op-amps because they often have different compensation terminals and networks. Get hold of the data sheet for the device you propose to use. Study it with care and follow closely the recommendations of the manufacturers on the *C* and *R* networks to be connected to the various terminals to prevent instability.

The other thing that is missing in most diagrams discussing op-amp uses is any indication of the d.c. power supply. In d.c. use, the op-amp must have both positive and negative supply rails, because of its 'd.c. integrity' (i.e. its output being at zero when its input is at zero). However, provided the precautions on adequate h.f. and l.f. decoupling on the supply rails discussed in earlier articles are followed, little difficulty will be met with in practice on this double supply requirement. Because it is so often overlooked, however, it might pay to look more closely at the question of providing supply rails which are positive and negative with reference to a signal earth.

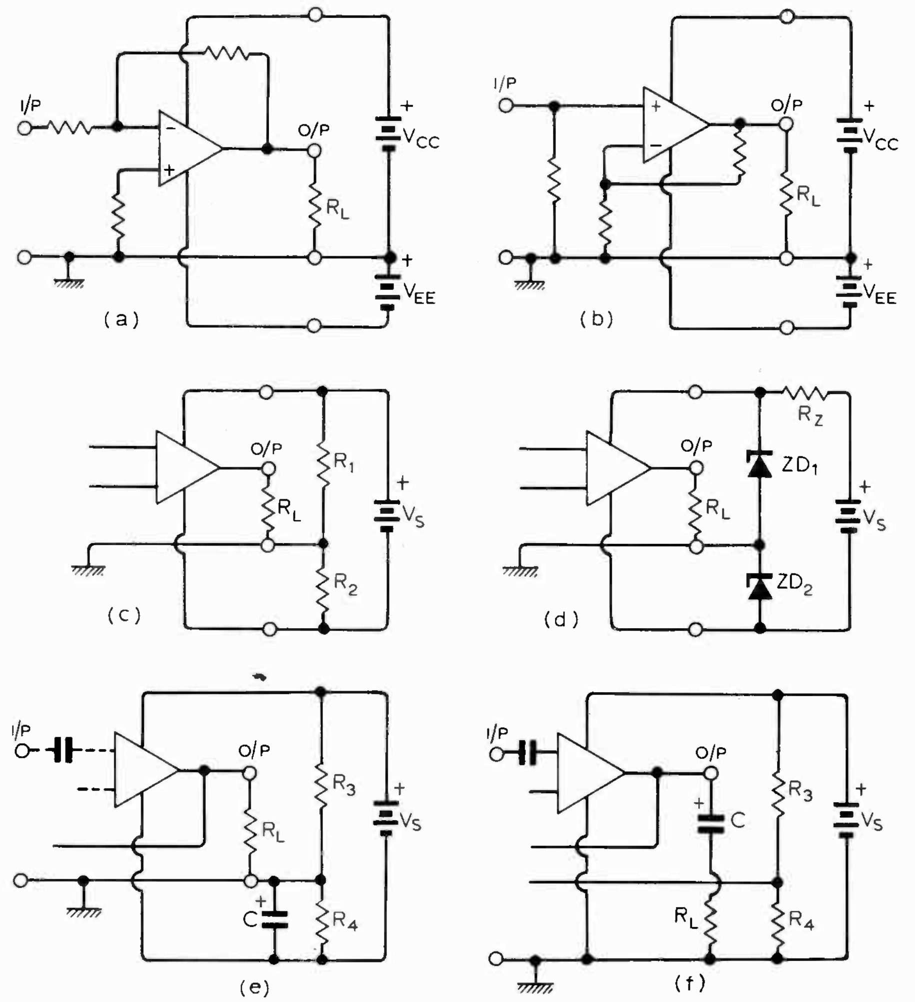


Fig. 4. Supply arrangements for monolithic op-amps; (a) 'inverted' configuration double (±) supply; (b) non-inverted double supply; (c) bleeder resistance-split single supply; (d) zener-split single supply; (e) resistance-split supply for a.c. use with signal earth to centre rail; (f) resistance-split supply for a.c. use with signal earth to negative supply rail.

D.C. supply for op-amps

In op-amp basic theory, two independent power supplies to give positive and negative rails are tacitly assumed as in Fig.4(a) and (b) for inverted and non-inverted configurations. The V_{CC} and V_{EE} batteries in Figs.4(a) and (b) could equally well be centre-tapped positive and negative mains powered d.c. supplies.

In working with op-amps many circuit men want to use a single power supply, and find some difficulty in adapting the single supply to perform the function of the double supply.

You will note in Figs.1(a) and (b) that both inputs of the op-amp have a continuous d.c. path to the centre rail or signal earth. With the single power supply, a centre-rail signal earth can be achieved by a bleeder resistance network R_1, R_2 across the power supply as in Fig. 4(c). In practice R_1 and R_2 are usually made equal. Also the values are chosen to give a bleeder current at least ten times the peak output current into the load resistance from the op-amp. This is necessary because the bleeder resistances are in series with the load resistance and must be low enough in value not to reduce

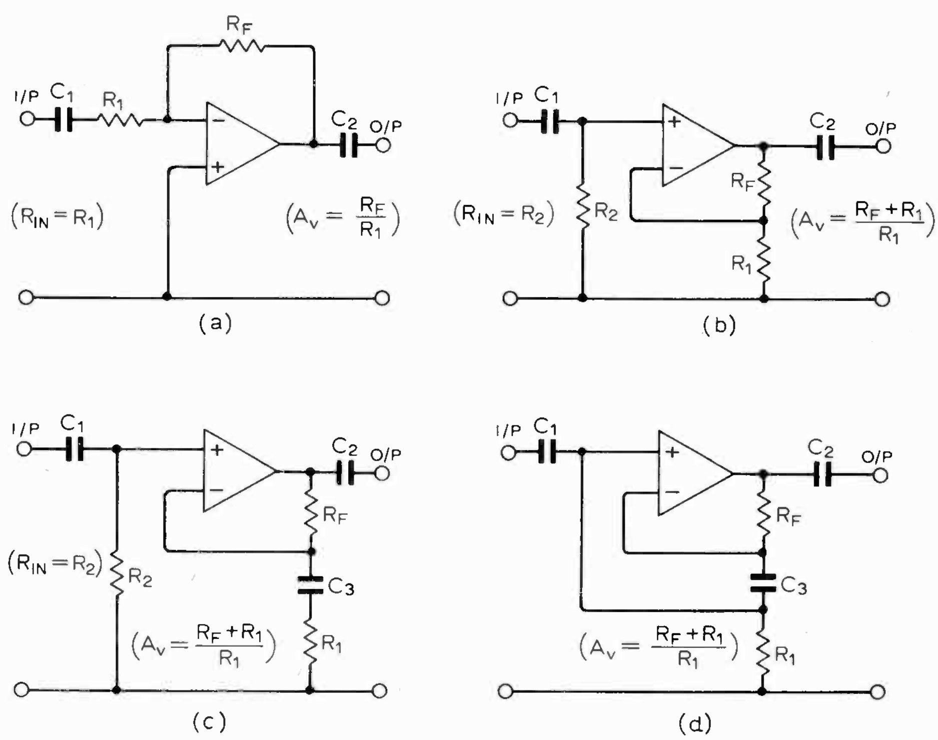


Fig. 5. Arrangements for a.c. amplifiers using basic op-amps; (a) inverted; (b) non-inverted; (c) non-inverted with 100% d.c. negative feedback; (d) high input impedance 'non-inverted'.

excessively the peak voltage swing across the load resistance.

For a 5mA peak current in the load the above rule for the bleeder network would mean a standing current of 50mA, and this might be unacceptable. An alternative is then to set up the centre rail with two zener diodes as in Fig. 4(d). Because of the low dynamic resistance of the Zener diodes, the standing current in the bleeder network need be only slightly larger than the peak current into the load (for a μA709 some 8mA).

So far, we have been considering single power supply arrangements for d.c. operation of op-amps. For a.c. operation, the bleeder current demands can be much less.

Fig.4(e) shows an a.c. amplifier resistance bleeder arrangement. Resistors R_3 and R_4 need be only small enough to provide a current which is large compared with the bias leakage currents at the op-amp inputs (which are usually, at most, only a few microamps). This means that the current through R_3, R_4 need be only a few tens or hundreds of microamps. The resultant large values of R_3 and R_4, being effectively in series with the load resistor R_L, would seriously limit the output drive under a.c. conditions were it not for the large decoupling capacitor, C, across R_4 from the centre rail to the negative of the power supply. The time constant CR_4 is chosen so that the bleeder network presents negligible impedance compared with the load resistance at the lowest frequency of a.c. operation.

The same low bleeder current can be used for a.c. applications in the arrangement of Fig.4(f). Here the input signal is applied between the op-amp input and the negative of the power supply. The load resistance is also connected via an isolating capacitor from the op-amp output to the negative of the power supply.

A.C. op-amp circuits

Although op-amps are essentially d.c. amplifiers, they are more and more being used by circuit engineers for a.c. applications.

The basic inverted configuration discussed earlier as Fig.1(a) can be simply converted to a.c. use as in Fig.5(a) by isolating capacitors C_1 and C_2 at input and output. The non-inverted configuration of Fig.1(b) can be similarly converted to a.c. use as in Fig.5(b).

Both Figs.5(a) and 5(b) have the disadvantage that the d.c. off-set voltages are amplified equally with the a.c. voltages with consequent dangers of excessive d.c. output voltage drift. The arrangement of Fig.5(c), with virtually 100% d.c. feedback, amplifies only the a.c. voltage so that no substantial d.c. off-set occurs at the output. Here the mid-band a.c. gain of the circuit is $(R_F + R_1)/R_1$.

Where a higher a.c. input impedance is required, the bootstrap circuit of Fig.5(d) is useful.

Frequency response tailoring

Thus far we have considered only the mid-band gain of a.c.-coupled op-amps. Apart from the use of the input and output capacitors to tailor low-frequency response, the wealth of resistors in the various feedback networks make a happy hunting ground for frequency response tailoring.

In the basic inverted configuration of Fig.6(a) R_3 and C_3 across the input resistance R_1 will boost top frequencies, while C_4, R_4 across the feedback resistance will cut them.

Similarly in the non-inverted configurations of Fig.6(b), C_4, R_4 across the input bias resistance, and C_5, R_5 across the feedback resistance R_F both act as top cut networks. C_6, R_6 across the lower resistor R_1 of the feedback network serve to cut bass frequencies, as does C_3 in series with R_1.

To illustrate frequency tailoring by these methods some practical circuits are given. Fig.6(c) is a 'flat' microphone amplifier with a 20 to 20,000 Hz response. Fig.6(d) is a tape replay amplifier where the networks provide the 17dB bass boost required. Fig.6(e) shows a pre-amplifier with the compensation necessary for a

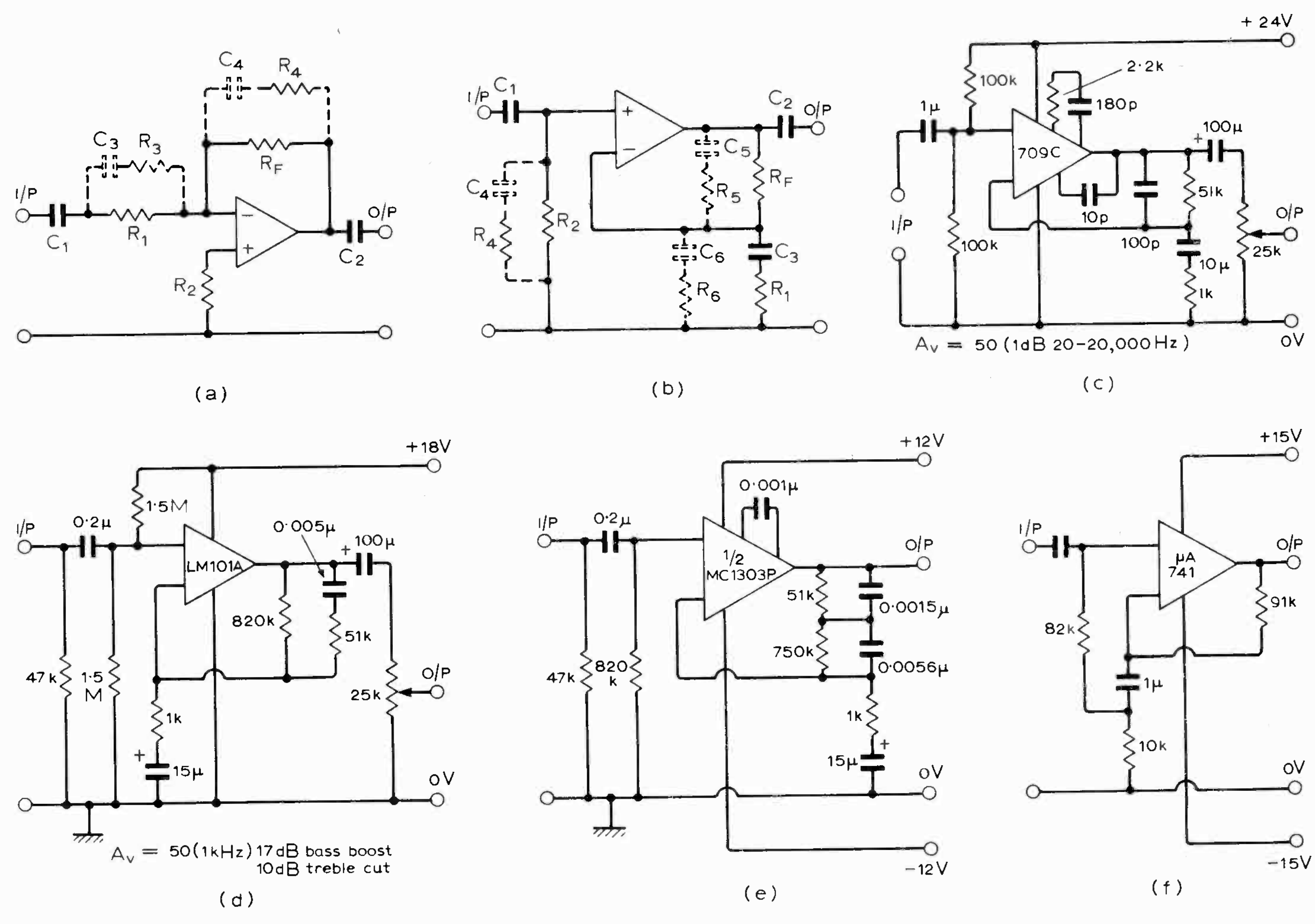


Fig. 6. Frequency response tailoring of op-amp amplifiers; (a) inverted configuration paths for incorporating frequency dependent networks; (b) non-inverted configuration frequency tailoring; (c) flat (microphone) pre-amp with bottom and top roll off; (d) tape replay pre-amplifier with bass boost; (e) magnetic pick-up pre-amp; (f) crystal pick-up pre-amp.

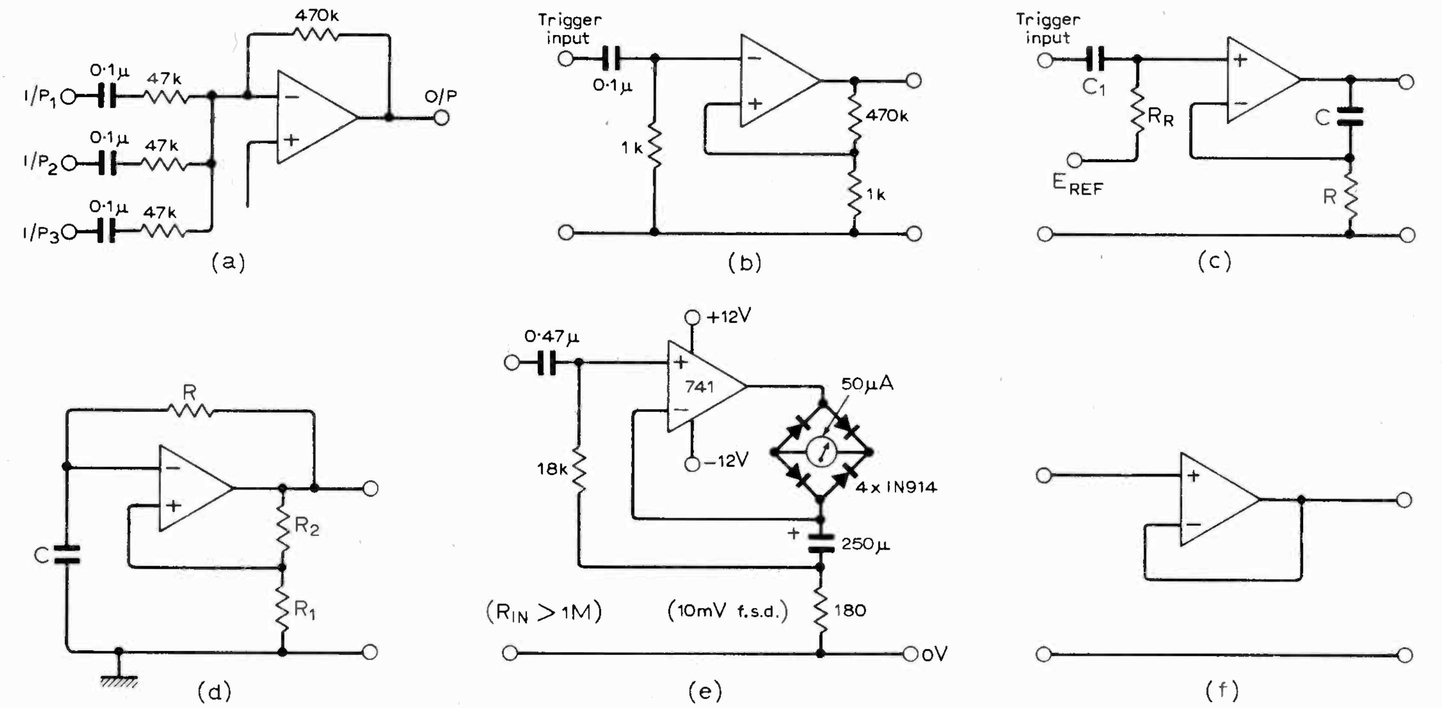


Fig. 7. Special op-amp a.c. circuits; (a) audio mixer; (b) bistable multivibrator; (c) monostable flip flop; (d) a stable multivibrator (symmetrical square wave); (e) linear a.c. millivoltmeter; (f) voltage follower (high to low impedance).

magnetic pickup. Finally Fig.6(f) shows a high-input-impedance circuit for use with a crystal pickup.

Frequency tailoring so far shown is confined to attenuating low and high frequencies. But, by incorporating frequency selective networks (such as the twin-T or Wein bridge) in the feedback network, there is great scope for making op-amps into band-pass and band-reject amplifiers with ease.

Table 1 Design difficulties with operational amplifiers

Skill required	Circuit type: Signal frequency	Signal voltage	Signal current	Circuit impedance	Accuracy	Slew-rate (unity gain, large signal)	Full power band-width
little	d.c.—100kHz	above 100mV	above 100nA	below 1MΩ	worse than 1%	below 1V/µs	below 10kHz
fair	100kHz—1MHz	3–100mV	3–100nA	1–30MΩ	0.1–1%	1–10V/µs	10–100kHz
high	1–100MHz	0.1–3mV	0.1–3nA	30–1000MΩ	0.01–0.1%	10–100V/µs	100kHz –1MHz
exceptional	above 100MHz	below 0.1mV	below 0.1nA	above 1000 MΩ	better than 0.01%	above 100V/µs	above 1MHz

Special op-amp circuits

Apart from 'simple' d.c. and a.c. amplifiers, op-amps have now become widely used for general circuit purposes. In an article of this length it is impossible to examine all the uses made of them, but the selection given in Fig.7 gives some indication of the scope.

An audio mixer can be made up with the arrangement of Fig.7(a). This is an adaptation of the 'adder' circuit of the analogue computer.

The circuit of Fig.7(b) gives you a simple slow-speed bistable flip-flop which can be triggered to either positive or negative rail saturation at the output. For a monostable flip-flop, the arrangement of Fig.7(c) can be used. The length of time the monostable is 'on' can be controlled by a d.c. voltage applied to the non-inverting (+) terminal. In Fig.4(d) an op-amp is used to provide an astable flip-flop with a symmetrical square wave output.

To overcome the non-linearity of the diodes used in meter rectification of a.c. signals, a very linear a.c. milivoltmeter circuit can be made up with an op-amp as shown in Fig.7(e). The circuit values given provide 10mV full-scale deflection when used with a 50µ A d.c. meter.

Finally a common requirement in circuit design is a voltage follower circuit which gives an output voltage equal to the input voltage but has a high input impedance and a low output impedance, i.e. an impedance conversion circuit. The op-amp can be connected as shown in Fig.7(f) to provide this facility.

Common sense precautions

The various circuits set out above give an indication of the multiple uses to which op-amps can be put. However, it is well not to be deceived by the apparent simplicity of the circuit diagrams. Many precautions must be taken in practice to prevent instability and unacceptable d.c. drift.

How well you use op-amps depends to a great extent on your skill. Some circuits you can make up knowing little more than the gain resistance ratio formula and having little practical bench experience. Other circuits call for a fair knowledge of frequency compensation techniques, and a good working experience with practical circuits. Some again call for considerable practical bench experience and theoretical knowledge. And finally some circuit areas are pushing the limits of currently available op-amps even for the most knowledgeable, skilled and highly experienced.

To give you some guidance on where, as Table 1 sets out types of circuit in degrees of difficulty, in terms of signal frequency, signal voltage, signal current circuit impedances, accuracy, slew rate and full-power bandwidth. In each of these areas it offers suggested limits to work to, dependent on your mathematics, your knowledge and your practical bench experience. There may be some argument among engineers about the exact crossover points between the different areas but the table should serve as a useful guide to tyro in the op-amp art.

(to be continued)

Stability and Reality

Life in a non-linear world

by Thomas Roddam

Playing with models, and from an engineer's standpoint mathematical analysis is just another nursery game, can be a very informative exercise, but it can also be dangerous. The practical system is not a party to your contract with the Devil: the simplifications stay on the paper, in the computer, and never reach reality at all. Searching back in memory and what I suppose could be called memory's memory for really early examples of this, perhaps the most, or one of the most, powerful examples was the deviation of reality from theory in early R.F. amplifiers. They were R.F., not r.f., in those days. They used triode valves, of which I remember the V24, with its filament running straight down the axis of the cylindrical glass tube, and an even earlier type, with a small roll of I don't know what, sealed into a sort of carbuncle which could be warmed to adjust the gas pressure inside.

I don't need to tell readers that if you connect a triode with a tuned-grid circuit and a tuned-anode circuit you get something happening which does not show on the static characteristics. The reaction can, retrospectively, be separated into three schools. The first school, the practical men, ran round in circles uttering cries of alarm and adding resistance everywhere. The cunning circuit men invented eighty-seven different ways of neutralizing the anode-grid capacitance. The modern student knows that if you don't like the world the way it is, you just change it, like by marching to the Met. Office to protest against rain on Easter Monday. Instead of just breaking the triodes, however, cunning old reactionaries added a screen electrode. R.f. amplifiers were stable again until other c.o.r.'s pushed their frequencies and coil Qs up to the limit all over again.

Over the last 30 years there has been enough written on the stability of linear systems to keep the printers the richest union men in the country. The only question these excellent works, among them my own, do not ask is this: who cares about the stability of linear systems? If the system is linear we do not need feedback. Before you write to contradict this statement, I do realize that we use feedback for response control, too, but we could deal with the response by perfectly conventional network techniques. We use feedback because our system is not linear: we discover this at the bench, and then go to the desk to do all the design in terms of linear systems.

Be sure your sins will find you out. The linear assumption works very well if the non-linearity is small. This usually means a good generous design, but a generous design is one in which the user's money is being given to a charity for inept designers, and money is getting, has become, tight. Non-linear systems may be hard to design, but they may also be cheap to use. We have moved on from "the best design we've got", and "you never had it so good" to "if you don't like the heat stay out of the kitchen", and now on to "no instant solutions".

It is easy to say "stay out of the kitchen", but if you have been selling sausages and instant mash, what do you do when all the customers start asking for soufflés? You can't just answer "blow off". At least you need some idea of what it's all about. How do the clever boys design non-linear feedback systems? Can they be discussed in language the likes of you and me understand? Obviously I am willing to try, and I propose, if possible, to make use of Roddam's Rule, "if you can't spell the name, don't use the theory". These pages will not be sullied with the names of Lyapunov and Lermentov, or not immediately. They may contain mention of such drab practical things as chopper regulators and thyristor power supplies.

Non-linearities come in a wide range of styles. In linear systems we find ourselves dealing with only two kinds of thing, terms like $(s+a)$ and terms like (s^2+as+b), which can be separated out by a number of techniques. What are the basic kinds of non-linearity? The definition will be in terms of the relationship between input and output and is best shown as some very simple graphs. Fig. 1 shows at (a) an ideal linear system, the input-output characteristic of our everyday dream world. In (b) we see what we may call ideal reality: up to some well-defined level the system is linear, and then saturation sets in. This is the way in which an amplifier with a good deal of feedback behaves. Fig. 1(c) is fairly familiar, too. The mechanical servo people have to live with this as backlash; we live with it as cross-over distortion; the systems theorists call it dead band because they think in terms of the width of the flat band in the middle. Finally we have one version, the symmetrical version, of a relay system. In this version the output is either at $+V$ or at $-V$, depending on whether the relay input is positive or negative. The reason for choosing this is to

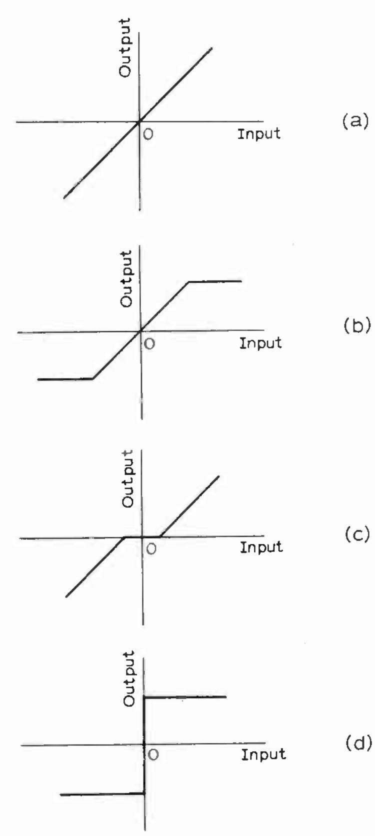


Fig. 1. Characteristics of: (a) linear system; (b) system with saturation; (c) system with dead band; (d) relay system.

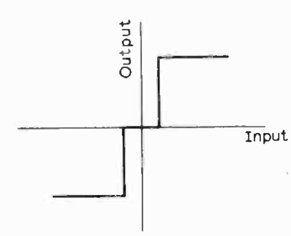


Fig. 2. Relay with dead band.

enable us to combine a relay and a dead-band to give Fig. 2, which shows a typical relay system with a stable centre zero. When the input is enough to operate the relay it moves to one side or the other. We shall come back to relays in a moment.

With linear systems there is no doubt that for any particular value of input we shall get a particular output. For non-linear systems this is not necessarily true. A very simple example, with a very direct way of drawing attention to itself, is a mains transformer using a C-core. When these were first used in instruments they caused a lot of alarm because sometimes, not always, when you switched on the fuses blew. A standard input, but by no means a standard current was not what we were used to observe. The trouble was caused by a characteristic shaped like Fig. 1(b) combined with hysteresis. We get hysteresis in relay circuits, too, because the pull-in current and the release current are different. Hysteresis gives us the response characteristics shown in Fig. 3. If we add saturation at the top and bottom of Fig. 3(a) we get the well-known shape of an ideal square-loop nickel iron alloy, while Fig. 3(b) is familiar in the Schmitt trigger circuit. The characteristic of Fig. 3(c) is rather less common in purely electronic systems, I think, although I have used it in anti-singing devices for preserving loop stability in a four-wire link between two two-wire systems.

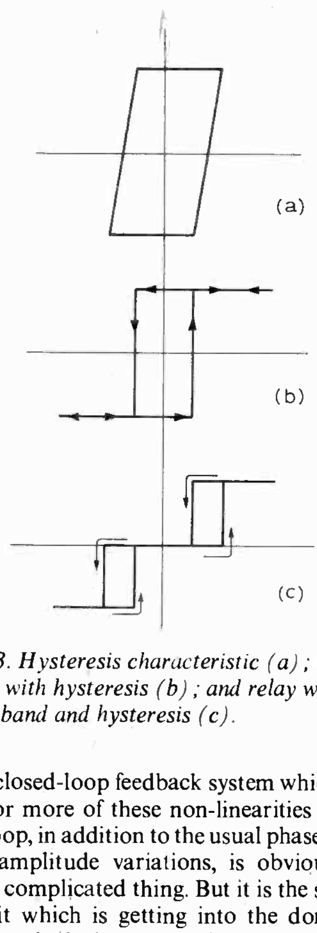


Fig. 3. Hysteresis characteristic (a); ideal relay with hysteresis (b); and relay with dead band and hysteresis (c).

A closed-loop feedback system which has one or more of these non-linearities inside the loop, in addition to the usual phase shifts and amplitude variations, is obviously a fairly complicated thing. But it is the sort of circuit which is getting into the domestic radio and television sets. There is a choice of techniques for studying these circuits, and I would not be surprised if new ones had not appeared between the writing and the reading of this article.

One method which has been widely used is described as the use of an analogue computer. Most, if not all, the non-linear functions can be simulated by using diodes with operational amplifiers. Computer study sounds very classy and responsible but what does it amount to? If the system itself is a low power one and we set it up on the bench and fiddle about with the values it does not sound as grand as saying we are using direct 1:1 correspondence analogue analysis. The

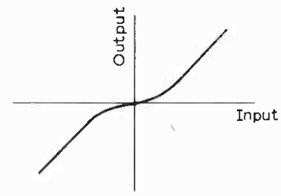


Fig. 4. Smooth variant of the dead band system of Fig. 1(c).

analogue computer method is fiddling without tears: the autopilot can crash the aircraft without even blowing a fuse. Obviously I cannot make an article out of the simple statement "Try changing some of the circuit values": I am not going to say you must work it all out in advance, however. There is a middle road. If you know something about the way in which non-linear systems can be designed entirely on paper, you can make your experimental studies in a more systematic, and thus in an easier, way.

The second method is to choose approximations for the non-linearities which are easy to describe mathematically. We can find a power series for a curve like the one in Fig. 4, write down all the differential equations for the system and then take them round to the friendly neighbourhood mathematician. If you are lucky he will carry out the analysis, so that you can work out how the system behaves with particular values. Answer: it is unstable. It is most unlikely that he will be able to carry out a synthesis procedure to indicate what values will give stability. Analysis means that you do your guessing on paper, where you cannot even stick in a potentiometer or two and try variations quickly.

The method we shall discuss immediately is the use of the describing function. It is a method which has the great advantage of being closely connected with the methods used for linear systems. The describing function for a non-linear element makes certain assumptions which can lead one into trouble, but it is a powerful tool. We assume that if we apply a sinusoidal input signal of fixed amplitude the output will be a periodic wave of the same frequency as the input sinusoid. A rectifier bridge is not, in this context, a permitted function. Trouble can arise in thyristor control systems, in which it is the controller input which is taken to be sinusoidal, if the controlled rectifier system

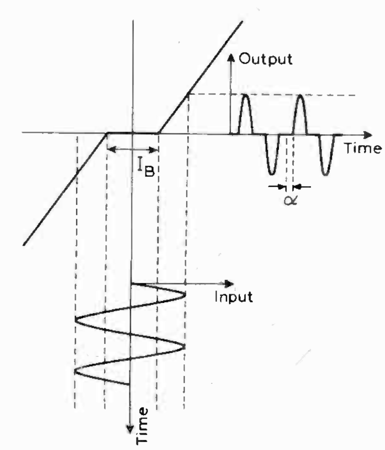


Fig. 5. Sine wave applied to dead zone characteristic.

jumps to a half-wave condition. Our ideal non-linearities naturally satisfy the conditions. It is a simple task of Fourier analysis to determine the amplitude and phase of the output fundamental when we know the input sine wave and the shape of the non-linear characteristic.

Let us consider this operation in terms of a dead band non-linear characteristic. The input signal we shall call $I_{max} \sin \omega t$. The dead band has a total width of I_B, so that the input and output are related in the way shown in Fig. 5. If we leave out any linear loss or gain, the output consists of the reduced angle of flow sine wave tops shown on the right of the figure. Calling the output $O(t)$, it will have a peak value of $(I_{max} - I_B/2)$ and in the active region

$$O(t) = I_{max} \sin \omega t - I_B/2$$

Taking an angle α such that

$$\sin \alpha = (I_B/2)/I_{max}$$

so that α is the phase of the input at which we begin to see an output

$$O(t) = I_{max} (\sin \omega t - \sin \alpha) \text{ for } \alpha < \omega t < \pi - \alpha$$

We want to extract the fundamental component from this. We need not put the working out down here: the answer is:

$$O_f = I_{max} \left[1 - \frac{2\alpha}{\pi} - \frac{\sin 2\alpha}{\pi} \right]$$

This value of O_f is, of course, the coefficient in $O_f \sin \omega t$: there is no phase angle to worry about. The describing function is the effective gain at a particular amplitude, which we can call $G(a)$, the (a) to remind us that we must know the size of the signal. For the dead band circuit,

$$G(a) = O_f/I_{max} = \left[1 - \frac{2\alpha}{\pi} - \frac{\sin 2\alpha}{\pi} \right]$$

This is, as we might expect, always less than unity, and, also as we might expect, is a maximum for very large signals. Suppose now that we put a device with this characteristic in tandem with the amplifier in the forward path of a feedback loop. When the level at this point is (a), the overall forward gain *at one frequency* will be

$$\mu . G(a)$$

The gain with feedback is

$$\mu_f = \frac{\mu G(a)}{1 - \beta \mu G(a)}$$

We are not allowed to say that if $\mu G(a)$ is large $\mu_f \approx -1/\beta$. This is the approximation we use to show that with enough feedback we get no distortion. Implicit in the use of the describing function, however, is the rule that we throw away the harmonics in order to concentrate our attention on the fundamental, on the term which may go round and round, increasing as it goes. We can, however, use the term $\beta \mu G(a)$ in constructing the Nyquist diagram. A typical ideal form is shown in Fig. 6. This is discussed in some detail in Chapter 7 of Principles of Feedback Design (Iliffe), so we need say no more about it. We draw this diagram first for the $\mu\beta$ of the linear system alone, since $G(a)$ is always less than unity. It will be seen that it goes round a part of a circle centred on the key

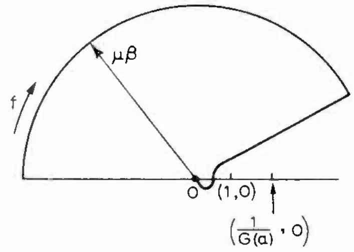


Fig. 6. Typical Nyquist diagram.

point, (1, 0), which means that we have a step of constant gain margin in the Bode plot. When we turn to the term $\beta\mu G(a)$ we know that for the dead band non-linear device $G(a)$ is always less than unity and that it does not introduce a phase angle. The classy thing to do is to draw a half-size picture inside Fig. 6. The lazy man draws this, enlarges it to twice the size, and notes that the point (1, 0) is now where $(1/G(a), 0)$ used to be: the rest of the diagram need not be drawn, because it just covers the $\mu\beta$ line. The effect of *this* non-linearity on *this* type of feedback system is to make it even more stable.

I chose this non-linearity because Fig. 5 is easy to draw. But if we have an arrangement with two branches, as in Fig. 7 we see that what doesn't go up must go down. The describing function for the saturation curve is simply $1 - G(a)$ (α.b.), or

$$\frac{2\alpha}{\pi} + \frac{\sin 2\alpha}{\pi}$$

Again this is less than unity. Overload, like cross-over distortion, will not make a stable amplifier unstable.

When you move into the higher reaches of closed loop systems, which means when you really have to earn your keep to try and meet a specification, you find that there is a class of design which is called "conditionally stable". A Nyquist diagram, or the right-hand half, which is all we need, might look something like Fig. 8. The phase shift exceeds 180° while the loop gain is still high, but the phase is pulsed back to bring the $\mu\beta$ line round the point (1, 0). We are accustomed to the idea that a feedback loop becomes unstable if we increase the gain sufficiently. Here we have a system which also becomes unstable if we reduce the gain. The region marked *R* in Fig. 8 shows the

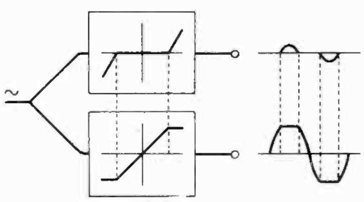


Fig. 7. Two complementary non-linearities.

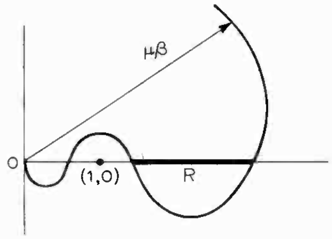


Fig. 8. A conditionally stable system.

values of $1/G(a)$ for which either of our dead band or saturation non-linearities will make this system unstable.

The problem which the user of conditionally stable systems meets first is quite simply the first switch on. While the heaters are heating, if you use valves, or the various circuit capacitances are charging, the gain is shifting in a way which you cannot reasonably predict. This type of system is therefore normally restricted to systems which are switched on and then left alone for days, months, years. It is reasonable to provide a switch of some kind to change the loop conditions once the start-up period is over. In conventional amplifiers of this kind the non-linearity is of the saturation type, and as it is simply overloading it is possible to limit the input signal so that the system can never be brought up to the level where the describing function starts to fall below unity. The

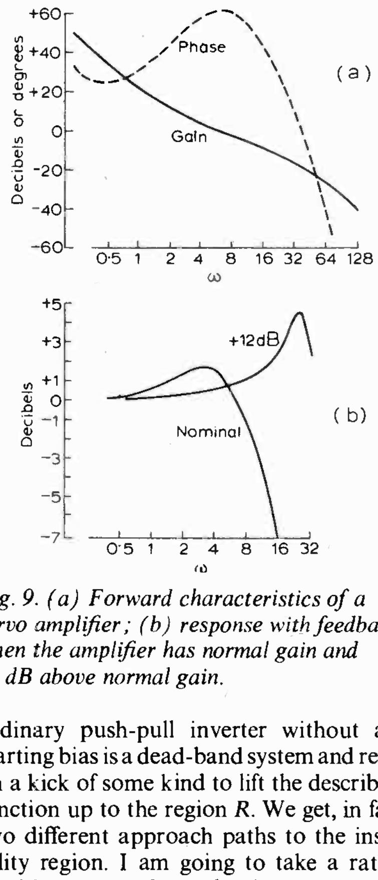


Fig. 9. (a) Forward characteristics of a servo amplifier; (b) response with feedback when the amplifier has normal gain and 12 dB above normal gain.

ordinary push-pull inverter without any starting bias is a dead-band system and relies on a kick of some kind to lift the describing function up to the region *R*. We get, in fact, two different approach paths to the instability region. I am going to take a rather intuitive approach to what happens.

Suppose we give the system some sort of jolt, which brings the non-linear device into a region where, round the loop we get a momentary ring at the right sort of frequency. We know that a system which is not particularly stable has its behaviour dominated by a pole very close to the imaginary axis. This shows up in a typical situation in the way shown in Fig. 9. The high-gain form has a nice peak developing, and we might guess that it will not take much more gain to get the system oscillating at around $\omega = 40$-50. Anyway, we have a "ring" when we shock the circuit, so that $G(a)$ has a meaning. As $G(a)$ brings the critical point inside the loop the system is unstable and the intuitive feeling is that the oscillations will grow until we come out of *R* on the other side. This gives us two different results for the two non-linearities we have considered so far. For the

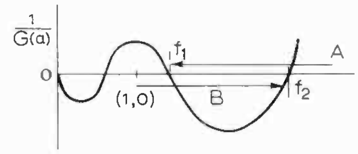


Fig. 10. Approaches to steady oscillation.

dead-band, $G(a)$ is very small if the signal is small, and so $1/G(a)$ is large, but becomes smaller as the signal grows. In Fig. 10 we come along the path *A*, the oscillations become self-sustaining at a frequency f_2 when we reach the $\mu\beta$ curve crossing, but this is an unstable point of instability and the system moves to the other edge and oscillates at a frequency f_1. With a saturation effect things go the other way round. Below saturation $G(a)$ is unity. Overloading reduces $G(a)$ until oscillation starts at f_1, but the working condition continues along *B* until at f_2 there is stable oscillation.

We must not try to be too clever about all this. Once oscillations begin we are producing in the output of our non-linear device a whole batch of harmonics. The describing function approach concentrates attention on the fundamental. The harmonics are there, even if we haven't put them in the analysis, and they will come round the loop and mix together in the non-linearity to produce some extra terms of fundamental. This modulator fundamental, however, gets its phase from the harmonics, so the overall effective value of $G(a)$ now has a phase shift. This is a well-known effect in oscillators, usually associated with the name of Groszkowski, and provides a mechanism which here may carry the working point round between f_1 and f_2 away from the axis.

Practical non-linear closed loop systems are not quite so complicated as this. If we take a characteristic like the one shown in Fig. 11 we have only one value of the describing function which corresponds to instability, and that is the point *P*. If we are travelling in the direction corresponding to saturation, the system will oscillate stably for $OP = 1/G(a)$. If we are travelling in the direction corresponding to a dead-band system we do not get a stable oscillation at *P*, because, in anthropomorphic terms, the system thinks it can get round to the f_1 point of Fig. 10. This is, in fact, the point at the origin, but once inside the region *OP* the oscillations grow until something else comes in to take control.

Relay type non-linearities are becoming more and more important. The switching regulator is one obvious form, and if we convert it from operating with a d.c. reference to operating with a signal as the reference we find that we are talking about what it is fashionable to call a class-D amplifier. For generality we use the symmetrical relay with

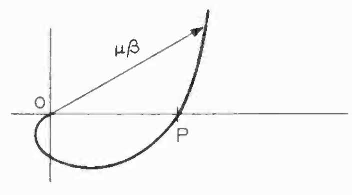


Fig. 11. More common μβ path for non-linear systems.

both hysteresis and a dead band, and we draw the characteristic and label it in the form shown in Fig. 12. The total dead band width is I_B, and the hysteresis is h. To find the describing function we apply a sine wave input, $I_{max} \sin \omega t$. When $I_{max} \sin \omega t$ reaches the switch-on value, the relay operates and gives unit output from the time that $I_{max} \sin \omega t$ crosses the level $(I_B+h)/2$ on the

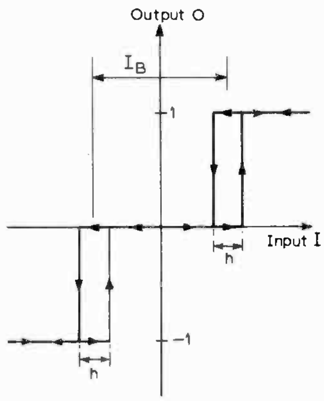


Fig. 12. Relay with dead band I_B and hysteresis h.

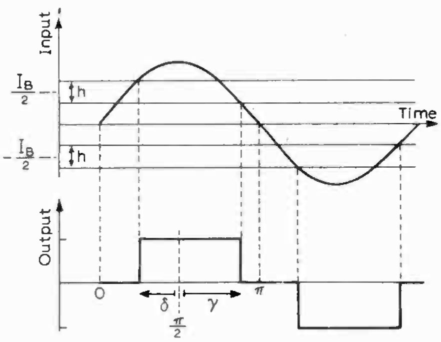


Fig. 13. Finding the describing function for the Fig. 12 relay by applying a sine wave.

way up until it falls again to $(I_B-h)/2$, when the output becomes zero. For the other half-cycle we just put in minus signs, and we get the wave-form shown in Fig. 13.

The size of the fundamental component of this sort of quasi-square wave is easily worked out. One very easy way of finding it is to look it up, in Bedford and Holt, for example.

$$|O_a| = \frac{4}{\pi} \sin(\delta+\gamma)/2$$

which has a maximum value of

$$4/\pi = \sqrt{2}/1{\cdot}11$$

when $(\delta+\gamma) = 180°$. There is also a phase angle. The fundamental component of the output lags the input, because of the hysteresis, by an angle of $(\gamma-\delta)/2$. The describing function is then

$$G(a) = \frac{4}{\pi I_{max}} \cdot \left|\sin\frac{\delta+\gamma}{2}\right| \angle -\frac{\gamma-\delta}{2}$$

δ and γ are expressed by a pair of equations which may be written rather compactly

$$\left.\begin{matrix}\delta\\ \gamma\end{matrix}\right\} = \arccos\left(\frac{I_B \pm h}{2I_{max}}\right)$$

The size of the describing function is very dependent on the input. For inputs of less than $(I_B+h)/2$ there is no output at all, and so $G(a) = 0$. When I_{max} is just equal to $(I_B+h)/2$ the theoretical situation is that the output jumps to a value which depends on h. The angle δ is minutely more than zero, while

$$\gamma = \arccos(I_B-h)/(I_B+h)$$

I have said that this is a theoretical situation, because anyone who has worked with circuits at all related to this class will know that there is always some lack of symmetry and that the transition is marked by a narrow range of "half-waving", or even by a range in which one gets the effect some of us associate with the gas engine or the Bofors gun. This region is not a trivial academic one in some applications: thyristor controlled power supplies may show this effect with alarming results.

As the input signal is increased the output rises, and at first this rise is rapid: roughly this takes place when δ is less than about 30 degrees. Then, however, the relay unit begins to look more and more like a limiter, so that the output stays nearly constant as the input rises. The describing function starts to fall. The phase angle when the circuit just starts to switch is clearly

$$\frac{\gamma}{2} = \frac{1}{2}\arccos\left(\frac{I_B-h}{I_B+h}\right)$$

but with a very large input the phase has fallen to zero. The behaviour of the describing function is shown in Fig. 14.

We must go back to the basic loop equation. We write

$$\mu_f = \frac{G(a)\mu}{1-\mu\beta G(a)}$$

I have used the minus sign here because it puts the diagram on the page right-handed, and because in designing systems I think:

$$|\mu\beta| = 1$$
$$\text{phase} = 180°$$

is the critical point, and I want to work with phase margins, so that if $\theta = 150°$ I see a $+30°$ margin. This is engineer's terminology: I turn the diagram upside down because I said before I started that this amplifier or whatever was to have negative feedback. When I reverse down the road I just don't think I am driving at -5 m.p.h. The critical condition is very simply

$$1-\mu\beta G(a) = 0$$

This is the commonsense condition, that $\mu_f \to \infty$. It corresponds to

$$\mu\beta = 1/G(a)$$

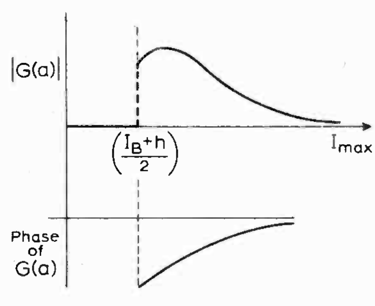


Fig. 14. Shape and angle of describing function for relay with hysteresis.

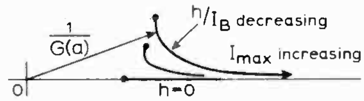


Fig. 15. Nyquist plot of $1/G(a)$ for relay.

We can see if this will happen by plotting $\mu\beta$ and $1/G(a)$ separately, and seeing where they meet. We did this implicitly in Fig. 10, although as $G(a)$ was a zero phase term it did not show very clearly. In Fig. 15 we see that hysteresis lifts the $1/G(a)$ curve away from the axis and because it offers an extra lag it will tend to make a typical system unstable.

Thus far we have really been working in terms of linear systems all the time. The describing function is a dodge which turns a non-linear system into the equivalent of a linear system with a variable inside the feedback loop. This is one important mode of operation which I hope we can discuss in a later article. A quite different situation appears if we allow the loop to be an unstable one in the language of linear systems. To make the diagram easy to draw I shall assume that the feedback amplifier is a d.c. amplifier: if you prefer you can consider that the whole picture represents one millisecond in the life of an audio amplifier which has, as its input, the note from the biggest ocarina in the world. In accordance with the principle discussed in the study of stability in the time domain we start, not with a whimper, but a bang. There are two different ways in which the system may behave. Essentially they are shown in Fig. 16. In the upper diagram, (a), the system oscillates with an amplitude which is the same

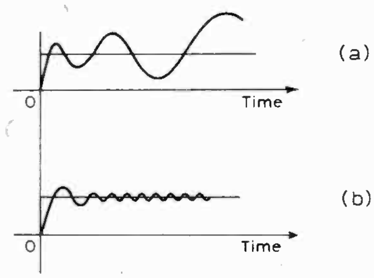


Fig. 16. The transient response of two non-linear unstable systems, (a) and (b).

sort of size as the signal itself. It makes matters even worse if it is, as the diagram shows, at a frequency which might be that of a signal. In (b), once the transient which is associated with the linear behaviour dies down the system buzzes away producing a small, high frequency, oscillation. In the use of non-linear systems we need to make a subjective judgment. Formalists, who only read my articles because they believe, like Sir Lawrence Jones, that it does you good if something makes your blood boil at regular intervals, will refuse to allow us to follow the rule: "when *I* use a word, it means just what I choose it to mean—neither more nor less." But an engineer must take the view that "when my customer makes a word do a lot of work like that, he always pays it extra". A very small high frequency ripple on a d.c. supply is usually tolerable, just as the switching frequency ripple on a class-D amplifier output annoys only the local bats. From a user's point of view the response shown in Fig. 16(b) is the response of a stable system. *De minimis non curat lex.*

If the system is an amenable one there will be just one intersection between the two curves, of $\mu\beta$ with frequency as a parameter and $1/G(a)$ with amplitude as a parameter. The intersection defines a frequency and a value of I_{max}. It is easy to see whether this is a small oscillation outside the frequency range of interest. There is often some sort of low-pass effect in the forward path and the output ripple may be greatly reduced by this part of the circuit. A more complicated system can have a number of modes of operation. It may be stable at one level of signal, may change to the acceptable type of instability at another level and may, finally, move into the gross kind of instability at a third level.

The elegance of the describing function treatment, in which the conventional Nyquist diagram is combined with a plot of the inverse describing function, can be extended to study the nature of multiple intersections. It is, however, an elegant illusion. The solution which is obtained at the end of the day is not as precise as the analysis suggests. The harmonics have been neglected, and although they are not in the mathematics they are there in the circuit. The describing function treatment tells you the sort of way the circuit will probably work, the sort of answer you may expect. It gives you hints on how to modify the system to get the answer you want.

The advantage which is gained with non-linear loops may be very real. Of course there are the special cases in which the problem is merely to make sure that a system which works well for small inputs will not get out of hand if it gets a momentary overload. These are important in some servo system problems. Our main interest comes in systems which are set in the tolerably unstable zone. These can be thought of as systems in which we have chosen to work with a very high value, for the particular problem, of $\mu\beta$. The non-linearity then acts to make the circuit self-adjusting, keeping up as high as possible without the instability providing a run-away condition. Like the discreet use of positive feedback inside a negative feedback loop, this process gives better performance at minimum cost in equipment.

We must, in another article, examine an alternative way of dealing with non-linear systems. Then we may turn to some of the applications, and see if we can get some idea of what we are doing before we start to build a regulated power supply which does not, to use the modern jargon, produce thermal pollution of the environment. Cook the equipment, I call it.

Books Received

20 Solid State Projects—for the car and garage by R. M. Marston. The car is a natural target for experimenters in electronics. The attraction is the car's ubiquity and the low cost of electronic devices. As a bonus the 12-volt supply makes bulky and costly power supplies unnecessary. The car seems a popular way of showing off all manner of gadgets and gimmicks so exhibitionism might also play a large part.

The devices in Marston's book are not really gimmicks—they all have a useful function. Unlike many other books of the multiple project kind, the circuits in this one have been tested by the author. Some in fact have already been published, for instance the capacitor-discharge ignition system originally appeared in the January 1970 issue of *Wireless World*. They include warning indicators of various kinds (e.g. low fuel level, engine over-heating, lighting failure), a tachometer and windscreen wiper pause controls. Two are for garage use—a drill speed control and a battery charger. Not all the 20 circuits are independent of each other—some are add-ons to add-ons like the tachometer excess speed indicator. Full constructional details are given with each project, together with adequate parts lists. Pp.115. Price £1.20 limp, £1.80 cased. Iliffe Books imprint of Butterworth & Co., 88 Kingsway, London WC2B6AB.

Industrial Electronics by N. M. Morris. Intended for technician and technician engineer students of electronic engineering this book is written to be used with up-to-date syllabuses for courses leading to City and Guilds of London Institute examinations. At least, we assume this is so from the numerous problems given at the ends of chapters, which are mostly taken from C.G.L.I. papers. (Numerical solutions are given.) The author, principal lecturer in electrical and electronic engineering at North Staffordshire Polytechic, gives a good grounding in circuits and devices for industrial application, with chapters on semiconductor devices, photoelectric devices, power converters and filters, amplifiers, feedback, oscillators, switching circuits, power supplies and measuring instruments. Discussion of vacuum and gas-filled devices comprises the first 15% of the book as they still fulfil useful engineering functions. The sections on semiconductor devices, which discuss most currently available kinds, make no mention of diode thyristors—leaving the reader with the impression that the s.c.r. and the triac are the only kinds of thyristor. Switching circuits have been split into two sections—multivibrators appear in one chapter dealing with feedback circuits, and the concept of Boolean algebra and logic in a chapter which includes thyristor power switching circuits and—oddly—the Schmitt trigger circuit. Chapters on regulated power supplies and measuring instruments are particularly appropriate and useful for the student. The discussion on frequency compensation of oscilloscope attenuators should save many students from getting perplexed over seeing distorted rectangular waveforms. An adequate index is provided. Pp.376. Price £2.40. McGraw-Hill, Shoppenhangers Road, Maidenhead, Berks.

Foundations of Wireless and Electronics (8th edition) by M. G. Scroggie. This book, first published in 1936, gives a full treatment of the elementary principles of electronics. Previous technical knowledge is not assumed. New material is included on transistors, i.cs, frequency modulation, v.h.f. and u.h.f., transmitters and television. New chapters are devoted to waveform generators and computers. Pp.521 with nearly 400 diagrams. Prices £3.00 for hard back and £1.80 limp. Iliffe Books, The Butterworth Group, 88 Kingsway, London WC2B 6AB.

Radio Transmitters by V. O. Stokes. This book provides a practical account of the design of power amplifiers at frequencies up to 30MHz. Reasons are given for the choice of power output, valve and component types, and circuit configuration. It is suitable for readers with a general knowledge of radio theory. Part I concerns cost and reliability in satisfactory designs. Part II covers the design of medium- and low-power amplifiers. The treatment includes discussions of wideband techniques, amplifiers for intermediate stages, ham requirements, and the use of solid-state devices for linear and non-linear applications. Modern transmitter techniques are described and recent developments discussed in engineering terms. Pp.190. Price £4.50. D. Van Nostrand Co. Ltd., 46 Victoria Street, London S.W.1.

Guide to Broadcasting Stations (16th edition). This revised list of l.w. and m.w. European stations, s.w. transmitters throughout the world, and the European v.h.f. sound broadcasting channels, is preceded by chapters on receivers, aerial and earth systems, propagation, signal identification, and reception reports. Pp.160. Price 50p. Iliffe Books, The Butterworth Group, 88 Kingsway, London WC2B 6AB.

Tuners and Amplifiers by John Earl, is a guide book written to assist in the buying of a tuner, an amplifier or a tuner-amplifier. What is presented is a general picture of design procedures, with emphasis on the increasing use of i.cs, and ceramic and crystal filters. Most of the terms of specification for tuners and amplifiers are given explanation. Useful practical points are made where suitable. Pp.187. Price £2.10. Fountain Press Ltd, 46-47 Chancery Lane, London W.C.2.

Tape Recorders by H. W. Hellyer. This is a companion to 'Tuners and Amplifiers' in the 'how to choose and use' series. The primary aim is to guide the buyer on what to look for in the way of functions, type variations, and specifications. Sections of the book cover maintenance, servicing and making test measurements. Pp.239. Price £2.25. Fountain Press Ltd.

ITV 1971, the new guide to Independent Television, contains over forty pages of technical and semi-technical information. There is a question-and-answer section on colour television, details of ITA transmitters (power output and location) and an account of the regional pattern. Pp.240. Price 75p. ITA, 70 Brompton Road, London S.W.3.

Electronic Building Bricks

9. The amplifier

by James Franklin

The purpose of an electronic amplifier, whether in a hi-fi equipment or an aircraft control system, is to increase the power of an electrical signal (Part 8) to enable it to operate some unit for which it would otherwise be too weak. The small electrical output of a gramophone pickup must be amplified to provide sufficient power to operate the relatively heavy mechanism of a loudspeaker.

A mechanical analogy is servo-powered steering in a motor car. The steering gear follows the driver's steering-wheel movements in exactly the same way as in a conventional car, but the servo system provides additional mechanical power so that a normal pull on the steering wheel will operate a heavy steering mechanism. What is happening is that the steering wheel movements merely *control* through valves a source of hydraulic power applied to the steering gear. Similarly, in an electronic amplifier the low-power input signal is used to control a relatively large supply of electrical power so that it will "drive" some load (e.g. another electronic "brick") in accordance with the signals.

To understand how this principle of electrical power control actually works in an amplifier we must go back to the idea of the electronic circuit (Part 5). In a working amplifier there are basically two circuits: a high-power circuit for driving the load and a low-power circuit for controlling the high-power circuit. This is shown schematically in Fig. 1. Here the high-power circuit contains an e.m.f. source (B) capable of

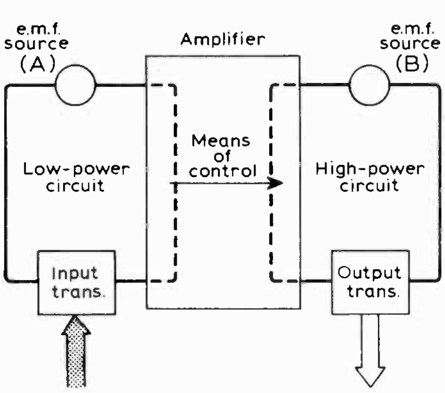


Fig. 1. This diagram shows that the basic function of an amplifier is to enable high power to be controlled by low-power variations.

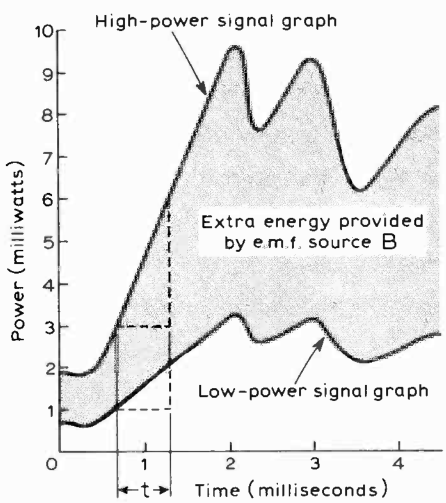


Fig. 2. Graphs of power varying with time: the lower one is an input (controlling) signal applied to an amplifier; the upper one is the resulting output signal.

generating sufficient energy to operate the load to its fullest extent. The load itself we have shown as an output transducer (Part 4) and this could be, for example, a loudspeaker. In the low-power circuit the e.m.f. source (A) need generate only the small amount of energy necessary to enable it and the input transducer—say a carbon microphone—to produce a signal. (Alternatively the transducer may be of the converter type, Fig. 1(a), Part 4, which generates its own electrical energy—say a moving-coil microphone.)

The amplifier proper, shown as a box, acts so that any variation of power with time (a signal) in the low-power circuit results in a corresponding but *larger* variation of power in the high-power circuit, as indicated by the linking arrow. What we mean by "corresponding but larger" variation can be seen from the curves in Fig. 2, which are both graphs of power (in milliwatts) with time (in milliseconds). The high-power signal follows faithfully the variations of the low-power signal, but one can see that the *changes* of power in the former are greater than the corresponding changes in the latter. This, in fact, is what amplification is, and we measure the amount of it by the following formula:

$$\text{Amplification} = \frac{\text{Output signal change}}{\text{Corresponding input signal change}}$$

In Fig. 2, for example, the amount of amplification can be calculated from what happens during the short interval of time t shown on the horizontal scale. During this period the low-power signal increases from 1 to 2 milliwatts (that is, by 1 milliwatt) while the resulting high-power signal increases from 3 to 6 milliwatts (by 3 milliwatts). Thus

$$\text{Amplification} = \frac{3 \text{ milliwatts}}{1 \text{ milliwatt}} = 3$$

Whatever power change occurs in the input circuit will result in a power change 3 times larger in the output circuit. This number, a factor, is called the *gain* of the amplifier.

The extra power in the output signal is, of course, drawn from e.m.f. source (B) in Fig. 1 and is indicated in Fig. 2 by the shaded area (=energy, see Part 8).

How does the amplifier provide the "means of control" in Fig. 1? In Part 7 we discussed methods of controlling electron flows in circuits and in particular a method using the property of resistance. From this idea one could go on to envisage some sort of arrangement in which the electron flow, and hence power, in the output transducer circuit is controlled by a variable resistor, the resistance of which is mechanically varied by a motor, which in turn is actuated by the signal in the low power circuit. Such a system would work but in practice would be cumbersome and expensive and would have severe limitations of performance. Fortunately there are electronic devices which perform the resistance-controlling function without needing mechanical operations—notably the thermionic valve and the transistor.* Each of these devices provides a path for electron flow, and allows the electron flow rate in this path to be varied in proportion to a low-power control signal. As can be seen in Fig. 3, the high-power circuit and the low-power circuit are completed through the electronic control device (as shown by the broken lines).

Fig. 3 is a purely functional diagram of a "one-stage" electronic amplifier. In practice resistors are used in conjunction with the control device, to set the currents through it to required values; and several such stages can be connected in a line, the output of one stage providing the input for the following one.

* From the point of view of external function the word 'valve' would be a good name for both, but the thermionic device came first and so claimed it. 'Transistor' is a contraction of 'transfer resistor'.

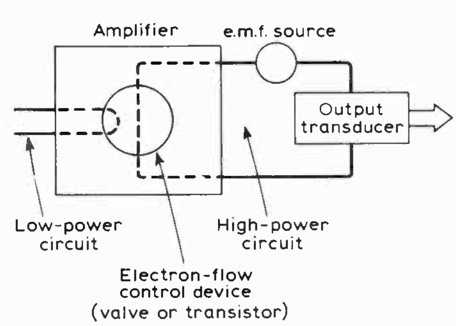


Fig. 3. Use of an electronic device to vary the high power in proportion to the low-power changes.

Direct Current Multimeter

A straightforward design employing the well known '709'

by J. Johnstone

The meter described in this article covers the ranges 1mV to 300V and 1μA to 300mA, switched in a 1-3-10 series. The input impedance on the voltage ranges is 1MΩ/V up to 30V, and a constant 30MΩ on the 100V and 300V ranges. The voltage drop across the input terminals is 1mV at 1μA, rising to 10mV on all other current ranges.

The voltage multipliers and universal shunt, together with their associated switches, are shown in Fig. 1. Ranges up to 30V are obtained by switching multiplier resistors into circuit. As semi-precision resistors are not readily available in values above 10MΩ, the 100V and 300V ranges are obtained by switching shunt resistors into the bottom end of the potential divider. These resistors are explained under the section describing setting up. If a single chain of resistors were used for the universal shunt some awkward values would be involved in obtaining the $\times 3$ ranges; this is avoided by switching in an additional shunt resistor for each range.

The resistors for both the shunt and multiplier chain should be either high stability carbon film or metal film. Metal film resistors are better than carbon film as far as stability, noise level, and thermo-electric effects are concerned. Metal oxide resistors are not suitable, as some types have a very marked thermo-electric effect, generating around 50μV/°C. This effect is due to the junction of the end cap and track forming a thermocouple, and should not be confused with the temperature coefficient of the resistor itself.

In order to reduce the level of input current the integrated circuit amplifier is preceded by a matched pair f.e.t. stage. The loop gain of the amplifier is defined by R_{26}, R_{27} and RV_5, and zero is set by adjusting RV_6. Frequency compensation is obtained by R_{31}, C_1 and C_2, and two diodes, D_1 and D_2, protect the amplifier from excessive inputs. The layout of the amplifier is not critical, but long leads should be avoided, and the instrument should be enclosed in a metal case. In the author's meter, the multiplier and shunt resistors, with the exception of the potentiometers and R_{21} and R_{22}, are mounted directly on to the switch terminals. The amplifier circuit is mounted on a piece of matrix board. Range and function switches—which were made from Maka-switch wafers—and the set zero control are mounted on the front panel, together with the meter and the input terminals for the test leads.

Calibration

The meter is set up by adjusting the five potentiometers and R_{15} and R_{16}. Four 1% resistors are required: 10MΩ, 1MΩ and 1Ω, all 0.5W, and 100Ω

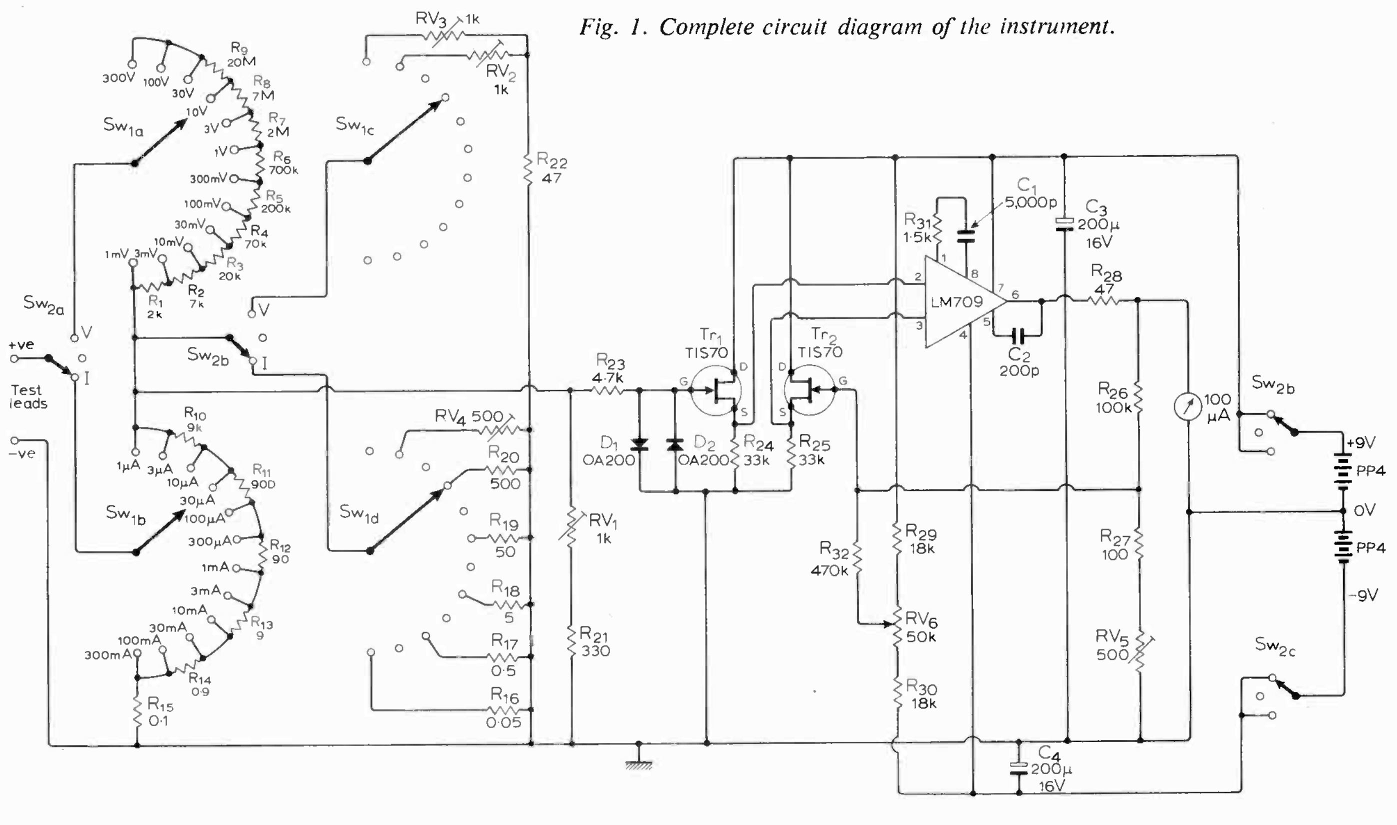


Fig. 1. Complete circuit diagram of the instrument.

Table 1

Range	Use Fig.	R_a Ω	V_S Volts	set f.s.d.
1mV	2(a)	—	10	RV_5
10V	2(b)	0	10	RV_1
100V	2(b)	0	100	RV_2
300V	2(b)	0	300	RV_3
3μA	2(b)	10M	30	RV_4
100mA	2(b)	100	10	R_{15}
300mA	2(b)	100	30	R_{16}

2W—also a low ripple power supply able to deliver 300mA at 10 and 30V, and 1mA at 100V and 300V is required. The order of adjustment is given in Table 1. The circuit of Fig. 2(a) is used to set the 1mV range. For the 10, 100 and 300V ranges the power supply is connected directly to the meter terminals. The three current settings are obtained by using the circuit of Fig. 2(b). Resistors R_{15} and R_{16}, are made from short lengths of resistance wire, and may be adjusted by filing away small amounts. If their value is too high, solder may be run along the wire. At least half an hour should then be allowed for the shunts to cool to room temperature, before any further adjustments are made.

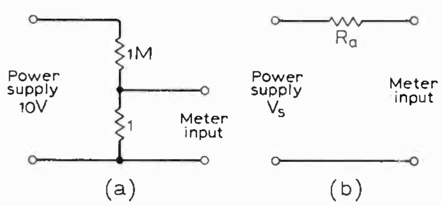


Fig. 2. (a) Circuit to adjust the 1mV range; (b) circuit used to adjust the other ranges.

The adjustment of RV_5 sets the amplifier gain required for 1mV to drive the meter to f.s.d.; RV_1 is then adjusted to correct the overall value of the universal shunt and potential divider. RV_2 and RV_3 reduce the amplifier input on the 100 and 300V ranges by further shunting the universal shunt. RV_4 has a similar effect on the 3μA range. In the author's meter all the potentiometers are multiturn presets; these offer very fine adjustment, but single turn wirewound types could be used and would offer a substantial reduction in cost.

Amplifier zero drift is negligible, after a five minute warm-up period; the zero temperature coefficient has not been properly checked, but appears to be in the region of 5μV/°C; noise level is negligible. No calibration drift has been found after five months' day-to-day use in the laboratory. With intermittent use a battery life of about one year may be expected, as the current drain is very small.

COMPONENTS LIST

Resistors (fixed)
The prefix R and the suffix Ω are omitted in the list below

1 — 2k	12 — 90	23 — 4.7k
2 — 7k	13 — 9	24 — 33k
3 — 20k	14 — 0.9	25 — 33k
4 — 70k	15 — 0.1	26 — 100k
5 — 200k	16 — 0.05	27 — 100
6 — 700k	17 — 0.5	28 — 47
7 — 2M	18 — 5	29 — 18k
8 — 7M	19 — 50	30 — 18k
9 — 20M	20 — 500	31 — 1.5k
10 — 9k	21 — 330	32 — 470k
11 — 900	22 — 47	

Resistors (variable)
The prefix RV and the suffix Ω are omitted in the list below

1 — 1k	3 — 1k	5 — 500
2 — 1k	4 — 500	6 — 50k

Resistors (additional information)
All resistors up to R_{22} as well as R_{24} and R_{25} should be 1% high stability carbon, or metal film. Other resistors should be of similar type, but may be of 5% tolerance. All potentiometers should be wirewound types. Although the resistors and potentiometers are operating at very low power levels, a minimum power rating of 0.5W should be chosen, as this will result in improved long-term stability.

Capacitors
The prefix C has been omitted in the list below

1 — 5,000p	3 — 200μ, 16V
2 — 200p	4 — 200μ, 16V

Other parts
Transistors — TIS70 (Texas)
Integrated circuit — LM709 (Nat. Semiconductor) or similar
Diodes — OA200
Meter—f.s.d. = 100μA
S_1 — 4-pole, 12-way Maka-switch
S_2 — 4-pole, 3-way Maka-switch
Batteries — PP4 or equivalent

Announcements

The subject of discussion at a residential vacation school being organized by the Electronics Division of the I.E.E. is **major developments in circuit theory.** The school will be held at the University College of North Wales, Bangor, from 22nd March to 2nd April. Details are available from the Secretary, I.E.E., Savoy Place, London WC2R OBL. Ref: LS(E).

A residential vacation school on **Semiconductor Circuit Design** is to be held at the University College of Swansea from 19th to 23rd April. Further details may be obtained from the Secretary, I.E.E., Savoy Place, London WC2R OBL.

The I.E.E. is organizing a **microwave solid state residential vacation school** at Leeds University from 12th to 23rd July. Further information can be obtained from the Divisional Secretary (Electronics), I.E.E., Savoy Place, London WC2R OBL.

The **Electronic Components Board** have moved from Winsley Street to Carrier House, Warwick Row, London S.W.1. This change of address also applies to British Radio Valve Manufacturers' Association, Electronic Valve & Semiconductor Manufacturers Association, Radio & Electronic Component Manufacturers Federation and Conference of the Electronics Industry. Tel: 01-828 7411.

The **Electronic Engineering Association** has moved into new offices at Leicester House, 8 Leicester Street, Leicester Square, London WC2H 7BN, which it shares with the British Electrical & Allied Manufacturers' Association.

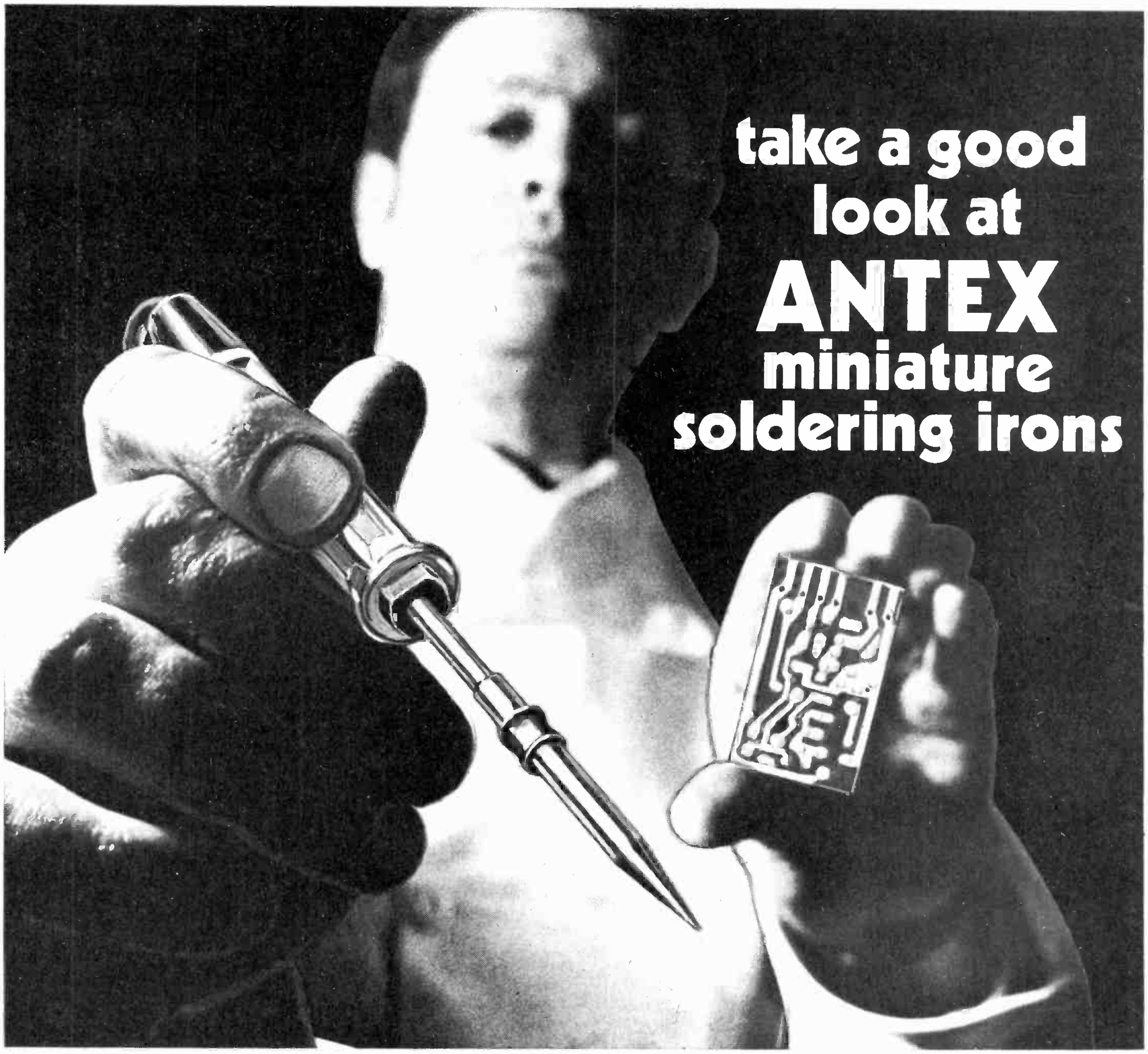
The Society of Electronic and Radio Technicians is to hold a weekend residential symposium on **marine electronics** at Churchill Hall, University of Bristol, from 9th to 12th July.

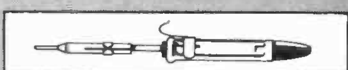
The **British Association for Brazing and Soldering** has been formed with offices at The British Non-Ferrous Metals Research Association, Euston Street, London N.W.1.

The **dimensional standards** room at the Mitcham plant of Mullard Ltd has received a certificate of approval for a wide range of mechanical measurements from the British Calibration Service.

Echometrix Ltd, 113-115 The Broadway, Leigh-on-Sea, Essex, have been appointed U.K. agents for test equipment manufactured by **Nordemende,** of Bremen, W. Germany.

Coventry Controls Ltd, Godiva House, 49 Allesley Old Road, Coventry, CV5 8BU, are now an agent for **"Werma"** of West Germany, manufacturers of audible signalling equipment.





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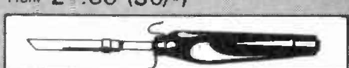

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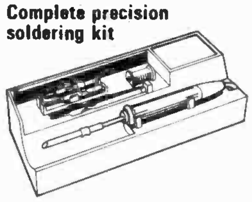

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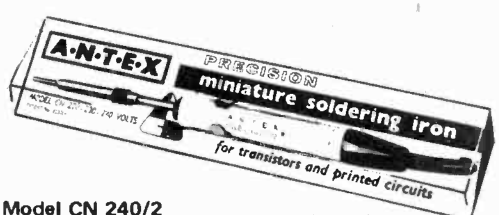

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Choosing a Vidicon

A summary of various tubes based on the vidicon

by D. J. Gibbons, M.A., Ph.D.*

Ten years ago the task of generating a television signal was a job attempted only by the expert. Although the simple vidicon was on the market the majority of television pick-up tubes in use then were photoemissive types which were more difficult to set up for good signal quality. In addition, the most important application of television was for broadcasting entertainment programmes where picture generation was largely confined to the big studios. Today the position is changing rapidly, because the comparative stability and ease of setting up of the modern vidicon (or one of its derivatives) has made it a camera tube that is suitable for a large number of applications. Among these are black-and-white and colour television broadcasting, aerospace telemetry, industrial and scientific c.c.t.v., and amateur television. Further applications from a very wide variety are discussed below. The greatly enlarged range of tubes based on the vidicon has made it much easier to choose the best tube for the job, and many new applications have now been brought within the scope of the vidicon or its derivatives.

Now that a good c.c.t.v. system can be purchased for less than an audio hi-fi set up [2] television signal generation, whether for a picture or not, is becoming increasingly within the grasp of the low-budget user in the industrial, educational, scientific and medical spheres as well as of the amateur and home user.

A review of the basic principles involved in generating a television signal is to be found in Ref. 7. The present comments and tables are intended to help make the vidicon a much more familiar device to those people whose primary task is not the generation of pictures for television broadcasting. To do this well still needs the co-operative skills of equipment manufacturers, lighting experts, cameramen and technicians in a studio. This article should be helpful to the ever-increasing number of users who now use a vidicon with much the same confidence as they select and use a photographic camera or a transistor.

The vidicon has lent itself to modifications more than any other pick-up tube. Fig. 1 gives some idea of the present-day range of tubes; the selection shown here is by no means complete.

Most modifications to the basic studio broadcasting versions have been in the directions of matching the spectral response to regions of the electromagnetic spectrum outside the visible and increasing the sensitivity in weakly illuminated conditions. Other special versions, however, are made for extra-high resolution pictures, for severe environmental conditions such as vibration or nuclear radiation, for applications where size is a constraint, for portable light-weight transistorized cameras, for slow-scan TV, and for colour broadcasting cameras.

Roughly speaking diameters of basic vidicons (excluding coils) range from 13 to 43 mm and lengths from 86 to 265mm. Almost the entire electromagnetic spectrum can be covered, from 200 keV X-rays (8 pm) through the u.v. and visible to 2.4 microns in the i.r. Sensitivities range from minimum target white light illumination levels of 1.0-10.0 lux for a simple broadcast quality or visible-light industrial quality vidicon to 10^{-2} lx for an intensifier vidicon or SEC tube. Light levels producing a total incident light flux on the target of less than about 10^{-6}lm (0.01 lx on the faceplate of a 26.7mm diameter vidicon) give rise usually to a more or less "laggy" picture, that is, one in which the signal generated by fast moving objects becomes smeared because a small amount of image retention occurs, fading in the tens of milliseconds range.

TABLE 1 Resolution of various types of Vidicon

TV lines	Points/ line	Line pairs/ diameter	M/M integral mesh	M/M sep. mesh	E/M or M/E	E/E	High resn. E/E	115mm FPS
0	0	0	100	100	100	100	100	100
100	133	83	95	96	98	89	99	100
200	267	167	80	90	88	71	90	93
300	400	250	60	81	71	45	62	70
400	533	333	45	70	57	28	39	52
500	667	417	34	54	40	17	28	39
600	800	500	25	39	25	11		30
700	933	583	18	30	15	7		23
800	1067	667	10	25	9			17
900	1200	750						12
1000	1333	833						8
Source of data			1	2	3	4	5	6

Symbols: M-magnetic. E-electrostatic. FPS-focus projection scanning.

With a high quality lens system and good scanning and focus coils, the resolution of most vidicons will lie within 10% of these modulation figures. The principal exceptions are tubes of diameters other than 26mm, the silicon vidicons, and lead oxide types.

Source of data: (1) EEV Co abbreviated catalogue (curve 5), (2) EEV Co abbreviated catalogue (curve 7), (3) Westinghouse slow-scan vidicon data sheet, (4) Westinghouse slow-scan vidicon data sheet, (5) EMI all-electrostatic vidicon data sheet, (6) GE, FPS vidicon data sheet.

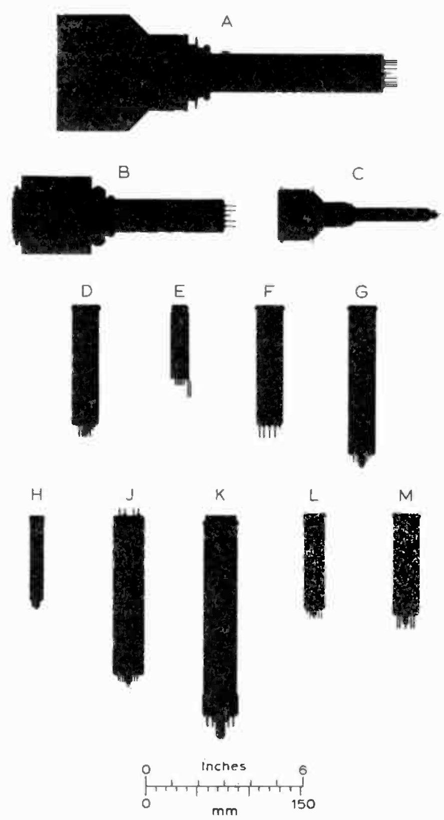

Fig. 1 Silhouettes to scale of modern vidicons and tubes based on the vidicon. A, intensifier vidicon; B, Esicon or SEC tube (TH-CSF and Westinghouse); C, Ebitron (EMI); D, F, G, H, K, L, M, various vidicons; E, integral-coil vidicon (GE); J, Printicon (EMI).

* Research laboratories of EMI Ltd.

Vidicons vary over wide limits in this respect, but the lead oxide types in particular have very low lag. Other types are manufactured to provide an extended lag response for special applications (see Table 5). General broadcast and industrial quality vidicons are increasingly used to generate particularly high quality and stable television signals whenever the scene illumination is capable of being maintained at a reasonably high level. Examples are TV film scanning or remote studio application, as well as many industrial scientific, educational, and c.c.t.v. uses where lighting can be readily controlled, or where broadcast-quality short lag is not demanded with very fast moving scenes.

Leaving aside for the moment the question of lag, target illumination levels, lower than 10^{-2}lx cannot be used at standard picture repetition rates because the video output signal from the vidicon becomes very noisy due to the particulate nature of the light. However, target illumination levels below 10^{-3}lx can be used by integrating the signal for several tens of seconds on a special slow-scan vidicon (Table 7).

If a lens optics system is used and the various tubes are put in order of white-light sensitivity (defined as video signal output for a given scene brightness), the list is as follows: Ebitron secondary electron conduction (SEC), intensifier vidicons, silicon and lead oxide vidicons, 22mm vidicons, 13mm vidicons. For a given depth of focus, the sensitivity of a camera using a lens system and a vidicon with a linear light transfer characteristic depends only on the f-number of the optical system and the vidicon signal output for a given number of lumens incident on the faceplate. Thus the camera sensitivity does not depend on tube diameter unless fibre-optics is used exclusively, in which case the sensitivity is greater for large diameter fibre-optics faceplate vidicons.

Manufacturers tend to specify in different terms the sensitivity of tubes in which the light transfer characteristic is not linear, since questions of light and signal level, dark current and emergence of background blemishes all need to be specified unless purely subjective criteria are used[9].

It is thus a simple matter accurately to compare the sensitivities of the silicon, lead oxide and ultra-violet types of vidicon, the SEC tube and the Ebitron, but not those of intensifier vidicons, or standard types for visible light applications, as shown in Table 2. These tubes have a less-than-linear light transfer characteristic and thus have a higher sensitivity at low light levels. Uniformity of dark current is more important than its absolute value, since all that is needed in the video channel to compensate for a constant dark current is admixture of a d.c. potential, although manufacturers of broadcast-quality colour cameras prefer negligible dark current[10]. The foregoing list can therefore only be used as a guide.

The usual video bandwidth for a

TABLE 2 Basic Vidicons for Visible Light

Type No.	Manufacturer	Scanning	Focus	Mesh	Spectral curve*	Max. length (mm)	Max. bulb dia. (mm)	Recommended applications
TH9806	TH-CSF	M	M	I	D	165	26.7	e, b
TH9806PA	TH-CSF	M	M	S	D	165	26.7	e, b
TH9807	TH-CSF	M	M	I	D	165	26.7	t, b
TH9807PA	TH-CSF	M	M	S	D	165	26.7	t, b
TH9808	TH-CSF	M	M	I	D	165	26.7	i
TH9808PA	TH-CSF	M	M	S	D	165	26.7	i
TH9812	TH-CSF	M	M	I	D	165	26.7	i′
TH9812PA	TH-CSF	M	M	S	D	165	26.7	i′
TH9813	TH-CSF	M	E	I	D	165	26.7	w
TH9814	TH-CSF	M	M	I	D	135	26.7	i, m
TH9814PA	TH-CSF	M	M	S	D	135	26.7	i, m
TH9815	TH-CSF	M	M	I	D	165	26.7	z
TH9815PA	TH-CSF	M	M	S	D	165	26.7	z
TH9817	TH-CSF	M	M	I	D	165	26.5	b, c
TH9817PA	TH-CSF	M	M	S	D	165	26.7	b, c
TH9821	TH-CSF	E	E	S	D	165	26.7	s, m
TH9823	TH-CSF	E	M	S	D	112	26.7	w, i, *S*
TH9824	TH-CSF	E	E	S	D	165	26.7	s
TH9830PA	TH-CSF	M	M	S	D	200	38.5	q, t, b, c, i′
TH9831	TH-CSF	M	E	I	D	265	38.5	b, c, t
9677 S1	EMI	M	M	S	C	159	26.6	b, q
9677 S2	EMI	M	M	S	C	159	26.6	b, e
9677 F1	EMI	M	M	S	C	159	26.6	q, t
9677 F2	EMI	M	M	S	C	159	26.6	t, e
9677 B	EMI	M	M	S	C	159	26.6	L, i′, z
9677 M	EMI	M	M	S	C	159	26.6	r
9677 C	EMI	M	M	S	C	159	26.6	i
9677 Amateur	EMI	M	M	S	C	159	26.6	a, p, x
9706 S1	EMI	M	M	S	C	130	26.6	b, q
9706 S2	EMI	M	M	S	C	130	26.6	b, e
9706 F1	EMI	M	M	S	C	130	26.6	t, q
9706 F2	EMI	M	M	S	C	130	26.6	e, t
9706 B	EMI	M	M	S	C	130	26.6	L, i′, z
9706 C	EMI	M	M	S	C	130	26.6	i
9706 M	EMI	M	M	S	C	130	26.6	r
9728 S1	EMI	M	M	S	C	159	26.6	b, q
9728 S2	EMI	M	M	S	C	159	26.6	b, e
9728 F1	EMI	M	M	S	C	159	26.6	t, q
9728 F2	EMI	M	M	S	C	159	26.6	t, e
9728 B	EMI	M	M	S	C	159	26.6	L, i′, z
9728 C	EMI	M	M	S	C	159	26.6	i
9728 M	EMI	M	M	S	C	159	26.6	r
9728 Amateur	EMI	M	M	S	C	159	26.6	a, p, x
9730 B	EMI	M	M	S	C	130	26.6	L, R, i, m, n
9730 C	EMI	M	M	S	C	130	26.6	i, R, m, n
9730 M	EMI	M	M	S	C	130	26.6	r, R
9745	EMI	E	E	S	C	159	26.6	w, i
9877	EMI	M	M	S	D	159	26.6	*S*, U
9806	EMI	M	M	S	D	130	26.6	*S*, U
9828	EMI	M	M	S	D	159	26.6	*S*, U
9845	EMI	E	E	S	D	159	26.6	*S*, w, U
1255	Heimann	M	M	I	B	162	26.6	g, o
2255 NOR	Heimann	M	M	S	B	162	26.6	b, c
2255 IND	Heimann	M	M	S	B	162	26.6	i
2255 AMR	Heimann	M	M	S	B	162	26.6	a, x, r
2255 FIM	Heimann	M	M	S	B	162	26.6	t
2255 ROE	Heimann	M	M	S	B	162	26.6	z, L
2255 ENT	Heimann	M	M	S	B	162	26.6	a, p, x
2700	Heimann	M	E	S	B	163	26.6	w, l, c′
XQ1010	Philips/Mullard	E	E	S	D	162	26	w, i, R, *S*
XQ1030	Philips/Mullard	M	M	I	D	152	26	a, i, p
XQ1040	Philips/Mullard	M	M	S	D	162	26	c′, i
XQ1041	Philips/Mullard	M	M	S		162	26	L, i, z
XQ1042	Philips/Mullard	M	M	S	D	162	26	b, e
XQ1043	Philips/Mullard	M	M	S	D	162	26	i
XQ1044	Philips/Mullard	M	M	S	D	162	26	i, r
NEC 7038	NEC	M	M	I	C	—	26.7	g, i
NEC 7262A	NEC	M	M	I	—	—	26.7	g, w, i
NEC 7735A	NEC	M	M	I	—	—	26.7	c′, e, g, i
NEC 8134	NEC	M	E	S	—	—	26.1	b, c, c′, w, i
NEC 8134-VI	NEC	M	E	S	D	161.5	26.1	c, t, b, w
NEC 8507	NEC	M	M	S	—	—	26.7	b, c, c′, i
NEC 8480	NEC	M	E	S	C	263.5	38.3	b, d, i′
NEC 8572	NEC	M	M	S	C	165	26.7	t
NEC 8480-VI	NEC	M	E	S	C	263.5	38.3	b, t′
4493/P893	EEV	M	E	S	—	162	26	c′, (red)
4494/P894	EEV	M	E	S	—	162	26	c′, (green)
4495/P895	EEV	M	E	S	—	162	26	c′, (blue)
7038	EEV	M	M	I	C	162	26.7	t, k
7262A	EEV	M	M	I	D	131.5	26.1	w, i, c′
7735B	EEV	M	M	I	D	162	26.7	b, e, t, i
8134	EEV	M	E	S	D	162	26.1	b, i
8134 V1	EEV	M	E	S	D	162	26.1	c, b
8507A	EEV	M	M	S	D	162	26.7	b, q, i′, e, t′, a
8541A	EEV	M	M	S	D	162	26.7	b, e, i, t′
8572	EEV	M	M	S	C	162	26	b, t, k
8625	EEV	M	M	S	B	162	26.7	b, e
8626	EEV	M	M	S	B	162	26.7	b, e
P810	EEV	M	M	I	C/D	162	26.7	i, r
P831	EEV	M	M	S	D	131.6	26.7	m, i, R
P844	EEV	M	M	S	C	162	26.7	b, t, k
P848	EEV	M	M	S	C/D	162	26.7	i, e, r
P849	EEV	M	M	S	C/D	162	26.7	i, e, r
P860	EEV	M	M	I	C	162	26.7	b, e
P863	EEV	M	M	S	D	162	26.7	m, i, R
7262A	Hitachi	M	M	I	D	131.5	26.7	i
7735A	Hitachi	M	M	I	D	162	26.7	i
8051	Hitachi	M	M	S	C	203	38.4	b, t, d
8134/VI	Hitachi	M	E	I	D	162	26.1	b, t, w, c′
8134A	Hitachi	E	M	S	C	159	26	*S*
8480/VI	Hitachi	M	E	I	C	266	38.2	b, t, w, c′
8507	Hitachi	M	M	S	C	162	26.7	b, i, c′

Type No.	Manufacturer	Scanning	Focus	Mesh	Spectral curve*	Max. length (mm)	Max. bulb dia. (mm)	Recommended applications
8507B	Hitachi	M	M	S	C	162	26.7	b, i, c′
8541B	Hitachi	M	M	S	D	159	26	b, i, c′
8572	Hitachi	M	M	S	C	162	26.7	i, b, t
8758	Hitachi	M	M	I	D	136	26.7	i, w
8758A	Hitachi	M	M	I	D	136	26.7	w, i
8815	Hitachi	M	M/E	I	C	266	38.2	b, t, c′
8816	Hitachi	M	M/E	I	D	162	26.1	b, t, c′
F4016	ITT	E	E	S	C	142	25.9	i, w, m, *S*
F4058	ITT	M	M	S	C	131	25.9	w, *S*
F4064	ITT	M	E	S	C	148	25.9	w, *S*
F4085	ITT	M	M	S	C	132	25.9	w, *S*
F4070	ITT	E	M	S	C	112	25.9	w, n, *S*
2048	RCA	M	M	I	C	133	26.2	m, i, a, R
4478	RCA	M	M	I	D	165	26.7	p, g, i
4493, 4494, 4495	RCA	M	E	S	D	163	26.1	b, c, i
4503A	RCA	M	M	S	D	133	26.1	m, i, a, R
4514	RCA	E	E	S	D	148	25.8	m, i, R, G
7038	RCA	M	M	I	C	165	26.7	t
7262A	RCA	M	M	I	D	132	26.7	b, w, i
7263A	RCA	M	M	I	D	132	26.8	m, i, w, a, R
7735	RCA	M	M	I	D	165	26.8	p, g, i
7735A	RCA	M	M	I	D	165	26.8	g, i
7735B	RCA	M	M	I	D	165	26.8	i′
8051	RCA	M	M	S	C	204	38	t, d, b
8134	RCA	M	E	S	D	161	26.2	i, w, c
8134/VI	RCA	M	E	S	D	161	26.2	c, w, b
8521	RCA	M	M	S	D	203	38	i
8480	RCA	M	E	S	C	263	38	t, w, d
8480/VI	RCA	M	E	S	C	263	38	c′, w, b
8507A	RCA	M	M	S	D	162	26.8	I, b
8541A	RCA	M	M	S	D	162	26.8	b, i
8573A	RCA	M	M	S	D	165	26.8	i′
8567	RCA	M	E	S	D	162	26.2	m, i, w, R, e
C23033	RCA	M	E	S	D	203	38	*S*
C23066	RCA	M	M	S	D	133	26.1	*S*, R
C23133	RCA	M	M	S	D	102	26†	u, *S*
C74127	RCA	M	M	I	D	132	26.8	n, m, i, w, *S*, R, j, r
TD1319	GEC	M	M	I	C	162	26.6	i
TD1325-001	GEC	M	M	I	C	162	26.6	i
TD1337	GEC	M	E	S	C	162	26.6	w
TD1339-001	GEC	M	E	S	C	147	26.6	R, w
TD1341-001	GEC	M	M	S	C	162	26.6	i′
TD1343-011	GEC	E	E	S	C	134	25.9	R
TD1347-001	GEC	E	E	S	C	147	26.6	R, w, n
TD1347-021	GEC	E	E	S	B/C	134	25.9	R, w, n, r
TD1348-001	GEC	M	M	S	C	163	26.6	b, i
TD1354-001	GEC	M	M	I	C	162	26.4	b, i
TD1355-010	GEC	M	M	S	C	121	25.9	R, w
7038	GEC	M	M	I	C	162	26.6	t
7226	GEC	M	M	I	C	118	26.6	w
7226A	GEC	M	M	I	C	133	25.8	R, w
GEC 7291	GEC	M	M	I	C	162	26.6	t, *S*
7522	GEC	E	E	S	C/D	162	26.6	w
7038	GE	M	M	S	C	151	26	t, b, i
7038V	GE	M	M	S	C	151	26	t′, b
7226	GE	M	M	I	C	151	26	w, i
7262a	GE	M	M	I	D	151	26	w, i, L
7363a	GE	M	M	I	D	151	26	R, w, i
7735a	GE	M	M	I	D	165	26	b, i
7735B	GE	M	M	I	D	165	26	b, L
7735BX	GE	M	M	I	D	165	26	z
8134	GE	E	M	S	C	165	26	i, g
8134V	GE	E	N	S	C	165	26	t′, i, c
8484	GE	M	M	I	C	165	26	w, i
8507	GE	M	M	S	D	165	26	b, i
8507a	GE	M	M	S	D	165	26	b
8541	GE	M	M	S	D	165	26	w, b, i
8541A	GE	M	M	S	D	165	26	w, b, i, r
8541X	GE	M	M	S	D	165	26	z
8572	GE	M	M	S	C	165	26	t
8572V	GE	M	M	S	C	165	26	t, t′
8604	GE	M	M	S	C	165	26	w, t, t′
Z7872	GE	E	M	S	C	95	26	*S*, w, (lim. resn. 800 TVL)
Z7873	GE	E	M	S	C	114	26	*S*, w, (lim. resn. 1200 TVL)
Z7894	GE	E	M	S	C	114	29	*S*, w, (lim. resn. 1000 TVL)
Z7912	GE	M	M	S	D	151	26	R, w, i
Z7917	GE	E	M	S	C	140	29	*S*, w, (lim. resn. 1000 TVL)
Z7929	GE	E	M	S	D	151	26	b, *S*
Z7929B	GE	E	M	S	D	151	26	b, c, *S* (B channel)
Z7929G	GE	E	M	S	D	151	26	b, c, *S* (G channel)
Z7929R	GE	E	M	S	D	151	26	b, c, *S* (R channel)
Z7933	GE	M	M	S	D	151	26	R, w, i, *S* (low pwr. htr. cpw. Z7912)

KEY TO APPLICATIONS RECOMMENDED BY MANUFACTURERS

† A dagger beside a dimension means inclusive of integral coils; * see figure 2; a, amateur and home use; b, black-and-white live-scene studio broadcasting; c, colour live-scene broadcasting; c′, CCTV and industrial live-scene colour; d, data transmission; e, educational black-and-white; E electrostatic; f, may be used without faceplace discoloration in areas of high radiation; g, general purpose; G, US government end-use only; h, high resolution; i, industrial; i′, extra high quality industrial; I, integral; j, internal reticule; k, caption scanning; L low light level; m, military; M, magnetic; n, aerospace; o, obsolescent replacement type; p, low priced economy tube; q, extra high picture quality; r, relaxed blemish specification; R, ruggedized; s, scientific; *S*, development tube available on sampling basis; t, telecine (TV film scanning); t′, colour telecine; u, integral coils; U, underwater television; v, very high pressures; w, lightweight cameras; x, experimental use; y, slow-speed scan; z, suitable for viewing X-ray fluoroscope screens; S, separate mesh.

high-resolution flicker-free television picture is between 3 and 10 MHz, at which all public entertainment broadcasting is undertaken. However, this is not the optimum for a high signal/noise ratio at low light levels in those applications where picture flickering is not troublesome, but is obviously linked to the picture repetition rate and the resolution required. Provided that the bandwidth is no higher than that needed for the resolution, the highest signal/noise ratio obtains at about 300 kHz for a 405-line picture. The exact scanning conditions may be readily calculated from the analysis given in Ref. 1. The enhanced signal/noise ratio results from employing the same number of scanning lines in the picture and the same horizontal resolution, but a lower video bandwidth and a slower frame rate.

Basic vidicons for visible light applications

This is by far the largest category, because tubes of this kind are widely used for applications which include broadcasting, c.c.t.v., industrial, educational and medical purposes, missile telemetry, space TV, and telecine (film scanning). Earlier tubes were specified to a larger extent than now by subjective criteria, such as whether a television picture 'looked good' or whether there were many background blemishes visible. Such valuable tests are always made, together with others, on all tubes, especially those employed in entertainment television. However, particularly since the introduction of multi-tube colour cameras, a much greater emphasis is placed on specifying more objective measurements such as light transfer characteristic, spurious signals, stability against light overload, and picture lag[10]. Therefore it is now possible to select a tube with much greater precision than formerly, provided that it is possible clearly to define tube requirements; this tends to be easier to do in scientific and industrial applications, and is more important in the design of colour cameras for broadcasting[10].

The electron beam can be scanned and focused either magnetically or electrostatically; this gives rise to four possible varieties of vidicon. Highest resolution tubes employ magnetic deflection and focus, next in resolution capability come those with magnetic focusing or deflection and electrostatic deflection or focusing, and then come the all-electrostatic tubes. The latter are capable of yielding the smallest cameras for a given target size, and are particularly well suited for small light-weight transistorized cameras of low power consumption, or for industrial uses where space is at a premium.

The most common and significant variation in electrode structure of all-magnetic tubes is the connection to the mesh electrode (g_4), which may be internally connected or brought out separately. Although separate mesh tubes require an extra voltage, a big gain in resolving power is attainable[8]. The optimum ratio of mesh to g_3 voltage for best geometry or for best uniformity lies in the range 1.2/1 to 1.7/1 depending on the scanning and focus coils used. The mesh should always be operated at a higher potential than g_3, otherwise most of its advantages are lost; in electrostatic tubes, g_5 is the separate mesh and this must be operated at the manufacturer's recommended voltage.

It is difficult to make a strict comparison between the resolving powers of tubes made by different manufacturers because different ways of specifying this are often used. 'Limiting resolution' is a subjective estimate so it cannot be used with precision, especially when different people make the test: a rough quantitative figure would be 2-3% output signal compared with the very low frequency output at the same light level. This is 'modulation depth'. Other ways of quoting resolution depend on specifying the modulation depth of a given number of spots per line or number of TV lines.

Table 1 summarizes the resolution figures for different types of vidicons, together with conversions from different ways of specifying this.

It must be emphasized that in magnetically scanned tubes, such factors as resolution, deflection defocusing and scanning orthogonality are very much a function of the scanning and focus coils used. The new printed-circuit scanning coils eliminate many of the disadvantages of the older kinds[3].

Obviously, the tables and comments can in no way replace the more detailed information to be found in the manufacturer's data sheets. An exact price for any country in the world may be obtained from his agent or from one of the manufacturers listed in next month's article. Prices range from about £10 for an economy or amateur-grade standard vidicon to £135 for a broadcast-quality tube; lead oxide types tend to be somewhat higher, and these range from about £500 to £600 for broadcast quality tubes, with £300 or so for industrial tubes and £50 each for setting-up tubes.

TABLE 3 Fibre Optic End-Window Tubes

Type No.	Manufacturer	Type	Sensitivity µA/lx	Notes	Resolution
WX30654	Westinghouse	Intensifier	9 @ 0.01 lx	*S*	30% @ 300 TV lines
TH9611	TH-CSF	Intensifier	1 @ 0.01 lx		
WL30691	Westinghouse	SEC	5 @ 0.01 lx	*S*	38% @ 300 TV lines
TH538	TH-CSF	Esicon	5 @ 0.01 lx		{ 40% @ 300 TV lines 10% @ 450 TV lines
TH9812FO	TH-CSF	FO vidicon	0.025*		
TH9813FO	TH-CSF	FO vidicon	0.025*		
TH9830FO	TH-CSF	FO vidicon	0.025*	h, q	85% at 400 TV lines
2255FO	Heimann	FO vidicon	0.027*		
P831F	EEV	FO vidicon	0.03*	R	
9686	EMI	FO vidicon	0.03*		1,000 TV lines limiting
9677D	EMI	FO vidicon		*S*	
9606D	EMI	FO vidicon		*S*	
9806D	EMI	FO vidicon		*S*	
9828D	EMI	FO vidicon		*S*	
9830D	EMI	FO vidicon		*S*	
9877D	EMI	FO vidicon		*S*	
C23055 (A)	RCA	(38mm) FO vidicon	0.02*-0.2*	Type A has integral clamping ring for coupling other FO components. *S*	
C23112 (A)	RCA	26.6mm FO vidicon	0.02*	Type A has integral clamping ring for coupling other FO components. *S*, R	
6XQ	Philips/Mullard	FO, PbO vidicon	0.14	*S*	650 TV lines limiting
7XQ	Philips/Mullard	FO, PbO vidicon	0.1	*S*	650 TV lines limiting
8XQ	Philips/Mullard	26mm FO, PbO vidicon	0.12	*S*	25% at 400 TVL
E 1004 F	Heimann	SEC	5	26mm diagonal	40% at 400 TVL
E 1322	Heimann	Intensifier	1		
E 1550	Heimann	Intensifier	1		

* Approximate. Sensitivity is higher for high dark currents or low illumination levels.
Other manufacturers offer to fit a fibre-optics end-window to special order in any of their standard range of tubes.
Symbols: h—high resolution. L—low light-level. q—extra high picture quality. R—ruggedized.
S—developmental tube available on a sampling basis.

TABLE 4 High Sensitivity Tubes used with Lens Optics

It should be noted that if tubes such as the intensifier vidicon or the SEC tube are used with lens optics, a very large angle of convergence should not be employed in the lens system. Not all tubes shown in Table 3 are listed here.

Type No.	Manufacturer	Type		Sensitivity µA/lumen	Resolution
9777	EMI	Ebitron	*S*	> 18,000	42% @ 400 TV lines
WL30691	Westinghouse	SEC		12,000-15,000	{ 62% @ 200 TV lines 38% @ 300 TV lines 20% @ 400 TV lines
TH538	TH-CSF	Esicon		15,000	{ 38% @ 300 TV lines 12% @ 450 TV lines
WX30654	Westinghouse	Intensifier	*S*	3,200	{ 65% @ 200 TV lines 30% @ 400 TV lines
TH9611	TH-CSF	Intensifier			
C23136	RCA	Silicon target vidicon	*S*	580*	{ 68% @ 200 TV lines 45% @ 300 TV lines 30% @ 400 V lines
XQ1023	Philips	Extra-red Plumbicon		> 450*	55% @ 400 TV lines
Z7974	GE	Intensifier	*S*	2,600-3,800	{ 85% @ 200 TV lines 52% @ 400 TV lines

* With manufacturer's recommended i.r. filter in position
S Developmental type available on an active sampling basis.

High sensitivity tubes

Since a vidicon type tube generates no noise, the signal/noise ratio of the video output signal depends on the signal level and the design of the TV head amplifier[1]. All commercially available TV systems incorporate a head amplifier designed so that the noise is minimized. However, in a standard television system employing a modified vidicon with a pre-scanning gain of 15-40, the signal/noise ratio is determined less by the head amplifier than by the shot noise in the photo-current.

It is possible to achieve a system signal/noise ratio nearly equal to the primary photo-current noise, which itself is very close to the signal/shot-noise ratio in the light—hence the term ultimate sensitivity is often applied to these tubes. To attain this limit at very slow scanning speeds may require an even larger pre-scanning gain to give an output signal of about 150 nA; this extra gain might be obtained from, for example, a separate image intensifier. A further advantage of operating the vidicon scanning section at a signal output level of about 150 nA or more is that the lag is negligible with one of the photo-conductors shown in Fig. 2, B, C, D, or Fig. 3, G, H or J.

Pre-scanning amplification may be achieved through incorporation of an image intensifier fibre-optic coupled to a fibre-optic vidicon (intensifier vidicon); through electron bombardment induced conductivity (Ebitron) or the phenomenon of secondary electron conduction, (SEC tube or Esicon). Profiles of these tubes to scale are shown in Fig. 1. Spectral characteristics of photo-emissive cathodes used in tubes of this type are shown in Fig. 4. Vidicons with fibre-optic faceplates (which have an effective f/1.0 optical system) are shown in Table 3. These vidicons may be compared directly with the intensifier vidicon and the SEC tube since these also employ fibre-optics input

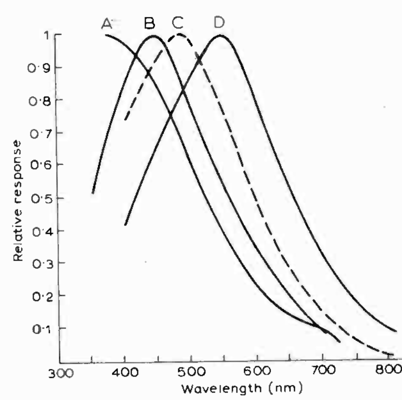

Fig. 2 Spectral response curves for various vidicon targets in which the light transfer characteristic is not linear. Similar response curves do not imply identical targets; in particular, factors such as dark-current uniformity and resistance to "burn-in" may be different as well as other parameters

TABLE 5 Long Storage Photoconductor Vidicons

Type	Manufacturer	Scanning	Focus	Applications
TD1325-044	GEC	M	M	r, v, ch, m
TD1326	GEC	M	M	d, s
P865	EEV	M	M	d, w
4500	RCA	M	M	s, i, m, G
4542	RCA	M	M	L, W
C23063	RCA	M	M	*S*
Z7856	GE			W, d, *S*
Permachons (Westinghouse)				
WX-5123	Westinghouse	M	M	s, t, *S*

Symbols: ch—transmitting only changes in readings. d—p.p.i. radar display distribution. L—very long lag. m—moving target indicators. r—elimination of ground radar clutter. s—slow scan TV. *S*—development type. t—temporary storage of transient events. i—limited motion industrial TV. v—narrow bandwidth "difference" video transmission. W—Weather radar. G—US Government use only. w—compact lightweight cameras.

systems. The important sensitivity criterion here is μA/lux. specified with the faceplate area, and not μA/lumen alone, which is the sensitivity specified for any tube employing lens imaging. Such fibre-optic end-window tubes can be coupled directly to other fibre-optics devices such as a light-pipe or an image intensifier, or used for in-contact film scanning and applications such as image conversion by using a phosphor deposited directly on the fibre-optic window.

Since conventional lens optics may be used with tubes employing fibre-optic faceplates provided that very high f-number lenses are not used, it is possible to compare all high-sensitivity tubes. Table 4 compares the sensitivity of these tubes when used with conventional lens optics of not too high light-convergence angle. Their use for satellite astronomy has been proposed.

Storage vidicons

It is often necessary to retrieve information from a television signal waveform as a repeated sequence of outputs. Two types of vidicon are made specially for this application.

In the first type, the target of the tube is so designed that the signal decays very slowly with successive scans; this is brought about partly by a slow decay of photoconductivity, and partly through the electron beam scanning off only a small proportion of the available charge pattern in each sweep. Tubes of this kind are used in p.p.i. to TV scan conversion for bright distributed radar displays, and in other applications where it is necessary to separate the functions of display and storage.

The target in the second type of tube, the Permachon, is capable of regenerating the scanned-off signal, to permit continuous reading for up to 30 minutes. If erasure of the stored information is required, this may be done quite simply in a single scanning period by interrupting the scanning beam. An alternative version uses a separate gun to write-in the information, but otherwise the storage properties of the target are the same. This scan-conversion Permachon can be usefully employed in TV systems conversion as well as for other purposes where somewhat greater flexibility is required than is available with the first type (Table 5).

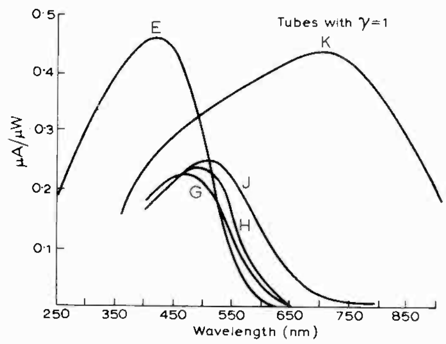

Fig. 3 Spectral sensitivity curves for various types of vidicon target in which the light transfer characteristic is linear.

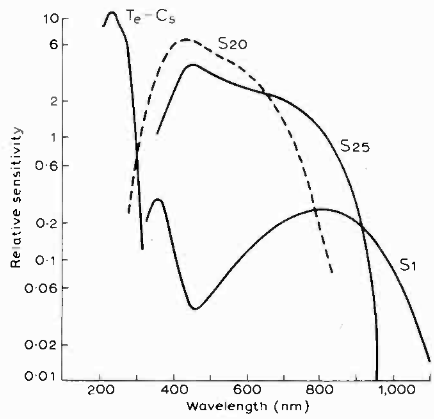

Fig. 4. Spectral response curves for photoemissive cathodes.

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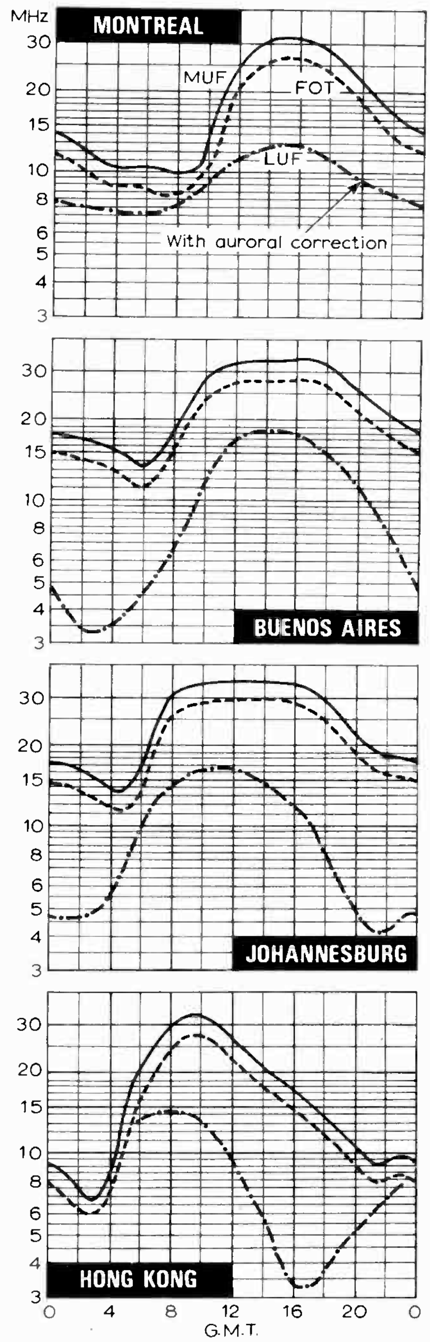
H.F. Predictions—February

The charts show median standard MUF optimum traffic frequency and lowest usable frequency for reception in the U.K. LUFs were calculated by Cable & Wireless for specific point-to-point telegraph circuits. LUFs for domestic reception of high-power broadcasting stations would be slightly higher and for the amateur service considerably higher, especially during daylight.

Commercial working frequencies are kept below FOT to allow for day-to-day variations in the ionosphere and seasonal trend over the month.

Amateur "openings" can be expected on bands up to 15% above MUF, but it is not possible to say on which days these will occur.



February Meetings

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

LONDON

3rd. IERE—"Electronic scanning systems" by M. F. Radord at 18.00 at 9 Bedford Sq., W.C.1.

4th. RTS—Shoenberg Memorial Lecture "The life and work of Sir Isaac Shoenberg" by Prof. J. D. McGee at 19.00 at the IEE, Savoy Pl., W.C.2.

9th. Royal Instn.—Schools Lecture "Waves and vibrations" by Prof. R. King at 17.30 (to be repeated on 10th, 16th, 17th & 18th) at 21 Albemarle St., W.1.

9th. AES—"Acoustic design of monitoring rooms" by Kenneth Shearer at 19.15 at the Mechanical Eng'g Dept., Imperial College, Exhibition Rd., S.W.7.

10th. IEE—"Design and constructional techniques for microelectronic equipment" by F. A. Robertson at 17.30 at Savoy Pl., W.C.2.

12th. IPPS/Brit.Soc. of Audiology—"Acoustic measurement in audiology" at 14.00 at the Inst. of Mech. Engrs, 1 Birdcage Walk, S.W.1.

15th. IEETE—"The engineer in the modern world" by the R. Hon. Anthony Wedgwood Benn at 18.00 at the IEE, Savoy Pl., W.C.2.

17th. BKSTS—"Acoustics and percussion instruments" by Dr. W. H. George at 19.30 at the College of Music, 47 Gt. Marlborough St., W.1.

18th. RTS—"Colour EVR" by Sir Francis McLean & B. J. Rogers at 19.00 at the ITA, 70 Brompton Rd, S.W.3.

19th. IEE—Discussion on "Modern developments in graphic recording devices" at 17.30 at Savoy Pl., W.C.2.

24th. IEE/R.Ae.S.—Discussion on "Built-in test equipment for the Concorde" at 18.00 at 4 Hamilton Pl., W.1.

24th. SERT—"Algorithms" by J. H. Robinson at 19.00 at the Manson Theatre, School of Hygiene & Tropical Medicine, Keppel St., W.C.1.

25th. IERE—"Television communication by satellite and conventional systems" by D. J. Whyte at 19.30 at the Medway College of Technology.

26th. Brit. Acoustical Soc.—Meeting on "Scattering phenomena in acoustics" at 14.30 at the Chelsea College of Science & Technology.

ABERDEEN

10th. IEE/IERE—"Electronics in the automobile" by W. F. Hill at 19.30 at the Robert Gordons Inst. of Technology.

BELFAST

16th. IEE Grads.—"Electronic techniques in archaeology" by Dr. M. J. Aitken at 18.30 at the Main Lecture Theatre, Ashby Institute.

BIRMINGHAM

3rd. RTS—"The modern methods of video tape editing and machine control" by Alan Pywell at 19.00 at the ATV Studio Centre, Bridge St.

8th. IEE Grads.—"Electronics in medicine" by M. F. Docker at 18.30 at the M.E.B. Offices, Summer Lane.

10th. IEE/I.Meas.Cont.—"The dynamic response of instruments" by Prof. L. Finkelstein at 19.00 at the Chamber of Commerce.

16th. RTS—"Television: hopes and constraints" by Brian Young at 19.00 at the ATV Studio Centre, Bridge St.

22nd. IEE—"The application of electronics in security systems" by J. McArthur at 18.00 at the M.E.B. Summer Lane.

BRADFORD

17th. IEETE—"Modern trends in hi-fi" by M. M. Tiley at 18.30 at the Cleveland Scientific Institute, Middlesbrough.

BRIGHTON

23rd. IEE—"Electronic telephone exchanges" by K. G. Marwing at 18.30 at the Polytechnic.

23rd. IERE—"A communication engineer's view of speech" by J. W. Reynolds at 18.30 at the College of Technology.

CAMBRIDGE

25th. IEE/IERE—"Satellite communications: the present and the future" by J. M. Brown at 18.30 at the Engineering Labs, Trumpington St.

CARDIFF

10th. IERE—"Concorde automatic flight control and landing system" by D. M. Fryer at 18.30 at the U.W.I.S.T.

17th. SERT—"Video tape recording" by H. W. Hellyer at 19.30 at the Llandaff Technical College, Western Avenue.

CHELMSFORD

10th. IERE—"Hyperbolic navigation systems" by C. Powell at 18.30 at the Civic Centre.

CROYDON

24th. IEE Grads.—"Long distance waveguides for telecommunications" by N. Lacey at 18.30 at the Technical College.

DORKING

24th. IEE—"Video recording" by A. H. Jones at 19.30 at the Star & Garter Hotel.

DUBLIN

4th. IEE Grads.—"Electronics—its future in navigation" by F. S. Stringer at 18.00 at the Trinity College.

DUNDEE

11th. IEE/IERE—"Electronics in the automobile" by W. F. Hill at 19.00 at the University.

EDINBURGH

9th. IEE/IERE—"Optical communications" by F. F. Roberts at 18.00 at the Carlton Hotel.

ENFIELD

17th. IERE—"Integrated circuit laboratories in colleges and universities" by J. Butcher at 19.00 at the College of Technology.

FARNBOROUGH

9th. IEE—"Near field inductive communications" by G. J. Walters at 18.30 at the Technical College.

GLASGOW

8th. IEE/IERE—"Optical communications" by F. F. Roberts at 18.00 at Rankine House, 183 Bath St.

GLOUCESTER

10th. IERE—"Modular design of single-standard colour television receiver" by B. Baldwin at 19.00 at the Technical College.

25th. IEE—"Use of light frequencies in communication" by R. B. Dyott at 19.00 at the Technical College.

LIVERPOOL

17th. IERE—"Automatic film analysis" by W. H. Evans at 19.00 at the Dept. of Electrical Eng'g, the University.

LOUGHBOROUGH

16th. IEE/IERE—"Some electrical and electronic applications in fully fashioned knitting machines" by R. Blood and R. L. Duthie at 18.30 at the Edward Herbert Bldg., the University.

MANCHESTER

3rd. IEE—"The design of data communications systems" by D. W. Davies at 18.15 at U.M.I.S.T.

18th. IERE—"P.O. communications for the Queen Elizabeth II and recent maritime radio development." by W. M. Davies at 19.15 at the Renold Bldg., U.M.I.S.T.

24th. IEE—"Electronic techniques in archaeology" by Dr. M. J. Aitken at 18.45 at Renold Bldg., U.M.I.S.T.

NEWCASTLE UPON TYNE

3rd. SERT—"Pulse code modulation" by W. Berrisford at 19.30 at the Charles Trevelyan Technical College, Maple Terrace.

10th. IERE—"Learning machines—the next revolution?" by I. Aleksander at 18.00 at the Polytechnic, Ellison Pl.

16th. IEE Grads.—"Electronics—its future in navigation" by F. S. Stringer at 18.30 at the University, Merz Court.

25th. IEE Grads.—"Superconductivity" by A. D. Appleton at 18.30 at the Newcastle Polytechnic, Ellison Place.

PLYMOUTH

3rd. RTS—"Commercial sound recording" by Robert Auger at 19.30 at the Studios of Westward Television Ltd.

4th. IERE/IEE—"Latest techniques in computer aided design" by E. Wolfendale at 19.00 at the Polytechnic.

READING

25th. IERE—"Node Logic" by B. S. Walker at 19.30 at the J. J. Thomson Laboratory, the University.

SHEFFIELD

18th. IEETE—"Presenting the microwave show" by Dr. J. Allison at 19.00 at Lecture Room 3, Engineering, Mappin Street, the University.

SOUTHAMPTON

2nd. Brit. Computer Soc.—"Interactive terminals—communication aspects" by W. Hillier at 19.15 at the Mathematical Dept. the University.

17th. IERE—"High speed switching characteristics of thyristors" by B. Holloway at 18.30 at the Lanchester Theatre, the University.

STAFFORD

23rd. IEE Grads.—"Electronic techniques in archaeology" by Dr. M. J. Aitken at 19.30 at the North Staffs. Polytechnic.

SUNDERLAND

4th. IEE Grads.—"Colour television" by C. B. B. Wood at 18.30 at the Polytechnic, Chester Rd.

22nd. IEE—"Electronic performance testing of motor vehicles" by R. Evans at 18.30 at the Polytechnic, Chester Rd.

UPPER TYTHING

15th. IEE Grads.—"Radio and radar astronomy" by Dr. J. E. B. Ponsonby at 19.30 at the Hillard Hall, Royal Gram. School.

UXBRIDGE

9th. IEE Grads.—"Space communications—present and future" by J. M. Brown at 18.30 at Brunel University.

WARRINGTON

8th. IEETE—"Records past and present" by G. Nathan at 19.30 at No. 1 Room, The Training Centre, Joseph Crosfield & Sons Ltd.

WHITBY

9th. IEE—"Logic and the engineer" by S. Towill at 19.00 at Botham's Cafe.

YORK

11th. IERE—"Recent applications of holography" by M. R. E. Forshaw at 19.00 at the Central College of Further Education, Tadcaster Rd, Dringhouses.

World of Amateur Radio

More v.f.o. operation on v.h.f.?

For many years, the vast majority of v.h.f. operators have used crystal-controlled transmitters on the 144 MHz band, with crystal frequencies usually chosen in accordance with a voluntary zonal band-plan. The object of this plan has always been to reduce the effects of interference from local stations on the weaker signals from more distant stations. It does result, however, in the necessity to search the full band for possible replies to CQ calls. In this respect, v.h.f. practice differs from h.f. operation where almost all contacts are effected by netting v.f.o.-controlled stations on to the frequency of the station calling CQ. Recently, the increasing use of variable frequency control on v.h.f. (for example using stable Vackar field-effect transistor oscillators such as the one designed by Peter Martin, G3PDM, *Wireless World,* February 1970) has given rise to considerable debate among amateurs on whether to adopt netting techniques on v.h.f. This is already being done to an increasing extent by amateurs on the Continent, and it seems likely to become increasingly popular also in the U.K. This does not imply immediate abandonment of the zonal system when *originating* CQ calls, though clearly if more and more stations opt for v.f.o. operation many of the reasons for zonal band-planning will disappear. Netting has long proved its value on h.f. and its use on v.h.f. has been delayed only because of the problem of building oscillators stable enough to be used on 144 MHz. In one respect, however, the zonal plan needs further enforcement; this is in keeping 'phone operation out of the sector 144.0 to 144.15 MHz used for c.w.

A place for simple h.f. equipment

During the past decade, amplitude modulation has been transformed from being the dominant mode for long-distance h.f. operation to what is fast becoming a rare technique. Today the domination of s.s.b., at least on some bands, is virtually unchallenged. Yet, increasingly, doubts are being expressed at certain implications of this revolutionary change.

For instance, many amateurs owe their introduction to the hobby from the casual reception of amateur transmissions on normal domestic receivers; still more found a.m. operation a most useful technique for newcomers equipped with only a minimum of test equipment and a standard of technical knowledge sufficient to pass the Radio Amateurs' Examination. Today, few non-amateur listeners are likely to resolve s.s.b. transmissions, and a valuable means of stimulating interest in amateur communication has been lost.

There are other signs of a spreading belief that h.f. operation has in recent years seen too much emphasis placed on complex equipment and high-gain aerials. It should therefore be stressed that effective world-wide communication, particularly on c.w., remains possible using simple dipole or vertical aerials which can be easily and economically erected even in the most difficult urban and suburban locations. A check has shown that during 1970 over 100 different countries were worked on 14 MHz c.w. from G3VA using simple wire aerials not exceeding 25 feet in height. Many other amateurs regularly achieve similar results. It would be most regrettable if would-be amateurs were discouraged by the belief that long-distance working calls for expensive equipment.

First transatlantic tests

Fifty years ago, starting at 03.15 G.M.T. on February 2nd, 1921, the first series of amateur transatlantic tests—the first organized attempt to receive in the United Kingdom transmissions from American and Canadian amateur stations operating on about 200 metres—were held. Some 250 British transmitting and receiving enthusiasts announced their intention to take part; in the outcome some 30 logs were received but—to quote the *Wireless World* report on the event —"no entrant received a single word which can *unquestionably* be attributed to an American amateur station". Many entrants reported interference from harmonics of commercial stations and jamming by self-heterodyne receivers. At this time some 150 transmitting and 4000 receiving licences had been issued by the British Post Office. A prize was awarded to a Mr. W. R. Wade, of Bristol, for his description of the attempt. The failure of these tests led to a determination on both sides of the Atlantic to show that such long-distance reception of amateur stations was feasible. Indeed very different results were recorded in the next series of tests in December 1921 when many American amateur signals were logged in the United Kingdom.

Microwave beacons

Plans are being made by the scientific studies group of the R.S.G.B. to establish two 1296 MHz beacon stations; one in London and another near the south coast. These continuously transmitting stations are expected to stimulate more activity in the 23-cm amateur band, and to allow further investigation of propogation over long sea paths to the Netherlands and elsewhere. The U.K. beacon stations, including those operating in the 28, 70, 144 and 432 MHz bands, have amply proved their value for such purposes. For example, the beacon GB3SX at Crowborough, Sussex, on 28.185 MHz, in conjunction with a similar beacon in West Germany has shown that the 28MHz band is open for long-distance communication much more frequently than is generally believed. It had been hoped that other amateur radio societies in Europe would have set up more of these 28 MHz beacon stations.

In brief

Some revealing statistics on West German v.h.f. and u.h.f. activity have been reported by the I.A.R.U. Region 1 Bureau: of a total of about 14,000 stations in the German Federal Republic, about 6800—almost 50%—are active on the 144 MHz band, compared with some 670 on 432 MHz, 44 on 1296 MHz and 14 on 2.3 GHz. But on 144 MHz only about 3% of active stations use transmitters having more than 100 W r.f. output, 26% use between 10 and 100 W while over 70% use less than 10 W..... The main h.f. contest season is approaching with the A.R.R.L. DX contest on February 6-7 and March 6-7 (phone sections) and February 20-21 and March 20-21 (c.w. sections). The 34th R.S.G.B. BERU contest—restricted to British Commonwealth amateurs—is on March 13-14..... The Dutch national amateur radio society V.E.R.O.N. formed at the end of World War II recently celebrated its 25th anniversary with a meeting at the Philips recreational centre in Eindhoven attended by 300 members . . . . Another recent 25th anniversary is that of the resumption of British amateur transmitting in January 1946 when the 28 MHz band was released to amateurs, followed during the next few months by the other bands—the early resumption of amateur activity was considered at the time as a tribute to the wartime services of amateur operators in many countries.

PAT HAWKER G3VA

Personalities

P. R. D. Shardlow, B.Sc., Ph.D., has joined EMI Electronics and Industrial Operations at Hayes, Middx, as technical advisor on audio-visual technology. He has also been appointed technical director of EMI Tape Ltd, one of the fourteen technically based divisions which are co-ordinated by EMI Electronics and Industrial Operations. Dr. Shardlow studied at London and Manchester universities and during his external Ph.D. course gained industrial experience with Sperry Gyroscope Co., Rolls-Royce, Ferranti and Brush Electrical. His final 18 months were spent in commissioning the control system at Jodrell Bank radio telescope. After a 15-month state scholarship at Massachusetts Institute of Technology he returned to the U.K. to join Decca Radar. His next appointment was as director of Arbiter Electronics and until recently he was joint managing director of Tape Systems Ltd.

W. J. Morcom, B.Sc., M.I.E.E., manager of Marconi's Radio Communications Division since 1965, has been appointed technical director of Marconi Communication Systems Ltd of which Tom Mayer is managing director. Mr. Morcom, who is 61, was educated at the Devonport Dockyard School, where he won the Admiralty Prize as top apprentice of all Naval Dockyards. He was awarded the Whitworth Scholarship to City and Guilds (Engineering) College in 1929, and took a degree in engineering. He joined Marconi as a design engineer working on broadcast transmitters in 1933. For nearly 20 years, after the war, Mr. Morcom was in charge of transmitter development.

W. J. Morcom

Peggy Hodges, responsible for guided weapon simulation and systems studies at the Stanmore Establishment of Marconi Space and Defence Systems, was presented with the 1970 Whitney Straight Award by The Prince of Wales on Demeber 9th, at the Royal Aeronautical Society. The Award recognizes the achievement and status of women in aviation and consists of a bronze sculpture and £200 in cash. The citation acknowledges Miss Hodges' work and that of her department in the design and development of the Seaslug and Sea Dart naval missiles, and draws attention in particular to her position as an authority on the use of simulation techniques in the design of guided weapons.

Peter Ward, who joined Independent Television News in 1968 as head of vision engineering, has been appointed chief engineer in succession to **Cyril Teed** who recently re-joined the Marconi Company. Prior to joining I.T.N. Mr. Ward, who is 39, was with ATV Network Ltd for twelve years. In 1959 he took charge of the Design and Maintenance Department and in 1961 was appointed engineer-in-charge, Wood Green Studios.

George King, B.Sc. (Eng.), A.C.G.I., F.I.E.E., F.Inst.P., chief scientist of Standard Telecommunication Laboratories Ltd, Harlow, Essex, has been appointed visiting professor in telecommunications in the University of Surrey's department of electronic and electrical engineering. After wartime research in radar for the Admiralty, Mr. King joined S.T.L. in 1946 as head of the microwave department, later becoming head of the materials division. In 1954 he was appointed chief engineer of the transistor division, Standard Telephones & Cables Ltd, and in 1958 returned to S.T.L. as director of research. In 1962 he became manager, exploratory research, and was appointed to his present post in 1964.

R. P. Gabriel, B.Sc., F.I.E.E., M.I.E.R.E., chairman of Rediffusion Engineering Ltd, has been appointed chairman of Rediffusion International Ltd which provides technical and administrative services to the Group's overseas stations. He succeeds **Hugh Dundas** who was recently appointed managing director of Rediffusion Ltd. After taking a first class honours degree in electrical engineering at King's College, London University, Mr. Gabriel joined Rediffusion in 1933 as a junior engineer.

C. J. Carter, M.A., F.I.E.E., who recently retired as director of electronics research and development (ground) in the Ministry of Aviation Supply, has joined Plessey Radar Ltd as a special assistant to the divisional director, **P. E. G. Bates.** From 1955 to 1961 Mr. Carter was director of air navigation and reconnaissance equipment research and development (Ministry of Aviation). He was deputy director general, defence research staff, at the British Embassy in Washington from 1961 to 1964.

Rediffusion also announced the appointment of **John C. Goodwin,** B.Sc. Tech., F.I.E.E., to the board of Rediffusion Ltd. Mr. Goodwin, who is 54 and a graduate of Manchester University, joined Rediffusion in 1964 as an engineer after a war-time post at the Admiralty. During his 24 years with the Group he has held positions as chief engineer, general manager, director and chairman of a number of member companies.

Arthur C. Haddy, a director of the Decca Record Company, has been presented with the Emile Berliner Award by the American Audio Engineering Society for "pioneering development of wide-range recording and playback heads and for his significant part in the international adoption of 45°–45° stereo disc recording". Mr. Haddy joined the Crystalate Gramophone Co. in 1929 and moved to Decca in 1937 when Crystalate was taken over by them.

J. Rawicz-Szczerbo has been appointed managing director of the Antiference Group Ltd in succession to **Norman M. Best** who remains as chairman of the Board. Mr. Rawicz joined the Group in 1964 and in 1966 became managing director of Antiference Ltd, a position he will continue to hold. Mr. Best founded Antiference in 1936.

NEW YEAR HONOURS

Few people in the field of radio & electronics were recipients of honours in the New Year list. Among them were:

C.B.

Air Vice-Marshal L. H. Moulton, D.F.C., F.I.E.R.E., A.O.C. 90 Group R.A.F.

K.B.E.

Major-General John E. Anderson, F.I.E.E., late Royal Corps of Signals, Colonel Commandant.

C.B.E.

Brigadier A. D. Brindley, M.B.E., M.I.E.E., late Royal Corps of Signals.

J. F. Crosfield, managing director, Crosfield Electronics Ltd.

J. M. Price, B.Sc., A.M.I.E.E., assistant managing director, GEC-AEI Telecommunications Ltd.

O.B.E.

Lt.-Colonel A. C. Birtwistle, M.A., M.I.E.E., Royal Corps of Signals.

J. Lait, M.I.E.R.E., principal lecturer, Electronics Branch, Royal Military College of Science.

S. J. Robinson, M.A., F.I.E.E., scientific adviser, Mullard Research Laboratories.

Prof. G. D. Sims, M.Sc., Ph.D., F.I.E.R.E., F.I.E.E., head of the Department of Electronics, University of Southampton.

S. N. Watson, F.I.E.E., chief engineer (television), B.B.C.

M.B.E.

G. Adamson, first radio officer s.s. *Empress of Canada.*

D. V. Staynor, M.I.E.R.E., chief development engineer, Mobile Radio Division, Elliott-Automation Radar Systems Ltd.

A. T. Whitehead, assistant director (telecommunications), Botswana.

C. B. B. Wood, head of image scanning section, B.B.C. Research Dept.

OBITUARY

Sir Gordon Radley, K.C.B., C.B.E., Ph.D., director general of the Post Office from 1955 to 1960, died on 16th December aged 72. Sir Gordon studied at Faraday House, and obtained his B.Sc.(Eng.) and Ph.D. degrees at London University. After serving with the Royal Engineers in the 1914-18 war he entered the engineering research laboratories of the General Post Office in 1920. He became the Post Office's first Controller of Research in 1944 and five years later was appointed deputy engineer-in-chief, becoming engineer-in-chief in 1951. On his retirement from the Post Office in 1960 Sir Gordon joined the boards of the Marconi Company, the Marconi International Marine Co., Marconi Instruments, and the English Electric Valve Co. He was still chairman of Marconi Marine at the time of his death, but had left the boards of the other companies.

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REL Equipment & Components Ltd., Croft House, Bancroft, Hitchin, Herts. Tel: 50551/2/3 52202 Telex: 82431 Grams: Robert, Hitchin

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ECS (Windsor) Ltd., Thames Avenue, Windsor, Berks. Tel: 68101 (20 lines) Telex: 84573

RCA Ltd., Electronic Components Division, Sunbury-on-Thames, Middlesex. Tel: Sunbury-on-Thames 85511 Telex: 24246 Grams: RCA London

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WW—071 FOR FURTHER DETAILS

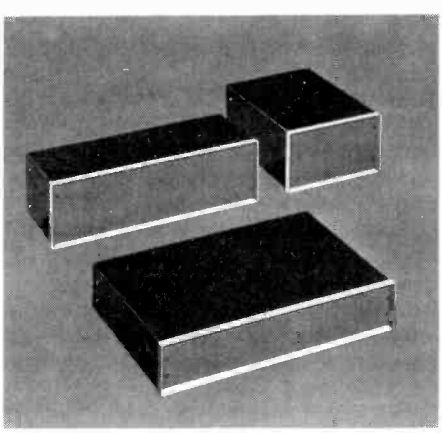
New Products

Pulse generator

General purpose pulse generator model 6640 from Texas Instruments replaces model 6613. The p.r.f., internal or external, can be from 1.5Hz to 15MHz. Pulse width is variable from 30ns to 300ms. Ranges and delay (of main pulse with respect to trailing edge of synchronizing pulse) is variable between 80ns and 300ms. The above ranges are each covered in seven overlapping sections. The main pulse output is 0.3 to 10V into 50Ω, continuously variable and direct coupled. Simultaneous positive and negative pulses are available, and the duty cycle is 90% at maximum. Pulse rise and fall times are 6ns to 15ms continuously variable in four overlapping ranges: rise and fall times are independently variable within each range. A sync output of +2.5V directly coupled into 50Ω is available with a width 50-80% of the duty cycle. A second pulse is provided which occurs before the fundamental pulse at the trailing edge of the sync pulse. Both pulses have similar amplitude, rise and fall times. The generator is mains powered. The bench-mounting version is 190×216×305mm. The weight is 5kg. Price £285. Texas Instruments Ltd, Digital Systems Division, Dallas Road, Bedford.
WW 328 for further details

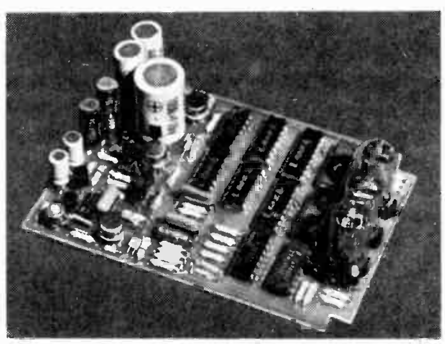
Instrument cases

Progressive Projects announce a range of instrument cases which are compatible with standard 19in rack mounting. Heights of cases are 3.5in (88.5mm), 5.25in (133mm) and 7in (177.5mm). Construction is in thick gauge mild steel with heavy section silver anodized aluminium extrusion round the front. A number of extra items are available including ventilated top and bottom covers, carrying handles, and front panels. Progressive Projects Ltd, PP Group of Companies, 58B Queensway, Stevenage, Herts.
WW 330 for further details



A to D display card

The DC 603 is an analogue to visual digital readout converter. The digital display has a maximum reading of 199 which can be scaled from 1.99A to 1.99mA. The unit can be supplied either with a transformer for mains input or as the rectifier system only, where a.c. voltages are available from the main system, when the a.c. required is 220V at 4mA, 18-0-18V r.m.s. at 25mA and 7.5V r.m.s. at 200mA. An alternative form powered from d.c. supplies is also available. The accuracy is 0.5%. B.C.D. information at t.t.l. levels is available as an extra provision. The data is updated 50 times per second but the speed for full accuracy is 2 measurements per second. The basic unit price is £40. Fenlow Electronics Ltd, Whittet's Eyot, Jessamy Road, Weybridge, Surrey.
WW 334 for further details



General purpose function generator

Model 5100 function generator made by Krohn-Hite is available in the U.K. from Allied International. It has a dynamic frequency range of 0.002Hz to 3MHz and provides sine, square, and triangle waveforms, and positive and negative ramps. The main output is 20V pk-pk (open circuit) and has a three-position amplitude control calibrated, open circuit, in peak volts (10, 1 and 0.1) with a separate infinite resolution vernier. An additional 5V pk-pk squarewave output with less than 15ns risetime may be used for synchronization, gating, blanking, etc. Frequency may be varied by a control voltage in either of two ways. In the external mode it can be swept over a range of 1000:1 with the maximum frequency determined by the frequency band. In the dial mode it may be used to frequency modulate ±5% around any selected frequency. The entire audio range of 20Hz to 20kHz may be covered in a single sweep by applying an external ramp. Frequency accuracy is ±5% of setting from 0.02Hz to 100kHz and ±10% from 0.002Hz to 3MHz. External synchronization can be provided by a 2V r.m.s. external signal which will lock the generator over a range of approximately ±5% with a slight change in distortion and amplitude. Input impedance is 1kΩ. The d.c. offset is controlled by a front panel potentiometer and switch (±5V open circuit, 2.5V across 50Ω). Drift is less than 50mV/°C. Frequency stability varies from ±0.05% per 10 min. to ±0.25% per 24 hours. Allied International Publicity Division, 59/61 Union Street, London S.E.1.
WW 303 for further details

Balanced microwave mixers

A range of broad-band microwave balanced mixers exhibiting a low noise figure, high isolation and low v.s.w.r., over multi-octave and octave frequency ranges from 1 to 18GHz, is available from Microwave International Ltd. Selected Schottky barrier diodes give large dynamic range. The broad-band mixer r.f. and local oscillator ports cover the frequency range 1 to 12.4GHz with a maximum input v.s.w.r. of 2.0 and the i.f. port covers the frequency range 5 to 250MHz. The noise figure is 9dB (single sideband measurement). The l.o. to r.f. isolation is 12dB minimum, and the corresponding figure from l.o. to i.f. is 26dB. This unit has a compression point of +12dBm, and the unit will handle a maximum c.w. r.f. input of +27dBm. Other units are available covering the above mentioned range in octave bandwidths. Microwave International Ltd, 33-37 Cowleaze Road, Kingston-upon-Thames, Surrey.
WW 333 for further details

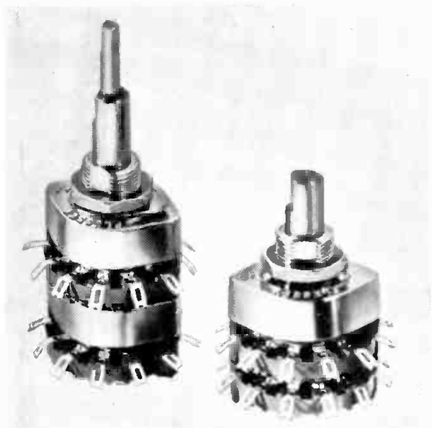
M.O.S. frequency divider

Now available from Auriema is the Philco Ford pL4CO7C monolithic frequency divider using m.o.s. technology. The divider circuit consists of seven flip-flops arranged in a 3-2-1-1 configuration and diffused into a single silicon substrate. The circuit can be driven from a sine- or square-wave input. Each flip-flop has a low impedance push-pull output which is capable of driving external circuitry as well as other flip-flops. Power consumption is low. Output power under standard conditions is 400mW pro-

viding a swing between −1 and −10 volts. Input repetition rate is 100kHz max. for the 4CO7C and 500kHz max. for version 4CO7AC. Both versions can operate down to d.c. Input capacity is 5.0pF max. at zero input, and input leakage current 1.0μA max. at an input level of −20V. The device is suitable for tone generation in electronic organs. Auriema Ltd, 23-31 King Street, London W.3.
WW 331 for further details

Rotary switches

A new 30mm rotary switch from Plessey can employ up to ten standard wafers in both shorting and non-shorting versions. Contact ratings are 500mA at 30V and 50mA at 300V for d.c. or a.c. resistive loads, and contact resistance is less than 10mΩ. The maximum continuous current carrying capacity is 2A. The spindle diameter is 6mm with either 10mm or ⅜in



diameter bush. Three standard spindle styles are available. Other options include panel and spindle sealing and double-pole on/off mains switching versions. The switch is also available as a dual concentric. Switching is through 12 positions (30°) as standard with 45°, 60° and 90° indexing also available. Professional Components Division, Plessey Components Group, Abbey Works, Titchfield, Fareham, Hants.
WW 329 for further details

Klystron power supply

Model 604D klystron power supply from Microtest allows resonator and reflector voltages to be continuously adjusted. Resonator voltage and current, and reflector voltage and heater voltage can be monitored on the integral meter to within ±2%. The heater supply is regulated. The reflector supply can be internally modulated with a square wave for on-off operation or with a sawtooth for f.m. operation.

output supply	cathode (resonator)	reflector	heater
voltage	15-400V	0-500V	5.5-7.0V d.c.
load current	0-100mA	0-0.5mA	0-1.5A
resolution	0.5V	0.1V	0.05V
regulation (±7% mains variation)	0.001%	0.001%	0.5%
ripple	1mV r.m.s.	0.5mV r.m.s.	10mV r.m.s.

Power supply for the instrument is 100-250V 50/60Hz. Microtest Ltd, 28 Walker Lines Industrial Estate, Bodmin, Cornwall.
WW 302 for further details

Precision measuring amplifier

The 2607 measuring amplifier from Bruel & Kjaer is designed for sound and vibration measurements. It has interchangeable scales to allow direct reading of sound level, acceleration, velocity, displacement, power spectral density, etc. when used with different transducers. Equipped with B & K condenser microphones it fulfils and exceeds the I.E.C. 179 specification for precision sound level meters. A special feature of the 2607 is a built-in lin-log converter and a rectifier allowing + peak, − peak and max. peak indication in addition to the r.m.s., impulse, and impulse hold readings. The lin-log converter gives a 50dB display on the meter and 60dB dynamic range on the output. Sensitivity is from 10μV to 300V. There are built-in A, B, C and D weighting networks, and a power supply for condenser microphones. The frequency range is 2Hz–200kHz, and external filters can be added. B & K Publicity Division, 59 Union Street, London S.E.1.
WW 322 for further details

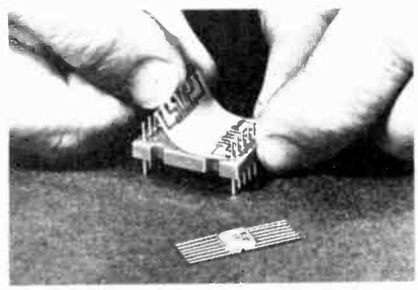
Dual power supplies

Two dual power supplies are available from Hewlett Packard. Each houses two identical 50W power supplies in one package. Operation can be independent, or one supply can track the other. The output of the slave supply matches that of the master supply to better than 0.2% ±2mV, when tracking. Each side of the new dual power supplies can be operated at constant-voltage or at constant-current. Each side has its own independent internal crowbar for over-voltage protection. In the tracking mode, on overvoltage in either supply trips both

crowbars. Model 6227B is rated at 0-25V and 0-2A, and model 6228B at 0-50V and 0-1A. Load regulation is ±(0.01% + 1mV) for constant-voltage operation or ±(0.01% + 25μA) for constant-current operation, for a change in load current or voltage, respectively, equal to the rating of the supply. Line regulation is ± 1mV or ± 100μA for a line voltage change from 207 to 253V. Ripple and noise (d.c. to 20MHz) is less than 250μV or 250μA r.m.s., and less than 4mV or 2mA peak-to-peak under any load conditions within ratings. Both supplies in each unit are isolated for up to 300V between any output and the chassis, or between one output and another. Hewlett Packard Ltd, 224 Bath Road, Slough, Bucks.
WW 324 for further details

Instant circuit boards

Individual circuit boards can be assembled and tested directly from engineering sketches, schematics and logic flow diagrams the same day using a complete family of Circuit-stik circuit sub-elements and circuit materials designed as a total packaging system. Sub-element conductors are pre-plated and flux coated and ready for soldering. The conductive circuits are supplied



on a thin substrate with a press-to-stick adhesive backing. They are designed to withstand soldering temperatures yet can be removed when required. The 1000 series sub-elements are pre-drilled on 0.1in grid, are directly compatible with pre-punched epoxy-glass board and require no terminals. Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx.
WW 320 for further details

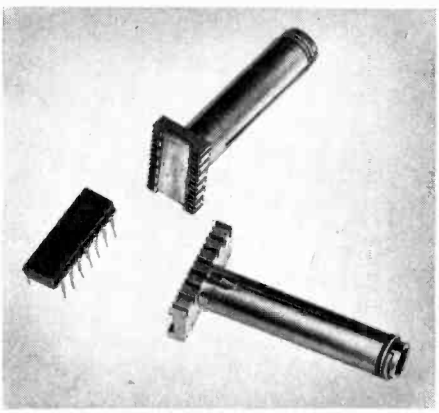
Range of coaxial terminations

The R.F. Components Division of Sealectro is marketing a range of low-power resistive terminations for coaxial use. The range covers power ratings from 0.5W to 10W and in various frequency ranges from d.c.

to 12.4GHz. Typical examples are the OTT956A which has a b.n.c. input connector and is designed for use from d.c. to 1GHz. and is rated at 1W continuous power handling. Impedance values are 51, 75, 100 or 150Ω. Another style is the OTT1597 s.h.f. which will operate from d.c. to 11GHz at 1W. This device is fitted with a t.n.c. connector and exhibits a maximum v.s.w.r. of 1.2 at 11GHz. Each item can be supplied with either male or female connectors and either silver plated for gold plated bodies. R.F. Components Division, Sealectro Ltd, Walton Road, Farlington, Portsmouth PO6 1TB.
WW 323 for further details

I.C. desolder heads

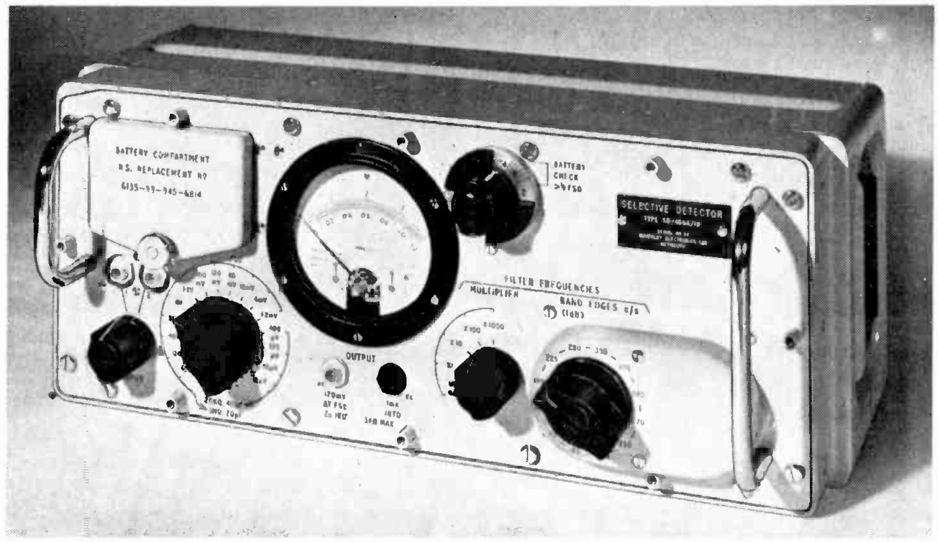
Solderstat announce a new accessory which, using the method of simultaneous desoldering, removes standard dual-in-line packages within a few seconds. The desolder head is simply pushed on to a standard H.M.S. series miniature soldering iron in place of



the standard copper bit. The desolder heads are machined in one piece to ensure good thermal condition and long life. Both 14-way and 16-way dual-in-line models are available. Solderstat Ltd, P.O. Box No. 10, Bush Fair, Harlow, Essex.
WW 327 for further details

Selective detector

Selective detector type SD466/1, from Waverley, is a battery-operated instrument primarily intended for use with an external attenuator, as a transmission measuring set or spectrum analyser. There are sixteen sensitivity ranges—from 12μV to 400V f.s.d. The frequency range is 100Hz-1MHz in 44 overlapping bands, and 40Hz-1.3MHz wide band. There are eleven bands per decade and four multipliers — ×1, ×10, ×100 and ×1000. Accuracy is ±2% as a voltmeter. The $\frac{1}{3}$ octave filters have band edges of —1dB. Second harmonic rejection is greater than 60dB (higher frequencies greater than 50dB). Input impedance is 1MΩ in parallel with 20pF over the ranges 1.2mV to 400V, and approximately 20kΩ in parallel with 40pF on the 12μV to 400μV ranges. The record output is 1mA d.c. into 3kΩ, and signal output 120mV from 1kΩ source. Two 9V dry batteries power the instru-



ment. The sealed case measures 178 × 445 × 254mm and weighs 9kg. Waverley Electronics Ltd, Waverley Road, Weymouth, Dorset.
WW 316 for further details

Multi-purpose signal generator

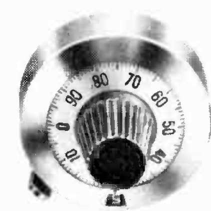
The decade a.m.-f.m. signal generator type MS100M, designed and manufactured by the Schomandl subsidiary of Rohde & Schwarz, is a multi-purpose generator with an output frequency of 10kHz to 100MHz adjustable in least increments of 1Hz whilst retaining the accuracy of the built-in crystal oscillator. Continuous frequency adjustment allows interpolation within each decade of ranges from ±5Hz to ±5MHz, and can be carried out manually, or externally by an analogue d.c. signal, or by sweeping. The frequency generating system of the MS100M is provided with a synchronized oscillator in each frequency-selection stage and produces very pure output signals. Since the set is immune to r.f. leakage, even low-voltage outputs can be accurately adjusted and the output level can be continuously adjusted over 10dB (meter indication in V and dB) and in increments of 1dB down to —132dB. The generator can also be supplied with tuning in crystal-controlled increments of 10Hz, 100Hz and 1kHz, and decade stages can be added. Output is 1V (Z_s=50Ω). U.K. agents Aveley Electric Ltd, Arisdale Avenue, South Ockendon, Essex.
WW 304 for further details

Photoconductive cell

Mullard have produced a subminiature cadmium sulphide cell type RPY.71. It is made by a technique providing extremely small and stable cells with a high-power dissipation. These cells have zero initial drift—or resistance overshoot—and a smaller memory effect than photoconductive cells made by the conventional sintering process. Changes in illumination and the resulting changes in cell resistance have a linear relationship. Maximum permissible dissipation is 50mW and maximum rating is 50V. Its resistance at 10 lux from a source with a colour temperature of 2700K does not exceed 6kΩ; dark resistance is more than 500kΩ. The cell has maximum dimensions of 5.3 × 5.3 × 1.3mm, and will operate in the temperature range −40° to +60°C. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.
WW 305 for further details

Turns-counting dial

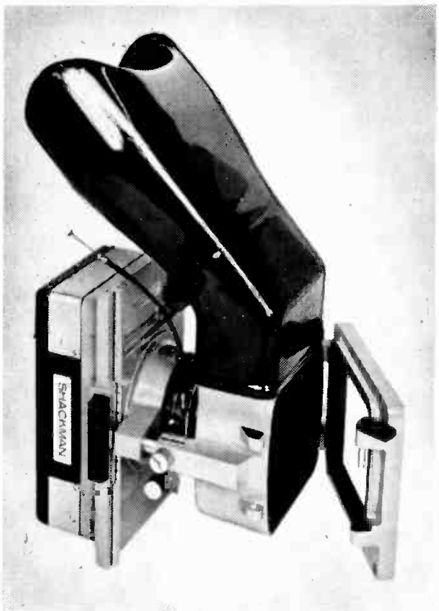
A 10-turn, 25mm diameter, turns-counting dial, type 25-10, is available from R. C. Knight. It has a guaranteed life of 2 × 10^6 rotations, and is designed for applications where space is restricted. Constructed for accurate and backlash-free readings, it



includes collett mounting for easy dial-to-shaft assembly. A selection of end cap colours for dial identification is available. Standard finishes are silver-satin or black anodized aluminium, with prices from 41s 9d (£2.09) each. R. C. Knight Ltd., 20 Solent Avenue, Lymington, Hants, SO4 9SD.
WW 326 for further details

Oscilloscope camera

With a new f1.9, 51mm lens, a Mark II version of the 'Super-seven' Polaroid oscilloscope camera has been introduced by Shackman Instruments. The lens is mounted in a rim-set multi-speed shutter and can be adjusted to give any desired object-to-image ratio between 1:0.7 and 1:1. It is also possible to record a single sweep spot on BE (P11) phosphor tubes, at a speed of 2ns/cm. Attachment to the oscilloscope is by bezel adaptors incorporating quick-change, left to right 'swing-away' hinges, to permit direct viewing of the c.r.o. screen without displacement of the camera, or the need to re-focus. The camera body, which houses the lens and shutter, is available in



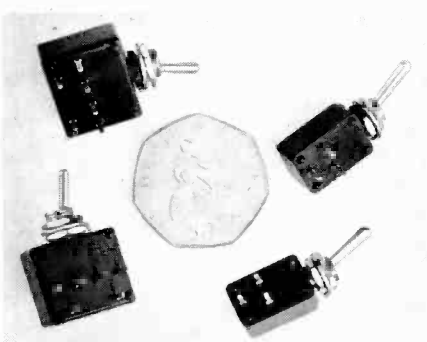
two types, either with or without a low-angle, off-axis binocular viewer. Three interchangeable film modules are available, all being par-focal—interchanged at will without the need to re-focus—offering the use of Polaroid instant pictures, 4 × 5in. single sheet films, $3\frac{1}{4} \times 4\frac{1}{4}$ in Polaroid roll films, flat eight-exposure cassettes, as well as conventional 4 × 5in cut film and 120-size roll film. All three film modules fit to a 9-position slide, which can be rotated to the vertical, or horizontal aspect, making the best use of film area at different ratios. Shackman Instruments Ltd, Mineral Lane, Chesham, Bucks.
WW 306 for further details

Electronic voltmeter

ITT have introduced a new electronic voltmeter, the VX208A, that will measure the mean value of an a.c. voltage from 10Hz to 10MHz. The meter has a pre-amplifier and attenuator giving a high input impedance (10MΩ shunted by 30pF) and a low noise factor. Twelve ranges enable it to measure a.c. voltages from 1mV to 300mV and from 1V to 300V. ITT Electronic Services, Edinburgh Way, Harlow, Essex.
WW 301 for further details

Subminiature toggle switches

Two subminiature toggle switches are available from Guest International. Type 21136 is single pole, and the double pole version is designated 21146. Each switch



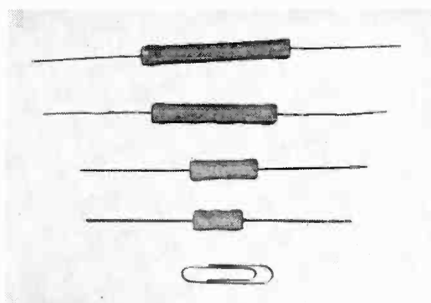
incorporates a printed-circuit tag having standard 0.2in spacing and a $\frac{1}{4}$in bush and nut for front panel fixing. The finish is matt-black and there is a choice of solid silver or gold for the contact material. The contacts are rated at 2A 250V with a resistance of less than 0.005Ω. The case is made of diallylphthalate. Industrial Electronic Components Division, Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey.
WW 321 for further details

Encapsulated reed relays

Keyswitch offer a range of encapsulated reed relays moulded in a semi-flexible epoxy resin. Terminating pins are on a 0.1 inch matrix for p.c. applications. The range is designed for 6, 12 or 24V coil operation, and up to four reed capsules may be included in one unit for complex switching functions. Form C (change-over) or form A (normally open) contact arrangements may be specified with a wide range of current and voltage ratings. Keyswitch Ltd, 120-132 Cricklewood Lane, London N.W.2.
WW 318 for further details

Metal-oxide resistors

FP style metal oxide resistors, available from WEL, are claimed to stand overloads up to 100 times rated power without any trace of flame. Available as 2, 3, 4, 5, 7



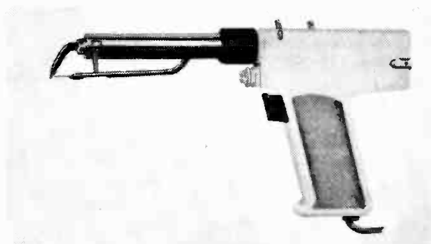
and 10W rated units, they have a working voltage rating of 500 and a resistance range from 9-90kΩ. Standard tolerance is 5%. WEL Components Ltd, 5 Loverock Road, Reading, Berks.
WW 310 for further details

Portable magnetic tape system

A compact portable magnetic tape system from Honeywell, model 5600, is a 14-channel instrumentation grade recorder. The basic recorder accommodates 16 data cards for any combination of record/reproduce channels totalling this number. An auxiliary housing is available for expansion to a total of 32 data cards. Built-in features permit easy on-the-spot conversion of tape width, power source and recording technique to meet a variety of special requirements at remote locations. It can use thin base tape on 267mm reels, and has a universal hub for 6, 13 and 25mm tape. Models are available to operate from 115/230V, 48-420Hz, or from 10-15V d.c. or 22-30V d.c. A phase-locked servo-controlled capstan system provides seven speeds ranging from $\frac{15}{16}$in to 60in per second. Ancillary components are available including meter monitors, attenuators, differential inputs, and remote control units. Test Instruments Division, Honeywell Ltd., Charles Square, Bracknell, Berks.
WW 315 for further details

Soldering gun

The L200 soldering gun from Klaus Schlitt has a solder feed control allowing single-handed operation. Solder is wound on various sized spools. Also built-in is a small lamp. The mains versions are for 110 or



220V; and 20, 30, 40, 50, 60, 80, and 100W models can be supplied. A 24V 40W version is also available. Klaus Schlitt, Löttechnik-Mech. Geräte, D-6000 Bergen-Enkheim b.Ffm., Postfach 44, West Germany.
WW 325 for further details

Miniature power supplies

A series of miniature power supplies by Bentron are available from Rastra. They provide stabilized d.c. outputs from unstabilized sources with a factor of 2000:1 without any auxiliary external voltage. The maximum input voltage, depending upon the model, is 40V to 70V and the output voltage 4V to 60V. All parts are protected against overload and each unit is short-circuit proof. Encapsulation is by epoxy resin. The user programmes current limit and output voltage by means of external resistors wired across four pins. There are 28 models with a wide variety of voltages available. Rastra Electronics Ltd, 275 King Street, Hammersmith, London W.6.
WW 319 for further details

Portable transceiver

An eight-channel portable 'man-pack' s.s.b. transceiver with a transmitting p.e.p. of 10W is available from Labgear. The transceiver, known as "Compak 8", is self-contained and housed in a plastic case. It contains four printed circuit boards. The boards for the transmitter and receiver functions are separate self-contained plug-in modules. The unit is designed for voice or key operation using a.m. with suppressed carrier. It is sealed (with its batteries) and may be carried on a halter or in a rucksack. The frequency range is 2-9MHz. Weighing 6.8kg the transceiver measures 356 × 216 × 114mm. Labgear Ltd, Cromwell Road, Cambridge.
WW 308 for further details

1971 U.K. Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Feb. 8-12 Bloomsbury Centre Hotel
Australian Trade Display
(Trade & Industry Office, Australia House, Strand, London W.C.2)

Feb. 17 & 18 I.E.E., Savoy Place
Electron Energy Analysis
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Mar. 16-19 Camden Town Hall
Sound '71
(Assoc. of P.A. Engineers, 394 Northolt Road, South Harrow, Middx HA2 8EY)

Mar. 29-Apr. 2 Earls Court
LABEX International
(U.T.P. Exhibitions Ltd, 36-37 Furnival St., London EC4A 1JH)

Mar. 30 & 31 Grosvenor House
Training 71
(Marketing Exhibitions Ltd, 113/123 Upper Richmond Rd, London S.W.15)

Mar. 31-Apr. 4 Skyway Hotel
SONEX 71
(Fed. of British Audio, 49 Russell Sq., London W.C.1)

Apr. 19 & 20 I.E.E., Savoy Place
Hybrid Microelectronic Circuits
(International Society for Hybrid Microelectronics, c/o Dr. R. G. Loasby, A.W.R.E., Building A37, Aldermaston, Reading RG7/4PR)

Apr. 21-29 Earls Court
International Engineering and Marine Exhibition
(Industrial & Trade Fairs Ltd, Commonwealth House, New Oxford St., London WC1A 1PB)

May 18-21 Olympia
Electronic Component Show
(Industrial Exhibitions Ltd, 9 Argyll St., London W1V 2HA)

May 18-21 Royal Garden Hotel
Electronic Components Conference
(Electronic Components Board, Carrier House, Warwick Row, London S.W.1)

June 8-10 Savoy Place
Aerospace Antennas
(I.E.E., Savoy Place, London WC2R 0BL)

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

July 12-17 Imperial College
Industrial Measurement and Control by Radiation Techniques
(I.E.E., Savoy Pl., London WC2R 0BL)

Sept. 8 & 9 I.E.E., Savoy Place
High Voltage Insulation in Vacuum
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Oct. 26-30 Olympia
Audio Fair
(Rex Hassan, 42 Manchester St., London W.1)

BRIGHTON

Apr. 4-6 University of Sussex
Vacuum Equipment
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Apr. 20-23 Hotel Metropole
Technical Communication in the 70s
(Business Conferences & Exhibitions, Mercury House, Waterloo Rd, London S.E.1)

BRISTOL

July 9-12 The University
Marine Electronics
(S.E.R.T., 8-10 Charing Cross Rd, London W.C.2)

Mar. 23-26 The University
EASCON 71—From learning to earning
(I.E.E.T.E., 2 Savoy Hill, London WC2R 0BS)

EASTBOURNE

May 18 & 19 Grand Hotel
Design and Control of Manufacture
(Sira Institute, South Hill, Chislehurst, Kent BR7 5EH)

EXETER

July 3-5 The University
Band Structure in Solids
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

HARROGATE

Mar. 2-4 Exhibition Hall
EL-EC 71—Electronic Equip. & Components
(Trade News Ltd, Drummond House, 203-209 North Gower St., London N.W.1)

LANCASTER

Apr. 5-7 The University
Elementary Particle Physics
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Sept. 14-16 The University
Solid State Devices
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

LIVERPOOL

Mar. 23-26 The University
Negative Ions
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

LOUGHBOROUGH

Sept. 7-10 The University
Displays
(I.E.E., Savoy Pl., London W.C.2)

MANCHESTER

Sept. 1-3 The University
Multivariable Control System Design and Applications
(UKAC 1971 Convention Secretariat, Savoy Pl., London WC2R 0BL)

Sept. 6-12 The University
Electron Microscopy
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Oct. 5-8 City Hall
MELEX—Electronics Exhibition
(Industrial Exhibitions Ltd, 9 Argyll St., London, W1V 2HA)

NOTTINGHAM

Mar. 29-Apr. 2 The University
Datafair 71
(British Computer Society, 29 Portland Pl., London W.1)

July 6-8 The University
Electronic Control of Mechanical Handling
(I.E.R.E., 9 Bedford Sq., London WC1B 3 RG)

SHEFFIELD

Sept. 7-9 The University
Computers in Medical and Biological Research
(I.E.E., Savoy Pl., London WC2R 0BL)

YORK

Apr. 5-8 The University
Atomic and Molecular Physics
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Overseas: FEBRUARY-MAY

Feb. 9-11 Los Angeles
Aerospace & Electronic Systems
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

Feb. 13-19 Monte Carlo
Colloque International de L'Audiovisuel
(Comité du Festival, Palais des Congrès, Avenue d'Ostende, Monte-Carlo)

Feb. 17-19 Philadelphia
Solid State Circuits Conference
(Lewis Winner, 152 W. 42nd Street, New York, N.Y. 10036)

Mar. 9-13 Basle
MEDEX 71—Medical Electronics and Bio-engineering
(Sekretariat MEDEX 71, CH-4000 Basel 21)

Mar. 9-13 Basle
INEL—Industrial Electronics
(Sekretariat INEL 71, CH-4000 Basel 21)

Mar. 9-14 Bordeaux
OCEANEXPO 71
(Salon International de l'Exploitation des Oceans, 8, rue de la Michodière, Paris 2)

Mar. 14-23 Leipzig
Leipzig Spring Fair
(Leipzig Fair, 701 Leipzig, Messehaus am Markt)

Mar. 22-25 New York
I.E.E.E. Convention and Exposition
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

Mar. 29-Apr. 2 Paris
Space and Communication
(L'Espace et la Communication, 16 rue de Presles, Paris 15e)

Mar. 31-Apr. 6 Paris
Salon International des Composants Electroniques
(Fed. Nat. des Industries Electroniques, 16 rue de Presles, Paris 15e)

Apr. 5 & 6 Atlanta
System Theory
(C.O. Alford, School of Electrical Eng., Georgia Institute of Technology, Atlanta, Georgia 30332)

Apr. 12-15 Washington
Telemetering Conference
(Washington Technical Consultants, 422 Washington Bldg, Washington D.C. 20005)

Apr. 13-15 Boston
Electronics in Medicine
(Electronics in Medicine, 330 W. 42nd St., New York, NY10036)

Apr. 13-15 New York
Computers and Automata
(Polytechnic Institute of Brooklyn, 333 Jay St, Brooklyn, New York 11201)

Apr. 13-16 Denver
Magnetics Conference
(C.D. Mee, IBM Corp., Building 015, Monterey & Cattle Rds, San Jose, California 95114)

Apr. 26-28 Atlantic City
Frequency Control Symposium
(U.S. Army Electronics Command, Solid State & Frequency Control Div., Electronic Components Laboratory, Fort Monmouth, New Jersey 07703)

May 10-12 Washington
Electronic Components Conference
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

May 12-14 Boulder
Electron, Ion & Laser Beam Technology
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

May 17-19 Dayton
Aerospace Electronics Conference
(I.E.E.E., 124 E. Monument Avenue, Dayton, Ohio 45402)

May 17-20 Washington
Microwave Symposium
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

May 21-27 Montreux
Television Symposium
(Case-Box 97, 1820 Montreux)

Literature Received

For further information on any item include the WW number on the reader reply card

ACTIVE DEVICES

Sprague Electric (U.K.) Ltd have added 50. TO—18 based, plastic transistors, rated at 360mW, to their range. A set of data sheets and an interchangeability chart for the range (Econoline) may be obtained from S.D.S. (Portsmouth) Ltd, Gunstore Rd, Hilsea Industrial Estate, Portsmouth. Hants WW401

We have received a semiconductor price list from ITT Semiconductors, Footscray, Sidcup, Kent WW402

Brief details of a wide range of active and passive electronic components from several manufacturers round the world are given in Electronic Component Selector Guide. Celdis Ltd, 37/39 Loverock Rd, Reading, Berks. RG3 1ED...............WW403

Hybrid "Helipot" microcircuits including voltage regulators, ladder networks and switches, power amplifiers, circuit protection devices and a lamp and relay driver are described in a publication "Helipot Microcircuits". Application data and details of the customer design service are also given. Beckman Instruments Ltd, Glenrothes, Fife, Scotland WW404

"Transistor selector" is a publication which enables a transistor to be chosen for a particular task on some aspect of its specification or by application. SGS (U.K.) Ltd, Planar House, Walton St. Aylesbury. Bucks WW405
A diode selector is also available WW406

Wel Components Ltd. 5 Loverock Rd, Reading, Berks. RG3 1DS, have published a semiconductor price list for 1971 ....WW407

Ferranti Ltd, Gem Mill, Chadderton, Oldham, Lancs, have published a new integrated circuit price list WW408

A bipolar transistor reliability report describing the extra testing of, and gives life test data for, transistors with the suffix Jan-TX. National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, California 95051 ....WW409
From the same address a t.t.l. and low-power t.t.l. guide is available WW410

We have received the following publication from Fairchild Semiconductor Ltd. Kingmaker House, Station Rd, New Barnet, Herts. "Linear integrated circuit condensed catalogue" gives brief data on a large range of linear i.cs and provide type application lists WW411

AEI Semiconductors Ltd, Carholme Rd, Lincoln, have published a 24-page booklet dealing with eight ranges of zener diodes. The booklet, number (4450 50. VREG), costs 5s.

"Solid-state microwave sources" is the title of a booklet which has been published by ITT Components Group Europe, S.T.C. Ltd, Edinburgh Way, Harlow, Essex WW412

PASSIVE COMPONENTS

Catalogue A-00001 describes the range of reed switches manufactured by the American company Hamlin. It is available from Inter-market Services Ltd, 47a Hay's Mews, Berkeley Square, London W.1 ....WW413

A price list covering the products of many companies' capacitors, resistors, semiconductors, valves, integrated circuits and hardware is available from Swift. Hardmans, Swift House, Bryan St, Hanley, Stoke-on-Trent WW414

Some details of the vast range of products manufactured by ITT Components Group Europe, S.T.C. Ltd, Edinburgh Way, Harlow, Essex, can be gleaned from the publication "Components-Product Digest" WW415
Also available is a list of U.K. sales offices for particular products (6000/463E) WW416

Catalogue No.1 (1971) list a wide range of electronic components available from the D-T-V- Group Ltd, 126 Hamilton Rd, London S.E.27 ....WW417

A leaflet giving technical data and prices for a range of loudspeakers has been received from Baker Reproducers Ltd, Bensham Manor Road Passage, Thornton Heath, Surrey WW418

The Dec '70/Mar' 71 catalogue is available from Radiospares Ltd, P.O. Box 427, 13-17 Epworth St, London EC2P 2HA WW419
Also available from Radiospares is the publication "Component Applications Data". This gives more complete data and advice on using some of the components listed in the catalogue WW420

APPLICATION NOTES

"Helipot 845 digital-to-analogue converter" is a publication which after discussing d.a.cs in general goes on to describe the hybrid microcircuit d.a.c. model 845 together with various methods of using it. Beckman Instruments, Queensway, Glenrothes, Fife WW421

An application note from Fairchild Semiconductor Ltd, Kingmaker House, Station Rd, New Barnet, Herts, gives suggested circuits for the μA740 junction f.e.t. op-amp and types μA715 (high speed), μA735 (micropower), μA725 (instrumentation) and the μA727 (temperature controlled) op-amps WW422

"Control line applications" suggests uses for a range of modules designed to interface low current control circuitry with high current actuators etc. Time delay units are also discussed. FR Electronics Ltd, Wimborne, Dorset WW423

"The case for subminiature switches" is a book which will appeal to all who need to use small switches. It contains the results of an exhaustive eighteen month switch test programme carried out by Waycom on more than 1000 switches. Copies can be obtained from Waycom Ltd (Publications). Wokingham Rd. Bracknell, Berks., price 25s

Application note AN 420. "An integrated circuit stereo pre-amplifier" describes the design of a pre-amplifier using one MC 1303P dual op-amp in each channel. Motorola Semiconductor Products Inc., York House, Empire Way, Wembley. Middlesex. WW424

EQUIPMENT

A leaflet available from Cole Electronics Ltd, Lansdowne Rd, Croydon CR9 2HB, describes a group delay measuring set (400 C) which complies with the P.O. spec. RC5178. The P.O. type number is measuring set 37A WW425

Literature describing f.m. tape equipment manufactured by Lennartz Electronic, of West Germany, is available from Haydon Laboratories Ltd, East House, Chiltern Ave, Amersham. Bucks WW432

"Don't dump your key punch machine till you've read this brochure" is the title of a publication which describes three optical character recognition machines manufactured by Interscan Data Systems (U.K.) Ltd, Hoechst House, Salisbury Rd, Hounslow, Middlesex WW433

A loose-leaf booklet produced by KGM Vidiaids Ltd, Clock Tower Rd, Isleworth, Middlesex, describes, and gives data on, a range of closed-circuit television equipment WW434

J Beam Engineering Ltd, Rothersthorpe Cres., Northampton, have produced a 56-page catalogue giving data on their range of radio communication and television aerials. A price list is included WW442

Avo Ltd, Avocet House, Dover, Kent, have produced a catalogue which gives details of all the Avometers now available WW444

A wide range of equipment for the communications industry is listed in the two catalogues from Rohde and Schwarz which we have received from Aveley Electric Ltd, South Ockendon, Essex RM15 5SR.
Measuring instruments WW445
Communications equipment WW446

HARDWARE

When equipment has been manufactured it must be packed. Literature available from Evans Bellhouse Ltd, Newton Heath, Manchester 10, is devoted to this problem.
Wood wool packing WW448
Moulded polystyrene packing WW449
Fabricated foam packing...............WW450

Mainly for the electrical industry is a brochure that describes "panel plates" for switches and the like made from either satin finished stainless steel or brushed brass. Sola Basic International, P.O. Box 753-Milwaukee, Wisconsin 53201, U.S.A. WW451

A catalogue called "Soldering instruments" is available from Light Soldering Developments Ltd, 28 Sydenham Rd, Croydon, CR9 2LL WW452

Black crepe tapes for printed circuit artwork are listed in a leaflet produced by Circuitape Ltd, High St, Tring, Herts WW453

GENERAL INFORMATION

The following new publications are available from the British Standards Institution, Sales Branch, 101 Pentonville Rd, London N1 9ND:
BS89: Part 1: 1970, 'Specification for direct acting electrical indicating instruments' ....price 20s
BS9400: 1970, 'Specification for integrated electronics circuits of assessed quality: generic data and methods of test' ....price 40s
CP95: 1970. "Fire protection for electric data processing installations". .... price 10s

A 52 page booklet "The international system of S.I. units" is a translation from the French by the National Bureau of Standards and the National Physical Laboratory. It is available from H.M.S.O. price 12s

Two metric conversion cards £/kg to £/lb and kg to cwts have been produced by The J.A.C. Wilkerson Co., 5 Beeches Ave, Carshalton, Surrey WW454

The '1970-71 bulletin of special courses in higher technology, management studies and commerce' is available from London and Home Counties Regional Advisory Council for Technological Education, Tavistock House South, Tavistock Square, London WC1H 9LR, price 10s

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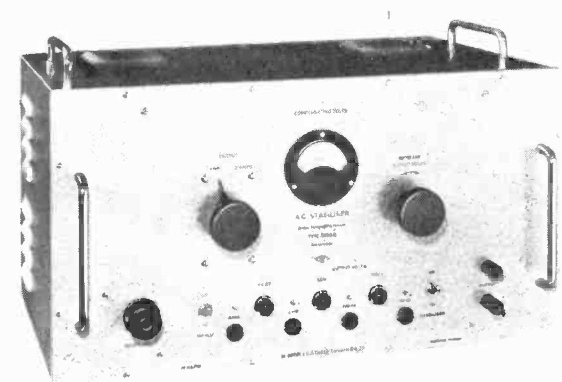

This instrument has been designed to fill the need for a very stable supply with a high purity of waveform for precision A.C. measurements.
The uhit is extremely simple in operation and is fitted with protective devices and alarms which automatically prevent any possibility of damage; it does not require any adjustments in setting up other than the output voltage selection. Output current:—
1 ampere maximum for stabilisation range of ± 7% change of input voltage
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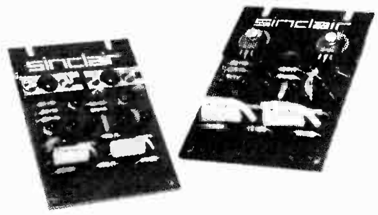
WW—074 FOR FURTHER DETAILS

Sinclair Project 60

Z.30 & Z.50 power amplifiers



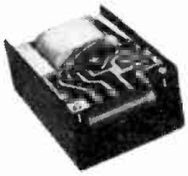
The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

SPECIFICATIONS ***(Z.50 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 $3\frac{1}{2}$ x $2\frac{1}{4}$ x $\frac{1}{2}$ in.

Z.30
Built, tested and guaranteed with circuits and instructions manual **89/6** (£4.47$\frac{1}{2}$)

Z.50
Built, tested and guaranteed with circuits and instructions manual **109/6** (£5.47$\frac{1}{2}$)

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* **£4.19.6** (£4.97$\frac{1}{2}$)
PZ-6 *35 volts stabilised* **£7.19.6** (£7.97$\frac{1}{2}$)
PZ-8 *45 volts stabilised (less mains transformer)* **£5.19.6** (£5.97$\frac{1}{2}$)
PZ-8 *mains transformer* **£5.19.6** (£5.97$\frac{1}{2}$)

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: $8\frac{1}{4}$ x $1\frac{1}{2}$ x 4 ins.
Built, tested and guaranteed. **£9.19.6** (£9.97$\frac{1}{2}$)

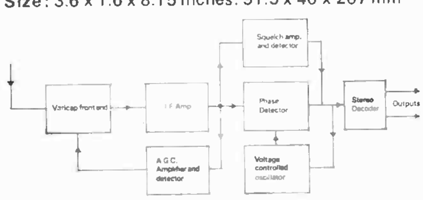
Active Filter Unit

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 **£5.19.6** (£5.97$\frac{1}{2}$)

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

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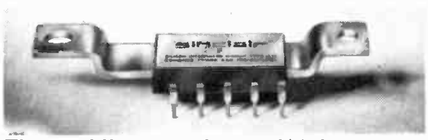
WW—076 FOR FURTHER DETAILS

Sinclair IC10/Q16/Micromatic

IC10



The world's most advanced high fidelity amplifier

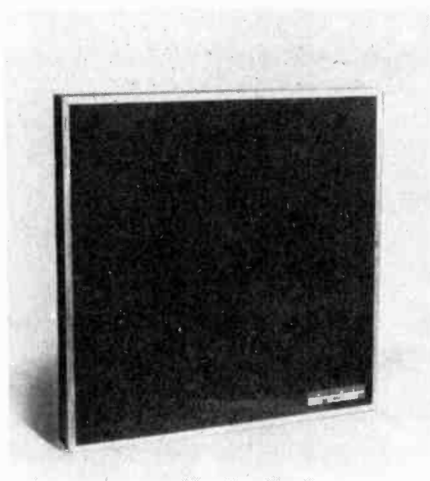
This is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself is a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, having 5 watts RMS output (10 watts peak). It contains 13 transistors (including two power types), 2 diodes, 1 zener diode and 18 resistors, and is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is more rugged and has considerable performance advantages, including complete freedom from thermal runaway and a very low level of distortion. The IC10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. It may also be used in other applications including car radios, electronic organs, servo amplifiers (it is dc coupled throughout) etc.

Circuit Description

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. There is generous negative feedback round both sections and the amplifier is completely free from crossover distortion at all supply voltages, making battery operation eminently satisfactory.
Each IC10 is sold with a comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include oscillators, etc. The pre-amp section can be used as an RF or IF, amplifier without any additional transistors.

Specifications:
Output: 10 watts peak, 5 watts RMS continuous.
Frequency response: 5Hz to 100kHz 1 ± dB.
Total harmonic distortion: Less than 1% at full output.
Load impedance: 3 to 15 ohms.
Power gain: 110 dB (100,000,000,000 times) total.
Supply voltage: 8 to 18 volts. (A Sinclair power unit, PZ.7 is available for mains operation).
Size: 1 x 0.4 x 0.2 in. plus heat sink and tags.
Sensitivity 5 mV.
Input impedance: Adjustable externally up to 2.5 Mohms.
Price (with manual): **59/6** (£2.97½) post free.

Q16



High fidelity loudspeaker

The Q16 employs the well proven acoustic principles specially developed by Sinclair in which a special driver assembly is meticulously matched to the characteristics of the uniquely designed cabinet. In reviewing this exclusive Sinclair design, technical journals have justly compared the Q16 with much more expensive loudspeakers. Its shape enables the Q16 to be positioned and matched to its environment to much better effect than is the case with conventionally styled enclosures. A solid teak surround with a special all-over cellular foam front is used as much for appearance as its ability to pass all audio frequencies.

This elegantly designed shelf mounting speaker brings genuine high fidelity within reach of every music lover.

Specifications:
Construction: Special sealed seamless sound or pressure chamber with internal baffle.
Loading: up to 14 watts TMS.
Input impedance: 8 ohms.
Frequency response: From 60 to 16,000 Hz, confirmed by independently plotted B and K curve.
Driver unit: Special high compliance unit having massive ceramic magnet of 11,000 gauss, aluminium speech coil and a special cone suspension for excellent transient response.
Size and styling: 9¾ in square on face x 4¾ in. deep with neat pedestal base. Black all-over cellular foam front with natural solid teak surround.
Price **£8.19.6.** (£8.97½).

Micromatic

Britain's smallest radio

Considerably smaller than an ordinary box of matches, this is a multi-stage AM receiver brilliantly designed to provide remarkable standards of selectivity, power and quality for its size. Powerful AGC counteracts fading from distant stations; bandspread at higher frequencies makes reception of Radio 1 easy. The plug-in magnetic earpiece provided matches the Micromatic's output to give wonderful standards of reproduction. Everything including the special ferrite rod aerial and batteries is contained within the minute and attractively designed case. Whether you build a Micromatic kit or buy this amazing receiver ready built and tested, you will find it as easy to take with you as your wrist watch, and dependable under the severest listening conditions.

Specifications:
Size: 36 x 33 x 13 mm (1⁴/₅ x 1³/₁₀ x ½ in.)
Weight: including batteries, 28.4 gm (1 oz.).
Case: Black plastic with anodised aluminium front panel and spun aluminium dial.
Tuning: medium wave band with bandspread at higher frequencies. (550 to 1,600 Hz).
Earpiece: Magnetic type.
On/off switching: By inserting and withdrawing earpiece plug.
Kit in pack with earpiece, case, instructions and solder **49/6** (£2.47½).
Ready built, tested and guaranteed, with earpiece **59/6** (£2.97½).
Two Mallory Mercury batteries type RM675 required. From radio shops, chemists, etc.

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WW271

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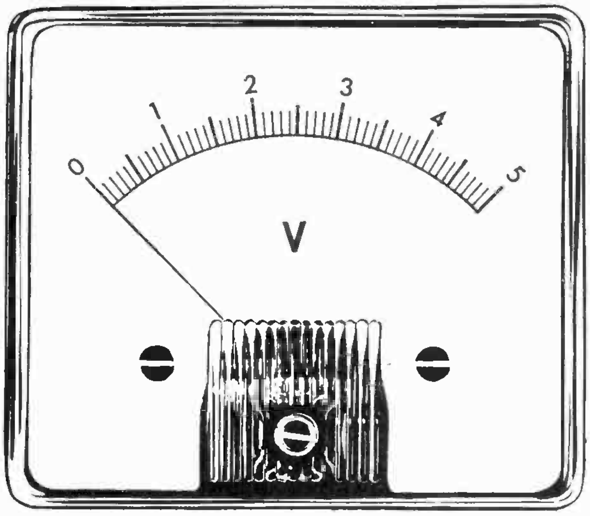
METER PROBLEMS?



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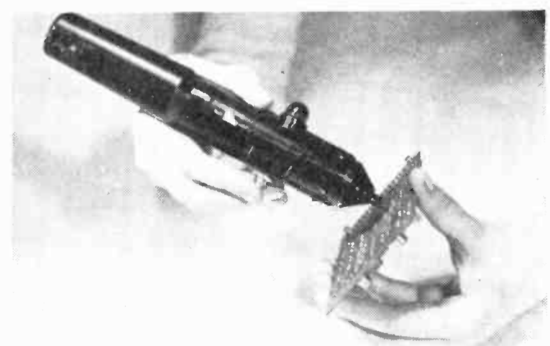
DIOTESTOR IN-CIRCUIT TRANSISTOR TESTER



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Tel: 01-930 3070

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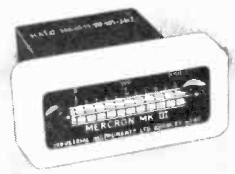
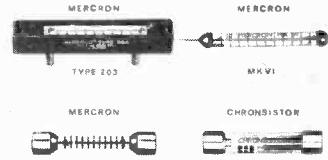
MERCRON Ⓡ—Electro-chemical E.T.I. based on mercury for 100, 1,000 and 10,000 hours. Exists in six different models.

HOROCONTROL Ⓡ—Electro-mechanical E.T.I. for A.C., or D.C. for 9999.9, or 999.99 hours.





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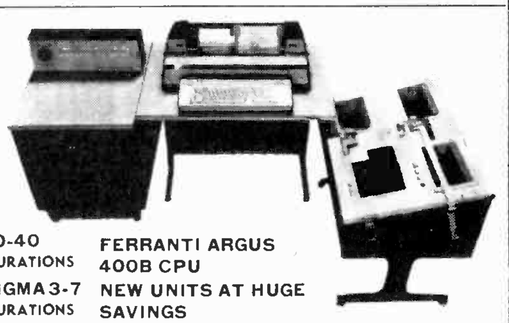

SOME COMPUTER SYSTEMS AVAILABLE

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VARIOUS CONFIGURATIONS

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VARIOUS CONFIGURATIONS

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AS ILLUSTRATED

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NEW UNITS AT HUGE SAVINGS

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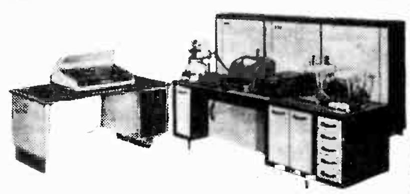
Type: 29.80 column Punch

A well-proven electro-mechanical card punch, with duplicating, spacing, and skipping facilities. Two types of keyboard are available for this model: Alpha/Numeric and Alphabetic.

FEATURES: Motor cut-out switch for clearing card jams. Stop Lever for stopping card at the 80th column. *Also available H129 card verifiers.*



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This is a well proved solid state digital computer, with well over 200 systems sold in the UK and abroad. Reliability has been proved by long periods of operation. **Typical Configuration:** Central Processor with 4096 Core Store. Type 3 Paper Tape Station. One Tape Reader 500 characters per sec. (Elliott TS/93). One Tape Punch 100 characters per sec. (Teletype BRPE E11). Keyboard console and associated desk. Creed Teleprinter. Automatic Floating Point Unit.

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PLESSEY	12,000 MF	50v. DC	4½″ × 2¼″	24/–
	8,000 MF	60v. DC	5″ × 2¼″	22/6
	5,000 MF	50v. DC	4½″ × 1¾″	19/6
	5,000 MF	15v. DC	4½″ × 1⅜″	10/–
HUNTS	2,000 MF	100v. DC	4½″ × 2″	10/–
PLESSEY	1,500 MF	100v. DC	4½″ × 1¾″	10/–
MALLORY	500 MF	50v. DC	2¾″ × 1⅜″	2 for 10/–
DUBILIER	14 MF	660v.	50c.	30/–
	13 MF —5+10%		660v. 50c.	30/–
TCC	2 MF	350v. DC		4 for 20/–
	2 MF	1,000v. DC		10/–
	8 MF	350v. DC		12/6
DUBILIER	8 MF	600v. DC		12/6
TCC	8 MF	1,000v. DC		17/6
	4 MF	500v. DC		12/6
	14 MF	350v. RMS 50/60c.		30/–
DUBILIER	4 MF	660v. 50c.		22/6
	50 MF	120v. (120 amp. Pk.)		£5

POWER TRANSISTORS

MOTOROLA	2N1557	90W	21/–
	2N2192	2·8W	4 for 10/–
SYLVANIA	2N1296	25W	10/–
BENDIX	2N3235	117W	18/–
	2N1146B	95W	10/–
RADIOTECHNIQUE	ASZ16	43W	12/–
TEXAS	2N457	50W	9/6
	2G240	25W	8/–
	2S025	100W	15/–

INTEGRATED CIRCUITS

TRANSITRON	D14	21/–
SYLVANIA	SG83 D34 811	21/–
TRANSITRON	D17	21/–

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STC RAS 508 AF Stud 800 PIV 5A	10/–
1 amp. wire-ended 450 PIV	4 for 10/–

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BROOKS 1961 LTD.	S66692	500 kc/s	25/–
BRUSH	2S114		12/6

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AEI	CR10101B	10A 100v.	10/–
STC	3/40	3A 400v.	10/–
TRANSITRON	TCR1010	8A 100v.	10/–
STC	1/40	1A 400v.	6 for 20/–

KEYSWITCHES

DOUBLE CO's .. 2 for 15/–

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MINIATURE SIEMENS	4 C.O. 2 Coils. 2K each	12/6
MINIATURE VARLEY	4 C.O. 1 Coil. 700 ohm	12/6
MINIATURE VARLEY	2 C.O. 1 Coil. 140 ohm	12/6
P.O. TYPE. SIMMOND	4 C.O. + 2 HEAVY DUTY OPEN 2K COIL	10/–
P.O. TYPE. SIMMOND	2 C.O. + 2 HEAVY DUTY OPEN 1K COIL	10/–
B.R. MAINS 240v. COIL	3 open 2 closed Heavy Duty Contacts	12/6
B.R. MAINS 240v. COIL	2 change-over Heavy Duty Contacts	15/–
WIRE LATCHING RELAY	4 change-over. Main coil 600 ohm. Release coil (if used) 300 ohm	2 for 10/–

Thermal: Coventry Controls Ltd. Series RM hermetically sealed. Adjustable basic time delay 160 sec., contact N/O heater 250 ohm .. 30/–
Mercury wetted contacts: Elliott Bros. Ltd., type EB2a contacts 2 C.O. at 5 amps, 500v. coil 300 ohms .. 50/–
Type EB1512 contacts 2 C.O. in parallel 5 amps at 500v. coil 120 ohm .. 40/–
Solenoid air pressure adjustable time delay switch, Ether Ltd., type 1104, coil 48v. DC switch 3A 440v. AC .. £3

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CRESSALL	100W	1,500 ohm	21/–
CRESSALL	100W	350 ohm (with black instrument knob)	21/–
BECKMAN HELIPOT	10 turns. 100 ohm. Lin-Tol. 0·25%		£2

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STC CN5 0–9 NUMBERING VALVES .. 50/–

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PLANNAIR 230v. 1 PH. 50 c/s. 9½″ × 8″ dia. 12 Turbine Blade Fans .. £10

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8 WAY 25 BANK 75 ohm COIL .. £5.10
16 WAY 52 BANK OPERATING COILS 44 ohm. LOCKING COIL 100 ohm .. £7.10

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PLESSEY Suppression Unit. 250v. AC 25A. E.E.L.M. Spec. 03715–011 .. £12.10
STANDARD ELECTRONICS CO. Filter Radio Interference. 10A 240v. AC 400 Hz .. £2

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115v. 50c. main input. 10A output variac adjustment smooting by choke and 28, 25,000 mfd. Daly condenser (total 700,000 mfd.), size 18½″ × 5½″ × 13½″. DC switched by circ. brea. rem. con. connection overload device fitted. DC voltages

+ 6	£50
— 6	£50
+18	£65
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Daly 25v. condensers, ditto .. £20
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COMPLETE UNIT COMPRISING SOLDER IRON, STAND/CLAMP, FOOT-PUMP AND RESERVOIR/BIT SPANNER. 200/220v. 110/115v. AC. HALF WHOLESALE PRICE. **£3.15.0.** Box/Post, etc., 6/– extra.

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	V-15/AT-3	£10.12.6
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GARRARD 5200 CHANGER with low mass pick-up arm and Stereo Cartridge. CONTROLS: TREBLE, BASS, VOLUME, STEREO BALANCE. Operation on 200-250 v. A.C. mains. Output rating I.H.F.M.

Luxurious Teak Veneer Finished Cabinets. Transparent plastic (tinted) cover included for main unit. Silver finished facia plate and matching control knobs.

PAIR OF LOUDSPEAKER UNITS incorporating high flux 8in. × 5in. speaker. Size approx. 13 × 7½ × 8¾ ins.

PRICE COMPLETE ONLY £42 Carr. £1·25

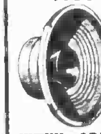
Terms: Deposit £5.50 and 9 monthly payments £4.50 (Total £46).

A REALLY SURPRISING STANDARD OF QUALITY IS OBTAINED FROM THIS COMPACT LOW PRICED SYSTEM

FANE 807 HIGH FIDELITY LOUDSPEAKER

A full range 8in. 10 watt Unit for excellent sound quality in suitable enclosure. Roll P.V.C. cone surround and long throw voice coil to achieve very low fundamental resonance at 30 c.p.s. Tweeter cone is fitted to extend high note response. Frequency range 25-15KHz. Impedance 3Ω or 8-15Ω. Cast Chassis. REMARKABLE VALUE. **£3.50**

AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS



Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround or "L" indicates Roll Rubber surround. "D" indicates Tweeter Cone providing extended frequency range up to 15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 8-15 ohms.

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HF 801D	8"	8W	£2·71	HF 120D	12"	15W	£4·49
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FANE ULTRA HIGH POWER LOUDSPEAKERS

All power ratings are R.M.S. continuous. 2 years' guarantee. High flux ceramic magnets. Heavy cast chassis. ALL CARRIAGE FREE.

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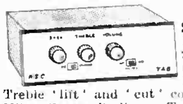
FOR BASS GUITAR OR ELECT. ORGAN, ETC.

FANE LOUDSPEAKERS 'POP' 25/2

Dual cone 15Ω (for uses other than Bass Guitar or Electronic Organ. Or dep.: £1 and 9 monthly payments 75p (Total £7·75). Carr. free.

12in. 25watt **£6·75**

R.S.C. TA6 6 Watt High Fidelity Solid State Amplifier



200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, approx. 9¼ × 2¾ × 5¼in. Attractive brushed silver finish facia plate 10¼ × 3¼in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. **£7.50** Carr. 40p

OR FACTORY BUILT with 12 months' g'tee. **£9.25**

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Type BM1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200/250 v. 50 c/s. is available. Complete kit with diagram £2·99 or, READY FOR USE £3·49.

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In teak or afrormosia veneered cabinets. **L13** 3 or 15 ohms. 13 × 8in. 8-10 Watt Model Gauss 10,000 lines, Carr. 40p **£5.25**

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Covered in Rexine and Vynair, ideal for vocalists and Public Address. 15 ohm matching. **TYPE C48S, 30 watts.** Fitted four 8in. high flux 8w. speakers. Or dep. £3 and 9 monthly payments £2 (Total £21). Carr. 50p **£17.75**

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Consisting of matched 12in. 11,000 line 15 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. Carr. 30p. **£5.75**

Or SENIOR 15 WATT inc. HF126 15,000 line Speaker £6·75. Carr. 30p.

HI-FI LOUDSPEAKER ENCLOSURES

Teak or Afrormosia veneer finish. Modern design. Acoustically lined. All sizes approx. Carr. 25p extra.

JE8 Size 16 × 11 × 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **£4.75**

SE8 For optimum performance with any 8in. Hi-Fi speaker. 22 × 15 × 9in. Ported **£5.75**

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SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 × 16 × 10½in. Pressurised. **£6.99**

TA12 MK III 6·5 + 6·5WATT STEREO AMPLIFIER

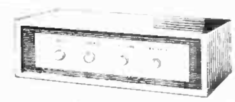
FULLY TRANSISTORISED. SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL

Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 20-20,000c.p.s. —2dB ★ Harmonic Distortion 0.3% at 1000c.p.s. Hum and noise —70dB ★ Sensitivities (1) 50 mV (2) 400 mV (3) 100 mV ★ Handsome finish Facia Plate and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. Carr. 40p. **£14.25**

FACTORY BUILT WITH 12 MTH GNTEE. £17·85. Or dep. £3 and 9 mnthly pymts. £1·95 (Total £20·55). Or in Teak or Afrormosia veneer housing. £21·52½ or Dep. £3.15 and 9 mthly. pymts. £2.35 (Total £24.30).

SELENIUM RECTIFIERS F.W. Bridged 6/12v. D.C. Output Input Max. 18v A.C. 1a., 25p; 2a., 35p; 3a., 50p; 4a., 65p; 6a., 80p

R.S.C. G66 6+6 WATT HIGH QUALITY STEREO AMPLIFIER

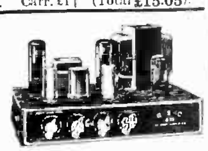


Individual Ganged controls: Bass, Treble, Volume and Balance. Printed circuit construction employing 10 Transistors plus Diodes. Output rating I.H.F.M. Suitable for Crystal Pick-ups etc., and for loudspeaker output impedances of 3 to 15 ohms. For standard 200-250 v A.C. mains operation. Attractive silver finished metal facia plate and matching control knobs. Complete KIT of PARTS INCLUDING FULLY WIRED PRINTED CIRCUIT and comprehensive wiring diagram and instructions. **£9.99** No leaflet supplied for this unit.

Or FACTORY BUILT in Teak veneered cabinet as illustrated £12.50. Carr. 40p. Or Deposit £2 and 9 monthly payments of £1.45 (Total £15.05).

PACKAGE OFFER, SAVE APPROX. £4. Above G66 assembled in cabinet plus pair DORCHESTER LOUDSPEAKER UNITS. **£27.50** Or Deposit £5·25 and 9 monthly payments £2·85 (Total £30·90). Carr. £1

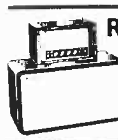
R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Hum level —70dB. Frequency response ±3dB 30-20,000 c/s. All high grade components. Valves EF86, EF86, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for **Clubs, Schools, Theatres, Dance Halls** or **Outdoor Functions**, etc. For use with **Electronic Organ, Guitar, String Bass**, etc. Gram, Radio or Tape. Reserve L.T. and H.T. for **Radio Tuner**. Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250 v., A.C. mains. For 3 & 15 ohm speakers. **Complete Kit parts wiring diagrams, instructions £15·75.** Twin-handled perforated cover **£1·75.** Or factory built with EL34 output valves and 12 months' guarantee for **£18·90.** Tech. figs. apply to factory built units. Carr. 65p.

TERMS: Deposit £3·45 and 9 monthly payments of **£2** (Total **£21·45**). Send S.A.E. for leaflet.

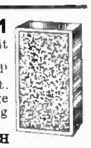
RSC BASS-REGENT 50 watt AMPLIFIER



A powerful high quality, all purpose unit. For lead, rhythm, bass guitar, vocalists, gram., radio, tape. Peak output rating. Employing current valves and reliable components. FOUR JACK INPUTS and TWO VOLUME CONTROLS for simultaneous use of up to 4 pick-ups or 'mikes'. SEPARATE BASS AND TREBLE CONTROLS. Or supplied complete with matched twin loudspeaker unit as illustrated for **£60.** Carr. £1.50.

ONLY £30 Carr. 90p Terms available

THE 'YORK' HIGH FIDELITY 3'SPEAKER SYSTEM



Moderate size (approx. 25 × 14 × 10 in.). Range 30-20,000 c.p.s. Impedance 15 ohms. **Performance comparable with units costing considerably more.** Consists of (1) 12in. 15 watt Bass unit with cast chassis. Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker. (4) High efficiency tweeter. (5) Appropriate quantity acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions.

Complete kit **£22** Carr. 65p

REMARKABLE VALUE HEAR IT AT ANY BRANCH

INTEREST CHARGES REFUNDED
On Credit Sales settled in 3 months

R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250v. 50c/s. Screened

MIDGET CLAMPED TYPE 2½ × 2½ × 2¼in.

250v., 60mA, 6.3v. 2a.	90p
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FULLY SHROUDED UPRIGHT MOUNTING

250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a.	£1·25
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350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
350-0-350v. 150mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·40
425-0-425v. 200mA, 6.3v. 4a. c.t., 5v. 3a.	£4·49
425-0-425v. 200mA, 6.3v. 4a., 6.3v. 3a, 5v. 3a	£4·69
450-0-450v. 250mA, 6.3v. 4a., c.t., 5v. 3a.	£4·99

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250-0-250v. 100mA, 6.3v. 3.5a.	£1·40
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a.	£1·45
350-0-350v. 80mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·50
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
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350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
350-0-350v. 150mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·35

FILAMENT or TRANSISTOR POWER PACK Types 6.3v. 1.5a. 45p; 6.3v. 2a. 49p; 6.3v. 3a. 69p; 6.3v. 6a. £1·15; 12v. 1a. 50p; 12v. 3a. or 24v. 1.5a. £1·20; 0-9-18v. 1½a. 99p; 0-12-25-42v. 2a. £1·60.

CHARGER TRANSFORMERS 0-9-15v. 1½a. 95p; 2½a. 99p; 3a. £1·10; 5a. £1·30; 6a. £1·49; 8a. £1·85.

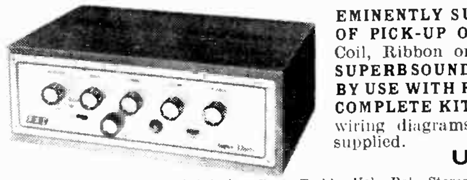
AUTO (Step UP/Step DOWN) Transformers 0-110/120v. 200-230-250v. 50-80 watts 99p; 150 watts £1·70; 250 watts £2·49; 500 watts £5·25.

OUTPUT TRANSFORMERS

Standard Pentode 5,000Ω to 7,000Ω to 3Ω	45p
Push-Pull 8 watts EL84 to 3Ω or 15Ω	75p
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15Ω	£1·25
Push-Pull EL84 to 3 or 15Ω 10-12 watts	£1·20
Push-Pull Ultra Linear for Mullard 510, etc.	£1·99
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15Ω	£1·80
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15Ω	£2·99

SMOOTHING CHOKES 150mA. 7-10H. 250Ω 65p; 100mA. 10H. 200Ω 55p; 80mA. 10H. 350Ω 45p; 60mA. 10H. 400Ω 25p.

R.S.C. SUPER 30 Mk II HIGH FIDELITY STEREO AMPLIFIER



HIGH GRADE COMPONENTS. SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE

Employing Twin Printed Circuits. 200/250v A.C. mains operation.

TRANSISTORS: 9 high-quality types per channel.
OUTPUT (Per channel): 10 Watts R.M.S. continuous into 15Ω 15 Watts R.M.S. continuous into 3Ω.
INPUT SENSITIVITIES: Mag. P.U. 4 m.v. Ceramic P.U. 35 m.v. Tape Amp. 400 m.v. Aux. 100 m.v. Mic. 5 m.v. Tape Head 2.5 m.v.
FREQUENCY RESPONSE: ±2dB. 10-20,000 c.p.s.
TREBLE CONTROL: +17 dB to —14 dB at 10 Kc/s.
BASS CONTROL: +17 dB to —15 dB at 50 c/s.
HUM LEVEL: —80 dB.
HARMONIC DISTORTION: 0.1% at 10 Watts 1,000 c.p.s.
CROSS TALK: 52 dB at 1,000 c.p.s.

CONTROLS: 5-position Input Selector, Bass, Treble, Vol., Bal., Stereo/Mono Sw., Tape Monitor Sw., Mains Sw.
INPUT SOCKETS: (1) P.U. (2) Tape Amp. (3) Radio. (4) Mic. or Tape Head. (Operation of Input Selector assures appropriate equalisation.)
CHASSIS: Strong Steel construction. Approx. 12 × 3 × 8in.
FACIA PLATE: Attractive design in rigid "Perspex" with silver background. Spun silver matching control knobs as available.

EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MIC. (Ceramic or Magnetic, Moving Coil, Ribbon or Crystal) **CURRENTLY AVAILABLE. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USE WITH FIRST-RATE ANCILLARY EQUIPMENT. COMPLETE KIT OF PARTS,** point to point wiring diagrams & detailed instructions supplied. **£23.25** Carr. 75p

UNIT FACTORY BUILT £30.50

Or deposit £4 and 9 mnthly payments £3·35 (Total £34·15).

Or in Teak or Afrormosia veneer housing as illustrated. Carr. 75p. **£33.75**

Terms: Deposit £4 and 9 monthly payments £3·75. (Total £37·75). Send S.A.E. for leaflet.

R.S.C. PLINTHS

Superior Solid Natural Wood Construction for Record Playing units.

Cut for Garrard 1025, 2025, 3000, AT60, SP25 etc. **£3.15**

Available with Transparent plastic cover. **£6.30**

RECORD PLAYING UNITS

MONEY SAVING UNITS Ready to plug into Amplifier.

RP2C Consisting of Garrard SP25 Mk. II (with heavy turntable) fitted Goldring CS90 high compliance ceramic Stereo/Mono cartridge with diamond stylus. Mounted on plinth. Transparent plastic cover included Carr. 50p **£24·65**

RP6C Garrard 5200 Auto Unit fitted Stereo Cartridge. Plinth and Cover as RP2C. Carr. 50p **£15**

OTHER TYPES with Magnetic P.U. Cartridges and 'Lift off' or 'Roll over' transparent covers at lowest prices.

R·S·C HI-FI CENTRES LTD.

BRADFORD 10 North Parade (Half-day Wed.). Tel. 25349
BLACKPOOL (Agent) O & C Electronics 227 Church St.
BIRMINGHAM 30/31 Gt. Western Arcade. Tel.: 021-236 1279. Half-day Wed.
DERBY 26 Osmaston Rd. The Spot (Half-day Wed.). Tel. 41361
DARLINGTON 18 Priestgate (Half-day Wed.). Tel. 68043
EDINBURGH 133 Leith St. (Half-day Wed.). Tel. Waverley 5766
GLASGOW 326 Argyle St. (Half-day Tues.). Tel. CITy 4158
HULL 91 Paragon Street (Half-day Thurs.). Tel. 20505

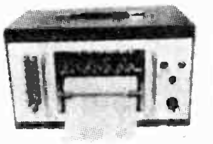
MAIL ORDERS to: 106 Henconner Lane, Leeds 13. Terms C.W.O. or C.O.D. Postage 25p extra under £2. 30p extra over £2. Trade supplied. S.A.E. with enquiries. Export enquiries welcomed. Branches open all day Sats. MAIL ORDERS MUST NOT BE SENT TO SHOPS.

LEICESTER 32 High Street (Half-day Thurs.). Tel. 56420
LEEDS 5-7 County (Mecca) Arcade, Briggate (Half-day Wed.) Tel. 28252
LIVERPOOL 73 Dale St. (Half-day Wed.). Tel. CENtral 3573
LONDON 238 Edgware Road, W.2 (Half-day Thurs.). Tel. PAD 1629
MANCHESTER 60A Oldham Street (Half-day Wed.) Tel. CENtral 2778
MIDDLESBROUGH 106 Newport Rd. (Half-day Wed.). Tel. 47096
NEWCASTLE UPON TYNE 41 Blackett Street (opp. Fenwicks Store) (Half-day Wed.). Tel. 21469
SHEFFIELD 13 Exchange Street (Castle Market Blds.) (Half-day Thurs.). Tel. 20716

EQUIPMENT AND COMPONENTS

MEASURING INSTRUMENTS AND RECORDERS

NEW 6-CHANNEL TIME & EVENT RECORDER

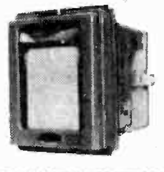


A self-contained instrument, specifically for recording events without the need for a combined recorder. There is a separate and independent paper drive, with a monitor lamp indicating when it is in operation. The pens are displaced 1/16 in., activated by a close contact system. Each of the 6 channels works independently of each other, with the pens writing at 72 hours per filling at a maximum speed of 10 pulses per second. **£75**. Send for leaflet.

FACSIMILE RECORDERS

D649 G/A 18 in. Chart Recorder. Helix speed: 60, 90, 120 rev./min. Transmission speed: ½ in.; 15/16 in.; 1½ 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 500 micro amps. Coil res. 1.53k. Fully interchangeable gears available to make a wide range of chart speeds. 200/250V. Size: 8×11×6 in. Almost new—complete with chart and ink. List over £100.
Our price .... **£52·50**
0–1mA version .... **£49·50**

POWER SUPPLY UNITS

O/P V	O/P A	S or U*	Input volt.	Price	Make	Type	Dimensions W H L inches	Location	Ref. No.
6 adj 4-16v	7	S	240	£30	Coutant	ELV700/6	6¼×5¼×11¼	876	36
6 adj 3-15v	5	S	240	£25	Coutant	ELV500/6	4½×7 ×12	876	37
4-15v	5	S	240	£20	Advance	PM7	4½×5¼× 9½	876	38
12	1	S	240	£15	Farnell	SSU12·1	4 ×6×10 1/16	876	39
± 150 200	mA	S	240	£12	Roband	B101/200	7½×6½× 9	876	40
28 adj 26-37	7	S	240	£30	Coutant	ES700/28	8½×7 ×12	875	42
+30 −20	300 mA	S	240	£10	B.P.L.	3	19×8½×12	875	41
12	20	S	110	£25	I.B.M.	Ex. comp.	6 ×5½×16	879	66
12	20	S	110	£25	I.B.M.	Ex. comp.	6 ×5½×16	878	70
12	20	S	110	£25	I.B.M.	Ex. comp.	6 ×5½×16	878	57
12	20	S	110	£25	I.B.M.	Ex. comp.	6 ×5½×16	878	56
12	20	S	110	£25	I.B.M.	Ex. comp.	6 ×5½×16	878	59
12	20	S	110	£25	I.B.M.	Ex. comp.	6 ×5½×16	878	58
12	20	S	110	£25	I.B.M.	Ex. comp.	6 ×5½×16	877	67
6	16	S	110	£23	I.B.M.	Ex. comp.	6 ×5½×13½	879	54
48	6	S	110	£19.50	I.B.M.	Ex. comp.	6 ×5½×16	879	55
30	7	S	110	£17	I.B.M.	Ex. comp.	6 ×5½×13½	879	62
12	15	S	110	£22.50	I.B.M.	Ex. comp.	6 ×5½×13½	879	64
12	12	S	110	£22	I.B.M.	Ex. comp.	6 ×5½×13½	874	60
12	12	S	110	£22	I.B.M.	Ex. comp.	6 ×5½×13½	874	61
20	6	S	110	£18	I.B.M.	Ex. comp.	6 ×5½×13½	874	65
6	8	S	110	£12.50	I.B.M.	Ex. comp.	6 ×5½× 9½	874	68
6	8	S	110	£12.50	I.B.M.	Ex. comp.	6 ×5½× 9½	874	63
12	4	S	110	£18	I.B.M.	Ex. comp.	6 ×5½× 9½	874	72
12	4	S	110	£18	I.B.M.	Ex. comp.	6 ×5½× 9½	874	71
6	8	S	110	£12.50	I.B.M.	Ex. comp.	6 ×5½× 9½	874	69
20 −10 −10	4½ 4 300 mA	U/S S S	240	£25	Power Electronics	SP110	8 ×6 ×13½	877	43
Do.	Do.	Do.	240		Do.	Do.	Do.	877	44
48	4	U/S	240	£18.50	Advance	DC8	5½×6 ×17	877	80
24	5	U/S	240	£18.50	Advance	DC22	5½×6 ×17	873	73
48	2	U/S	240	£15	Advance	DC122	5½×6 ×17	866	74
12/15	5	S	240	£25	Advance	DCR12/12	5½×8 ×17	873	53
6	20	S	240	£45	Coutant	R205	19×8½×13½	873	51
+6 −6	10 2	S	240	£45	Coutant	R206	19×7 ×12	873	47
28	20	S	240	£50	Coutant	R204	19×8½×14	870	85
190-250	350 mA	S	240	£16.50	Airmec	705	19×12×8½	872	52

* = Stab./Unstab.

This is a small selection of our range. Further details on application.

PRECISION POTENTIOMETERS

TEN TURN 3600° ROTATION BRAND NEW (Ref. C5)

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
100/100/100		Beckman	A	160/-
100	0.5	Beckman	A.S.	60/-
200	0.5	Beckman	A	60/-
500	0.1	Beckman	S.	70/-
500		Colvern	2501	45/-
500		Foxes	PX4	40/-
500		Colvern	2610	50/-
500		Colvern	26/1000/11	60/-
500	1.0	Relcon	HEL107-10	45/-
1K		Relcon	HEL0710	45/-
2K	0.5	Beckman	SA1101	60/-
2K	0.25	Beckman	7216	60/-
2K		Reliance	GPM15	40/-
2K		General Controls	GPA15/4	40/-
5K		Relcon	07-10	50/-
5K		Colvern	CLR2503	60/-
10K	0.5	Beckman	A	60/-
10K	0.1	Beckman X	A	70/-
10K	0.1	Colvern	CLR26/1001	70/-
15K		Colvern	CLR2402	60/-
18K		Beckman	A	60/-
25K	0.5	Helipot	SAJ337	60/-
29K	0.05	Beckman	SA1244	90/-
30K		Colvern	2402	30/-
30K		Beckman	SA95C	60/-
30K	0.1	Beckman	A.S8	70/-
30K	0.5	Beckman	SA1692	60/-
30K	0.25	Beckman	SA1679	65/-
30K	1.0	Colvern	2402/1	30/-
50K		Reliance	07.10	45/-
50K			07.5	45/-
50K		Colvern	2503	45/-
50K	X	Foxes	PX4	45/-
50K	0.5	Beckman	A	60/-
50K	0.1	Beckman	A	70/-
100K/100K		Ford	A	100/-
100K	0.1	Beckman	A	70/-
100K	0.5	Beckman	A	60/-
100K		Colvern	2501	45/-
100K		Colvern	2610	50/-
298K	0.1	Beckman	SA3902	70/-
300K	0.1	Beckman	A	70/-

THREE TURN 780° ROTATION

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
100/100	0.5	Beckman	C	60/-
100/100		Beckman	Type C	60/-
300		Beckman	9303	45/-
1K		Fox	PX2/H3	45/-
10K	0.5	Beckman	C.ss	45/-
20K/20K	0.1	Beckman	C.S	60/-
10K/10K	0.1	Beckman	C	60/-
50K	0.5	Beckman	C.S	35/-

FIFTEEN TURN 5400° ROTATION

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
25K/25K		Beckman B	10 watts	£6·50
46K/46K		Beckman B	10 watts	£6·50

TWENTY TURN 7200° ROTATION

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
1 Meg		General Controls	PXM130	80/-
50K		Reliance		40/-

156 TURN 56160° ROTATION

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
460		Kelvin Hughes	KTP0701	£9/10/-

FIVE TURN 1800° ROTATION

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
200		Relcon	HELO7.05 -F/11	45/-
500		Colvern	CLR2505	40/-
U1.5K		Colvern	CLR2605	40/-

FIVE-AND-A-HALF TURN

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
500		Colvern	2405	40/-

SINE COSINE

Values	Type	Maker	Price
5 Kohms	CLR 8601	Colvern	£17·50
14 Kohms	SCP 5	Smith	£22·50
15 Kohms	CLR 8601	Colvern	£17·50
20 Kohms	CLR 8602	Colvern	£22·50
25 Kohms	CLR 9602	Colvern	£17·50
30 Kohms	CLR 8601	Colvern	£17·50
32 Kohms	SCP 4	Kelvin-Hughes	£17·50
35 Kohms	SCP 1	Smiths	£17·50

P. & P. EXTRA

LOW FREQUENCY RESOLVED COMPONENT INDICATOR BY SOLARTRON

Type VP 253.2A. This instrument will indicate by means of two centre zero 6 in. scale meters the resolved components of a signal voltage with respect to the applied reference energisation. Frequency Range: 0.5 c/s-1 Kc/s. Signal Voltage Ranges: 50MV, 150MV, 500MV, 1.5V, 5V, 15V, 50V and 150V with either balanced or unbalanced input. Signal Input Resistance: 10M Ω unbalanced, 20M Ω balanced. Reference Input. Voltage 90/130 or 230/240V. Standard Rack Panel, 19 in. 12½ in. high, **£175** new condition, complete with manual.

VIBRON ELECTROMETER

This unit is a vibration condenser amplifier which is suitable for the measurement of small D.C. potentials covering the range of 1M-1V. This unit can also be used as high impedance null detector for the comparison of ironation currents of very high resistance. **£89.10.0.**

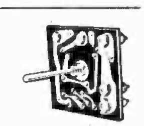
PLATINUM RESISTANCE THERMOMETER PROBES

SOLARTRON Type NT 1198/c and NT 1687. Accuracy ±1°C. Probes in stainlesssteel case. ½ in. diameter. Temp. range NT 1198/C-50°C to + 250° C. Price **£12·50** each. p. & p. 3/6.

FENLOW LOW FREQUENCY ANALYSER

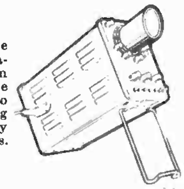
0.3 Hz to 1 K Hz. Power density 0-10. Bandwidth switching range. .06: 0.3: 1.5: 7.5: 37.5 Hz. Price **£275**.

LINEAR THRYRISTER CONTROLLED LIGHT DIMMER



400w. module. Ideally suitable for photo-flood or speed controller, etc. Will mount into standard socket boxes.
Our price **59/6**. P. & P. 5/-.

OSCILLOSCOPE TYPE CT 52



A very handy miniature portable instrument for general purpose applications. 2½ in. diam. tube. Wave form investigation from 10 Hz-20 MHz. Pulse monitoring duration 50 microseconds to 0.1 microsecond. Time base free running 10 Hz-40 kHz. Also single sweep facility from 50 microseconds to 3 microseconds.

Price **£22·50**. P. & P. 30/-.

BRAND NEW COMPUTER TAPES AND EMPTY SPOOLS

Made by well known manufacturers

½ in. certified 2,400 ft. 800 b.p.i.	£8·50
½ in. 2,400 ft.	£6·50
½ in. Highest grade 2,400 ft.	£3·00
½ in. 10½ in. dia. spool and cassette	£1·50
½ in. 8½ in. dia. spool and cassette	£1·50
1 in. metal 10½ in. dia. spool and cassette	£2·50
½ in. N.A.B. centres 10½ in. spool only	£1·00

L.F. SIGNAL GENERATOR SG66 NEW CONDITION

Frequency range 5 c/s to 125 kc/s in five bands. Accuracy ±(1%+1 c/s). Sine wave distortion less than 1% at 1W. Output Sine wave continuously variable, 0 to 30V r.m.s. into 600 Ω. Sine wave 0 to 1W into 5 Ω. Square wave 0 to 30V pk.pk. Output impedance varies up to 5k Ω depending on output level setting. Rise and fall times up to 0.75μs maximum. Power requirements 100 to 130V and 200 to 260V, 40 to 60 c/s, 100W. Dimensions 19in. wide × 10½in. high × 8½in. deep. Weight 32½lb. Rack mounting. Price **£75** carriage extra.

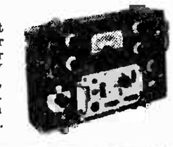
MULTI-RANGE TRANSISTORISED VOLT-METER 1063

Employing silicon planar F.E.T., this instrument gives long-term stability and negligible drift over a wide temperature range. Wide frequency band 0-300 MHz. using HPV 1063. Voltage range 0-30KV. Centre zero on DC ranges for differential circuit application. Input resistance 1 M.ohm/Volt on all DC ranges. Accuracy + 3— F.S.D. Meter scale 5in. with 1M different colour for different scales.
Special price **£42·50** each. Carriage £1·50.

SYNCHRONOUS CHOPPERS

Base B-9. Coil 6.3 v., 50-60 Hz. Proportion of time contacts are closed 45%. Model CK4 available. Also available 100 Hz and 400 Hz. Price **£5**. P. & P. 25p.

AVO TRANSISTOR ANALYSER CT 446



A portable direct-reading instrument capable of giving accurate transistor measurements in the grounded emitter configuration. Battery power unit 1.5V to 10.5V in 5 steps. Base current 0-1 mA, 1-40 mA. Collector current 250 mA. Size: 15½×9½×5 ins. Weight with batteries: 15 lbs. Price **£42·50**. Carriage extra.

7-TRACK DIGITAL MAGNETIC TAPE STORAGE DECK (Ref. 13)

These machines, originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay heads encased in one common unit. Low resistance heads. Frequency response approximately 0 Kc/s. to 50 Kc/s. Bit density 557 b.p.i. ½ in., 10½ in. spools 230 v. to 380 v. A.C. Capstan Motor speed 1,500 r.p.m. 48 v. D.C. Rewind motors. Finished in brush aluminium and matt-black. Size 27 in. × 26 in. × 8 in. Weight 90 lb. Price **£65**. Carriage extra.

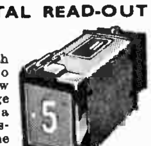
MEMORY PLANES (Ref. C4)

Ferrite core memory planes with wired Ferrite cores. Used for building your own computer or as an interesting exhibit in the demonstration of a computer. Mounted on plastic material, frame 5×8 in. Consisting of matrices 40×25×4 cores each one individually addressable and divided into 2 halves with independent sense and inhibit wires. **£6·50**. P. & P. 15p.

MINIATURE DIGITAL DISPLAY

Operates on a rear projection 6.3 pilot lamp. The lamp projects the corresponding digit on the condensing lens through a projector lens, on to the viewing screen at the front of the unit. 1 in. width, 3 5/16 in. deep. 1 5/16 in. high. Weight 3½ oz. Character size ⅝ in. high, 0,9 with 8 right hand decimal point and degree. Available to special order, words and other characters or colour, at cost of artwork or plates. List price 6 gns. ⅝ in characters **£2·45½**. 1 in. characters **£2·75**. 4 in. characters **£8·60**.

EAC DIGIVISOR Mk. II DIGITAL READ-OUT DISPLAY



Ideally suitable for use in conjunction with transistorised decade counting devices. No need for amplifiers or relays as only a few milliwatts of power are required to charge the digits. The DIGIVISOR incorporates a moving coil movement which moves a translucent scale through an optical system and the resultant single plane image is projected on a screen. The translucent scale is made to represent digits 0.9. Specification: 6.3 volt, 250 microamp. Image height ½ in. Size 4 9/16×2 39/64×1½ in. Our price **£3·68** List price 8½ gns.

(Dept. W.W.) 49-53 PANCRAS ROAD, LONDON, N.W.1. Tel: 01-837 7781/2. Cables: SELELECTRO
Telex No. 267307 (Open Mon-Fri 9 a.m. - 6 p.m.) ALL ORDERS ACCEPTED SUBJECT TO OUR TRADING CONDITIONS A COPY OF WHICH MAY BE INSPECTED AT OUR PREMISES DURING TRADING HOURS OR WILL BE SENT ON APPLICATION THROUGH THE POST.

EX COMPUTER PRINTED CIRCUIT PANELS 2" × 4" packed with semi-conductors and top quality resistors, capacitors, diodes, etc. Our price, 10 boards, **50p.** P. & P. 7p. With a guaranteed minimum of 35 transistors. Transistor Data included.

SPECIAL BARGAIN PACK. 25 boards for £1. P. & P. 18p. With a guaranteed minimum of 85 transistors. Transistor Data included.

PANELS with 2 power transistors sim. to OC28 on each board plus components. 2 boards (4 × OC28) **50p**. P. & P. 5p.

9 OA5, 3 OA10, 3 Pot Cores, 26 Resistors, 14 Capacitors, 3 GET872, 3 GET872B, 1 GET875. All long leaded on panels 13" × 4". 4 for £1. P. & P. 25p.

12V 4A POWER SUPPLY

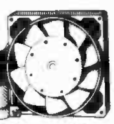
Extremely well made by FRAKO GmbH in W. Germany, with constant voltage mains transformer, tapped input from 115V to 240V. Full wave rectification and capacitor smoothing. Size 9"×6"×5", weight 11 lb. These units are brand new, unused and fully guaranteed. Maker's price believed to be around £80. Our Price £9·5. Carr. 50p.

250 MIXED RESISTORS
¼ and ½ Watt **62p**

DIODES EX EQPT. SILICON

1 Amp 1,000 PIV 4 for **50p**
20 Amp 150 PIV 4 for **£1**
P. & P. 5p

EXTRACTOR/BLOWER FANS (Papst)



100 c.f.m. 4½" × 4½" × 2", 2800 r.p.m. 240V AC
£2·5 each. P. & P. 25p.

RELAY OFFER

Single Pole Changeover Silver Contacts 2" × 6" × 7". 2.5KΩ Coil operates on 25 to 50V. 8 for **50p.** P. & P. 8p.

BUMPER BARGAIN PARCEL

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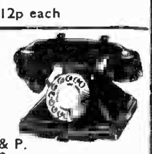

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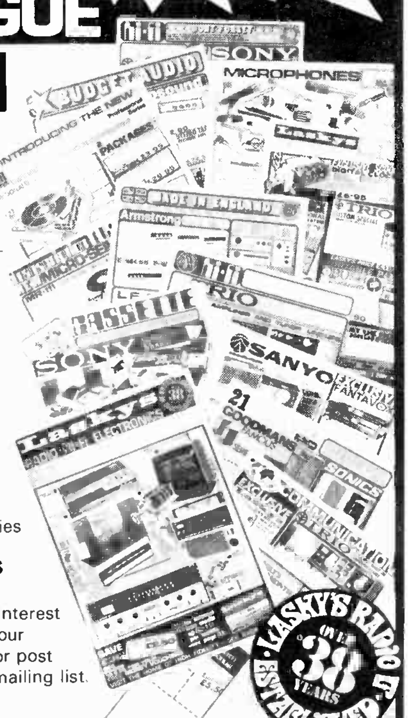

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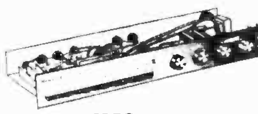

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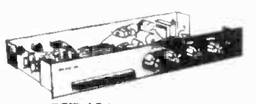

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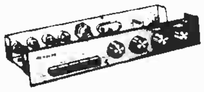

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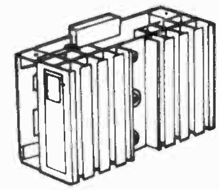

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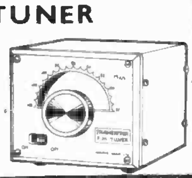

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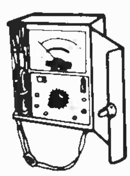

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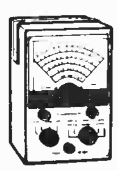

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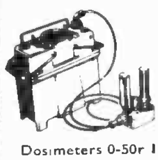

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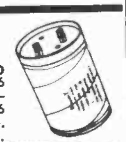

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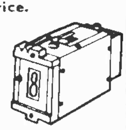

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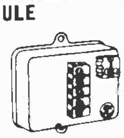

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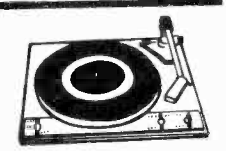

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SP25 Mk. III **£12.10.0.** AP75 **£16.19.6.** SL65 B **£14.9.6.** SL72 B **£25.** SL75 B **£28.** SL95 B **£37.10.0.** MP60 **£10.19.6.** MP610 **£13.19.6.**

FREE COMPLETE LIST ON REQUEST no. 16/17.

SPECIAL OFFER. Above supplied with cartridge 9TAH/C diam. add £2, magnetic 940 add £3, G850 or AT66 add £5, with G800 add £7.10.0. De-luxe plinths and covers for above. **Price £8.15.0** p.p. 6/-, standard for SP25, SL65B, **89/6** p.p. **4/6.** Goldring GL69 Mk. II deck. **£23** p.p. 2/6. With G800 **£30** p.p. 7/6. Mk. II GL69 add 30/-. Garrard 30001 m **£9.15.0.** 2025T/C **£8.17.6** (fitted 9TAHC diam. carts.) p.p. 7/6. Plinths covers **99/6** p.p. 6/-. Goldring GL69 Mk. II fitted G800 with plinth/cover and cables. **Price £35** p.p. 12/6. SP25 fitted G800 with plinth/cover, cables etc., **£20.19.6** p.p. 10/-. Mk. III **£22.19.6.** 2025T/C fitted 9TA H/C with plinth/cover, cables, etc., **£13.19.6** p.p. 10/-. MP60 (see above for cartridge) with plinth/cover, cables, etc., **£17.12.6** p.p. 10/-.

HI-FI equipment to suit EVERY POCKET

★ PA AND DISCOTHEQUE EQUIPMENT

Complete range now in stock ready to use, light and modular equipment, special effects.

★Complete systems and individual units at special low prices—choose from **100** selected stereo systems. Call in for a demonstration when in London.

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★MODERN ALL BRITISH TRANSISTORISED DESIGNS AVAILABLE AS KITS OR READY BUILT

★VENEERED CABINETS FOR ALL MODELS

★49 NOTE, 61 NOTE SINGLE MANUAL DESIGNS ALSO TWO MANUAL 49 NOTE

★KITS AVAILABLE IN SECTIONS AS REQUIRED

★HP and CREDIT SALE FACILITIES

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★LET US quote for all your organ component requirements.

VISIT THE *NEW* DEMONSTRATION ROOMS (see below)

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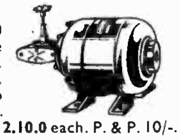
OPEN 9 a.m. to 6 p.m. MONDAY TO SATURDAY — 9 a.m. to 1 p.m. THURSDAYS — OPEN ALL DAY SATURDAY

GEARED MOTORS



"**Parvalux**" **Reversible 100 RPM Geared Motor.** Type S.D.14, 230/250v. A.C. 22 lb./in. ¼" spindle. 1st class condition. **£7.10.0** each. P. & P. 10/-. Also limited number only as above. Without spiggot. **Brand New. £12.10.0** each. P. & P. 10/-.

ELECTRO CONTROL (CHICAGO). Shaded pole 240v. 50 Hz, 110 rpm, 16 lb./in. **45/-.** P. & P. 5/-. 200 rpm 10 lb./in. **50/-.** P. & P. 5/-.

MYCALEX. Open frame, shaded pole motors. 240v. 50 Hz, 7 rpm. 28 lb./in. 80 rpm. 12 lb./in. **45/-** each. P. & P. 5/- each.

SMITHS SYNCHRONOUS MOTORS. 12 r.p.h. 240v., 50 Hz, 2 watts. **17/6** each. P. & P. 5/-.

KLAXON, HEAVY DUTY. 240v. 50Hz. 250 rpm Continuous rating. Torque 45 lb./in. Weight 36lbs. **£18.10.0.** Carriage 30/-.

"TANSITOR" (U.S.A.) TANTALUM WET SINTERED ANODE POLARISED CAPACITORS. DC size: 1¼" long × ⅜" dia. 200µF. 25v. DC size: ¾" long × ⅜" dia. 180µF. 25v. DC size: ¾" long × ⅜ dia. 150µF. 30v. DC size: ¾" long × ⅜" dia. 33µF. 0·75v. DC size: ⅜" long × ⅟₁₆" dia. One wire each end. Also few only, Tansistor "MICRO-MODULE" capacitors 0·2 mfd. 15v. wire-ended, size: ⅟₁₆" dia. (disc). T.A.G. and Union Carbide 15 mfd. 10v. All types **25/-** per doz. (mixed or as required). Carriage paid.

VINKOR POT CORE ASS. TYPE LA.2103. Normal price 29/6. Our price **15/-** each. Special quote for quantity.

AMPEX. Dynamic stick microphone, high impedance, low noise. Offered well below makers price at **£8.10.0.** P. & P. 5/-.

Special offer of AMPEX professional tape heads, mu-metal shrouded. Full track record, or playback, **£4.10.0.** Erase head **£2.10.0.** Set of 3 with mounting bracket and cover **£10.10.0.** Half track record or playback only, **£4.10.0.** each or **£8** per pair with bracket and cover. Carriage paid.

SYLVANIA CIRCUIT BREAKERS gas filled providing a fast thermal response between 80° and 180°C. 10 amp. at 240v. continuous. Fault currents of 28 amps. at 120v. or 13 amp. at 240v. silver contacts. Supplied in any of the following opening temperatures: 90, 95, 100, 115, 120, 125, 130, 135, 140, 145, 150, 160, 170, 175. 3 for **£1. £3.10.0** per dozen.

"TEDDINGTON" CONTROLS THERMOSTAT TYPE TBB.—Adjustable between 75° and 120°C. Circuit cuts in again at 3° below cut-out setting. 42" capillary and sensor probe. The thermostat actuates a 15 amp. 250v. c/o switch. A second single pole on/off switch is incorporated in the adjustment mechanism. **17/6.** Carriage Paid.

Painton Rotary Switch. Type 72 (to P.O. spec. RC1416). 3 pole, 3 position, 2 bank. Offered at less than half normal price at **32/6.** Carriage Paid.

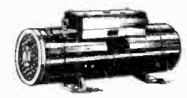
"GOYEN" PRESSURE SWITCH. Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. ½ p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube ⅟₁₆". On Projection ⅟₁₆". Overall size: dia. 3⅛", depth 2" plus ⅟₁₆" (air tube). **25/-.** Carriage Paid.

THORN KEY SWITCH. 3 change-over. Neat action, either locking or spring-return, as required determined by reversing fixing plate. Attractive plastic prestle. Available red, green, grey, cream. **12/-** each. Carriage paid.

HONEYWELL (USA) Sub-miniature 2 bank panel mounting micro-switch, positive toggle action giving 2 change-overs. Size: ⅟₁₆" × ⅟₁₆" × ¾". **12/6** each. Carriage paid.

MARCONI SANDERS Micro-wave switch. Type No. 6442. Maker's list price £75. Our price **£7.10.0.**

BRAND NEW ALTERNATORS BY ENGLISH ELECTRIC.



All outputs are at 400 c.p.s.

Type	Input V.	C.P.S.	Ph.	
1	220	50	3	All these types give the same dual outputs as below: V. 115, Ph. 3, V.A. 50; V. 85, Ph. 1, V.A. 300
2	380/440	60	3	
3	115	60	3	
4	220	60	3	
5	220 D.C.			
6	110 D.C.			

£30 each. Carriage extra

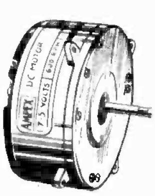
The following types each have 4 separate outputs (all at 400 c.p.s.).

Type	Input V.	C.P.S.	Ph.	Outputs
7	380/440	50	3	115v. 28 W; 115v. 250W; 20v. 6W; 28v. 250W;
8	110	D.C.		115v 28 W; 85v. 250W; 20v. 6W; 115v. 250W.
9	24	D.C.		115v. 28W; 115v. 250W; 20v. 6W; 28v. 250W.
10	110	D.C.		115v. 28W; 115v. 250W; 28v. 250W; 20 v. 6W.
11	220	D.C.		115v. 28W; 85v. 250W; 20v. 6W; 115v. 250W.

£42.10.0 each. Carriage extra

WESGROVE VIDEO TAPE RECORDERS. Unused but offered without guarantee to personal callers only at the extremely low price of **£60** each. The following features are incorporated: Fixed heads (pre-heated reversible), speed 12 ft. per second, ½" twin-track tape will take 7,600 ft. triple play, 26 transistors (22 silicon). F.M. pulsed sound. Camera and mike inputs. 405/625. A real bargain for the enthusiast! Also available a few decks complete with heads **£15** each. Also cameras **£75** each (tested O.K.).

MOTORS



AMPEX 7.5v. D.C. MOTOR. This is an ultra-precision tape motor designed for use in the AMPEX model AG20 portable recorder. High torque at minimal consumption (60ma), 600 rpm ± 5% speed adjustment, internal AF/RF suppression. ⅛" dia. × 1" spindle, motor 3" dia. × 1.⅞". Original cost £16.10.0. **Our price 85/-.** P. & P. 5/-. Large quantity available (special quotations). Mu-metal enclosure available **15/-** each.

NEW HYSTERESIS MOTORS BY WALTER JONES. Type 14050/12, 240v. 50 c/s 1500 rpm cont. rating, output 2.0 oz./in. Size: 3½" × 2½" × 2½". Spindle 1" × ⅟₁₆". Weight 3 lb. Maker's price in region of £22.10.0. Our price **£6.10.0.** each. Carriage Paid.

VACTRIC PRECISION D.C. MOTOR. Type XO7P19. 10v. D.C. 0.66 amp. 8000 rpm. 30 gm/cm. Size 7. Original makers packing. Limited supply. **£3.10.0.** Carriage Paid.

VACTRIC PRECISION D.C. MOTOR AND COUPLED GEAR HEAD. Motor type 11P101, 28 volts, 5000 rpm, 120 gm/cm. Gear head type 15H102 ratio 300-1. Torque 10 lb./in. Makers packing. **£14.10.0.** Carriage Paid.

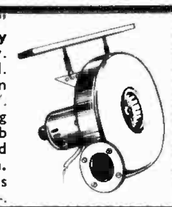
PULLIN. Type 18PM 187. 12 volt, 5000 rpm. 200 gm/cm. Makers packing. **£5.10.0.** Carriage paid.

MYCALEX MAINS. Shaded pole, 1425 rpm. ⅟₁₆" spindle. 2 for **25/-.** Carriage Paid.

MAINS INDUCTION MOTOR. Open frame, ⅟₁₆" spindle, weight ¾ lb. Powerful. **17/6** each. P. & P. 2/6.

E.M.I. PROFESSIONAL TAPE MOTOR. 110/240 v. 50 Hz. 3000 rpm, reversible, silent running. 4½" dia. × 4½" long. Spindle ⅟₁₆" × 2". Weight 6 lbs. **70/-** each or **£6** per pair. P. & P. 10/- each.

Brand New "DISCUS" Centrifugal Blower by Watkins & Watson. 240v. 50 Hz. Powered by A.E.I. continuous rating 2850 rpm motor. Cowl diameter 10". Outlet flange 2" I.D. Coupling flange supplied. These superb precision units are ideally suited for **Organ construction.** Offered at approx. half makers price **£15.10.0.** Carriage 30/-.



PRECISION AND SERVO POTENTIOMETERS

PRECISION LINE (USA). Size 15. 300Ω ± 5% LIN. Continuous track plat. wipers set at 180°. **45/-** each. Carriage Paid.

PENNY & GILES. Size 15. 500Ω. Type Q26201-72/1. Continuous track. **50/-** each. Carriage Paid.

BECKMAN. Type AS.506, 10 turn. Tol. ±1%. LIN Tol. ±.07%. 40k. Long spindle. **40/-** each. Carriage Paid.

S.T.C. Type B330 CT. 2500Ω. 2½" dia. × 1½". Completely copper encased. **25/-** each. Carriage paid.

OXLEY P.T.F.E. BARB TERMINALS. Lead thro' ⅟₁₆" or ⅛". Stand-Off 11/32" or ⅜". **55/-** box of 100 all types.

HARWIN. Tapped (6 Ba) high voltage "stand off" insulators, length ⅜" or ⅝", tapped (8 Ba) ⅜" long. 60/- per 100. Carriage Paid.

K.L.G. SEALED TERMINALS. Type TLSI AA, overall length ⅟₁₆", box of 100, **20s.** Type TLSI BB, overall length 1", box of 100, **30s.** Carriage Paid.

CRYSTAL OVENS G.E.C. Type QC940. 6/12v., AC/DC, 75°C. Takes 2⅛" min. crystals. Similar to above 12v. only by **SNELGROVE** (Toronto), **55/-** each, carr. paid.

BERCO. Rotary rheostat. Type L25. 100 Ω. 25 watt. 1½" dia. ¼" spindle. **10/-** each. 2/6 Carr.

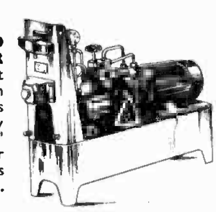
PAINTON BOURNS TRIMPOTS. 1k, 2k, 2.5k, 5k, 10k, 20k, 50k, 500k. Other Trimmer pots in stock. RIL 10k. MORGANITE 1k. MEC 200 Ω (tubular) 50 Ω. Any 3 for **22/-** carr. paid.

"TEXAS" Unmarked, Tested, TO5 Geranium general-purpose transistors. 24 for **£1.** P. & P. 2/6. Large quantity available.

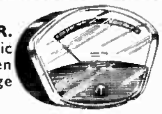
CINEMA ENGINEERING Precision "Standard" Wire Wound Resistors. Extremely high stability over very wide temperature range. 1/6 Watt 0·25% 30K, 75K **6/-** ea. 1/3 Watt 0·05% 9K, 10·02K, 50K, 200K, **12/-** ea. 0·1% 100K, 250K, 625K, **12/-** ea. 0·25% 477K, **12/-** ea. 0·5% 500K, **12/-** ea. 1% 500Ω, 850Ω, 3,770Ω, 3K, 4K, 5K, 10K, 15K, 50K, 90K, 375K, 450K, **12/-** ea. ½ Watt 0·05% 200Ω, **12/-** ea. 0·1% 9·651K, 14·67K, 15·33K, 500K, 800K, 1 meg, **12/-** ea. 0·5% 81K, 2·2 meg, **12/-** ea. 0·1% 20K, 1·35 meg, 1·5 meg, 2 meg, 3·3 meg, **12/-** ea. 1 Watt 0·05% 0·24959K, **20/-** ea. 0·1% 3·24K, 1 meg, 3 meg, 4 meg, 3·75 meg, **20/-** ea. 1% 2·4 meg, 2·5 meg, 3·6 meg, **20/-** ea. 2 Watt 0·05% 5 meg, **30/-** ea. 0·1% 5·714 meg, 10 meg, **30/-** ea. ±0·1% 2 meg, 2KM, **30/-** ea. 0·5% 5·9 meg, 10 meg, **30/-** ea. 1% 2K, 5K, 5 meg, 10 meg, **30/-** ea.

RIL Type 2 ±0·01% 6·666K **20/-** each.
RIL Type 9 ±1% 560Ω **2/6** each.
ALMA ∓0·05% 50K **15/-** each.
ALMA ±0·1% 141·46K **10/-** each.
SHALLCROSS ±0·5% 3400Ω **6/-** each.
ELECTRO-THERMAL PRECISTOR ±0·1% 2·4K **10/-** each.

VICKERS-SPERRY-RAND HYDRAULIC POWER UNIT. This is a Pump Unit made for use in conjunction with a power ram. This equipment was originally designed for use with ships' steering but has many other applications. Further details on request. **£95.** Carr. extra.



METERS



ERNEST TURNER 800µa METER. 160Ω movement, 2" case, eliptic plastic front. Green-Red-Green uncalibrated scale **30/-** each. Carriage Paid.

MINIATURE B.P.L. 500-0-500 MICRO-AMMETER. ⅟₁₆" dia. scale. Through panel mounting. Hermetically sealed. **32/6.** Carriage paid.

ERNEST TURNER 5" × 4" 0-1ma scaled in 50 equal divisions, mirror scale, chrome escutcheon. Quality instrument. **85/-.** Carriage Paid.
5" × 4" 0-100µa 1000Ω. Mirrored scale, few only. **95/-.** Carriage Paid.

ELECTROLYTIC CAPACITORS MULLARD. 900µF 100v. heavy ripple screw terminals 1⅟₁₆" dia. × 3½", **14/-** ea., **£6** per doz. 1600µF 64v. 1⅜" dia. × 3", **7/6** ea., **70/-** per doz. 10,000µF 10v. 1⅜" dia. × 3", **7/6** ea., **70/-** per doz. 1250µF 25v. 1" dia. × 2", **10/-** ea., **90/-** per doz.
HUNTS 1000µF 50v. 1⅜" dia. × 2", **5/-** ea., 10,000µF 6v. 1⅜" dia. × 2", **6/-** ea., **60/-** per doz. 16µF 350v. ⅟₁₆" × 1⅜" wire ends, **40/-** per doz. 1000µF 50v. 1" dia. × 3", **6/-** ea., **60/-** per doz. 32-32µF 275v. 1" dia. × 2", **7/6** ea. 100µF 100v. 1" dia. × 2", **5/-** ea.

ERIE. Ceramicon capacitor. Type CHV411P. 500 P.F. 30KV Size 1.5" dia. × 1.44" long. **10/-** each. Carriage Paid.

DEPENDATHERM ELECTRONIC THERMOMETER. This precision instrument is invaluable in any application where fast temperature readings are required between 90°F.-106°F. or 32·2°C.-41·2°C. ±0·2°F/0·1°C. Fitted plastic case with scale window. Size: 1⅞" × 3" × 4½". Offered at half maker's price. **£8.10.0.** P. & P. 5/-.

TIME ELAPSED REGISTER. 24v. D.C. Has a 5 digit readout plus dial reading 1 hour (60 1 min. div.) metering. Total of 99,999 hrs. Non-reset sealed unit, chrome bezel, through panel mounting. Size 2⅟₁₆" dia. × 3⅟₁₆" overall. **65/-.** Carriage Paid.

RELAYS

Perspex enclosed, plug in, with base. Size 1½" × 1½" × ⅞"
MQ 308 600Ω 24v. 4 c/o. **12/-** ea., **£5** per doz.
MQ 508 10,000Ω 100v. 4 c/o, **10/-** ea., **90/-** per doz.

SIEMENS Miniature, plug in, Perspex cover, 1000Ω 6/12v. 2 c/o, ⅞" × ⅟₁₆" × 1⅛" high. Complete with base. **14/-** ea., **£7** per doz.

A.E. Perspex enclosed, plug in, 50Ω 6v. 2 c/o, **12/6** ea. 470Ω 12v. 4 c/o, **14/6** ea. 2,780Ω 48v. 4 c/o, **14/6** ea. 1,260Ω 48v. 6 c/o, **16/6** ea.

CLARE. Sealed relay. Type RP3716G4, **25/-** ea.

CLARE ELLIOTT. Sub-min 675Ω 24v. Type WJ 2 c/o. Similar to above, 340Ω 17·6v. **15/-** ea.

MAGNETIC DEVICES. Sub-min 24v. 2 c/o, ¾" × ⅟₁₆" + ⅟₁₆", **15/-** ea.

BOURNE. Trimpot sub-miniature relay 18v. 1,000Ω 1 amp. 1 c/o encapsulated ⅜" × ⅟₃₂" × ⅟₁₆" high. **25/-** ea.

SIEMENS. High speed type 89L. 1,700Ω + 1,700Ω, **12/6** ea.

DIAMOND "H" sealed relay. Type BR115CIT-IC 26v. 150Ω 4 c/o encapsulated in heavy brass case glass sealed terminals. Robust. **15/-** ea.

SCHRACK. Octal base 24v. 2 HD c/o. Perspex enclosed, **12/6.**

E.R.G. 1,000Ω 6v. DC. 1 make encapsulated reed type. Size: ⅜" × ⅟₁₆" × 1⅞", 4 for **20/-.**

SANGAMO WESTON. Moving coil relay 315Ω 310µa, complete with base, **15/-** ea.

S.T.C. Midget sealed relay. Type 4190EC. 12v., 40mA 170Ω. Single HD make, **10/6** ea.

F.I.R.E. Plug in relay, 115v., coil 50/60 c.p.s., 3 heavy duty silver change-over contacts. Very robust, **12/6** ea.

LATCH-MASTER. Miniature relay 6, 12, 24v. DC. One make one break 5 amp contacts. Once current is applied relay remains latched until input polarity is reversed. ⅟₁₆" dia. × ⅞". Please state vertical or horizontal mount and voltage. Original cost £8, now offered at **32/6** ea.

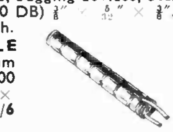
G.E.C. Sealed relay. Type M 1492. 24v. 670Ω. New condition but ex-equipment, **20/-** ea. Type M 1527. 80v. 7,600Ω. New. Few only, **25/-** each.

HELLERMANN DEUTSCH. Type L26F18. Latching relay. Latch coil 200Ω 26v. DC. Reset 375Ω 6 change-over switching. A truly superb relay. Measuring only 1⅟₁₆" × 1" dia. **75/-** ea. Limited stock. All Carriage paid.

SCHRACK Rotary Selector Relay RT304. 48v. coil (280 ohm). 48 positions, 4 sweep arms (4 pole 12 way). There are 2 secondary switches: (1) one c.o. H/duty contact set which changes over and back with each step; (2) two H/duty change-overs which change over on each 12th step and return on the following pulse. Size: 3¼" × 1⅞" × 4½" high. Also as above but 110v. (1,290 ohm coil). All new and in original maker's packing. **65/-.** Carriage paid.

KNOWLE (U.S.A.) MINIATURE MICROPHONE CAPSULES. Impedance approx. 200Ω, output 60 or 80 DB at 1 Kc. As used in deaf aids, bugging devices, etc. Size (60 DB) ⅟₃₂" × ⅟₃₂" × ½". (80 DB) ⅛" × ⅟₁₆" × ⅛". Ex-equipment, all tested. **20/-** each.

DEAC. RECHARGEABLE PERMA-SEAL Nickel-Cadmium Batteries Type 900B. 1·22v. at 900 mA (10-hr. rate). Size 90 mm. × 3·5 dia. Weight 40 gr. Unused **12/6** ea. P. & P. 2/6.



"DECCO" MAINS SOLENOID. Compact and very powerful. 16 lb. pull. ⅜" travel which can be increased to 1" by removing captive-end-plate. Overall size 2" × 2½" × 2¾" high. **27/6.** P. & P. 5/-.

American **"POWERSTAT"** Variable Voltage Transformer. Input: 120v. 50/60 c.p.s. Output: 0-120v. at 2·25 amps. ¼" spindle with alternative pre-set locking device. Size (approx.): 3" dia. × 2" long. First class condition. **40/-.** Carriage paid.

We welcome orders from established companies, educational depts., etc. (To cover invoicing costs minimum 50/-, please.) A discount of 10% may be deducted from all orders of £20 or over.

ELECTRO-TECH SALES

BUSINESS HOURS: 9.30-6 (1 p.m. Sats.)

264 PENTONVILLE ROAD, LONDON, N.1
(ONE MIN. FROM KINGS X STATION) Tel. 01-837 7401/2

SEMI-CONDUCTORS/VALVES
BRAND NEW & FULLY GUARANTEED

TRANSISTORS

IN914	1,6
IN4001	1/6
IN4002	1/6
IN4003	2/-
IN4004	2/-
IN4005	2/6
IN4006	3/-
IN4007	4/-
IN4148	1/6
IN5054	4/6
2G301	4/-
2G302	4/6
2G303	5/-
2G306	7/6
2G308	6/-
2G309	6,-
2G371	4/6
2G374	5/6
2G381	5/-
2N696	3/6
2N697	3/6
2N698	8/6
2N706	2/-
2N706A	2/6
2N708	3/-
2N914	4/6
2N916	4/6
2N918	7/6
2N929	4/6
2N930	5/6
2N1131	6/-
2N1132	6/-
2N1302	4/-
2N1303	4/6
2N1304	5/-
2N1305	5/-
2N1306	5/-
2N1307	5/-
2N1308	6/-
2N1309	5/-
2N1613	4/6
2N1711	5/-
2N1889	6/6
2N1893	10/-
2N2147	15/-
2N2160	12/6
2N2193	9/6
2N2217	5/6
2N2218	6/-
2N2219	6/6
2N2368	3/6
2N2369	4/-
2N2369A	4/-
2N2484	4/-
2N2613	7/-
2N2646	10/6
2N2904	6/-
2N2923	3/6
2N2924	3/6
2N2925	3/6
2N2926G	2/6
2N2926Y	2/6
2N2926O	2/6
2N3053	5/-
2N3054	10/-
2N3055	15/-
2N3391A	6/-
2N3416	7/6
2N3702	2/6
2N3570	17/6
2N3703	2/6
2N3704	3/6
2N3705	3/-
2N3706	4/6
2N3707	3/-
2N3708	3/6
2N3709	2/6
2N3710	2/6
2N3711	2/6
2N3819	7/-
2N3903	7/-
2N3904	7/-
2N3905	7/6
2N3906	7/6
2N4058	3/6
2N4059	5/-
2N4061	3/-
2N4062	4/6
2N4286	3/-
2N4287	3/6
2N4288	3/-
2N4289	3/6
2N4290	3/-
2N4291	3/-
2N4292	3/-
2N5354	5/6
2N5355	5/6
2S102	5/-
2S103	7/6
2S104	7/6
40250	10/-
40361	11/-
40362	12/-
AC107	7/6
AC126	5/-
AC127	5/-
AC128	5/-
AC154	3/-
AC176	5/-
AC187	6/-
AC188	6/-
ACY17	6/-

ACY18	5/-
ACY19	5/-
ACY20	4/6
ACY21	4/6
ACY22	3/6
ACY28	3/6
ACY40	3/-
AD140	10/-
AD149	10/-
AD161	7/6
AD162	7/6
AF114	6/6
AF115	6/-
AF116	6/6
AF117	5/-
AF118	12/6
AF119	4/-
AF124	5/-
AF126	3,6
AF127	3,6
AF139	6/-
AF178	9/6
AF180	10/6
AF181	8/6
AF186	8/-
AF239	8/6
ASY26	5/-
ASY27	6/6
ASY28	5/-
ASZ17	8/6
AUY10	19/6
BAY31	1/6
BC107	2/6
BC108	2/6
BC109	2/6
BC113	5/-
BC116	8/-
BC125	11/-
BC126	11/-
BC147	3/6
BC148	2/6
BC149	4/-
BC167	3/-
BC172	3/6
BC177	7/6
BC186	7/6
BC182L	4,-
BC184L	4/-
BC212L	4/6
BCY30	5/-
BCY31	6/-
BCY32	10/-
BCY33	4/-
BCY34	5/-
BCY38	6/-
BCY42	3/-
BCY43	4/-
BCY71	6/-
BCY72	3/6
BCZ11	7/6
BD121	13/-
BD123	16/6
BD124	12/-
BF115	5/-
BF117	9/6
BF167	5/-
BF173	6/-
BF180	7/6
BF181	7/6
BF182	6/6
BF184	5/-
BF185	5/-
BF194	3/6
BF195	3/-
BF200	7/6
BF224	6/-
BF225	6/-
BF244	9/6
BFX12	4/6
BFX13	4/6
BFX29	6/-
BFX30	6/6
BFX44	7/6
BFX85	8/-
BFX86	6/6
BFX87	6/6
BFX88	5/-
BFY18	5/-
BFY20	12/6
BFY50	4/6
BFY51	4/-
BFY52	4/6
BFY90	13/6
BSX19	3/6
BSX20	3/6
BSX21	7/6
BSX76	3/-
BSY26	3/6
BSY27	4/-
BSY28	3/6
BSY38	4/-
BSY39	4/6
BSY51	6/6

BSY56	18/-
BSY95A	3/-
BY100	3/6
BY124	3/-
BY126	3/-
BY127	4/-
BYZ10	8/-
BYZ11	7,-
BYZ12	6/-
BYZ13	5/-
MJ480	19/6
MJ481	25/-
MPF102	8/6
MPF103	7/-
MPF104	7/6
MPF105	8/-
NKT213	5/-
NKT214	3/-
NKT216	7/6
NKT217	8/-
NKT224	4/6
NKT241	5/6
NKT261	4/-
NKT271	5/-
NKT272	5/-
NKT274	4/-
NKT275	5/-
NKT278	5/-
NKT281	5/6
NKT403	15/-
NKT404	12/6
NKT405	15/-
NKT773	5/-
NKT10439	7/6
OA5	3/-
OA10	5/-
OA47	2/-
OA70	2/-
OA79	2/-
OA81	2/-
OA85	2/6
OA90	2/-
OA91	1/6
OA95	1/6
OA200	1/6
OA202	2,-
OA210	3/6
OC19	7/6
OC20	19/6
OC22	9/6
OC23	10/-
OC24	10/-
OC25	7/6
OC26	5/-
OC28	12/6
OC29	12/6
OC35	10/-
OC36	12/6
OC41	5/-
OC42	6/-
OC44	3/6
OC45	3/-
OC46	5/6
OC70	2/6
OC71	3/-
OC72	5/-
OC73	6/-
OC74	6/-
OC75	5/-
OC76	5/-
OC77	8/-
OC78	4/-
OC81	5/-
OC81D	4/-
OC83	5/-
OC84	5/-
OC139	5/-
OC140	7/6
OC169	4/-
OC170	5/-
OC171	6/-
OC200	7/6
OC201	9/6
OC202	12/6
OC203	7/6
OC204	8/-
OC205	12/6
OC207	15/-
OCP71	19/6
ORP12	10/-
ORP60	8/-
P346A	5/-
PL4001	2,9
PL4002	3/-
PL4003	3/3
PL4004	3/6
PL4005	3/9
PL4006	4/-
PL4007	4/9
TIS43	8/-
TIS44	2/6
TIS45	3/6
TIS46	3/6

SEND SAE FOR FULL LISTS!
DISCOUNTS:
10% on 12+ any one type
15% on 25+ any one type
Large quantity discounts on application. Postage: Semi Conductors 1/6; Valves 3/-.

VALVES

OA2	6/6
OB2	6/6
OZ4	6/-
1L4	2/6
IR5	7/-
IS5	5/-
IT4	4/6
IU4	6/-
IU5	9/6
2D21	6/6
3Q4	8/-
3S4	7/-
3V4	8/-
5R4	11/-
5U4	6/-
5V4	8/-
5Y3	6/-
5Z4G	7/6
6/30L2	15/-
6AC7	4/-
6AG7	7/6
6AK5	6/-
6AK6	11/6
6AL5	3/3
6AM6	4/6
6AQ5	6/6
6AS6	6/-
6AT6	5/-
6AU6	5/-
6AV6	6/6
6BA6	4/6
6BE6	5/-
6BH6	8/6
6BJ6	8/6
6BQ7A	7/6
6BR7	17/-
6BR8	13/-
6BW6	16/-
6BW7	13/6
6BZ6	6/6
6C4	6/-
6CD6	23/-
6CL6	10/-
6CW4	12/6
6F1	12/6
6F6G	5/-
6F13	7/-
6F14	12/-
6F15	11/-
6F18	8/-
6F23	15/6
6H6	3/-
6J4	9/6
6J5	4/-
6J5GT	6/-
6J6	3/6
6J7	8/6
6K8G	6/-
6L6GT	9/-
6LD20	6/6
6Q7	7/6
6SA7	7/-
6SG7	6/-
6SJ7	7/-
6SK7	6/-
6SL7	6/-
6SN7	5/6
6SQ7	8/-
6U4	12/6
6V6G	5/-
6V6GT	6/6
6X4	5/-
6X5G	5/6
6X5GT	5/6
10C2	10/-
10F1	18/-
10P13	11/-
10P14	20/-
12AT6	5/-
12AT7	4/-
12AU7	5/-
12AX7	6/-
12AV6	6/-
12BA6	6/6
12BE6	6/6
12BH7	6/6
19AQ5	6/6
20D1	9/-
20F2	15/-
20L1	20/-
20P1	10/-
20P3	12/-
20P4	20/-
20P5	20/-
25L6	7/6
25Z4	6/-
25Z5	8/6
25Z6	11/6
30C15	15/-
30C17	16/-
30C18	15/-
30F5	17/-
30FL1	15/-
30FL12	18/6

30FL14	15/6
30L15	17/-
30L17	17/-
30P12	16/-
30P19	15/-
30PL1	15/6
30PL13	18/-
30PL14	17/-
35L6	9/6
35W4	5/-
35Z4	5/-
35Z5	7/-
50B5	7/-
50C5	7/-
80	9/-
85A2	7/6
807	9/6
1625	6/-
5763	13/-
6146	30/-
AZ31	10/-
CY31	7/-
DAF91	5/6
DAF96	7/9
DF91	4/6
DF96	7/9
DK91	7,-
DK92	9/-
DK96	8/-
DL92	7/-
DL94	8,-
DL96	7,6
DM70	6/6
DY86	6/6
DY87	7/-
E88CC	12/6
E180F	15/-
EABC80	6/6
EAF42	10/-
EB91	3/3
EBC41	10/6
EBC81	6/6
EBF80	8/-
EBF83	8/6
EBF89	6/6
EBL21	12/-
EC86	12/-
EC88	12/-
ECC40	11/-
ECC84	6/-
ECC85	5/6
ECC88	8/-
ECF80	7/-
ECF82	7/-
ECF86	2/6
ECH21	11/6
ECH35	12/-
ECH42	13/-
ECH81	5/6
ECH83	8/6
ECL80	9/-
ECL82	6/6
ECL83	12/6
ECL86	8/6
EF37A	8/-
EF39	8/-
EF40	10/-
EF41	12/6
EF42	14/-
EF80	5/-
EF85	7/-
EF86	6/6
EF89	5/6
EF91	4/6
EF92	7/6
EF183	6/6
EF184	7/-
EH90	8/-
EL33	17/6
EL34	10/6
EL41	11/-
EL42	11/6
EL81	10/-
EL84	5/-
EL85	8/3
EL91	5/-
EL95	7/-
EM80	8/-
EM81	8/6
EM84	7/6
EM85	11/-
EM87	11/-

EY51	8/-
EY86	8/-
EY87	8/6
EZ40	7/6
EZ41	9/-
EZ80	5/6
EZ81	5/6
GZ32	9/6
GZ34	11/-
KT66	27/6
KT88	33/6
MU14	8/-
PABC80	8/-
PC86	11/6
PC88	13/-
PC97	8/6
PC900	9/6
PCC84	7/-
PCC85	8/-
PCC88	12/-
PCC89	10/6
PCC189	11/-
PCF80	6/6
PCF82	6/9
PCF84	9/-
PCF86	11/-
PCF800	15/-
PCF801	10/-
PCF802	10/-
PCF805	15/-
PCF806	13/-
PCF808	15/6
PCL82	7/9
PCL83	13/-
PCL84	8/9
PCL85	9/6
PCL86	9/6
PFL200	11/-
PL36	11/-
PL81	9/6
PL82	9/-
PL83	8/-
PL84	7/-
PL500	15/-
PL504	16/-
PY32	11/-
PY33	12/6
PY80	6/6
PY81	6/-
PY82	6/-
PY83	7/6
PY88	8/-
PY800	10/-
PY801	10/-
U25	15/-
U26	15/-
U50	6/-
U52	6/-
U191	14/-
U281	8/-
U282	8/-
U301	11/6
U801	20/-
UABC80	6/9
UAF42	10/6
UBC41	9/6
UBC81	8/-
UBF80	7/3
UBF89	7/-
UCC84	9/9
UCC85	8/-
UCF80	10/6
UCH21	11/-
UCH42	13/-
UCH81	6/6
UCL82	7/-
UCL83	12/-
UF41	10/-
UF80	7/6
UF85	8/-
UF89	7/-
UL41	12/-
UL84	6/6
UY41	8/-
UY85	6/-
VR105/30	5/6
VR150/30	5/-

ZENER DIODES

400mw. (3.3 to 33v) 3/-	1.5 watt (2.4 to 200v) 4/-	10 watt (3.9 to 100v) 5/-

THYRISTORS

1 AMP 50PIV 5/–; 100PIV 5/6; 200PIV 7/6; 300PIV 8/–; 400PIV 9/6. 3 AMP 50PIV 6/–; 100PIV 7/6; 200PIV 8/–; 300PIV 9/–; 400PIV 10/–. 5 AMP 100 PIV 11/–; 200PIV 13/–; 400PIV 15/–. 7 AMP 100PIV 11/–; 200PIV 13/–; 300PIV 14/–; 400PIV 19/6. 100 AMP 350PIV 50/–; 400PIV 55/–.

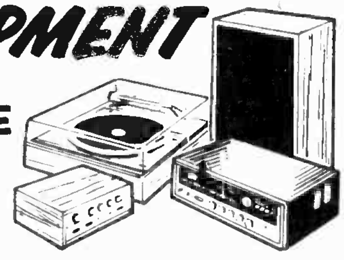
TRIACS

SC41A 100PIV 6A 19/6	SC41B 6A 200PIV 22/-	SC41D 400 PIV 6A 27/6

INTEGRATED CIRCUITS

L900	9/9	CA3005	25/6	FJH221	10/-
L914	9/9	CA3011	16/6	FJH231	10/-
L923	12/6	CA3052	36/6	FJH241	10/-
IC-10	50/-	FCH131	10/-	FJH251	10/-
SL403	42/6	FCH161	10/-	FJJ121	17/6
MC1303	52/6	FJH141	10/-	FJJ131	17/6
MC1304	55/-	FJH171	10/-	FJJ211	25/-
PA246	52/6	FJH181	10/-	FJY101	10/-

HI-FI EQUIPMENT
SAVE UP TO 33⅓% OR MORE
SEND S.A.E. FOR DISCOUNT PRICE LISTS AND PACKAGE OFFERS!



GARRARD

Full current range offered brand new and guaranteed at fantastic savings

40 Mk II Stereo	£8.8.0	SL65B	£14.19.6
2025 T/C Stereo	£8.17.6	SL72B	£24.19.6
3000 Stereo	£9.19.6	AP76	£22.10.0
SP25 Mk III	£11.15.0	SL75	£25.19.6
		SL75B	£27.19.6
		SL95B	£37.10.0
		A70/11	£11.19.6
		401	£25. 0.0

Carriage 7/6 extra each item.

TEAK BASES AND PERSPEX COVERS
1. For SP25, SL65, SL55, 3000, 2025T/C, 2025 1000, **£3.19.6.**
2. For AP75, SL75, SL95, **£5.19.6.**
3. For SP25 etc. to operate with lid in place **£5.19.6.** Carriage 7/6 extra each type.

B.S.R. McDONALD

MP60 **£11.19.0** 610 **£15.19.0**
510 **£12.19.0** 310 **£10.19.0**
Carriage 7/6 extra each item

TEAK BASE AND PERSPEX COVER for above BSR range **£3.19.6.** Carriage 7/6.

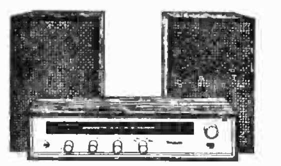
TPDI SERIES with plinth and cover and ready wired.
MP60 **£19.10.0** 610 **£22.19.0**
510 **£20.19.0**
Carriage 10/- extra each item.

SPECIAL OFFERS

Garrard SP25 Mk III fitted Goldring G800 cartridge and wooden plinth with perspex cover, ready wired. Total list price £35. OUR PRICE £22.10.0. Carr. 10/-

GOLDRING GL69/2 fitted Goldring G800 cartridge complete with de luxe base and cover. Total list price £50.16.0. OUR PRICE £39. Carr. 20/-

TELETON SPECIAL OFFER!



CR10T AM/FM STEREO TUNER AMPLIFIER WITH MATCHING PAIR SA1003 SPEAKER SYSTEMS Output 4 watts per channel. Excellent reception AFC, built-in MPX. Cer/XTAL Input. Total List £50/5/-. OUR PRICE **£29/19/-** Carr. 12/6.
Also available with Garrard 2025T/C Record Changer. Plinth, cover and stereo cartridge. Ready wired. **£45.** Carr. 20/-.

AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities. Postage 2/-. Over £3 post paid.

3in. 225ft. L.P. Acetate	3/6
3¾in. 600ft. T.P. Mylar..	10/-
5in. 600ft. Std. plastic..	8/6
6in. 900ft. L.P. acetate..	10/-
5in. 1,200ft. D.P. Mylar	15/-
5¾in. 1,200ft. L.P. acetate	12/6
5¾in. 1,200ft. L.P. Mylar	16/-
5¾in. 1,800ft. D.P. Mylar	22/6
5¾in. 2,400ft. T.P. Mylar	39/6
7in. 1,200ft. Std. acetate	12/6
7in. 1,800ft. L.P. acetate	15/-
7in. 1,800ft. L.P. Mylar	20/-
7in. 2,400ft. D.P. Mylar	25/-
7in. 3,600 ft. T.P. Mylar	45/-

TAPE CASSETTES

Top quality in plastic library boxes.
C60— 60 min. **8/6**; 3 for **24/6**.
C90— 90 min. **12/6**; 3 for **36/–**.
C120—120 min. **15/–**; 3 for **43/6**.
Cassette Head Cleaner **11/3** All Post Extra.

HOSIDEN DH-02S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable headband. 8 ohm impedance. 20-12,000 cps. Complete with lead and stereo jack plug. ONLY **47/6** P. & P. 2/6.

HOSIDEN DH04S 2-WAY STEREO HEADPHONES

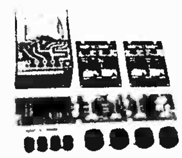
Each headphone contains a 2½in. woofer and a ⅞in. tweeter. Built in individual level controls. 25-18,000 c.p.s. 8Ω imp. with cable and stereo plug. **£5/19/6.** P. & P. 2/6.

GOLDRING CARTRIDGES!

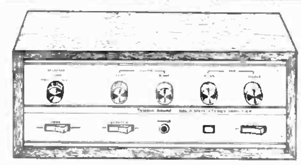
G850..	£5 2 6
G800..	£7 10 0
G800E	£11 19 6
G800 Super E	£16 16 0

P. & P. 2/6 any type.

SINCLAIR EQUIPMENT
Project 60. Package Offers



2 × Z30 amplifier, stereo 60 pre-amp, PZ5 power supply. **£19.0.0.** Carr. 7/6. Or with PZ6 power supply, **£21.0.0.** Carr. 7/6 2 × Z50 amplifier, stereo 60 pre-amp. PZ8 power supply. **£21.10.0.** Carr. 7/6. Transformer 4 PZ8, **59/6** extra. Add to any of the above **£4.17.6** for active filter unit and **£16.0.0** for a pair of Q16 speakers. PROJECT 60 FM TUNER **£20.19.6.** Carr. 7/6. All other Sinclair products in stock: 2,000 amplifier **£23.0.0.** Carr. 7/6. 3,000 Amplifier **£36.** Carr. 7/6. Neoteric amplifier **£46.0.0.** Carr. 7/6.



TELETON SAQ 203E STEREO AMPLIFIER

Popular solid state hi-fi amplifier incorporating 16 semi-conductors. Output 6 watts r.m.s. Inputs for magnetic ceramic, tuner and aux. Stereo phone socket and tape output. Controls: Volume, balance bass, treble. Oiled Walnut case with brushed aluminium front panel. **SPECIAL PRICE £20.** Carr. 7/6.

Latest Catalogue

Our latest edition giving full details of a comprehensive range of HI-FI EQUIPMENT COMPONENTS, TEST EQUIPMENT and COMMUNICATIONS EQUIPMENT. FREE DISCOUNT COUPONS VALUE 10/-. 248 pages, fully illustrated and detailing thousands of items at bargain prices.

SEND NOW! ONLY 7/6 P & P 1/6

← See previous page • **G. W. SMITH & Co. (RADIO) LTD** • Also see opposite page →

FLUORESCENT CONTROL KITS

Each kit comprises seven items—Choke, 2 tube ends, starter, starter holder and 2 tube clips, with wiring instructions. Suitable for normal fluorescent tubes or the new "Grolux" tubes for fish tanks and indoor plants. Chokes are super-silent, mostly resin filled. Kit A—15-20 w. **19/6**. Kit B—30-40 w. **19/6**. Kit C—80 w. **23/6**. Kit E—65 w. **23/6**. Kit F for 8ft. 125 w. tube **35/-**. Kit MF1 is for 6in., 9in. and 12in. miniature tubes. **19/6**. Kit MF2 for 21in. 13 w. miniature tube, **20/-**. Postage on Kits A and B 4/6 for one or two kits then 4/6 for each two kits ordered. Kits C, D and E 4/6 on first kit then 3/6 for each kit ordered. Kit F 6/6 then 4/6 for each kit ordered. Kit MF1 3/6 on first kit then 3/6 on each two kits ordered.

3 amp 12v. Battery Charger Kit—comprising 230/40 mains transformer with 3 amp secondary and 3 amp rectifier **22/6** plus 4/6 post.

12 volt 1½ amp Power Pack. This comprises double-wound 230/240v. mains transformer with full wave rectifier and 2000 m.f.d. smoothing. Price **27/6**.

12 volt Car Battery Trickle Charger. Made in Japan, this is very small and neat. Regular use will keep your car battery in good trim throughout the winter. Silly price, **25/-** plus 4/6 postage and insurance.

Sonotone Stereo Cartridge. Turnover type, ref. No. 19 T1. This fits most British pick-ups and is a really excellent reproducer. Limited quantity, **19/6**.

5 amp 3 pin Sockets. These are always good stock, you never know when you will need some. Famous make, brown bakelite, standard size, 12 for **13/-** plus 4/6 post.

Ditto but with switch. 12 for **£1** plus 4/6 post.

13 amp sockets, flush mounting. Bakelite, cream, less switch. 6 for **£1**.

Bakelite Panels, many thicknesses. We have just taken delivery of approximately 10 tons of bakelite in varying thicknesses from 2 in. to a few thou. If you have a need for any of this then we would be glad to supply. The thickest is very heavy and could be used, for instance, as a bed for a motorised unit. Medium thickness is useful for front panels of instrument, etc., etc. Cut to your size price is **6/-** lb. plus 6/- cutting charge plus carriage.

2 amp 3 pin Switched sockets for surface mounting, brown bakelite. Made by famous maker, **2/6** each or **24/-** dozen.

100 Assorted Silicon Rectifiers G.P. and Switching Diodes. Small and very small sizes. A real snip for experimenters, **12/6** per 100.

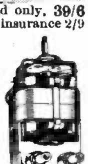
Mains Suppression Adaptor for preventing mains interference caused by vacuum cleaners, razors, sewing machines, etc., rated at 4 amps, simply plug this into your 5 amp 3 pin socket, **6/-** each.

5 in. Cathode Ray Tube. Sylvania type, No. 8E5 J31, replacement in many scopes and instruments, brand new and unused, **£6.0.0** plus 10/6 postage and insurance. Mu Metal shield for this tube, **£2. 10. 0.**

ELECTRIC CLOCK WITH 25 AMP SWITCH

Made by Smith's, these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only. **39/6** less than the value of the clock alone—post and insurance 2/9

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 ¼in. diameter and approximately 1in. 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. 2in. dia. × 5in. long, mains 230/240v. Price **17/6** plus 4/6 postage and insurance. 12 or more post free.

Nicad Battery Charger. This plugs into a shaver socket, has switch for 240 or 115 v. mains, has a charge rate of 7 mA and 2 slide-in compartments designed to take 120 mAH. standard Nicads, but by using washers or rings these charger can be easily modified to take mercury deaf aid cells, complete with adaptor, **8/6**.

Quadruple Recording Tape. On a 3in. spool giving 600ft. of very good quality tape. Made by a famous company for talking books, especially suitable for message tapes and portable equipment. Regular price about 30/- per spool. Our price, **7/6** or **21/-** for 3 spools if ordered together.

8 ohm Speaker. 5in. round, made by E.M.I. Suit most transistor amplifiers, **14/6** ea.

Heat and Light Lamp 275 watt, internal mirrored, B.C. cap, **16/6** plus 3/6 post & ins.

Grundig Stenorettor. Portable office dictating machine, German made and very efficient. We have a few only of these, secondhand but in perfect working order, any not so would be exchanged. **£10** each.

Rechargeable Nicad Battery Packs for this machine, **£3.10** each.

110 r.p.m. Geared Motors. This is a powerful 2 pole mains-operated Induction motor as used in record players but much more powerful (¾in. stack). The gearbox is sealed and the final drive shaft is 1in. long and ¼in. diameter. Overall size of motor and gearbox 3 × 3 × 4in. approx., **35/-** each, post and ins. 4/6.

Mains Operated Relay. A small size relay but with 3 pairs of 10 amp contacts. **12/6** each.

Spot Welders. These comprise step-down transformer, welding heads, foot switch and auto cut-out. Not many of these available, price **£40** complete plus carriage at cost. Approx. weight 40lb.

6-way Shorting Switch. This resembles an ordinary rotary wave change switch, but the tags instead of being switched separately, are progressively shorted together. This is sometimes known as an incremental switch, **4/6** each.

Buzzer. This is a normal size bakelite buzzer, made for the G.P.O. so obviously very good. Ex-equipment but perfect order, **4/6** each or **48/-** dozen.

Miniature Fluorescent Tubes. These have a diameter of only approximately ⅝in. and are available as follows: 9in.—6 watt, 12in.—8 watt, 21in.—12 watts. All **10/6** each or **9/-** dozen lots. Control gear for these is available, MF1 for 6 and 12in. tubes and MF2 for 21in. tubes, **19/6** per set plus 3/6 post.

2 speed 12 volt Blowers. Made by Delco these are very powerful at full speed. Ideal if you are making a blower heater for car or caravan or for extracting bad air where only a 12 volt supply is available. **39/6** plus 4/6 p. & p.

Panel Lamp Holders. These require only one hole through the panel, removeable glass front and back, uses normal small M.E.S. bulb, **1/3** each, **12/-** dozen.

Spartan Radio. Long and medium wave 7 transistor radio, and size approx. 6 × 4 × 1¾in., with larger than average speaker, better than average tone. Also telescopic aerial for receiving distant stations. A good set, complete with leather case and carrying sling, **£3.15** each plus 5/- post and ins.

13 Amp Fuses for ring main plugs. Made by G.E.C. these are very good, **5/-** per dozen, **50/-** gross.

ERGOTROL UNITS

These units made by the Mullard Group are for operating and controlling d.c. Motors and equipment from A.C. mains.

Thyristors are used and these supply a variable d.c. resulting in motor speed control and operating efficiency far superior to most other methods.

The units are contained in wall mounting cabinets with front control panel on which are fuses—push buttons for on/off and the variable thyristor firing control.

4 models are available—all are brand new in makers cases:

Model 2410 for up to 5 amps **£17.10.0**
Model 2411 for up to 10 amps **£27.10.0**
Model 2413 for up to 45 amps **£47.10.0**
Model 2415 for up to 80 amps **£95. 0.0**
Note: 2415 is a floor mounting unit.

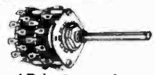
HORSTMANN "TIME & SET" SWITCH

(A 30 Amp Switch.) Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price **29/6**. Post and ins. 4/6.

FULL FI 12" LOUDSPEAKER.

This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi lead and Rhythm Guitar and public address. Flux Density 11,000 gauss—Total Flux 44,000 Maxwells-Power Handling 15 watts R.M.S. Cone Moulded fibre—Freq. response 30-10,000 c.p.s.—Specify 3 or 15 ohms—Mains resonance 60 c.p.s.—Chassis Diam. 12in.—12⅜in., over mounting lugs—Baffle hole 11in. Diam.—Mounting holes 4 holes—¼in. diam. on pitch circle 11⅝in. diam.—Overall height 5½in A £6 speaker offered for only **£3.19.6** plus 7/6 p. & p. **Higher powered models with equally good specification**: 12in. 40 watt **£6.19.6** plus 8/6 p. & p.; 15in. 25 watt **£7.19.6** plus 10/6 p. & p.; 18in. 100 watt **£19.10** plus 30/- p. & p.

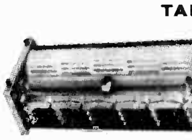
STANDARD WAFER SWITCHES



Standard size 1¼ wafer—silver-plated 5-amp contact, standard ¼" spindle 2" long—with locking washer and nut.

No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	9 way	10 way	12 way
1 pole	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6	6/6
2 poles	6/6	6/6	6/6	6/6	6/6	6/6	6/6	10/6	10/6
3 poles	6/6	6/6	6/6	6/6	10/6	10/6	10/6	14/6	14/6
4 poles	6/6	6/6	6/6	10/6	10/6	10/6	10/6	18/6	18/6
5 poles	6/6	6/6	10/6	10/6	14/6	14/6	14/6	22/6	22/6
6 poles	6/6	10/6	10/6	10/6	14/6	14/6	14/6	26/6	26/6
7 poles	6/6	10/6	10/6	14/6	18/6	18/6	18/6	30/6	30/6
8 poles	10/6	10/6	10/6	14/6	18/6	18/6	18/6	34/6	34/6
9 poles	10/6	10/6	14/6	14/6	22/6	22/6	22/6	38/6	38/6
10 poles	10/6	10/6	14/6	18/6	22/6	22/6	22/6	42/6	42/6
11 poles	10/6	14/6	14/6	18/6	26/6	26/6	26/6	46/6	46/6
12 poles	10/6	14/6	14/6	18/6	26/6	26/6	26/6	50/6	50/6

TANGENTIAL HEATER UNIT



These heater units are the very latest type, most efficient, and quiet running. As fitted in Hoover and blower heaters costing £15 or more. Comprises motor, impeller, and two elements allowing variable heat switching and with thermal safety cut-out. Can be fitted into any metalline case or cabinet. Only need control switch. 1¼ kW. model **39/6**; 2½ kW., **59/6**; and 3 kW. model **79/6**. Postage and insurance 6/6. Control switch **8/6**.

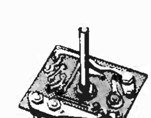
THIS MONTH'S SNIP
HONEYWELL PROGRAMMER

This is a drum type timing device, the drum being calibrated in equal divisions for switch purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 change-over micro switches each of 10 amp type operated by the trips thus 15 circuits may be changed per revolution. Drive motor is mains operated 5 revs. per min. Some of the many uses of this timer are Machinery control, Boiler firing, Dispensing and Vending machines, Display lighting animated signs, Signalling etc. Price from Makers probably over £10 each. Special snip price **£5.15** plus 5/- post and ins. Don't miss this terrific bargain.

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*.

THYRISTOR LIGHT DIMMERS

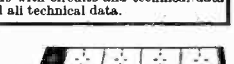


Will dim incandescent lighting up to 600 watts from full brilliance to out. Suitable to mount on M.K. switch plate, same size and fixing as standard wall switch, so may be fitted in place of this, or mount on surface. Price complete with control knob **59/6**.

INTEGRATED CIRCUITS

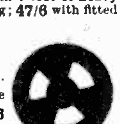
A parcel of integrated circuits made by the famous Plessey Company. A once in a lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first grade device definitely not sub-standard or seconds. The ICs are all single silicon chip General Purpose Amplifiers. Regular price of which is well over £1 each. Full circuit details of the ICs are included and in addition you will receive a list of 50 different ICs available at bargain prices 5s. upwards with circuits and technical data of each. Complete parcel only **£1** post paid or List and all technical data.

DISTRIBUTION PANELS



Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work, **39/6** less plug; **45/-** with fitted 13 amp plug; **47/6** with fitted 15 amp plug, plus 4/6 P. & I.

COMPUTER TAPES



2,400ft. of the best magnetic tape money can buy. Made by E.M.I., 1in. wide, almost unbreakable and on a 10½in. metal computer spool. Users have claimed successful results with video as well as sound recordings. **19/6** plus 6/6 post. Cassette to hold spool **10/-** extra.

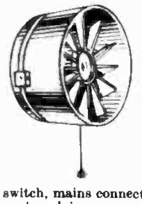
MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6 v., 9 v., 12 v. for up to 500 mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **16/6** plus 3/6 postage.

A.C. Ammeter. These are very useful in the workshop as they will read very high currents in fact 0-250 amps, but being moving iron the most useful section of the scale permits accurate readings between 5-50 amps. These are beautifully made, 3in. dial, made by Sangamo Weston. Probable cost from the makers over £10 each. Our price **59/6**. Brand new in makers' cartons.

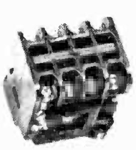
Case Handle. Bakelite with metal attachments. Ideal for all portable equipment and for tool boxes, etc., **1/3** each, **12/-** dozen.

EXTRACTOR FAN

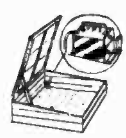


Cleans the air at the rate of 10,000 cubic ft. per hour. At the pull of a cord it extracts grease, grime and cooking smells before they dirty decorations. Suitable for kitchens, bathrooms, factories, changing rooms, etc., it's so quiet it can hardly be heard. Compact, 5½" casing with 5½" fan blades. Suitable wherever it is necessary to move air fast. Kit comprises motor, fan blades, sheet steel casing, pull switch, mains connector, and fixing brackets. **39/6** plus 6/6 post and ins.

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. **19/6** each.



Be first this year!
SEED AND PLANT RAISING

Soil heating wire and transformer. Suitable for standard size garden frame. **19/6**. post and ins. 5/6.

BLANKET SWITCH

Double pole with neon let into side so luminous in dark. Ideal for dark room light or for use with waterproof element—new plastic case. **5/6** each. 3 heat model **7/6**.

WATERPROOF HEATING ELEMENT. 26 yards length 70W. Self-regulating temperature control. **10/-** post free.

2½kW FAN HEATER

Three position switching to suit changes in the weather. Switch up for full heater (2½kW), switch down for half heat (1¼kW), switch central blows cold for summer cooling—adjustable thermostat acts as auto-control and safety cut-out. Complete kit **£3.15.0**. Post and ins. 7/6.

THERMOSTATS

Type "A" 15 amp. for controlling room heaters, greenhouses, airing cupboard. Has spindle for pointer knobs. Quickly adjustable from 30-80 deg. F. **9/6** plus 1/- post. Suitable box for wall mounting, **5/-**. P. & P. 1/-.

Type "B" 15 amp. This is a 17in. long rod type made by the famous Sunvic Co. Spindle adjusts this from 50-550 deg.F.

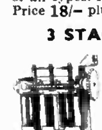
Internal screw alters the setting so this could be adjustable over 30 deg. to 1000 deg. F. Suitable for controlling furnace, oven, kiln, immersion heater or to make flame-stat or fire alarm. **8/6** plus 2/6 post and insurance.

Type "D". We call this the Ice-stat as it cuts in and out at around freezing point, 2/3 amps. Has many uses, one of which would be to keep the loft pipes from freezing, if a length of our blanket wire (16 yd. **10/-** is wound round the pipes. **7/6**. P. & P. 1/-.

Type "E". This is standard refrigerator thermostat. Spindle adjustments cover normal refrigerator temperature. **9/6**, plus 1/- post.

Type "F". Glass encased for controlling the temperature of liquid—particularly those in glass tanks, vats or sinks—thermostat is held (half submerged) by rubber sucker or wire clip—ideal for fish tanks—developers and chemical baths of all types. Adjustable over range 50 deg. to 150 deg. F. Price **18/-** plus 2/- 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 2¼ × 2 × ½in. thick) with reduction gear for fine tuning. **12/6**. with circuit of front end suitable for car radio or as a general purpose tuner for use with Amplifier.

TELESCOPIC AERIAL

For portable, car radio or transmitter. Chrome-plated—six sections extends from 7¼ to 47in. Hole in bottom for 6BA screw. **7/6**

TOGGLE SWITCH

3 amp 250v. with fixing ring. **1/6** each **15/-** doz

Rod Thermostats. As normally used in water heaters, 2 lengths 10in. and 18in. **12/6** each.

13 amp Ivory Sockets. Unswitched, **3/6** each, switched **4/6** each.

15 amp Micro Switch. Made by Burgess this is standard, 15 amp on/off, **2/6** each, **27/-** dozen.

Resettable Impulse Counter. 24 volt operated and each impulse moves one digit and the instrument is resettable by push button. Ideal for any counting operations, 49/6.

A New Service to Readers. A bulletin bringing news of new lines, special snips and "too few to advertise" lines will be posted to subscribers during first week of each month. The bulletin will be called "Advance Advert News" and the Subscription is **12/-** per year. Subscribers will also receive our completed 1971 catalogue when this is published.

Where postage is not stated then orders over £5 are post free. Below £5 add 2/9. S.A.E. with enquiries please.

ELECTRONICS (CROYDON) LTD

Dept. WW, 266 London Road, Croydon CRO-2TH
Also 102/3 Tamworth Road, Croydon

BI-PAK=LOW COST I.C's VALUE ALL THE WAY

BI-PAK Semiconductors now offer you the largest and most popular range of I.C's available at these **EXCLUSIVE LOW PRICES.** TTL Digital 74N Series fully coded, brand new. Dual in-line plastic 14 and 16 pin packages.

BI-PAK Order No.	Sim. Type	Description	1-24	25-99	100 up
BP00	7400N	Quad 2-Input NAND GATE	6/6	5/6	4/6
BP01	7401N	Quad 2-Input NAND Gate—OPEN COLLECTOR	6/6	5/6	4/6
BP02	7402	Quadruple 2-Input NOR GATE	6/6	5/6	4/6
BP04	7404N	HEX INVERTER	6/6	5/6	4/6
BP10	7410N	Triple 3-Input NAND GATE	6/6	5/6	4/6
BP20	7420N	Dual 4-Input NAND GATE	6/6	5/6	4/6
BP30	7430N	Single 8-Input NAND GATE	6/6	5/6	4/6
BP40	7440N	Dual 4-Input BUFFER GATE	6/6	5/6	4/6
BP41	7441AN	BCD to decimal decoder and NIT Driver	22/6	20/-	17/6
BP42	7442N	BCD to decimal decode (TTL O/P)	22/6	20/-	17/6
BP50	7450N	Dual 2-Input NAND/OR/NOT GATE—expandable	6/6	5/6	4/6
BP53	7453N	Expandable 4-Wide 2-Input NAND/OR/NOT GATE	6/6	5/6	4/6
BP60	7460N	Dual 4-Input—expandable	6/6	5/6	4/6
BP70	7470N	Single JK Flip-Flop—edge triggered	9/-	8/-	7/-
BP72	7472N	Single Master Slave JK Flip-Flop	9/-	8/-	7/-
BP73	7473N	Dual Master Slave JK Flip-Flop	10/-	9/-	8/6
BP74	7474N	Dual D Flip-Flop	10/-	9/-	8/6
BP75	7475N	Quad Bistable Latch	11/-	10/-	9/6
BP76	7476N	Dual Master Slave Flip-Flop with preset and clear	11/-	10/-	9/6
BP83	7483N	Four Bit Binary Adder	26/-	22/6	20/-
BP90	7490N	BCD Decade Counter	22/6	20/-	17/6
BP92	7492N	Divide by 12 4 Bit binary counter	22/6	20/-	17/6
BP93	7493N	Divide by 16 4 Bit binary counter	22/6	20/-	17/6
BP94	7494N	Dual Entry 4 Bit Shift Register	22/6	20/-	17/6
BP95	7495N	4 Bit Up-Down Shift Register	22/6	20/-	17/6
BP96	7496N	5 Bit shift register	24/-	21/-	18/6

(Price and qty. prices)

Data are available for the above Series of Integrated Circuits in booklet form. Price 2/6

TTL INTEGRATED CIRCUITS

Manufacturers' "Fall outs"—out of spec. devices including functional units and part functional but classed as out of spec. from the manufacturers' very rigid specifications. Ideal for learning about I.C's and experimental work, on testing some will be found perfect.

PAK No.		PAK No.		PAK No.	
UIC00 = 5 × 7400N	10/-	UIC42 = 5 × 7442N	10/-	UIC80 = 5 × 7480N	10/-
UIC01 = 5 × 7401N	10/-	UIC50 = 5 × 7450N	10/-	UIC82 = 5 × 7482N	10/-
UIC02 = 5 × 7402N	10/-	UIC51 = 5 × 7451N	10/-	UIC83 = 5 × 7483N	10/-
UIC03 = 5 × 7403N	10/-	UIC60 = 5 × 7460N	10/-	UIC86 = 5 × 7486N	10/-
UIC04 = 5 × 7404N	10/-	UIC70 = 5 × 7470N	10/-	UIC90 = 5 × 7490N	10/-
UIC05 = 5 × 7405N	10/-	UIC72 = 5 × 7472N	10/-	UIC92 = 5 × 7492N	10/-
UIC10 = 5 × 7410N	10/-	UIC73 = 5 × 7473N	10/-	UIC93 = 5 × 7493N	10/-
UIC20 = 5 × 7420N	10/-	UIC74 = 5 × 7474N	10/-	UIC94 = 5 × 7494N	10/-
UIC40 = 5 × 7440N	10/-	UIC75 = 5 × 7475N	10/-	UIC95 = 5 × 7495N	10/-
UIC41 = 5 × 7441AN	10/-	UIC76 = 5 × 7476N	10/-	UIC96 = 5 × 7496N	10/-

PAK No. UICX1 = 20 × Assorted 74's 30/-

Packs cannot be split but 20 assorted pieces (our mix) is available as PAK UICX1. Every PAK carries our BI-PAK Satisfaction or money back GUARANTEE.

BRAND NEW, FULL TO MANUFACTURERS' SPECIFICATION

	Price each 1-24	25-99	100 up
BP709 Operational Amplifier, dual-in-line 14 pin package = SN72709 and similar to MIC709 and ZLD709C	10/6	9/-	8/-

This is a high performance operational amplifier with high impedance differential inputs and low impedance output.

BI-PAK WAREHOUSE CLEARANCE

Over I Million Semiconductors must be sold.

Order any or all of these. Bargain "SALE" PAKS Listed Below "NOW"

UNSORTED/UNTESTED/UNCODED/UNBEATABLE VALUE

PAK. Order No.	Qty.	Description	Price per PAK
SA1	150	Germ. Trans PNP Mixed lots	10/-
SA2	200	Germ. & Sil. Alloy Trans. PNP	10/-
SA3	100	Germ. A.F. Trans. 300mW PNP	10/-
SA4	200	Sil. Alloy Low gain switching Trans. PNP	10/-
SA5	100	Sil. planar plastic trans. PNP	10/-
SA6	100	Sil. plastic planar trans. NPN	10/-
SA7	100	Sil. planar Trans. TO5 plastic NPN 800mW	20/-
SA8	100	Sil. planar trans. TO18 plastic NPN 500mW	20/-
SA9	100	Sil. planar trans. plastic NPN med. & high gain	20/-
		DIODES	
SB1	200	GERM. Diodes Gen.P.	10/-
SB2	200	GERM. Gold Bonded	10/-
SB3	200	Sil. Switching Diodes 50mA	10/-
SB4	200	Sil. Gen.P. Diodes 200mA	10/-
SB5	300	Sil. & Germ. Mixed Diodes	10/-

The following are all new and Fully Tested Transistor Packs.

PAK. Order No.	Qty.	Description	Price per PAK
ST1	50	PNP Trans. Mixed all coded Germ.	20/-
ST2	40	NPN Germ. To-5 2G339 Eqvt. 2N1302 AC127	20/-
ST3	40	PNP Germ. AF 2G371B OC71-75 type	20/-
ST4	30	PNP Germ. VHF-2G407L=AF117=OC170 uncoded	20/-
ST5	30	PNP Metal Alloy VHF 800m/cs Trans.	20/-
ST6	40	PNP/NPN Assorted Trans. all coded	20/-
ST7	40	D1374 RF Trans. Eqvt. ASY52 OC44/45	20/-
ST8	40	2N706 NPN Switching Sil. Trans.	20/-
ST9	30	2N708 NPN Sil. Trans.	20/-
ST10	30	BSY28 NPN Sil. Trans.	20/-
ST11	25	2N3703 PNP Sil. Trans.	20/-
ST12	25	TIS48=2N2368 NPN 400m/cs	20/-
ST13	25	SE/2N3646 NPN TO-18 plastic 350m/cs	20/-
ST14	40	2S3010 Sil. Alloy Trans. PNP TO5	20/-

WHEN ORDERING PLEASE MENTION PAK. ORDER NO. IN ALL CASES. CLUBS, SCHOOLS & OTHER ORGANISATIONS REQUIRING LARGER QUANTITIES (100 MIN.; 100 MIN. ST1 to ST14; 1,000 MIN. SA1 to SB5) MAY SUBMIT THEIR OFFERS NOT LATER THAN 1st FEBRUARY, 1971.

QUALITY-TESTED PAKS

6 Matched Trans. OC44/45/81/81D ... 10/-
20 Red Spot AF Trans. PNP ... 10/-
16 White Spot RF Trans. PNP ... 10/-
5 Silicon Rects. 3A 100–400 PIV ... 10/-
2 10 A Silicon Rects. 100 PIV ... 10/-
2 OC1 140 Trans. NPN Switching ... 10/-
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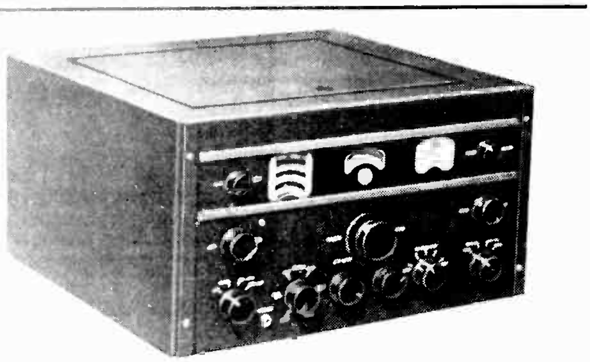

BRAND NEW and in original cases—A.C. mains input. 110V or 250V. Freq. in 6 bands 535 Kc/s-32 Mc/s. Output impedance 2.5-600 ohms. Complete with crystal filter, noise limiter, B.F.O., H.F. tone control, R.F. & A.F. variable controls. Price **£87·50** each, carr. £2.

Same model as above: Fully Recond. by M.O.D. **£65** ea., or sec. hand cond. (guaranteed working order) from **£45** to **£60,** carr. £2.

***SET OF VALVES:** new, **£3·50** a set, post 37p; **SPEAKERS:** new, **£3** each, post 50p. ***HEADPHONES:** new, **£1·25** a pair, 600 ohms impedance. Post 25p.

AR88 SPARES. Antenna Coils L5 and 6 and L7 and 8. Oscillator coil L55. Price **50p** each, post 13p. RF Coils 13 & 14; 17 & 18; 23 & 24; and 27 and 28. Price **63p** each. 13p post. By-pass Capacitor K.98034-1, 3 × 0·05 mfd. and M.980344, 3 × 0·01 mfd., 3 for **50p,** post 13p. Trimmers 95534-502, 2-20 p.f. Box of 3, **50p,** post 13p. Block Condenser, 3 × 4 mfd., 600 v., **£2** each, 20p post. Output transformers 901666-501 **£1·37** each, 20p post.

** Available with Receiver only.*

FOR EXPORT ONLY

BRITISH & AMERICAN COMMUNICATION EQUIPMENT

VRC.19X Trans-ceiver, 150-170Mc/s, 2 Channel, 20 Watts, Output 12/24V d.c. operation. General Electric Transmitter, 410-419Mc/s, thin line tropo scatter system, with antennae. W.S. Type 88, Crystal controlled, 40-48 Mc/s. W.S. Type HF-156, Mk. II, Crystal controlled, 2.5-7.5 Mc/s. W.S. Type 62, tunable, 1.5-12 Mc/s. C.44, Mk. II, Radio Telephone, Single Channel, 70-85 Mc/s, 50 watts, output, 230V. a.c. input. G.E.C. Progress Line Tx Type DO36, 144-174 Mc/s, 50 watt, narrow band width. A.C. input 115V. BC-640 Tx, 100-156 Mc/s, 50 watt output, 110V or 230V input. STC Tx/Rx Type 9X, TR1985; RT1986; TR1987 and TR1998, 100-156 Mc/s. TRC-1 Tx/Rx, Types T.14 and R.19, FM 60-90 Mc/s. With associated equipment available. Redifon GR410 Tx/Rx, SSB, 1.5-20 Mc/s. Sun-Air Tx/Rx Type T-10-R. Collins Tx/Rx/Type 18S4A. Collins Tx/Rx Type ARC-27, 200-400 Mc/s, 28V d.c. With associated equipment available. ARC-5; ARC-3; and ARC-2 Tx/Rx. BC-375; 433G; 348; 718; 458; 455 Tx/Rx. Directional Finding Equipment CRD.6 and FRD.2 complete Sets available and spares. Complete system with full set of Manuals.

MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25Mc/s in 8 ranges. Incremental: ± 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52.5 ohms. Internal Modulation: 400c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100c/s. Consumption approx. 40 watts. Measurements 29 × 12¼ × 10 in. Secondhand condition. **£25** each, carr. £1·50.

TRIPLETT SIGNAL GENERATOR Model 1632: Contains an R.F. Oscillator calibrated in 10 fundamental bands, covering a freq. of 100 Kc/s-120 Mc/s. Also a buffer amplifier and modulator stage, a metering system, crystal Oscillator stage, and a self-contained Heterodyne Detector. The wide frequency range covers broadcast, standard short-wave, T.V. and FM channels. Operates 115V a.c. 50/60 c/s. Output Meter 0-0.3 V. Controls: Ext. Mod.; Int. Mod.; CW; Het. Det.; Xtal.; AFO put; RF Level; O/put Units; and O/put Multiplier. Slow and Fast motion dial. Price **£12·50** very good second-hand cond.; or **£15·50** "as new" cond. Carr. 75p.

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BC171=BC107	13p	2N1302-3	20p
BC172=BC108	13p	2N1304-5	25p
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OC44	13p	OC25	25p
OC45	13p	OC26	25p
OC71	13p	OC28	30p
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TU.2 CONTAINING 2 AF186's & 2 AF178's
PRICE 50p *P&P 13p EACH UNIT*

All the units have many other components, e.g. Capacitors, Resistors, Coils and tuning condensers, etc. Although these are manufacturers rejects they are not beyond repair as has been proven by many of our customers.

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Designed to give 25 K.V. when used with PL509 and PY500 valves. As removed from colour receivers at the factory.
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SPECIAL LINE

1 AMP. Bridge rectifiers .... ¾" Square.
100 PIV.=25p   400 PIV.=33p   800 PIV.=40p

PAK F.3 .... **13p** PAIR
Complementary Set. NPN/PNP Germ. Trans.

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These parcels contain all types of surplus electronic components, printed panels, switches, potentiometers, transistors and diodes, etc.

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B96	5	2N3136 PNP SIL. TRANS. TO—18 HPE100-300 IC, 600mA, 200MHz	50p
B98	10	XB112 & XB102 EQUIV. TO AC126 AC156, OC81/2, OC71/2, NKT271, ETC.	50p
B99	200	MIXED CAPACITORS, POST & PACKING 13p APPROX QUANTITY COUNTED BY WEIGHT	50p
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Full of Short Lead Semiconductors & Electronic Components, approx. 170. We guarantee at least 30 really high quality factory marked Transistors PNP & NPN, and a host of Diodes & Rectifiers mounted on Printed Circuit Panels. Identification Chart supplied to give some information on the Transistors.

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PNP Silicon alloy, metal TO-5 can. 2S300 type, direct replacement for the OC200/203 range	**PNP Silicon** PLASTIC ENCAPSULATION, low voltage but good gain, these are of the 2N3702/3 and 2N4059/62 range.	**NPN Silicon planar** PLASTIC TO-18 CASE. Audio preamplifier or 500 mV output stage, of the BC113/4/5. range.	**PNP Germanium** AF OR RF please state on order. Fully marked and tested.

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B88	50	Sil. Trans. NPN, PNP, equiv. to OC200/1, 2N706A, BSY95A, etc.	50p
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2N1302	4/-	2N3906	7/6	AD149	12/-	BC177	6/3	NKT405	15/-
2N1303	4/-	2N4058	4/-	AD161/AD162		BC178	5/8	OA47	1/9
2N1304	4/6	2N4059	4/-	(matched)	14/-	BC179	6/-	OA90	1/3
2N1305	4/6	2N4060	4/-	AF114	7/-	BC182L	2/6	OA91	1/3
2N1613	6/-	2N4061	4/-	AF115	7/-	BC183L	2/3	OA95	1/3
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2N3704	2/6	40408	14/6	BC125	11/-	BFX88	5/3	ZTX531	6/9
2N3705	2/6	40430	37/-	BC126	11/-	BFY50	4/6		
2N3706	2/6	40512	39/-	BC147	3/-	BFY51	4/-		

RESISTORS

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99	100 up
					(see note below).		
C	1/20W	5%	82Ω–220KΩ	E12	18	16	15
C	1/8W	5%	4·7Ω–330KΩ	E24	2·5	2	1·75
C	1/4W	10%	4·7Ω–10MΩ	E12	2·5	2	1·75
C	1/2W	5%	4·7Ω–10MΩ	E24	3	2·5	2·25
C	1W	10%	4·7Ω–10MΩ	E12	6	5	4·5
MO	1/2W	2%	10Ω–1MΩ	E24	9	8	7
WW	1W	10% ± 1/20Ω	0·22Ω–3·9Ω	E12	1/6 all quantities		
WW	3W	5%	12Ω–10KΩ	E12	1/6 all quantities		
WW	7W	5%	12Ω–10KΩ	E12	1/9 all quantities		

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on 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, **3/9 each**; 1W: 6·8V to 82V, **9/- each; 1·5W**: 4·7V to 75V, **12/- each.**
Clip to increase 1·5W rating to 3 watts (type 266F), **9d.**

CARBON TRACK POTENTIOMETERS, long spindles. Double wiper ensures minimum noise level.
Single gang linear 220Ω to 2·2MΩ, **2/6**; Single gang log, 4·7KΩ to 2·2MΩ,, **2/6**; Dual gang linear, 4·7kΩ to 2·2MΩ, **8/6**; Dual gang log, 4·7KΩ to 2·2MΩ, **8/6**; Log/antilog, 10K, 47K, 1MΩ only **8/6**; Dual antilog, 10K only, **8/6**. Any type with ½A D.P. mains switch, extra **2/3.**
Please note: only decades of 10, 22 and 47 are available within 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, **1/- each.**

COLVERN 3 watt Wire-wound Potentiometers. 10Ω, 15Ω, 25Ω, 50Ω, 100Ω, 250Ω, 500Ω, 1K, 1·5K, 2·5K, 5K, 10K, 15K, 25K, 50K, **5/6 each.**

ENAMELLED COPPER WIRE even No. SWG only: 2 oz. reels: 16-22 SWG **4/3**; 24-30 SWG **5/-**; 32, 34 SWG, **5/6**; 36, 38 SWG, **6/3.**
4 oz. reels: 16-22 SWG only **7/6.**

TYGAN SPEAKER MATERIAL
7 designs, 36 × 27 in. sheets, **31/6** sheet.
Pattern book, S.A.E. plus 6d. stamp.

MULLARD polyester C280 series
250V 20%: 0·01, 0·022, 0·033, 0·047 **8d. each;** 0·068, 0·1, **9d. each;** 0·15, **11d.,** 0·22, **1/-.** 10%: 0·33, **1/5**; 0·47, **1/8**; 0·68, **2/3**; 1μF, **2/9**; 1·5μF, **4/2**; 2·2μF, **4/9**

MULLARD SUB-MIN ELECTROLYTICS
C426 range, axial lead .. .. .. 1/3 each
Valves (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, **5/6**; 1000/50, **8/2**; 1000/100, **16/3**; 2000/25, **7/4**; 2000/50, **11/4**; 2000/100, **28/9**; 2500/64, **15/5**; 2500/70, **19/6**; 5000/25, **12/6**; 5000/50, **21/11**; 5000/100, **58/3**; 10000/15, **17/-**; 10000/25, **24/6**; 10000/50, **44/-**; 10000/70, **61/-.**

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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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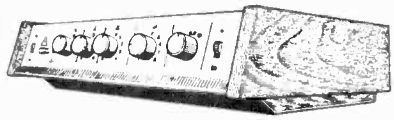
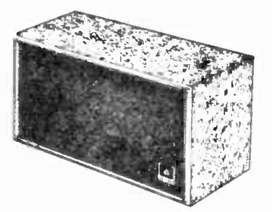


ENGLEFIELD 12+12 AMPLIFIER

Stereo amplifier in modular kit form 12 watts per RMS channel into 15Ω **£38/9/-**;
Cabinet kit only **£6.** These prices nett.
As reviewed in *Hi Fi Sound* and other important journals.



BAXANDALL SPEAKER SYSTEM

Designed by Peter Baxandall. Superb reproduction for its size. Handles 10 watts with ease. Uses ELAC 15Ω 59RM109 speaker unit. Kit **£13/12/-** nett; built **£19/8/6** 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	**168/-** nett	**92/-**
25W	**190/-** nett	N/A
40W	**210/-** nett	**115/1**
70W	**252/-** nett	**138/10**

30 WATT BAILEY AMPLIFIER PARTS

Sensitivity 1·2V for full output into 8Ω.
Transistors and PCB for one channel **£7/5/6**
Transistors and PCBs for two channels **£14/11/-**
Capacitors and resistors (metal oxide), **40/-** per channel.
Complete unregulated power supply pack, **£4/15/-**

INTEGRATED CIRCUITS

PLESSEY SL403A 3 watts into 7·5 ohms. Data book supplied FREE when two of these units are purchased. Price per unit, nett **42/6.**

SINCLAIR IC.10 as advertised, complete with instructions and applications manual **59/6** nett.
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S-DeCs PUT AN END TO BIRDS NESTING
Components just plug in—saves time—allows re-use of components. S-Dec (70 points), **20/-.**
Complete T-Dec, may be temperature-cycled (208 points), **50/-.**
Also μ-Decs and IC carriers.

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Axial leads: 50/50, **1/9**; 100/25, **1/9**; 100/50, **2/6**; 250/25, **2/6**; 250/50, **3/9**; 500/25, **3/9**; 500/50, **4/6**; 1000/25, **4/-**; 1000/50, **6/-**; 2000/25, **6/-.**

SMALL ELECTROLYTICS
Axial leads: 4·7/10, 4·7/25, 5/50, **1/- each**; 10/10, 10/25, 10/50, 33/10, 50/10, **1/- each;** 25/25, 25/50, 47/25, 100/10, 220/10, **1/3 each.**

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Pri 10,000 Ω CT. 10-60 cycles 40 M/A D.C. per half. Sec tapped 50, 100, 200 Ω 6 watts, fully shrouded. **35/-.** P. & P. 6/6. Pri 20,000 Ω CT. 10-60 cycles 15 M/A D.C. per half. Sec tapped 10, 20, 30, 40 Ω. **25/-.** P. & P. 5/-.

HEAVY DUTY LT TRANSFORMERS
By famous maker. Fully Tropicalised. Pri tapped 100, 110, 120, 200, 220, 240v. E.S. Three Separate Secondies 27v. 9a., 9v. 9a., 3v. 9a. Plus 17-0-17v. 0·25a and 17v. 0·25a. Table Top Connections. **79/6.** Carr. 10/6.

PARMEKO C CORE TRANSFORMERS
Pri. tapped 110-200-240v. Sec. 1 250v. 197 m/a. Sec. 2 161v. 110 m/a. Sec. 3 152v. 76 m/a. Sec. 4 124v. 25 m/a. Sec. 5 28v. 0·4a. Sec. 6 6·4v. 6·2a. 6·3v. 3·25a. 6·3v. 1·4a. Table top connections. Size 5 × 4 × 4 ins. Brand new boxed. **35/-.** P. & P. 7/6. Special prices for qtys.

SPECIAL OFFER OF PARMEKO NEPTUNE SERIES TRANSFORMERS ALL PRIMARIES TAPPED 115-230v.
Sec. 6·3v. CT 5a. 6·3v. CT 3a. 6·3v. CT 2a. **37/6** P. & P. 5/-.
Sec. 9-10v. 0·5a. 6·3v. 3·5a. 6·3v. 1·2a. **19/6** P. & P. 4/-.
Sec. 400-0-400v. 150 m/a. **50/-** P. & P. 7/6.
Sec. 350-0-350v. 100 m/a. 3-8-12-18v. 5a. **£3.19.6** P. & P. 8/6.
Sec. 6·3v. CT 5a. 6·3v. 1·2a. 6·3v. 1·2a. **27/6** P. & P. 5/-.
Sec. 6·3v. 1·8a. 6·3v. 1a. 6·3v. 1a. **17/6** P. & P. 3/6.
Sec. 29·5-32·5v. **32/6** P. & P. 5/-.
Sec. 4v. 0·5a. four times. **15/-** P. & P. 3/6.
Sec. 6·3v. CT 0·6a. 6·3v. 0·6a. **12/6** P. & P. 3/6.

Pri 200-220-240v. Sec. 250-0-250v. 50 M/A. 6·3v. 1a. **22/6** P. & P. 5/-. Pri 230v. 4·2v. 1a. **10/6** P. & P. 3/6.

WILLESDEN POTTED TRANSFORMER
Pri. 10-0-200-220-240v. Sec. 2.5v 5a four times. **50/-** Carr. 8/6.

T.E.C. 240-110v. ISOLATION TRANSFORMERS
Pri Tapped 10. 0. 200. 220. 240v. sec. Tapped 110-112.5-115v. Conservatively rated at 9 amps. Tropicalised open frame type. Terminal Board connections. Size 9×9×7 ins. Weight 60 lbs. **£15.** Carr. 17/6.

ISOLATION TRANSFORMERS
By Magestic Winding Co. Pri 240v. Sec. 240v. Centre tapped. 2kva. Mounted in strong metal case. Size 11 × 9 × 8 ins. Conservatively rated. **£27.10.0.** Carr. 30/-.

ENGLISH ELECTRIC FUSES
Cartridge Type T.I.A.30, Class Q 30 amp and Type T.I.A.20, Class Q 20 amp. **25/-** per dozen. P. & P. 2/6. Fusetron Edison Screen Type 15 amp and 20 amp. **25/-** per dozen. P. & P. 2/6. Standard 1¼ ins. Type Glass Fuses. 10a., 3a. 150 M/A. 50 for **10/6.** P. & P. 1/6.

AIR MINISTRY 2-IN. ROUND METERS
0-20 amps D.C. **12/6.** 0-40 amps D.C. **15/-.** 0-50 volt D.C. **15/-.** 2/6 P. & P.

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CURRENT RANGE OF BRAND NEW L.T. TRANSFORMERS. FULLY SHROUDED (*excepted) **TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220/240v**

No.	Sec. Taps	Amps	Price	Carr.
1A	25–33–40–50	15	£10 10 0	12/6
1B	25–33–40–50	10	£7 12 6	9/6
1C	25–33–40–50	6	£6 15 0	9/6
1D	25–33–40–50	3	£4 0 0	7/6
2A	4–16–24–32	12	£7 2 6	8/6
2B	4–16–24–32	8	£5 7 6	8/6
2C	4–16–24–32	4	£3 12 6	7/6
2D	4–16–24–32	2	£2 7 6	5/–
3A*	25–30–35	40	£16 10 0	12/6
3B*	25–30–35	20	£10 5 0	10/6
3C	25–30–35	10	£7 5 0	8/6
3D	25–30–35	5	£4 2 6	7/6
3E	25–30–35	2	£3 2 6	7/6
4A*	12–20–24	30	£13 0 0	12/6
4B	12–20–24	20	£8 5 0	9/6
4C	12–20–24	10	£4 5 0	8/6
4D	12–20–24	5	£3 12 6	7/6
5A	3–12–18	30	£9 12 6	9/6
5B	3–12–18	20	£7 2 6	8/6
5C	3–12–18	10	£4 5 0	7/6
5D	3–12–18	5	£2 17 6	7/6
6A	48–56–60	2	£3 12 6	6/6
6B	48–56–60	1	£2 12 6	6/6
7A*	6–12	50	£10 7 6	10/6
7B	6–12	20	£6 2 6	8/6
7C	6–12	10	£3 17 6	7/6
7D	6–12	5	£2 15 0	6/6
8A	12–24	1	£1 12 6	6/6
9A	17–32	8	£6 5 0	8/6
10A*	9–15	2	£1 9 6	6/6
11A	6·3	15	£2 10 0	7/6
12A	30–25–0–25–30	2	£3 12 6	6/6

Note: By using the intermediate taps many other voltages can be obtained.
Example: No. 1 .. 7–8–10–15–17–25–33–40–50v.
No. 2 .. 4–8–12–16–20–24–32v.
No. 5 .. 3–6–9–12–15–18v.

AUTO TRANSFORMERS
240v.-110v. or 100v. Completely Shrouded fitted with Two-pin American Sockets or terminal blocks. Please state which type required.

Type	Watts	Approx. Weight	Price	Carr.
1	80	2½ lb	£1 19 6	5/6
2	150	4 lb	£2 12 6	6/6
3	300	6½ lb	£3 12 6	6/6
4	500	8½ lb	£5 2 6	8/6
5	1000	15 lb	£7 2 6	9/6
6	1500	25 lb	£9 15 0	10/6
7*	1750	28 lb	£14 15 0	12/6
8*	2250	30 lb	£17 17 6	15/–

* Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

G.P.O. L.T. SUPPLY UNIT
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Wire Wound single tube. 1 Ω 12a. **15/-.** P. & P. 3/-. 14 Ω 1—4a. **17/6.** P. & P. 3/-. 57.2 Ω 2.8a. Adjustable metal clip type. **27/6.** P. & P. 5/-. 71.5 Ω 2.8a. Fixed type. **17/6.** P. & P. 3/6. 1 Ω 12a. Fixed type. **7/6.** P. & P. 2/6. 758 Ω 0.7a. Twin tube **37/6.** P. & P. 6/6. 30 Ω 1.5a. Right angle geared drive. **19/6.** P. & P. 4/6. Colvern ceramic rheostats. 1500 Ω 0.18a. **7/6.** P. & P. 2/6. 1500 Ω 0.1a. **5/-.** P. & P. 2/-. 20K inst. pots 3 ins. dia. **6/6.** P. & P. 2/6.

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Input 240v., output 0-80v., 15 amps or 0-40v. 30 amps. Open-type slider control. Size: length 2 ft. 8 ins. × 8 ins. × 7 ins. **£15.** Carr. 25/–.

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Pri 200, 220 240v. Sec. 350-0-350v. 25m/a. 6·3v. 1a. 6·3v. 0·6a Sealed potted type. **15/-.** P. & P. 4/6.

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15H 300m/a 50 ohm. "C" Core Potted Type. **62/6.** Carr. 10/-.
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ACY19	20p	C6V2	15p	NKT80214	75p	2N696	15p
ACY20	19p	C6V8	15p	NKT80215	75p	2N697	17p
ACY21	19p	C7V5	15p	NKT80216	75p	2N698	30p
ACY22	19p	C8V2	15p	OA5	20p	2N706	10p
ACY40	15p	C9V1	15p	OA10	25p	2N706A	12p
ACY41	15p	C10	15p	OA47	8p	2N708	16p
AD140	55p	C11	15p	OA70	8p	2N711	37p
AD149	57p	C12	15p	OA73	8p	2N711A	37p
AD161	37p	C13	15p	OA79	8p	2N911	50p
AD162	37p	C15	15p	OA81	8p	2N914	20p
AF114	25p	C16	15p	OA85	8p	2N918	42p
AF115	25p	C18	15p	OA90	8p	2N1090	30p
AF116	25p	C20	15p	OA91	8p	2N1091	33p
AF117	25p	C22	15p	OA95	8p	2N1131	30p
AF118	44p	C24	15p	OA200	10p	2N1132	30p
AF124	25p	C27	15p	OA202	10p	2N1302	20p
AF126	17p	C30	15p	OC19	37p	2N1303	20p
AF139	37p	D13T1	45p	OC20	97p	2N1304	25p
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BC108	12p	NKT125	40p	OC42	30p	2N2160	62p
BC109	12p	NKT126	37p	OC44	15p	2N2368	17p
BC147	15p	NKT128	25p	OC45	15p	2N2369	17p
BC148	15p	NKT135	26p	OC71	15p	2N2369A	20p
BC149	15p	NKT137	32p	OC72	23p	2N2646	50p
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BC182	12p	NKT212	25p	OC77	40p	2N2905	65p
BC182L	10p	NKT213	25p	OC81	23p	2N2905A	75p
BC183	9p	NKT214	23p	OC81D	20p	2N2906	44p
BC183L	9p	NKT215	21p	OC81Z	55p	2N2906A	54p
BC184	15p	NKT216	46p	OC82	25p	2N2926 all colours	10p
BC184L	15p	NKT217	50p	OC82D	15p	2N3053	25p
BC212	17p	NKT218	25p	OC83	23p	2N3054	63p
BC212L	12p	NKT219	25p	OC84	25p	2N3055	75p
BCY30	25p	NKT223	27p	OC139	25p	2N3702	11p
BCY31	48p	NKT224	25p	OC140	35p	2N3703	10p
BCY32	50p	NKT225	21p	OC170	25p	2N3704	11p
BCY33	20p	NKT229	29p	OC171	30p	2N3705	10p
BCY34	25p	NKT237	31p	OC200	37p	2N3706	9p
BCY38	30p	NKT238	19p	OC201	47p	2N3707	11p
BCY70	19p	NKT239	23p	OC202	63p	2N3708	7p
BCY71	37p	NKT240	20p	OC203	37p	2N3709	9p
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BD123	£1·10	NKT243	56p	OC206	75p	2N3819	35p
BD124	£1·03	NKT244	17p	OC207	75p	2N3820	60p
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BF115	25p	NKT261	21p	ORP12	50p	2N4058	17p
BF163	40p	NKT262	19p	ORP60	60p	2N4060	20p
BF167	25p	NKT264	21p	ORP61	40p	2N4061	20p
BF173	30p	NKT271	18p	P346A	19p	2N4062	20p
BF178	52p	NKT272	17p	ST140	15p	2N4284	15p
BF180	37p	NKT274	18p	ST141	20p	2N4287	15p
BF181	37p	NKT275	23p	TD716	60p	2N4289	15p
BF184	25p	NKT279A	12p	TIP31A	62p	2N4871	40p
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BFX13	25p	NKT402	77p	ZTX303	18p	40250	55p
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BFX85	34p	NKT405	79p	ZTX320	30p	40312	48p
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BFY53	16p	NKT613F	30p	IN34A	20p	40408	51p
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BSX21	37p	NKT713	29p	IN87A	23p	40601	55p
BSY27	20p	NKT717	44p	IN914	7p	40602	40p
BSY29	25p	NKT734	26p	IN4001	7p	40603	49p
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SC146D	10 Amp 400 PIV Plastic Flat-pack	£1·75
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(Available vertical or horizontal mounting.) Usual values 100 ohms to 5 Meg.

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Mfd.	*Volt. Wkg.*	
2·5	16	8p
10	16	6p
20	16	6p
40	16	6p
80	16	6p
1·6	25	8p
6·4	25	6p
12·5	25	6p
25	25	6p
50	25	6p
80	25	6p
1	40	8p
4	40	6p
8	40	6p
16	40	6p
32	40	6p
50	40	6p

Mullard Metallised Polyester 250v. C280 series

Mfd.	
0·01	3p
0·015	3p
0·022	3p
0·033	3p
0·047	4p
0·068	4p
0·1	4p
0·15	5p
0·22	5p
0·33	7p
0·47	8p
0·68	11p
1·0	14p
1·5	20p
2·2	24p

Mullard Electrolytic C437 series

Mfd.	*Volt. Wkg.*	
250	16	9p
400	16	12p
640	16	15p
1,000	16	18p
160	25	9p
250	25	12p
400	25	15p
640	25	18p
100	40	9p
160	40	12p
250	40	15p
400	40	18p

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63 volt working. Range 1·8pf to 220pf (usual pref. values).
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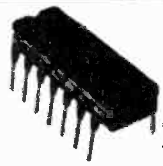

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SN7400N	Quad 2-input NAND gate	32p	27p	22p
SN7401N	Quad 2-input NAND gate open collector	32p	27p	22p
SN7402N	Quad 2-input NOR gate	32p	27p	22p
SN7403N	Quad 2-input NOR gate open collector	35p	30p	25p
SN7404N	Hex Inverter	32p	27p	22p
SN7410N	Triple 3-input NAND gate	32p	27p	22p
SN7413N	Schmidt Trigger	45p	10p	35p
SN7420N	Dual 4-input NAND gate	32p	27p	22p
SN7430N	8-input NAND gate	32p	27p	22p
SN7440N	Dual 4-input NAND Buffer	32p	27p	22p
SN7442N	BCD to decimal decoder TTL output	£1·12	£1·00	88p
SN7450N	Expandable Dual 2-wide 2-input AND-OR-INVERT gate	32p	27p	22p
SN7453N	Expandable 4-wide 2-input AND-OR-INVERT gate	32p	27p	22p
SN7460N	Dual 4-input expander	32p	27p	22p
SN7470N	J-K Flip-flop	45p	40p	35p
SN7472N	J-K master-slave flip-fllop	45p	40p	35p
SN7473N	Dual J-K master-slave flip-flop	50p	45p	43p
SN7474N	Dual D-type edge-triggered flip-flop	50p	45p	43p
SN7475N	Quadruple bistable latch	65p	60p	55p
SN7476N	Dual J-K master-slave flip-flop with preset and clear	55p	50p	47p
SN7483N	Four-bit binary full-adder	£1·30	£1·20	£1·10
SN7490N	Decade counter	£1·12	£1·00	87p
SN7492N	Divide-by-12 counter	£1·12	£1·00	87p
SN7493N	Four-bit binary counter	£1·12	£1·00	87p
SN74141N	BCD to decimal decoder/driver (replaces the obsolete SN7441AN)	£1·45	£1·30	£1·15

MIX PRICES: Devices may be mixed to qualify for quantity price. Larger quantities—prices on application.

LINEAR AND DIGITAL ICs

R.C.A.

CA3004	£1·80
CA3005	£1·20
CA3011	75p
CA3013	£1·05
CA3014	£1·25
CA3018	85p
CA3020	£1·30
CA3028A	75p
CA3035	£1·25
CA3043	£1·40
CA3044	£1·20
CA3046	75p
CA3047	£1·40
CA3048	£2·05
CA3049	£1·60
CA3052	£1·65

BARGAIN OP-AMPS!!
LM709C .. 60p (DIL high gain op-amp)
LM741CN .. 95p equiv. SN72741P)

PC1006/1 Multimeter Sensitiser Packaged circuit KIT includes all Accessories. £7·55

Fairchild	1-11	12-24	25+
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

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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)

IR

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.

ZENNER DIODES

400mW 10% GLASS CASE TEXAS Manufacture

1S2036	3·6 volt	1S2062	6·2 volt	1S2120	12 volt
1S2039	3·9 volt	1S2068	6·8 volt	1S2160	16 volt
1S2043	4·3 volt	1S2075	7·5 volt	1S2180	18 volt
1S2047	4·7 volt	1S2082	8·2 volt	1S2270	27 volt
1S2056	5·6 volt	1S2100	10 volt	1S2300	30 volt
		1S2110	11 volt		

PRICES: 1-24, 15p; 25-99, 11p; 100+, 9p

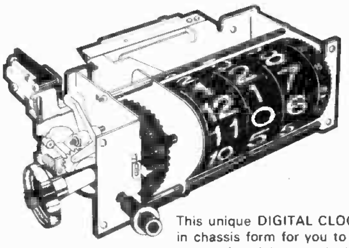
ENCAPSULATED BRIDGES

Type No.	Current	RMS Volts	Price
W005	1 Amp	50	50p
W06	1 Amp	600	65p

Laskys

EXCLUSIVE

DIGITAL CLOCK MECHANISM

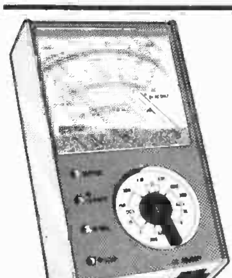


- **Made especially for Lasky's by famous maker**
- **Mains operation**
- **12 hour alarm**
- **Auto "sleep" switch**
- **Hours, minutes and seconds read-off**
- **Forward and backward time adjustment**
- **Silent operation synchronous motor**
- **Shock and vibration proof**
- **Built in alarm buzzer**

This unique DIGITAL CLOCK is now available **EXCLUSIVELY FROM LASKY'S** in chassis form for you to mount in any housing that you choose. All settings are achieved by two dual-concentric controls at the front including: ON-OFF-AUTO and AUTO ALARM. "sleep" switch, 10 minute division "click" set alarm (up to 12 hour delay), time adjustment. Ultra simple mechanism and high quality manufacture guarantee reliable operation and long life.
The sleep switch will automatically turn off any appliance—radio, TV, light, etc., at any pre-set time up to 60 min. and in conjunction with the AUTO setting will switch on the appliance again next morning.
The clock measures $4\frac{3}{4}$W x $1\frac{3}{4}$H x $3\frac{3}{8}$D (overall from front of drum to back of switch). SPEC: 210/240V AC, 50Hz operation; switch rating 250V, 3A. Complete with instructions. **HUNDREDS OF APPLICATIONS.**
COMPLETE WITH KNOBS

LASKY'S PRICE £6.95 P & P 18p *SPECIAL QUOTATIONS FOR QUANTITIES*

LASKY'S TM5

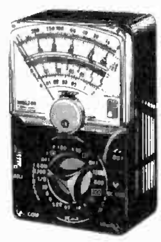


Another new look pocket multimeter from Lasky's providing top quality and value. The "slimline" impact resistant case—size $4\frac{3}{4}$in. x $2\frac{7}{8}$in. x $1\frac{1}{8}$in., fitted with extra large $2\frac{7}{8}$in. square meter. Readability is superior on all low ranges; making this an excellent instrument for servicing transistorised equipment. Recessed click stop selection switch. Ohms zero adjustment. Buff finish with crystal clear meter cover.

- **DC/V: 3-15-150-300-1,200 at 5K ohms/V**
- **AC/V: 6-30-300-600 at 2.5K ohms/V**
- **DC Current 0-300µA 0-300mA**
- **Resistance: 0-10K ohms, 0-1M ohms**
- **Decibels: –10dB to 16dP**
- **Complete with test leads, battery and instructions**

LASKY'S PRICE £2.95 P & P 13p

TMK 200 METER KIT

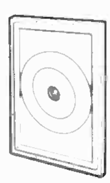


This meter kit by TMK offers the unique opportunity of building a really first-class precision multimeter at a worthwhile saving in cost. The cabinet is supplied with the meter scale and movement mounted in position: the Model 200 also has the range selector in position. The highest quality components and 1% tolerance resistors are used throughout. Supplied complete with full constructional, circuit and operating instructions.
20,000 O.P.V. Multimeter. Features 24 measurement ranges with mirror scale. Large 3 x 2in. meter. Full scale accuracy. DCV and current: ±2% ACV: ±3%, resistance: ±3%. Special 0.6V DC range for transistor circuit measurements.

SPECIFICATION
●DCV: 0-0.6-6-30-120-600-1,200V at 20K/OPV. ●ACV: 0-6-30-120-600-1,200V at 10K/OPV. ●DC current: 0-0.6-6-600mA. ●Resistance: 0-10K-100K-1M-10M/ohms (58-580-5.8K-58K at mid-scale). ●Capacitance: 0.002-0.2µF (AC 6V range). ●Decibels: –20 to +63dB ●Output: 0.05µF blocking capacitor. Uses two 1.5V (U7 type) batteries. Black bakelite cabinet—Size $5\frac{1}{4}$ x $3\frac{5}{8}$ x $1\frac{7}{8}$in. Complete with test leads.

KIT PRICE ONLY £4.59 P & P 13p

POLY-PLANAR WAFER TYPE ELECTRO DYNAMIC

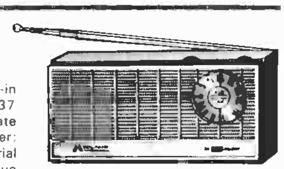


This revolutionary idea in sound reproduction functions basically in a similar manner to that of the cone loudspeaker system. In place of the conventional paper cone is a flat, rigid plastic panel which is only a fraction of the depth of the equivalent cone structure. To obtain the desired acoustic properties the panel incorporates a combination of circular grooves. With a flat rectangular panel a larger piston area is also available thereby reducing the size compared with an equivalent cone loudspeaker
Power capacity: 20 watts (peak). Frequency range: 40Hz-20,000Hz. Input impedance: 8 ohms. Size: $11\frac{3}{4}$in. x $14\frac{11}{16}$in. x $1\frac{7}{16}$in. Weight: 9oz.

LASKY'S PRICE £5.75 each **£11** for 2
P & P 20p each

ONLY $1\frac{7}{16}$in. THICK

MIDLAND 10-406 AM/AIRCRAFT RADIO



The first pocket size receiver of its type allowing you to tune-in to the entire air communications band covered by 108–137 MHz in addition to full AM medium wave. Intermediate frequencies: AM 455 KHz; VHF 10.7 mc/s. Output power: 200mV $2\frac{1}{2}$in. P.D. 8 ohm speaker. A built in ferrite rod aerial is provided or AM reception. The 10-406 is finished in blue with chrome trim, chrome telescopic antenna. Size' $6\frac{5}{8}$ x $3\frac{5}{8}$ x $1\frac{7}{8}$in. complete with batteries, magnetic earphone instructions and circuit

LASKY'S PRICE £8.37 P & P 13p

207 EDGWARE ROAD, LONDON, W.2.
33 TOTTENHAM CT. RD, LONDON, W1P 9RB.
109 FLEET STREET, LONDON, E.C.4.
152/3 FLEET STREET, LONDON, E.C.4.
HIGH FIDELITY AUDIO CENTRES
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118 EDGWARE ROAD, LONDON, W.2.
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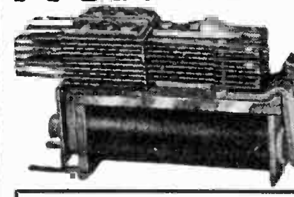
Wilkinsons EST. 1921



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"VISCONOL-CATHODRAY" CONDENSERS. .002 mfd. 15 kV, **45p**; .02 mfd. 10 kV, **50p**; .025 mfd. 2.5 kV, **25p**; .05 mfd. 5 kV, **45p**; 0.1 mfd. 4 kV, **45p**; 6 kV, **90p**; 0.5 mfd. 2.5 kV, **90p**; 1 mfd. 2 kV, **90p**. Post 10p on each.
From Stock: P.O. Standard Equipment Racks. 6 ft. U channel sides, drilled for19 in. panels. Heavy Angle Base **£9.50 each.** Cge. £1.
GEARED MOTORS. 1 r.p.m. or 3 r.p.m. 4 watts very powerful, reversible 24v. A.C. **£1.75**, post 15p, can be operated from 230 v. with our £1 Transformer. Post 25p.
FREQUENCY METERS. 45/55 c.p.s. 230 v. A.C. 6 in. dia. flush round **£10.** Post 50p.
ROOM THERMOSTAT. Adjustable between 45 and 75 deg. Fahr., 250 v. 10 amp A.C. Ideal for greenhouses, etc., **£1.75**, post 25p.
SUBMINIATURE MICRO SWITCHES HONEYWELL. 115M1-TN13. S.P.D.T. Size .781 in. x .250 in. x .356 in. **35p** each. Full details on request. Quantities available at low prices.

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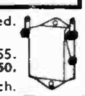

MINIATURE BUZZERS, 12 volts, with tone adjuster **40p** each as illustrated. Quantity Rates on request.
LEDEX ROTARY SOLENOIDS AND CIRCUIT SELECTORS, size 55. 4 pole 11 way and off **£5.50**, 24 pole 11 way and off **£10.50**, 54 pole On/Off **£7.50.**
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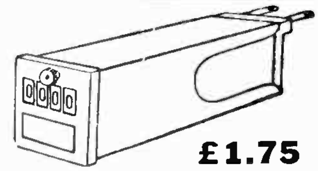
VEEDER-ROOT MAGNETIC COUNTERS WITH ZERO RESET 800 COUNTS PER MINUTE. 6 Figures. General Purpose Type. 110 v. A.C. £3.25 post 15p.

HIGH SPEED COUNTERS



$3\frac{1}{2}$ in. x 1 in. 10 counts per second, with 4 figures. The following D.C. voltages are available, 6 v., 12 v., 24 v., 50 v., or 100 v.
Also supplied with auxiliary contacts, normally open 40p extra.

£1.75

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Phone: 01-684 0236 **Grams: WILCO CROYDON**

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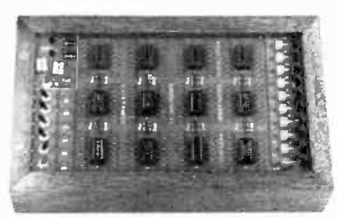

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Complete Stereo System £41

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 (including teak veneer base and transparent cover) with diamond cartridge or 2025 TC and the very successful DUO type 2 speakers.

Measuring 17½" × 10¾" × 6¾" the Duo type 2 speakers are teak finished with matching Vynair grills. They incorporate a 3 ohm, 13 × 8" drive unit and Parasitic tweeter. Max. power handling 10 watts, Price 12 gns per pair plus p&p £1.10.0.

WITH MK II amplifier and magnetic cartridge £45 plus £2.10 P & P.

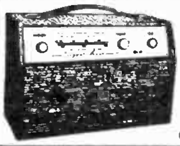
The Viscount F.E.T. Mk I £14.5s. plus 7/6 P. & P.

High fidelity transistor stereo amplifier employing field effect transistors. With this feature & accompanying guaranteed specifications below, the Viscount F.E.T. vastly surpasses amplifiers costing far more. *Size: 12½" × 6" × 2¾" in simulated teak case.* **BUILT & TESTED.**

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.

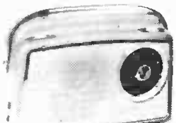
Overload Factor: Better than 26 dB.
Signal to noise ratio: 70 dB on all inputs (with vol. max).
Controls: 6 position selector switch (3 pos. stereo & 3 pos. mono). Separate Vol. controls for left & right channels. Bass ± 14 dB @ 60 Hz. Treble (with D.P.S. on/off) ± 12 dB @ 10 kHz. Tape Recording output sockets on each channel.

Mk II (MAG. P.U.) £15.15.0 *plus 10/- 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: 9/6 extra.
Price **£5.5.0** plus 7/6 P. & P.
Circuit 2/6 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: 9/6 extra.
Price **£5.5.0** plus 7/6 P. & P.
Circuit 2/6 FREE WITH PARTS

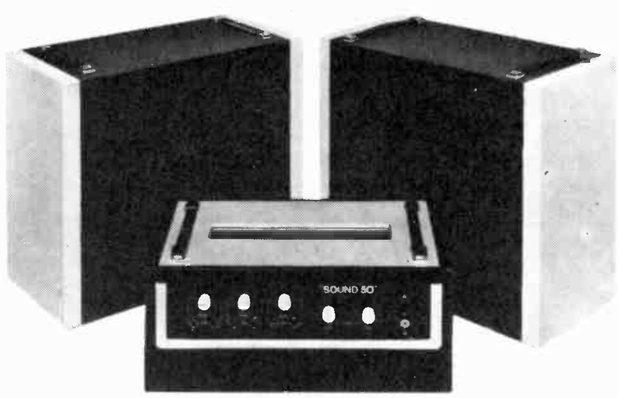
SOUND 50

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.

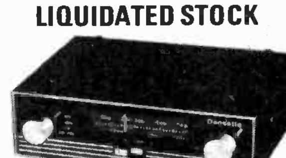
To protect the output valves, the incorporated fail safe circuit will enable the amplifier to be used at half power. *SPEAKERS:* Size 20" x 20" x 10" incorporating Baker's 12" heavy duty 25 watt high flux, quality loudspeaker with cast frame. Cabinets attractively finished in two tone colour scheme—Black and grey.



COMPLETE SYSTEM **£45** plus 80/- P & P

Amplifier £28.10.0 + 20/- P & P.
Speakers ea. £12.10.0 + 30/- P & P.

LIQUIDATED STOCK



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SET OF PARTS
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Plus 7/6 P. & P.

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14	1·25
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20	1·30
20A	1·60
21	1·60
22	1·30
23	1·30
26	1·00
28A	0·75
28B	1·05
29	0·90
29A	1·65
30	1·40
35	1·25
36	0·75
39	0·85
41	1·10
42	1·10
43	1·40
44	1·20
45	1·25
46	0·75
47	1·40
48	2·05
49	1·60
50	1·85
51	1·35
52	1·65
53	0·50
54	1·10
55	2·40
59	1·65
64	1·20

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MC788P	0·82½	—	0·69
MC789P	0·66	—	0·55½
MC790P	1·24	—	1·03½
MC792P	0·66	—	0·55½
MC799P	0·66	—	0·55
MC1303L	2·70	—	2·25
MC1304P	3·60	—	3·00
MC838P	5·49	—	4·57½
MC1552G	4·61	—	3·84
MC1435L	3·45	—	2·87½
MC1709CG	0·95	—	0·82½

Data Sheets £0·12½ extra.

FAIRCHILD	1-5	6-11	12+	50+
L900	0·42½	0·40	0·37½	0·34
L914	0·42½	0·40	0·37½	0·34
L923	0·62½	0·59	0·55	—
702C	1·12½	1·05	0·97½	0·85
709C	0·75	0·67½	0·65	0·62½
710C	0·75	0·67½	0·62½	0·55
711C	0·75	0·67½	0·62½	0·55
716C	2·80	2·50	—	—
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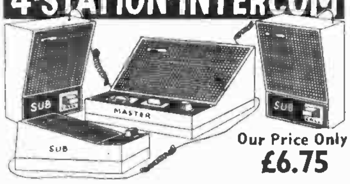

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G2/5	10/6V	9d	H2/6A	24/275V	1/-	H5/3A	500/25V	2/-	H7/2A	20/6.4V	9d	H7/11	64/25V	1/6
G3/7	100/25V	2/-	H2/8	32/150V	1/-	H5/6A	40/3V	6d	H7/3	25/12V	9d	H7/13	75/15V	1/6
G3/14	100/180V	2/-	H2/9A	2/150V	1/-	H5/7	30/6V	6d	H7/4	25/25V	1/6	H7/14	100/4V	1/-
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H1/1	1/6V	6d	H3/7A	500/12V	1/6	H5/14	5/6V	6d	H7/6	50/3V	6d	H8/7	12/25V	1/6
H1/3	4/4V	6d	H3/8	750/12V	1/6	H6/1	100/50V	1/6	H7/6A	26/50V	1/6	H8/7A	15/15V	1/6
H1/4	6/6V	6d	H3/10A	30/10V	6d	H6/6	200/3V	6d	H7/7	50/12V	1/6	H8/10	2/275V	1/-
H1/7	20/6V	6d	H3/12	16/50 (REV)	2/-	H6/7	200/16V	1/6	H7/7A	50/10V	1/-	H8/11A	250/12V	1/6
H1/9	60/6V	6d	H4/1	20/4/275V	1/6	H6/13	500/3V	9d	H7/8	50/15V	1/6	H8/13	100/25V	2/-

CAN TYPES

REF. NO.			REF. NO.			REF. NO.			REF. NO.			REF. NO.		
G1/8A	16/35V	1/-	G3/13A	2,000/30V	5/-	G5/12	100/20/10/350/20/50V	2/6	H1/10A	10/10/350V	1/6	H4/3A	500/50V	1/6
G1/10	32/275V	1/-	G4/1	300/700/320V	7/6	G5/13	40/100/350V	2/6	H1/12	200/275V	2/-	H4/4	400/6 (REV)	2/-
G1/14	16/275V	1/-	G4/3	250/150V	2/-	G5/13A	40/40/40/40/350V	2/6	H1/15	100/200/60/275V	5/-	H4/5	32/32/350V	2/-
G2/1	6,000/30V	7/6	G4/4	50/50/200V	2/-	G6/1	12,000/15V	15/-	H2/4	50/80/300V	2/-	H4/6	64/275V	2/-
G2/5	125/200V (REV)	5/-	G4/5A	60/350V	1/-	G6/2A	2,500/50V	7/6	H2/5	100/100/100/275V	2/6	H4/8	8/8/8/275V	2/6
G2/11	100/350V	2/-	G4/6	60/200/175V	2/6	G6/3A	2,000/15V	3/-	H2/6	50/275V	1/6	H4/9	500/6V	1/-
G2/12	100/150V	2/-	G4/7	40/40/275V	1/6	G6/4A	1,000/25V	2/6	H2/9	16/16/450V	2/-	H4/10	10/10/425V	2/6
G2/14	20/10/10/450V	2/-	G4/7A	40/40/450V	2/6	G6/5	1,000/1,500/25V	7/6	H2/10	1,000/100V	7/6	H4/11	75/400/16/275V	7/6
G3/1	60/100/350V	3/-	G4/11	2,000/25V	3/-	G6/5A	1,600/70V	7/6	H2/11	32/32/250V	1/6	H5/2	64/32/8/275V	2/-
G3/2	200/200/350V	6/-	G4/12	150/30V	1/-	G6/6	1,000/60V	6/-	H2/12	50/50/150V	1/6	H5/3	500/25V (REV)	2/6
G3/2A	200/200/100/350V	7/6	G4/13	100/200/16/275V	6/-	G6/8	200/250V	3/-	H3/4	1,000/50V	6/-	H5/9	100/100/150V	2/-
G3/4	650/300V	7/6	G5/3	35,000/15V	15/-	G6/9	60/200/300V	5/-	H3/4A	3,000/25V	3/-	H5/9	50/50/50/350V	3/-
G3/6A	50/50/350V	2/-	G5/5	400/275V	3/-	G6/11	40/350V	1/-	H3/6	2,500/9V	2/6	H5/13	32/32/8/300V	2/-
G3/9	100/200/250V	6/-	G5/6	60/100/275V	2/6	G6/12	250/25V	2/-	H3/6A	5,000/18V	4/-	H6/4	150/150V	1/6
G3/10	40/20/10/10/350V	2/-	G5/7	100/400/300V	7/6	H5/4	325/25V	1/6	H3/9	100/275V	2/-	H6/14	1,000/20V	2/-
G3/10A	200/350V	2/-	G5/7A	45,000/12V	15/-	H1/5	2,000/18V	3/-	H3/11	150/200V	2/-	H8/12	3,000/6V	3/-
G3/12	100/200/16/16/300V	5/-	G5/10	100/100/50/350V	3/-	H1/6	125/200V	2/-	H3/13	16/16/375V	2/-	H8/13	6,000/6V	4/-
G3/13	64/275V	2/-	G5/11	100/200/25V	2/-				H4/3	500/12V	1/6	H8/13A	100/25/200/25V	1/6

TAG ENDS

REF. NO.			REF. NO.			REF. NO.			REF. NO.			REF. NO.		
G1/4	4/150V	1/-	G2/4	40/300V	1/6	G4/9	8/8/350V	2/-	H1/9A	50/150V	1/-	H4/12	500/50V	2/-
G1/5	8/275V	1/-	G2/13	100/50V	1/-	G4/10	350/25V	2/-	H3/5	250/150V	2/-	H5/6	250/50V	2/-
G1/15A	32/350V	1/-	G4/3A	200/25V	1/6	G6/1A	3,000/15V	3/-	H4/2	250/25V	1/6			
G1/7	16/16/275V	2/-	G4/5	16/300V	1/-	G6/12	1,000/12V	2/-	H4/7A	32/32/275V	2/6			

PRINTED CIRCUIT. CAN TYPE

REF. NO.			REF. NO.			REF. NO.			REF. NO.			REF. NO.		
G1/6	16/32/450V	2/-	G3/12	100/200/16/16/300V	5/-	G5/14	8/8275V	1/6	H3/9	100/275V	2/-	H5/2	64/32/8/275V	2/-
G1/8A	16/350V	1/-	G3/13	64/275V	2/-	G6/4A	1,000/25V	2/6	H3/10	100/250V	2/-	H5/3	500/25V (REV)	2/6
G1/10	32/275V	1/-	G4/3	250/150V	2/-	G6/11	40/350V	1/-	H3/13A	16/16/275V	1/6	H5/8	32/32/275V	1/6
G1/14	16/275V	1/-	G4/4	50/50/200V	2/-	G6/12	250/25V	2/-	H4/3A	500/50V	1/6	H5/9	100/100/150V	2/-
G2/10	100/100/350V	3/-	G4/8	40/40/450V	2/-	H1/10A	10/10/350V	1/6	H4/4	400/6 (REV)	2/-	H5/13	32/32/8/300V	2/-
G2/12	100/150V	2/-	G5/6	60/100/275V	2/6	H1/12	200/275V	2/-	H4/6	64/275V	2/-	H5/9	50/50/50/350V	3/-
G2/14	20/10/10/450V	2/-	G5/8A	100/65/250V	2/-	H1/13	250/150V	2/-	H4/7	32/32/350V	2/-	H6/4	150/150V	1/6
G3/1	60/100/350V	3/-	G5/10	100/100/50/350V	3/-	H2/4	50/80/300V	2/-	H4/8	8/8/8/275V	2/6	H6/14	1,000/20V	2/-
G3/6	100/250V	2/-	G5/11	100/200/25V	2/-	H2/5	100/100/100/275V	2/6	H4/10	10/10/425V	2/6	H8/11	250/25V	2/-
G3/6A	50/50/350V	2/-	G5/12	100/20/10/350/20/50V	2/6	H2/6	50/275V	1/6	H4/13	400/250V	3/-	H8/12	3,000/6V	3/-
G3/8A	100/25V, 100/12V	2/-	G5/13	40/100/350V	2/6	H2/11	32/32/250V	1/6	H5/1	150/200V	2/-	H8/13A	100/25/200/25V	1/6
G3/11	100/350V	2/6	G5/13A	40/40/40/40/350V	2/6	H2/12	50/50/150V	1/6				H3/11	150/200V	2/-

PRINTED CIRCUIT TYPE. WIRE LEADS.

REF. NO.			REF. NO.			REF. NO.			REF. NO.			REF. NO.		
G1/9	16/275V	1/6	H3/15	350/12V	1/6	H6/10	300/9V	1/-	H7/12	65/15V	1/6	H8/4	5/15V	1/-
H2/7	10/25V	1/-	H5/1	150/30V	1/6	H6/11	300/15V	1/6	H7/15	100/16	1/6	H8/8	20/9	1/-
H2/12A	350/12V	1/-	H5/14A	1,100/10V	2/-	H6/14A	900/15V	2/-	H8/1	1/350V	1/-	H8/9	40/15	1/6
H2/15	12.5/40V	1/6	H6/5	150/25V	1/6									

£5 WORTH OF COMPONENTS FREE! ! ! !
Thinking of learning another language? If so, apply to us for details of Linguaphone courses. We will GIVE you £5 worth of components of your selection when you purchase a language course! ! ! ! !

SCREENED LEADS. Specially designed to fill the demand for the most popular types—all leads consist of 9 ft. screened lead—except SL 11 which has 10 ft. co-axial cable.

SL 1 Phono plug to Phono plug	5/3	SL 11 Car Aerial plug to Car Aerial socket	7/6
SL 2 Standard Jack Plug to Standard Jack Plug	12/-	SL 12 3-pin DIN to 3-pin DIN	9/-
SL 3 Standard Jack Plug to Phono Plug	9/-	SL 13 Co-ax plug to 3.5mm Jack Plug	7/6
SL 4 3-pin DIN to Phono Plug	7/6	SL 14 3-pin DIN to 3.5mm Jack Plug	8/3
SL 5 Phono Plug to Wander Plugs	9/-	SL 15 Standard Jack Plug to 3-pin DIN	10/6
SL 6 Standard Jack Plug to Wander Plugs	9/-	SL 16 3.5mm Jack to Wander Plugs	6/9
SL 7 3-pin DIN to Wander Plugs	6/9	SL 17 3.5mm Jack to Standard Jack	10/6
SL 8 Phono Plug to Phono Coupler	9/-	SL 18 3.5mm Jack to 3.5mm Jack	8/3
SL 9 3.5mm Jack to Phono Plug	7/6	SL 19 3-pin DIN to 5-pin DIN 'A'	9/-
SL 10 Co-ax Plug to Co-ax Plug	6/9	SL 20 3-pin DIN to Soldered ends	6/-
		SL 21 5-pin DIN 'B' to 2 Phono	9/-

MULLARD POLYESTER CONDENSERS
1,000 pf., 1,200 pf., 1,800 pf., 2,200 pf., 400 volts, **3d.** each. 25 per cent discount 100 any type. .15uf., .22uf., .27uf., 160 volts **6d.** each. 25 per cent discount 100 any one type.

RESISTORS
¼ and ½ watt. Most values in stock. **10/-** per 100 of any one value. **2/-** dozen. **3d.** singles. MAINS DROPPER TYPE. Hundreds on values from .7 ohm upwards. 1 watt to 50 watts. A large percentage of these are multi-tapped droppers for radio/television. Owing to the huge variety these can only be offered 'assorted'. **10/-** per dozen.

SILVER MICA/ CERAMIC/ POLYSTYRENE CONDENSERS
Large range in stock. 15/- per 100 of any one value. 3/- per dozen. Singles 6d. each

RECORDING TAPE BARGAIN! The very best British Made low-noise, 'high-quality Tape! 5in. Standard, **7/6d.** Long-play **9/-.** 5¾in. Standard **9/-.** Long-play **12/-** 7in. Standard **12/-.** Long-play **16/3.** We are getting a fantastic number of repeat orders for this tape. Might we suggest that you order now whilst we still have a good stock available?

RECORD PLAYER AMPLIFIERS
1 watt, 8 ohm output. All transistor, complete with screened input lead, volume control and speaker leads. This excellent unit has built-in rectifier and smoothing components enabling it to be used direct from any 6 to 9 volt bell transformer. Perfect for baby alarm or inter-com. Few only left. Cannot be repeated at **30/-** each.

TRANSISTOR RADIOS
Once again we have a supply of these excellent radios which offer superb quality sound and excellent sensitivity. They are packed in a colourful presentation box complete with battery, earpiece and carrying case. Each one is guaranteed. You would expect to pay at least £5—but our price due to a bulk purchase is only **37/6d.** Many of our customers have made a considerable profit by buying these radios and re-selling them to friends!

RECORD PLAYER CARTRIDGES. Well below normal shop price!
ACOS GP 67/2 **15/-.** (Mono). ACOS GP 91/3 **20/-.** (Compatible) ACOS GP 93/1 **25/-** (Stereo) ACOS GP 94/- **30/-.** (Stereo, Ceramic). ACOS GP 93/- DIAMOND **32/6.** ACOS 94/1 DIAMOND **37/6.**

TRANSISTORISED FLUORESCENT LIGHTS. 12 volt. All with Reverse Polarity protection. 8 watt **59/6.** 15 watt **79/6.** 13 watt **99/6.** Postage 3/- per fitting. These can be sent on approval against full payment. Thousands already sold.

MULLARD 'UNILEX' AMPLIFIERS
In our opinion these units are the best value for money ever offered. A complete stereo unit consisting of Control unit, Pre-amplifier, Two Main Amplifiers and Power Pack complete and ready for use—NO extra components to buy—yours for **£15.** (Normal retail price is £16.10s.)
GARRARD SP 25 UNITS also offered at a discount. Our price only **£12.10s.** Postage 9/-.

SINCLAIR AMPLIFIERS AND SPEAKERS. Complete range in stock. All at 10 per cent discount on list.

VEROBOARD

2½in. × 1in. × .15	1/3	5in. × 3¾in. × .15	5/6	3¾in. × 3¾in. × .1	4/9
3¾in. × 2½in. × .15	3/3	17in. × 2½in. × .15	11/-	5in. × 2½in. × .1	4/7
3¾in. × 3¾in. × .15	3/11	17in. × 3¾in. × .15	14/8	5in. × 3¾in. × .1	5/6
5in. × 2½in. × .15	3/11	3¾in. × 2½in. × .1	4/2		

Spot Face Cutter **7/6.** Pin Insert Tool **9/6.** Terminal Pins (.1 or .15) **3/6** for 36.
Special offer pack consisting of 5 2½in. × 1in. boards and Spot Face Cutter 10/-

VOLUME CONTROLS
DOUBLE POTS. Most with concentric Spindles.

500k log	+ 50k lin.	+ Switch	3/-	10k log	+ 10k log	+ Switch	4/6
50k S/log	+ 1m log	+ Switch	3/-	1M lin.	+ 1M lin.	no Switch	2/6
100k lin.	+ 100k log	+ Switch	3/-	500k lin.	+ 1M lin.	no Switch	2/6
100k log	+ 100k log	+ Switch	3/-	1M lin.	+ 2.5M lin.	no Switch	2/6
250k log	+ 500k log	+ Switch	3/-	500k lin.	+ 500k log	no Switch	2/6
250k log	+ 100k lin.	+ Switch	3/-	100k log	+ 100k log	no Switch	2/6
1M log	+ 1500 ohm lin.	+ Sw.	3/-	2M log	+ 2M log	no Switch	3/6
1M log	+ 100k lin.	+ Switch	3/-				

SPECIAL 10/- PACKS. ORDER 10 PACKS AND WE WILL INCLUDE AN EXTRA ONE FREE ! ! ! !

RESISTORS. ¼/½ watt assorted	100	10/-	**TRANSISTORS**		
Wire-wound 1 to 3 watt	20	10/-	P.N.P. Untested but mainly O.K.	50	10/-
5 to 7 watt	15	10/-	N.P.N. Untested but mainly O.K.	50	10/-
10 watts	10	10/-	OCP 71 equivalent	5	10/-
Multi-tapped	12	10/-	Light-sensitive Diodes	10	10/-
PAPER CONDENSERS TV types	50	10/-	*(These produce up to 1ma from light)*		
Miniature	100	10/-	OC 44 Mullard 1st grade	4	10/-
ELECTROLYTIC CONDENSERS			OC 45 Mullard Boxed	4	10/-
Suitable for Mains Radio/TV	10	10/-	2G378 Output. Marked	4	10/-
Transistor types	20	10/-	2G371 Driver. Marked	4	10/-
Mixed (both types)	15	10/-	ASY 22. Marked	5	10/-
POLYSTYRENE CONDENSERS	100	10/-	BY 127 Rectifiers	4	10/-
MULLARD POLYESTER COND.	50	10/-	1N4007 Rectifiers (1200V peak)	4	10/-
SILVER MICA	100	10/-	STC 3/4 Rectifiers	6	10/-
WIRE WOUND 3-Watt SLIDERS	15	10/-	DIODES (0A 81 & 0A 91)	40	10/-
VOLUME CONTROLS. Assorted	5	10/-	WIRE. Solid Core. Insulated	100yds.	10/-
NUTS AND BOLTS. Mixed length/type			Stranded ditto	50yds.	10/-
8 B.A.	100	10/-	SOLAR CELLS. Large Selenium	2	10/-
6 B.A.	100	10/-	Small	3	10/-
4 B.A.	100	10/-	(6 cells will power a Micromatic radio)		
2 B.A.	100	10/-	CO-AXIAL CABLE.		
METAL SPEAKER GRILLS			Semi Air-spaced	15yds.	10/-
7½in. × 3½in.	6	10/-	CRYSTAL TAPE RECORDER MIKES	1	10/-
EARPIECES. Magnetic No Plug	6	10/-			
2.5mm Plug	4	10/-	CRYSTAL EARPIECES 3.5mm Plug	2	10/-
3.5mm Plug	4	10/-	TRANSISTORISED Signal Injector	1	10/-
500 MICRO-AMP LEVEL METERS	1	10/-	TRANSISTORISED Signal Tracer	1	10/-
VERO-BOARD. TRIAL PACK 5 BOARDS + CUTTER		10/-	TRANSISTORISED CAR REV. COUNTER KIT (Needs 1ma. meter as indicator)	1	10/-

G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 2/-.

SERVICE TRADING CO

Postage and Carriage shown below are inland only. For Overseas please ask for quotation. We do not issue a catalogue or list.

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.


50 AMP


1 AMP

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
0-260 v. at 2·5 amps	£6·75
0-260 v. at 5 amps.	£9·75
0-260 v. at 10 amps.	£18·50
0-260 v. at 15 amps.	£25·00
0-260 v. at 20 amps.	£37·00
0-260 v. at 25 amps.	£49·00
0-260 v. at 37·5 amps.	£72·00
0-260 v. at 50 amps.	£92·00

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. 38p.

RING TRANSFORMER

Functional Versatile Educational

This multi-purpose Auto Transformer, with large centre aperture, can be used as a Double wound current Transformer, Auto Transformer, H.T. or L.T. Transformer, by simply hand winding the required number of turns through the centre opening. E.g. Using the RT.100 V.A. Model the output could be wound to give 8V @ 12½Amp., 4V. @ 25Amp. or 2V. @ 50Amp., etc.

Price: RT.100VA 3.18 turns per volt, £2·25+17p p. and p.
RT.300VA 2.27 turns per volt, £4·20+28p p. and p.
RT.1KVA 1.82 turns per volt, £6.50+33p p. and p.
RT.2KVA 1.5 turns per volt, £10·50+48p p. and p.
RT.2KVA 1.5 turns per volt, £14·00+50p 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	30p
3	30, 40, 50 v. at 5 amps.	£6·88	33p
4	10, 17, 18 v. at 10 amps.	£4·95	22p
5	6, 12 v. at 20 amps.	£6·43	33p
6	17, 18, 20 v. at 20 amps.	£7·28	33p
7	6, 12, 20 v. at 20 amps.	£6·88	38p
8	24 v. at 10 amps.	£5·23	28p
9	4, 6, 24, 32 v. at 12 amps.	£7·15	33p

AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3·63 each. P. & P. 23p. 500 watt type £5·13 each. P. & P. 33p. 1,000 watt type £7·13 each. P. & P. 38p.

LIGHT SENSITIVE SWITCHES

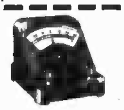
Kit of parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. **Price £1·25**, plus 13p P. & P. **ORP. 12 and Circuit 63p post paid.**

220/240 A.C. MAINS MODEL incorporates mains transformer rectifier and special relay with 1 make, 1 break, H.D. contacts. Price inc. circuit £2·75, plus 13p P. & P.

INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 10p each. Post paid.

GALVANOMETER



300-0-300 microamp. Calibrated 30-0-30. Mounted in sloping fron. case £2·50. P. & P. 18p. **D.C. Voltmeter** 0-3 V and 0-15 V, £2·00 plus 18p P. & P. **D.C. Ammeter.** 0-6 amp. and 0-3 amp. £2·00, 18p P.&P. The set of 3 matching instruments £6·00, P. & P. 33p.

SANWA MULTI RANGE TESTERS

LATEST TYPE
NEW MODEL U-50DN MULTI TESTER, 20,000 O.P.V. MIRROR SCALED WITH OVERLOAD PROTECTION. Ranges: D.C. volts: 100mV., 0.5 v., 5 v., 250 v., 1,000 v. A.C. volts. 2.5 v., 10 v., 50 v., 250 v., 1,000 v. D.C. current: 50μA., 0.5 mA., 5 mA., 50 mA., 250 mA. Size: 5¼ × 3⅛ × 1⅝ in. Complete with batteries and test prods. **£8.00** Post paid

TEN OTHER MODELS FROM STOCK. LEAFLET ON REQUEST.

'AVO' MODEL 48A

Ex-Admiralty in good condition with instructions, leads, plus D.C. Shunts for 120 Amp and 480 Amp. A.C. Transformer for 60 Amp. and 240 Amp. Multiplier for 3600 volt. Complete outfit in fitted case. £15·00, P. & P. 50p.

SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY

7 adjustments, precision tooled, speed adjustable 10 w.p.m. to as high as desired. Weight 2½lb. £4·63 post paid.

POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES: 100 WATT** 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm ·7a., 500 ohm ·45a., 1k ohm 280mA., 1·5k ohm 230mA., 2·5k ohm ·2a., 5k ohm 140mA., Diameter 3½in. Shaft length ⅜in. dia. ¼in., £1·50. P. & P. 8p. **50 WATT** 1·12/10/25/50/100/250/500/1K/1·5K/2·5K/5K ohm. All at £1·5, P. & P. 8p. **25 WATT** 10/25/50/100/250/500/1K/1·5K/2·5K ohm. All at 78p, P. & P. 8p.

Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia. brass bush. Ideal for above Theostats, **18p** ea.

MOTOROLA MAC11/6 PLASTIC TRIAC 400 PIV 8 AMP

Now available EX STOCK supplied complete with full data and applications sheet. Price £1·5 plus 8p P. & P.

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.

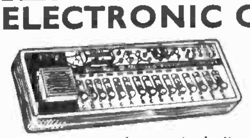
EXPERIMENTERS "ECONOMY" KIT
Adjustable 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Uniiunction Xenon Tube+instructions **£5·25** plus 25p P. & P.

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**. 38p 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. 38p.

7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price **53p** and 13p P. & P. or post paid with kits.

ELECTRONIC ORGAN KIT

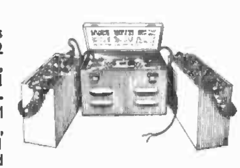


Easy to build, solid state. Two full octaves (less sharps and flats). Fitted hardwood case, powered by two pen-lite 1½v. batteries. Complete set of parts including speaker, etc., together with full instructions and 10 tunes. £3·00. P. & P. 23p.

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.

COMPLETE NI. CAD. BATTERY OUTFIT (EX W.D.)

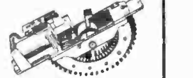


2 metal carrying cases each containing 10 × 1.2 volt 7 AH (12v) batteries, also 10 × 1.2v 22 AH (12v) batteries (40 batteries in all). 1 Dual voltage, dual meter, thyristor controlled charging unit. Designed for charging the 7AH and 22AH batteries simultaneously. Input voltage can be adjusted between 100-250v AC. Built to ministry specification. Ideal power supply for field work. Offered at fraction of makers price. 2 sets of batteries, 1 charging unit. The set £45·00, c. & p. £1·50.

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 2⅛in. × 1⅛in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 63p. P. & P. 13p.

UNISELECTOR SWITCHES *NEW*



4 BANK 25 WAY FULL WIPER
25 ohm coil, 24 v. D.C operation. £5·88, plus 13p P. & P.

6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. operation. £6·50, plus 13p P. & P.

8-BANK 25-WAY FULL WIPER
24 v. D.C. operation. £7·63, plus 20p P. & P.

RELAYS *NEW* SIEMENS PLESSEY, etc.

MINIATURE RELAYS AT COMPETITIVE PRICES.

1	2	3	4	1	2	3	4
52	6- 9	6M	63p*	700	12-24	2 c/o	63p*
180	6-12	2 c/o E-E	43p*	700	16-24	6M	63p*
185	6-12	4 c/o E-E	50p*	1250	24-36	4 c/o	63p*
230	6-12	2 c/o	63p*	1250	36-45	6M	63p*
280	6-12	2 c/o	73p*	2500	36-45	6M	63p*
700	16-25	4M 2B	63p*	5800	80-85	4 c/o	50p*
700	16-24	4 c/o	78p*	9000	40-70	2 c/o	50p*
*including Base				15K	85-110	6M	50p*

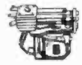
(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price E-E Ex. Equipment. All Post Paid.

MINIATURE RELAYS

9—12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1in. × ⅞ × ½in. Price **58p** Post paid.

30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3.200 ohm coil. Size only 1 × 7/16 × 1 1/16in. **43p** post paid.

SPECIAL OFFER

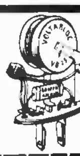


Relay 18/24 v. D.C. 2 c/o 3 Amp contacts. 400 ohm coil. NEW. **48p**. P. & P. 8p or 3 for **£1·50** post paid.

TYPE A.G.C. 1M 1B 12v. A.C. 3 amp contacts. NEW **48p** + 8p. p. & p. or 3 for **£1·50** post paid.

MAINS RELAY
230 v. A.C. coil 3 c/o, 10 amp. A.C. contacts. **73p** + 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.

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. 13p. Complete with lead and stereo jack plug.

BURGESS MICRO SWITCH

Lever operated. c/o contacts. Price 20p plus 4p P. & P. 10in. maker's carton £1·75 post paid.

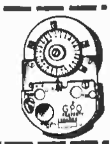
200-250 v. 1 R.P.M. MOTOR

Dimensions: 4" × 3" × 2¼"
Spindle length 13/16", diameter ⅛". Manufactured by SEC. Price £1·13 plus 18p p. & p.

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 23p P. & P. or less transformer £2·13 plus 23p P. & P.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines etc. etc.

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. £3·75, 20amp. £3·75, P. & P. 23p. Also available with Solar Dial ON at dusk, OFF at dawn. Prices as above.

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.

NEW MODEL HIGH FREQUENCY TRANSISTORISED MORSE OSCILLATOR

Adjustable tone control. Fitted with moving coil speaker, also earpiece for personal monitoring. Complete with morse key. £2·25 plus 18p p. & p.

SERVICE TRADING CO.

ALL MAIL ORDERS. ALSO CALLERS AT:
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Closed Saturdays.

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AMPLE PARKING

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9 LITTLE NEWPORT STREET, LONDON, WC2H 7JJ.
Tel.: 01-437 0576

APPOINTMENTS VACANT

TECHNICAL WRITER

Do you want an attractive salary and a choice working location? The world's leading manufacturer of precision electronic test and measuring equipment offers these and other outstanding benefits to the Technical Writer who joins our technical publications group. You may qualify if you have a sound background in electronics and are an experienced writer. Some knowledge of German would also be advantageous.

HEWLETT PACKARD

Hewlett-Packard GmbH, 703 Böblingen, Herrenberger Str. 110 GERMANY, Tel: 07031/667 205

OXFORD UNIVERSITY

DEPARTMENT OF EXPERIMENTAL PSYCHOLOGY

JUNIOR ELECTRONIC ENGINEER

To assist in design, construction, development and maintenance of a wide range of devices for the Psychological Laboratories, under guidance of the Electronic Engineer.

Candidates must have experience in design/development, preferably in a research environment, but not necessarily in the behavioural/medical field. Some experience of digital systems or electro-physiological techniques is desirable.

Minimum qualifications, degree of H.N.C. (preference will be given to those actively studying for higher qualifications such as corporate I.E.E. or I.E.R.E. membership). Salary on University Departmental Research Assistant Grade C scale, £932-£1,917 (under review).

The post provides an opportunity for varied and interesting work with excellent facilities in a well equipped Electronics Section.

Please apply with details of past experience and the names of two referees to:

THE ADMINISTRATOR
Department of Experimental Psychology,
1 SOUTH PARKS ROAD
OXFORD

1033

AUDIO SERVICE ENGINEERS

Vacancies exist for Field Service Engineers covering areas: LONDON AND HOME COUNTIES, SOUTH WALES, SCOTLAND

Salary compatible with experience. Vehicle provided.

Apply to:
SERVICE MANAGER, B.V.C. LTD. (SOUND PRODUCTS) 725 FULHAM RD., LONDON, S.W.6

1009

HTV

have immediate vacancies for:

1. ENGINEER (Telecine/VTR). A.C.T.T. Category D. Television broadcasting experience essential.
2. TECHNICAL ASSISTANT/ ASSISTANT ENGINEER A.C.T.T. Categories H/E. Experience in Electronics associated with television or allied fields required.
3. TRAINEES. The minimum qualifications required, 'A' level Maths and Physics.

applications to:

Personnel Department
HTV Television Centre
CARDIFF

1000

CITY OF LEEDS & CARNEGIE COLLEGE

SENIOR WORKSHOP TECHNICIAN

T3 £1,089-£1,272

Applications are invited for this post in the Audio-Visual Aids section of the College, to be responsible for the maintenance of all electronic equipment including a closed circuit television apparatus and to assist in the other work of the section.

Application forms and further particulars from the Senior Administrative Officer, City of Leeds and Carnegie College, Beckett Park, Leeds LS6 3QS, to be returned as soon as possible. Previous applicants need not re-apply. 1037

UNIVERSITY of LANCASTER

ELECTRONICS TECHNICIAN

DEPARTMENT OF ENGINEERING

Must be experienced in solid state electronics and instrumentation; duties will include assisting in the design and making of new equipment for teaching or research and the maintenance of laboratory equipment. Salary will be within the scales £1,041-£1,410 or £1,398-£1,707 depending on age, qualifications and experience.

Application form (to be returned as soon as possible) available from the Deputy Establishment Officer, University House, Bailrigg, Lancaster.

1027

Got ambitions in science *or Engineering*

Try for a Shrivenham Cadetship and give yourself the best possible chance of a degree.

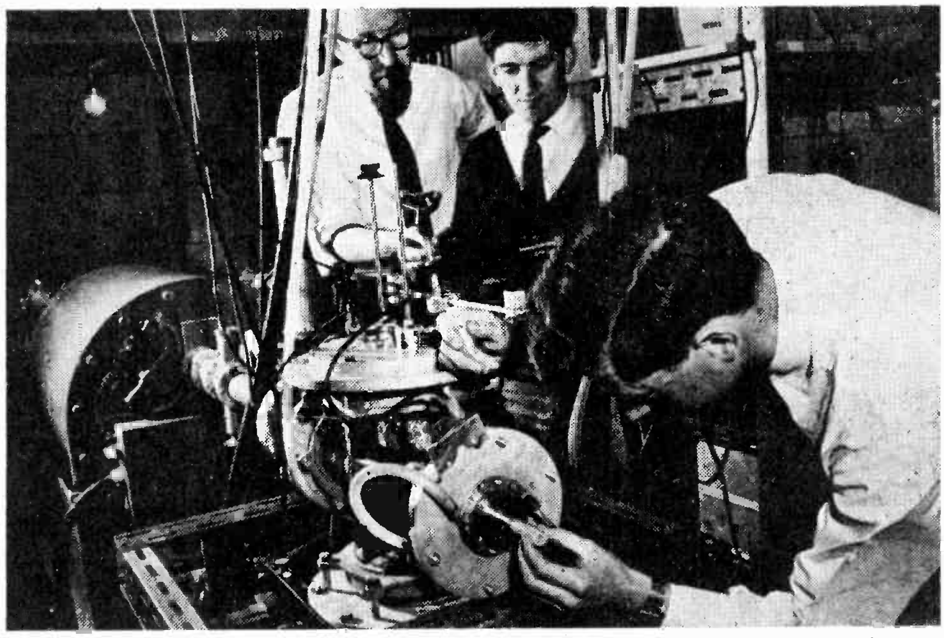
"I don't know whether the staff are really better at Shrivenham than at *****, but they certainly devote a great deal of time and trouble to us. It's not just that there's a good staff/student ratio. There's also a first class staff/student relationship, and that's what matters. I expect to do distinctly better at Shrivenham than if I'd stayed at*****."

The speaker is a student who has studied at University elsewhere and is now reading for a B.Sc. at Shrivenham – known more formally as the Royal Military College of Science. This is where most of the technically qualified Officers, needed in growing numbers by an Army as modern as ours, do their degree courses. Its academic record is summed up in one readily grasped statistic. In 1969, when Shrivenham was still one of 52 establishments whose students competed for external degrees, London awarded a total of eight First Class Honours degrees in Chemistry (Special) and Engineering. Five of them went to Shrivenham.

Spotting Potential

Does this mean that the ordinarily able man will be out of his depth? No. Shrivenham has the same basic entry requirements as most universities. If there's any difference here, it tends to favour the late developers. The Army's selection procedures are rather more sophisticated than most, and can spot potential ability. Given that, it is prepared to consider young men whose 'A' level grades would lead to automatic rejection elsewhere. People with 'D's have done well at Shrivenham. And a young man who was told after his first year at a university that he "would never reach degree standard", went on to win First Prize for Engineering at Shrivenham and a London First Class Honours degree.

Today Shrivenham runs its own degree courses leading to CNAA awards. Its students are mostly young Army Officers who have been through Sandhurst. There are also a number of civilian students, most of them on County Awards. And there are young men who have won Cadetships.



Officer Students assist in setting up an experiment on a linear accelerator in the Rutherford Nuclear Physics Laboratory of the College.

How to get a Cadetship

Cadetships in Science and Engineering at Shrivenham carry a probationary commission as Second Lieutenant. To get one, you need at least 5 GCE passes, two of them—in Maths and Science subjects—at 'A' level. You have to satisfy the Shrivenham Selection Board that you are 'degree' material, and pass the Regular Commissions Board at Westbury, where you spend three days while they find out if you have the practical imagination and leadership needed by an Army Officer. And you have to undertake to serve as an Officer for five years after completing your course.

In return you get over £1,000 a year while you're studying (which makes you better off than any other undergraduates), as well as free tuition. And, as we have seen, you get a very much improved chance of getting a degree.

Tutorial System

There are three main reasons for this. One is that the staff can, and do, take a lot of trouble with individuals (Shrivenham operates a tutorial system comparable to that at Oxford or Cambridge). The second is the good equipment (there are no less than four particle accelerators of up to $4\frac{1}{2}$ MeV, a wind-tunnel, a rocket-motor and a computer). The third is that they are not at all indulgent about slacking. "After *****", says the student who knows both, "it's quite a change being made to work."

Incidentally, nobody wears uniform, and there are no parades. But during vacations you are expected to spend some time on attachment to an Army unit.

If you'd like to know more, fill in the coupon. You'll get some interesting reading—and a chance to visit Shrivenham and have a look round for yourself.

To: Col. C. A. Noble, MC, BA, MPI(A), Dept. 743 (RMSS A4), Lansdowne House, Berkeley Sq., London, W1X6AA. Please send me the illustrated prospectus for the R.M.C.S., Shrivenham.

Name ____________________

Address ____________________

I have .... GCE (or equivalent) passes, including .... at Advanced level in ____________________

MSL

Management Consultants in Human Resources
17 Stratton Street London W1

Technical Development Manager

£3500 – £4000

Our client is the EVR Partnership, the joint TV recording company set up by Columbia Broadcasting System of America, ICI and CIBA-Geigy. Electronic Video Recording is a system for playing professionally recorded programmes of sound and vision through any normal television receiver. The processing of film or video tape programme material into telecartridges requires highly advanced electronic and photographic equipment. The man appointed will lead a team at the Basildon, Essex, factory in developing and maintaining methods of using this equipment. Candidates should be graduate or professionally qualified engineers with several years' knowledge and experience in the television industry on the development or the operational side. Some knowledge of the photographic problems that would be involved is also desirable. J. G. French reference ZH.2054.

The MSL Consultant has analysed this appointment
Further information will be sent if you provide your name and address by telephoning 01-629 1844 or writing to the consultant quoting the reference. Your enquiry will be in confidence.

MICROWAVE/RADIO TELEMETRY SYSTEMS

The West Midlands Gas Board uses microwave radio equipment, digital supervisory systems and U.H.F. radio scanning gear for telemetry and data transmission throughout the West Midlands area. V.H.F./U.H.F. Mobile R/T systems are operated from fixed and mobile transmission centres and are extensively utilised by the Service and Conversion Departments.

The Telecommunications Department as part of the expanding management services directorate require the following personnel:—

Assistant Engineer (Microwave)

Ref: WWA155

To undertake preparation of specifications, installation planning and performance analysis of high capacity microwave systems together with integrated radio telemetering equipment. Experience in large microwave multi-channel system design essential. Salary £1,665 to £2,178 per annum.

Technicians

Ref: WWA156

To assist in the maintenance and commissioning of equipment. Knowledge of comprehensive modern testing procedures, appropriate maintenance experience and the ability to work alone are essential. Initial salary £1,185 to £1,725 per annum according to experience, with progression to Senior Technician and up to £1,968 per annum on proven ability.

These posts are based at Board Headquarters, Solihull, but involve travel throughout the Board's area. Excellent working conditions include assistance with removal expenses in suitable cases.

Please apply in writing, quoting appropriate reference number, to:—

The Senior Personnel Officer, (Headquarters) West Midlands Gas Board, 5 Wharf Lane, Solihull.

Giving full details of career to date.

West Midlands GAS

BATH UNIVERSITY OF TECHNOLOGY

School of Chemistry and Chemical Engineering

EXPERIMENTAL OFFICER—COMPUTER SYSTEMS

Applications are invited for the above post, tenable within a group concerned with the development of computer-based systems for the control and automation of laboratory experiments: this project is supported by the Science Research Council.

Duties include the design and construction of special-purpose electronic equipment and the development of on-line programs for a PDP8/K70 computer system.

Experience in solid state electronics, modern wiring and construction techniques is essential, whilst experience in computer systems and programming will be an advantage.

The starting salary for suitably qualified applicants will be within the range £1,536—£2,182.

Informal enquiries can be made of Mr. P. E. Sawyer, School of Chemistry and Chemical Engineering.

Application forms should be obtained from the Registrar (S), The University, Claverton Down, Bath, quoting reference 71/1. 1010

UNIVERSITY OF SHEFFIELD

TECHNICIAN OR JUNIOR TECHNICIAN required for Electronic Section of Department of Physics, dealing with design, maintenance and production of Electronic equipment for teaching and research purposes. Training given in workshop practice. Day release training scheme. Salary: Technician £1,041—£1,410 p.a. Junior Technician £528 (age 16)—£774 p.a. (age 20). Write to the **Bursar (Ref. B.738), The University, Sheffield, S10 2TN.** 1024

UNIVERSITY OF SOUTHAMPTON INSTITUTE OF SOUND AND VIBRATION RESEARCH

CONTRACT ASSISTANT

Applications are invited for the above technical post, which is supported by a long term Medical Research Council grant, commencing on or soon after 1 March, 1971.
The work involves construction of audio-frequency stimulus generators and associated equipment, operation of a digital computer and general assistance with electro-physiological experiments.
Candidates should have experience in the fields of electronic construction and application, and would be instructed in the new techniques involved in operating the computer and assisting with experimental work.
This is an important position in a research team working on the problems of deafness. Salary on scale: £1,368-£1,677 per annum plus allowances for approved qualifications. Applications giving details of age, qualifications and experience and the names of two business referees should be sent to the Deputy Secretary, The University, Southampton, SO9 5NH by 1 February, 1971, quoting ref.: W.W.998. 998

audio engineers

for design and development

There are opportunities for senior engineers in the design and development laboratories of a major company located in the Southern Home Counties.

The Company designs and manufactures T.V., and audio equipment for the consumer market.

Senior Engineers and those with less experience who have a background of design for quantity production and a good knowledge of audio and radio circuitry will find the environment stimulating and absorbing.

Test Gear Engineers are also required with experience of T.V. or audio equipment.

Conditions of employment are good, including Pension scheme and Life Assurance. Removal expenses will be met by the Company and a contribution towards solicitors and agents fees.

These appointments carry salaries of up to £2,200 according to experience, plus the opportunity for foreign travel.

Please write in the first instance to Position No. CGA 2616, Austin Knight Limited, London, W1A 1DS. Companies in which you are not interested should be listed in a covering letter to the Position Number Supervisor.

Ministry of Aviation Supply

TECHNICAL OFFICER

(Electronic Engineering)

This post, in the Electronics Production (Telecommunications) Branch of St Giles Court, London, WC2, is concerned with various aspects of the production and procurement of electronic valves and semi-conductor devices for Service use. The work will involve planning and progressing of production; specification of technical content of contracts; handling and co-ordination of associated technical matters; and liaison with various industrial organisations and government bodies.

Candidates must have an ONC in engineering, electrical engineering or applied physics, or an acceptable equivalent or higher qualification. They must have served a recognised engineering apprenticeship or have had equivalent training; they should also have sound knowledge of and experience in the electronic engineering field. The total period of training and experience must be at least eight years.

SALARY: £2,022 on entry, rising to £2,484. Non-contributory pension. Promotion prospects.

For full details and an application form (to be returned by 3 February 1971) write to Civil Service Commission, Alencon Link, Basingstoke, Hants., or telephone BASINGSTOKE 29222 ext 500 or LONDON 01-734 6464 (24-hour "Ansafone" service), quoting *T/7648/71*.

ELECTRONIC MAINTENANCE TECHNICIANS

THORN

are required for interesting and varied work concerned with the maintenance and manufacture of a variety of equipment used in the production of Cathode Ray Tubes.

Vacancies exist on both day and night shift. We offer good conditions of employment and a competitive salary.

Applications are invited from men who have served an indentured apprenticeship or who have had equivalent experience and should be made to:–

The Personnel Manager, (ET/WW), Thorn Radio Valves & Tubes Ltd., Mollison Avenue, Brimsdown, Enfield, Middx.

997

Electronics Maintenance Engineers

There are excellent opportunities in the Installation and Maintenance Division of U.K. Electronics and Industrial Operations of E.M.I. Ltd., at Hayes, Middlesex, for engineers to carry out maintenance work on a wide variety of electronic equipments including laboratory test gear and trans-ceivers.

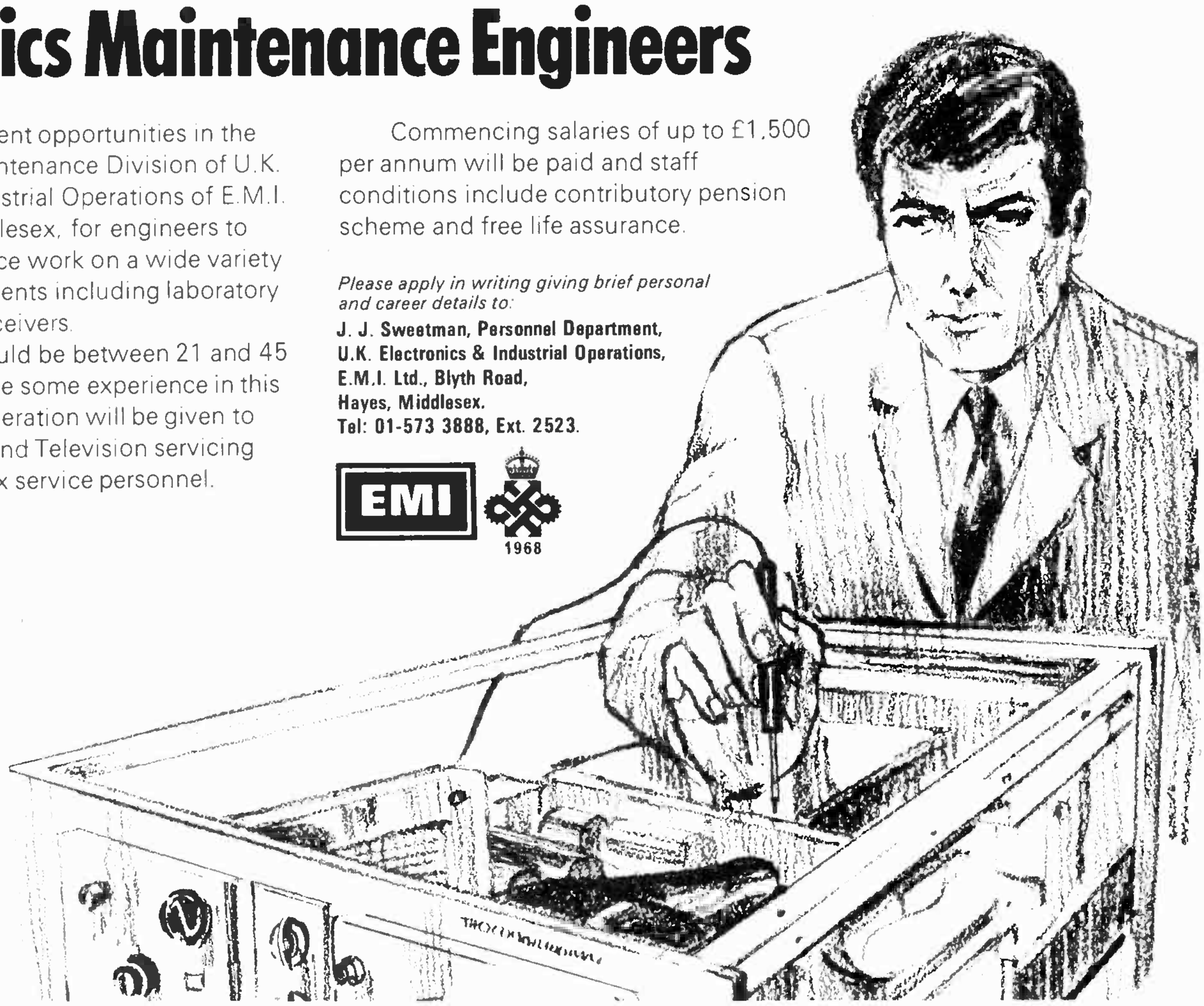
Candidates should be between 21 and 45 years of age and have some experience in this type of work. Consideration will be given to experienced Radio and Television servicing technicians and to ex service personnel.

Commencing salaries of up to £1,500 per annum will be paid and staff conditions include contributory pension scheme and free life assurance.

Please apply in writing giving brief personal and career details to:

J. J. Sweetman, Personnel Department,
U.K. Electronics & Industrial Operations,
E.M.I. Ltd., Blyth Road,
Hayes, Middlesex.
Tel: 01-573 3888, Ext. 2523.

EMI 1968



836

computer engineering

NCR requires additional ELECTRONIC, ELECTRO MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.

Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.

Starting salary will be in the range of £900/£1,350 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.

Excellent holiday, pension and sick pay arrangements. Please write for Application Form to
Assistant Personnel Officer
NCR, 1,000 North Circular Road,
London, NW2
quoting publication and month of issue.

Plan your future with NCR

Electronic Design Engineers - H.F. Receivers

The Racal Group leads the world in the design and manufacture of H.F. Communications equipment, and has a wider range of receivers in production than any other organisation.

A further expansion of our activities into new areas of development is now taking place and we are seeking experienced design engineers at all levels to join us.

Engineers in Racal are encouraged to take a high degree of responsibility for their products, of which they normally control all technical aspects from initial conception to quantity manufacture. In return we demand enthusiasm and ability in the field of product oriented design.

Salaries at all levels up to about £3000 per annum may be payable and brief details should be sent before interview to:

RACAL THE ELECTRONICS GROUP

Mr. G. J. Lomer,
Director of Development
Racal-BCC Limited,
Western Road,
Bracknell, Berks.

85

Materials / Electronic Engineers

If you are qualified to first Degree level in Electronic Engineering or a Pure Science subject, then we may be able to offer you an interesting and challenging career. Of the many elements and compounds with applications in the electronics field, we are particularly interested in the properties displayed by quartz crystal and ferri-magnetic materials.

Specialized Components Division of the Marconi Company is engaged in the R and D, manufacture and marketing of a wide range of components using these two materials. Continuing expansion has created opportunities for Engineers with circuitry experience to work on both the fundamental Research of material characteristics and the Development of devices (eg crystal filters and oscillators; microwave circulators and isolators) which are used throughout the electronics industry.

It would be naive of us to suppose we could give you a concise description of the jobs we have to offer in this advertisement, so please telephone (reverse charges) either John Penney (Deputy Technical Manager) on Billericay 2654 Ext 37 or H.W. Cooke (Divisional Personnel Officer) on Chelmsford 53221 Ext 593 for further details. Initial interviews can be arranged at a mutually convenient location.

Marconi Communication Systems

Attractive commencing salaries will be offered, coupled with excellent conditions of employment and the opportunity for further promotion within the largest electronics Company in Great Britain. Assistance with removal expenses will be given in appropriate circumstances. If you are unable to telephone, please write to Divisional Personnel Officer, Marconi Communication Systems Limited, Marconi House, New Street, Chelmsford, Essex, quoting reference WW/SCD/21.

GEC-Marconi Electronics

Billericay

ST. LOYE'S COLLEGE
FOR THE TRAINING AND REHABILITATION OF THE DISABLED, EXETER

The following posts on the Instructor Staff are vacant

1) BASIC WORKSHOP PRACTICE

This course calls for an

INSTRUCTOR

to train new candidates in Light Engineering Bench work, both mechanical and electrical. The post calls for a varied background in engineering and considerable experience. Some teaching experience would, of course, be an advantage. Five-day week. Three weeks' leave rising to four after three years' service. Superannuation Scheme.

Salary Scale: Grade III—£1,415 - £1,790

2) INSTRUCTOR OF ELECTRONICS THEORY AND PRACTICE INCLUDING RADIO AND TV SERVICING

An Electronics Engineer with industrial experience is required for the above post. Five-day week. Three weeks' leave rising to four after three years' service. Superannuation Scheme.

Salary Scale: Grade III—£1,415 - £1,790

Applications (no forms) to:

The Principal

1041

BUSINESS OPPORTUNITY

Earn a substantial extra income through a fascinating part-time business of your own that you could share with your wife and operate from your own home. This is an outstanding business opportunity with rewards exceeding £5000 per annum at the higher levels. We are looking for organisational and managerial ability.

Telephone for an appointment.

VISTA MARKETING MAIDENHEAD 28754

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AUDIO TESTERS/ TROUBLE SHOOTERS

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This private College provides efficient theoretical and practical training in the above subjects. One-year day courses are available for beginners and shortened courses for men who have had previous training.

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RADIO SERVICE ENGINEER

Are you an engineer who wishes to join a large International Group and one who looks forward to being involved in the Common Market?

We are seeking such a man for our Service Department with knowledge of transistor circuitry and, if possible, experience with tape recorder and television repairs.

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1007

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These appointments will be in the PHYSICS and CONTROL AND COMMUNICATIONS Divisions at the Central Electricity Research Laboratories, Kelvin Avenue, Leatherhead, Surrey, where the successful candidates will be concerned with either one or more of the following:—

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(c) development of novel instrumentation for use in generating stations, initially on a radio-telemetry project.

Senior Scientific Assistants and Laboratory Technicians should have either a relevant HNC qualification, extensive commercial experience or possess a good theoretical and practical knowledge of electronics and be capable of working with a minimum of supervision. In either case they should be at least age 25. Scientific Assistants should have 5 'O' levels at age 16 or 2 'A' levels at age 18 or possess an ONC in a relevant subject.

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1005

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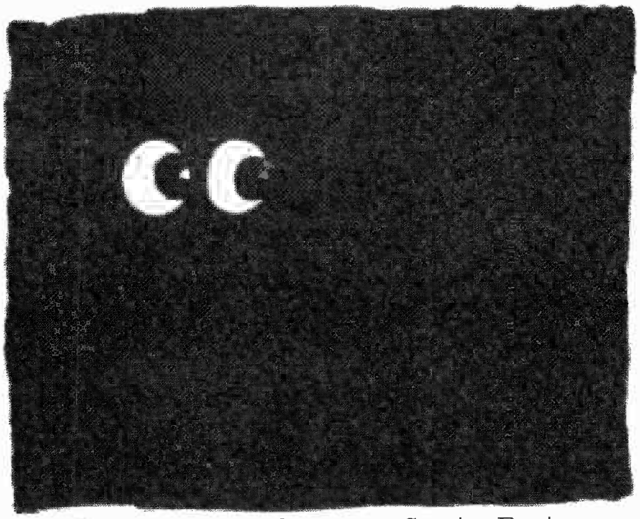

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- An all-consuming interest in telecommunications ☐
- At least one year's practical experience in telecommunications, preferably with 'ONC' or 'C and G' technical qualifications ☐
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- Willingness to undergo a rigorous programme of training ☐
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ELECTRONIC ENGINEERS

are invited to apply or the post of Medical Physics Technician Grade II in the Department of Physics at the Liverpool Clinic. The work is concerned with the maintenance, development and construction of electronic instruments to be used in connection with nuclear medicine. Candidates should have a wide experience of electronics and preferably have passed the O.N.C. or equivalent.

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1006

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67

ARE YOU INTERESTED IN HI FI? If so, and you have some experience of selling in the Retail Radio Trade, an excellent opportunity awaits you at Telesonic Ltd., 92 Tottenham Court Road, London, W.1. Tel. 01-387 7467/8. [21

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The Work entails checking to an exacting specification VHF/UHF radio-telephone equipment before customer delivery; applicants must therefore have experience of fault finding and testing electronic equipment, preferably communications equipment. Formal qualifications while desirable, are not as important as practical proficiency. Armed service experience of such work would be perfectly acceptable.

Pye Telecommunications is the world's largest exporter of radio-telephone equipment and is engaged in a major expansion programme designed to double present turnover during the next five years. There are therefore excellent opportunities for promotion within the company. Pye also encourages its staff to take higher technical and professional qualifications.

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FULL-TIME courses for P.M.G. certificates and the Radar Maintenance certificate.—Information from College of Technology, Queen's Gardens, Kingston-upon-Hull. [18

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ELECTRICAL ENGINEERIING DEPARTMENT

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OCTOBER 1971

FULL TIME : SANDWICH
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19 Coleshill Street,
Birmingham B4 7PB.
1001

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The Hatfield Polytechnic

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The project, sponsored by the Ministry of Aviation Supply (Signals Research and Development Establishment), has been running successfully for a year. The work involves the construction and testing of digital integrated circuit systems. Applicants should preferably be educated to at least HNC standard and have a good Electronics background. The post is offered initially for one year but there are good prospects of a permanent appointment.

Salary in a range up to £1,766 p.a., depending on qualifications and experience.

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943

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Please write to:—

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975

CHIEF TEST ENGINEER

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972

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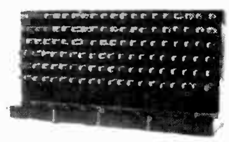

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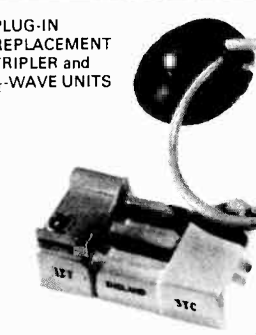

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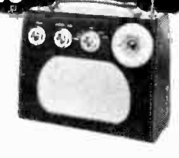

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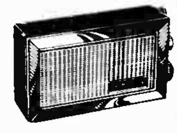

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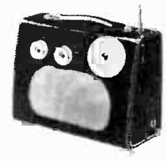

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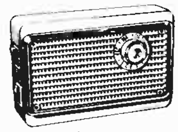

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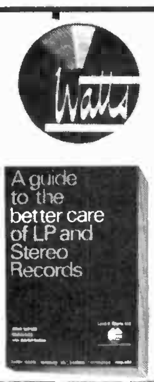

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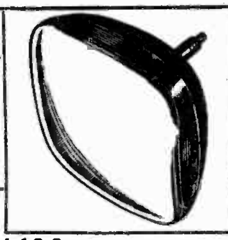

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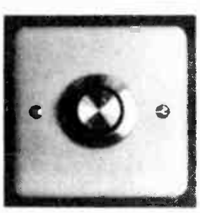

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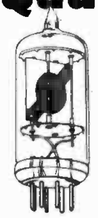

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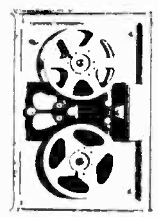

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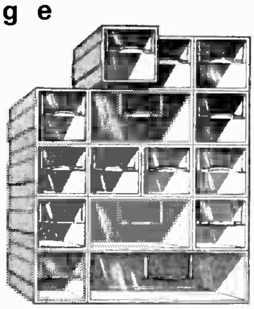

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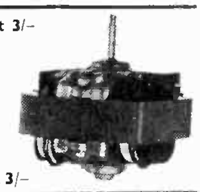

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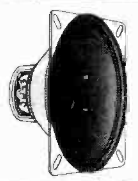

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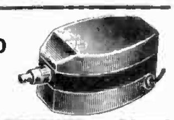

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BAILEY PRE-AMPLIFIER still offers lowest distortion level and best overload capability. Edge Connector Mounted Printed Circuit in Fibreglass or Paxolin material to choice. Highest quality parts including gain graded transistors.

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LINSLEY HOOD CLASS A. Full sets of parts now available to the new specification given in the December, 1970, Wireless World.

LINSLEY HOOD CLASS AB. We have some parts for this design but a Printed Circuit will not be available. We can supply information re thermal stability to constructors interested in this circuit.

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J. R. STUART TAPE CIRCUITS. We will be designing Printed Circuit Boards and supplying parts for this interesting design.

Full details are given in our Free lists. Please send foolscap s.a.e.

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WW—114 FOR FURTHER DETAILS

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Savbit Type 1 alloy contains 5 cores of non-corrosive extra fast rosin based Ersin Flux. Melting point is 215°C. Recommended bit temperature is 275°C.
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Available in standard wire gauges from 10–22 swg., on strong plastic reels.

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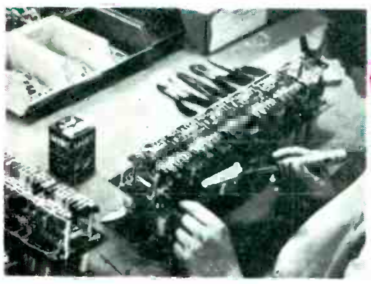

HOLLAND
Ersin Multicore Savbit Alloy is used by Bull Nederland of Amsterdam, Holland for the assembly of administration and statistics machines.

NEW ZEALAND
Ersin Multicore Savbit Alloy is seen being used at the factory of Bell Radio Television Corpn. Ltd., Auckland, New Zealand.

For further details, please apply on your Company's notepaper to:
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