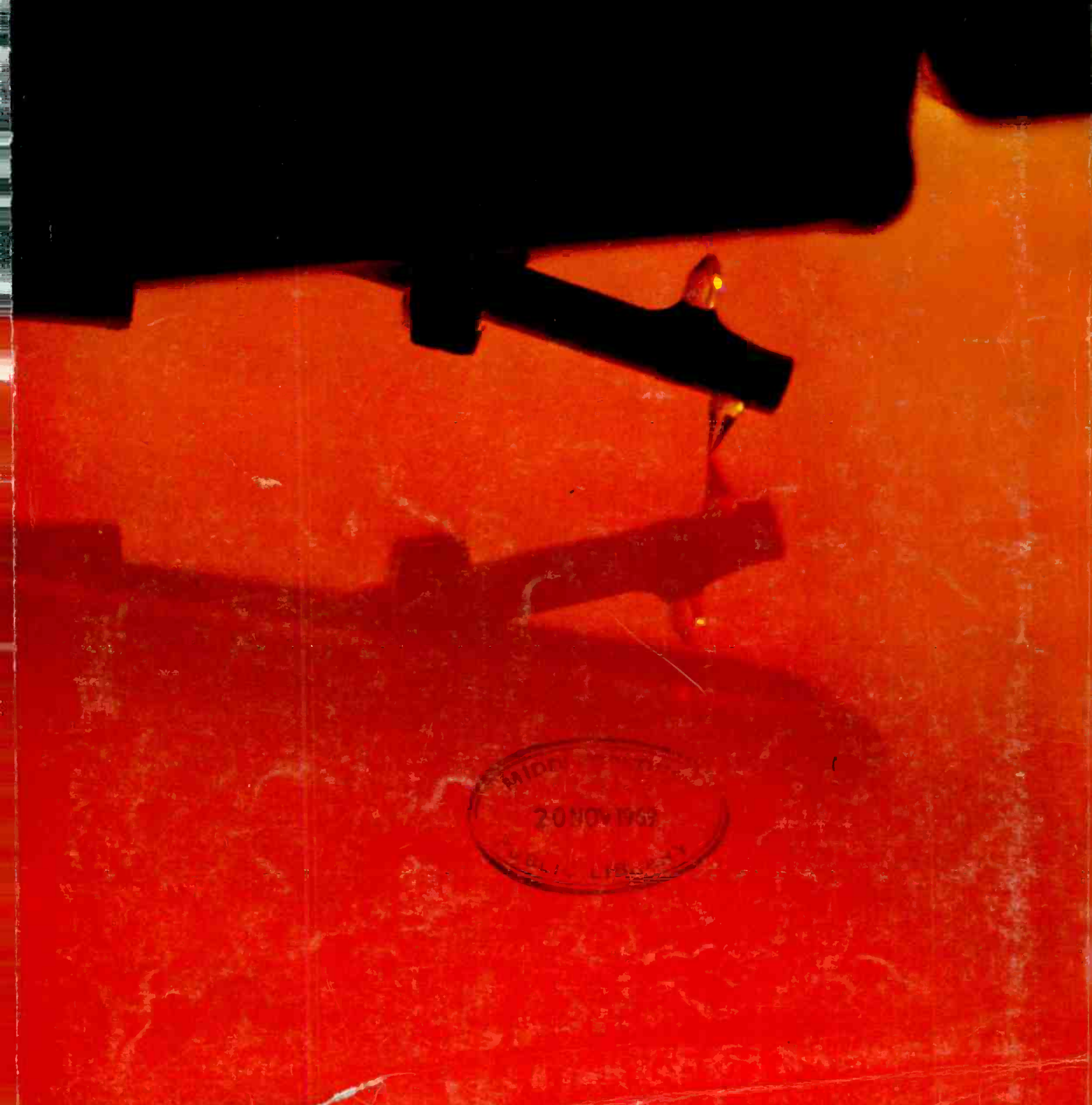
Wireless World

December 1969 Three Shillings

Gramophone pickup review

Thermistor hygrometer design



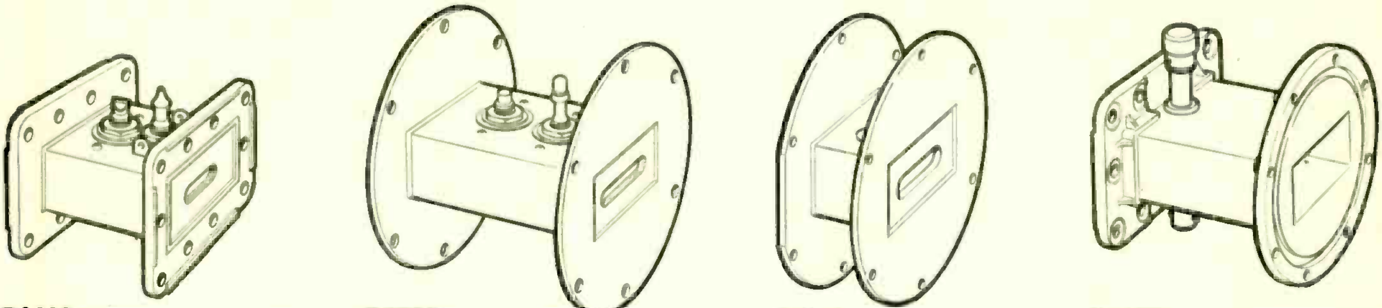
The Monsanto Model 100A Counter/Timer measures frequency up to 12.5 MHz, single period or frequency ratio ; or counts total events. It has a crystal controlled clock and integrated circuits .... Its price is £300.
In addition, the range includes new models tailored to meet your needs . . . the 101B has BCD output, and is twin channel with a frequency range of 5 Hz to 50 MHz on channel A . . . the 103A has four digit readout and a line-frequency clock and sells for £185 . . . the 104A is a preset counter (all five decades are pre-settable from 1 to 9) . . . And the latest in the family, the 106A is a fully reversible counter . . . *We shall be pleased to send you full details.*

Exclusive agent in U.K.
G. & E. BRADLEY LTD.
Electral House, Neasden Lane, London, N.W.10.
Telephone : 01-450 7811. Telex : 25583

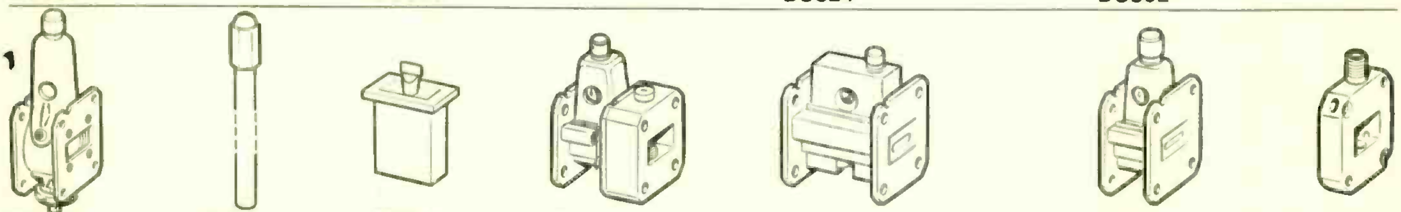
Monsanto

WW—001 FOR FURTHER DETAILS

Choose your duplexer devices from EEV's extensive range



BS390 BS800 BS824 BS802



BS332 BS834 BS310 BS814 BS458 BS452 BS460

Brief data on some of the many types available.

Product	Type No	Band	Frequency range (MHz)	Peak power (kW)
Pre TR cells	BS834	—	2000-12000	2500
	BS870	—	1240-1365	2500
TR cells	BS390	S	2925-3075	1250
	BS800	S	2840-3100	1250
	BS824*	S	2700-3100	250
	BS156	X	9000-9600	200
	BS452	X	9310-9510	100
	BS810	X	9250-9550	75
	BS850	X	9300-9500	50
TB cells	BS310	X	9375	5-200
TR limiter cells	BS814	X	9000-9700	200
	BS828	X	9325-9425	50
Solid state microwave switches	BS392	S	2925-3075	0.5
	BS460	X	8500-12000	0.5

*For protection of travelling waveguide amplifiers

Send for this booklet giving full details of the complete range of EEV duplexer devices and waveguide switches.

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

Please send me a copy of "Duplexer Devices". I am interested in a tube with the following parameters:

Frequency range Power Type of cell

NAME POSITION

COMPANY

ADDRESS

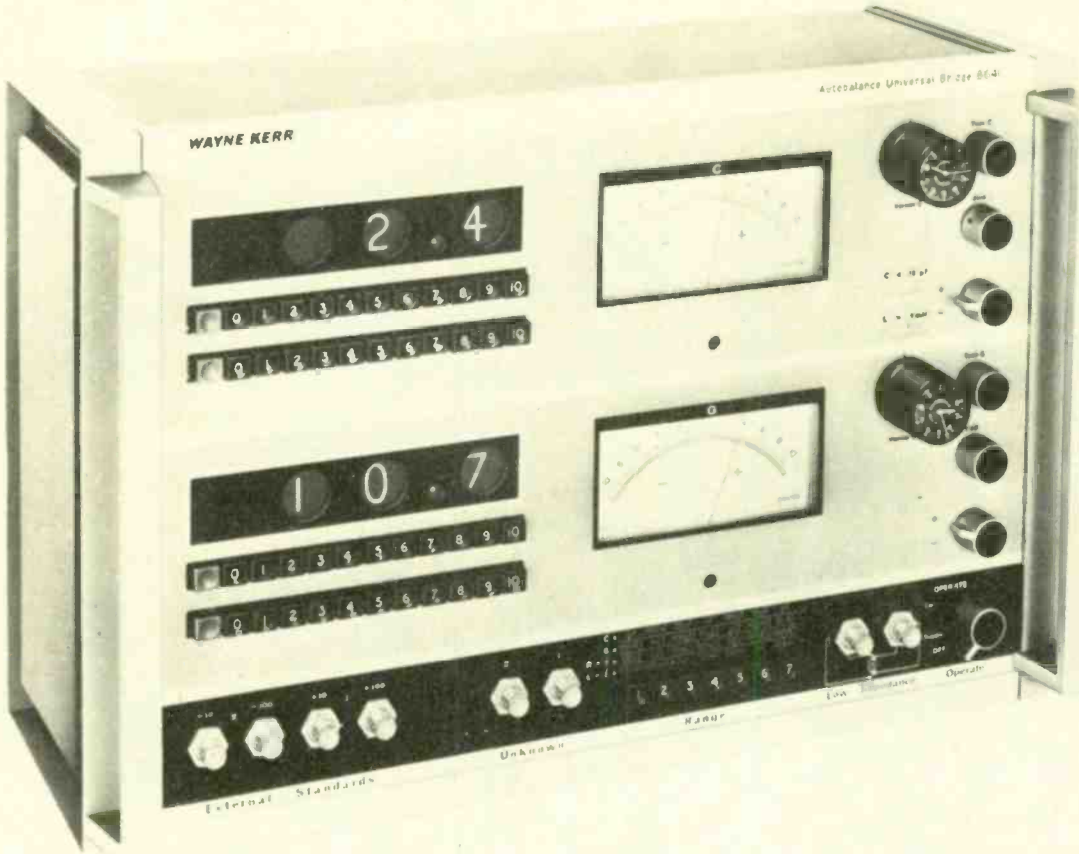
TELEPHONE NUMBER EXTENSION

WW38
AP 365

WW—006 FOR FURTHER DETAILS

WAYNE KERR

Autobalance Universal Bridge



8 ranges covering 0.002pF – 50 000μF; 20p℧ – 500℧; 200nH – $5x10^6$H; 2mΩ – 50 000MΩ

2 -figure readout of resistive and reactive terms immediately component is connected

3 or **4** -figure readout by backing-off first digits of meter readings on push-buttons

1 2 4 8 BCD outputs for Printers (optional). Analog outputs for DVMs and recorders

1 5 9 2 Hz internal source/detector. Sockets for external 200Hz – 20kHz

0.1% is the accuracy.
Simplicity of operation is the key feature.

B641
£495

THE WAYNE KERR COMPANY LIMITED
NEW MALDEN SURREY ENGLAND

Telephone 01-942 2202
Cables Waynkerr, Malden
Telex 262333

WW—009 FOR FURTHER DETAILS

prepare now for tomorrow's world

Today there is a huge demand for technologists such as electronics, nuclear and computer systems engineers, radio and television engineers, etc. In the future, there will be even more such important positions requiring just the up-to-date, advanced technical education which C.R.E.I., the Home Study Division of McGraw-Hill Book Co., can provide.

C.R.E.I., Study Programmes are directly related to the problems of industry including the latest technological developments and advanced ideas. Students claim that the individual tuition given by the C.R.E.I. panel of experts in each specialised field is comparable in technological content with that of technical colleges.

Why C.R.E.I. Courses are best

No standard text books are used — these are often considerably out-of-date when printed. C.R.E.I. Lesson Material contains information not published elsewhere and is kept up-to-date continuously. (Over £50,000 is spent annually in revising text material.).

Step-by-step progress is assured by the concise, simply written and easily understood lessons.

Each programme of study is based on the practical applications to, and specific needs of, Industry.

Take the first step to a better job now—enrol with C.R.E.I., the specialists in Technical Home Study Courses.

C.R.E.I. PROGRAMMES ARE AVAILABLE IN:

Electronic Engineering Technology * Industrial Electronics for Automation * Computer Systems Technology * Nuclear Engineering * Mathematics for Electronics Engineers * Television Engineering * Radar and Servo Engineering
City and Guilds of London Institute: Subject No. 49 and Advanced Studies No. 300.

CREI

Member of the Association of British Correspondence Colleges
C.R.E.I. (London), Walpole House, 173-176 Sloane Street, London S.W.1.
A subsidiary of McGraw-Hill Inc.

POST THIS COUPON TODAY FOR A BETTER FUTURE

To C.R.E.I. (London), Walpole House, 173-176 Sloane Street, London, S.W.1.
Please send me (for my information and entirely without obligation) full details of the Educational Programmes offered by your Institute.

My interest is City and Guilds ☐ please tick General ☐

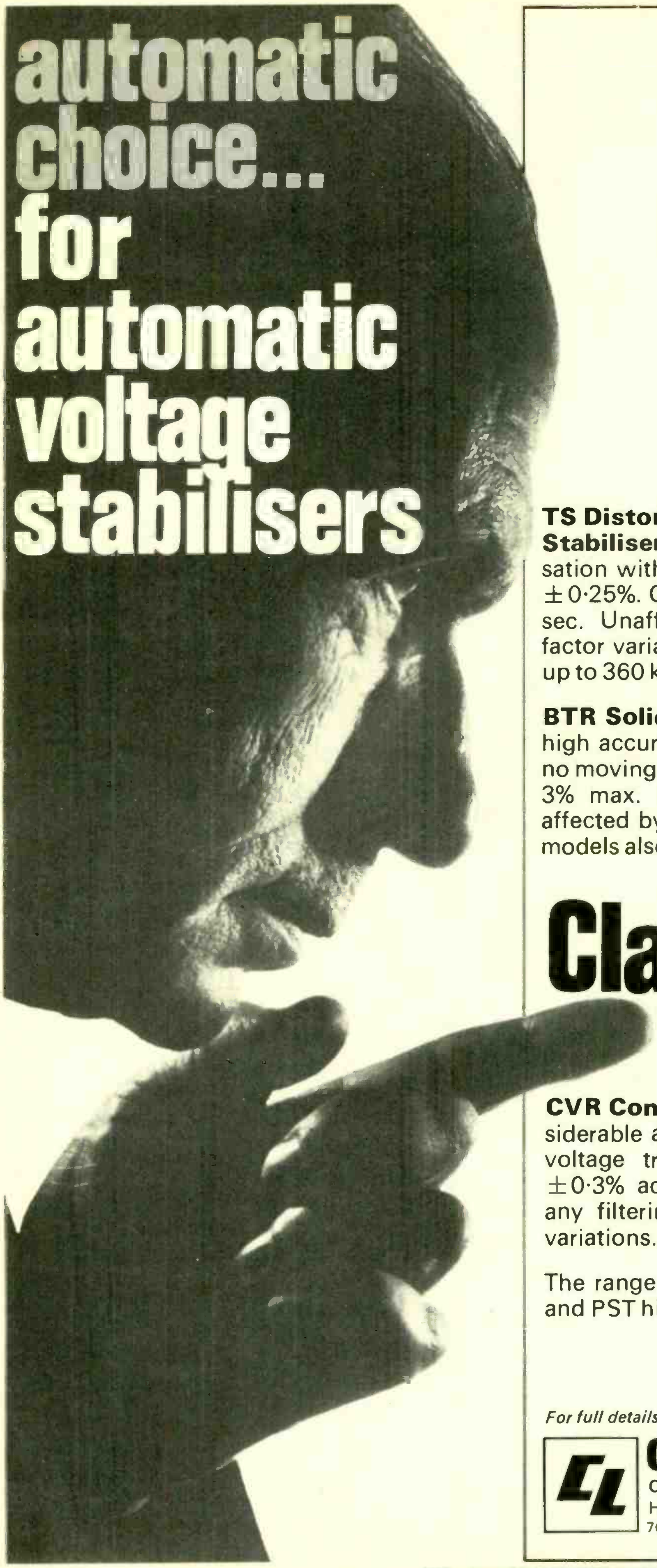
NAME

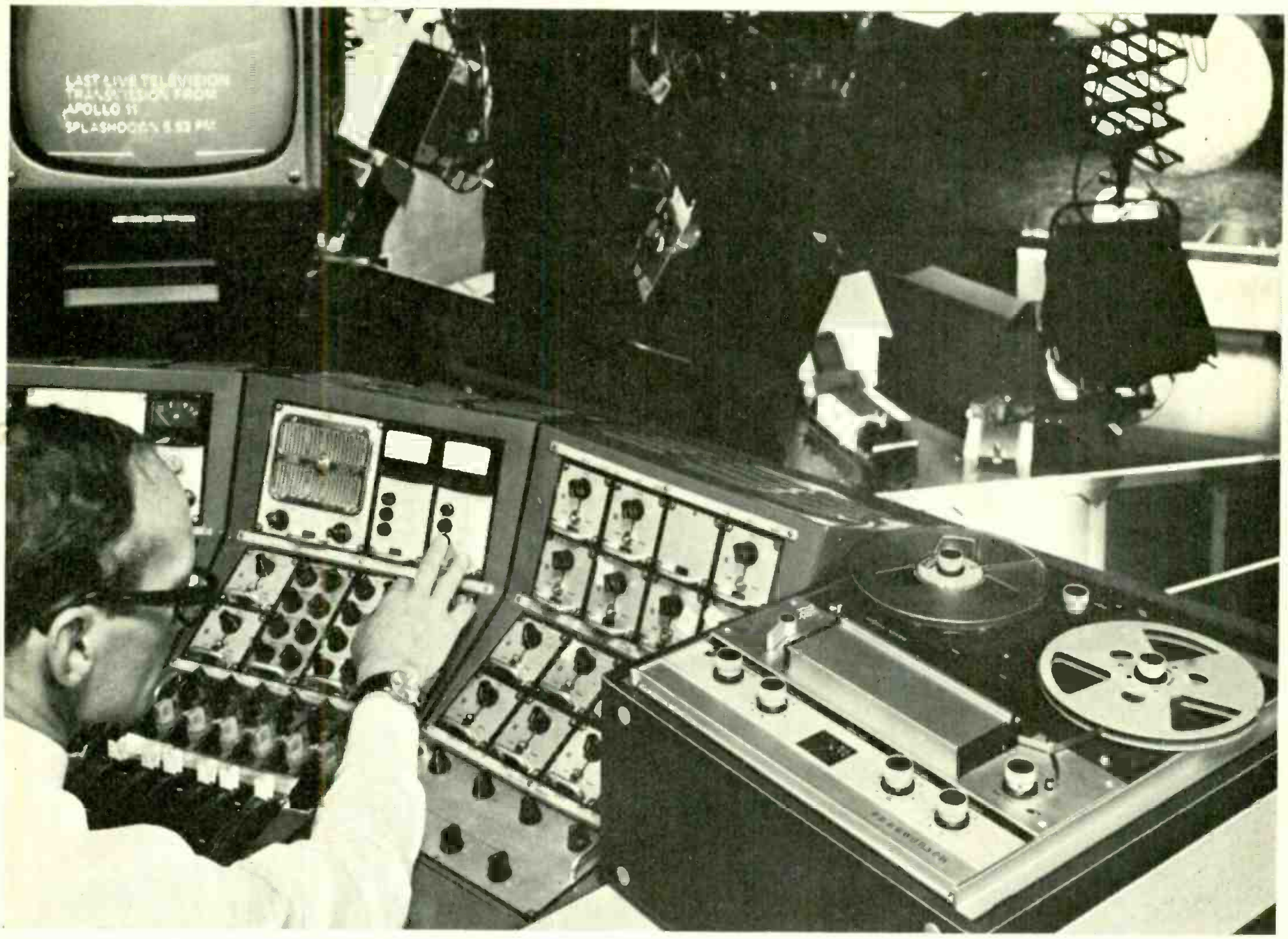
ADDRESS

EDUCATIONAL BACKGROUND

ELECTRONICS EXPERIENCE WW125

WW—010 FOR FURTHER DETAILS


automatic
choice...
for
automatic
voltage
stabilisers



BBC T.V.–moonshot: Where there can be no re-take you'll find Ferrograph.

During the Apollo 11 moon landing, the BBC used Ferrograph Series 7 Tape Recorders to monitor the NASA commentary. The recorders were in use continuously 24 hours a day. There could be no break, there could be no re-take. The BBC now has over 40 Ferrograph Series 7 recorders in use throughout the country.

Every Ferrograph Series 7 recorder is made in Britain and combines quality, reliability and a unique range of facilities. Available in mono or stereo, with or without amplifiers, all solid state, three-speed, with two inputs per channel and independent mixing. Retail prices from £175 including P.T.

Follow the professionals; choose the recorder you know will serve you best at home or in your work: Ferrograph—it makes sound sense. See your nearest stockist or send the coupon for details and address of nearest Ferrograph specialist or ring 01-589 4485.

Ferrograph

A member of the Wilmot Breeden Group

To the Ferrograph Co Ltd,
Mercury House, 195 Knightsbridge,
London, S.W.7.

Please send me a free brochure on the Ferrograph Series 7 ☐
or the Ferrograph Manual for which I enclose £1. ☐

Name ____________________

Address ____________________

____

____

WW

the choice in over 50 different countries!

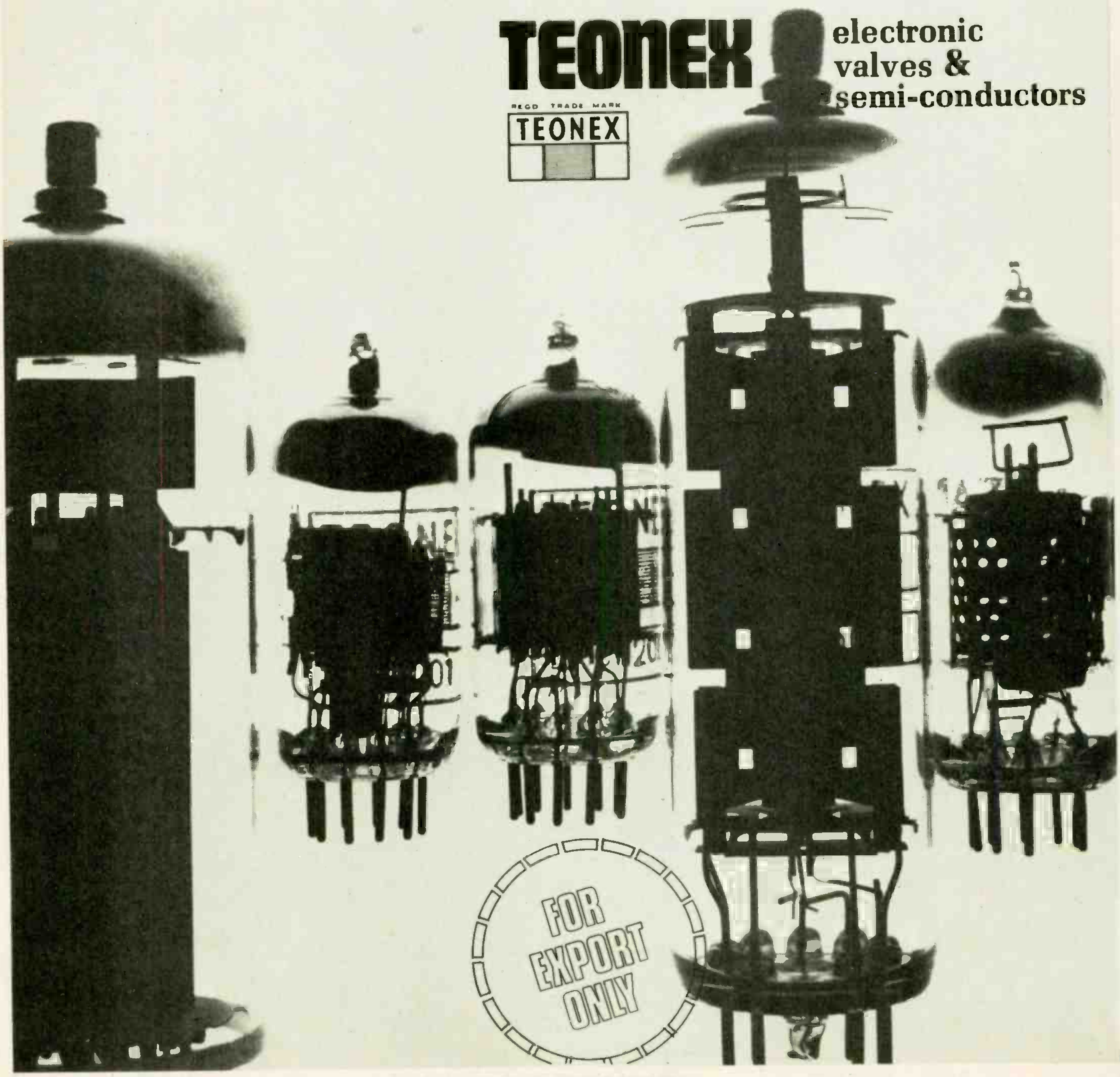
Teonex electronic valves and semi-conductors are supplied all the world over where quality and reliability count.

Teonex offer a comprehensive range of receiving, professional and special quality valves. Whether you require a device to Mil specifications for government work or a commercial device for replacement in a television set, Teonex products are equally suitable.

For technical specifications and price lists, please write to Teonex Limited
2a Westbourne Grove Mews
London W.11 · England
Cables: Tosuply London W.11.

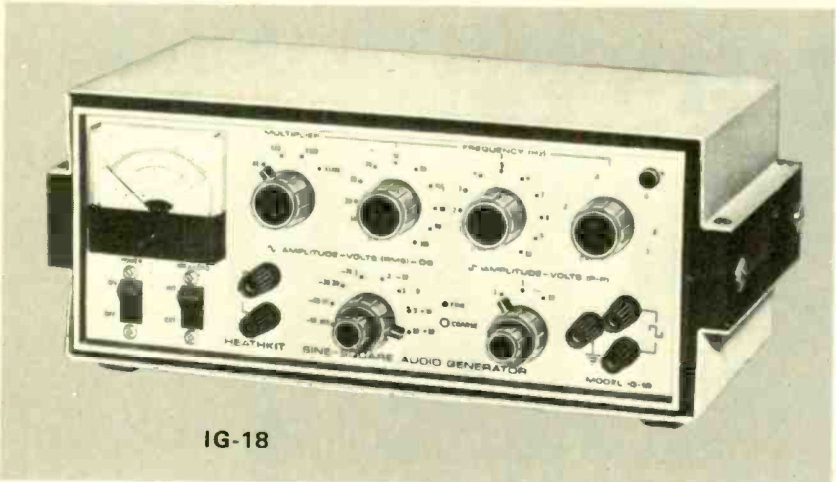
TEONEX electronic valves & semi-conductors

REGD TRADE MARK TEONEX



WW—015 FOR FURTHER DETAILS

Heathkit for Instrumentation



IG-18

FOR INDUSTRY

The Heathkit range of scientific and electronic test instruments including the latest advances in solid state instrumentation has been especially prepared for the industrial and scientific laboratory instrument user. Whatever your requirements, be they Potentiometric Chart Recorders, Monochromators, Universal Digital Instruments as well as VVMs and general test instruments, substantial savings against similar specifications of other manufacturers can be made by using Heathkit instrumentation.

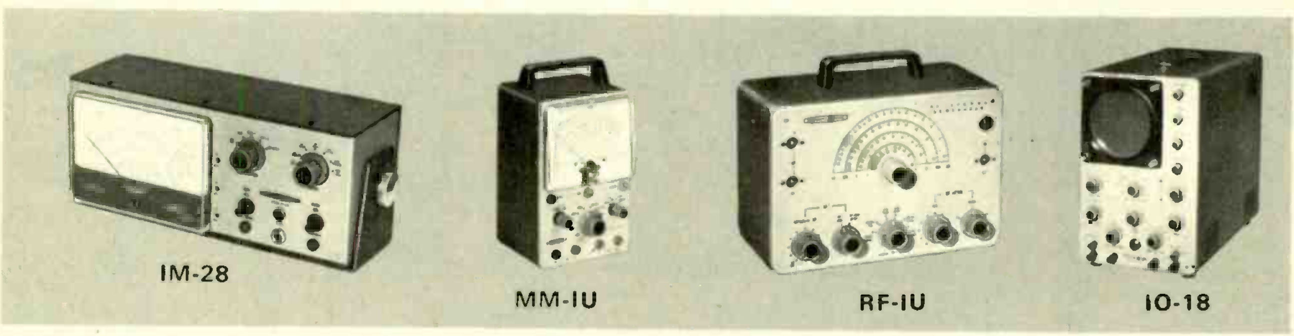
THE NEW SOLID-STATE SINE SQUARE WAVE AUDIO GENERATOR, Model IG-18 is typical of the latest Heathkit instrumentation styling.

- Sine Waves from 1Hz to 100kHz.
- Square Waves from 5Hz to 100kHz.
- Repeatable switch selected output frequency.
- Sine and square wave output available simultaneously.
- Metered sine wave output.
- Less than 0.1% sine wave distortion.

Kit K/IG-18 £37 Carr. 8/-

- Less than 50 nanoseconds square-wave rise time.
- Floating outputs.
- 8 output voltage ranges for sine wave from 0.003 to 10V rms.
- 3 output voltage ranges for square-wave from 0.1 to 10V pk to pk.
- $2\frac{1}{2}$" meter with one dB and two voltage ranges.
- 120 or 240 volt wiring options.

Ready to Use A/IG-18 £49 Carr. 8/-



IM-28 MM-IU RF-IU IO-18

NEW RESTYLED TEST, SERVICE AND WORKSHOP INSTRUMENTS

The Heathkit range of instrumentation can adequately provide engineers with quality instruments at lowest cost, whatever your requirements, be they VVMs, Generators, Oscilloscopes, Transistor Testers or Power Supplies.

FOR THE HOME WORKSHOP

The householder and hobbyist can, by purchasing easy-to-build Heathkits, obtain low cost models for testing household appliances, automobile circuitry, electrical/electronic models.

SEND FOR THE LATEST 1970
FREE HEATHKIT CATALOGUE
and see for yourself the wide Heathkit range of instruments, HiFi, Amateur and Leisure products.

To: **DAYSTROM LTD**, Gloucester, GL2 6EE, England
○ Please send me full details of Heathkit models
NAME ....
ADDRESS ....
WW-12B

HEATHKIT

DAYSTROM LTD, Gloucester GL2 6EE, England.
Tel: Glos 29451. Telex: 43216

QUAD 50 is a single channel 50 Watt amplifier designed for Broadcast, Recording and other applications in the Audio industry, completely proof against misuse and giving the highest quality of reproduction.

INPUTS – 0·5 Vrms unbalanced with provision for an optional plug-in transformer for bridging 600 ohms lines.
OUTPUTS – isolated providing 50 watts into almost any impedance from 4 to 200 ohms.
DIMENSIONS – $12\frac{3}{4}'' \times 6\frac{1}{4}'' \times 4\frac{1}{2}''$

Complete the coupon and post today.

Please send me full details of the QUAD 50 Amplifier

NAME ....

POSITION ....

COMPANY ....

ADDRESS ....

....

(BLOCK CAPITALS)

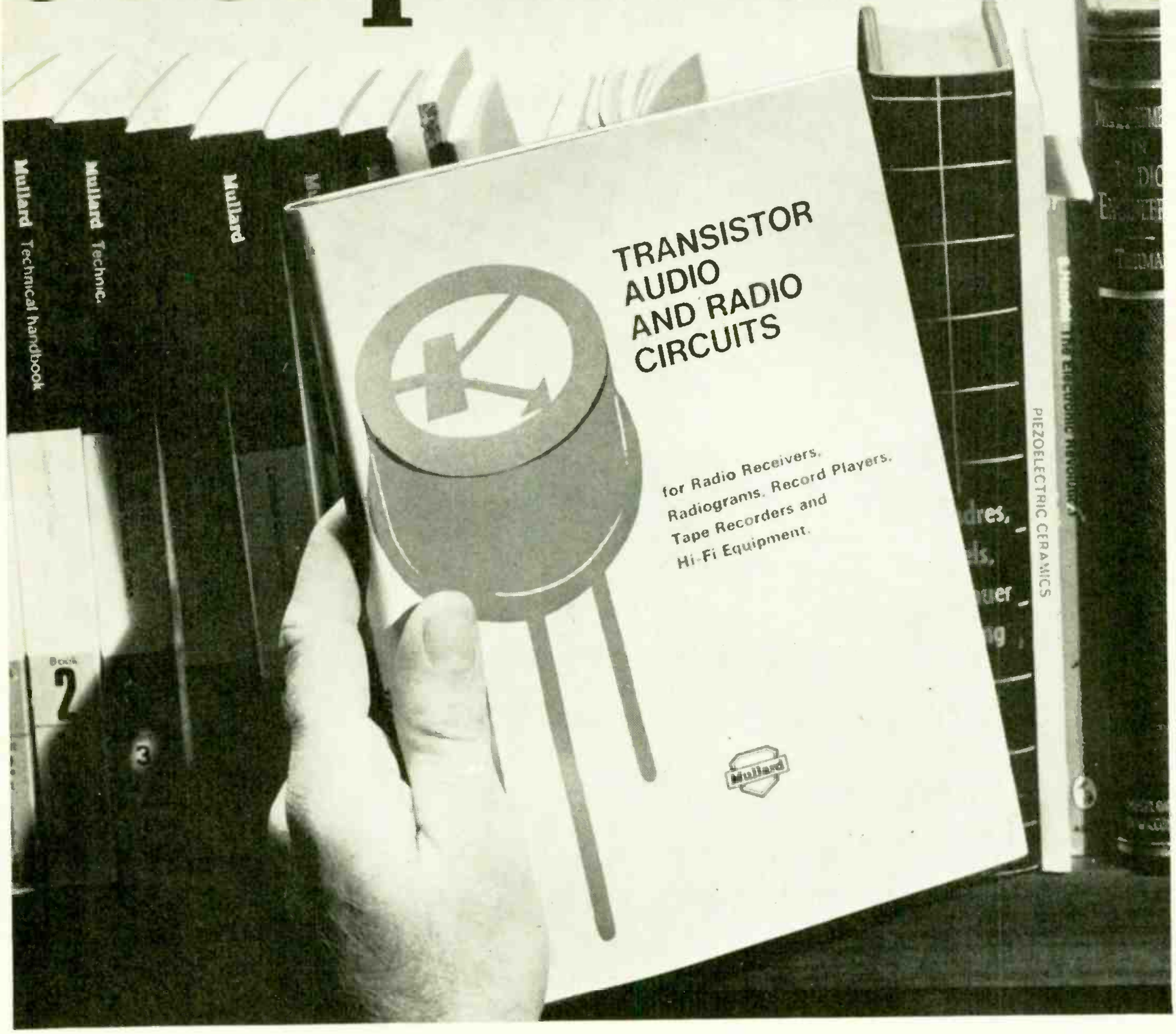
ACOUSTICAL MANUFACTURING CO. LTD.,
HUNTINGDON. Telephone: Huntingdon (0480) 2561/2

WW

QUAD

for the closest approach to the original sound

Just published!



Produced by experts for Engineers, Students and Enthusiasts

This is the book you've been waiting for! Over 200 information-packed pages. Circuits for audio amplifiers, record players, tape recorders, f.m. tuners and portable radio receivers up to hi-fi standards, all designed and proven in Mullard laboratories.

Mullard publications are renowned for the technical authority of their contents and the clarity and style of their presentation.

'Transistor Audio and Radio Circuits' is another outstanding example – there's bound to be a big demand.

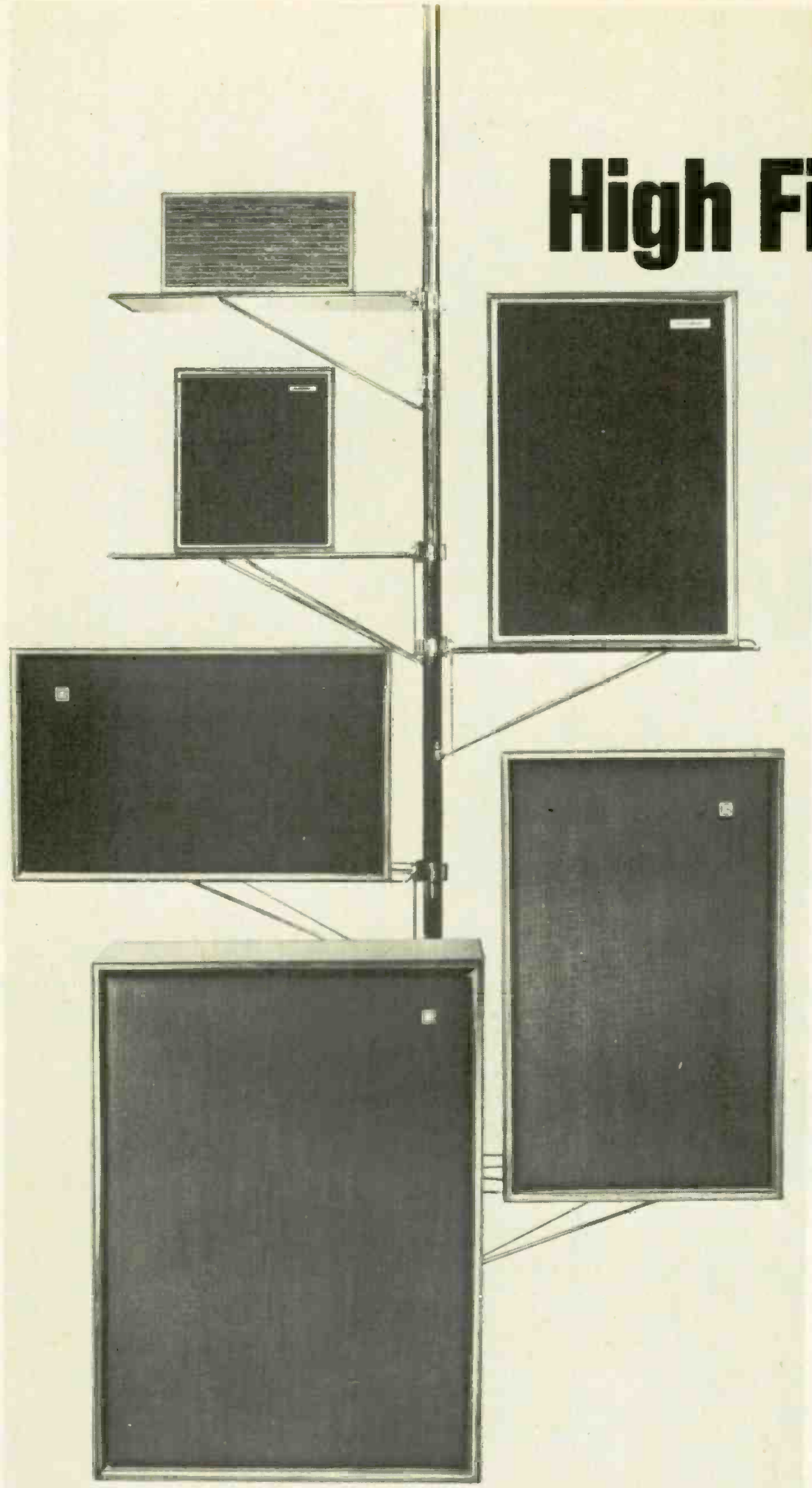
It's handy sized and strongly bound. Tremendous value at 30/-.

Get your copy from your local radio retailer, bookshop or direct from Mullard (cash with order) 32/- per copy including postage and packing.

Mullard

Mullard Limited, Distributor Sales Division, Mullard House, Torrington Place, London W.C.1.

CBD91



High Fidelity ....you ....and Goodmans

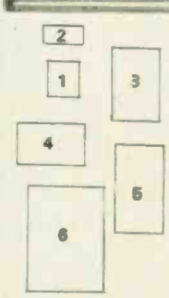
Goodmans Loudspeakers come into your life to stay. And stay! And that's why Goodmans make High Fidelity loudspeakers you can be proud to own.

From the smallest, Maxim, right up to the new king-size Magister you have Goodmans guarantee of quality ...... right along the line.

Goodmans have been in the Audio field for over 40 years, perfecting High Fidelity reproduction for your listening pleasure, check out that High Fidelity 'pure sound' at your Goodmans dealer today.

Complete the coupon for your free copy of the illustrated Magister leaflet/ 28 page Manual.

Goodmans
for High Fidelity



1. MAMBO* $10\frac{1}{4}''$ x $8\frac{3}{4}''$ x 8" deep. Each £17.18.0 + £4.0.5 P.T.
2. MAXIM Mini system $10\frac{1}{2}''$ x $5\frac{1}{2}''$ x $7\frac{1}{4}''$ deep. Each £16.7.0 + £3.13.5 P.T.
3. MARIMBA* For wall mounting 19"x13"x$5\frac{1}{2}''$ deep. Each £19.5.0 + £4.6.3 P.T.
4. MEZZO II Flush fitted attenuator $19\frac{1}{2}''$x12"x9" deep. Each £30.18.0.
5. MAGNUM K 3 speakers, 2 attenuators. 24" x 15" x $11\frac{1}{4}''$ deep. Each £40.2.0.
6. MAGISTER The new King-size. 27"x20"x$14\frac{1}{8}''$ deep. Each £57.0.0.

Recommended retail prices.
All finished in Teak or Walnut to order.
* Sold in ready matched pairs.

Goodmans Loudspeakers Ltd.,
Axiom Works, Wembley, Middlesex. Tel: 01-902 1200

FREE. Please send me:
☐ Goodmans Magister Leaflet
☐ Goodmans High Fidelity Manual
featuring all Goodmans products.
Tick which required.

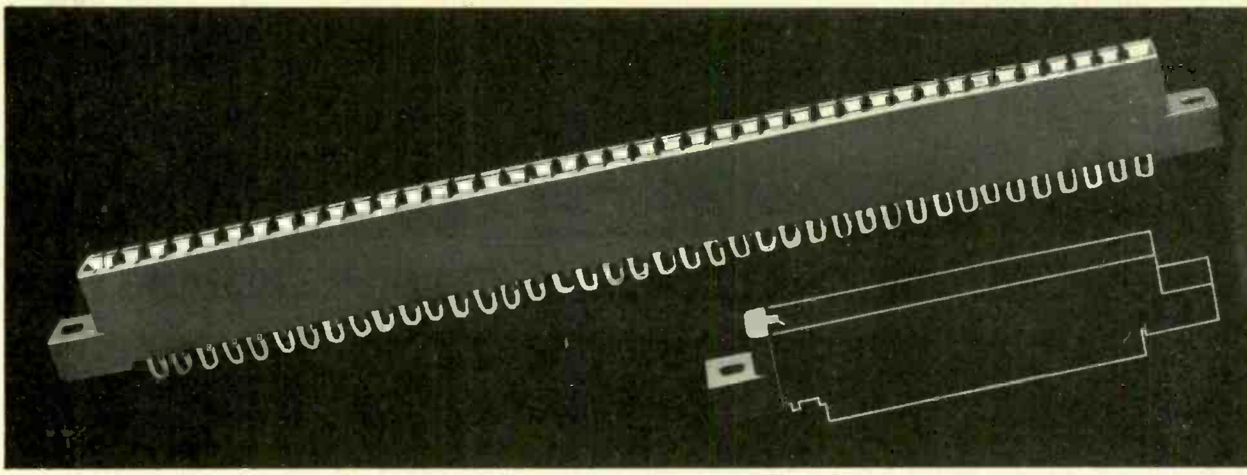
Name ______________________

Address ______________________

____

WW12

WW—024 FOR FURTHER DETAILS

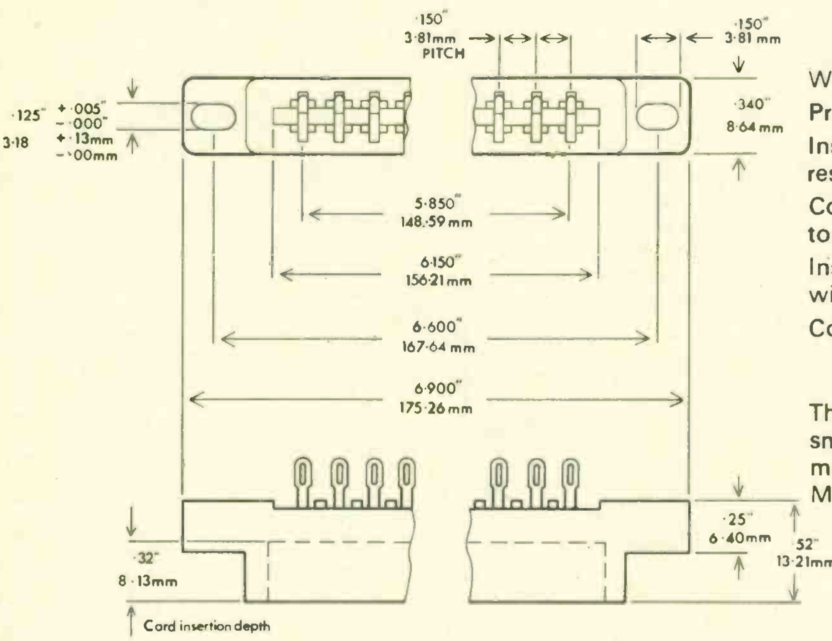


MP 1468 End Foot.

0.150" Edge Connector

"RL" SERIES

40 way single sided with solder tails	MP 1469
80 way double sided with solder tails	MP 1470
40 way single sided with printed wiring tails	MP 1471
80 way double sided with printed wiring tails	MP 1472
End foot	MP 1468
Polarising key	MP 1467



Working voltage	750V. D.C.
Proof voltage	2.5 KV
Insulation resistance (dry)	10^6 Megohms min.
Contact resistance to test gauge	10 Milli-ohms max.
Insertion and withdrawal forces	6 oz. per contact max.
Contact finish	Flow tin or hard gold (specify when ordering)

The connector can be reduced to a smaller number of poles by cutting the moulding and fitting a separate end foot, MP 1468.

mcmurdo

great facility for service

Member of the Louis Newmark Group, with access to the combined facilities of all other member companies.

Send for quotation

To: McMurdo Instrument Co. Ltd.,
Rodney Road, Portsmouth, Hampshire.
Telephone: Portsmouth 35361. Telex: 86112

Authorised Stockists:– **Lugton & Co. Ltd.**, 209/210 Tottenham Court Road, London W.1. Tel: Museum 3261 **Sasco**, P.O. Box No.20, Gatwick Road, Crawley Sussex, Tel: Crawley 28700 (also Chipping Sodbury 2641, Cumbernauld 25601 and Hitchin 2242) and agents in principal overseas countries.

WW—027 FOR FURTHER DETAILS

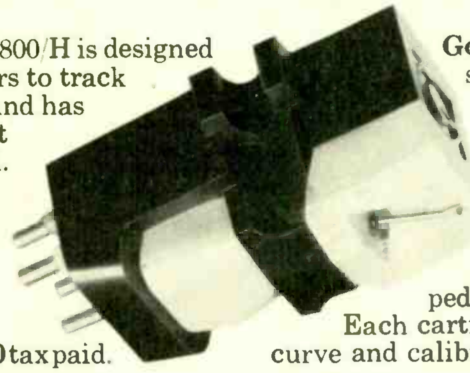
HIGH FIDELITY MOVING COIL STEREO HEADPHONES (TYPE LS43) Now available from DAYSTROM LTD. GLOUCESTER

WW—028 FOR FURTHER DETAILS

You're on the right track- with Goldring 800 magnetic cartridges

Goldring 800 magnetic cartridges track unerringly. Because that's the way we make them. They're designed to translate even the most delicate information stored in the groove back into an identical electrical signal. We call it the sound of true transduction.

Hear it for yourself. You'll know you're on the right track.



Goldring 800/H...the 800/H is designed for inexpensive changers to track between 2½—3½ grams and has a high output of at least 8mV. **£10.13.6** tax paid.

Goldring 800
...the 800 is designed for standard arms and changers where the requirements of high fidelity and robustness usually conflict. **£13.0.0** tax paid.

Goldring 800 E...is designed for transcription arms and a micro-elliptical diamond is fitted to a finer cantilever, end damped against natural tube resonance **£18.17.1** tax paid.

Goldring 800 Super E...the 800 Super E is for those to whom perfection is barely good enough. Extraordinarily low mechanical impedance for superb tracking capabilities. Each cartridge is supplied with its individual curve and calibration certificate. **£26.0.0** tax paid.

Send for details and complete range of Goldring Hi-Fi equipment
Goldring Manufacturing Co. (Great Britain) Ltd.
486-488 High Road, Leytonstone, London, E.11. Tel: 01-539 8343.

WW—029 FOR FURTHER DETAILS

TINSLEY STABILISED SUPPLY UNITS

TYPE 5260

Mains operated. Output voltage is selected in 1V. steps by means of decade dials calibrated in volts.
Stability: for voltages of over 100 V. better than 0.02% for the total load range with a mains variation of 20%.
Maximum output current: 100 mA.
Ripple and noise: less than 25 mV.
Effective output resistance: 0.01 Ω
Dimensions: 534 x 552 x 314 mm (21½ x 22 x 12½ in)

TYPE 5260A

1 V. to 3,000 V. d.c.

TYPE 5260B

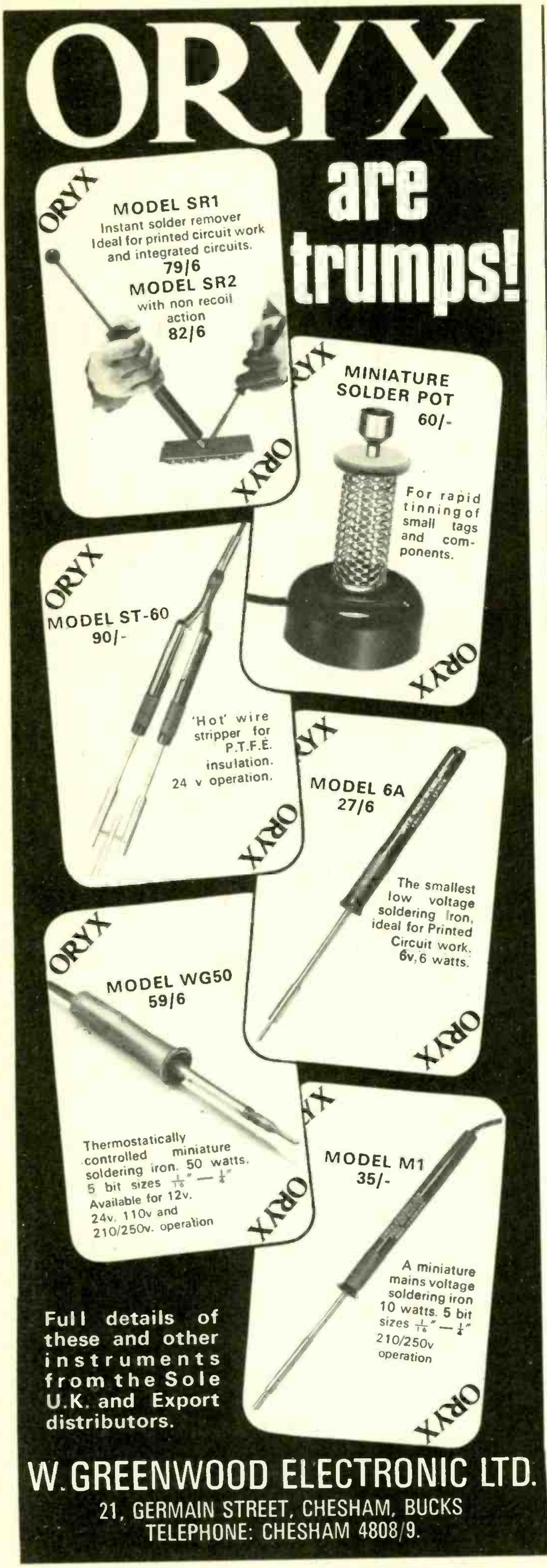
0.1 V. to 600 V. d.c.

For further details—List 211, sheet 3581

H. TINSLEY & CO LTD

Pacemakers in Precision Measurement
WERNDEE HALL, SOUTH NORWOOD, LONDON, S.E.25. Tel: 01-654 6046

WW—030 FOR FURTHER DETAILS



WW—035 FOR FURTHER DETAILS

M. R. SUPPLIES (London) LTD.,
(Established 1935)

Universally recognised as suppliers of UP-TO-DATE MATERIAL, which does the job properly. Instant delivery. Satisfaction assured. Prices nett.

ROOM THERMOSTATS. Danfoss wall-mounted Thermostats, 40 deg. F.-80 deg. F., 380 v. A.C., 4 amps.; 240 v. A.C., 6 amps. Our nett price **£1/12/6** (des. 2/-).

MINIATURE RUNNING TIME METERS (Sangamo). We have great demands for this remarkable unit and now can supply immediately from stock, 200/250 v. 50 c. synchronous. Counting up to 9,999 hours, with 1/10th indicator. Only 1¼ ins. square, with cyclometer dial, depth 2 ins. Many industrial and domestic applications to indicate the running time of any electrical apparatus, easy to install. **63/-** (des. 1/6).

SYNCHRONOUS TIME SWITCHES. (Another one of our popular specialities) 200/240 v. 50 c., for accurate pre-set switching operations. Sangamo S.254, providing up to 3 on-off operations per 24 hours at any chosen times, with day-omitting device (use optional). Capacity 20-amps. Compactly housed 4 in. dia., 3½ in. deep. **£6/4/6** (des. 4/6).

ELECTRIC FANS (Papst), for extracting or blowing. The most exceptional offer we have yet made. 200/250 v. A.C. Induction motor—silent running. 2,800 r.p.m. duty 100 C.F.M. Only 4½in. square and 2in. deep. Ideal for domestic or industrial use. Easy mounting. **£3/5/-** (des. 3/6).

SMALL GEARED MOTORS. In addition to our well-known range (List GM.169), we offer small open type S.P. Units 200/250 v. A.C., 1, 6, 12, 24, 60 r.p.m., approx. 5in. long, with 1in. shaft projection each side and enclosed gearbox. Suitable for display work and many industrial uses. Only **75/-** (des. 5/-).

MINIATURE COOLING FANS. 200/250 v. A.C. With open type induction motor (no interference). Overall 4in. × 3½in. × 2½in. Fitted 6-bladed metal impeller. Ideal for projection lamp cooling, light duty extractors, etc., still only **31/6** (des. 5/-).

AIR BLOWERS. Highly efficient units fitted induction totally enclosed motor 230/260 v. 50 c. 1 ph. Model SD.26, 60 CFM (free air) to 11.5 CFM at .15 WG (size approx.) 6 × 6 × 7in. Outlets 2½in. square. **£8/10/-** (des. 5/-). Model SD27, 120 CFM (free air) to 40 CFM at 1.2 WG, 8 × 7 × 9in. outlet 2½in. sq., **£11/15/6** (des. 5/-). Model SD28, 260 CFM (free air) to 127 CFM at 1.5 WG, 11 × 8 × 9in., outlet 3in. sq., **£13/17/6** (des. U.K. 7/6).

SYNCHRONOUS ELECTRIC CLOCK MOVEMENTS (as mentioned and recommended in many national journals). 200/250 v. 50 c. Self-starting. Fitted spindles for hours, minutes and central sweep second hands. Central one-hole fixing. Dia. 2½in. Depth behind dial only 1in. With back dust cover. **39/6** (des. 2/-). Set of three brass hands in good plain style. For 5/7in. dia. 2/6 For 8/10 dia. 3/6 set.

SYNCHRONOUS TIMER MOTORS (Sangamo). 200/250 v. 50 c/s. Self-starting 2in. dia. × 1¾in. deep. Choice of following speeds: 1 r.p.m., 12 r.p.h., 1 r.p.h., 1 rev. 12 hours, 1 rev. per day. Any one **42/-** (des. 2/-). Also high-torque model (G.E.C.). 2½in. × 2in. × 1¾in. 6 r.p.m., **57/6** (des. 2/-).

SMITHS TIMER MOTORS. Synchronous, self-starting 200/250 volts, 1 ph., 50 c. Clockwise. 4 r.p.m. only. Only **25/-** (des. 2/-).

MINIATURE D.C. MOTORS. 6/12 volts D.C. Ideal model makers. 4,000/9,000 r.p.m. no load. 1¾ in. × 1½ in. diameter. Flange fixing. Only **9/6** (des. 1/6).

EXTRACTOR FANS. Ring mounted all metal construction. T/E induction motor, silent operation, 8in. blade, 10in. max. dia., 400 CFM, **£6/2/6** (des. 5/-). Same model 10in. blade, 12in. max. dia., 500 CFM, **£6/12/6** (des. 6/-).

IMMEDIATE DELIVERY of Stuart Centrifugal Pumps, including stainless steel (most models).

OFFICIAL STOCKIST: "PARVALUX" Electric Motors (List G.M. 169)

M. R. SUPPLIES (LONDON) LTD., 68 New Oxford Street, London, W.C.1

(Telephone: 01-636 2958)

TELEPRINTERS · PERFORATORS REPERFORATORS · TAPEREADERS DATA PROCESSING EQUIPMENT

Codes: Int. No. 2 Mercury/Pegasus, Elliot 803, Binery and special purpose Codes.

2-5-6-7-8- TRACK AND MULTIWIRE EQUIPMENT

TELEGRAPH AUTOMATION AND COMPUTER PERIPHERAL ACCESSORIES
DATEL MODEM TERMINALS, TELEPRINTER SWITCHBOARDS

Picture Telegraph, Desk-Fax. Morse Equipment; Pen Recorders; Switchboards; Converters and Stabilised Rectifiers; Tape Holders, Pullers and Fast winders; Governed, Sychronous and Phonic Motors; Teleprinter Tables and Cabinets; Silence Covers; Distortion and Relay Testers; Send/Receive Low and High Pass filters; Teleprinter, Morse, Teledeltos Paper, Tape and Ribbons; Polarised and specialised relays and Bases; Terminals V.F. and F.M. Equipment; Telephone Carriers and Repeaters; Diversity; Frequency Shift, Keying Equipment; Line Transformers and Noise Suppressors; Racks and Consoles; Plugs, Sockets, Key, Push, Miniature and other Switches; Cords, Wires, Cables and Switchboard Accessories; Teleprinter Tools; Stroboscopes and Electronic Forks; Cold Cathode Matrics; Test Equipment; Miscellaneous Accessories, Teleprinter and Teletype Spares.

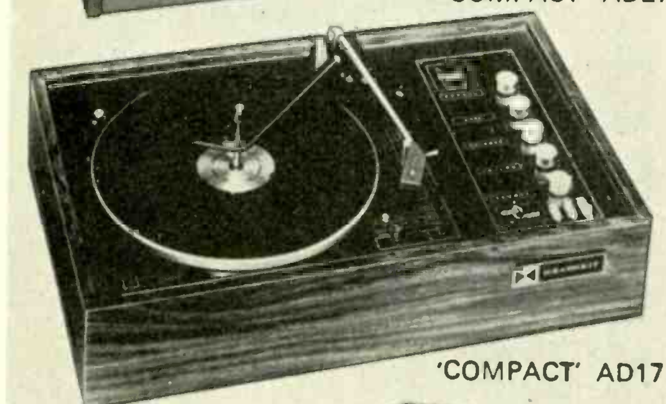
W. BATEY & COMPANY

Gaiety Works, Akeman Street, Tring, Herts.
Tel.: Tring 3476 (3 lines) Cables: RAHNO TRING
STD: 0442 82 TELEX 82362

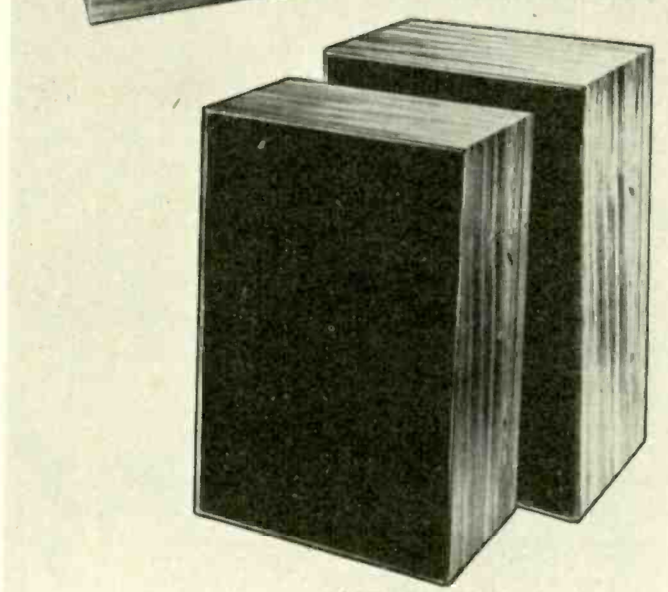
WW—036 FOR FURTHER DETAILS

Heathkit Present The 'Compact' Sound of the 70's

'COMPACT' AD27



'COMPACT' AD17



AMBASSADOR SPEAKERS

HERE'S VALUE IN 'STEREO COMPACTS'

Heathkit engineers took the highly praised AR-14 solid-state stereo receiver, modified it to fit the handsome teak or walnut veneered cabinet and combined it with a top performing BSR turntable. The result is a thoroughly impressive 15 watt per channel stereo performance. 4 to 16 ohms output impedances are more than enough to match any Hi-Fi speaker system. The BSR turntable comes fitted with a famous Shure magnetic cartridge. Easy to build, a real pleasure to listen to . . . the Heathkit AD-27 represents a remarkable value in stereo compacts at only £82 in kit form. Carr 13/- extra.

HERE'S VALUE IN 'STEREO COMPACTS'

Heathkit engineers took the solid-state stereo amplifier from the AD-27 mentioned above, matched it with a precision BSR turntable and put them in a handsome teak or walnut veneered cabinet. The 17 transistor, 6 diode amplifier is more than enough to drive any efficient Hi-Fi speaker system. Wide range Volume, Bass, Treble and Balance controls give you full command of the performance. Tuner and Aux inputs allow the addition of stereo FM or tape recorder at your convenience. The BSR turntable is equipped with a Shure magnetic cartridge. The AD-17 offers value for money at £54 in kit form. Carr 13/-. Plastic cover available at £3.12.0 extra.

HERE'S VALUE IN 'A HI-FI SPEAKER SYSTEM'

For the Hi-Fi enthusiast who demands outstanding performance . . . the New Ambassador offers this plus modern clean styling and quality. This entirely new 3 way Hi-Fi speaker system incorporates the very latest techniques in speaker design. The results are thoroughly impressive and the low price, £29.16.0 in kit form, represents wonderful value. Carr 15/-. Grille cloth available in dark grey or gold, brown fleck on white ground, please state requirements.

The impressive Heathkit range of Hi-Fi offers something for all tastes. Heathkit offers the best in quality sound, at direct from factory prices plus the added attraction of saving money by building D.I.Y. kits.

SEND FOR THE LATEST 1970
FREE HEATHKIT CATALOGUE

And see for yourself the wide Heathkit range of Hi-Fi, Instruments, Amateur Radio and Leisure products.

HEATHKIT

DAYSTROM LTD,
Gloucester, GL2-6EE
Tel Glos 29451 Telex 43216

To DAYSTROM LTD, GLOUCESTER GL2-6EE

☐ Please send me details of the new Heathkit Hi-Fi models

NAME ....

ADDRESS ....

WW.12A

Litesold

SOLDERING INSTRUMENTS

as selected for the DESIGN CENTRE LONDON

- SEVEN SIZES—10 WATTS TO 60 WATTS
- EXCELLENT THERMAL STABILITY (see new Litestat models for thermostatic control)
- STRONG, LIGHTWEIGHT, COMFORTABLY ELEGANT DESIGN
- UNEQUALLED PERFORMANCE
- LONG-LIFE BITS, PHILIPS IRON-COATED OR 'PERMATIP'
- INDICATOR LAMPS OPTIONAL ON ALL MODELS
- ALL VOLTAGES
- MANY ACCESSORIES: Heat Guards, Bench Stands, Bit-temperature Pyrometers, Thermal Wire Strippers, Solder pots.

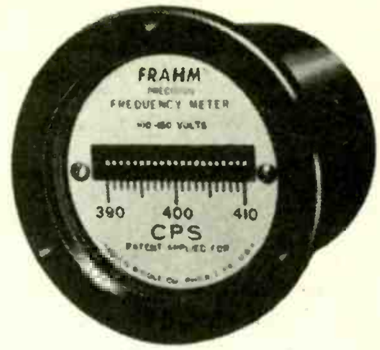
Please ask for colour catalogue L5

LIGHT SOLDERING DEVELOPMENTS LTD

28 Sydenham Road, Croydon, CR9 2LL
Telephone 01-688 8589 and 4559

WW—043 FOR FURTHER DETAILS

FRAHM vibrating reed FREQUENCY METERS



are widely used as standards in many industries because:—

1) They are accurate (to ±0.3% or ±0.1% as specified)
2) They are not voltage or temperature sensitive, within wide limits
3) They are unaffected by waveform errors, load, power factor or phase shift
4) They will operate on A.C., pulsating or interrupted D.C., and superimposed circuits
5) They need only low input power
6) They are compact and self-contained
7) They are rugged and dependable

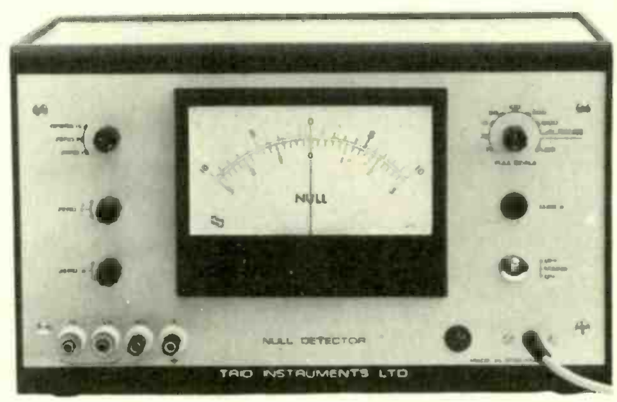
FRAHM Vibrating Reed Frequency Meters are available in miniature switchboard and portable forms, in ranges from 10 to 1700 cps. Descriptive literature on these meters, and on FRAHM Resonant Reed Tachometers, freely available from the sole U.K. distributors:—

ANDERS METER SERVICE

ANDERS ELECTRONICS LTD. 48/56 BAYHAM PLACE, BAYHAM STREET LONDON NW1 TEL: 01-387 9092.

WW—044 FOR FURTHER DETAILS

trio D. C. NULL DETECTOR



TRIO INSTRUMENTS Null Detector is a mains operated instrument intended for use with D.C. potentiometers and bridges. It features extremely high sensitivity combined with low noise and drift. Maximum sensitivity is 1 uV., F.S.D. which combined with a noise level of less than 0.05 uV peak to peak permits the use of this instrument at voltage levels of 0.1 uV.

TRIO INSTRUMENTS LTD.,
BURNHAM ROAD,
DARTFORD, KENT. Telephone: Farningham 2082

WW—045 FOR FURTHER DETAILS

PYE SPANS THE WORLD

Pye Telecommunications is the world's largest exporter of radiotelephone equipment. Pye Radiotelephones are used all over the world to ensure *instant* contact. Pye research development and quality control really *do* keep in touch with tomorrow.

rely on PYE

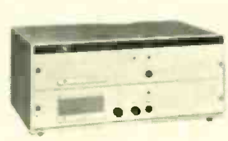
the vital contact

Pye 'Pocketfone' Personal Radiotelephone

New battery economy circuit · Extremely light-weight and compact · Reception free from noise and interference · Minimum of controls · Transmit button automatically extends antenna · Hearing aid socket · Easily accessible batteries.

Pye 'Bantam' Portable VHF Radiotelephone

Fully transistorised transmitter and receiver · Very high performance receiver · Crystal filter selectivity · 0·5W transmitter output · 250mW audio power · Long endurance with rechargeable or dry batteries · Can be used with external antenna to give greater range · Weatherproof.



Pye VHF Radiotelephone Fixed Station

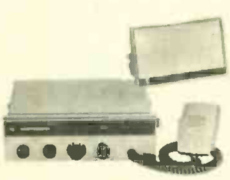
Solid-state receiver and transmitter · 10-15W R.F. output · Field-effect transistors used in receiver · Suitable for all climates · Electronic squelch · Designed to meet all relevant specifications.

Pye UHF Radiotelephone Fixed Station

Solid state receiver and transmitter · 8-10W R.F. output · Very high R.F. selectivity using field-effect transistors · Very low noise factor · Electronic squelch · A. C. or 24V d.c. operation · Suitable for all climates · Designed to meet all relevant specifications.

Pye 'Westminster' Remote Mounted Radiotelephone

Completely solid state · 5-8W R.F. output · 1-10 channels with solid state switching · Illuminated channel indicator · Suitable for all climates · Meets all relevant specifications.

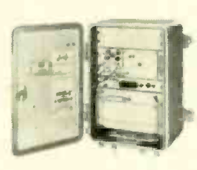


Pye 'Westminster' Front Mounted Radiotelephone

Completely solid state · 5-8W R.F. output · 1-10 channels with solid state switching · Suitable for all climates · Meets all relevant specifications.

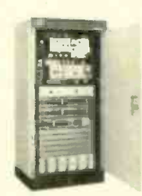
Pye Single-Sideband Radiotelephone

125W (p.e.p.) R.F. output · Fully transistorised receiver · C.W. facilities provided · Sideband selection by crystal filter · Carrier insertion for a.m. compatibility · Fixed or mobile application · Advanced transmitter design.



Pye 'Pioneer' Radiotelephone

Fully transistorised · For use with automatic, CB manual, or magneto exchanges · Weatherproof cabinet · Unattended operation over long periods · Facility for fitting privacy equipment · Optional single antenna operation.



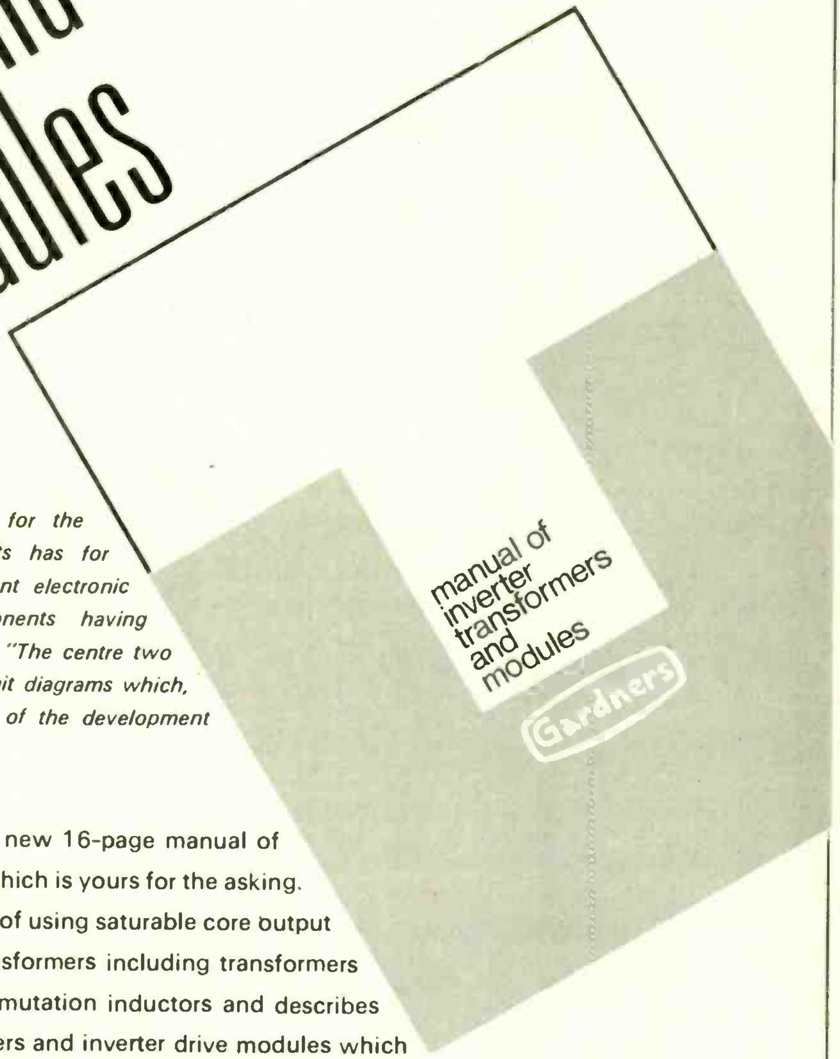
Pye 5-Circuit UHF Radiotelephone

Compact 5-circuit radio terminal · Fully-transistorised channelling equipment · Frequency-shift signalling · Continuous unattended operation in all parts of the world · Twelve standard plans for terminals and repeaters.

PYE
equipment gives you instant-contact with mobility

PYE TELECOMMUNICATIONS LTD. Cambridge England Telephone: Cambridge (0223) 61222 Telegrams: Pyetelecom Cambridge Telex: 81166

inverter transformers and modules



"The freedom to choose suitable line voltages for the operation of different types of electronic circuits has for many years, enabled engineers to produce efficient electronic equipment comprising many individual components having different optimum power supply requirements . . ." "The centre two pages of this brochure depict a series of basic circuit diagrams which, if taken in sequence, provide an historical survey of the development of modern inverter and converter systems".

This is an extract from the introduction to our new 16-page manual of inverter transformers and modules – a copy of which is yours for the asking. The contents include descriptions and methods of using saturable core output and driver transformers, linear core output transformers including transformers for the capacitively timed inverter circuit, commutation inductors and describes a number of representative converter transformers and inverter drive modules which have been added to our stock range of transformers and inductors.

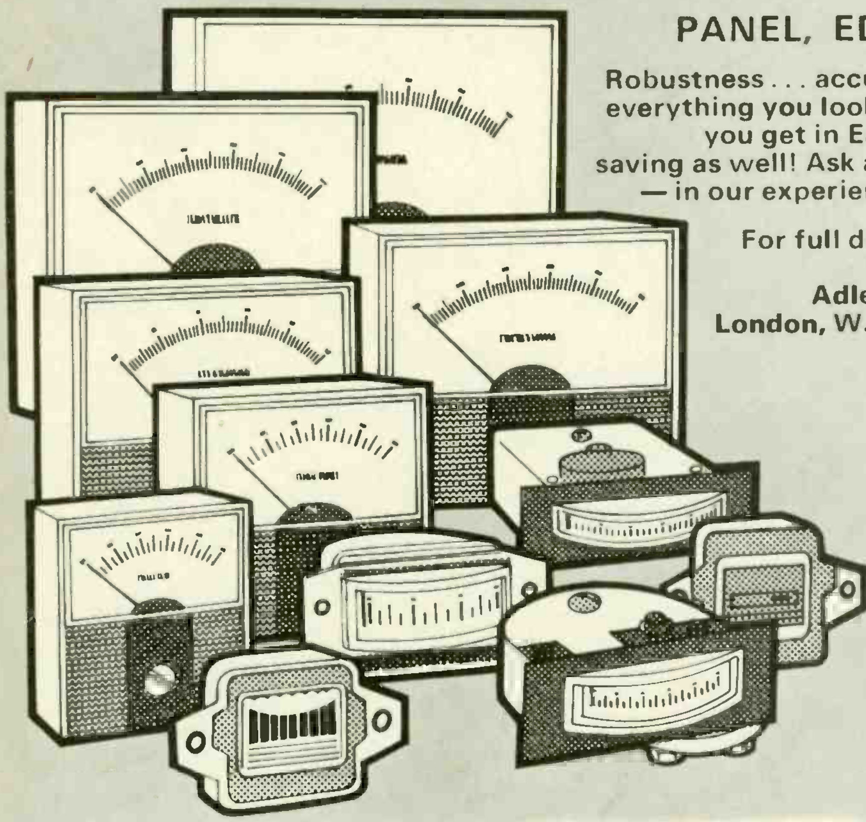
Please write to us and we will post to you your own personal copy of this new manual.

Gardners

a *vade mecum* on inverters!

Gardners Transformers Limited
Christchurch Hampshire BH23 3PN
Tel: Christchurch 2284
(STD 0201 5 2284)
Telex 41276 GARDNERS XCH

EAGLE INDUSTRIAL METERS



PANEL, EDGEWISE OR MINIATURE

Robustness . . . accuracy . . . reliability . . . good looks — everything you look for in the most costly instruments you get in Eagle meters! And at a very welcome saving as well! Ask anyone who uses Eagle instruments — in our experience every user becomes a salesman!

For full details send coupon to The Industrial Division of Eagle Products— **Adler Micro Electronics, Coptic Street, London, W.C.1** or quicker still ring 01-580 3914.

EAGLE PRODUCTS

DETAILS OF INDUSTRIAL METERS AND LATEST CATALOGUE PLEASE

NAME ....

COMPANY ....

ADDRESS ....

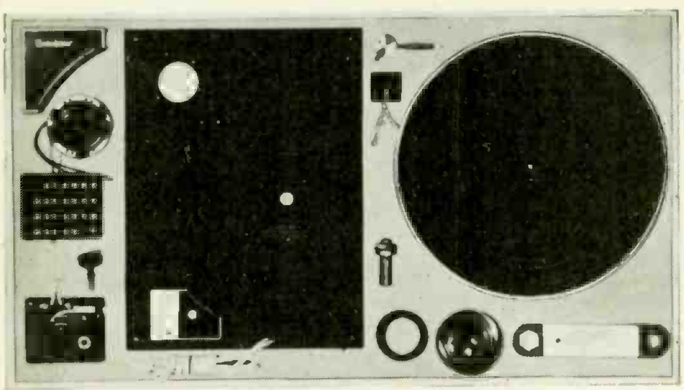
50

WW—055 FOR FURTHER DETAILS

Connoisseur

Precision in Sound

TURNTABLE KIT



The Famous B.D.1. Turntable which operates at $33\frac{1}{3}$ and 45rpm and incorporates a flexible belt drive system, virtually eliminating vibration and transmission noise, is now available in kit form. So simple to construct—such a beautiful performance!

Full details on request to

A. R. SUGDEN & Co. (Engineers) Ltd.

Market Street, Brighouse, HD6 1DX, Yorkshire. Tel.2142

WW—056 FOR FURTHER DETAILS

Valradio DC to AC TRANSVERTORS

(transistorised DC Invertors/Convertors)

Carry out your field tests using standard AC equipment.

A VALRADIO TRANSVERTOR will enable you to use all types of test instruments in the field or in motor vehicles.

Standard models are available for loads of 20W to 1000W for battery inputs of 12V & 24V and equally important to you most types are available from stock.

Prices range from £5 to £170.

The range is covered by three basic groups, having distinct characteristics.

T series—Square wave, frequency tolerance ± 3Hz
Q series—Square wave, frequency tolerance ± ¼Hz
S series—Sine wave, frequency tolerance ± ¼Hz

Typical model B12/200S input 12V output 115-230V 200W.

Price £67-12-0

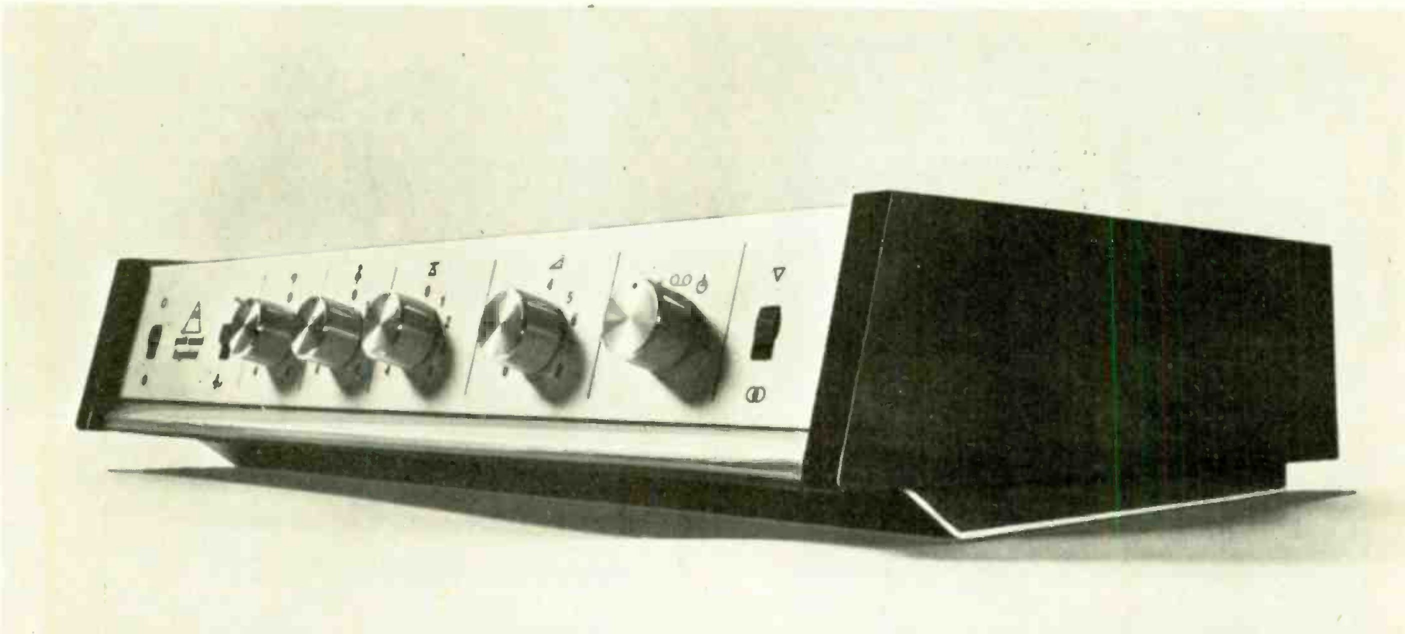
Type B12/200S

Send for full information and technical details:
VALRADIO LTD., Dept. W.C.4,
Browell's Lane, Feltham, Middlesex, England. Tel.: 01-890 4242

WW—057 FOR FURTHER DETAILS

peak sound englefield

peak sound



NEW DESIGN FROM PEAK SOUND

Proved-performance high fidelity with specification guarantee

The Peak Sound Englefield is a new system which assembles from laboratory designed modules to provide a cost-performance ratio which has never been bettered in high fidelity. Here is top-flight circuitry housed in a cabinet of elegantly original design which is both beautiful and completely practical back and front. By assembling these Peak Sound units, you can own one of the best high fidelity instruments you have ever heard or seen and all for a cost of about £38. The assembly is supplied complete down to the necessary connecting wires supplied colour coded, cut to length and stripped at the ends for soldering. You can use the Englefield Cabinet design to house either the 12 + 12 system as published in *Practical Wireless*, or the 25 + 25 watt system as approved for the *Hi-Fi News* Twin Twenty by Reg Williamson. Go to your stockist and ask to see and hear Peak Sound equipment now.

Matching F.M. Tuners will be available very shortly.

and this is the Peak Sound Specification Guarantee

Peak Sound guarantee that their equipment meets all specifications as published by them and that these are written in the same terms as are used in equipment reviews appearing in this and other leading high fidelity journals. Audio output powers are quoted at continuous sine wave power in terms of Root Mean Square values (R.M.S.) into stated loads at stated frequencies.

THE SPECIFICATION

Using two Peak Sound PA.12-15's, driven simultaneously at 1 KHz from 240 V. mains supply.

Output per channel: 11 watts into 15Ω: 14 watts into 8Ω (*see spec. guarantee*).

Frequency bandwidth: 10Hz to 45 KHz for 1dB at 1 watt.

Total Harmonic Distortion at 1 KHz at 10 watt into 15Ω—0.1%.

Input sensitivities: Mag PU.3.5 mV imp. R.I.A.A. equalized into 68 KΩ: Tape. 100 mV linear into 100 KΩ: Radio. 100 mV linear into 100 KΩ.

Overload factor: 29 dB on all input channels.

Signal/noise ratio: −65 dB on all inputs. Vol. control max.

Controls: Volume, Treble, Bass, Low-pass Filter, Mono/Stereo: On/off: Balance.

Using two PA.25-15 amplifiers, output is then 25 watts into 15Ω or 8Ω per channel at 1 KHz.

Power bandwidth for −1 dB at 20 watts R.M.S. into 15Ω at less than 0.25% distortion is 20 Hz to 20 KHz.

THE MODULES

Englefield Amplifier Cabinet with front panel, knobs, sockets, cut and stripped wire, fuses, edge connectors, etc.	£6 0 0
Two PA. 12-15 power amp. built modules	£11 19 0
SCU/400 Pre-amp/Control module, built	£15 15 0
PS/45 Power Supply kit	£4 10 0
	£38 4 0

Using two PA.25-15 modules at £11/15/– each and PS/68S Stabilized Power Supply Unit at £13/10/–, total price for complete system comes to **£58 15 0**

peak sound

Go to your Stockist. Peak Sound products are already available from dealers in many parts. If your own local stockist is not yet ready with the Peak Sound items you require, please send direct together with your supplier's name and address and your requirements will be dealt with without delay.

TRADE ENQUIRIES INVITED.
**PEAK SOUND (HARROW) LTD.,
32 St. Jude's Road, Englefield
Green, Egham, Surrey**

Telephone: EGHAM 5316

To Peak Sound, 32 St. Jude's Rd., Englefield Green, Egham, Surrey.

Details of Englefield systems, please and ....

Name ....

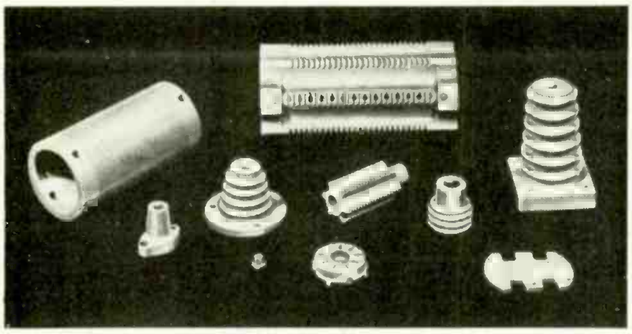
Address ....

.... WW12

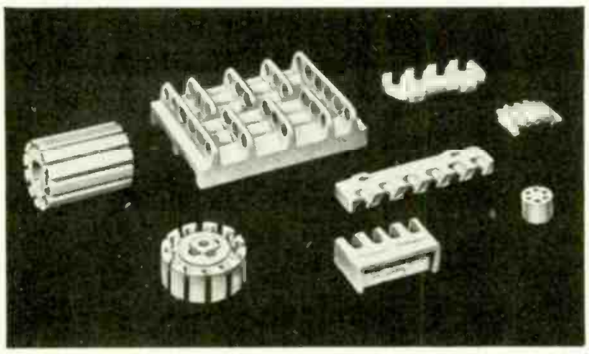
Write your stockists name and address in margin below and cut out with coupon if necessary.

WW—058 FOR FURTHER DETAILS

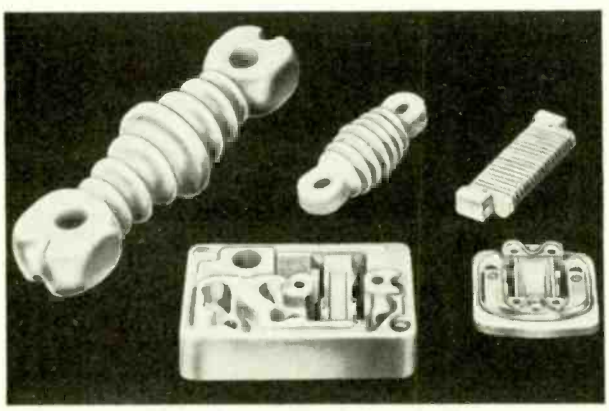
Bullers CERAMICS
for the ELECTRONIC INDUSTRY
(and Electrical Appliance Manufacture)



Frequelex—for high-frequency insulation.



Refractories for high-temperature insulation.



Bullers porcelain for general insulation purposes.

Meticulous care in manufacture, high quality material, with particular attention applied to *dimensional precision and accuracy*, explain the efficiency and ease of assembly when using Bullers die pressed products.

Write today for detailed particulars.

BULLERS LIMITED
Milton, Stoke-on-Trent, Staffs.
Phone: Stoke-on-Trent 54321 (5 lines)
Telegrams & Cables: Bullers, Stoke-on-Trent

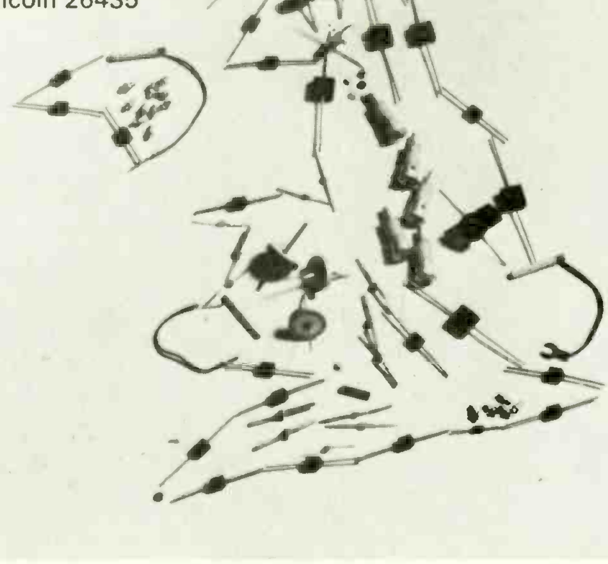
WW—059 FOR FURTHER DETAILS

The most advanced microwave devices are here.

Schottky Barrier Diodes
*Ga As Mixers *Ga As Detectors *LID, Reversible Ceramic
Oscillators
*Ga As Gunn Diodes *Si Avalanche (Impatt) Diodes
*Welded Ceramic S3
Backward Diodes
*Ge Planar Detectors *LID, Coaxial
Microwave Transistors
*Si 1 watt Power amplifiers *Si Low Noise, 5dB receiver
Tuning Varactor Diodes
*Si VHF & HF plastic, High Q *Si Hermetic, Wide Capacitance Range
Varactor Multiplier Diodes
*160 GHZ, Si welded Ceramic
P-I-N Diodes *Switches
*Limiters *Modulators *Stick, Coaxial, Epoxy and Pill
Point Contact Diodes
*Mixers *Detectors *Coaxial, Single Ended Ceramic
Microwave Integrated Circuits
*Microstrip SUB-SYSTEMS incorporating microwave semiconductors

AEI SEMICONDUCTORS

Write for your copy of abridged catalogue to:
AEI Semiconductors Ltd.
Carholme Road, Lincoln
Telephone:
Lincoln 26435



WW—060 FOR FURTHER DETAILS

The Sansui truth machine.

You're as close to the truth as you can get when you hear your favorite music through this professional stereo system from Sansui.

Program sources come to you in a new and exciting form with the TU-555 AM/FM Multiplex Tuner and SR-3030BC 2-speed manual turntable. The professional tuner brings FM sensitivity to as low as 2.5μV (IHF) with advanced FET circuitry. The precision direct belt-drive turntable brings you flawless characteristics of wow and flutter, along with maximum stereo separation and a high S/N ratio.

From whatever the program source, the 60 watt solid state AU-555 Stereo Control Amplifier handles incoming signals in a way that really gets the truth across to the speakers. It offers a power bandwidth from 20 to 30,000Hz with a distortion factor of less than 0.5%.

You're face-to-face with the truth when you hear your favorite selections through the SP-200 3-way 5-speaker high fidelity speaker system. Featuring Sansui's unique bass reflex design, this system offers a full 40 watts in handling capacity and a wide 35 to 20,000Hz in frequency response.

And to hear the truth with your ears alone, the Sansui truth machine is topped off with the SS-2 stereo headphone set. It gives you 20 to 18,000Hz in frequency response with maximum stereo separation.

See and hear the Sansui truth machine soon at your nearest authorized dealer.

sansui

England: TECHNICAL CERAMICS LTD. Thornhill, Southampton Hampshire Tel: Southampton 45166 / 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: MICHAEL SHEN, EUROTEX 15, Rue Glesener / Italy: ELECTRONICA LOMBARDA S.P.A. Via Montebello 27, 20121 Milano / Austria: THE VIENNA HIGH FIDELITY & STEREO CO. 1070 Wien, Burggasse 114 / Belgium: MATELECTRIC S.P.R.L. 199, Boulevard Leopold II Laan, 199, Bruxelles 8 / Netherlands: TEMPOFOON BRITISH IMPORT COMPANY N.V. Tilburg, Kapitein Hatterasstraat 8, Postbus 540 / South Africa: GLENS (PTY) LTD. P.O. Box 6406 Johannesburg / Southern Yemen: BHICAJEE COWASJEE LTD. Steamer Point, Aden / SANSUI ELECTRIC CO., LTD. FRANKFURT OFFICE Schillerstrasse 31, 6 Frankfurt am Main, West Germany / SANSUI ELECTRIC CO., LTD. 14-1, 2-chome, Izumi, Suginami-ku, Tokyo, Japan

Some notes on Bridge Measurement by WAYNE KERR

Number 5

Self-Balancing Bridges

In this series of notes we have examined some of the advantages of the Transformer Ratio-Arm Bridge and the facilities which are available when this type of bridge is used. However, only manually balanced networks have been considered, but there are many times when it is desirable to have an analogue output voltage in proportion to the value of the component being measured. Such a voltage may be used to operate remote indicators, chart recorders or alarm circuits, apart from providing a convenient form of local display which may consist of either a moving coil meter or a digital voltmeter.

Figure 1 shows a basic transformer ratio-arm bridge circuit.

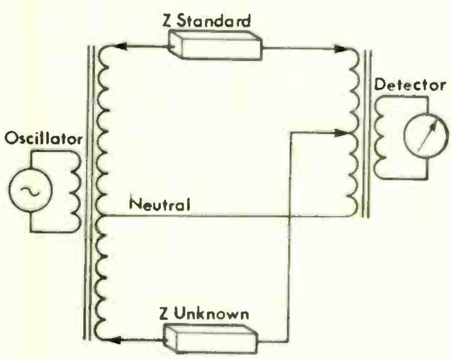


Fig. 1

Normally, the network is manually balanced so that the currents flowing in the right hand transformer give zero flux, and it is clear that any variation in either the a.c. voltage produced by the oscillator or the gain of an amplifier forming part of the detector will not affect the balance point. However, if an attempt is made to connect a voltmeter to the output of the detector and calibrate the output voltage against the value of the unknown impedance, the following difficulties arise:

(a) Variations in oscillator output level and amplifier gain directly affect the indicated voltage.
(b) The voltmeter will indicate the modulus of the impedance, and variations in both the resistive and the reactive terms will affect the indicated value.
(c) When the network is substantially off balance, the ability of the neutral connection to control an electric field is impaired. The last issue of these notes showed that this control facility was due to balanced currents flowing in the transformer.

Figure 2 shows a block-schematic circuit which removes these difficulties by forming a self-balancing network.

A stable oscillator provides the signal for the bridge and also a phase reference voltage which is fed to two phase-sensitive detectors.

The output of the amplifier provides a bridge balancing voltage which is applied through a resistor to a winding on the right hand transformer. The initial current flowing in the transformer is therefore opposed by this 'feedback' current which can be made very nearly equal to the initial current. The approach to the ideal condition of equality is limited only by the gain of the amplifier, which can be made as large as necessary.

The amplifier output is also connected to the phase-sensitive detectors, one of which incorporates a unity gain, 90° phase shift network. Analogue voltage outputs are therefore formed which independently show the amount of variation of the resistive and reactive terms from the value set by the standard impedance.

The use of this circuit now extends the usefulness of the transformer ratio-arm bridge to include many process control and monitoring applications. The precision of measurement and the facility for measuring high impedances accurately at the end of long lengths of cable, together with the self-balancing network, offer unique advantages for the measurement of transducer parameters.

The basic circuit shown in Figure 2 can be adapted to give many different varieties of transformer ratio-arm bridge. These bridges can be designed for use in industrial measurement with suitable transducers as well as forming valuable tools for research.

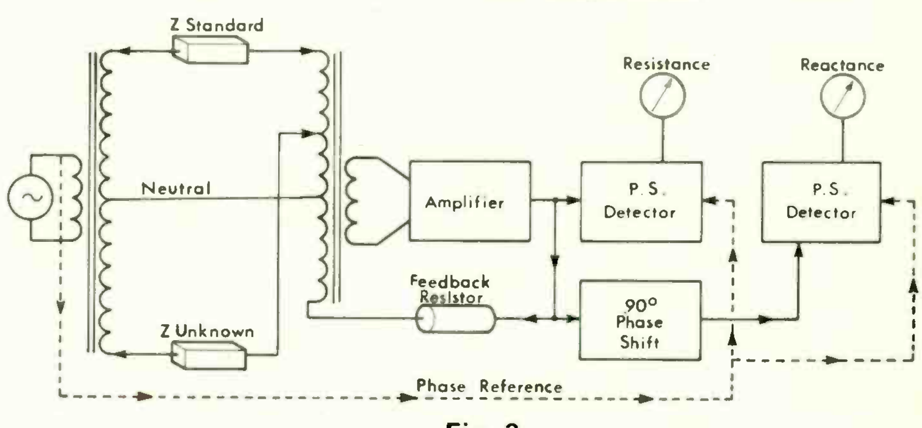


Fig. 2

from the new Bradley, six not-so-new Bradleys

These days you can be fairly sure that Bradleys are working on something new. But it's reassuring to know that they aren't abandoning their old friends. Like the 127B Voltage Calibrator. Like the 132 Current Calibrator. The 144 Current Multiplier, the 125B a.c. Voltage Calibrator, and the 156 Oscilloscope Calibrator. Or the Battery Line Oscilloscope.

And when you see the story behind them, you'll soon see why we're hanging on to them.

Take the 127B. And the 125B. And the 132. They're all designed to make your calibration simpler. So you can read off directly the percentage error. They're guaranteed for a year. And you can carry them anywhere.

The 127B gives you an accuracy of 0.05% over the range of 0 to 509 volts d.c.

The 125B has an accuracy of 0.2% from 0 to 511 volts a.c. (It also has extremely low harmonic distortion.) Spot frequencies 50, 60, 400 and 1000 Hz, with alternative frequencies up to 2400 Hz available.

The Model 132 provides current up to 100 mA in 1μA steps, at an accuracy of 0.05%. *And there is the recently introduced new 144 multiplier.* This will extend the range to 10 amps with the same high accuracy.

For the oscilloscope user, there is the 156 Oscilloscope Calibrator. It calibrates vertical amplitude and sweep speeds. It checks risetime. And it features direct reading of percentage deviation.

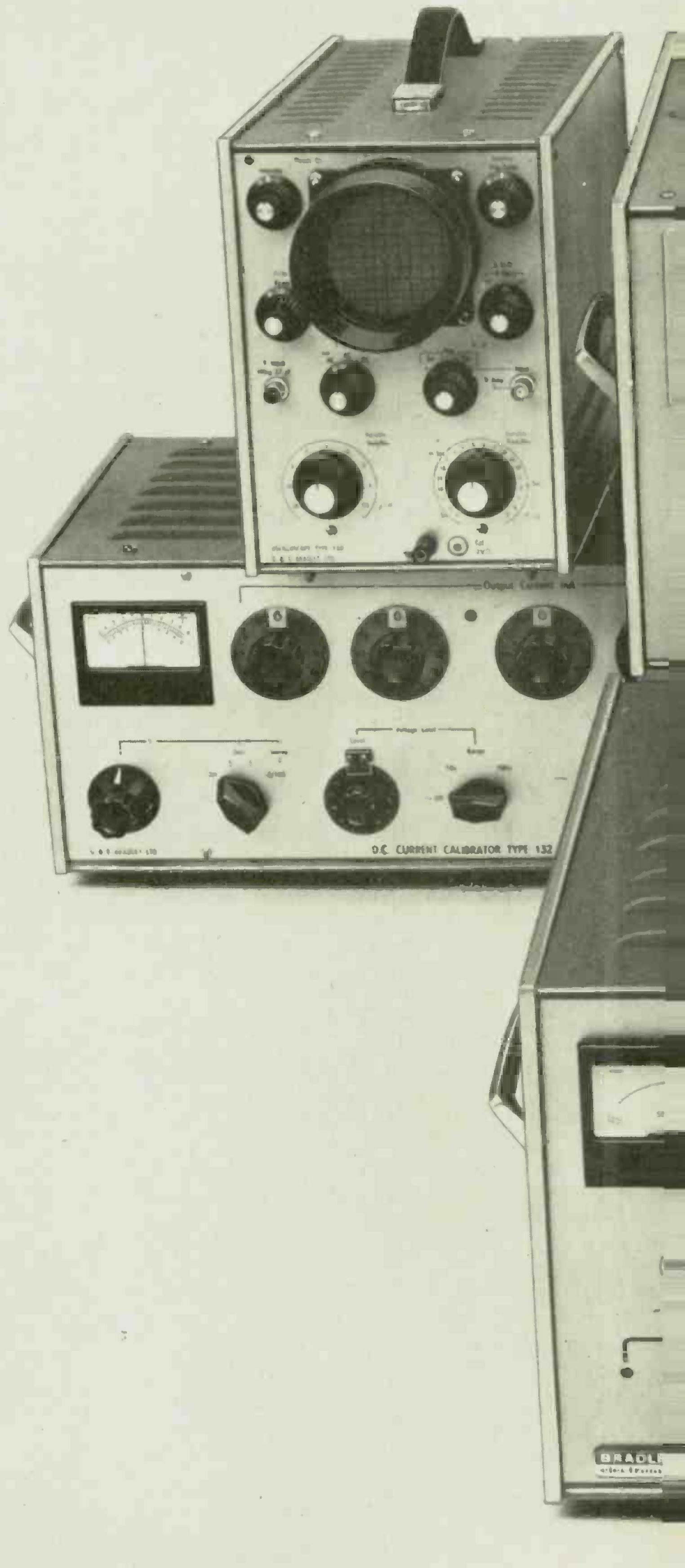
Finally there's the Battery/Line Oscilloscope. It has a bandwidth of 20MHz and an input sensitivity of 5mV per division. It can be operated from its own self contained batteries or from a.c. mains.

They're all part of the new Bradley. Even if they're firm friends of yours.

G. & E. BRADLEY LTD.
Electral House,
Neasden Lane,
London, N.W.10.
Tel: 01-450 7811 Telex: 25583

EXPECT MORE FROM THE NEW BRADLEY

BRADLEY electronics



WW—070 FOR FURTHER DETAILS


PLUG-IN UNIT
TYPE 1254F
A.C. CALIBRATOR
Time
Risetime
X1
X10
4V
40V
1A
X100
4V
10A
Input
L
H
Output
L
H
PRECISION D.C. MULTIPLIER TYPE 144

TRIO's New JR-310 SSB Professional Perfection for Amateur Enjoyment

JR-310

SSB COMMUNICATIONS RECEIVER

* High-stability VFO of 2 FET's and 2 transistors and easily handles QSO's for hours. * Precision double gear dial—a TRIO innovation —with linear frequency variable capacitor. Possible to get finer reading 1KHz. One dial rotation covers 25KHz, makes SSB demodulation easier. * Frequency range covers entire amateur band from 3.5MHz to 29.7MHz. One-touch selection system switches bands. WWV reception of 15MHz possible. * MHz band circuit structure patterned on Collins type double conversion system so first oscillation is by crystal control, second local oscillation by VFO.

SPECIFICATIONS OF JR-310

* FREQUENCY RANGE: 3.5-29.7MHz (7 Bands)
* SENSITIVITY: 1μV (at 10dB S/N)
* IMAGE RATIO: More than 50dB
* FREQUENCY STABILITY: ±2KHz in 1–60min. after switching on, subsequently within 100Hz per 30min.
* Dimensions: 13"(W), 7-3/32"(H), 12-3/16"(D).

Model SP-5D
COMMUNICATION SPEAKER

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

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

* A mechanical filter enabling superb selectivity with ordinary IF transformers. * Frequency Range: 550KHz to 30MHz (4 Bands) * Sensitivity: 2μV for 10dB S/N Ratio (at 10MHz) * Selectivity: ±5KHz at −60dB (±1.3KHz at −6dB). When using the Mechanical Filter * Dimensions: Width 15", Height 7", Depth 10"

the sound approach to quality
TRIO
TRIO ELECTRONICS, INC.

TO: B.H. Morris & Co., (Radio) Ltd. WW
Send me information on TRIO COMMUNICATION RECEIVERS & name of nearest TRIO retailer.
NAME: AGE:
ADDRESS:

TRIO-KENWOOD ELECTRONICS S.A. 160 Ave., Brugmann, Bruxelles 6, Belgium
Sole Agent for the U.K. **B. H. MORRIS & CO., (RADIO) LTD.** 84/88, Nelson Street. Tower Hamlets, London E. 1, Phone: 01-790 4824

WW—073 FOR FURTHER DETAILS

WEYRAD

COILS AND I.F. TRANSFORMERS IN LARGE-SCALE PRODUCTION FOR RECEIVER MANUFACTURERS

P.9 SERIES 10 mm. × 10 mm. × 14 mm. Ferrite cores 6 mm. 472 kc/s operation. Single-tuned I.F.s and Oscillator Coils.

P.55 SERIES 12 mm. × 12 mm. × 20 mm. Ferrite cores 4 mm. 472 kc/s operation. Single-tuned I.F.s and Oscillator Coils.

T.41 SERIES 25 mm. × 12 mm. × 20 mm. Ferrite cores 4 mm. 472 kc/s operation. Double-tuned 1st and 2nd I.F.s and Single-tuned 3rd I.F. complete with diode and by-pass capacitor.

These ranges are available to manufacturers in versions suitable for most of the popular types of Transistors. The Oscillator coils can be modified to enable specific tuning capacitors to be used provided that bulk quantities are required.

OUR WINDING CAPACITY NOW EXCEEDS 50,000 ITEMS PER WEEK

On the most up-to-date and efficient machines backed by a skilled assembly labour force for all types of coils and assemblies.

WEYRAD (ELECTRONICS) LIMITED, SCHOOL ST., WEYMOUTH, DORSET

WW—074 FOR FURTHER DETAILS

DIOTESTOR IN-CIRCUIT TRANSISTOR TESTER

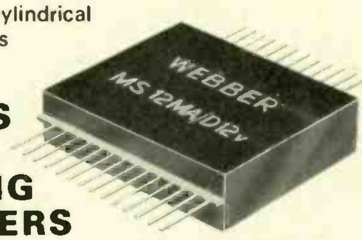
BRITEC LIMITED, 17 Charing Cross Road, London, W.C.2
Tel: 01-930-3070

WW—075 FOR FURTHER DETAILS

ENCAPSULATION–

low tool cost method for cylindrical coils and potting. Enquiries also for—

REED RELAYS
SOLENOIDS
COIL WINDING
TRANSFORMERS to 8 K.V.A.



Relay module 12-way "MS" range

R. A. WEBBER LTD.
Knapps Lane, Bristol 5. 0272 657228

WW—076 FOR FURTHER DETAILS

Wideband Modulators

FROM STOCK

Hatfield Types MD4 and MD6 are wideband ring modulators designed for use in 50/75-ohm systems. Type MD4 is fully shielded and fitted with BNC connectors. Alternatively, Type MD6 is a miniature encapsulated package for printed circuit board mounting. Both units are of robust design, and are capable of very good performances as an amplitude modulator, mixer, phase detector or current controlled V.H.F. Attenuator.

New units include Types MD5 and MD7. These are of similar construction to Types MD4 and MD6, but operate in the frequency range 10KHz-100 MHz, MD5 being fully shielded and fitted BNC Connectors, and MD7 a miniature encapsulated type for direct mounting on a printed circuit board.

- Excellent Balance
- Wide Band
- Low Insertion Loss
- Flat Response
- Low Noise Factor
- P.C.B. and B.N.C. Models
- Hot Carrier Diodes

Write for full details—deliveries from stock.

Dept. WW,
HATFIELD INSTRUMENTS LTD., Burrington Way, Plymouth, Devon
Telephone: Plymouth 72773/5. Telex: 45592 Cables: Siglen Plymouth
SOUTH-EAST ASIA—for prompt service and deliveries contact:
HATFIELD INSTRUMENTS (NZ) LTD., P.O. Box 561, Napier, New Zealand.

HATFIELD BALUN

WW—077 FOR FURTHER DETAILS

There are a couple of things you should know about the Welbrook All Silicon Stereo Amplifier

DISTORTION

0.1% at all output levels

PRICE

£42. 0. 0d.

A new and unique method of equalising impedances in the output stage enables only Welbrook to offer such true high fidelity reproduction at such low cost.

This technical breakthrough brings you the Welbrook W20 Stereo Amplifier, with no distortion rise at any level, for only £42. 0. 0d. This is a truly remarkable bargain among high quality stereo amplifiers, using Class B operation.

Performance:
Power Output:
24 watts R.M.S. (12 watts per channel) into 4 ohms load.
20 watts R.M.S. (10 watts per channel) into 8 ohms load.
14 watts R.M.S. (7 watts per channel) into 15 ohms load.
Total Harmonic Distortion:
Typically 0.1% for 10 watts per channel into 8 ohms load at 1 kHz with no increase at low levels.
Hum and Noise:
With volume control at minimum-80 dB. With volume control at maximum-55 dB.
Frequency Response:
-1 dB at 30 Hz and 15 kHz.
Inputs: Pickup:
R.I.A.A. characteristic, sensitivity adjustable up to 3 mV to suit crystal, ceramic or magnetic cartridges.
Tuner:
Flat characteristic-sensitivity 100 mV-input impedance 100 k ohms.
Tape:
Flat characteristic-sensitivity 100 mV-input impedance 100 k ohms.
Outputs:
Loudspeaker outputs to suit 4, 8 and 15 ohms. Tape output for recording-200 mV for rated input sensitivities-minimum external impedance 10 k ohms.
Tone Controls: **Bass:**
Ganged control giving ± 14 dB at 30 Hz
Treble:
Ganged control giving ± 14 dB at 15 kHz
Balance Control:
Facility to reduce output from either channel continuously from maximum output to zero.
Dimensions:
$14\frac{3}{4}$" wide x 9" deep x 4" high (cabinet)
Price:
Recommended retail price; £42. 0. 0d. including cabinet.

For full details of the Welbrook Stereo Amplifier post the coupon to:

WELBROOK ENGINEERING & ELECTRONICS LIMITED,
BROOKS STREET, STOCKPORT, CHESHIRE, SK1 3HT

To: Welbrook Engineering & Electronics Limited;
Please send me full details of the Welbrook Stereo Amplifier.

NAME ....

ADDRESS ....

....

.... (WW2)

WW—078 FOR FURTHER DETAILS

A.P.T. transistor stabilised power units

THE POWER PACK PEOPLE

Model TCU 250 transistor stabilised power supply provides d.c. output of 2A at voltages of 0–50V in five 'continuous control' 10V steps, making it suitable for use in laboratories where adjustable voltages are required. Attractively styled, the TCU 250 incorporates a number of novel features resulting in an exceptionally small size for its performance.

FEATURES

Output voltage fully variable 0–50V 2A.
Adjustable overload trip protection.
Small size 15.2 x 15.2 x 25.4 cm high (6" x 6" x 10").

Price £65 nett ex works, prompt delivery.

Please send me details of the TCU range of transistorised power supplies.

NAME ....

COMPANY ....

ADDRESS ....

....

....

A.P.T. ELECTRONIC INDUSTRIES LTD
Chertsey Road, Byfleet, Surrey.
Tel: Byfleet 41131/2/3/4.

WW 12

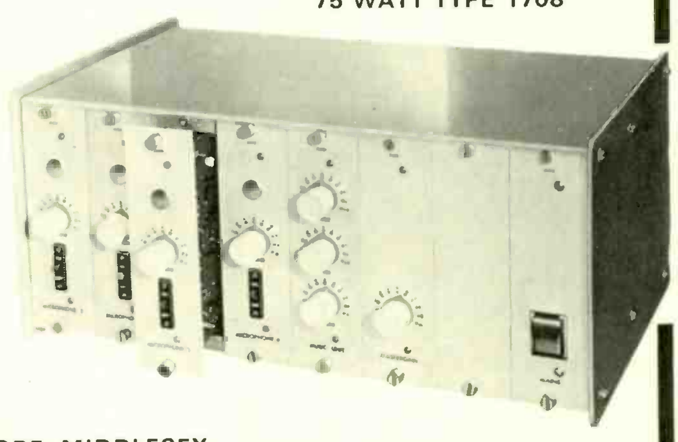
WW—079 FOR FURTHER DETAILS

"Astronic" series 1700

HIGH QUALITY AMPLIFIERS
10 WATTS—70 WATTS
ALL TRANSISTOR

10 WATT
TYPE 1700 100V OUTPUT
TYPE 1746 8OHM

75 WATT TYPE 1708



Details on request from:—

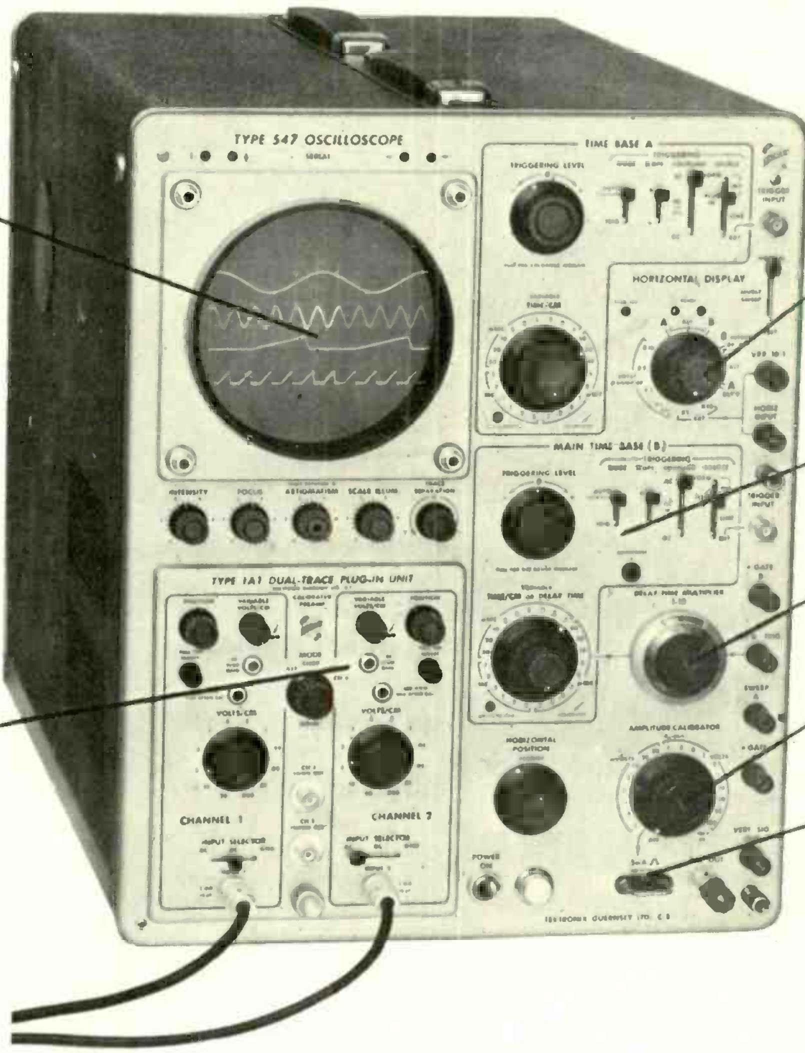
ASSOCIATED ELECTRONIC ENGINEERS LTD. DALSTON GARDENS, STANMORE, MIDDLESEX.
TELEPHONE: 01-907 4474/5/6.

WW—080 FOR FURTHER DETAILS

TEKTRONIX TYPE 547 VERSATILITY WITH AUTOMATIC DISPLAY SWITCHING

6 x 10 cm High-resolution Display, Bright Uniform Trace, Illuminated Parallax-free Graticule

25 Plug-in Units Vertical Display Switching up to 4 channels and Special Purpose, Differential, Spectrum Analyzers and Sampling



Horizontal Display Switching views two time scales simultaneously

DC—50 MHz Full Bandwidth Triggering

Calibrated Sweep Delay

0·2 mV to 100 V Square Wave Amplitude Calibrator

Current Probe Calibrator

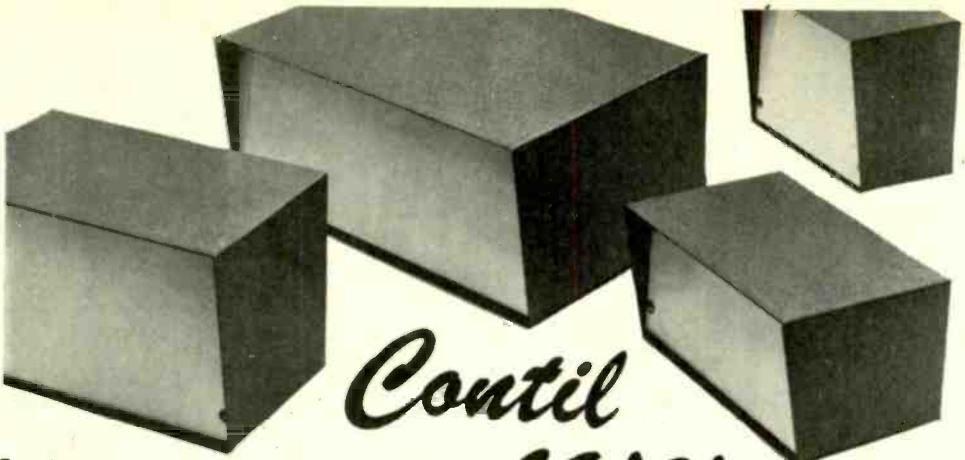
Price:
£873 delivered U.K.
(without plug-in unit)

For detailed information on any of our products, please fill in reader reply card or write, telephone or telex.

Tektronix U.K. Ltd. *Beaverton House, P.O. Box 69, Harpenden, Herts. Telephone Harpenden 61251. Telex 25559*

For overseas enquiries: **Australia**: Tektronix Australia Pty. Ltd., 4-14, Foster Street, Sydney, N.S.W. **Canada**: Tektronix Canada Ltd., Montreal, Toronto & Vancouver. **France**: Relations Techniques Intercontinentales, S.A., 91, Orsay, Z.I. Courtaboeuf, Route de Villejust (Boite Postale 13). **Switzerland**: Tektronix International A.G., P.O. Box 57, Zug, Switzerland. **Rest of Europe and the Middle East**: Tektronix Ltd., P.O. Box 36, St. Peter Port, Guernsey, C.I. *All other territories: Tektronix Inc., P.O. Box 500, Beaverton, Oregon, U.S.A.*

WW—081 FOR FURTHER DETAILS



Contil cases

Contil cases are mass-produced to give lowest prices yet. In 21-gauge steel. Finished hammer blue, with 18-gauge front panel supplied with easy-to-strip protective covering for easy marking out. For ease of ordering Contil cases are described by their dimensions, i.e. 755 is 7 × 5 × 5. Individually packed, including feet and screws.

Contil cases are also available with aluminium panels and Contilcote, which is appliedafterdrilling and cutting.

CASE PRICES (*All supplied with protective coated steel panels*)

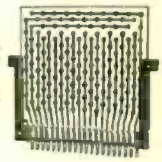
Nos. denote size in inches	1	5	10	25	50	100	200
755	43/6	41/6	40/6	39/6	38/6	36/–	35/–
867/975	45/6	44/–	43/6	41/6	40/6	38/6	37/–
1277 white or black panel	49/6	47/–	46/–	45/–	43/6	43/–	41/6
1277 unpainted	40/6	39/6	38/6	36/–	35/–	32/6	31/6
16127	96/6	94/6	92/6	91/6	89/6	88/–	86/–
191010	130/6	127/6	125/–	123/–	122/–	121/–	119/–
191010D	185/6	182/6	180/–	178/–	176/–	173/6	173/6

Postage and packing extra

CONTIL LOW COST PRINTED CIRCUIT BOARDS

	1	10	50
Standard transistor board "A"	9/9	9/–	8/6
Half board "B"	7/6	7/–	6/6
Connectors 20-way "M"	9/6	9/–	8/–
Connectors 10-way "N"	6/–	5/6	5/–
"Q" Chassis	42/6	41/6	39/–

We also stock Veroboard as below	1	20	100
.2 Pitch, 18" × 4¾"	17/7	15/9	15/–
.15 Pitch, 17⅞" × 3¾"	14/2	12/8	12/1
.1 Pitch, 17" × 3¾"	16/5	14/9	14/–



"A" board shown plugged into "M" 20-way connector with "S" board supports.
Note: Power supply rails at right angles to signal rails.

MOD-2 Cases see Oct. 1969 or Jan. 1970 Advertisements.

TRANSFORMERS

West Hyde have three transformers for transistorised equipment. TRA which provides low voltages at 2 Amps. and high voltages at ·1 Amp. for driving neons or number tubes. TRB which provides 2 Amps. and TRC, a 1 Amp. transformer. The low voltages on TRA, TRB are 6, 10, 15, 18, 30 which can of course be connected to give 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 with 12-0-12 and 15-0-15. The 1 Amp. transformer gives 6, 10, 18 voltage outputs. The TRA also gives 150-80-0-80-150. TRA at 57/6 each. TRB at 47/– each TRC at 35/6 each.

Your third hand

The ONTOS UNIVERSAL VICE is a new type of multi-purpose, multi-position light engineering vice and stand, fully adjustable for any angle and location in any desired plane. Applications are virtually limitless within its size capacity; i.e. holding P.C. boards for assembly or testing, building up modules, as a micrometer or gauge stand, as a light general purpose vice, in the chemical laboratory, or in fact for all those occasions when you could use a third hand! The ONTOS TWIN TWO-IN-ONE UNIVERSAL VICE is a unique two-in-one version of the Ontos vice, with two sets of jaws, each capable of rotation through 360 deg. of every plane independently of each other. Positive locking enables any such setting to be maintained for repetition work. Ideal for copying P.C. boards, assembly, soldering, bonding, welding, laboratory testing, etc.

ONTOS: 67/6 plus P&P 4/6.

ONTOS TWIN £5 18 0 plus P&P 4/6

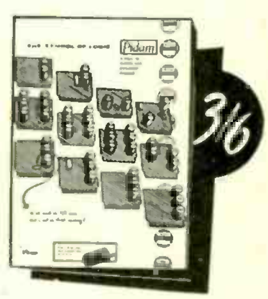
PIDAM (Plug-in Digital and Analogue Modules) perform all the usual logic functions, but, unlike other units, can be plugged in, using their B9A bases and can be quickly connected to the required configuration. To help learning, the module covers are easily removable for circuit examination and sets of components are available.
The 22 modules have an enormous range of use, from a single MONO for a tachometer, to over 300 units in a computer interface; nevertheless, their greatest asset is extreme simplicity. Design time is cut and elaborate breadboards superseded and any reader of "Wireless World" could with **PIDAM**, build up a low cost system for his own needs.
6 NEW modules—send for free information.

PIDAM PLUG-IN MODULES - PRICES **NEW**

Prices range per module from 10/– to 28/– and all necessary accessories are supplied. A complete starting kit is only £21 19s. 0d. (normally £24 6s. 0d.).

PIDAM BROCHURE

Send for this complete explanatory booklet showing detailed examples and circuit diagrams of all modules. Examples and circuits given include voice-operated switch, alarms, flashers, tachometer, timers, batch counters, etc.

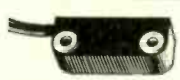


'Brightlife' NEONS

25,000 hour average life. PC type ⅜" diameter, 6" leads with resistor inside. Nine different caps available. 160–260 V, 10 at 2/10 each, 100 at 2/6 each, 1,000 at 2/2 each, 10,000 at 2/– each. Also available with 30" leads; 110 volt resistor values. PP type ⅜" diameter also supplied with 30" leads and 110 volt variants. 10 at 2/10 each, 100 at 2/6 each, 1,000 at 2/2 each, 10,000 at 2/– each. Neon/resistor assemblies, 100 at 9d. each, 10,000 at 8d. each. Neons only, 100 at 9d. each, 10,000 at 6d. each. Neons driven by neon oscillator for 6 to 24 volt input down to 50 mW input. Neons driven by transistors with or without alphanumeric caps.

SUB-MINIATURE NEONS

The smallest yet, type "Q". Overall diameter $\frac{3}{16}$", body .7", resistor mounted externally, medium intensity. Minimum quantity 10 at 3/10 each, 100 at 3/4 each, 500 at 3/2 each.



REED SWITCH

The West Hyde reed switch works up to 2,000 operations per second with a life of up to 50,000,000,000 operations when used in the recommended circuit. The hermetically sealed switch is protected in a brass tube and moulded into a polypropylene block giving accurate placing of the contents in relation to the mounting screws. 30" nominal leads fitted. Used for Rev. Counters, flowmeters, burglar alarms, under and over speed monitors, etc. 1 at 15/–, 10 at 12/6 each, 100 at 9/6 each.

ACCESSORIES

Flexible insulated test prods, colour red or black, at 13/– each with fine steel clips at the tip, opened by button on top. High speed resetting counter including bezel and socket with speed of over 40 operations per second 165/–. Plug in octal relay, 24 volts, with two changeovers 17/6.

WH WEST HYDE

WEST HYDE DEVELOPMENTS LTD.
30 HIGH STREET NORTHWOOD MIDDX.
Telephone: Northwood 24941

PLEASE NOTE
All products ex-stock for normal quantities. Return of post service. Minimum order £1. Fully detailed leaflets available.

WW—085 FOR FURTHER DETAILS

RADFORD

In an article in the Journal of the Audio Engineering Society for July 1967, Bart N. Locanthi, Vice-President, J. B. Lansing Sound Inc. describes the development of an ultra low distortion direct current audio amplifier. In it he says "... to get the highest accuracy possible, an English made RADFORD Low Distortion Oscillator was used which has less than 0.01% harmonic distortion at 20kHz."

LOW DISTORTION OSCILLATOR (Series 2)

An instrument of high stability providing very pure sine waves, and square waves, in the range of 5 Hz to 500 kHz. Hybrid design using valves and semiconductors.

Specification

Frequency Range:	5 Hz-500 kHz (5 ranges).
Output Impedance:	600 Ohms.
Output Voltage:	10 Volts r.m.s. max.
Output Attenuation:	0-110 dB continuously variable.
Sine Wave Distortion:	0.005% from 200 Hz to 20 kHz increasing to 0.015% at 10 Hz and 100 kHz.
Square Wave Rise Time:	Less than 0.1 microseconds.
Monitor Output Meter:	Scaled 0-3, 0-10, and dBm.
Mains Input:	100 V.-250 V. 50/60 Hz.
Size:	17½ × 11 × 8in.
Weight:	25 lb.
Price:	£150.

DISTORTION MEASURING SET (Series 2)

A sensitive instrument for the measurement of total harmonic distortion, designed for speedy and accurate use. Capable of measuring distortion products as low as 0.002%. Direct reading from calibrated meter scale.

Specification

Frequency Range:	20 Hz-20 kHz (6 ranges).
Distortion Range:	0.01%-100% f.s.d. (9 ranges).
Sensitivity:	100 mV.-100 V. (3 ranges).
Meter:	Square law r.m.s. reading.
Input Resistance:	100 kOhms.
High Pass Filter:	3 dB down at 350 Hz. 30 dB down at 45 Hz.
Frequency Response:	±1 dB from second harmonic of rejection frequency to 250 kHz.
Power Requirements:	Included battery.
Size:	17½ × 11 × 8in.
Weight:	15 lb.
Price:	£120.

Descriptive technical leaflets are available on request.

RADFORD LABORATORY INSTRUMENTS LTD.

ASHTON VALE ROAD, BRISTOL 3

Telephone: 662301/3

WW—086 FOR FURTHER DETAILS

'WATTS' THE NAME FOR RECORD MAINTENANCE

THE ONLY COMPREHENSIVE RANGE OF RECORD MAINTENANCE EQUIPMENT

HI-FI PARASTAT (Reg'd.)Pat. App. 58216/67.

Gramophone Record Maintenance and Stylus Cleaning Kit

Designed for use on NEW records or records in new condition which are to be played with pick-ups requiring very low tracking pressures. The 30,000 finely pointed tips of the Hi-Fi Parastat Brush positively explore every detail in the record groove to provide the high degree of record cleanliness necessary when using ultra lightweight pick-ups tracking at 2 grammes or less. The cover pad in the lid of the case is provided for the purpose of cleaning and activating the brush which when enclosed within the case is kept at the correct level of humidity required to control all static at the working surface. Perfectly clean records must be played with a perfectly clean stylus and an integral part of the kit is the new Watts Stylus Cleaner which provides a safe and efficient method of cleaning the stylus.

Supplied complete with instructions, 1 oz. New Formula dispenser, Distilled Water dispenser, spare pad cover and ribbons. Price 42/6 plus 1/3 P.T.

Replacements: 1 oz. New Formula dispenser 4/6 Distilled Water Dispenser 4/– Pad Cover and Ribbons 1/9.

STYLUS CLEANER

Available separately complete with instructions.

Price 5/–. Plus 1/3 P.T.

'PARASTAT' Regd. Manual Model Mk.IIA

A dual purpose record maintenance device. Keeps new records in perfect condition. Restores fidelity to older discs. Complete with 1 oz. New Formula dispenser and instructions. **Price 45/–.**

Replacements: Pad Covers 2/– each. Brush 12/6. Sponge Cover Pad 1/–. 1 oz. New Formula Dispenser 4/6.

HUMID MOP. Recommended for use in conjunction with the Manual Parastat and Preener. Cleans and conditions the bristles and velvet pads. Ensures correct degree of humidity at the time of use. Complete with spare sponges and instructions. Price 4/6. Replacements: Set of Sponges 2/6.

The original 'DUST BUG' Regd. (Patent No. 817598)

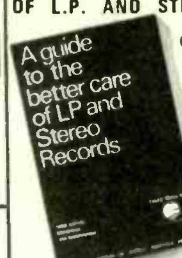
Automatic Record Cleaner. Easily fitted to any transcription type turntable. Provides a simple and effective method of removing static and dust while the record is being played. Surface noise and record and stylus wear is reduced, resulting in cleaner reproduction. Complete with ½ oz. New Formula Dispenser and instructions. **Price 18/9 plus 4/5 P.T.**

Replacements: Nylon Bristle and Plush Pad 1/9. ½ oz. New Formula Dispenser 2/6.

'PARASTATIK' Regd. DISC PREENER (Patent No. 982599)

Keeps new records like new. Expressly designed for use with records which have not had previous antistatic treatment. Complete with instructions. Price 6/9. Replacements: Packet of 4 wicks 2/–.

A GUIDE TO THE BETTER CARE OF L.P. AND STEREO RECORDS



Completely revised. 48 pages, fully illustrated, providing all necessary information on Record Care.

2/6 Post Free.

All obtainable from your local specialist or direct:

To CECIL E. WATTS LTD. DARBY HSE. SUNBURY ON THAMES, MIDDX.

Please send (Post Free U.K. and Commonwealth)

........Disc Preeners @ 6/9 ....Hi-Fi Parastats @ 42/6 plus 1/3 P.T.

........Dust Bugs @ 18/9 plus 4/5 P.T. ....Manual Parastats @ 45/-

........48 page Booklets @ 2/6 ....Stylus Cleaners @ 5/- plus 1/3 P.T.

Replacement Parts: ....

I enclose cheque/P.O. value £........ *(Do not send postage stamps)*

Name ....

Address ....

WW—087 FOR FURTHER DETAILS

TECHNICAL TRAINING

in radio television and electronics

Whether you are a newcomer to radio and electronics, or are engaged in the industry and wish to prepare for a recognized examination, ICS can further your technical knowledge and provide the specialized training so essential to success. ICS have helped thousands of ambitious men to move up into higher paid jobs—they can help you too! Why not fill in the coupon below and find out how?

Many diploma and examination courses available, including expert coaching for:

- **C. & G. Telecommunication Techns'. Certs.**
- **C. & G. Electronic Servicing**
- **R.T.E.B. Radio/T.V. Servicing Certificate**
- **Radio Amateurs' Examination**
- **P.M.G. Certs. in Radiotelegraphy**
- **General Certificate of Education, etc.**

Examination Students coached until successful

NEW SELF-BUILD RADIO COURSES

Learn as you build. You can learn both the theory and practice of valve and transistor circuits, and servicing work while building your own 5-valve receiver, transistor portable, and high-grade test instruments, incl. professional-type valve volt meter—all under expert tuition. Transistor Portable available as separate course.

POST THIS COUPON TODAY

for full details of ICS courses in Radio, T.V. and Electronics.

INTERNATIONAL CORRESPONDENCE SCHOOLS

Dept. 222, Intertext House, Stewarts Road, London, S.W.8

Please send me the ICS prospectus—free and without obligation.

(state Subject or Exam.) ....

....

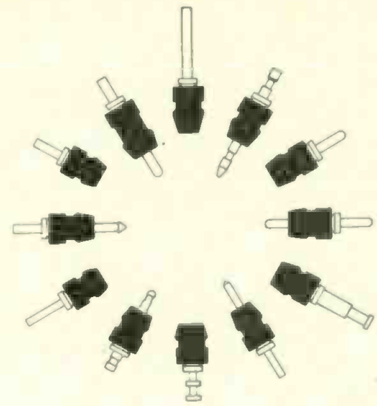
NAME ....

ADDRESS ....

.... 12/69

INTERNATIONAL CORRESPONDENCE SCHOOLS

NON-CONFORMIST

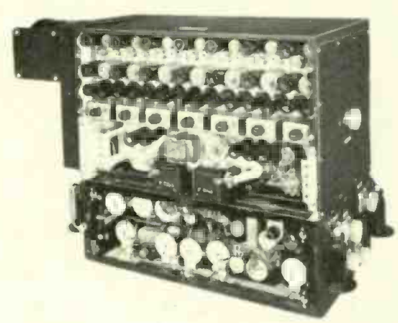


Oxley "Barb" cone-lock Insulators may remind you of just another lead-through or stand-off insulator.
But don't say anything. Oxley insulators deserve your respect and attention.
For sheer ease of assembly; for sheer quality, and for sheer brilliance, in the use of the Oxley "barb" cone-lock principle, Oxley insulators are IMPORTANT.
Write for details. After all, you don't want mere competence; you want to work with an artist.

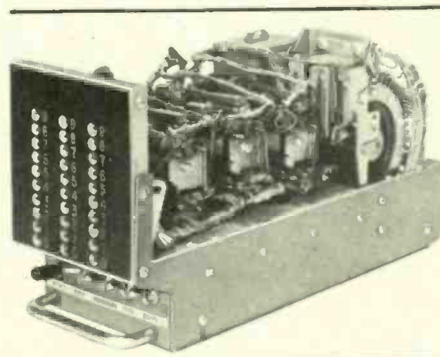
OXLEY DEVELOPMENTS COMPANY LIMITED
Priory Park, Ulverston, Lancashire.
Telephone: 2621 Telex: 5461

OXLEY

WW—089 FOR FURTHER DETAILS



Ballistics Computers by Westinghouse. Nine servo amplifiers with associated motors. Brand new in sealed containers. £95, delivered.



Automatic Numbering Machine by Western Union. Four Uniselectors and 30 neons. Ideal amateur computer. Application leaflet. £12.10s. post free.

PUNCHES, READERS, VERIFIERS AND TELEPRINTERS AT REALISTIC PRICES TO EDUCATIONISTS. MOBILE SHOWROOM CALLS ON REQUEST.

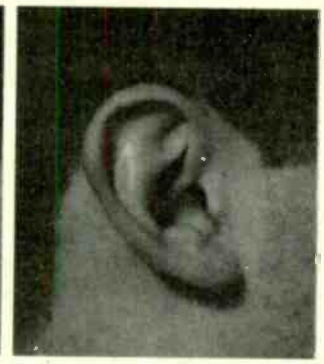
COMPUTER TRAINING PRODUCTS

2 Lordship Lane, LETCHWORTH, HERTS. Tel: 4536 0462/6

WW—090 FOR FURTHER DETAILS

NOW...
Guarantee your audience's listening comfort



Our Automatic Loudness Controller delivers the sound that's right for every ear. Automatically eliminates excessive loudness. Unconditionally guaranteed!

No doubt about it. Other devices can control volume and modulation levels. That's what they're for.

But only one instrument can analyze and automatically control loudness levels.

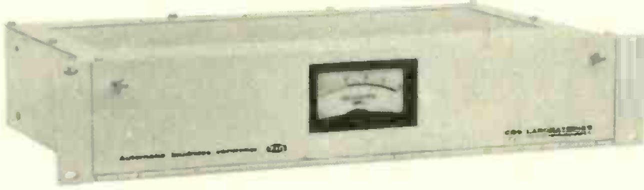
Ours.

Reason? We designed it "from human ears". At CBS laboratories, we tested every conceivable sound sensation: Frequency content. Peak factors. Ballistic response. Combinations of complex signals. All the characteristics that affect even the most sensitive ear.

Result? An instrument so "humanly" perceptive it automatically keeps loudness levels under control. And does it inaudibly. Keeps your audience in their chairs . . . listening comfortably. No constant jumping up and down to flip the dial. They enjoy continuous listening pleasure.

Why not let your audience hear you at your best? Install this remarkable instrument in your studio. You *will* believe your ears. It's guaranteed. Unconditionally.

For further information, write:



PROFESSIONAL PRODUCTS
CBS LABORATORIES
Stamford, Connecticut 06905
A Division of Columbia Broadcasting System, Inc.

WW—091 FOR FURTHER DETAILS

Wireless World

Electronics, Television, Radio, Audio

Fifty-ninth year of publication — **December 1969** — **Volume 76 Number 1410**

The review of gramophone pickups in this issue is typified by the **cover illustration** of a close-up of an Acos cartridge.

Contents

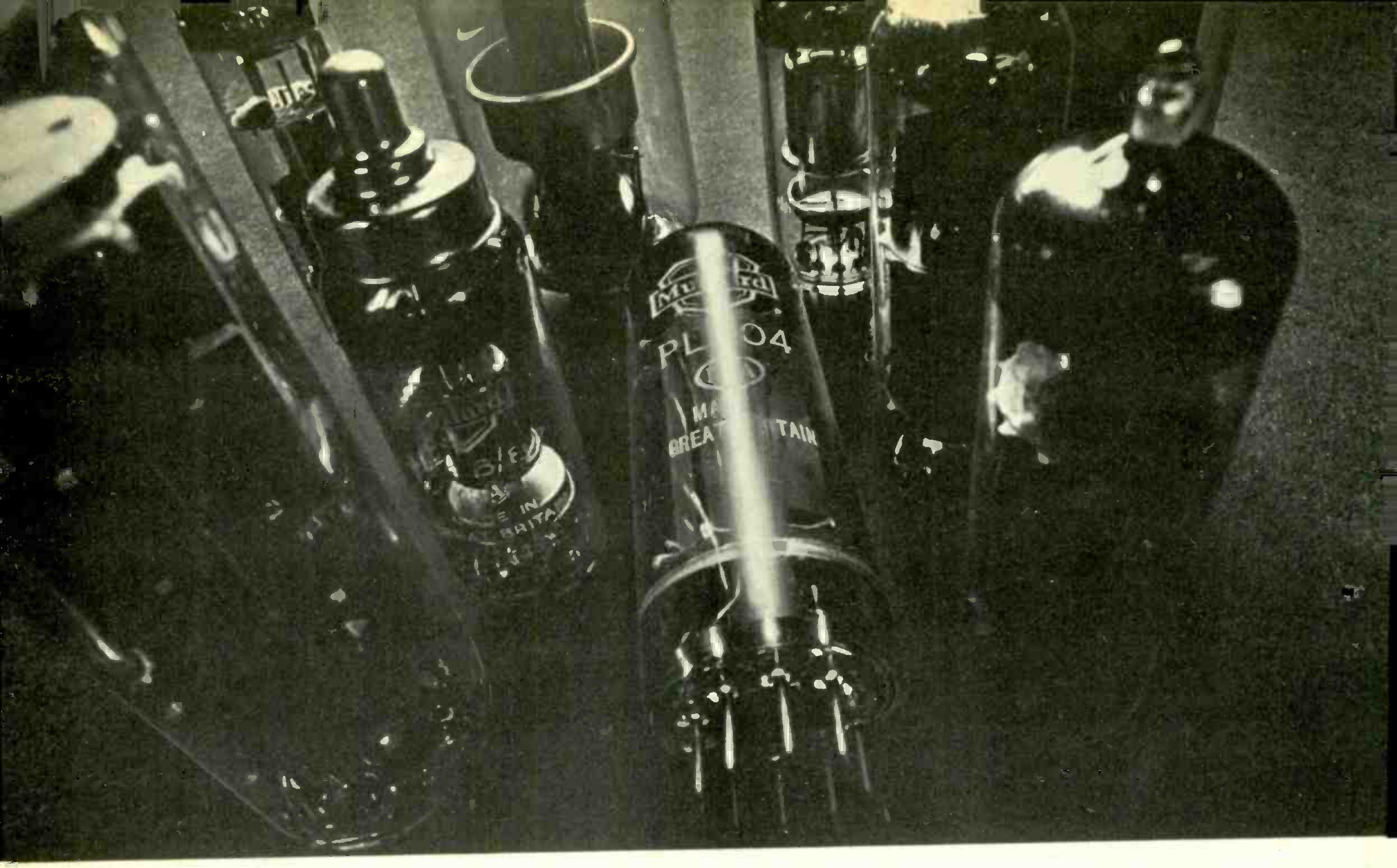
OUR NEXT ISSUE

Capacitor-discharge Ignition System which provides improved car engine performance.
Linear Integrated Circuits: a plea for some degree of standardization.
Industrial Telemetry: a review of recent developments.

ibpa
International Business Press Associates

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

PUBLISHED MONTHLY (3rd Monday of preceding month). *Telephone:* 01-928 3333 (70 lines). *Telegrams/Telex:* Wiworld Iliffepres 25137 London. *Cables:* "Ethaworld, London, S.E.1." *Annual Subscriptions: Home;* £2 15s 0d. *Overseas;* 1 year £2 15s 0d. (*Canada and U.S.A.;* $6.75). 3 years £7 0s 0d. (*Canada and U.S.A.;* $17.50). Second-Class mail privileges authorised at New York N.Y. Subscribers are requested to notify a change of address four weeks in advance and to return wrapper bearing previous address. BRANCH OFFICES: *BIRMINGHAM:* 202, Lynton House, Walsall Road, 22b. *Telephone:* 021-356 4838. *BRISTOL:* 11, Elmdale Road, Clifton, 8. *Telephone:* OBR2 21204/5. *GLASGOW:* 2-3 Clairmont Gardens, C.3. *Telephone:* 041-332 3792. *MANCHESTER:* Statham House, Talbot Road, Stretford, M32 OEP. *Telephone:* 061-872 4211. NEW YORK OFFICE U.S.A.: 300 East 42nd Street, New York 10017. *Telephone:* 867-3900.



Wireless World

The Engineer in State and Private Enterprise

This was the title of Harvey Schwarz's presidential address on October 22nd to members of the Institution of Electronic and Radio Engineers. While not denigrating the need for Government co-operation and assistance in certain circumstances he came down heavily on the side of private enterprise—as managing director of Decca Navigator Company this is not surprising. As he rightly pointed out, there are, of course, many projects which no company, unaided, could possibly implement without Government help. But Government and industry must together hammer out some means whereby the delays, which seem inherent in obtaining such effort, can be cut drastically.

Because of the different approaches of Government and commercial enterprises there is an incompatibility which can be, and often is, detrimental to the advancement of a project. However sympathetic towards or enthusiastic for a project a Government Department may be, it is less concerned with the time factor than private enterprise. Mr. Schwarz pointed out that this is because the very structure of the civil service business quite rightly starts by ensuring that public funds are properly spent and used to the best advantage. "All too frequently, this prerequisite breeds a caution which often becomes so exaggerated that by the time the project has been surveyed from every possible aspect by a series of committees, the chance may well have been lost. . . . The cushioning effect of reliance on governmental support can—human nature being what it is—stultify initiative and enterprise."

There is, however, an aspect of commercial enterprise which can be just as stultifying, and is likely to hamstring the enthusiastic engineer. Mr. Schwarz described this as "Gadarene swine-manship" which manifests itself in "a seemingly almost frenetic compulsion—not to dash over a cliff as did those unfortunate animals—but to huddle together in larger and larger conglomerates in a positive fury of gregariousness, and by a curious paradox the more entities such conglomerates absorb, the more amorphous they become". Few will not share Mr. Schwarz's regret at the growing wave of mergers with the resultant loss of famous household names and inherent danger of stifling initiative and enthusiasm.

The position of the engineer in industrial mergers and take-overs was also voiced at the meeting announcing the formation of the U.K. Association of Professional Engineers (see p. 562), membership of which is open to members of all the 14 institutions constituting the Council of Engineering Institutions. The president of UKAPE (G. B. M. Oliver) said that industrial mergers "too often produced the result that professional men . . . were lost in a vast impersonal machine where they were unable to make their voices heard".

Whereas Mr. Schwarz was concerned with the position of the individual engineer, the trade union (UKAPE) is concerned with collective bargaining on behalf of professional engineers as a body. While we are in full sympathy with any legitimate movement to improve the status, image and emoluments of the engineer—whether professional or technician—we cannot help but question what there is in common between, say, a gas or marine engineer and one in electronics. One could go still further and try to find a common denominator for the electronics engineer in, say, the guided weapons division of one of the major groups and his counterpart in the television development laboratory of a receiver manufacturer.

Wireless World is written for the individual engineer, both in his professional capacity and as a hobbyist, and we would therefore reiterate Mr. Schwarz's dictum that the engineer must be given freedom in which to exploit his natural talents: "Discovery cannot be made by order or regulation, nor can the engineer's ingenuity be trammelled by limitation of opportunity."

Stereo Gramophone Pickups

A review of the various types of transducer available

by Stanley Kelly

By definition a gramophone pickup should translate the information stored mechanically in the groove of a gramophone record into an exactly corresponding electrical signal. As is well known, it accomplishes this feat by the application of motion from a modulated Vee-shaped groove in the gramophone record via a hemispherical stylus coupled to the actual transducer element. In the case of two-channel "stereo" records the two groove walls are independently modulated. Therefore, the parameters of the record groove and the record material are major factors affecting the performance of the pickup.

Present-day styli are either sapphire or diamond, and are several orders of magnitude harder than the record material. Therefore upon the application of pressure between the stylus and the record it is the record rather than the stylus that deforms. The contact area of the stylus tip and the record groove will be a function of the effective force between the two surfaces and the mechanical constants of the record, and the attrition of the stylus will be strictly a function of this contact area and the length of travel of the stylus. This latter factor is usually equated in terms of playing time. It has been determined experimentally that at playing weights greater than about 0.5 gramme the record material is stressed beyond its elastic limit[3,4] and it is the aim of cartridge designers to produce pickups which will satisfactorily track heavily modulated records at playing weights below this figure. Therefore in the interests of reduced record wear and concomitantly stylus wear, the ideal limit would obviously be playing weights less than 0.5 gramme, and certainly 1.5 grammes can be taken as the upper limit to maintain maximum record life. Despite many extravagant advertising claims, there are probably fewer than a dozen pickup cartridges produced today which actually track all music records at playing weights less than 1.5 grammes. Stylus wear is generally expressed as the size of "flat" developed at the point of contact with the record, and is a complex function of playing weight, stylus dimensions, record material, and the dynamic mechanical constants of the pickup referred to the stylus tip.

Fig. 1 shows the life of a diamond stylus at two playing weights, 2 grammes and 5 grammes, and for different radii. It will be seen that even at only 2 grammes playing weight with an 0.5 thou* stylus point, the life is only 500 hours for a "flat" diameter of 0.25 thou,

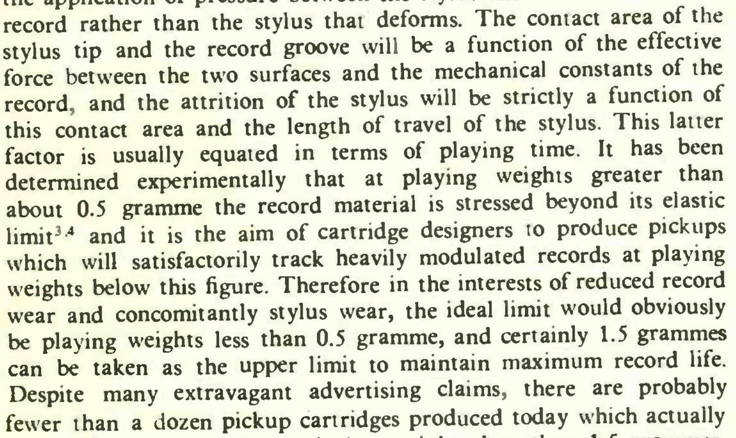


Fig. 1. Playing time for flat diameter diamond styli.

which with wide-range low-distortion equipment is currently accepted as being the maximum "flat" diameter to be tolerated. Increasing the stylus diameter to 0.7 or 1 thou considerably reduces stylus wear but at the expense of increased tracing distortion. The elimination of tracing distortion requires a stylus of minimum tip radius—ideally zero!—but apart from stylus life other factors control the minimum tip radius. The bottom of the record groove is not infinitely sharp; with commercial pressings it is of an indeterminate radius. This is maintained at minimal value by the record manufacturers but can sometimes approach 0.5 thou! Indeed, until the advent of stereo recording the groove bottom radius was not under strict manufacturing control and some of the earlier L.P. pressings are unplayable if the tip radius of the stylus is less than 1 thou.

The elliptical or biradial tip has been evolved to overcome the difficulty. The major radius—across the groove—is of the order of 0.7 thou, whilst the minor or "working" radius can be as small as 0.2 thou with consequent reduction in tracing distortion, although stylus life is reduced accordingly. The upper limit for the major axis i 0.7 thou because under conditions of maximum vertical modulation the groove width can be (and often is) instantaneously reduced t 1 thou; thus if the tip radius (either spherical or the major axis o an elliptical) is greater than 0.7 thou the stylus will ride on the interface of the groove and the record land with the possibility o groove jumping in addition to the increased distortion.

One specifies a given dimension and euphemistically hopes that thi dimension will be achieved. Modern production methods work t incredibly fine tolerances and ± 0.1 thou is the norm for tip radiu limits. Thus a maximum specified radius of 0.7 thou in reality mean a dimension of between 0.5 and 0.7 thou although by selection close tolerances can be achieved. Even so, using optical methods of measure ment the confidence limits of the measuring equipment are usually c the order of ± 1 micron (one twenty-fifth of a thou) which sets practical limit.

[The projected use of the metric system throughout our commerci and industrial life and the introduction of SI units for all scientifi work poses a number of problems at all levels of industry. This especially exemplified in design and production of gramophone picku where dimensions are microscopic—masses of the order of milligram length in microns or tenths of a thou—and to this author at least seems ridiculous to think of a milligram as 10^{-6} kilogramme and th micron as 10^{-6} metre. The magnet industry both in this country ar the United States and the pickup cartridge manufacturers througho the world all insist on specifying their products in c.g.s. unit Conversations with many commercial and technical personnel indica an obdurate insistence on the familiar, thus c.g.s units are used this article.]

Before specifying the parameters of a pickup it is necessary to kno the maximum modulated levels available from the record. The levels are controlled at low frequencies by the maximum groo displacement (normally 0.005 cm) and at higher frequencies by styl tip dimensions and groove velocity. Fig. 2 shows these limits. Curve relates r.m.s. velocity to maximum displacement, and B, C, D, and to stylus tip radius: G is the generally accepted maximum velocity f music records although these values are sometimes exceeded, especia on "gimmick" and "pop" records. From this graph it would appe that mis-tracking must occur with all styli in which the radius

* "Thou" = 1,000th of an inch.

greater than 0.0003 inch; this assumption is modified by the fact of record deformation, but is nevertheless substantially correct for the inner grooves at high modulation levels. These limitations are reduced as the groove diameter increases and at diameters exceeding about 7 inches are negligible even for 0.0007 inch tip radius.

The basic design requirements for a pickup are fundamentally mechanical and relate to the dynamics of the moving system and one must design to track the maximum velocities shown in Fig. 2. It is convenient to divide the frequency spectrum into three sections: (a) below about 500 Hz; (b) 500 to 5000 Hz; and (c) above 5kHz. One can relate Fig. 2 to maximum "needle tip impedance" that is, the mechanical impedance at the stylus point when in contact with the record, for a given playing weight. Fig. 3 relates this premise for a playing weight of 1.5 grammes, using curves A and B as limits. The dotted lines refer to a compliance of 5×10^{-6} cm/dyne and mass of 2.25 milligrammes. These values may be modified by other considerations: (1) the record compliance-stylus mass resonance and the head mass/restoring force compliance resonance should be outside the recorded frequency range; (2) appreciable amounts of damping may be introduced. The high-frequency resonance can be evaluated assuming a record compliance of 3×10^{-8} cm/dyne. The low-frequency resonance is controlled by the mass moment of inertia of the arm plus cartridge related to the stylus tip and the cartridge compliance; it should be less than 22.5 Hz (the "slip" frequency of most induction motors used in turntables and a frequent source of "rumble") and above 10 Hz—at lower frequencies than this value the pickup system becomes very sensitive to external vibrations; and the motor board must be adequately decoupled to prevent shock excitation of the pickup and attendant acrobatic antics across the record surface.

It is generally assumed that compliance and stylus tip mass are the usual parameters hopefully specified by the manufacturer in relation to the mechanical constants of the pickup cartridge, but especially with highly damped systems the "loss" component achieves major importance in the mid-band frequencies, thus the evaluation of input mechanical impedance is necessary to the design engineer. Of more immediate importance to the user is the minimum playing weight for tracking music records. One method is to produce a disc with a (slow) sweep frequency covering the major frequency range (say, 80 Hz to 8 kHz) at maximum music modulation levels. In use the output from the pickup is observed on a cathode-ray oscilloscope and the playing weight is reduced until a "break" occurs on the waveform—usually at the point of maximum acceleration. A disc (7 inch $33\frac{1}{3}$ r.p.m., 80 Hz to 8 kHz) has been produced as a tentative industry standard and the modulation levels are shown in curve G on Fig. 2. The disc has "left" channel information on one side and "right" channel on the other; because of tracing distortion, and also harmonic distortion generated by some pickups at these high levels, the interpretation is sometimes difficult but it does attempt to set an industry standard. Another practical method is to use discs with fixed modulation (say, 5 cm/sec. at frequencies above 500 Hz and 1.57 cm/sec. at lower frequencies), adjust the playing weight for the "break" and equate the results to the maximum music level at that frequency. Fig. 5 shows such a plot for a well damped moving magnet cartridge.

The mechanical impedance at mid-frequencies is determined almost wholly by damping of the moving system. Indeed, with most modern magnetic pickup cartridges the mechanical impedance over the major part of the audio frequency spectrum is controlled by this factor. In order to realize the design requirements mentioned above, only the simplest mechanical system can be used, and this would in essence consist of a stylus directly coupled to the armature suspended by some elastic medium, the mass being concentrated at the stylus tip and the restoring force being the only other constant, as shown in Fig. 5. These ideals cannot be achieved in practice but in the best examples of variable reluctance or moving-magnet type structures they are closely approximated.

Crystal pickups

By far the most popular pickup cartridge is the crystal type. This is sub-divided into two groups—(a) those using Rochelle salt elements, and (b) ceramic elements[5]. Rochelle salt has the material advantages of high sensitivity, high dielectric constant (and hence high capacitance and relatively low electrical impedance, it can be produced as torsional bimorphs with a low mass moment of inertia and high compliance, but suffers from the disadvantage of being highly temperature-sensitive for electrical capacitance and being deliquescent requires elaborate moisture proofing for an adequate service life. Ceramic elements are produced as bender units only, and in order to obtain reasonable mechanical values are made in the form of narrow relatively thick elements with resulting low capacitance and require a load impedance in excess of 2 megohms for adequate low frequency response. They possess the very material advantages of being impervious to moisture and have an indefinite service and shelf life.

Rochelle salt pickups have their major use in the record players produced for the mass market where cost is of primary consideration. Because of their high sensitivity and the fact that the electrical output is "corrected" only the simplest of amplifiers are needed. Many millions of reproducers have been produced using only a single valve with a few resistors as electronic complement to the ubiquitous Rochelle salt pickup.

The demand for better reliability and consistency and freedom from the worst temperature effects led to the introduction of the piezo-electric ceramic elements. The original form of this material was barium titanate, but the crystal structure has been modified by various additions, and sensitivities of present day materials are between two and three times that of the original material.

Although there are individual differences between manufacturers the design of crystal cartridges is now fairly stable; a typical example uses a moulded case with a "turnover" stylus assembly—one point for L.P. and stereo and the other for 78 mono. In the absence of any modern 78 records being pressed this seems a needless extravagance, but then many millions of record changers have been produced with a $16\frac{2}{3}$ r.p.m. position on the speed control, and to the author's best knowledge only a handful of $16\frac{2}{3}$ records were ever produced and that was ten years ago—doubtless the marketing pundits have sound reasons for these anomalies. But to the pickup proper: an aluminium alloy cantilever and sapphire or diamond stylus is used, the rear suspension is approximately equally compliant in all directions, and it then drives two crystal elements through individual arms mutually perpendicular and at 45° to the record surface. The mechanical crosstalk between the two units should be a function only of the ratio of the compressional compliance to the flex-

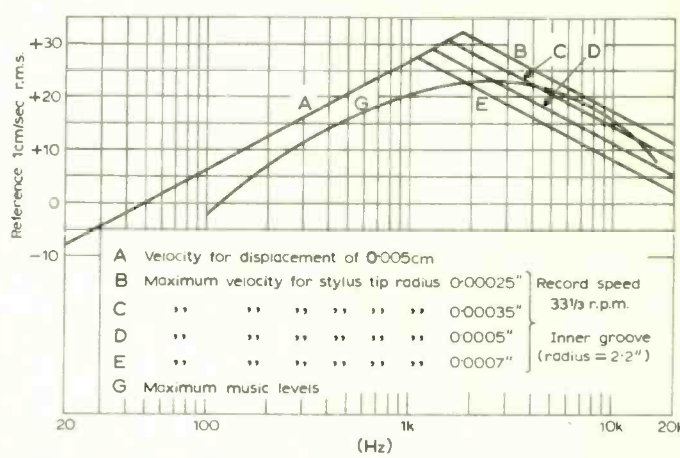


Fig. 2. Maximum velocities on music records.

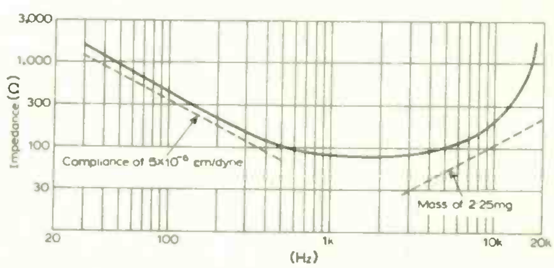


Fig. 3. Maximum mechanical impedance required to track music records with maximum modulation, at a playing weight of 1.5g.

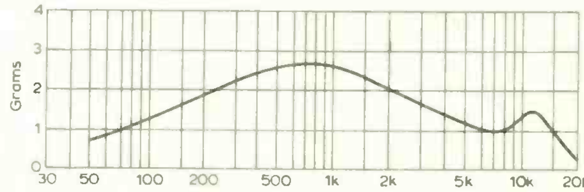


Fig. 4. Minimum playing weight for music levels with maximum modulation.

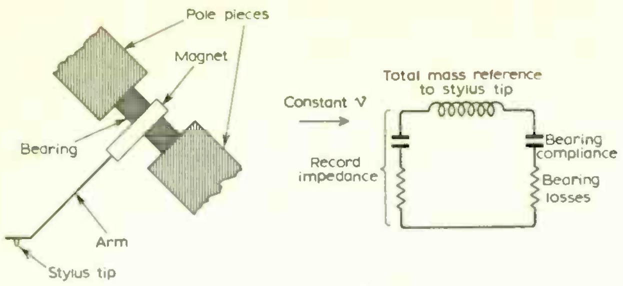


Fig. 5. Analogue of a simple armature system.

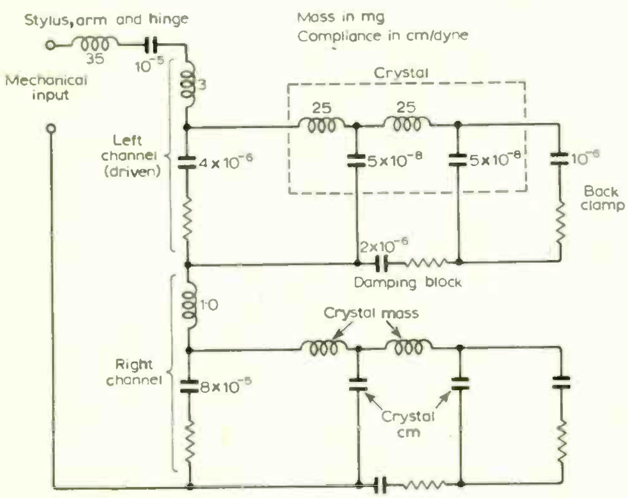


Fig. 6. Analogue of a crystal stereo pickup.

ing compliance. Now, assuming that the material is isotropic, the flexing compliance is proportional to the cube of the length and inversely proportional to the cube of the thickness times the width, whilst the compressional compliance is proportional to length and inversely proportional to the cross-sectional area. Thus for a given cross section any degree of isolation can be obtained by increasing the ratio of length to width, and for a design centre of, say, 26dB, the ratio of length to width need only be 4:1.

The lead zirconate crystals operating in flexure are supported at the rear end by a stiff block of plastic and an additional damping member is placed amidships, this also acts as the stylus cantilever support. The sections of the crystals are mutually perpendicular and 45° to the horizontal.

The analogue is shown in Fig. 6. The cantilever stylus is driven from the record, and the mass M_1 and compliance Cm_1 are respectively the dynamic mass and the restoring force of the stylus itself. Normally the compliance between the stylus point and the compliant members driving the crystals is zero, therefore any shunt effect of motion to ground can be neglected. At the driving point the motion splits into two, and drives two identical crystal elements. Because the back support of the crystal is soft compared with the stiffness of the crystal as a whole there is appreciable motion over the whole of the crystal, and it is therefore more amenable to analysis if we split the crystal mass and put clamping impedances at the centre and rear end of the crystal. The compliance and loss resistance at the crystal driving point is the compressional compliance of the coupling member between the stylus and the crystal, whilst the compliance and resistance at the remote end of the crystal is the clamping member. It will be seen that the series masses of coupling members will form resonant circuits which modify considerably the high-frequency crosstalk—indeed because of the multiplicity of resonances analysis is approximate only.

Resistances represent the losses deliberately introduced into the system in order to make the steady state response of the cartridge as smooth as possible.

The force developed across the compliances of the crystal itself is converted into electrical energy by means of the transducer action, the e.m.f. being generated in series with the electrical capacitance of the crystal. It is the finite value of this capacitance which limits the output voltage at low frequencies when the pickup is terminated in a practical value of resistance. The series mass between the cantilever and the crystal is the total mass of the coupling member. The other half of the circuit represents the load imposed at the driving point from the other crystal. Here, the reflected dynamic mass of the other channel coupling member is reduced because it is operated in flexure rather than in compression, whilst the compliance is very materially increased.

The low-frequency crosstalk separation is, to all intents and purposes, the ratio of these two compliances. Connected in parallel with this latter compliance is the complex impedance presented by the other crystal and its supports; it forms various resonant circuits at different frequencies, and if the impedance at this point rises unduly it will be reflected in increased crosstalk.

During this analysis it is assumed that one channel only is being driven, but as both channels are symmetrical and identical, the analysis can be considered to be fairly rigorous. Because the pickups are high impedance devices, a common ground connection can be used without introducing any substantial increase of crosstalk due to common ground impedance.

It will be appreciated from the foregoing that a rigorous analysis of this type of cartridge is very difficult, and it is usual to rely on "know-how" and empirical trial and error rather than to design the cartridge from basic piezo-electric and mechanical constants.

Compared with a single channel cartridge, it will be appreciated that the effective dynamic mass referred to the stylus must be greater than that of a single channel unit of the same crystal and stylus dimensions by virtue of the reflected impedances of the unwanted channel. Because the impedance is complex, the impedance changes rapidly with frequency, and is responsible for the wide variations in crosstalk, especially in the upper frequencies. Whilst, theoretically, the mechanical impedance of the twin channel cartridge should not be appreciably greater than that of the single channel (because of the de-coupling effect of the transmission members) in point of fact for a given sensitivity it is usually found that the mechanical impedance is about 50% greater than that of an equivalent single channel cartridge.

The external mechanical constants of this cartridge are compliance at 30 Hz, 5×10^{-6} cm/dyne. Effective tip mass at 10 kHz, 7.5 milligrammes, playing weight 3 to 4 grammes. Fig. 7 shows the response of this pickup. It is not claimed to be high fidelity but gives an acceptable performance with domestic equipment.

As can be expected, the mechanical input impedance varies with frequency, as shown in Fig. 8. The rise at low frequencies is due almost entirely to the stiffness of the mounting and damping parts. The various drive members and supports are usually moulded from plasticized copolymers of vinyl chloride and acetate or other thermo-plastic material. The elastic constants of these plastics vary rather widely with temperature and both the output and compliance decrease with increasing temperature, as shown in Fig. 9. Be this as it may, about 90% of all twin channel cartridges presented to the public today are crystal or ceramic.

To summarize: A crystal cartridge has the prime advantages of low cost, ease of manufacture, and a high output voltage, which are precisely the requirements for transducers in the domestic reproducing field. To date, all crystal pickups are of the 45-45 sensing variety, that is, the two elements are sensitive only to forces in the direction of their required plane, and no "sum and difference" crystal cartridges have yet appeared on the market.

Magnetic cartridges

Magnetic pickup cartridges are fundamentally different from crystal in that the output voltage is proportional to the velocity of the armature and by inference to the velocity of the record groove modulation whereas crystal devices produce a voltage which is proportional to the force applied to the crystal and, to a first approximation, to the amplitude of the modulated groove.

In order to achieve wide frequency response and low playing weight the dynamic mass and the restoring force of the moving system must be minimal. At high frequencies of the order of 10kHz, accelerations in excess of 1000 g are experienced at high modulation levels, thus for playing weights of the order of 1.5 grammes the maximum dynamic mass referred to the stylus point should be of the order of 1 milligramme.

The majority of magnetic cartridges are of the moving magnet variety although because of patent restrictions variable reluctance systems using the same mechanical configuration as that of the moving magnet (but using an external polarizing magnet) are now appearing on the market in increasing numbers. The overall design considerations and performance are approximately similar to those in the moving magnet design although it is possible in theory at least to reduce the mass moment of inertia (and hence the mechanical impedance at high frequencies) by substituting a thin walled tube in place of the solid rod used in movin magnet systems. The point of no return is quickly reached because of magnetic saturation of the subsequent very small cross-sectional area of the armature.

The magnetic circuit consists essentially of two pairs of pole pieces arranged symmetrically around the centre line of the armature with pickup coils wound over the yokes connecting opposite pairs of poles. The armature is usually a small cylindrical magnet about 0.030 inch diameter by 0.1 inch long cemented to a thin walled aluminium or duraluminium tube approximately 0.3 inch long and carrying a miniature diamond tip at the front end. The assembly is supported by a compliant hinge at its centre of gravity and in some models a tie bar, usually 0.002 inch diameter stainless steel, is connected to prevent longitudinal motion. By suitable proportioning the dimensions of the tie bar it can also be used as the major restoring force, the plastic collar then providing central support and damping. The hinge can be one of a variety of elastomers, either copolymers of polyvinyl chloride or polyvinyl acetate; butyl plus neoprene rubber is sometimes used, as have been some of the polyurethanes. Silicone elastomers have not been very successful because of their low internal damping. The success (or failure) of the pickup is intimately bound up with this bearing design. The bearing is highly stressed in one direction due to the force developed by the playing weight—it is well known that most types of elastomers have a non-linear relation between stress and strain under these conditions. Additionally, hysteresis shows itself as distortion in the middle to high frequencies. At low frequencies the armature system vibrates about the centre of the plastic bearing but it is very rare for the inertial centre of gravity to coincide; the result of this is that with increasing frequency the effective mass increases, thus reducing tracking capabilities at high frequencies.

The static mass of this system is between 8 and 20 milligrammes depending on the particular design and the dynamic mass at 10 kHz in the best designs can approach 1.2 to 2 milligrammes. The static compliance varies between 5×10^{-6} cm/dyne and, in extreme cases, 40×10^{-6} cm/dyne, but because of the deliberately introduced mechanical damping (due to losses in the plastic hinge and sometimes by the addition of silicone or other grease) the mechanical impedance can be made almost wholly resistive between limits of 100Hz and 10kHz.

Clearance between the magnet and the poles is about 0.15 thou and because of the efficient magnetic circuit, generally using Mumetal or other high permeability materials, leakage flux is extremely low and from a magnetic point of view the system is extremely efficient. The sensitivity is generally of the order of 1 to 2 millivolts/cm/sec., although some recent Japanese cartridges have been produced with five times this output. The development of this elegant type of cartridge is due to Schmidt of Elac, Kiel, Germany, and has been extensively copied throughout the world.

Because of the magnetic symmetry, mutual induction between the coils is small and crosstalk arising from this factor is usually less than −40dB whilst overall crosstalk varies between about −10dB or −15dB at the extremes of the frequency band (20 Hz and 20 kHz) improving to a maximum of about −30dB in the mid frequencies, say, 500 Hz to 3 kHz. This crosstalk is due almost entirely to unwanted modes of vibration of the armature system. As an example, increasing the stylus length by only 0.01 inch can increase crosstalk caused by torsional vibrational modes by 15dB in the mid-upper frequency range. Notwithstanding the technical criticisms, the performance of the best examples of moving magnet type cartridges are impressive.

The field strength (and hence sensitivity) of the variable magnetic field transducer, whether variable reluctance or moving magnet, is limited by saturation of the armature or the pole pieces and by the "negative compliance" due to the pull of the steady magnetic field on the armature. If the field exceeds a critical value determined by the static compliance of the armature restoring force it will result in the armature being attracted to one of the pole faces and hence no music! It is this negative compliance which generally limits the sensitivity of the pickup, requiring coils of several thousand turns of fine gauge wire to produce a usable output.

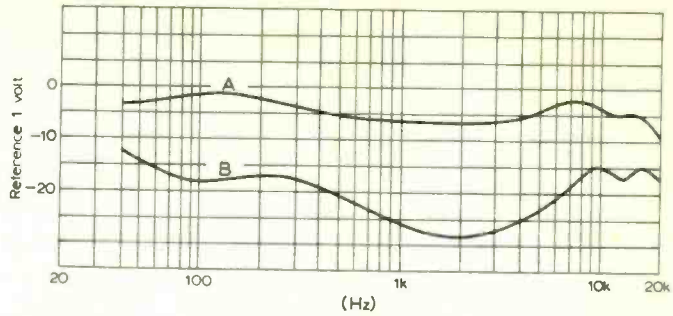


Fig 7. Curves A and B show, respectively, the wanted signal and the crosstalk into the second channel, from a ceramic cartridge loaded by 2M Ω and of 5g playing weight. The temperature is 21°C and the test record TC5702.

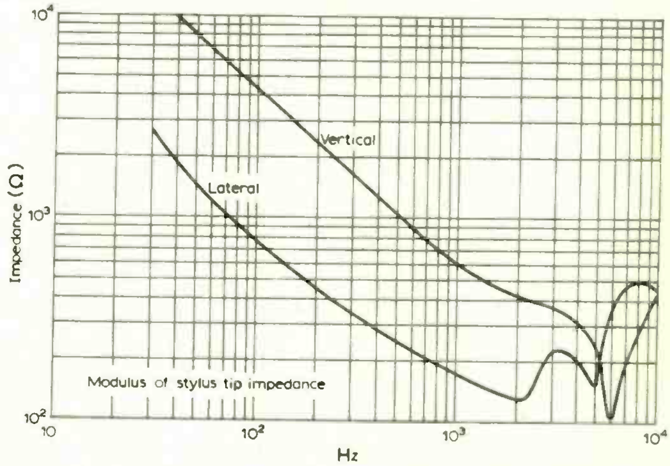


Fig. 8. A graph showing the stylus-tip impedance changes (lateral and vertical) with changing signal frequency.

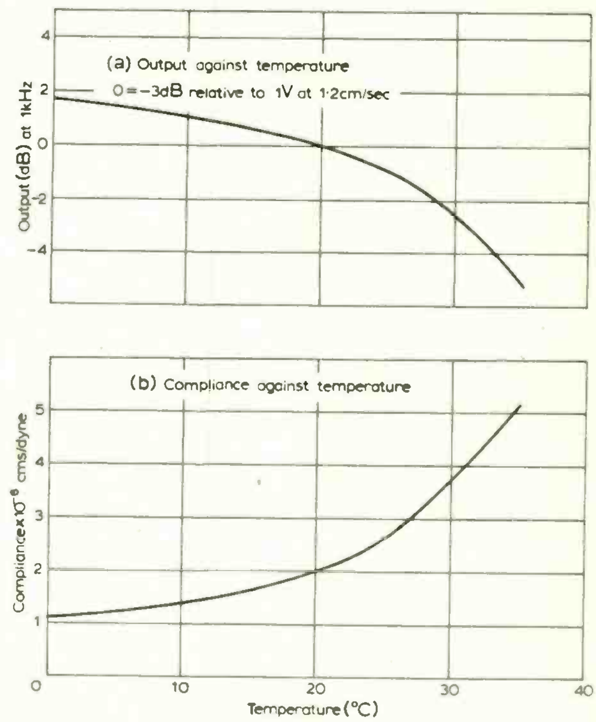


Fig. 9. Variations with temperature in a crystal pick-up cartridge.

Moving-coil pickup

The moving-coil pickup suffers none of the disadvantages listed above. If the magnetic field is linear and this condition is not difficult to achieve, the output will be strictly a function of coil velocity with no inherent generated distortion. Because of the absence of negative compliance the magnetic field can be increased to the limit and field strengths of the order of 15 kilogauss instead of a few tens or hundreds of gauss are possible. In addition to increasing the output the signal to noise ratio is improved proportionately. The secret of success is in the design of the coil and the support system.

The most popular moving-coil cartridge uses a coil former in the form of a rectangular plate 2 mm square $\times$ 0.5 mm thick wound with four coils each with ten turns symmetrically placed about the centre line. Thus each generator consists of two coils in series; rising perpendicularly from the centre plate is an aluminium tube cantilever about 7 mm long

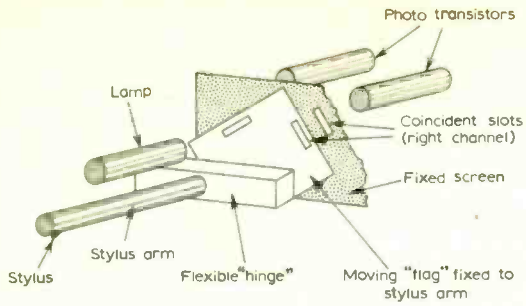


Fig. 10. Diagrammatic representation of Toshiba C100P pickup cartridge.

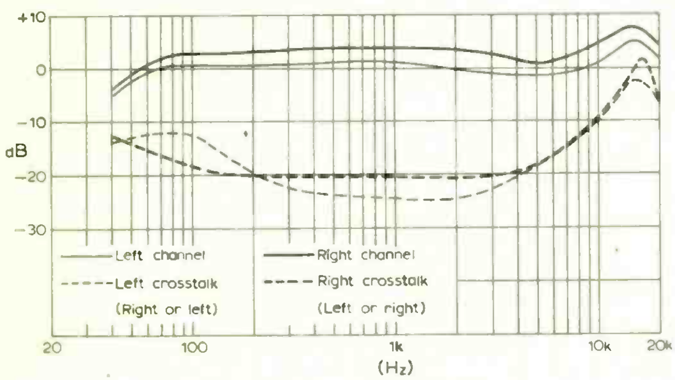


Fig. 11. Frequency response curves for photo-electric cartridge.

carrying the stylus at its free end. The rear end of the coil is flexibly mounted on to a steel tube which forms one pole of the magnet. The other pole in front of the coil is bored to take the cantilever and its protecting tube. The flexible mounting carries a damping block and is arranged to prevent fore and aft movement. There is, however, some torsional movement which shows as a minor resonance in the 7 kHz to 9 kHz region. The ratio of cantilever length to coil dimension is 7:1, giving a mechanical ratio of 50:1, and this results in an extremely low mechanical impedance at the stylus tip. Static compliance is of the order or 20×10^{-6} cm/dyne, but because of mechanical damping the resistive component becomes predominent between 100 Hz and 3 kHz, and approximates 40 mechanical ohms. Stylus resonance is at 26 kHz giving a calculated mass of 1.24 milligrammes. The coils are low impedance, about 2 ohms, and a matching transformer is used to raise the voltage sensitivity to about 2 millivolts/cm/sec.

The best examples of the magnetic cartridges (both variable field and moving coil) described above can generally be produced to give a flat frequency response with velocity from 20 Hz to 10 kHz ± 1dB and 10 kHz to 20 kHz within ± 2dB. Crosstalk will generally approximate 25dB between 400 Hz and 5000 Hz, gradually deteriorating to 10dB or 15dB at the extremes of the frequency range. With lower priced units the frequency response is somewhat more variable, generally being characterized by a "suck out" of a few dB between 5 kHz and 15 kHz, the extreme high frequencies being restored by the stylus/record resonance.

"Strain Gauge" pickup

Recently a number of novel types of transducers have made their appearance, the first using a "strain gauge" transducer which unlike magnetic and piezo-electric pickups is not a generator but operates by modulating a d.c. current supplied from an external source in sympathy with the mechanical information. The transducer proper is a tiny doped silicon element, $0.020 \times 0.008 \times 0.004$ inch, similar to the base material of modern transistors. It is cemented to a plastic beam which in turn is driven through a flexible member by the stylus. For stereo use two such members are used, and the general assembly is very similar to that of the modern ceramic cartridge. The *modus operandi* of the transducer is that the resistance changes when subjected to a force across the driving points. The magnitude of the resistance change has a linear function of the applied force thus providing that the current through the element is constant the transducer is inherently distortionless. The element is fed with a constant current and the resultant voltage which is proportional to displacement is applied to the amplifier through a coupling capacitor. Thus to a first approximation the response is similar to that of a crystal or ceramic cartridge.

The art in designing this type of pickup is to so proportion the dimensions and the material of the drive back clamp and damping members as to give a mechanical transfer that is the inverse of the record amplitude characteristic, at the same time taking into account the fact that the mechanical impedance of the transducing element is several hundred times greater than the permissible stylus tip impedance. The semiconductor transducer by virtue of its small size has a major advanatage over the ceramic element in that resonances associated with it are outside the audio frequency spectrum (the average ceramic transducer has at least one major resonance in the mid-upper frequency range) although resonances can and are introduced by other parts of the mechanical system.

The virtue of this type of pickup is that because the transducer is a modulating element the electrical output power can be considerably greater than with "generating" types of transducer. Comparison between the high quality moving coil and this type of pickup may be instructive. The moving coil cartridge requires a playing weight of 1.9 grammes at a velocity of 20 cm/sec. at 1 kHz and produces an output of 800 millivolts from a source impedance of 2 ohms. Thus the input power is 2.7 milliwatts and the output power 0.32 milliwatts giving a conversion efficiency of 0.012 per cent. A representative strain gauge pickup requires a playing weight of 3 grammes at a velocity of 20 cm/sec. at 1 kHz and gives an output of 120 millivolts from a source impedance of 400 ohms. Thus the input power is 4.2 milliwatts and the output power is 36 milliwatts and the overall efficiency is 1.16 per cent. Neglecting the electrical input power, the overall efficiency of this type of cartridge is approximately one hundred times as great as its ceramic counterpart! Distortion is commendably low, and signal to noise ratio more than adequate, but frequency response and crosstalk are inferior to the better magnetic units and because the response of the system is flat to d.c., motor rumble and low frequency feedback can be troublesome unless a rumble filter is fitted to the amplifier.

Photo-electric pickup

During 1968 a new type of pickup (or more correctly a new version of a pre-war type of pickup) made its appearance, namely the photo-electronic pickup. Fig. 10 shows a sketch of the system. The diamond stylus is placed at one end of an aluminium alloy tube 0.02 inch diameter $\times$ 0.25 inch long. The remote end of the tube supports a small flag approximately 0.1 inch square $\times$ 0.002 inch thick. Pierced in this flag are two slots, 0.062×0.008 inch. The slots are mutually perpendicular and 45° to the horizontal. Behind the flag is a fixed screen with two similar slots and behind the screen are two photo transistors complete with miniature focusing lens each approximately 0.62 inch diameter. The moving assembly is supported by a compliant hinge approximately 0.040 inch in front of the flag. Under operating conditions the two pairs of slots overlap by 50%, displacing the stylus tip around this mean position will vary the amount of overlap and hence the total quantity of light received by the photo transistor and finally the output voltage developed by it. The lamp is fed from a stabilized d.c. power supply and the outputs from the photo transistors are taken through a correcting amplifier to the normal hi-fi amplifier.

Like the strain gauge and ceramic cartridges, this is a displacement type of pickup in which the output is proportional to amplitude rather than to velocity. The frequency response is shown in Fig. 11, and it will be seen that the main resonance occurs at approximately 15 kHz, whilst at frequencies above 20 kHz the pickup exhibits two resonant modes, one at 28 kHz in which the output drops to practically zero, and the other with a sharp peak at 35 kHz. These two resonances are probably connected with the dynamics of the light valve system. Distortion at middle and low frequencies is quite low, being less than 1% at 2 kHz but increasing to 6% at 5 cm/sec. at 10 kHz.

This brief survey of currently available pickups of necessity only skims the surface of technical development; considerable engineering skill is being constantly applied to the problems outlined above, and although the possibility of novel forms of transducer are remote, detailed improvements of established designs are continually appearing, thus automatically outdating any survey.

References

1. United States Patent No. 1,520,378.
2. British Patent No. 394,325.
3. F. V. Hunt, *J.A.E.S.*, Vol. 3, No. 1, pp. 2-18.
4. S. Kelly, *Hi-Fi News*, Vol. 2, pp. 339-342.
5. S. Kelly, *Wireless World*, June & July 1954.

Pickup Characteristics: Details of some of the models available in the U.K.

The author of the preceding review of gramophone pickups sent a questionnaire to manufacturers and agents asking for characteristics of their products. From the replies received the following tables have been prepared. It is hoped that the information given, together with Mr. Kelly's comments, will assist readers in selecting the transducer best suited to their needs.

	A.D.C.					ACOS									
Model	220	660	660/E	550/E	10/E	91/1SC	91/2SC	91/3SC	92/1SC	93/1	94/1	95/1	96/1	94/5	104
Type[1]	SI	SI	SI	SI	SI	MR	MR	MR	MC	SR	SC	SR	SC	SC	SC
Frequency response (Hz)	10-18k	10-20k	10-20k	10-20k	10-20k	10-17k	30-17k	30-15k	30-16k	30-20k	30-16k	30-20k	30-16k	30-16k	30-18k
Channel separation (dB)	20	30	30	20	30	—	—	—	—	15	15	15	15	15	20
Output voltage[2] **(mV)**	5	7	7	5	4	850	1500	2500	530	1400	500	1400	500	315	500
Load impedance (Ω)	47k	47k	47k	47k	47k	1M	1M	1M	1M	1M	1M	1M	1M	200k	1M
Stylus[3]	D	D	D	D	D	D or S	D or S	D or S	D or S	D or S	D or S	D or S	D or S	D or S	D
Stylus dimensions (10^{-3}in)	0.7	0.5	0.3 × 0.7	0.3 × 0.7	0.3 × 0.7	0.5—0.7	0.5—0.7	0.5—0.7	0.5—0.7	0.5—0.7	0.5—0.7	0.5—0.7	0.5—0.7	0.5—0.7	0.5—0.7
Compliance (10^{-6} cm/dyne)	15	20	20	28	35	5	3	4	5	5	12	5	12	12	20
Dynamic mass (mg)	<1	<1	<1	<1	<1	2.5	3.5	3.5	2.5	2.5	3.5	2.5	3.0	3.5	2.5
Playing weight (g)	2-5	1½-4	1½-3	¾-2½	½-1½	3-6	5-10	5-10	5-10	4-8	3-6	4-8	3-6	3-6	3
Inductance/capacitance	200mH	600mH	600mH	200mH	600mH	800pF	800pF	800pF	500pF	800pF	900pF	800pF	900pF	4200pF	800pF
D.C. resistance (Ω)	400	1k	1k	400	1k	—	—	—	—	—	—	—	—	—	—
Weight (g)	7	7	7	7	7	5.6	5.6	5.6	5.6	4.75	3	4.75	3	3	2
Mounting	½in	½in	½in	½in	—	½in	½in	½in	½in	½in	½in	½in	½in	½in	½in
Retail price inc. P.T.	£9.4.10	£16.6.6	£22.9.10	£3.16.6	£8.14.2	D £2.4.8 S £1.14.0	D £2.4.8 S £1.14.0	D £2.4.8 S £1.14.0	D £2.9.6 S £1.17.2	D £3.1.11 S £2.9.6.	D £3.8.1 S £2.15.9	D £3.1.11 S £2.9.6.	D £3.8.1 S £2.15.9	D £3.17.4 S £3.5.1	£4.18.6

	BANG & OLUFSEN								CONNOISSEUR	DECCA ffss			DERAM
Model	SP1	SP2	SP6	SP7	SP8	SP9	SP10	SP12	SCU	Mk II	C4E	4RC	Trans.
Type[1]	SV	SV	SV	SV	SV	SV	SV	SV	SC	S	S	S	S
Frequency response (Hz)	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k	15-25k	15-25k	30-16k	40-16k	20-20k	30-16k	18-18k
Channel separation (dB)	16	16	20	20	20	20	25	25	25	20	20	20	20
Output voltage[2] **(mV)**	7	7	7	7	7	7	5	5	40	6	6	6	150
Load impedance (Ω)	47k	47k	47k	47k	47k	47k	47k	47k	100k	50k	50k	50k	2M
Stylus[3]	D	D	D	D	D	D	D	D	D	D	D	D	D
Stylus dimensions (10^{-3}in)	0.6	0.6	0.6	0.6	0.7×0.2	0.7×0.2	0.7×0.2	0.7×0.2	0.5×0.6	0.5/0.7	0.3×0.65	0.5/0.7	0.5/0.7
Compliance (10^{-6}cm/dyne)	12	12	15	15	15	15	25	25	12	10	30	15	9
Dynamic mass (mg)	—	—	1.5	1.5	1.5	1.5	<1	<1	1	<1	<1	<1	0.6
Playing weight (g)	1½-3	1½-3	1½-2	1½-2	1½-2	1½-2	1-1½	1-1½	2-4	3½	1½	3½	2½
Inductance/capacitance	—	—	—	—	—	—	—	—	—	285mH	285mH	285mH	—
D.C. resistance (Ω)	—	—	—	—	—	—	—	—	—	4.9k	4.9k	4.9k	—
Weight (g)	11	8.5	11	8.5	11	8.5	8.5	8.5	8	14	13	13	3.5
Mounting	½ in	†	½ in	†	½ in	†	½ in	½ in	½ in	Decca	Univ.	Univ.	Univ.
Retail price inc. P.T.	£5.19.6	£5.19.6	£7.19.6	£7.19.6	£12.19.6	£12.19.6	£9.19.6	£14.19.6	£5.16.9	£16.0.0	£22.10.0	£17.0.0	£5.5.0

† B & O arm.

(1) First letter: S = stereo, M = mono. Second letter: M = moving magnet, V = variable reluctance, D = moving coil, C = ceramic, R = rochelle salt, I = induced magnet, F = free field.
(2) at 1 kHz at 5cm/sec. (3) D = diamond. S = sapphire.

	E.R.C.										EAGLE	
Model	Compat X	Compat X2	Compat C	2SB	2SX	5MX	7MX	5MB	ERC1	Power Point	LCO5	LCO7
Type[1]	MR	MR	MC	SC	SR	MR	MR	MC	MC	MC	SM	SM
Frequency response (Hz)	40-12k	40-12k	30-12k	30-12k	40-12k	40-12k	40-10k	30-12k	60-10k	40-12k	30-18k	20-21k
Channel separation (dB)	—	—	—	20	20	—	—	—	—	—	20	28
Output voltage[2] (mV)	925	2150	700	420	800	1450	2300	875	625	1670	6	7
Load impedance (Ω)	1M	1M	1M	1M	1M	1M	1M	1M	1M	1M	47k	47k
Stylus[3]	S-D	S-D	S-D	S-D	S-D	S-D	S-D	S-D	S-D	S-D	D	D
Stylus dimensions (10^{-3}in)	0.6/0.7	0.6/0.7	0.6/0.7	0.6/0.7	0.6/0.7	0.6/0.7	0.6/0.7	0.6/0.7	0.6/0.7	0.6/0.7	0.7	0.7
Compliance (10^{-6} cm/dyne)	3	2.5	2.5	5	4	2	1.2	1.2	2.5	1	9	12
Dynamic mass (mg)	—	—	—	—	—	—	—	—	—	—	—	—
Playing weight (g)	5	8	5	3	4	5	7	4	5	7	2-4	1½-2½
Inductance/capacitance	700pF	700pF	600pF	850pF	700pF	700pF	700pF	700pF	600pF	600pF	—	—
D.C. resistance (Ω)	—	—	—	—	—	—	—	—	—	—	—	—
Weight (g)	3.2	3.2	3.2	3.5	3.5	3.2	3.2	3.2	2	0.3	—	—
Mounting					clip-bracket ½ in. centre or slim-line pick-up mounting						½ in	½ in
Retail price inc. P.T.	£1.6.0	£1.6.0	£1.11.0	£2.3.4	£1.17.2	£1.6.0	£1.6.0	£1.11.0	—	17.4	£4.19.9	£6.19.6

	ELAC							EMPIRE						
Model	244-17	244-C	244-65	344-17	344-E	444-12	444-E	808	808E	888	888E	888TE	888VE	999VE
Type[1]	SM	SM	MM	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM
Frequency response (Hz)	20-20k	20-20k	20-20k	20-22k	20-22k	10-24k	10-24k	15-20k	10-25k	10-24k	10-30k	8-32k	6-32k	6-35k
Channel separation (dB)	<2	<2	<1.5	<1.5	<1.5	<1.5	<1.5	30	30	30	30	30	30	30
Output voltage[2] (mV)	7.5	7.5	7.5	5	5	5	5	8	8	8	8	8	8	5
Load impedance (Ω)	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k
Stylus[3]	D	D	S	D	D	D	D	D	D	D	D	D	D	D
Stylus dimensions (10^{-3}in)	0.7	0.7	65M	0.7	0.2/0.8	0.5	0.2/0.8	0.7	0.4×0.9	0.7	0.4×0.9	0.2×0.7	0.2×0.7	0.2×0.7
Compliance (10^{-6}cm/dyne)	18	10	—	25	25	33	33	8	12	10	12	25	30	30
Dynamic mass (mg)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Playing weight (g)	1½-3	2½-5	2½-5	1-2	1-2	¾-1½	¾-1½	1-5	1-4	¾-6	¾-5	¾-3	¾-2	¾-1½
Inductance/capacitance	320mH	320mH	320mH	320mH	320mH	320mH	320mH	—	—	—	—	—	—	—
D.C. resistance (Ω)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Weight (g)	—	—	—	—	—	—	—	7	7	7	7	7	7	7
Mounting	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in
Retail price inc. P.T.	£7:17.6	£7.17.6	£7.17.6	£11.7.0	£16.5.6	£16.5.6	£22.0.0	£9.9.6	£13.14.6	£12.11.1	£17.4.8	£24.17.6	£29.5.7	£36.6.6

	GARRARD			GOLDRING						ORTOFON					
Model	GCM31	GCS35	KS40A	800H	800	800E	800SE	CS90	CS91E	SL15	SL15E	M15G	M15B	MF15G	MF15B
Type[1]	MR	SR	SC	S	S	S	S	SC	SC	S	S	S	S	S	S
Frequency response (Hz)	100-8k	100-8k	50-10k	20-20k	20-20k	10-23k	10-23k	30-20k	30-20k	10-40k	10-40k	20-20k	20-20k	20-20k	20-20k
Channel separation (dB)	—	12	15	20	20	20	25	20	20	30	30	>30	>30	>30	>30
Output voltage[2] (mV)	3.5	1.9	0.5	8	5	5	4	250	100	10	10	4.5	4.5	4.5	4.5
Load impedance (Ω)	2M	2M	2M	50-100k	50-100k	50-100k	50-100k	2M	2M	47k	47k	47k	47k	47k	47k
Stylus[3]	D/S	D/S	D/S	D	D	D	D	D	D	D	D	D	D	D	D
Stylus dimensions (10^{-3}in)	2.5/0.7	2.5/0.7	2.5/0.7	0.7	0.5	0.8/0.3	0.8/0.3	0.5 or 0.7	0.8/0.3	0.6	0.6×0.3	0.7×0.2	0.6	0.7×0.2	0.6
Compliance (10^{-6} cm/dyne)	1.5	0.6	2	18	20	30	35	8	12	25	25	—	—	—	—
Dynamic mass (mg)	5	7	3.5	1.2	1	<1	<1	1	1	0.9	0.9	0.4	0.4	0.4	0.4
Playing weight (g)	7	8	5	3	2	1.5	1	4-5	2-3	1-2	1-2	¾-1½	¾-1½	1-2	1-2
Inductance/capacitance	1000pF	1000pF	600pF	450pF	450pF	450pF	450pF	900pF	900pF	—	—	0.5H	0.5H	0.5H	0.5H
D.C. resistance (Ω)	—	—	—	500	500	500	500	—	—	2	2	1.1k	1.1k	1.1k	1.1k
Weight (g)	2.5	2.6	2.5	7.5	7.5	7.5	7.5	5.5	5.5	—	—	5	5	5	5
Mounting	Brkt.	Brkt.	Brkt.	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in
Retail price inc. P.T.	—	—	—	£10.13.9	£13.0.0	£18.17.1	£26.0.0	£5.4.0	£7.16.0	£36.12.11	£29.10.11	£29.12.11	£23.9.5	£24.14.1	£18.10.7

(1) First letter: S = stereo, M = mono. Second letter: M = moving magnet, V = variable reluctance, D = moving coil, C = ceramic, R = rochelle salt, I = induced magnet, F = free field
(2) at 1 kHz at 5cm/sec. (3) D = diamond. S = sapphire.

	ORBIT	PHILIPS					PICKERING				SHURE				
Model	NM22	GP412	GP411	GP410	GP200	GP300	AC2	AT2	AM2	AME2	M3D	M31E	M32E	M32-3	M44-5
Type[1]	—	SM	SM	SM	SC	SR	SV	—	—	—	SM	SM	MM	SM	SM
Frequency response (Hz)	20-20k	20-20k	30-18k	30-18k	50-16k	50-17k	20-20k	20-20k	20-20k	20-20k	20-15k	20-18.5k	20-17.5k	20-17.5k	20-20k
Channel separation (dB)	20	25	20	20	20	20	35	35	35	35	>20	>20	>20	—	>25
Output voltage[2] (mV)	5	>5	>5	>5	>300	>500	7.5	6.9	5.5	5.5	5	10.5	9.3	5.5	7
Load impedance (Ω)	50k	47k	68k	68k	1M	1M	47k	47k	47k	47k	47k	47k	47k	47k	47k
Stylus[3]	D	D	D	D	D	S	D	D	D	D	D	D	D	D	D
Stylus dimensions (10^{-3}in)	0.7	0.7×0.3	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.4×0.9	0.7	0.7×0.2	0.7×0.4	2.5	0.5
Compliance (10^{-6}cm/dyne)	5	25	10	10	2.5	2.5	—	—	—	—	4	15	10	10	25
Dynamic mass (mg)	—	<0.75	1	1	—	—	—	—	—	—	—	—	—	—	—
Playing weight (g)	2-3½	¾-1½	2-4	2-4	3-7	3-7	3-7	1-5	¾-3	¾-1½	3-6	1-2	2½-5	2½-5	¾-1½
Inductance/capacitance	—	75mH	550mH	550mH	700pF	1000pF	—	—	—	—	420mH	720mH	720mH	720mH	720mH
D.C. resistance (Ω)	—	1030	1k	1k	—	—	—	—	—	—	280	630	630	630	630
Weight (g)	10	7	5.6	11.5	11	11	5	5	5	5	8.5	6	6	6	7
Mounting	½ in	½ in	½ in	5 pin	5 pin	5 pin	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in
Retail price inc. P.T.	£7.8.9	£39.0.0	£13.15.0	£14.1.1	£3.16.0	£1.18.11	£12.17.0	£14.1.4	£16.12.0	£23.1.8	£7.8.3	£12.19.5	£12.0.11	£11.2.4	£11.2.4

	SHURE (contd.)												STANTON		
Model	M44-7	M44C	M44E	M55E	M75C	M75E	M75EJ	M75E-D19	M75E-959	M75SG	VIS-II	VIS-II-7	500A	500AA	500E
Type[1]	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM	S	S	S
Frequency response (Hz)	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k	20-20k
Channel separation (dB)	>25	>25	>25	>25	>25	>25	>25	>25	>25	>25	>25	>25	>35	>35	>35
Output voltage[2] (mV)	11	9.3	6.6	9.3	5	5	5	5	5	5	3.5	3.5	4	4	4
Load impedance (Ω)	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k	47k
Stylus[3]	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Stylus dimensions (10^{-3}in)	0.7	0.7	0.7×0.4	0.7×0.2	0.6	0.7×0.2	0.7×0.4	0.7×0.2	0.7×0.2	0.6	0.7×0.2	0.7	0.7	0.5	0.9×0.4
Compliance (10^{-6} cm/dyne)	20	7.5	15	20	T	T	T	T	T	T	T	T	—	—	—
Dynamic mass (mg)	—	—	—	—	T	T	T	T	T	T	T	T	—	—	—
Playing weight (g)	1½-3	3-5	1¾-4	¾-2	1½-3	¾-1½	1½-3	1½	1½	¾-1½	¾-1½	¾-1½	2-5	¾-3	2-5
Inductance/capacitance	720mH	720mH	720mH	720mH	720mH	720mH	720mH	720mH	720mH	720mH	720mH	720mH	0.4H	0.4H	0.4H
D.C. resistance (Ω)	630	630	630	630	630	630	630	630	630	630	630	630	850	850	850
Weight (g)	7	7	7	7	6	6	6	—	—	6	6.8	6.8	5	5	5
Mounting	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in	½ in
Retail price inc. P.T.	£10.3.10	£10.3.10	£14.16.6	£16.13.6	£16.13.6	£25.18.10	£24.1.9	£27.15.11	£27.15.11	£17.12.1	£40.15.3	£38.18.3	£12.7.0	£14.15.6	£18.10.0

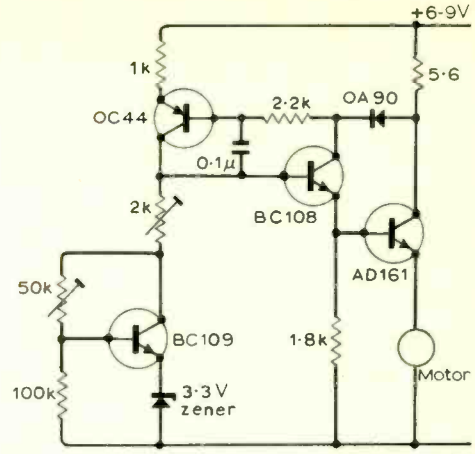
T = Trackability figures are available

	SONOTONE							SONY			TANNOY
Model	2T	8T4A	9TA	9TAHC	2109	2539	3509	VC-8E	VM-10P	VM-11G	Turnover
Type[1]	MC	SC	SC	SC	MR	SR	SC	SD	SI	SI	MV
Frequency response (Hz)	30-10k	30-12k	30-15k	30-20k	100-8k	100-8k	100-10k	15-25k	20-20k	20-25k	40-14k
Channel separation (dB)	—	25	25	25	—	12	20	30	15	20	—
Output voltage[2] (mV)	180†	90†	80†	55†	700†	550†	140†	4	5	3	15
Load impedance (Ω)	2k	2k	2k	2k	2k	2k	2k	10-10k	47k	47k	50k
Stylus[3]	S/D	S/D	S/D	S/D	S/D	S/D	S/D	D	D	D	D or S
Stylus dimensions (10^{-3}in)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.2×0.7	0.7	0.5	—
Compliance (10^{-6}cm/dyne)	1	1.4	4	8	1.5	1	2	30	—	30	—
Dynamic mass (mg)	—	—	3.5	2.5	—	—	—	—	—	—	—
Playing weight (g)	6-10	4-6	2-4	1-3	6-8	8-10	5-7	½-2	3	1½-3	3-7
Inductance/capacitance	650pF	650pF	450pF	800pF	800pF	800pF	600pF	40Ω	5kΩ	5kΩ	280mH
D.C. resistance (Ω)	>50M	>50M	>50M	>50M	>50M	>50M	>50M	40	1300	1300	—
Weight (g)	4	4.5	3	3	<3.5	<3.5	<3.5	15.5	—	8	16
Mounting	½ in	½ in	½ in*	½ in*	½ in*	½ in*	½ in*	EIA	—	—	½ in
Retail price inc. P.T.	£1.0.10	£2.3.3	£3.1.9	£3.1.9	£1.14.0	£2.8.7	£2.16.0	£37.3.7	£8.15.3	—	—

† at 1 cm/sec at 1kHz. * or centre.

(1) First letter: S = stereo, M = mono. Second letter: M = moving magnet, V = variable reluctance, D = moving coil, C = ceramic, R = rochelle salt, I = induced magnet, F = free field.
(2) at 1 kHz at 5cm/sec. (3) D = diamond. S = sapphire.

Circuit Ideas



Electronic governor, devised by D. Williams for a battery tape recorder.

A.M. oscillator

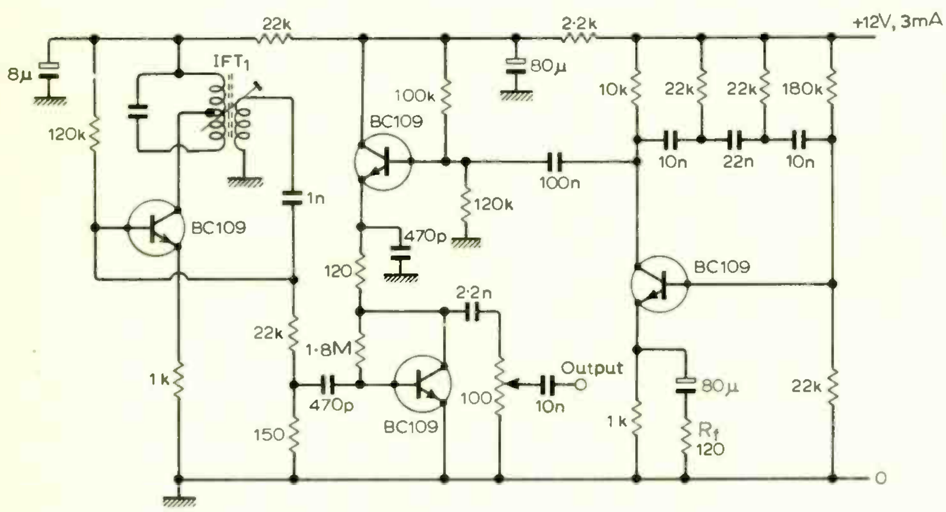
The circuit shown is that of a 470kHz a.m. oscillator. The a.f. component is about 220Hz and is a pure sine wave. Modulation is fixed at about 90% but may be increased or decreased by varying the a.c. feedback resistor R_f in the a.f. oscillator. IFT_1 is an ordinary i.f. transformer from a transistor radio, and is tuned to give the required carrier frequency. The maximum peak-to-peak output is 60mV which is more than adequate, and the output impedance is 100 Ω. The modulator section has a perfectly linear relationship between modulation depth and a.f. input.

K. E. POTTER,
Iverley,
Worcs.

Motor speed control

The circuit was devised for a battery tape recorder, in lieu of a centrifugal governor which was inclined to be erratic and produce interference in the audio. The motor required about 3V at 180mA. The circuit is virtually a fixed voltage source, with a negative output resistance that can be adjusted to be slightly less than the motor winding resistance (10 Ω). This has the effect of keeping the motor's back e.m.f. constant. The AD161 supplies to the motor a voltage which is determined by the BC109 and zener diode, plus a voltage which increases in proportion to the current taken by the motor, as monitored by the 5.6 Ω resistor. The OA90 is merely to offset the V_{be} of the OC44, and the 2.2k Ω, 0.1μF combination is to filter out fast current fluctuations from the motor's commutator. In use the 2k Ω potentiometer is set just short of 'hunting' of the system, and then the 50k Ω potentiometer is adjusted for fine speed setting. The circuit is practically independent of battery and temperature variations.

DAVID WILLIAMS,
Sidcup,
Kent.

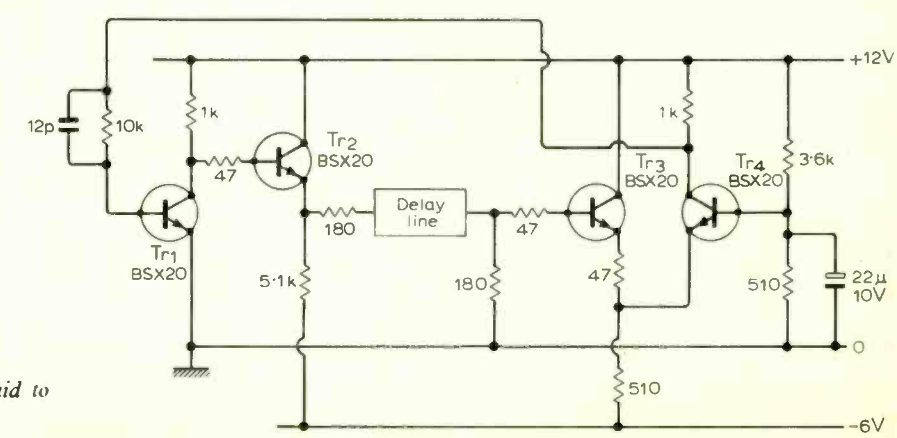


470kHz oscillator with 220Hz modulation, submitted by K. E. Potter. Modulation is at about 90%.

Delay-line coupled multivibrator

This astable circuit is a simple square-wave generator that has an excellent frequency stability. Unlike the conventional *RC* coupled multivibrator, change in collector-to-emitter saturation voltage cannot cause a frequency drift. Drifts in the base-to-emitter voltage influence the frequency slightly because the rise and fall times are finite. The signal on the base of Tr_3 has comparatively slow edges that have been slowed down by the delay line. In this way turn on and off time varies with fluctuations of base-to-emitter voltage. Although this stage is more critical than Tr_1 and Tr_2, it changes the length of period by only a few nanoseconds, since a voltage swing of roughly 200mV on the base of Tr_3 drives Tr_4 from cut-in to saturation. In a temperature range of 0 to 45°C the total frequency drift is much better than 0.1%. Selection of components was not necessary to achieve such stability.

J. HEINZL,
St. Albans,
Herts.



Astable multivibrator, submitted by J. Heinzl, which is said to have excellent frequency stability.

A Thermistor Hygrometer

Instrument uses an i.c. op. amp. as a computing element

by D. Bollen

Atmospheric humidity is an important factor in many industrial processes. To give just two examples; the size and register of printing paper will vary with moisture content, and some textiles can generate dangerous amounts of static electricity in dry air. Equally important outside industry is the damaging effect of incorrect storage humidity on valuable items, such as oil paintings and antique furniture.

Hygrometry instruments which give a direct indication of relative humidity are usually far from precise because of temperature dependence or a drift of calibration with time. The popular hygroscopic hair hygrometer will only behave consistently over a restricted temperature range, and needs to be re-calibrated at frequent intervals. Successful attempts have been made to adapt the potentially more accurate wet and dry bulb hygrometer (psychrometer) to control applications, but the major difficulty here lies in converting two temperature signals into a continuous electrical output which is proportional to humidity. Also, where delicate d.c. amplifiers are employed with low output temperature sensors, the problem of drift occurs.

The thermistor hygrometer described here uses a single i.c. operational amplifier as a computing element, to convert wet and dry temperatures into a voltage which varies with humidity. The circuit is relatively insensitive to changes in air temperature, and will retain its calibration over long periods of time. Typical accuracy for humidities between 40% and 100% over a temperature range of 15°C to 40°C is ±5% of full scale.

Relative humidity

Water vapour in air can be expressed as a percentage of the amount of water vapour that would be present if the air was completely saturated, and the result is a dimensionless ratio known as relative humidity. Unlike absolute humidity, relative humidity is approximately related to evaporation and the moisture content of absorbent materials, and is therefore the most widely used humidity parameter. It is important to remember that, for a given weight of water vapour in a volume of air, relative humidity decreases as temperature is raised.

Quantities of water vapour are often measured in terms of vapour pressure, that is, the contribution made by water vapour to the total air pressure. If e is the variable vapour pressure at air temperature T_a, and e_a is the saturated vapour pressure at T_a, then,

$$h\% = \frac{100e}{e_a} \qquad (1)$$

Obviously, if the air being examined is saturated $e = e_a$ and $h = 100\%$, but if the air is absolutely dry $e = 0$ and $h = 0$.

Wet and dry bulb psychrometer

The Assmann psychrometer will give accurate readings over a wide range of air temperatures, and is often employed as a secondary standard for calibrating other types of hygrometer. Basically, the Assmann consists of two mercury thermometers which are aspirated at a constant rate by a small clockwork or electric fan. While one thermometer serves to display air temperature, the other is cooled by evaporation of water from a moist muslin sleeve surrounding the thermometer bulb. A humidity value can be obtained from the two temperatures with the aid of formulae or, more conveniently, a set of hygrometric tables[1]. It will be evident that the Assmann psychrometer is cumbersome in use, and does not provide a direct output for control applications. An obvious line of thought is to replace the two mercury thermometers by thermistors, and use their negative temperature characteristic to provide outputs which are then processed to yield a voltage analogue of humidity.

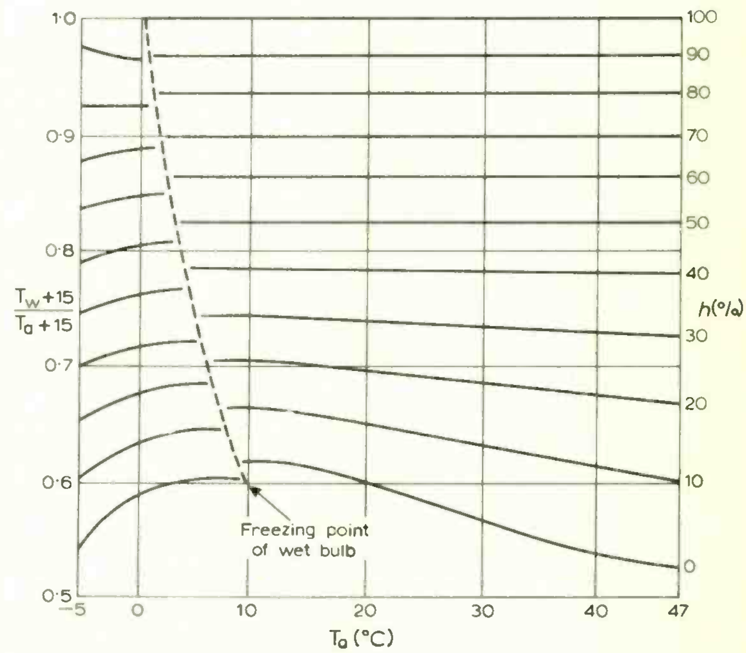


Fig. 1. Humidity curves based on $(T_w + 15)/(T_a + 15)$ versus T_a.

The relationship between vapour pressure e and wet and dry bulb temperatures T_w and T_a, is given by,

$$e = e_w - Ap(T_a - T_w) \qquad (2)$$

where e_w is the saturated vapour pressure at T_w, A is a constant determined by the ventilation rate and mechanical construction of the hygrometer, and p is atmospheric pressure. For an Assmann psychrometer aspirated by an airflow of more than 3·6 metres/sec (where pressure is in millibars and temperature °C) $A = 6{\cdot}66 \times 10^{-4}$ when T_w is above 0°C. When the wet bulb is covered by ice

1. Hygrometric Tables, Part 3. (Aspirated Psychrometer readings degrees Celsius) Met.O.265C. H.M. Stationery Office 1964.

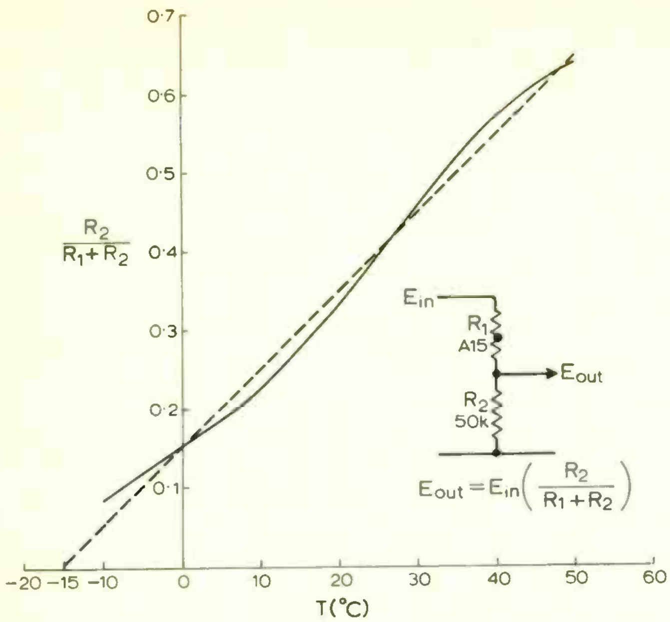


Fig. 2. Performance of potential divider with a thermistor which gives an output nearly proportional to $T + 15$.

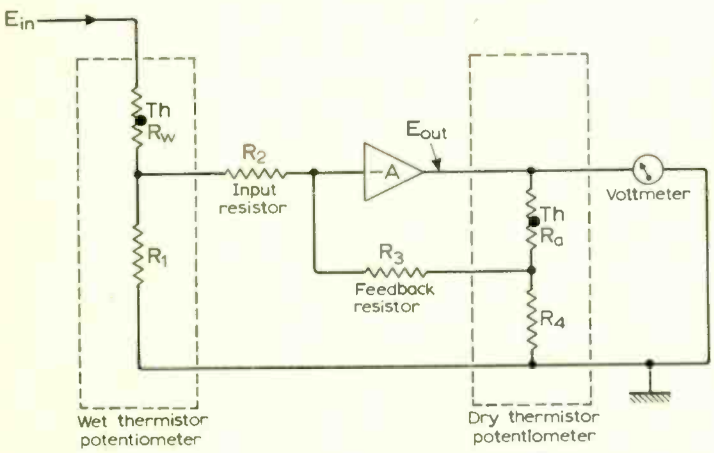


Fig. 3. Basic circuit using an operational amplifier which gives an output nearly proportional to $(T_w + 15)/(T_a + 15)$.

$A = 5{\cdot}94 \times 10^{-4}$. Below 3,000 ft, p can be taken as a constant 1,000 mb. A table of saturated vapour pressures will give e_a for equation (1) and e_w for equation (2).

Although the above equations could possibly be implemented with, say, a couple of diode function generators, a summing amplifier, and an analogue division circuit, the necessary equipment would be costly. However, a search for a more simple relationship between T_w, T_a, and h reveals that the gradient $\Delta T_w/\Delta T_a$ is almost constant for fixed levels of h over a wide range of T_a. If a plot is made of several values of h on a T_w *versus* T_a graph, it will take the form of a series of straight lines originating from a point near $-15°$ T_w and $-15°$ T_a on a Celsius scale. The situation is made clearer by Fig. 1, where $(T_w + 15)/(T_a + 15)$ *versus* T_a presents h as a set of almost horizontal curves, with the resulting humidity scale on the right-hand side. Fig. 1 curves were obtained by calculation from hygrometric tables, and show the transition between the two values for A at the point where the wet bulb freezes. Because an attempt has been made to simplify the original law, accuracy falls at low temperatures and at low humidity levels, and the resulting humidity scale is not linear. Nevertheless, if a simple circuit can be devised to yield the quotient $(T_w + 15)/(T_a + 15)$, the output function will represent high levels of humidity with reasonable accuracy over a wide range of air temperatures above about 5°C.

Thermistor characteristic

Thermistor characteristic curves are invariably plotted against a logarithmic resistance scale, and it is difficult to obtain selected values from them. Given three or four measured values of thermistor resistance at known temperatures, however, the characteristic can be plotted with fair accuracy from the formula

$$R_{th} = ke^{B/T} \qquad (3)$$

where R_{th} is the thermistor resistance, k is a constant determined by substituting known values of R_{th}, B is the characteristic temperature obtained from manufacturer's data, and T is the temperature in degrees Kelvin. A table can be prepared from formula (3) which gives selected values of resistance over the required temperature range.

If a thermistor is used as one arm of a potential divider, an

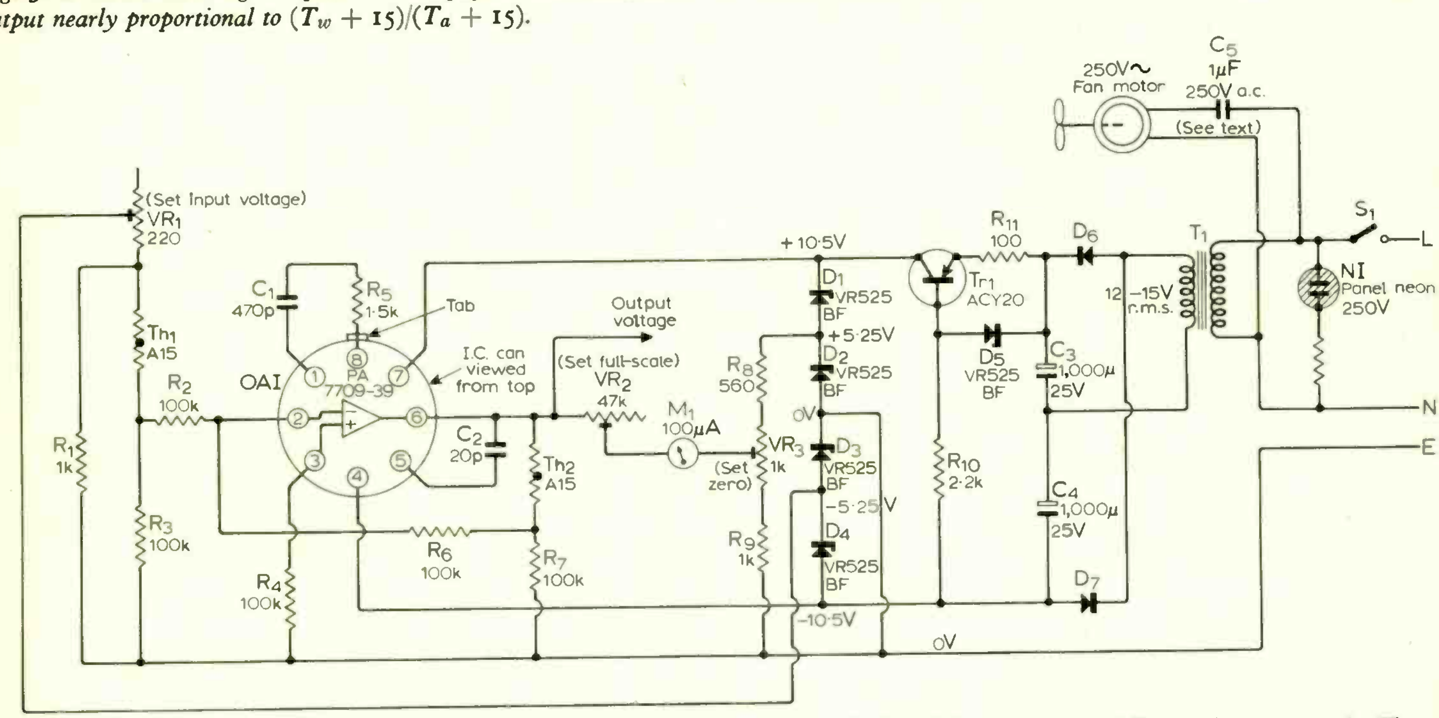


Fig. 4. Complete circuit diagram of the hygrometer. R_1–R_4, R_6, R_7 *should be 2% high-stability resistors and* R_{11} *10% wire-wound 1W; other resistors can be 10% carbon types. Except* R_{11}*, all resistors are 0·5W.* C_1 *and* C_2 *are 125-V polystyrene types. Diodes* D_1 *and* D_5 *are A.E.I. VR 525BF and* D_6 *and* D_7 *are A.E.I. SJ 403-F, while* T_1 *is Mullard ACY 20. The operational amplifier is PA 7709-39 (Philco Ford) available from Rastra Electronics Ltd., 275 King Street, Hammersmith, London W.6.*

output approximating to a linear relationship between temperature and resistance can be obtained. Looking at Fig. 2 a thermistor type A15 is allied with a 50 kΩ resistor, and the resulting potential divider output curve falls close to a straight line based on $T + 15$ degrees Celsius. As we are interested here in the quotient of two such thermistor thermometer outputs, non-linearity errors are not quite so bad as they would appear to be from Fig. 2, provided that tracking between the two thermistors is good.

Division circuit

The division circuit of Fig. 3 is of the type employed in analogue computers, except that here temperature dependent potentiometers replace conventional potentiometers. The operational amplifier of Fig. 3 supplies an output E_o which is related to input E_{in} in the following way.

$$E_o = -E_{in} \frac{\dfrac{R_1}{(R_{thw} + R_1)R_3}}{\dfrac{R_4}{(R_{tha} + R_4)R_2}} \quad (4)$$

Assuming that

$$\frac{R_1}{(R_{thw} + R_1)} \approx T_w + 15, \text{ and } \frac{R_4}{(R_{tha} + R_4)} \approx T_a + 15, \text{ and}$$

$R_2 = R_3$, then,

$$E_o \approx -E_{in} \frac{T_w + 15}{T_a + 15} \quad (5)$$

Thus, the output from the wet thermistor potentiometer has been divided by the output from the dry thermistor potentiometer.

In practice, resistors R_2 and R_3 will load the thermistor potentiometers because the amplifier input is at virtual earth, but this can be obviated by making the parallel combinations R_1, R_2, and R_3, R_4, equal to 50 kΩ. Another practical point is that an output corresponding to $h = 0\%$ will not be zero volts, therefore an offset voltage must be supplied to the voltmeter to give the required suppressed zero.

Thermistor hygrometer circuit

The complete hygrometer circuit appears in Fig. 4. VR_1 sets the negative input voltage across wet thermistor potentiometer Th_1 and R_3. R_2 is the operational amplifier input resistor and R_6 the feedback resistor, while the dry thermistor potentiometer consists of Th_2 and R_7. The i.c. operational amplifier chosen for use with the hygrometer has an open-loop gain >5,000, and is contained in an eight lead TO-5 can. C_1 and R_5 provide input frequency compensation, and C_2 output frequency compensation, to ensure stability with capacitive output loads of less than 0·05 μF. It is anticipated that many currently available i.c. operational amplifiers will operate satisfactorily in the Fig. 4 circuit, although the lead connections may differ.

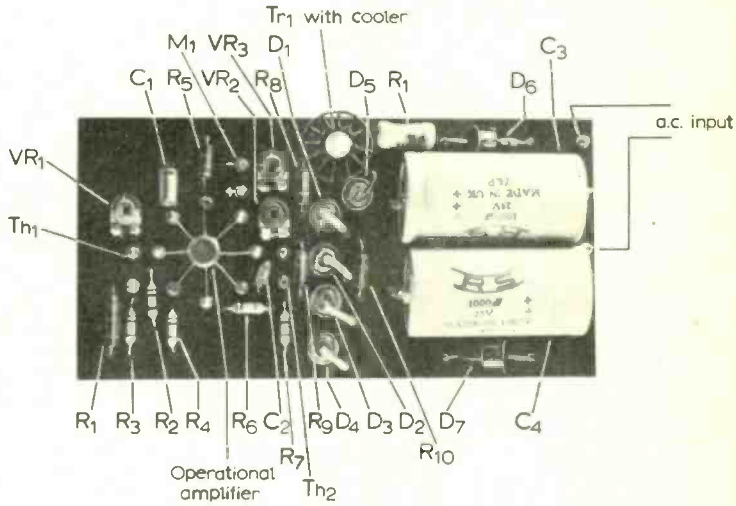
In Fig. 4, the power supply is composed of a 12–15V r.m.s. output mains transformer, with voltage-doubler C_3, C_4, D_6, and D_7 to give a smoothed d.c. output in the region of 35V. A string of zener diodes D_1–D_4 is supplied from a constant-current source Tr_1, D_5, and R_{11}; this arrangement conveniently allows a centre-tap as well as two intermediate voltages.

The positive offset voltage for the meter is obtained from potential divider R_8, VR_3, and R_9. Meter sensitivity is controlled by VR_2. It is thus possible to expand or contract the meter scale to obtain optimum accuracy over the desired range of operating temperature. In addition, the operational amplifier output is capable of driving a load of up to 600Ω to operate an external humidity control switch.

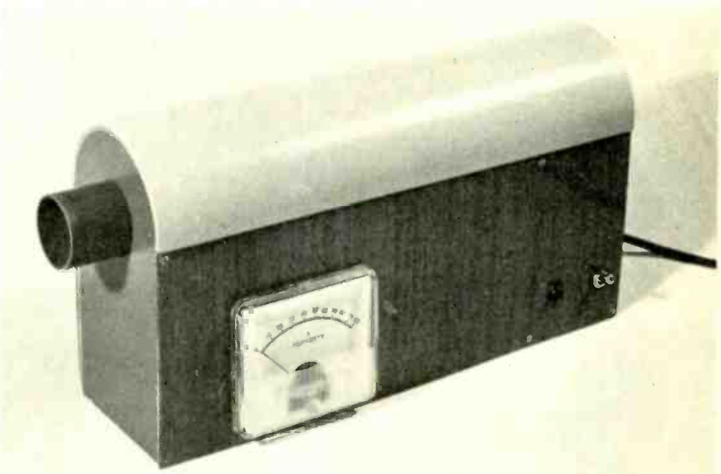
Because of their short life, small d.c. motors are not suitable for continuous ventilation of the wet thermistor. A shaded pole or similar 250V a.c. motor will give adequate ventilation without excessive heat if it is underrun on a supply of about 50–100V r.m.s., achieved by placing an appropriate value of capacitor in series with the motor (C_5).

Constructional notes

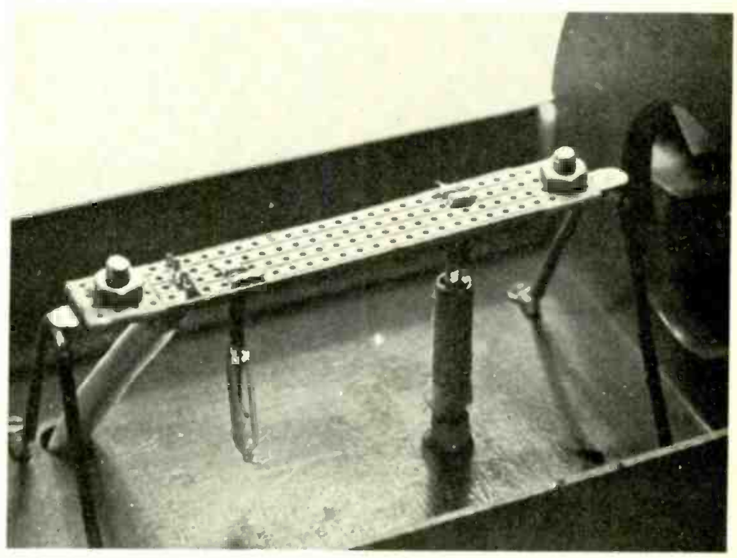
If suitable precautions are taken to ensure freedom from temperature and air pressure gradients around the thermistors, the way in which the instrument is arranged can depend on individual circumstances and preferences.



This photograph shows the layout of the main components.



General view of the complete instrument.



Close-up of the dry (left) and wet (right) thermistors and their mount.

The layout of the prototype hygrometer is depicted in Fig. 5, and in the photographs. No attempt was made to achieve a compact layout as space was not at a premium. There is no particular reason why the hygrometer should not be miniaturised for desk-top use if so desired.

In Fig. 5, the hygrometer case is made up of four compartments, air-sealed from each other by strips of draught excluder on the two side panels. An air duct forms the top of the case, and is ventilated by a centrifugal impeller, with the two thermistors mounted on a strip of Veroboard inside the duct. The wet thermistor is enclosed by a thin brass sleeve, and this is covered by a single layer of muslin. Underneath the wet thermistor is a container holding about 100cc of distilled water; enough for continuous operation over several weeks at normal levels of humidity. The muslin is long enough to act also as a wick, which dips into the water container. Housed in the fan motor compartment is the mains transformer and C_5, with the neon indicator and on-off switch mounted on the side panel. The remaining compartment, underneath the air intake, contains the circuit panel and humidity meter. The purpose of the air-filter bag shown in Fig. 5 is to prevent the ingress of large particles which could cause damage to the thermistors and fan blades.

Pressure gradients will inevitably occur within a system of forced-air flow. It may be that the air in the immediate vicinity of the wet thermistor is found to be slightly above or below atmospheric pressure. It is possible to compensate for this constant pressure deviation, without affecting accuracy, by suitable adjustment of VR_2 and VR_3. More serious, however, is a reduction of air flow caused by a partly-blocked air intake. Quite apart from a general lowering of pressure within the air duct, the reduced flow will modify the calibration constant A in equation (2), and thus introduce serious errors.

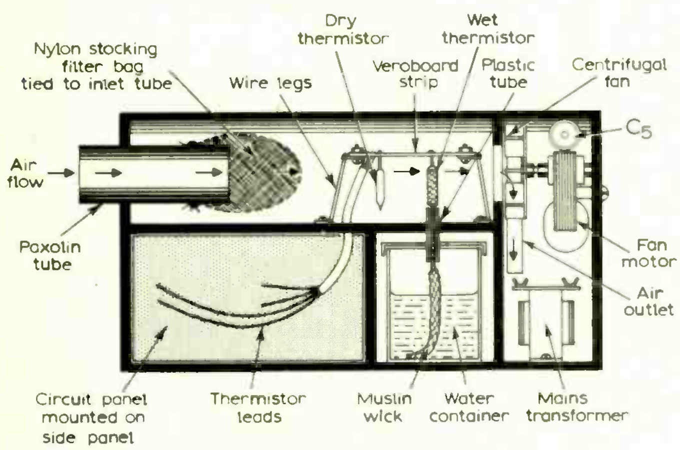


Fig. 5. General form of construction adopted.

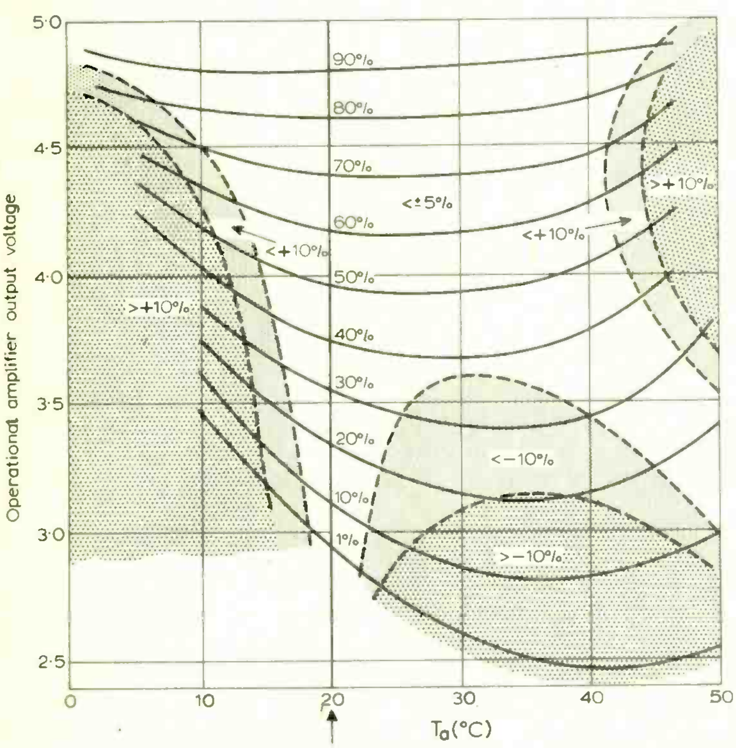


Fig. 6. Thermistor hygrometer error distribution for calibration at 20°C.

Table 1
Meter Scale Calibration

μA	h%
0	0
14	10
25	20
36	30
47	40
58	50
66	60
75	70
84	80
93	90
100	100

Table 2
Voltmeter Offset Voltages

Calibration at T_a =	Offset voltage
10°C	+3·45
15°C	+3·15
20°C	+2·9
25°C	+2·7
30°C	+2·55
40°C	−2·4

The thermal inertia of the thermistors used in the hygrometer is such that the instrument will take about 39 seconds to respond to a 10% increment of humidity, which is considerably faster than the majority of direct-reading hygrometers. However, a rapid response also gives rise to overshoot when abrupt changes of air temperature are experienced. A slow reponse can be achieved, without increasing the thermal capacity of the thermistors, by placing a large-volume cotton-wool filter in front of the air intake. The cotton wool acts as a kind of integrator, by taking up and releasing moisture slowly, and also buffers sudden changes of temperature.

Meteorological advice suggests that the muslin on an Assmann hygrometer wet bulb should be changed before it becomes dirty. Tests with the thermistor hygrometer show that dirt certainly does increase the apparent temperature of the wet thermistor by reducing evaporation, but it is usually sufficient merely to wash the muslin wick after it has become noticeably blackened by dirt. The frequency of washing will depend on the air being sampled. In a grimy room heated by an open fire, the wick becomes dirty after barely 12 hours running time, but in normally clean air the hygrometer will run for several weeks without needing any maintenance.

Table 1 will facilitate calibration of the humidity meter scale, and is derived from calculations based on standard hygrometric tables and thermistor characteristics.

Setting up the hygrometer

Prior to wetting the muslin wick, measure with a voltmeter the voltage between the operational amplifier output and the earth rail, and adjust VR_1 for a reading of 5V. Next, establish the correct offset voltage for a desired mean air temperature by adjustment of VR_3, after referring to the Table 2. Offset voltage is measured between the slider of VR_3 and earth. Next, set VR_2 for a full-scale deflection of the humidity meter.

It is as well to check for good tracking of the two thermistors, still with the muslin unmoistened, by placing the instrument first in a refrigerator and then in a warm oven. Ignoring temporary overshoot caused by abrupt temperature changes, look for a steady full-scale deflection of the humidity meter over 0 to 50°C, within about ±2% at the extreme limits of temperature.

The above procedure is sufficient to calibrate the low humidity coverage of the thermistor hygrometer, but takes no account of high humidity errors caused by those small air pressure gradients when the ventilating fan is in operation. The simplest way of calibrating the high humidity end of the hygrometer scale is to operate the hygrometer in a saturated atmosphere. Construct a simple sling psychrometer from two mercury-in-glass thermometers taped to a wooden dowel. Place a single layer of muslin around the bulb of one thermometer and moisten with distilled water. Take the improvised sling psychrometer out of doors early in the morning, after there has been an appreciable fall of rain and the sky is still clouded over, and wave it vigorously to and fro for several minutes. If both thermometers continue to display the same reading, the atmospheric humidity will be 100%. Set up the thermistor hygrometer close to the ground, with the muslin wick moistened, the fan operating, and the air duct cover in place, and then trim VR_2 for a humidity meter reading of 100%.

Performance and operation

The chart Fig. 6 gives calibration curves and a typical error distribution when the hygrometer is calibrated for a mean air temperature of 20°C. It can be seen that if the hygrometer error is not to exceed $\pm 5\%$, the permissible air temperature variation is only 18·5–22°C at a humidity level of 1%, but increases to 15–42°C at 50% humidity. When the instrument is calibrated for a mean air temperature of 10°C or less, the limits of air temperature variation become very close, even at high humidities. Also, if T_w is below 0°C, the muslin wick will freeze and cut off the supply of water to the wet thermistor.

From the above it is evident that the thermistor hygrometer is not suitable for use at temperatures near the freezing point of water, and is not very accurate at low humidity levels. Nevertheless, with its wide humidity coverage, and satisfactory performance at higher temperatures, the hygrometer will operate well in indoor environments in temperate and tropical climates.

As has already been mentioned, the operational amplifier output voltage is available for control purposes, and could also be employed for driving a chart recorder or telemetry link. In some cases it will be necessary to supply an offset voltage when zero output is required at zero humidity, which entails a floating output. Circuit details will depend on the particular application, but in the case of a simple on-off switch which operates equipment for wetting or drying air, the hygrometer operational amplifier could feed a simple Schmitt trigger and relay.

Flying Laboratories

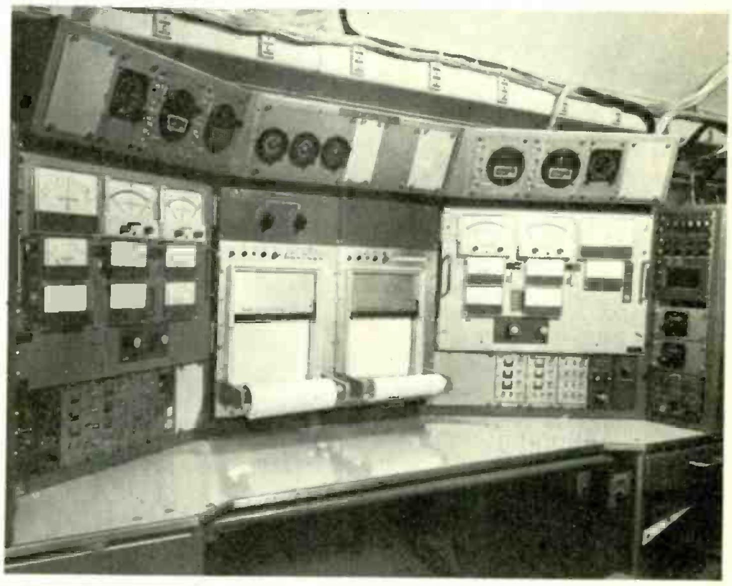
Signals radiated by radio navigational aids for civil aviation are periodically carefully checked by ground maintenance engineers and are continually sampled automatically by monitoring equipment to ensure that proper signals are being radiated. However, the signals may be modified in a manner which is not detectable by ground measurement (for example, by reflection from terrain or man-made objects at comparatively large distances from the transmitting aerial systems) and the consequent deficiencies in the signal can only be determined by making measurements in the air, i.e. by flight inspection. All the radio navigation aids installed and operated in the U.K. by the National Air Traffic Control Services are therefore calibrated and regularly checked by the Civil Aviation Flying Unit of the Board of Trade. This unit, which was formed in 1944 and costs about £1M a year to operate, has recently taken into service two new Hawker Siddeley 748 aircraft fitted with the latest equipment for the flight inspection of navaids. The handing over of the two new HS 748 aircraft, bringing the fleet up to 17, afforded us an opportunity of seeing the Unit.

Between three and four hundred flight inspections covering all the civil v.h.f. omni-ranges (v.o.rs) and distance measuring systems and most of the civil instrument landing systems and radar approach aids in this country are carried out annually by C.A.F.U. All these tests require navigation and flying to a high order of accuracy and demanding a great deal of care in the preparation and operation of the measuring equipment used for the work and in the post flight data analysis processes. The data thus gathered are used to assist the N.A.T.C.S. to maintain the internationally agreed standards required of radio navigation and communication systems for civil aviation.

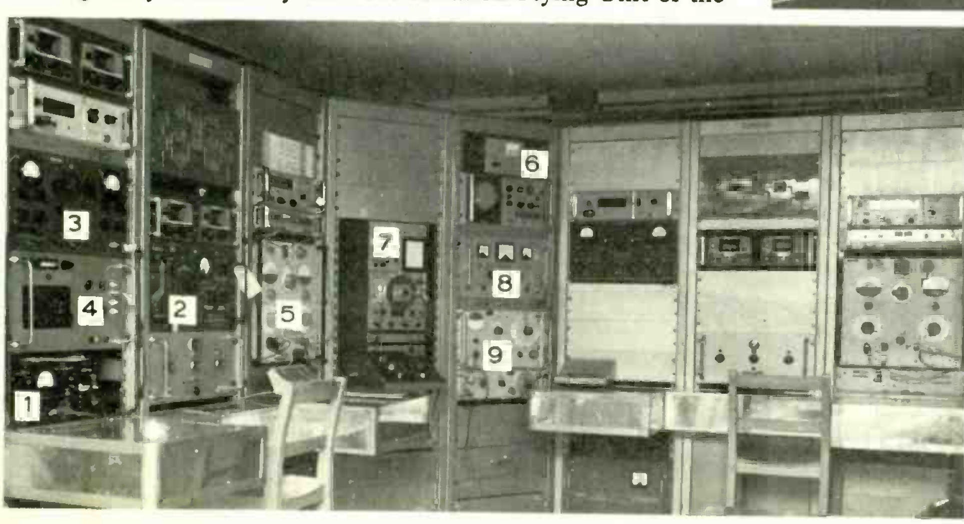
In order to maintain the accuracy of the equipment used in the aircraft for the inspection and recording of the navaids, a standards laboratory has been established at Stansted and the aircraft are in essence "transfer standards". Some idea of the standard maintained can be gathered from the fact that for i.l.s. the glide path error is not more than 0.25 inch (in height) and azimuth is within 2.75 inches.

In addition to these routine tests, aids are subjected to an exhaustive initial scrutiny at installation, to prompt inspection if at any time there is evidence of possible deficiency, and to immediate examination if an accident should occur when an aid has been involved. Another C.A.F.U. task is the flight testing of new types of radio and radar systems.

In addition to its main task of flight inspection the unit also examines civil pilots' flying ability.



One of the two flight checking positions in the new aircraft. The one shown here handles i.l.s. and the other up to four v.o.r. or two TACAN checks simultaneously.



(Left) The C.A.F.U. standards laboratory at Stansted. The annotated instruments are: 1, v.o.r. standard; 2 and 3, v.o.r. tones generator and r.f. signal generator; 4 and 5 i.l.s. tones generator and signal generator; 6, off-air (200 kHz) standard frequency receiver; 7, prototype "Modscope"—i.l.s. modulation measuring oscilloscope; 8, i.l.s. precision calibrator to determine zero d.d.m. (difference in modulation depth); and 9, wave analyser.

News of the Month

European broadcasting satellite

A new European consortium (COMSET—Communications European Satellite Team) led by the French company Thomson-CSF, has submitted a bid to ESRO to provide a European communications satellite which will carry sound and television programmes within the Eurovision countries and Africa, and will be operated by the European Broadcasting Union responsible for operating the Eurovision network. The proposed satellite system will allow the simultaneous exchange of two colour television programmes and ten sound channels between ground terminals situated in Europe and in Africa. Each of these stations will be able to use the satellite both for the transmission and reception of programmes. Command and telemetry systems will be provided separately, as will a channel for the exchange of engineering service messages.

The British representative in the consortium is GEC-Marconi Electronics Ltd. Other countries participating in COMSET are Sweden, W. Germany, Italy, the Netherlands and France.

Since the announcement of the formation of COMSET we have been notified of another European consortium to provide the E.B.U. satellite. It includes companies in Germany, the U.K. (British Aircraft Corporation), Sweden, Belgium, France and Italy.

Four-in-one television receiver

Family arguments as to which television channel to watch will be a thing of the past for those who can afford a new television receiver which is manufactured by the German firm Nordmende and marketed in the U.K. by British Relay. The new receiver has a 63cm (25 inch) colour tube with three smaller, 14cm (5.5 inch), monochrome tubes ranged below it. The main programme of interest can be viewed on the colour tube while the three monitors can each show a different programme. Any of the programmes being shown on the monochrome monitors can be switched to the main screen if desired. Sound for the three monitor channels is available at sockets for connection to earphones if required.

Nordmende's four-tube television receiver being marketed in the U.K. by British Relay.

The first set is on show in London at 84 Victoria St., S.W.1, and other demonstration models will shortly be on show in Birmingham and Edinburgh.

Although primarily intended for the use of actors, critics and television correspondents British Relay will make the receivers available on the retail market for about £850 should there by any demand.

Trade Union for professional engineers

The United Kingdom Association for Professional Engineers (UKAPE) has launched a recruiting drive which started with a press conference in London recently. "The aims of the Association are to protect the individual from exploitation by unprincipled employers and unions, to promote his interests, to improve his conditions of employment and to regulate the relations between him and his employer."

In a statement the vice-president of UKAPE, R. L. Clarke, said: "We are most concerned by the fact that professional engineers are often separated through having to join unions which are at odds with one another". Mr. Clarke went on to say that he hoped that relations with other unions would be friendly and that the Association had no ambitions outside the engineering profession. UKAPE is non-political and seeks no affiliations.

All professional engineers who are members of one of the fourteen institutions within the Council of Engineering Institutions (C.E.I.) are elegible for membership in UKAPE.

The aims of UKAPE cannot be satisfied by the institutions federated under C.E.I. as these are not constituted to handle protection or negotiation, in fact the interests of the chartered engineer could conceivably conflict with the interests of pure learning and an institution could not be on both sides of the fence at the same time. Also the institutions, because of their very nature, cannot give UKAPE any form of financial support. Because of this the Association is to be financed by subscription (full member—£6 and associate member—£4 10s per annum). The Engineers Guild is urging all its members to join the new association. Application forms can be obtained from: UKAPE, 400-403 Abbey House, 2 Victoria Street, London S.W.1.

Film on i.c. production

The latest 24-minute colour film added to the Mullard Film Library is called "Something big in microcircuits". It gives a detailed account of the various processes in the production of integrated circuits at the Mullard plant at Southampton. The film, which includes some excellent macrophotography of devices in various stages of production, is both interesting and informative. Copies (16mm) are available on free loan in the U.K. from Mullard Film Library, 269 Kingston Road, London S.W.19.

Incidentally, although Mullard produce a large quantity of semiconductors they do not require "over 1000 tons of silicon a week" at the Southampton factory as was stated on p.517 last month. That quantity lasts them a year!

Radio and TV relay

Speaking at the annual luncheon of the Relay Services Association of Great Britain, Ralph Gabriel (chairman of the council) criticized the "pettifogging restrictions" under which relay companies are operating and also of the competition likely to come from the new Post Office.

He cited the American Federal Communications Commissions report on "communal antenna television" under which companies in the States will be permitted to relay *any* programmes (in this country they are limited to those normally receivable in the area) and may originate programme material (which is taboo in the U.K.) and in fact any C.A.T.V. system with more than 3,500 subscribers is required as a condition of its licence, to originate programmes to a significant extent.

Mr. Gabriel, who is chief engineer of Rediffusion, also spoke of the selection of programmes by the "dial-a-programme" system which, if it were permitted in this country, might well find a ready market in the U.S.A.

Earth stations for Hong Kong and Jamaica

In a £2.7M contract the Marconi Company are to build satellite earth stations in Hong Kong and Jamaica for Cable & Wireless. Both stations will have paraboloids of 29.6 metres (97ft) diameter. The new aerial will be Hong Kong's second, the first was also built by Marconi, enabling simultaneous communications to both the east and the west. Hong Kong's first station together with the Marconi installation at Bahrain are said to be the first civil 90ft. aerials (and there are 23 of them) to meet all eighteen parts of the Comsat specification.

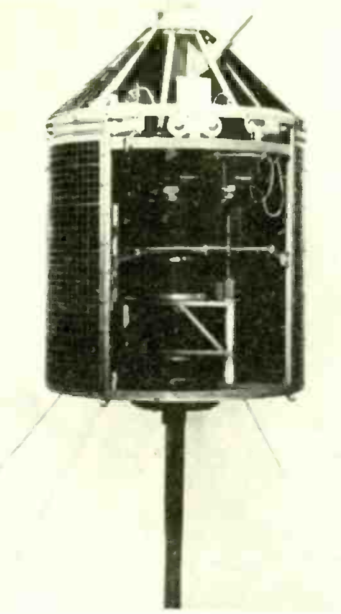
On completion of the new aerial, Hong Kong will be able to communicate with the United States, Australia, Japan and Thailand via the Pacific satellite and with the U.K., Bahrain, East Africa, India, Indonesia, Lebanon, Pakistan and Singapore or Malaysia via the Indian Ocean satellite.

Jamaica's station will allow communication to the western countries using the Atlantic Ocean satellite.

The principal standard of performance used by Comsat is the G/T figure, defined as the measure of aerial gain to the noise temperature of the system, measured at the input to the first stage of the receiver. The Comsat specification, defined by the Interim Communications Satellite Committee, calls for a G/T of 39dB and preferably better than 40.7dB, measured at the centre frequency in the receivng band with an aerial elevation of 5° above the horizon. The figure achieved for the first Hong Kong station was 41.3dB and slightly less for the Bahrain station but still above 40.7dB.

A vernier servo loop operates in conjunction with the more conventional conical scan system used to "hold" the satellite. The vernier servo eliminates the small but rapidly changing pointing errors which occur in high winds. This will mean that the station will be able to operate in marginal weather conditions with winds gusting at up to 80 m.p.h.

Contributing to the low noise figure is a new design of azimuth beaming which assists in keeping the aerial accurately aligned with the satellite. This employs a system of plastic pads running on machined steel bearing surfaces which are lubricated by a continuous feed. However, the aerial will still operate if the oil feed fails. Another advantage of this system is that the plastic bearing can be changed while the aerial is still in operation. When it is considered that the rotating section of the aerial weighs 200 tons, this is no small achievement.



Cut-away view of the 157-pound, German-built GRS-A (German Research Satellite), the first spacecraft in a co-operative programme between the Federal Republic of Germany and the American National Aeronautics and Space Administration. The satellite will study the earth's radiation belts, the auroral zone and the effects of solar proton events.

R.S.R.S. Open Days

Open days were held on 23rd and 24th October at the Science Research Council's Radio and Space Research Station at Ditton Park, Slough, Bucks., at which displays illustrating the work carried out there were arranged. The work is concerned with the propagation of radio waves and related physics. The ionosphere and the effects on it of electromagnetic and particle radiation from the sun, the troposphere and the effects on it of meteorological factors are among the matters to which primary attention is paid.

The work, both experimental and theoretical, is being carried out with the very practical end of improving communications by a better understanding of propagation. The radio frequencies covered range from 10kHz to 1000GHz and the distances being studied range from a few metres to several earth radii. Rockets and satellites are employed in this work.

The major part of the work is carried out at Slough, but there are four outstations; at Chilbolton, Hants., where there is a large steerable aerial; at Winkfield, Berks., where satellite tracking and data acquisition is carried out in conjunction with N.A.S.A.; at Singapore and in the Falkland Islands.

An Englishman's home is his office?

To mark its rebirth as a public corporation the Post Office in collaboration with the Council of Industrial Design has organized an exhibition at the Design Centre, 28 Haymarket, London S.W.1. Open until December 13th the exhibition describes existing services offered by Post Office telecommunications and outlines developments in design and technology from Edwardian times to the present day with a prediction for the future. By 1990 (more probably 2000) it will be possible for many office workers to be able to stay at home and talk to business colleagues by viewphone, transmit data and plans by television or facsimile equipment, and communicate with computers and information services by telex and visual display units.

The viewphone screen will probably have about 230 lines, and the method used in linking sound and vision channels will depend on the demand for such a system. It would be possible to transmit the sound as a p.c.m. code in the vision signal, but this method would exclude the system from the standard telephone network using microwaves.

It is forecast that by 1980 about 64% of all households will have a telephone—instead of the present 30%. There will be a very rapid increase in the use of data transmission and a continued large-scale expansion of the telex services.

1969-70 Faraday lecture

This year's Faraday lecture tour will start on November 18th at Rugby, Staffordshire, and will spotlight, as it has done in the past, aspects of modern electrical and electronic science and technology in straightforward language with particular emphasis on practical demonstrations.

The lecture, which is arranged by the I.E.E., is to be given by J. H. H. Merriman and is called "People, Communications and Engineering". Mr. Merriman is the senior director (development) with the British Post Office and also member for technology on the Board of the Post Office Corporation. The deputy lecturer is C. H. May who is a staff engineer in the Post Office Telecommunications Department. The lecture will be given in thirteen towns in the British Isles.

S.R.C. annual report

The Science Research Council's report for the year 1968-69 has just been published and is available from H.M.S.O. for 8s 6d. Apart from various organizational matters the report gives facts on all manner of research projects being carried out up and down the country and in Europe and makes very interesting reading.

One of the announcements made in the report is that the University Science and Technology Board is to be dissolved and its place taken by two boards one responsible for science and the other for engineering.

Selling Colour

Mullard have produced a quick-reference manual entitled "Selling Colour—A Promotion Pack for dealers". This contains largely information which has already reached dealers from many different sources, but is here collated. In addition to advice on demonstrating and selling, it contains maps and estimated dates for the start of new colour transmissions.

It is available only to dealers and in the first place to those in the initial BBC-1 and I.T.V. colour areas. Applications for a copy should be made to Distributor Sales Division, Mullard Ltd., Mullard House, Torrington Place, London W.C.1.

Diode Line Pulse Shaper

Circuit for use with t.t.l. gate

by B. L. Hart, B.Sc., M.I.E.R.E.*

Typical logic voltage levels for the t.t.l. gate[1] are $V_{OUT(1)} = 3{\cdot}3$ V and $V_{OUT(0)} = 0{\cdot}2$ V (at a sink current of 16 mA). Thus when it is desired, as in the field of nuclear pulse instrumentation, to drive d.c.-terminated low-impedance coaxial cable, the outer conductor of which is earthed, a voltage-level compatibility problem arises.

The interface circuit arrangement shown inside the dashed square in Fig. 1 has proved useful for cable driving. Operation is as follows: when the input at A is at logic 0 it acts as a sink for the current in R, point B is at $\{V_{OUT(0)} + V_{D1}\}$ and point C is at earth because,

$$\{V_{OUT(0)} + V_{D1}\} < \{V_{\gamma D2} + V_{\gamma D3} + V_{\gamma D4}\} \quad (1)$$

where γ indicates "threshold-of-conduction" level and V_{D1} = forward voltage drop in D_1.

When A is at logic 1, C assumes a potential V_0 where,

$$V_0 = \{V - V_{D2} - V_{D3} - V_{D4}\} \times R_T/(R + R_T) \quad (2)$$

provided,

$$V_{OUT(1)} > \{V_0 + V_{D2} + V_{D3} + V_{D4}\} \quad (3)$$

Variation of V permits control of output pulse amplitude.

In the circuit used D_1, D_2 are hot-carrier diodes (Hewlett-Packard type HP5082–2301). D_1 cuts off without significant carrier storage when the logic level changes from 0 to 1 permitting a flat-topped output pulse, while rapid switch off in D_2 ensures no significant reverse current in R_T and hence no undershoot in the output for the reverse logic-level change. D_3 and D_4 are Si diodes type TMD7000 (Transitron): these are micro-versions of the closely specified SG5000 (IN4308). The noise margin, V_{NMO}, for logic level 0 is given, from equation (1), by

$$V_{NMO} = \{V_{\gamma D2} + V_{\gamma D3} + V_{\gamma D4} - V_{OUT(0)} - V_{D1}\} \quad (4)$$

Obviously V_{NMO} may be improved by adding a diode in series with D_2: this is permissible providing equation (3) is still true when allowance is made for the extra diode drop. Circuit waveforms are shown in Figs. 2 to 5. If the connection from the t.t.l. unit is short the waveform at A is clean but when the interconnection comprises, as in the present case, a length of twisted-pair reflection effects, well discussed in the literature,[2] are observed, as in Fig. 2. The negative portion of the waveform following the $1 \rightarrow 0$ transition may be reduced in amplitude by the connection of a diode, shown dotted as D_5 in Fig. 1.) No trouble due to reflection occurs providing V_{NMO} is not exceeded. Figs. 3 and 4 show, on an expanded time and voltage scale, details of the leading and trailing edges of the waveform at C. Fig. 5 shows that delay-line differentiation is possible when a length of cable (RG213U) shorted at the far end is connected to C. The magnitude of the negative-going pulse for undistorted output depends on V_{NMO}. In cases where it is desirable to use a fixed voltage supply V, the resistor R may be replaced by a variable current source, such as a suitably biased common-base transistor stage with a potentiometer in its emitter circuit.

*West Ham College of Technology, London E.15

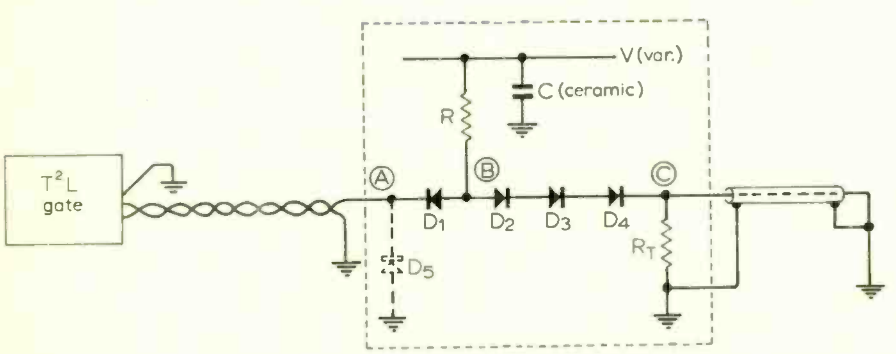


Fig. 1. Diode pulse shaper. D_1, D_2 = HP5082–2301 (Hewlett-Packard); D_3, D_4 = TMD7000 (Transitron); T²L gate = SN7400 (Texas); R = 1 kΩ (Metal Film); R_T = 50 Ω B.N.C. termination.

References

1. "Texas Instruments Semiconductor and Components Data," Book 2. 1968.
2. "Simple graphical method to determine line reflections between high-speed-logic elements". M. Abdel-Latif and M. J. O. Strutt, *Electronics Letters.* Nov. 1968, Vol. 4, No. 23, pp 496-498

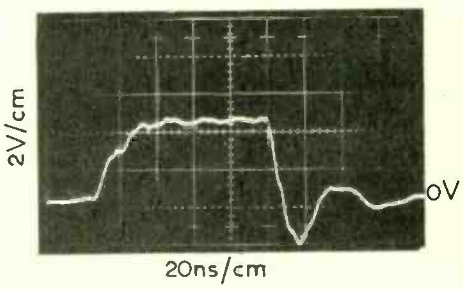


Fig. 2. Input waveform at A in Fig. 1.

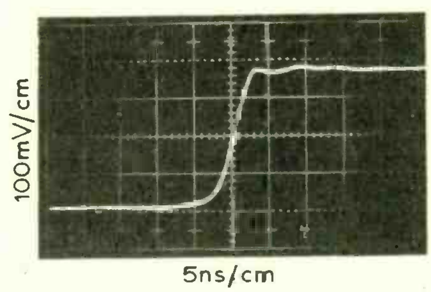


Fig. 3. Leading edge of output waveform at C.

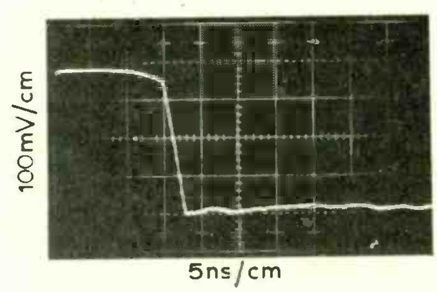


Fig. 4. Trailing edge of output waveform at C.

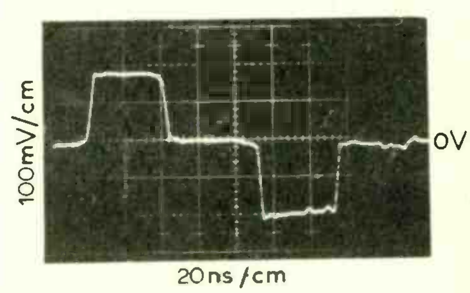
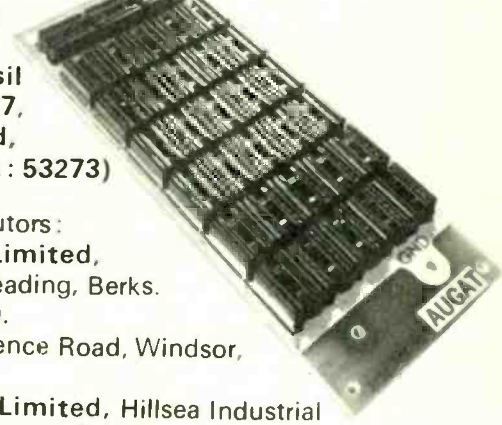


Fig. 5. Waveform at C with shorted line connected at C.

Packaging? 'Augat' have time-and-cost saving all wrapped up

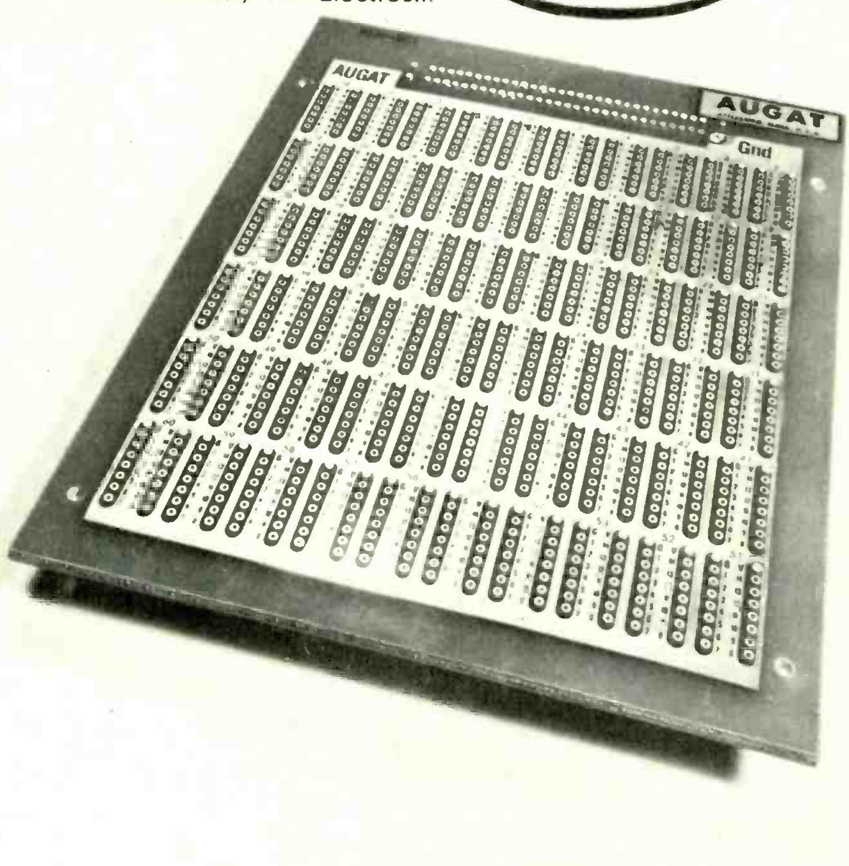
'Augat' just can't let up being ingenious with packaging systems and I.C. hardware. Customers keen on cost saving, time saving and the utter reliability that comes from 'Augat' quality keep coming back for more to Electrosil, their U.K. source. Take actual mounting panels. 'Augat' construct them from $\frac{1}{8}$" thick epoxy glass boards, making reinforcement brackets unnecessary. One less complication. The sockets used are either closed entry or, in the case of dual-in-line sockets, protected entry. The hazard of fouled contacts, therefore, is sharply reduced. One worry less. And the 'Augat' breadboarding system is small, compact and astonishingly robust. Dual-in-line I.C. sockets range from solderpots to wire-wrap, and can be custom designed; LSI and MOS series come at prices that make plugging a worthwhile consideration. And Electrosil keep a hot supply line going that means instant availability ... wherever. To itemise—'Augat' for Sockets, Breadboard and Test Panels, High Density Packaging Panels, Sockets and Connectors for flat packs and TO-5 packages, Teflon and glass epoxy sockets, Crystal and transistor sockets, Jumper leads and accessories for 'Augat' breadboards. Data sheets on application. Available in the U.K. only from Electrosil.

Contact Electrosil direct and speak to Alan Johnston, telephone number: Sunderland 58704; or write to Electrosil Limited, P.O. Box 37, Pallion, Sunderland, Co. Durham. (Telex: 53273)



or to Electrosil distributors:
WEL Components Limited, 5 Love Rock Road, Reading, Berks. Tel: Reading 40616-9.
Electrautom, 8 Clarence Road, Windsor, Berks. Tel: 64258.
SDS (Portsmouth) Limited, Hillsea Industrial Estate, Portsmouth, Hants. Tel: 62332

Electrosil LIMITED have the experience



Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Transistor distortion characteristics

I have read with interest the article by Mr. Linsley Hood in the November issue. Mr. Hood has come to the conclusion that his amplifier stage gives more distortion for low collector currents and high h_{fe}s. He has shown 13 curves to prove his point, but he has not made any attempt to explain why the situation is so troublesome to audio pre-amplifier designers.

If we take the BC109 as an example and try to control the collector current from an ideal voltage source applied to the base, what will happen? Suppose that the transistor has the recommended quiescent point of $I_C = 2$mA and $U_{CE} = 5$V with h_{FE} and h_{fe} of approximately 300. The base current of the transistor will of course be $I_B = I_C/h_{FE} = 2/300\text{mA} \approx 7\mu\text{A}$.

When a voltage source of, say, $E_s = 10$mV r.m.s. is applied to the base, this will appear across the h_{ie} of the transistor and give a change of base current. For BC109 $h_{ie} = 4.5\text{k}\,\Omega$ for the mentioned quiescent point, and the change in base current will be approximately $\pm 10\sqrt{2}\ /4.5\mu\text{A} \approx \pm 3\mu\text{A}$, which is almost $\pm 50\%$ of the quiescent base current! The collector current is of course $h_{fe}I_b$ and will also make a 50% swing, from 1mA to 3mA.

A look at the $h_{ie} = f(I_C)$ curve published by Telefunken shows a very great dependence. For $I_C = 1\text{mA}, h_{ie} \approx 9\text{k}\ \Omega$ and for $I_C = 3$mA, $h_{ie} \approx 3\text{k}\Omega$, a change with a factor 3:1! Thus the base current will not follow a linear relationship to the source voltage, neither $I_b = F(E_s)$ nor $I_c = f(E_s)$ will be straight lines.

A high value of quiescent base current (low h_{FE} and/or high I_C) will obviously make things brighter, at least as far as distortion is concerned. If this is not possible, one solution is to make certain that the change in base current comes from a *current* source, for example a preceding stage with high output impedance. An f.e.t. common-source stage will do admirably as it can be regarded as a voltage controlled current source if drain resistance is high compared to the h_{ie} of the following transistor.

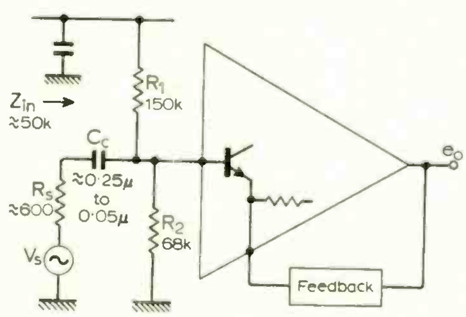
The other solution is to use negative feedback from an un-bypassed emitter resistor R_e. This will appear (for the source voltage) as a resistance of the value $h_{fe}R_e$ (approx.) in series with the h_{ie} and so the change of h_{ie} will be negligible if $h_{ie} \ll h_{fe}R_e$. This is exactly what Mr. Hood has done in circuit D of his article. He also mentions that the distortion factor increases with a decrease of un-bypassed resistance. The open loop gain is said to be about 8000 and the 47Ω resistance will probably appear as a $47 \times 8000 \approx 400\text{k}\,\Omega$ resistance in series with the input impedance of the first transistor.

Conclusion: The important thing for a transistor voltage amplifier stage is that $I = f(E_s)$ is a straight line. The influence of the non-linearities of transistor input impedance should be minimized by applying a high (equivalent) resistance in the signal path of the input.

PER ENGSTRÖM, Lund Institute of Technology, Sweden.

Noise in transistor amplifiers

While working with amplifiers using input and feedback stages similar to that outlined, a curious low-frequency noise was encountered. The amplitude and frequency were Gaussian in nature and extended from approx 5Hz to 100Hz. However, this noise was much greater than the normal wideband noise inherent in all amplifiers.



The Johnson noise contributed by R_s ($\approx 600\,\Omega$) is fairly low. However, some noise is injected into base by transistor action; there is also a considerable amount of noise contributed by R_1 and R_2. The sum of this Gaussian noise appears at the junction of R_1 and R_2, so we can represent the source impedance of such a noise generator by the lowest impedance that contributes to it, i.e. parallel impedance of R_1 and R_2. This is approximately $50\text{k}\,\Omega$.

This noise generator, with its $50\text{k}\,\Omega$ source resistance, appears across the reactance of C_c added to R_s. Thus one would have expected this noise to be low. However, the reactance of C_c ($0.25\,\mu$F) rises considerably at 5–10Hz. Thereby, R_s and C_c form a shunt low-pass filter for the noise source, injecting into the amplifier all the low-frequency components arising within the Gaussian distribution of the noise.

When C_c was increased to $10 \sim 16\mu$F, the effect disappeared, leaving only the normal Gaussian noise. The noise level, as monitored on a peak programme meter, dropped, by -6dB, as would be expected because of the nature of the unintended filter.

It is possible to select low-noise components for R_1, R_2 and transistor but then it is always possible to secure an additional -6dB change in noise level by just increasing C_c. In fact there is then no advantage in using expensive components for R_1 and R_2 since trouble might later arise when they begin generating noise near end of life. Also, it is no longer possible to change R_1 and R_2 if one begins to use them in integrated form.

The corollary is that one would be well advised in having selected as large a value of C_c as is practicable, such that the reactance of $C_c + R$ at 5Hz or so does not increase substantially above Z_{in} for the particular amplifier. Most high-quality amplifiers, operational amplifiers and all integrated d.c. and operational amplifiers will readily respond to 5Hz or so and since most high-input impedance stages use similar potential dividers, this factor should be carefully weighed. When R_s is comparable to Z_{in}, the problem should not arise of course.

R. THANKY,
London N.19.

Stereo decoder adaptor

Having seen the circuit for a stereo decoder adaptor in "Circuit Ideas" in the September issue I am prompted to send you a much simpler circuit which I have been using for several months.

Instead of having a variable gain amplifier on each channel a 0.5 attenuator is placed before the decoding matrix when a mono programme is being received. With a mono signal Tr_9 saturates and earths one end of the attenuator chain formed by the two $10\text{k}\,\Omega$ resistors. Thus only half the mono sign is applied to the matrix. On stereo Tr_9 is off and the full signal is applied to the matrix. The $100\text{k}\,\Omega$ resistor ensures that the 1μF capacitor does not have to change its charge when going from mono to stereo.

A. ROYSTON,
University of Warwick,
Coventry.

Local radio

In the reference to local radio in your November Editorial you say "While the use of such (directional) aerials would certainly avoid the stations causing interference with other transmitters sharing the frequencies, it would not eliminate interference from Continental stations". This would indeed be the case if the operating frequencies of the proposed British Local Radio System were indiscriminately chosen, without regard to those stations which are capable of causing interference with United Kingdom transmitters.

My company has carried out exhaustive tests in many parts of the United Kingdom. These tests demonstrate that, of some twenty-five channels selected for initial evaluation, at least eleven are suitable for use in some, if not all, of the areas which would probably be served by British Local Radio. In addition, these channels would be available under the terms of Article 8* of the Copenhagen Convention.

Using no more than eight of the channels it would be both technically and legally possible to operate at least one hundred low-power medium frequency stations in the British Isles, each one of which would be sixty miles from its nearest neighbour on the same frequency.

Many critics of this proposal overlook the fact that very few of the proposed stations would need to cover a service area greater than five miles in diameter. In consequence, not more than fifteen of the stations would utilize a power in excess of 1.5kW, whilst the vast majority would use 500 watts or less. (Incidentally, although 100 stations are theoretically possible, my company is of the opinion that not more than fifty would be economically viable).

The credibility of this statement is clearly demonstrated by the performance of some existing B.B.C. stations. Current B.B.C. Engineering Information Department lists show 43 low-power medium frequency stations (of 2kW or less) as operational in the United Kingdom. Between them they carry all the B.B.C. domestic services, and they all operate from early morning until about midnight. The 1484-kHz transmitter at Bournemouth is on the air from 05.00 until 02.00 the following morning. This station was opened as recently as November 1968, and it is difficult to imagine that it would have been authorized if the Engineering Department of the B.B.C. and the Broadcasting Department of the Post Office (responsible for ensuring the observance of the Radio Regulations of the International Telecommunications Union and issuing licences for the operation of transmitters) had not been satisfied that it would provide a satisfactory service within the area it was designed to serve.

The Bournemouth transmitter is of particular interest in that it uses an International Common Frequency, and, in consequence, shares this frequency with some 150 other stations throughout Europe. Nevertheless, to quote the words of the B.B.C. Engineering Information Service, "It provides a perfectly acceptable signal in the town of Bournemouth".

If further evidence were needed what better authority could be quoted than Lord Hill, Chairman of the B.B.C. who is reported as having said recently "I hope there is going to be some medium-wave reinforcement for local radio—a question we are now discussing with the Post Office Minister who has the authority for frequency allocation". His Lordship went on to say that there was some availability of medium wavelengths, and that medium frequency local broadcasting was technically possible "or we should not be putting it to The Minister". The Director General of the B.B.C. said much the same thing two days earlier.

To sum up, providing that the main criteria of low power, suitably engineered aerial systems, and an intelligent selection of operating frequencies are observed, there is no reason to doubt that a chain of local radio stations could be established in the medium-frequency band.

DEREK FARADAY,
Commercial Broadcasting Consultants Ltd.
London, W.C.2.

---

* This permits modifications to the European Frequency Allocation Plan provided agreement is reached between Administations operating in the channel.—ED.

I could not agree more with your November Editorial particularly in connection with the subject raised in Mr. Uden's interesting letter appearing in the same issue.

The B.B.C. claims to offer a v.h.f. service and yet Radio 1 is always regarded as the poor relation by "Aunty".

There are several programmes transmitted only by Radio 1 which would benefit the listener if they were available on the interference-free, high-quality v.h.f. service; and yet listeners must tolerate, at best, low bandwidth audio and, at worst, high distortion and frequent fading.

Another important factor is the education, if I may use the word, of the general public; many individuals have never heard "live" music and have come to regard the m.w. "sludge" as the real thing.

We are supposed to be in an age of technical innovation and development, particularly in the field of electronics and communications, and yet an important part of our radio service is still living in the dawn era of wireless.

E. W. FIRTH,
Saltney,
Chester.

Combating television interference

I read with great interest the letter from S. E. Jones, regarding the suppression of television interference, in your February 1969 issue. I was immensely happy to note that the method tried by Mr. Jones is basically the same as the one tried by me here some two years back. Since our TV receiving aerial is very near the high power s.w. transmitting centre, the intensity of the harmonic interference used to be very severe. One of the harmonics—which happened to be 240kHz below the TV carrier—was very strong and when it came up, the picture and the sound as well used to be wiped off completely. To eliminate this interference the method tried was as follows: The interfering signal was picked up from another three-element yagi and fed into a single stage v.h.f. amplifier in which the phase and gain of the harmonic could be adjusted by means of the tuning and gain controls respectively. The output of the amplifier was then fed into the television receiver input where the TV aerial was already connected. The length and polarity of the cable from the pick-up aerial was adjusted suitably so that the amplifier tuning point is optimum, i.e., with minimum gain. Even after tuning the amplifier for best results, there used to be some faint lines on the picture of varying intensity on account of the modulation on the interfering signal. This was also reduced considerably by introducing a filter (with 12dB cut off for 240 ± 10kHz) in series with the video input to the picture tube.

T. S. VASAN,
Delhi,
India.

Tolerance!

What a consolation it was to read Mrs. Dinsdale's "Living with Hi-Fi" in the November issue! For years I had wondered if my husband was unique in involving the whole household when designing and constructing electronic equipment; but now I know there are others, the upheavals will seem more tolerable.

I can go one stage further though. Our son of 15 has "adopted" electronics and his "bedroom" is full of equipment in various stages of development. So when the air is full of talk of "pots, resistors, capacitors, etc." and conversation too highly technical for our ears, my daughter and I retire to the kitchen and prepare to "feed the brutes".

At least Mrs. Dinsdale has good music to listen to sometimes!

MAUREEN NELSON-JONES,
Bournemouth, Hants.

Wireless World Diary

Clearer type, enlarged page size (75 x 128mm) and therefore larger diagrams, and a complete revision of the information in the 64-page reference section make the Wireless World Diary 1970 even more useful than its predecessors. It still has a week-at-an-opening diary section and costs 10s (leather) and 7s (rexine). It will be available on December 1st. Postage, if ordered from Dorset House, Stamford St., London S.E.1, is 4d.

Logic Symbols

A quick look at the new British Standard

The shapes and symbols used to portray logic functions are as varied as they are numerous. The time taken to discover what the symbols mean in any particular case can be appreciable and sometimes even then the function is uncertain.

To combat this the British Standards Institution has produced BS3939, section 21, "Pure logic and functional symbols" which drastically alters earlier British Standards on the subject to bring them in line with the International Electrotechnical Commission's proposals made at a meeting in Stockholm in September 1967.

The symbols are intended for use in any branch of logic engineering, be it electrical, electronic, pneumatic, hydraulic or mechanical.

The basic gate symbol is shown at (a) and is the half moon shape. The new symbols also show the logic convention in use at any particular point in the diagram as shown at (b) and (c). The gate shown at (a) therefore has a positive logic input and output. Mixed positive and negative logic inputs and outputs may be employed.

The symbol at (d) shows a gate with an inhibiting input (shown by the bar) and a negated output (the circle). A negated inhibiting input is shown at (e). The oblique line of (f) indicates an executive, strobe or clock input. The five basic functions AND, OR, NAND, NOR, NOT are shown at (g) to (k). The symbol of (l) is an identity element, or equivalence element, where the output represents "1" only when all the inputs are also "1".

Multistable elements have a square for each stable state, so the symbol at (m) is a bistable. It has one input. The application of a "1" at this input would cause a "1" output from the upper square. The input lines can be drawn with the same negating and inhibiting symbols as used for the gates. A stepping input is shown at (o). Outputs are drawn from the appropriate squares as illustrated at (p). A quasi stable state is portrayed as a shaded triangle and *t* is the quasi stable duration. For distributed OR or AND connection the symbol is the diamond of (r) with a "1" or "&" adjacent to the diamond as appropriate.

The BS states that large blocks of logic may be denoted by a suitably labelled square with appropriate inputs and outputs. We have devised our own two; (s) is used at the very beginning of a system design and (t) is often appropriate a little later on!

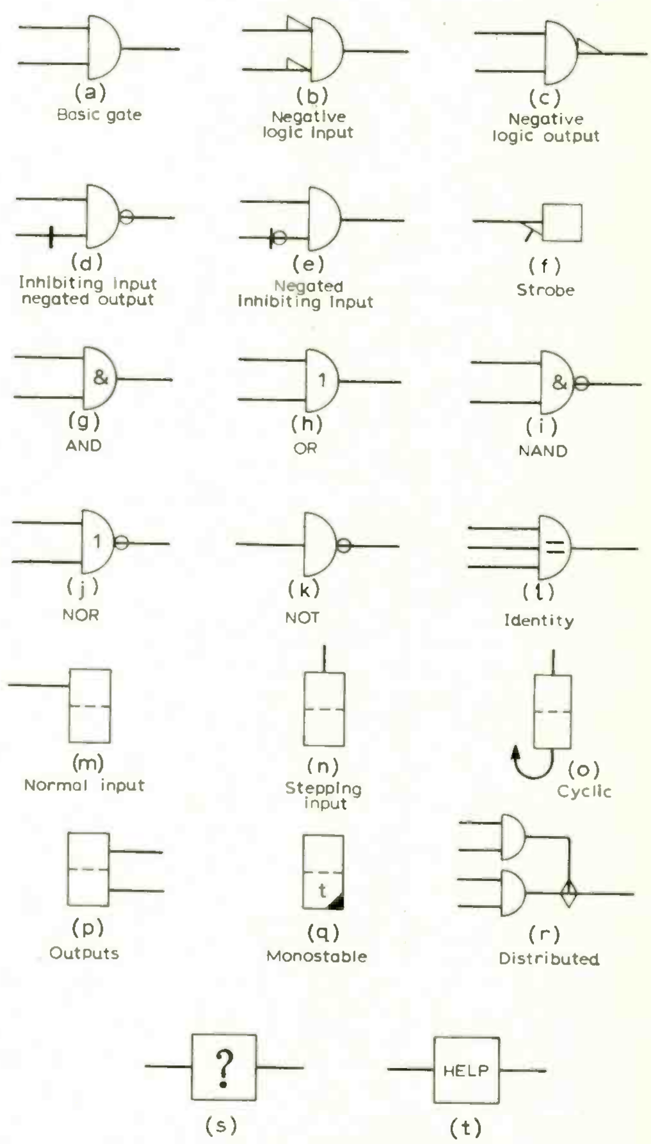
The identification of signal lines follows what is now accepted as almost standard practice. The signal name should relate to the "1" state of that signal and a bar placed over the signal name refers to the logic negation of the signal.

e.g. $\overline{\text{SUM}}$ = the logic negation of SUM.

This labelling is the subject of only one limitation, the NAME and $\overline{\text{NAME}}$ labels must not be used to indicate the two states of the same signal at different times.

This has been just a quick look at BS3939, Sect. 21. For more information the BS is available from the British Standards Institution, 2 Park St., London W.1, price 12s.

$\overline{\text{BEGINNING}}$



Some of the new logic symbols are shown above and it can be seen that these differ a good deal from the earlier standard which used a circle as the basic gate symbol. The only change that is really likely to cause confusion is the use of the bar, in gate symbols, to represent inhibition instead of negation as was done earlier. It would be a good idea if manufacturers would, in addition to adopting the new standard, agree as to which logic convention should be used to specify the function their components perform.

Active Filters

5. An integrator and a lag in a loop

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

Practical circuits for realising the theoretical schemes discussed in Part 4 will use feedback in one form or another to stabilize amplifier gain. One of the simplest arrangements for a 2nd-order filter is a feedback loop containing an integrator and a lag, and in many cases this allows a circuit using only one amplifier.

Analysis shows, however, that high Q factor calls for a wide spread of capacitance values (or CR products) and high amplifier gain. In general, therefore, the arrangement is most suitable for low Q factors.

Shunt feedback—the virtual earth principle

When the amplifier is sign-reversing, negative feedback can be applied by the "see-saw" arrangement of impedances shown in Fig. 1. As A tends to infinity the driving voltage at the input of the amplifier, $-V_0/A$, tends to zero. This leads to the concept of the virtual earth and the idealized relationship

$$\frac{V_0}{Z_0} = -\frac{V_1}{Z_1} \quad \text{or} \quad \frac{V_0}{V_1} = -\frac{Z_0}{Z_1} \qquad (1)$$

If $Z_0 = Z_1$ the magnitude of the overall gain is unity, and the circuit gives the superficial appearance of being an example of 100% feedback. The correct analysis, however, is that the feedback fraction $\beta = Z_1/(Z_0 + Z_1)$, and that because of "potting down" by the same two impedances the effective input voltage is $V_1Z_0/(Z_0 + Z_1)$.

When a second input channel is added V_1 and V_2 are summed, ideally, according to the equation

$$V_0 = -\left\{\frac{Z_0}{Z_1}V_1 + \frac{Z_0}{Z_2}V_2\right\} \qquad (2)$$

Finite gain

When allowance must be made for the finite gain of a practical amplifier the equivalence shown in Fig. 2 can be used. This result is established by finding the shunt impedance to earth which makes the input current i the same for the two versions of the circuit.

It can be seen that to a first approximation

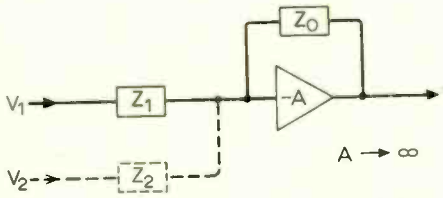


Fig. 1. Basic arrangement for applying feedback and adding signals by the shunt or virtual-earth method

the overall gain of a shunt-feedback circuit will be affected by finite amplifier input impedance only if this is comparable with the equivalent shunt impedance $Z_0/(A + 1)$. The correct analysis of the circuit outlined in the preceding section, however, shows that the operation of the circuit is seriously affected (in zero drift, signal/noise ratio, linearity, for example) if the amplifier input impedance is equal to or less than the net parallel value of Z_0, Z_1, Z_2, etc., (Fig. 1), and in general this is a condition to be avoided.

Lag-and-integrator loop

In Part 1 under the heading *direct synthesis* it was shown that the response of the second-order low-pass network, Fig. 3(a), can be reproduced by an active system containing a lag and an integrator in a feedback loop; i.e. (when $\beta = -1$)

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

if

$$\mu = \frac{1}{1 + qpT}\cdot\frac{1}{pT/q} \qquad (4)$$

Blumlein (or Miller) integrator

The most familiar electronic integrator is the feedback type shown in Fig. 4(a). From equn. (1), when $A \to \infty$,

$$\frac{V_0}{V_i} = -\frac{1}{pCR} = -\frac{1}{pT} \quad [T = CR] \qquad (5)$$

There is, therefore, for the lag-and-integrator loop shown in Fig. 3(b) a minus sign in front of the expression for μ, and the loop is closed in the correct sense by adding V_{out} to V_{in}. The boxes in the diagram are intended to indicate that the several parts of the loop are effectively isolated by buffers.

The internal gain of an integrating amplifier limits the performance of an active filter. The equivalent circuit, Fig. 4(b), shows that when allowance is made for finite amplifier gain the integrator degenerates to a simple lag, time constant $(A + 1)CR$, multiplied by the gain factor A; i.e.

$$G(p) = \frac{A}{1 + (A + 1)pCR},$$

$$G(\omega) = \frac{A}{1 + (A + 1)j\omega CR} \qquad (6)$$

A perfect integrator, $G(p) = 1/pCR$, $G(j\omega) = 1/j\omega CR$, gives a constant phase

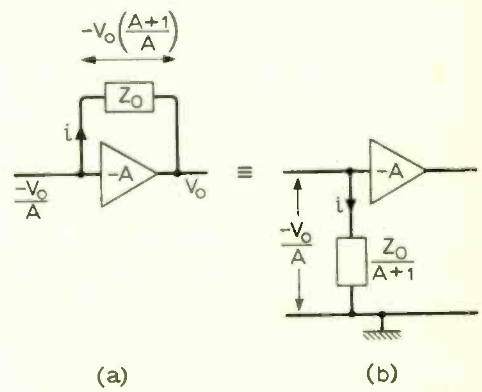


Fig. 2. Mathematical equivalent of an amplifier with a shunt feedback impedance

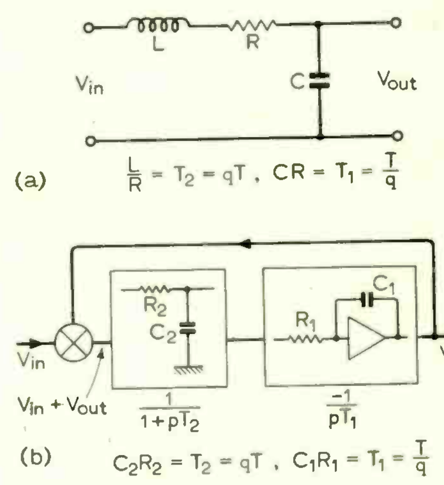


Fig. 3. (a) a 2nd-order passive low-pass network; (b) an active equivalent, a lag-and-integrator loop

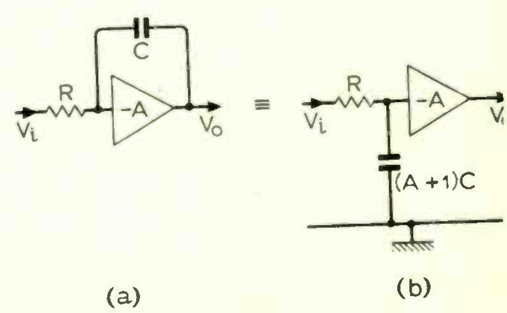


Fig. 4. The equivalence shown in Fig. 2 applied to a Blumlein feedback integrator

*Royal Radar Establishment.

shift of 90°, and an amplitude response that falls indefinitely at −6 dB/octave from zero frequency to infinite frequency and passes through $|G(j\omega)| = 1$ at $\omega CR = 1$. The "curves" numbered (1) in Fig. 5 correspond. The gain of an imperfect (finite-gain) integrator levels off at low frequency to the value A, and equn. (6) shows that the phase shift falls short of 90° by θ, given by

$$\tan\theta = 1/\omega(A+1)CR \qquad (7)$$

Thus when $A \gg 1$, at the approximate unity-gain frequency $\omega = 1/CR$, $\theta = 1/(A+1) = 1/A$ approx., and below this frequency θ increases (i.e., the phase shift ϕ decreases) until at zero frequency $\phi = 0$. These characteristics are indicated in Fig. 5 by the curves numbered (2).

The Q factor of an integrator

Finite gain is to an integrator the equivalent of series resistance to an inductor or parallel resistance to a capacitor, and similarly limits the Q factor that can be obtained in a resonant loop. Also similarly the quality of an integrator can be defined as the ratio of the part of the output in quadrature with the input to the part in phase. Hence, from equns. (6) and (7)

$$Q = 1/\tan\theta = (A+1)\omega CR \simeq A\omega CR, \qquad (8)$$

and it is useful to notice that at $\omega = 1/CR$

$$Q = A + 1 \simeq A. \qquad (9)$$

In a lag-and-integrator loop, however, the undamped resonant frequency $\omega_c = 1/qCR$; i.e., a frequency q times below the unity gain frequency of the integrator (equn. (4)). The effective Q factor of the integrator in such a loop is therefore A/q approx., which $< A$ when $q > 1$.

The potential zero-frequency loop gain A is often in practice eroded by the presence of attenuating networks. Fig. 6 shows that these may be of two types, exemplified by R' acting in conjunction with R, and by a network such as R_2', R_2 outside the integrator feedback loop. Both reduce the zero-frequency gain—by factors $k_1 = R'/(R+R')$ and $k_2 = R_2'/(R_2 + R_2')$ respectively—and so reduce Q by these factors. R' may represent the input resistance of a transistor amplifier, and it is important to note that there is a serious reduction in Q if $R \gg R'$.

By applying Thévenin's theorem, or otherwise, it is easily found that in the ideal case, $A = \infty$ (and $k_1 > 0$), the presence of R' leaves the voltage transfer ratio unaltered, $1/pCR$, and therefore has no effect on tuning. The presence of R_2', R_2, on the other hand, directly affects the open-loop transfer function, and in the ideal case is equivalent to having in the loop an integrator with

$$G(p) = -k_2/pCR. \qquad (10)$$

Comparison with $G(p) = -1/pT$ gives $T = CR/k_2$; i.e., the "T" of the integrator is multiplied by $1/k_2$. The effect of k_1 and k_2 on tuning in the presence of finite A is dealt with in a later section.

Effect of finite gain in a 2nd-order loop

Substituting the equivalent form, Fig. 4(b), of a finite gain integrator for the ideal integrator in Fig. 3(b) gives Fig. 7, which shows the equivalence to a two-lag loop with negative gain, and the results obtained in Part 4 can be applied. In particular, the open-loop q_0 is increased by the factor $\sqrt{(A+1)}$,

$$q = q_0\,(A+1)^{\frac{1}{2}} \qquad (11)$$

and since for two buffered lags the maximum value of q_0 is $\frac{1}{2}$ (obtained when the two time constants are equal, i.e., $(A+1)T_1 = T_2$)

$$q_{max} = \tfrac{1}{2}(A+1)^{\frac{1}{2}}. \qquad (12)$$

In general, q_0 is given by substitution in equn. (4), Part 3, as

$$\frac{1}{q_0} = \left(\frac{(A+1)T_1}{T_2}\right)^{\frac{1}{2}} + \left(\frac{T_2}{(A+1)T_1}\right)^{\frac{1}{2}} \qquad (13)$$

and therefore, from equn. (11),

$$\frac{1}{q} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{2}} + \frac{1}{A+1}\left(\frac{T_2}{T_1}\right)^{\frac{1}{2}} \qquad (14)$$

Thus the ideal value of q (the value when $A \to \infty$) is given by

$$\frac{1}{q_i} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{2}}, \qquad (15)$$

and equn. (14) may be written

$$\frac{1}{q} = \frac{1}{q_i} + \frac{q_i}{A+1} \qquad (16)$$

Now the undamped resonant frequency $\omega_c = 1/T = 1/q_iT_1$ (see equn. (4) and Fig. 3), and substitution in equn. (8) shows that $(A+1)/q_i$ is the Q of the integrator at ω_c. Hence

$$\frac{1}{q} = \frac{1}{q_i} + \frac{1}{Q\text{ of integrator}}. \qquad (17)$$

And as at ω_c the frequency-response function of the lag $= 1/(1 + jq_i)$, q_i may be identified as the Q of the lag at ω_c. Equn. (16) may therefore be further rewritten as

$$\frac{1}{q} = \frac{1}{Q\text{ of lag}} + \frac{1}{Q\text{ of integrator}} \qquad (18)$$

This is an example of the general principle that circuit losses add directly, and that hence Qs add by reciprocals. The principle is very useful for finding the Q factor of practical circuits, especially when the alternative involves handling a long and cumbersome transfer function.

In practical circuits A is usually $\gg 1$ and is not known precisely. There is then no sensible distinction between A and $(A+1)$. It seems unnecessary, however, in the algebra constantly to refer to this approximation.

The solution to equn. (16) gives the value of q_i that has to be set in to the design to achieve the desired value of q,

$$\frac{1}{q_i} = \frac{1}{2q}\left\{1 \pm \left(1 - \frac{4q^2}{A+1}\right)^{\frac{1}{2}}\right\}. \qquad (19)$$

Fig. 8, which is a plot of q against $(T_2/T_1)^{\frac{1}{2}}$, i.e. against q_i, with A as parameter, clarifies the relationship. For the moment only positive values of A (negative values of amplifier gain, $-A$) are of interest; i.e., that part of Fig. 8 below the diagonal representing $A = \infty$. For $4q^2 < (A+1)$, i.e. $q < q_{max}$, equn. (19) gives two real values of q_i; but the value given by taking the negative value of the square root should not be used as it corresponds to the region beyond the point where q_{max} has been reached, and in this region q is very sensitive

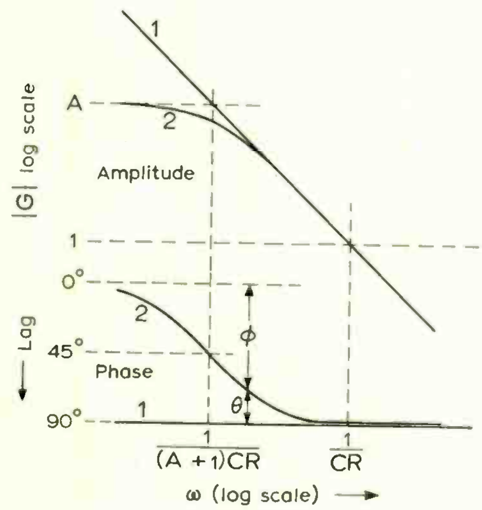


Fig. 5. Amplitude and phase curves for an ideal integrator (1), and a finite-gain integrator (2)

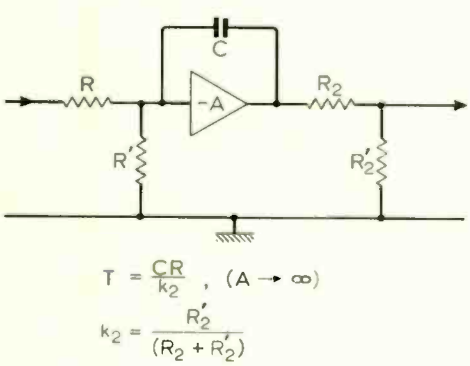


Fig. 6. Showing loss of effective gain by passive attenuation

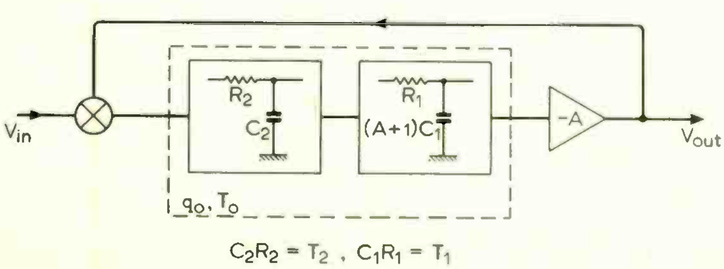
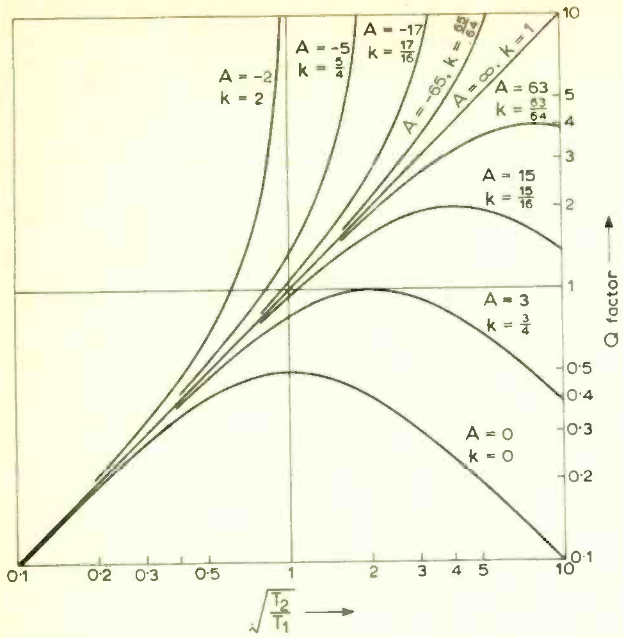


Fig. 7. The two-lags-and-gain equivalent of a lag-and-integrator loop with finite gain integrator



(*Left*) *Fig. 8. Illustrates equn. (16). Shows the effect of internal gain, A, and the ratio, T_2/T_1, on the Q factor of a lag-and-integrator loop*

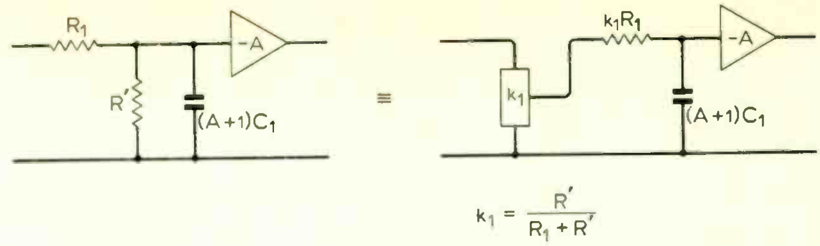


Fig. 9. Equivalent circuits for the integrator when the amplifier has finite gain and input resistance

to changes in A. Indeed "designable" circuits, which can accommodate large uncertainties in the value of A, should use values of A which give q close to q_t.

Fig. 8 will be recognised as a duplicate of Fig. 9 of Part 4, the parameters A and K being related by

$$K = A/(A + 1), \qquad (20)$$

which gives

$$A = K/(1 - K); \qquad (21)$$

and this foreshadows an important identity that will be proved later in the analysis of the Sallen-and-Key circuit.

Effect of finite gain on T

In the basic lag-and-integrator loop shown in Fig. 3(b), and in equivalent form in Fig. 7, $T(=1/\omega_c)$ is not affected by A. The open-loop transfer function is

$$\frac{A}{(1 + pT_2)\{1 + p(A + 1)T_1\}},$$

and so $T_0 = \{(A + 1)T_1T_2\}^{\frac{1}{2}}$. But, as shown in Part 4, closing the loop divides T_0 by $(A + 1)^{\frac{1}{2}}$. Hence closed-loop $T = (T_1T_2)^{\frac{1}{2}}$ and is independent of A. If, however, there is attenuation k_2 in the loop as given by R_2', R_2 in Fig. 6,

$$T = \left\{\frac{(A + 1)T_1T_2}{k_2A + 1}\right\}^{\frac{1}{2}}$$

and so

$$\omega_c^2 = \frac{k_2}{T_1T_2}\left\{1 + \frac{1 - k_2}{k_2(A + 1)}\right\} \qquad (22)$$

Similarly for attenuation by R', R_1 (Fig. 9), although k_1 does not does not give a large change in ω_c

$$T_0^2 = k_1(A + 1)T_1T_2 \qquad (23)$$

and so, since

$$T^2 = T_0^2/k_1(A + 1)$$

$$w_c^2 = \frac{1}{T_1T_2}\left\{1 + \frac{1 - k_1}{k_1(A + 1)}\right\} \qquad (24)$$

Sensitivity to component values

For the passive LCR network, Fig. 3(a), the parameters T and q are defined by

$$T = (LC)^{\frac{1}{2}} \text{ and } q = \frac{1}{R}\left(\frac{L}{C}\right)^{\frac{1}{2}} \qquad (25)$$

For the ideal active system ($A \rightarrow \infty$), Fig. 3(b),

$$T = (C_1R_1C_2R_2)^{\frac{1}{2}} \text{ and } q = \left(\frac{C_2R_2}{C_1R_1}\right)^{\frac{1}{2}} \qquad (26)$$

Thus, by inspection of equns. (25) and (26), any variations in C_1 and C_2 have the same effect as variations in L and C respectively. Considering the arbitrary situation where R_1 and R_2 are in error in opposite directions and become, say, xR_1 and R_2/x, there is no change to T and the effect on q is the same as if R changed to xR. On the other hand, if R_1 and R_2 are in error in the same direction and become xR_1 and xR_2, there is no change to q but T becomes xT; i.e., the effect is the same as if L and C change to xL and xC. Other situations lie somewhere between, so it may be concluded that the active system behaves in an essentially similar manner to the passive prototype.

Effect of parasitic phase lags

The effect of additional lags in the loop can be deduced from the Bode plots (i.e., the amplitude and phase plots of $\mu\beta$), and in many practical cases a simple addition of phase angles at the frequency of unity loop gain gives sufficient information.

The curves numbered (1) in Fig. 10 represent the loop gain of an ideal integrator-and-lag loop of arbitrary q (2 approx. in the Fig.), and the curves numbered (2) and (3) the individual characteristics of the lag and of the integrator respectively. For the moment the additional lag, curve (4), is ignored. As q increases the curves for the lag and the curves for the integrator move further apart, those for the lag towards lower frequencies and those for the integrator towards higher frequencies; and

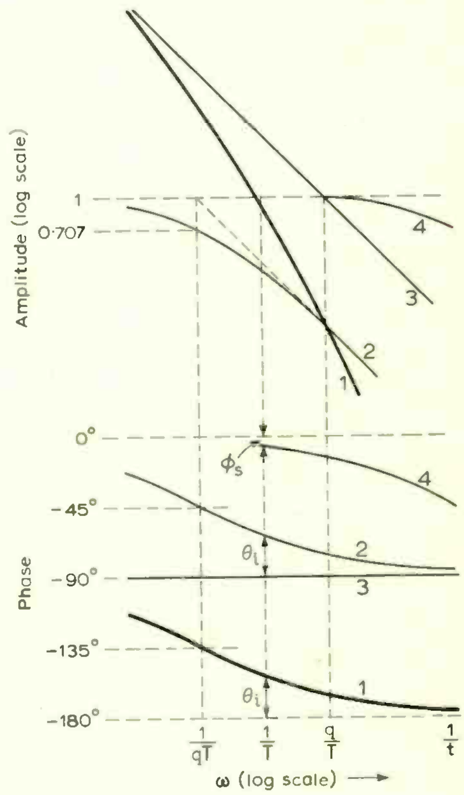


Fig. 10. Amplitude and phase curves, open loop

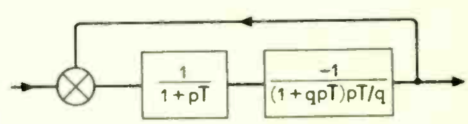


Fig. 11. System when extra lag, time constant t, is introduced into the loop

the amplitude curve of the loop characteristic moves nearer to the level 1 at $\omega = 1/T$.

Now since the integrating amplifier gives a sign reversal, the critical phase lag for the loop is 180°; and in the ideal case, since the phase lag of the integrator is a constant 90°, the angle θ by which the loop phase shift falls short of 180° is the angle by which the phase shift of the lag falls short of 90°, and is therefore given by $\tan\theta = 1/\omega T_2 = 1/\omega qT$. Hence at the approx. unity-loop-gain frequency $\omega_c = 1/T$

$$\tan\theta = 1/q, \qquad (27)$$

which gives, as examples, the following pairs of values of q and phase margin: $q = 1$, $\theta = 45°$; $q = 2$, $\theta = 26{\cdot}5°$; $q = 10$, $\theta = 5{\cdot}7°$; etc. For high values of q, at ω_c

$$\theta \text{ (in radns)} = 1/q \text{ approx.} \qquad (28)$$

Consider now the introduction of a small additional lag, time constant t, into the loop as shown in Fig. 11. This adds the curves (4) to Fig. 10. It is a characteristic of a simple lag (Figs. 3 and 4, Part 2) that a significant phase shift appears at frequencies where there is still little fall in the amplitude response. Thus, for example, at (corner frequency)/10 the gain is 0·995, while the phase lag is already 5·7°; and even at (corner frequency)/2, where the phase lag is 26·5°, the gain has only just fallen below 0·9. Therefore, since in a practical filter the additional phase lag must be small if the filter is to be "designable", it is reasonable to assume that for any such lag the time constant $t \ll T$, and that in the critical region around $\omega_c (= 1/T)$ only the phase shift of the additional lag need be considered.

This will be

$$\phi_s \simeq t/T \text{ radns approx.,} \qquad (29)$$

and the net phase margin will be

$$\theta_m = \theta_i - \phi_s = \frac{1}{q_i} - \frac{t}{T} \qquad (30)$$

where θ_i and q_i are the ideal values; i.e., the values when there is no additional lag. The trend of the Nyquist plots for conditions where the above analysis is valid is shown in Fig. 12.

Stability in a mathematical, or Nyquist, sense requires that $t < T/q$. Stability in the engineering, or everyday, sense of ensuring a stable effective q will generally require that $t \ll T/q$, so that the unwanted phase lag is small compared with the intended phase margin; but if the circuit is such that t is known with some precision, then q_i may be reduced to compensate. Several additional lags of time constants $\ll T$ may be added and treated as one

$$\Sigma\phi_s = (t_1 + t_2 + \ldots)/T \qquad (31)$$

A lag internal to an amplifier is effectively divided by the zero-frequency gain around the local feedback loop. Thus in an integrator, if the amplifier is stabilized with a single dominant lag of time constant τ, there is added phase shift approximately equivalent to an additional lag of time constant τ/A. This explains why an operational amplifier, z.f. gain = 3,000 (say), which when stabilized shows a corner frequency at 100 Hz, can be suitable for use in a filter with corner, or resonant, frequency at some thousands of Hz, provided the stabilization does not seriously affect the output available at these frequencies. There is also an increase in the effective CR product equal to $1/\omega'$, where ω' is the frequency where the amplifier characteristic crosses unity gain. But this is unlikely to be of importance except in a high-q circuit.

The summation of phase angles described above is virtually an extension of the summation of the reciprocals of Q-factors given in equn. (17), and when the approximations given apply, the net phase margin is given by

$$\frac{1}{q} = \frac{1}{q_i} + \frac{1}{Q} - \sum\frac{t}{T}. \qquad (32)$$

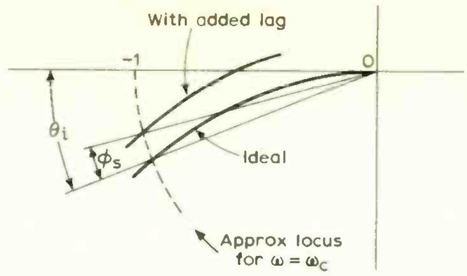


Fig. 12. Shows trend to Nyquist plots when the additional phase angle $\phi_s \ll \theta_i$, the ideal phase margin

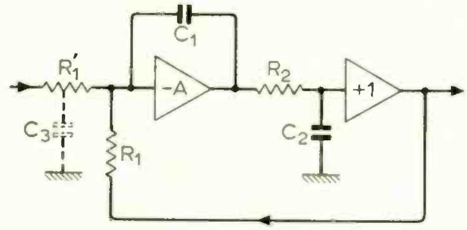


Fig. 13. Integrator-and-lag circuit using two amplifiers

At low frequencies where stray capacitance is low compared with the working capacitances, unwanted lags are of little account; especially when simple amplifiers are used which need little or no Nyquist stabilization, and when q is moderate or low and there is a comfortable phase margin. The circuit is in any case not very suitable for high q. When high-gain amplifiers are used, however, it is likely that except at very low frequencies the maximum practical value of q will be set by unwanted lags, and that the value will fall with increase in ω_c.

Implementation

An obvious way of setting up an integrator-and-lag loop is shown in Fig. 13. With present-day amplifiers, and with $R_1 = R_1'$, the nominal zero-frequency loop-gain may be 5,000; which gives $q(max) = 35$, a nominal 10% loss of q from finite amplifier gain for $q \simeq 20$, and a 1% loss for $q \simeq 7$. For 3rd-order response a lag can be introduced by tapping R_1' and connecting a capacitance to earth. With the tap at the centre this lag has time constant $= C_3R_1'/4$.

If R_1' is removed, the virtual earth at the input of the integrator provides a natural low-impedance node for current input. Provided the source resistance $R_s > R_1$ the z.f. loop gain $\rightarrow A$, and the benefits of high internal gain with almost 100% feedback are obtained. If an extra lag is to be used to give a 3rd-order filter, it must now be placed after the resonant loop. It should be remembered that for frequencies below cutoff most of the input current flows through R_1, and at frequencies above cutoff through C_1. The latter point is important if out-of-band currents of considerable magnitude must be accepted—for example carrier frequency and harmonics from a rectifier—and it is essential that the output of the integrating amplifier should accept such currents without overload.

Whatever the economic and other advantages of silicon integrated circuits, it

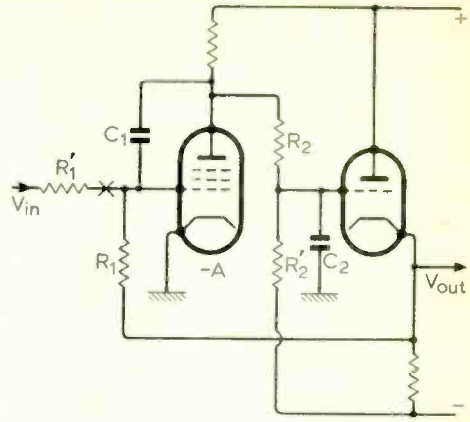


Fig. 14. Representative of simple circuits possible for low q applications

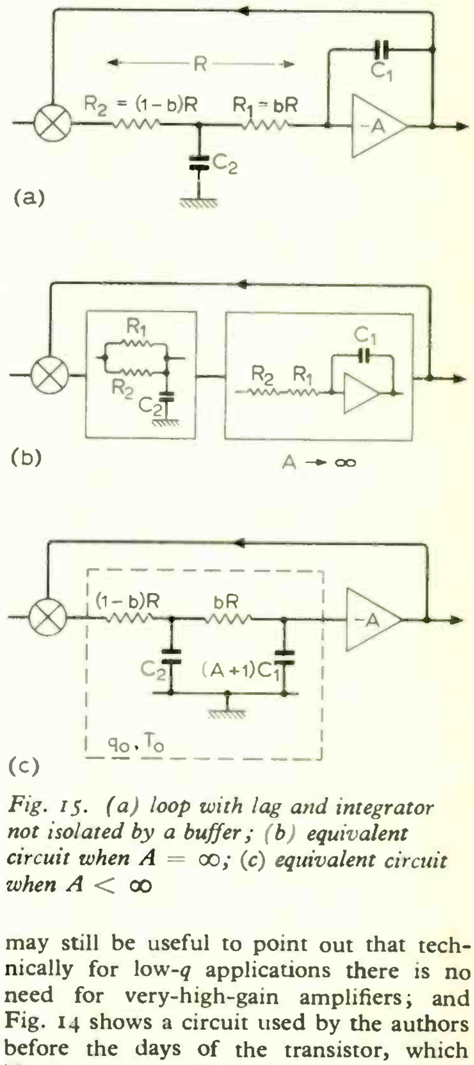


Fig. 15. (a) loop with lag and integrator not isolated by a buffer; (b) equivalent circuit when $A = \infty$; (c) equivalent circuit when $A < \infty$

may still be useful to point out that technically for low-q applications there is no need for very-high-gain amplifiers; and Fig. 14 shows a circuit used by the authors before the days of the transistor, which illustrates most of the principles involved. A typical application was following a phase-sensitive detector of current-output type, when the input current was taken straight to point X.

The ideal design equations are:

$$T_2 = qT = k_2C_2R_2 \qquad (33)$$

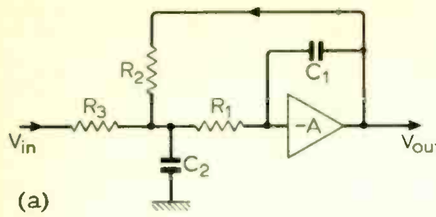
where

$$k_2 = R_2'/(R_2 + R_2'); \qquad (34)$$

$$T_1 = T/q = C_1R_1/k_2. \qquad (35)$$

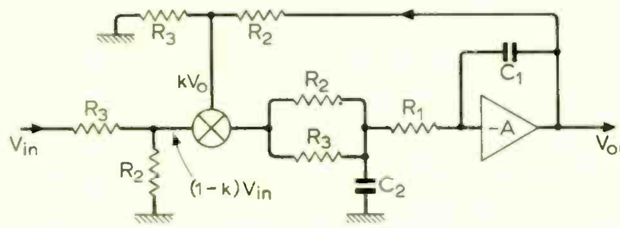
The z.f. loop gain (if $R_s \gg R_1$) is k_2A, so

$$q_{max} \simeq \tfrac{1}{2}(k_2A)^{\frac{1}{2}}. \qquad (36)$$

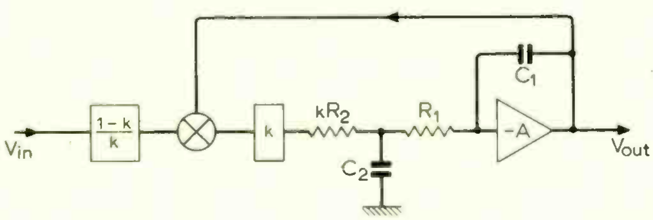


(a)

Fig. 16. (a) The Rauch circuit; (b) intermediate step leading to the equivalent circuit (c)



(b) $k = \dfrac{R_3}{R_2 + R_3}$, $(1-k) = \dfrac{R_2}{R_2 + R_3}$, $\dfrac{1-k}{k} = \dfrac{R_2}{R_3}$



(c) $T_2 = \dfrac{C_2 R_1 k R_2}{R_1 + kR_2}$, $T_1 = \dfrac{C_1(R_1 + kR_2)}{k}$

$$\frac{V_{out}}{V_{in}} = \frac{R_2}{R_3}\,\frac{1}{1 + \frac{1}{q}pT + p^2T^2}$$

It is of no great consequence if the cathode-follower gain is somewhat < 1; it merely means that the effective k_2 in equns. (35) and (36) is somewhat smaller than the k_2 given by equn. (34). When input currents of considerable magnitude must be handled, the points already mentioned must be watched.

Lag-and-integrator loops using one amplifier

Fig. 15(a) shows a schematic of a lag-and-integrator loop in which the integrator follows the lag, and in which the lag and the integrator are not isolated from each other by a buffer. The placing of the integrator second gives the circuit the advantage that when q is high no large voltage is built up in the middle as in the previous arrangement. A usually more important change arises from the absence of buffering: when the circuit is drawn in equivalent form as in Fig. 15(c) a 2nd-order CR network appears; and since in practice this must give $q_0 < \frac{1}{2}$, the complete circuit must, for a given A, give a lower q_{max} than circuits which can have $q_0 = \frac{1}{2}$.

When $A \to \infty$ the equivalent circuit of Fig. 15(b) applies,

$$T_1 = T/q = C_1(R_1 + R_2) = C_1R \qquad (37)$$

and

$$T_2 = qT = C_2R_1R_2/(R_1 + R_2) = b(1-b)C_2R. \qquad (38)$$

With A finite the equivalent circuit is as shown in Fig. 15(c), and equn. (11), Part 3, gives

$$\frac{1}{q_0} = \left(\frac{(A+1)T_1}{T_2}\right)^{\frac{1}{2}} + \frac{1}{b}\left(\frac{T_2}{(A+1)T_1}\right)^{\frac{1}{2}} \qquad (39)$$

and for the maximum value of q_0

$$q_m = \sqrt{b}/2 \qquad (40)$$

The relationship $q = q_0(A+1)^{\frac{1}{2}}$

$$\frac{1}{q} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{2}} + \frac{1}{b(A+1)}\left(\frac{T_2}{T_1}\right)^{\frac{1}{2}} \qquad (41)$$

Hence if $R_1 = R_2$, since $b = \frac{1}{2}$,

$$q_m = 1/2\sqrt{2} \text{ [when } C_2 = 2(A+1)C_1] \qquad (42)$$

and

$$q_{max} \simeq \frac{1}{2}\left(\frac{A}{2}\right)^{\frac{1}{2}} \qquad (43)$$

The Rauch circuit

The above analysis may be applied to the well known Rauch circuit, Fig. 16, if allowance is made for the extra attenuation of the input signal and of the feedback. The ideal ($A \to \infty$) design formulae are easily derived with the help of the equivalent circuit of Fig. 14(c), following the intermediate step shown in Fig. 14(b). Commonly the circuit is arranged for unity gain at zero frequency, $R_2 = R_3 = R$ (say). Then, if also $R_1 = R$ (as in the circuit for $q = 1$ shown in Part 1)

$$C_1 = C/3q \qquad (44)$$
$$C_2 = 3qC \qquad (45)$$

where

$$C = T/R.$$

With finite gain, and $R_1 = R_2 = R_3$, the z.f. loop gain is $A/2$ (if there are no other resistances in shunt from the virtual earth to ground) and $b = \frac{2}{3}$. This gives

$$q_m = \left(\frac{1}{6}\right)^{\frac{1}{2}} \qquad (46)$$

and

$$q_{max} \simeq \left(\frac{A}{12}\right)^{\frac{1}{2}} = \frac{1}{2}\left(\frac{A}{3}\right)^{\frac{1}{2}} \qquad (47)$$

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Dec. 10–12 Savoy Place
Reliability in Electronics
(I.E.E. Savoy Place, London W.C.2.)

OVERSEAS

Dec. 1–3 Gaithersburg
Image Storage and Transmission for Libraries
(Madeline M. Henderson, Center for Computer Sciences and Technology, National Bureau of Standards, Room B226-Inst., Washington, D.C. 20234).

Dec. 8–9 Chicago
Consumer Electronics Symposium
(C. Hepner, Zenith Radio Corp., 6101 W. Dickens Ave., Chicago, Ill. 60639)

Dec. 8–10 Chicago
National Electronics Conference and Exhibition
(N.E.C., Oakbrook Exec. Plaza 2, 1121 W. 22 St., Oak Brook, Ill. 60521)

Dec. 8–10 Los Angeles
Applications of Simulation
(P. J. Kiviat, Simulation Assoc. Inc., 10884 Santa Monica Blvd., L.A. Calif.)

Dec. 8–10 San Francisco
Circuit Theory
(R. A. Rohrer, Fairchild Semiconductors, 4001 Junipero Serra Blvd., Palo Alto, Calif.)

Dec. 9–11 Rehovot
Application of Magnetism in Bio-engineering
(Weizmann Inst. of Science, Rehovot, Israel)

Dec. 10–12 Pacific Grove, Calif.
Circuits and Systems
(Shu-Park Chan. Univ. of Santa Clara, Santa Clara, Calif.)

spot check or 100% inspection?

There is nothing random about quality control with BRIMAR data display tubes. Every single tube is subjected to an exacting test at every stage of production, from the raw materials used, through the various complex stages of manufacture, to the finished product.

A typical example of BRIMAR'S advanced inspection methods is the use of Spatial Frequency measuring equipment, built to their own uncompromising standards, and used for the measurement of final spot size and focus uniformity in such tubes.

And in addition to this, an unparalleled capability in chemistry, electron optics and vacuum physics enables Brimar to offer the widest design diversity backed by a *personalised customer service.* This service, provided by engineers with extensive experience of the electronics industry, covers advice on tube characteristics, operating conditions and associated components.

Tailored packaging, and reliable delivery to meet production schedules are also part of the BRIMAR Service.

Want to know more about BRIMAR Industrial Cathode Ray Tubes? - ask to see our latest catalogue.

BRIMAR

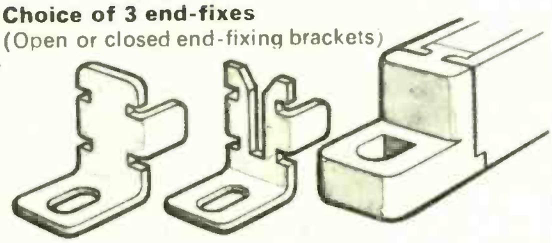
Thorn Radio Valves and Tubes Limited

THORN

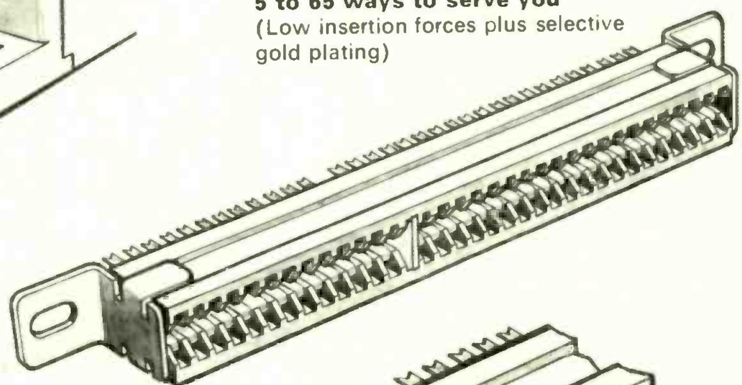
7 Soho Square, London, W1V 6DN.
Telephone: 01-437 5233

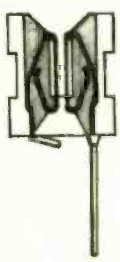
Our Decimal one is a Cinch!

Choice of 3 end-fixes
(Open or closed end-fixing brackets)

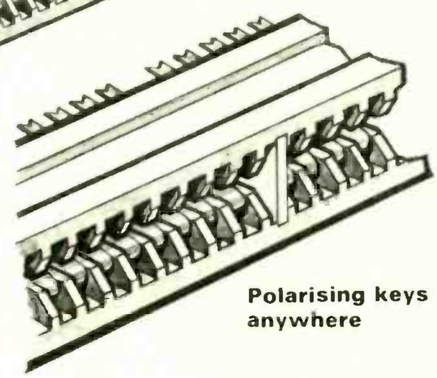


5 to 65 ways to serve you
(Low insertion forces plus selective gold plating)





Well proven "Greenline" contact geometry



Polarising keys fitted anywhere

0.1 pitch 'Cinch Greenline' Modular Edge Connector

No of ways	65 max
Contact pitch	2.54 mm (0.100")
Available terminations	Solder Slot—hand solder wiring Short Vee Form—hand or flow solder wiring Mini-wrap—wire wrap
Moulding	Glass filled Diallyl Phthalate. Colour green
Contacts	Phosphor Bronze
Plating	.0002" selective gold where it matters—on contact mating areas

Write for our fully descriptive literature

CARR FASTENER

CARR FASTENER COMPANY LIMITED
Stapleford, Nottingham
Telephone Sandiacre 2661
Sales Offices: London
Birmingham, Sale and Glasgow

Cinch TRADE MARK (REGD)

WW—103 FOR FURTHER DETAILS

London's Audio Fair

A look at the arrangements and a selection of products

This year's London Audio Fair which was held at Olympia for the first time can, and will, be rated a great success. Although tiring and nerve-racking the experience for any audio enthusiast—a genus, not a species remember—must have been exhilarating. As usual engineering personalities associated with complex and expensive equipment designs or with revered articles in learned journals were there in the flesh—not aloof, detached, and unavailable, but marshalling the columns, patiently answering any number of naïve questions, and generally sweating and swearing like the rest of us.

All in all there was a democratic fellowship, a commonalty of single purpose, and the circumstances which can so thoroughly humanize are beyond praise, but deserve careful analysis.

The category audio enthusiast, we have said, is a genus. Having said this we must acknowledge the countless species. The audio enthusiast may have lots of money or very little: he may build all his own equipment or buy some commercial gear: he may put performance well before appearance; etc. etc. We all know this, but two facts must be emphasized if we are to keep the audio world in perspective. First, virtually "perfect" performance regardless of cost *is* attainable and a very close approximation to this can be attained at much much less than the cost of typical systems of commercial equipment. Secondly, our notion of audio fidelity is not a simple instinctive response but represents a stage in our aural education, and this fact goes towards explaining the value of the Audio Fair demonstrations. The owner of equipment providing a particular grade of sound will, during his rounds, hear standards new to him. If he can assimilate the experience his notion of fidelity will be advanced and he will be at once both elated and depressed! It is worth mentioning a remark heard outside one of the demonstration rooms—"It goes down to twenty cycles so it should be a perfect loudspeaker shouldn't it?"

Each listening room measured 20 x 16 feet and was about 8 feet high. Seats were arranged to cover about half the floor area and the equipment, depending of course on the manufacturer's products, stood at the far end away from the door. Most rooms had a noisy extractor fan in one corner—usually just above the right-hand channel loudspeaker(s). A few had no fan but a permanently open door (Mordaunt-Short and Goldring) and K.E.F. had a pair of air-conditioning units which operated between sessions.

In all these demonstrations the sound was supposed to tell the story and sell the goods. Yet the rooms defeated the object of the exercise on three counts. (1) Though the walls were quite adequately insulated against outside noise the extractor fan contributed enough noise to drown ambient sounds in the programme material and thus destroyed realism. (2) Being so small and often over-full of listeners the room's cut-off frequency was rather high and thus bass performance was often disappointing. (3) The flexible walls tended to resonate at various frequencies giving unusual colouration to speakers.

The only demonstrations which got round this problem had the speakers positioned against the rear wall or had the speaker mounted in a solid framework. Goldring went a step further and employed special "monitor" units built on the transmission line principle—an inverted horn—which, unlike most speakers, gives even performance in very different circumstances.

To these criticisms—which are the reasons why visitors to the Audio Fair should not be expected to believe their ears on all occasions—must be added one more. Even if the listening rooms were acoustically excellent how could one judge, say, a new cartridge? Not, as it seems to be generally assumed, by playing it without comparison in a named system. Very few visitors to the Fair are likely to have exactly the arm/amplifier/speaker combination as that demonstrated. Perhaps the best answer is simply to have cartridges of different makes demonstrated in turn by different manufacturers in a listening room set aside for the purpose. (Any amplifier/speaker combination of good overall quality could be used.) Tape decks and even radio tuners could be compared in this way.

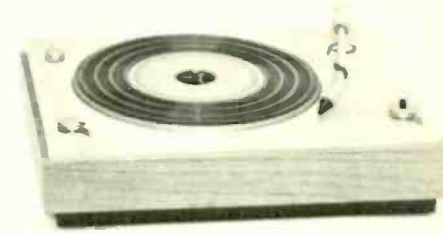
Apart from the live demonstrations the Audio Fair could be only an audio supermarket with the goods on view and data sheets to indicate performance.

Accepting that Olympia has proved itself able to contain multiple live demonstrations the following recommendations are made. (1) That extractor fans be housed at the end of a tube connected to the listening room. (2) That each room be enlarged if possible to say 25 feet in length. (3) That short of having plaster-board walls, rigid panels be fixed where possible especially for demonstrations employing direct radiator loudspeakers.

In discussing new equipment that seems of especial interest it seems sensible to proceed from signal sources through to the speakers.

The M15 range of moving magnet cartridges with replaceable styli now offered by **Ortofon** have a frequency response of 20Hz to 20kHz $\pm$2dB (20Hz to 10kHz$\pm$1dB), a channel separation of 30dB (at 1kHz), a recommended stylus pressure of 1.5g, and an output of 12mV (into 47kΩ) from a normally recorded level. No transformer is required. A variant range, the MF15, is available for heavier duty work such as on automatic record changers and for playing 78 r.p.m. records. Metrosound (Sales) Ltd., Cartersfield Road, Waltham Abbey, Essex.

From **Bang & Olufsen** the Beogram 1800, a semi-automatic record-player unit, features a pickup arm with built-in bias compensation, and uses the new SP10A cartridge. The arm operates automatically on pressing a button. At the end of the record the arm lifts and the motor is automatically switched off.



Provision has been made for a pre-amplifier which is simply pushed into a slot in the base. Specification includes a wow figure of $\pm$0.2% peak and a rumble level better than 35dB below reference voltage from pickup at 10cm/s. Speeds are 45 and $33\frac{1}{3}$ r.p.m. with $\pm$5% fine speed adjustment. Stylus pressure is adjustable up to 3.5g. The cartridge specification includes frequency response 15Hz–25kHz$\pm$3dB, channel separation better than 20dB between 500Hz and 10kHz, output of 5mV (into 47kΩ) at 5cm/s, compliance of 25×10^{-6}cm/

dyne, and recommended stylus pressure of 1g. Bang & Olufsen U.K. Ltd., Eastbrook Road, Gloucester.

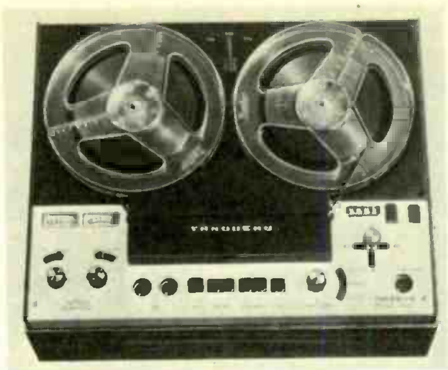
The Truspeed is a new turntable and pickup combination from **Leak.** Frequency response is said to be free from resonance in the range

20Hz—20kHz and stereo separation better than 25dB at 1kHz. Wow is less than 0.1% and flutter less than 0.02%. The unit as illustrated costs £65 13s 3d. H. J. Leak & Co. Ltd., Brunel Road, London W.3.

The **Goldring Lenco** turntable model GL69 has a continuously variable speed adjustment (30—86 r.p.m.) and the pickup arm has a removable plug-in shell which can accommodate all standard fixing cartridges for both mono and stereo reproduction. Both the height of the arm and the position of the stylus in the headshell can be adjusted to give opti-

mum tracing. The stylus pressure is adjustable (by sliding counterweight) and the pickup can be lowered on to the record by means of a viscously damped lowering device. A plinth-mounted version (GL 69/P) is also available. The L 69 pickup arm which is fitted to the GL 69 is also available separately. The chassis version of the GL 69 costs £25 1s 6d. Goldring Manufacturing Co. (G.B.) Ltd., 486-488 High Road, Leytonstone, London E.11.

Two new tape decks were demonstrated by **Tandberg.** The 6000X (illustrated) costing £194, comes in two-track and four-track versions. It has provision for magnetic and ceramic cartridge inputs, independent record and playback systems, sound on sound facilities, a centre channel amplifier, four way mixing, and a 25dB limiter. Wow and flutter figures given are 0.07%, 0.14%, and 0.28% at $7\frac{1}{2}$, $3\frac{3}{4}$, and $1\frac{7}{8}$ i.p.s. respectively. The 1600X is a very simple deck, costing £89. It has a frequency response similar to that of the

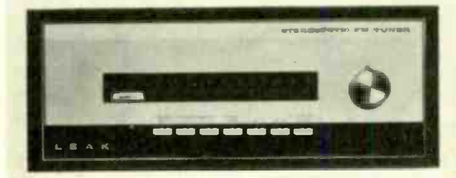


6000X but has not quite as good a signal-to-noise ratio. Farnell Tandberg Ltd, Hereford House, Vicar Lane, Leeds 2.

The Variocord 263 from **Uher** is a stereo tape recorder with interchangeable head mounts allowing a quick change-over between $\frac{1}{4}$-track and $\frac{1}{2}$-track recording. A comparator controls tape tension during record, playback, rewind and breaking. This contributes to the wow and flutter figure of $\pm 0.05\%$ at $7\frac{1}{2}$ i.p.s.

This recorder has a frequency range of 30Hz—20kHz at $7\frac{1}{2}$ i.p.s. At $3\frac{3}{4}$, and $1\frac{7}{8}$ i.p.s. the upper limit is 15 and 8kHz respectively. Each channel amplifier can deliver 4W into 4 . Bosch Ltd., Rhodes Way, Radlett Road, Watford, Herts.

The Stereofetic f.m. tuner from **Leak** has high sensitivity, low distortion, and four unusual controls. One button is pressed to search for stereo transmissions (mono signals being automatically muted). Two press buttons control the noise level during stereo reception giving, all in all, three intermediate steps between mono and full stereo. A 'mono lock' can be used to obtain a mono effect even with the 'stereo only' button pressed. Also, an a.f.c. control is included. Specifications for perfor-



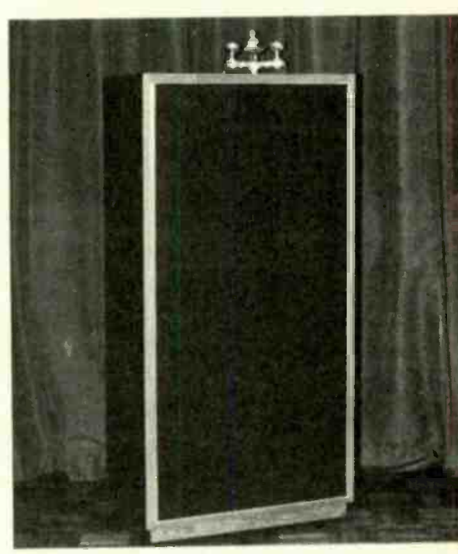
mance include a.m. suppression of 50dB and a signal-to-noise ratio of 60dB. Five filters are included to eliminate whistles when using a tape-recorder. Price of chassis model £56 11s: wood case model £63 14s 5d. H. J. Leak & Co. Ltd., Brunel Road, London W.3.

A stereo f.m. tuner with a sensitivity of $1\mu V$ for 30dB signal-to-noise ratio was displayed by **Revox.** The input section features dual gate f.e.ts and quadruple variable capacitor tuning while the i.f. strip consists of a passive Gauss filter followed by an i.c. amplifier of 5MHz bandwidth. Delay lines are employed for demodulation without reducing the bandwidth. A 76kHz oscillator runs phase-locked to the subcarrier and supplies—after binary scaling—the switching frequency to the stereo demodulator. The A76 tuner costs 155gn. C. E. Hammond & Co Ltd, 90 High Street, Eton, Berks.

The **Sinclair** Project 60, comprising a Stereo Sixty pre-amp, two Z30 power amps, and a power supply is a low-distortion integrated system. The instruction manual

is comprehensive and seems to leave nothing to chance. It should be noted that though the Z30 amplifiers are advertised as being capable of delivering 24W continuous sine-wave this power level can only be delivered into 3 Ω with a rail just above 30V. With a 12-volt rail and a 16 Ω load the maximum continuous output power is reduced to 0.75W. Sinclair Radionics Ltd, 22 Newmarket Road, Cambridge CB5 8DU.

Howland-West were demonstrating I.M.F. transmission-line speakers. At low frequencies the line adds acoustic mass to the diaphragm,



doubles its effective area, and more tha halves diaphragm motion. At higher fre-quencies the line absorbs the back wav from the driver. A professional monito model (as used by Goldring in their listening room) and a smaller domestic monitor model are available. Howland-West Ltd, 2 Park End, South Hill Park, London N.W.3.

The latest loudspeaker developed by **Celestion** is the Ditton 25. The mid range, from 2 to 9kHz, is handled by two moving-coil pressure units, the upper frequencies, 9 to 40kHz, by a u.h.f. unit, and the bass by a 12in driver coupled to a 12in auxiliary bass radiator. Overall frequency response is from 20Hz to 40kHz and this is within ±2dB from 60Hz to 20kHz. The power handling capacity is 25W (r.m.s. signal) and the impedance 4-8Ω. Price £59 17s. Rola Celestion Ltd, Thames Ditton, Surrey.

A new large loudspeaker from **Richard Allan**, the Super Sarabande, employs a 15in bass speaker and has a frequency range of 25Hz to 17kHz. The impedance is 8 or 15Ω and the power handling capacity 20W. Cost £56. Richard Allan Radio Ltd, Bradford Road, Gomersal, Cleckheaton, Yorks.

A frequency range of 26Hz to 22kHz and a power-handling capacity of 40W are two characteristics of the new Magister loudspeaker from **Goodmans.** The bass is handled by 15in unit. It is claimed that adequate listening levels in the home will be obtained using a 10W amplifier output. Goodmans Loudspeakers Ltd, Axiom Works, Lancelot Road, Wembley, Middx.

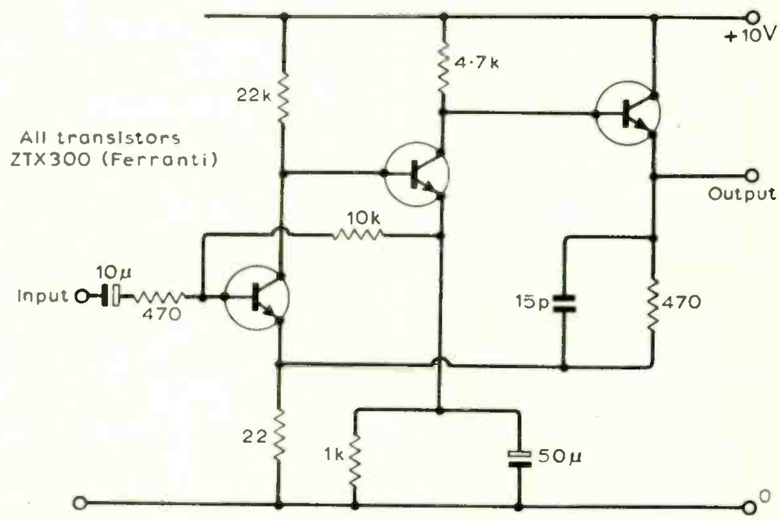
The model 70 speaker, which incorporates the 701 electrostatic mid-range and h.f. unit and the DW13/2 bass radiator (illustrated) took pride of place at **Bowers and Wilkins** demonstration. The eleven module doublet electrostatic unit handles all

equencies above 40Hz. The unit has a unique stribution pattern to obtain good stereo ability and increase the ratio of reverberant direct sound. The pattern is virtually rcular in a vertical plane through mid band equencies, providing a wide and uniform arc rwards, with a strong rear radiating pattern er which the customer has control. Less an 0.5% distortion is obtained from model at 35W r.m.s. input. Also introduced was e DM1 speaker. This is a three unit system th a laminated glass cone bass radiator and e Celestion HF1300 Mk 2 tweeter. Power ndling capacity is 10W. Frequency response the bass end rolls off gradually below 0Hz. The model 70 speaker costs £150 d the DM1 £32. B & W Electronics, tlehampton Road, Worthing, Sussex.

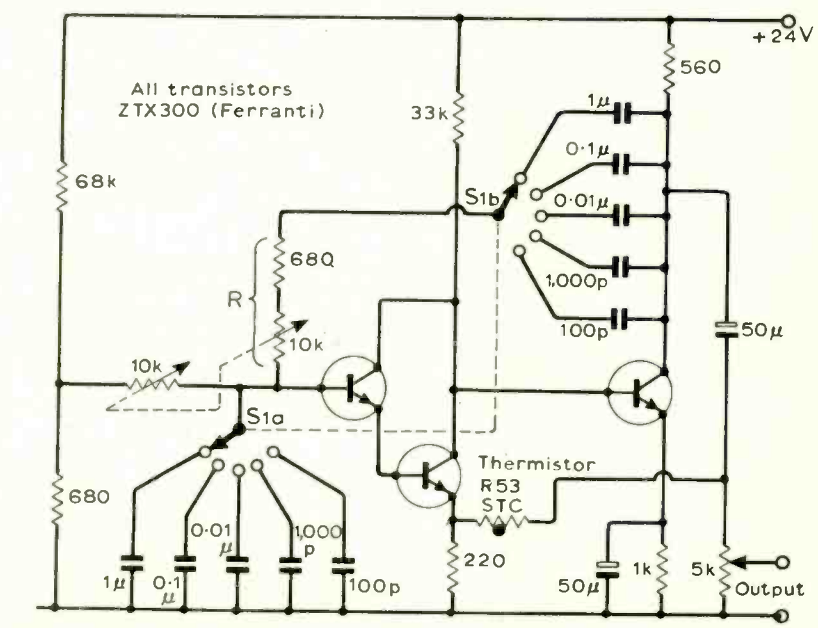
Application Notes

Circuitry selected from device manufacturers' literature

Wideband Amplifier. The Amplifier shown below has a 3-dB bandwidth of 14MHz and a voltage gain of 20. The input impedance is 10kΩ. R_1 is a parasitic stopper, which may not be needed with careful construction. Circuit extracted from the publication "E-Line Transistor Applications" produced by Ferranti Ltd.



Wide-range Wien Bridge Oscillator. The oscillator has five ranges as follows: 15-200Hz, 150Hz-2kHz, 1.5-20kHz, 15-200kHz and 150kHz-2MHz. The output is 1V r.m.s. with less than 0.2% harmonic distortion at 1kHz. Frequency of oscillation is given by $1/2\pi RC$. Extracted from the publication "E-Line Transistor Applications" produced by Ferranti Ltd.



Electronically Stepped Curve Tracer

Equipment for displaying transistor characteristic curves and load lines on a c.r.o.

by A. J. Sargent

The principle of a simple curve tracer in which base current is stepped by means of a manually operated switch has been described in a previous *Wireless World* article[1]. The arrangement provides a useful aid for students, and inspired the development of an electronic stepping circuit with provision for displaying load lines.

The principle of operation is the same as in the original article and is illustrated by Fig. 1. The collector-emitter p.d. is swept in half-wave rectified pulses and provides the c.r.o. X-deflection signal. The test transistor current flowing in R_Y develops the Y-deflection p.d. Base current is stepped in equal increments by the staircase generator on successive sweeps of the collector voltage and recycles back to zero after the required number of steps. The polarity of the collector supply p.d. and of base current increments is reversed by the switch S_3 for p-n-p or n-p-n operation and for diode forward and reverse characteristics. The magnitude of base current steps is selected by switch S_4. The switch S_5 allows an external load resistor to be connected in series with the transistor if required.

The electronic stepping circuit is shown in Fig. 2. A normal power supply provides 12V d.c. to the remainder of the stepping circuit. R_1 and D_3 produce a 6V, 50Hz square wave which is applied to the pump[2] formed by C_3, D_4, Tr_1 and C_4. The values of C_3 *and* C_4 are chosen so that the p.d. across C_4 is pumped up in 1V steps. One step occurs for each positive going edge of the square wave input. When C_4 p.d. reaches the peak-point potential [3] of the u.j.t., the emitter-base 1 circuit becomes highly conducting and rapidly discharges C_4 to the valley-point potential[3] of the u.j.t. Tr_2 and Tr_3 form an emitter-follower with high enough input impedance to ensure negligible sag of the staircase waveform due to charge leaking from C_4. The number of steps in the staircase can be controlled by RV_1 which varies the interbase p.d. of the u.j.t. and so alters the peak-point potential at which C_4 is recycled. The relative d.c. levels of the staircase output and the test transistor can be adjusted as required by means of RV_2. The waveforms obtained for the whole system with an n-p-n transistor are shown in Fig. 3. It is important to phase the supply transformer secondary windings so as to obtain the collector sweep p.d. during the second half of the step horizontal region as shown in Fig. 3. If this is not done then the traces obtained are spoilt by the slow rising edges of the steps which cause base current to change during the collector sweep. Direct coupling to the c.r.o. X and Y plates is preferable, although the writer has obtained quite reasonable results by using a Telequipment Serviscope with direct Y coupling and a.c. coupling to the X plates. The recycling frequency is $50/n$ Hz where n is the number of steps in the staircase. With 5 or more steps the recurrence frequency is rather slow and a long persistence tube would be an advantage.

Load-line display is obtained by connecting an external load resistor in series with the test transistor. Switch S_5 serves this purpose in Fig. 1. The resulting traces are illustrated in Fig. 4. The ends of the curves correspond with points on the required load line. The test transistor may be heated with the load in circuit and the resulting shift of the traces helps to give students a clear insight into the need for d.c. stabilisation in common-emitter circuits.

Most of the components used are not critical. Those needing some selection are D_3 to obtain 1V steps, the base input resistors to obtain the required magnitude of current increments and R_Y to obtain Y deflection calibration. An alternative way of obtaining adjustment of step height is to tailor the value of C_3 or C_4. The main transformer used must have two separate secondary windings. A Radiospares rectifier transformer with two 45V windings was

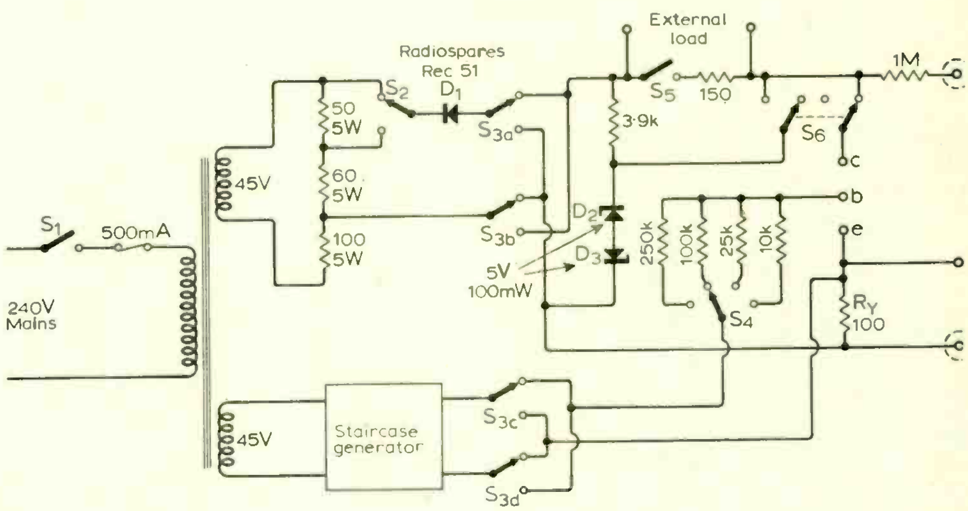


Fig. 1. Main circuit of curve tracer.

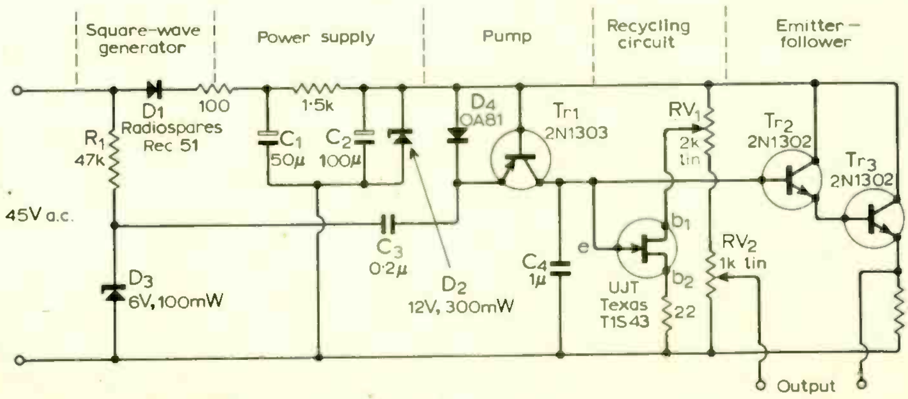


Fig. 2. Circuit of staircase generator.

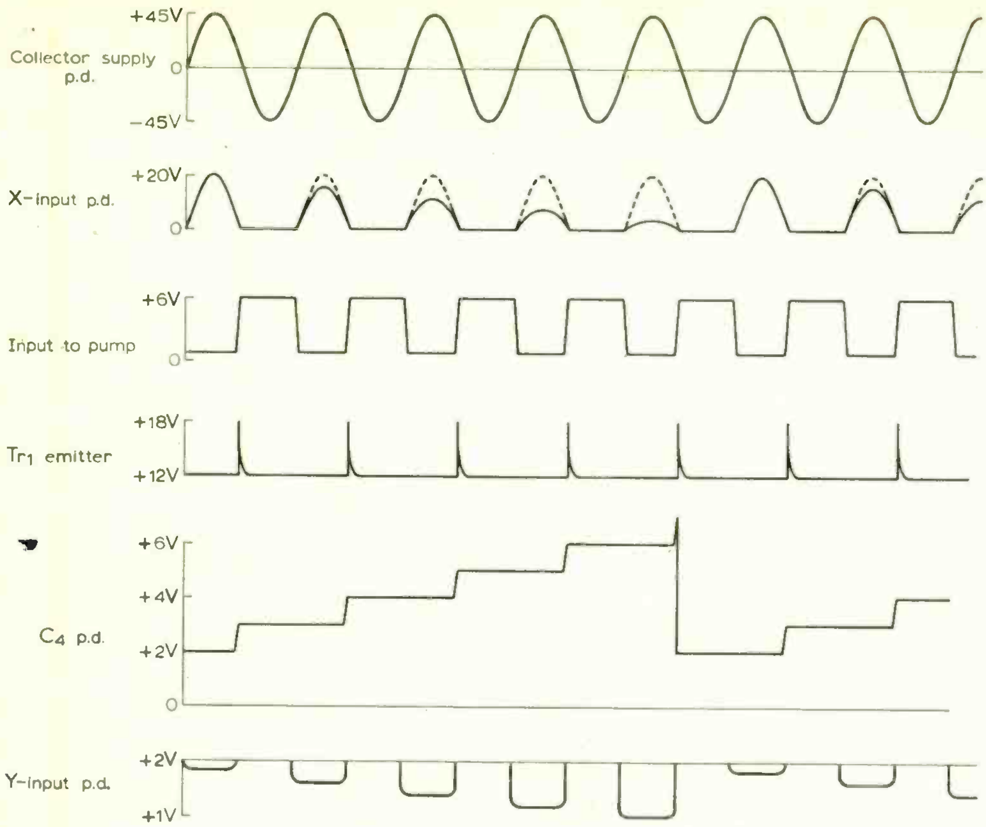


Fig. 3. Waveforms of potential with respect to staircase generator negative rail, when the test transistor is an n-p-n type with an external load.

used. A potential divider across one winding provides the collector sweep p.d., and this resistor chain should be ventilated and mounted well away from the rest of the circuit. A potentiometer could be used to give incremental control of collector voltage. Both windings need to be floating with respect to the c.r.o. earth terminal to allow them to take up varying potentials in both positions of the polarity switch. A complementary two-transistor bistable circuit[2] may be used to replace the u.j.t. if no unijunction transistor is available.

The Y scale is 10mA per deflection volt when R_Y has a value of $100\,\Omega$. The current scale of the displayed curves is obtained by dividing this figure by the volt/cm setting of the Y amplifier. For example, a setting of 0.5V/cm gives a current scale of 20mA/cm. The X scale can be calibrated in one of several ways. The test transistor may be replaced by a known resistor connected between collector and emitter terminals. This produces an oblique line trace whose slope is $1/R$ mA/V where R is the resistance in kilohms. For example, a $1\,k\Omega$ resistor gives 1mA/V so that the X scale can be calibrated by interpolation between X and Y scales. Another method is to connect the staircase p.d. to the X input with Y input disconnected. This gives a horizontal row of bright spots at intervals of 1V on the c.r.t. The method shown in Fig. 1 uses zener diodes as a calibration reference. When switch S_6 is put in the calibration position the test transistor is disconnected and the zener diode reference potential is connected to the X input. The resulting trace is a horizontal line with a bright point at each end. The separation distance of the bright points corresponds to the zener reference p.d. Two diodes are used so that the calibration system works irrespective of the position of the polarity switch. The calibration of base current increments depends on the values of the base input resistors. The potential applied to the resistors has 1V steps so that current increments are given by $1/R_b$. The values $250k\,\Omega$, $100k\,\Omega$, $25k\,\Omega$ and $10k\,\Omega$ give current steps of 4μA, 10μA, 40μA and 100μA respectively. The adjustment of RV_2 allows the first step to be set to give zero base current. This adjustment compensates for the valley-point potential of the u.j.t. and for the emitter junction volt drops of Tr_2 and Tr_3.

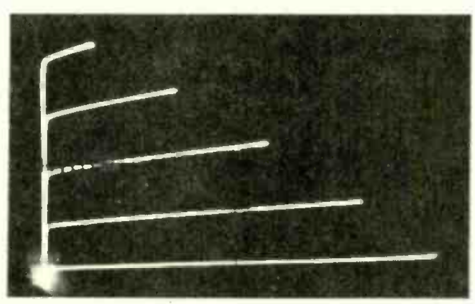
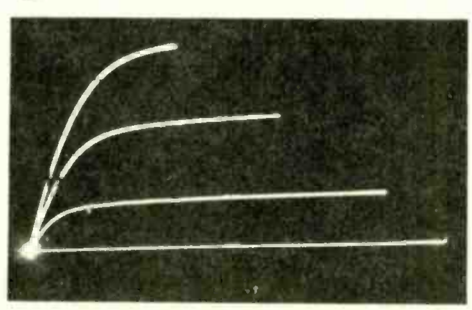


Fig. 4. Characteristic curves for (above) 2N1304— $\Delta I_b = 10\mu A$, $I_c = 0.4mA/cm = 1.5V/cm$, load $= 5k\,\Omega$ (below) 2N3819— $\Delta V_{gs} = 1V$, $I_d = 3.2mA/cm$, $V_{ds} = 1.5V/cm$, load $= 560\,\Omega$



The curve tracer has been used to display characteristics of junction transistors, field effect transistors and zener diodes. Temperature effects can be examined and if collector sweep p.d. is increased sufficiently then the avalanche region of characteristics can be displayed without damaging the transistor. The system is capable of considerable refinement but even in its simple form it provides a valuable teaching aid that is capable of yielding useful measurements.

REFERENCES

1. G. B. Clayton, 'Transistor Curve Tracing', *Wireless World*, June 1967.
2. D. E. O'N. Waddington, 'The Diode Transistor Pump', *Wireless World*, July 1966.
3. H. R. Henly, 'The Unijunction Transistor', *Wireless World*, March 1964.

Books Received

Hi-Fi Year Book 1970 follows the same pattern as the previous issues. It presents in concise form detailed specifications and up-to-date prices for almost every item of hi-fi equipment currently available on the British market. Details are given of over 2,000 items from more than 300 manufacturers or importers, and there are over 700 illustrations. The first 54 pages are taken up by seven articles describing theoretical and practical points about speakers, tape recorders and radio tuners. Pp.431. Price 20s, postage 3s. IPC Electrical-Electronic Year Books Ltd, Dorset House, Stamford Street, London S.E.1.

Classificatore Universale dei Transistori, by Vittorio Banfi, is in two volumes. In Vol. 1 about 4,000 types of transistors with allowable dissipation in excess of 5W are described, and in Vol. 2 about 10,000 lower power devices are described. Data are presented in a very useful manner; e.g. power dissipation and cut-off frequency are given for identical conditions, and the grouping and subgrouping method used facilitates tracking down devices for specific applications. Antonio Benvenga, Editrice Antonelliana, Via Legnano 27, 10128 Torino, Italy.

Radio Year Book 1969/70, lists recent television sets, radiograms, record players, table and portable radio receivers, mains operated and battery tape recorders, and tape recording accessories. There are over 1000 entries and more than half are illustrated. The tape recorder section has been limited to models costing up to £130. (The more expensive tape recorders are to be found in "Hi-Fi Year Book".) Technical details of models are given along with addresses and telephone numbers of suppliers and makers. Two articles, one on television the other on v.h.f. radio, take up the first 16 pages. Pp. 215. Price 15s, postage 2s 6d. IPC Electrical-Electronic Year Books Ltd, Dorset House, Stamford Street, London S.E.1.

Simple Linear A.C. Voltmeter

*by G.W. Short**

A simple single-stage transistor amplifier can be used to improve the linearity of a rectifier type a.c. voltmeter without altering its sensitivity. This is often useful when an ordinary d.c. meter with a linear scale has to be adapted for a.c. measurements. Simply adding a rectifier would spoil the linearity and render the original calibration unusable; at least over the lower part of the scale. If the voltages to be measured are less than about 1 V there is no easy way out of the problem, and if a rectifier is used, the meter scale must either be re-calibrated or, more probably, a fairly elaborate amplifier-rectifier circuit with at least two transistors must be employed.

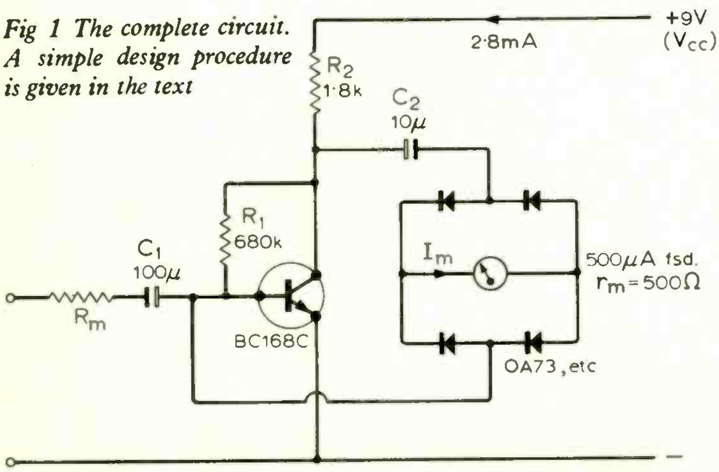
The circuit described here is for use with inputs which are too large to justify building a sensitive millivoltmeter circuit but small enough to impair linearity, from say, 1 to 10 V r.m.s.

A relatively simple active circuit (Fig.1) is sufficient to produce a very worthwhile improvement in linearity at this sort of input level while leaving the meter sensitivity virtually unchanged. Meter multiplier resistances can be added and are calculated on the basis of the d.c. characteristics of the meter movement, or if desired, an existing multiplier can be used.

Operation of the circuit is quite straightforward. The meter is connected between output and input of the amplifier stage, thereby introducing a large amount of negative feedback. Study of the circuit will show that the signal source must supply slightly more r.m.s. current than is needed for normal meter full-scale deflection. The extra current being the base input current of the amplifier transistor. Looked at in a slightly different way, the feedback current which flows via the meter back to the base cancels all of the input signal current except that which is needed to drive the transistor.

If the transistor gives a high current gain the base current is so small that it can be neglected. If, for example, the working current gain is 200—readily obtainable with modern transistors —then the input signal current for f.s.d. need only be about 0.5% greater than the nominal meter f.s.d. current. In practical applications a 0.5% error is negligible.

Fig 1 The complete circuit. A simple design procedure is given in the text



Linearizing action

To account for the improvement in linearity it is easiest to consider signal voltages rather than the signal currents. The non-linearity of a rectifier-meter results from the fact that the diodes used pass very little current until their forward zener voltage is exceeded. An ideal rectifier would pass no current at all until forward biased by a voltage equal to the forward zener voltage and thereafter its forward resistance would fall to zero and unlimited current would flow. All practical rectifiers have finite forward resistances and curved voltage-current characteristics which blur the non-linearity somewhat, but it is still there. In this circuit, the diodes are in the negative feedback path. If the voltage across the diodes is too small to overcome the forward zener voltage then the negative feedback is small. Small feedback, however, implies high gain. It follows that for very small inputs, the input signal is subject to something approaching the non-feedback gain. A small signal voltage at the base is sufficient to produce enough amplified voltage at the collector to bias the diodes to conduction, whereupon negative feedback is increased and the amplification made more or less independent of the transistor characteristics.

To put some numbers in, if germanium diodes are used in a bridge rectifier circuit, then the total forward bias needed to overcome the zener voltage is about 500mV. If the stage gain (base to collector) is 100, then an input of 5mV peak at the base will just make the rectifiers conduct strongly. The non-linearity is thus reduced by a factor approximately equal to the voltage gain. The figure of 100 for voltage gain is quite practical, as mentioned earlier. With this order of amplification, and an input of 1 V or more for f.s.d., the non-linearity is compressed into the first tenth of the scale, or less, and is negligible for most purposes.

Circuit design

The circuit is not unduly sensitive to variations in supply voltage or transistors (provided that h_{fe} is high). With the capacitance values shown in Fig. 1 and a multiplier resistance R_m of 1 kΩ (the lowest practicable value for the f.s.d. of 500 μA chosen) the response is 10% down at 7 Hz. The upper frequency limit depends on the compactness of the wiring and the rectifiers. Using point contact diodes, with an amplifier built on a tag strip supported by the meter terminals, the upper limit was about 3 MHz. Ordinary copper oxide meter rectifiers will give improved linearity but a much lower cut-off frequency.

A step-by-step design procedure is given below. This makes provision for moderately peaky waveforms by allowing for peak voltages and currents five-times the r.m.s. values.

Design Procedure

I_m = meter current for full scale deflection.
r_m = meter coil resistance.
V_f = forward drop of diode at $5.\,I_m$

(1) $I_C = 5.\,I_m$
(2) $V_{CE} = 5.\,I_m\,r_m + 2V_f$
(3) $R_1 = h_{fe}\,(V_{CE} - 0.7)\,/I_C$ for silicon transistors
$R_1 = h_{fe}\,(V_{CE} - 0.2)\,/I_C$ for germanium transistors
(4) $R_2 = (V_{cc} - V_{CE})\,I_c$
(5) $R_M = V_{IN}\,(\text{f.s.d.})\,/I_m$
(6) $C_1 > 10/\,(2\pi\, f_{MIN}.R_{M\,(MIN)})$
(7) $C_2 > 1/\,(2\pi\, f_{MIN}.R_2)$

Stereo Image Width Control

A circuit designed to give linear control of the width of a stereo image

by A. Roberts

Although modern stereophonic recordings of music are steadily improving, one still comes across disc recordings in which the apparent image width or spread of stereo reproduction is unsatisfactory. In some cases excessive crosstalk between channels reduces the image width. On the other hand, the increasingly popular technique, used mainly in light music, of recording the left and right channels with little or no cross-talk, produces odd effects such as "hole in the middle". To get the best results, some degree of control over the image width at the reproducer appears to be desirable.

There are several well known ways of controlling stereophonic image width. The most popular method involves matrixing the left hand (a) and right hand (b) signals into $a + b$ and $a - b$, introducing relative attenuation between these signals, and then matrixing the modified outputs into a' and b' by addition and subtraction as before. It is difficult to include gain in such circuits and the necessary laws of the controls are usually not easy to obtain with normal components.

The circuit described below provides gain and gives fairly linear control of the output image width from 0% (mono) to approximately 165% of the image width, using two ganged linear controls.

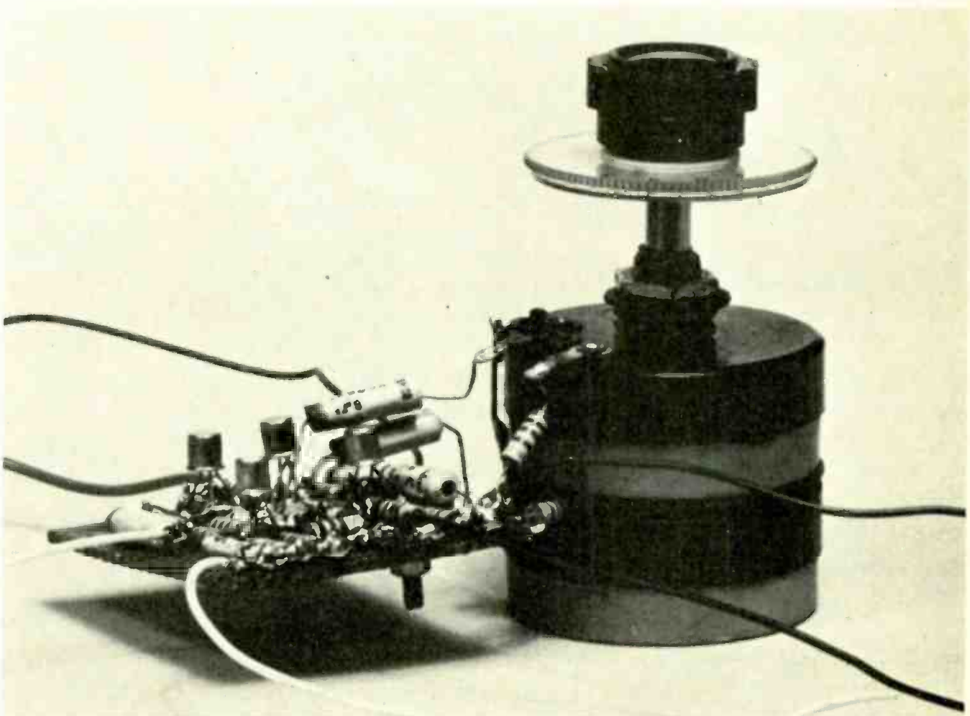
The action of the circuit (Fig. 1) is quite simple. Cross-coupling the emitters of the two transistors Tr_1 and Tr_2 by R_x introduces a negative component of crosstalk in the emitter currents. This in itself would produce image widening if R_y were not present. When R_y is a short-circuit the outputs are made common, and the image width is zero. When

$$R_y = \frac{R_x R_z}{R_w}$$

it cancels the effect of R_x and there is no widening of the image. If R_y is greater than

$$\frac{R_x R_z}{R_w}$$

the output image is widened since not all of the negative crosstalk currents at the emitters is removed by R_y at the collectors. The two outputs V_a' and V_b' (Fig. 1) can be written as, $V_a' = -p(V_a + nV_b)$ and $V_b' = -p(V_b + nV_a)$, where n is variable between $+1$ and -0.25 for the practical circuit. The factor p is also controlled to give constant subjective loudness, independent of the width setting. For a more detailed analysis, see Appendix 2.



Practical circuit

The prototype (Fig. 2 and photograph) was designed to operate at a signal level of -10 dBm (250 mV r.m.s.) with unity gain and an overload factor of 18 dB (clipping occurs at about 1·75 V r.m.s.). Such conditions should satisfy most users, more complicated techniques are needed to operate at higher levels without drastically increasing the rail voltage. The control, R_7 and R_{13}, is a two-gang 1 kΩ linear wire-wound potentiometer, connected so that the wipers move apart on the circuit diagram to increase the image width.

The transistors Tr_3 and Tr_4 allow separation of the a.c. and d.c. collector loads of Tr_1 and Tr_2, since they both operate as current sinks to the d.c. components of Tr_1 and Tr_2 collector currents. The circuit equations are functions of the emitter and collector resistor networks of Tr_1 and Tr_2, and so the output load resistances must be large compared with the collector network in order to eliminate errors. However,

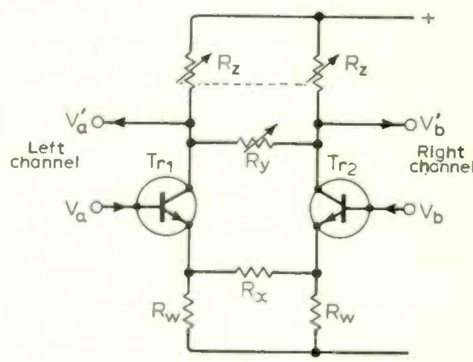


Fig. 1. Basic a.c. circuit of the design.

transistors Tr_3 and Tr_4 also operate as emitter followers of the collectors of Tr_1 and Tr_2, providing good output isolation and low source impedances for the outputs. In fact the resistances presented to the collectors of Tr_1 and Tr_2 by Tr_3 and Tr_4 are respectively R_8 and R_{11}, each in parallel with the output load impedance multiplied by the h_{fe} of the transistors Tr_3 and Tr_4. This is effectively 30 kΩ each, much larger than the network of R_6, R_7, R_{13}, R_{14}. The output source resistance has been measured at about 30 Ω.

The circuit has only one drawback, it needs to be driven from low impedance signal sources to avoid major discrepancies between theoretical and practical responses. This is because the emitter resistances of Tr_1 and Tr_2 must be small compared with the emitter network.

Now,

$$R_e = \frac{R_s}{h_{fe}}$$

where R_s is the source resistances and h_{fe} is approximately 400 for 2N930 transistors. Thus for R_e to be less than 5 Ω, R_s must be less than 2 kΩ. These values introduce approximately 0·5% error in the responses.

Overall d.c. feedback is applied to stabilize the operating conditions, the two feedback paths have a common decoupling capacitor C_5, so that relative drift in the two channels is eliminated. This is desirable since it removes d.c. from R_{10}. Any d.c. present in R_{10} would reduce the clipping level of the circuit.

As expected, the gain/frequency characteristic is a straight line between 15 Hz and 50 kHz, ±0·5%. The input resistances are basically those of the bias chains, and distortion is typically −45 dB of second harmonic, relative to the working level, 250 mV. The minimum impedance the circuit can drive to full output is 750 Ω.

In practice the amplitude and crosstalk responses are precisely those predicted mathematically in Fig. 4. Since the crosstalk coefficient n is basically logarithmic over a large section of the control range, the image of a stereo signal processed by the circuit has width nearly linearly dependent on the control setting. This relationship holds until the image fills the available sound stage, i.e. at least part of the image appears to come from one loudspeaker directly. If it is attempted to further widen the image, the extremes will "fold back" towards the centre and become indistinct, because the two channels have some negative correlation. The effect is similar to that of phase reversal of one channel. Fig. 5 shows the output crosstalk of a stereo signal pair processed by the circuit, when 10 dB crosstalk is present in the inputs. Comparisons between this and published curves of image width versus crosstalk[1] show that the relationship between image width and control setting is very nearly linear.

Because of the large amounts of d.c. and a.c. negative feedback employed, the functioning of the circuit is independent of the transistor parameters, provided that h_{fe} is large. The measured h_{fe} of the 2N930 transistors used in the prototype was greater than 400 in each case. BC109s are suitable alternatives, particularly in view of their low cost and extremely low noise figure.

[1] Harwood, H. D., "Stereophonic Image Sharpness", *Wireless World*, July 1968.

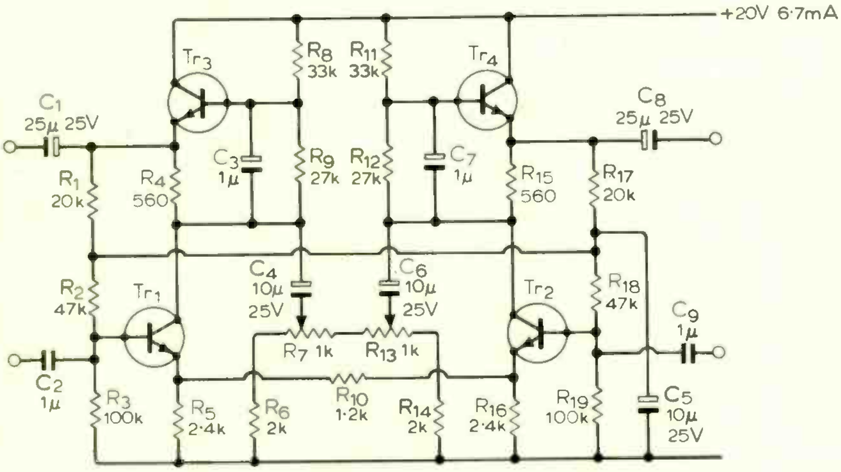


Fig. 2. Practical circuit for construction. R_7 and R_{13} are ganged.

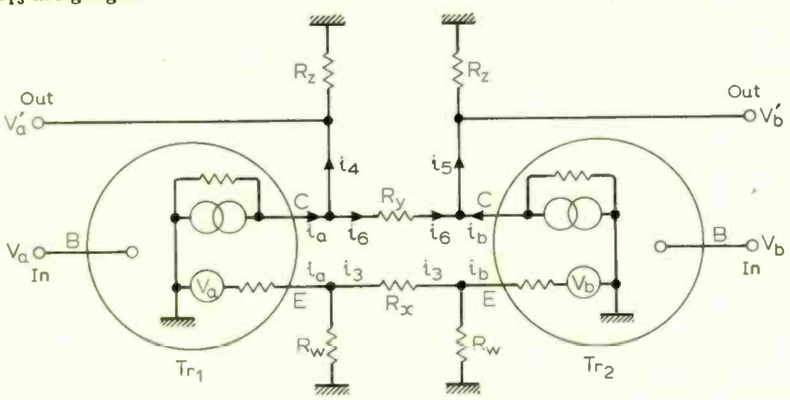


Fig. 3. Equivalent circuit of Fig. 1.

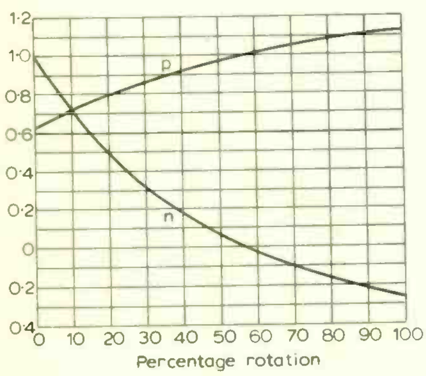


Fig. 4. Calculated response of the control circuit.

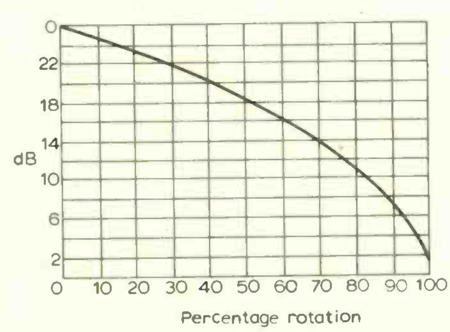


Fig. 5. Crosstalk coefficient of processed signals, when input crosstalk is 10 dB.

Acknowledgement

The author wishes to express his thanks to the Director of Engineering of the British Broadcasting Corporation for permission to publish this article.

Appendix 1

The outputs V_a' and V_b' (Fig. 1) are to follow the equations $V_a' = -p(V_a + nV_b)$ and $V_b' = -p(V_b + nV_a)$ where V_a and V_b are the two inputs. When $n = 0$ the outputs are the unmodified inputs, multiplied by p, which in the practical circuit under these conditions is unity. There will be a statistical correlation between V_a and V_b in general, therefore the subjective loudness of the outputs will rise as n is increased towards +1, since when $n = 1$, $V_a' = -p(V_a + V_b)$ and $V_b' = -p(V_b + V_a)$. Accordingly, the factor p is reduced to 0·625 for the mono condition, i.e. a 4 dB reduction in gain.

When the circuit is used to compensate for unwanted crosstalk, the inputs can be expressed in the form, $V_a = a + mb$ and $V_b = b + ma$ where a and b are the "true" left and right channels respectively. The operation, $V_a + -p(V_a + nV_b)$ results in,

$$V_a' = -p(a + mb + mna + nb)$$

$$= -p[a(1 + mn) + b(m + n)]$$

Now if $n = -m$, then $V_a' = -pa(1 - m^2)$, i.e. crosstalk is eliminated and the output is reduced in amplitude by $(1 - m^2)$. To compensate for this gain reduction, p is increased to 1·12 for the condition when $n = -0{\cdot}25$, i.e. a 1 dB rise.

Appendix 2

Fig. 3 shows the equivalent a.c. circuit of Fig. 2, using the small signal equivalent circuit of the transistors, modified for simplicity. If the emitter voltage source resistance R_e is small, the emitter voltages are V_a and V_b respectively. Stating Kirchoff's current junction law at the emitters,

$$I_a - I_1 + I_3 = 0$$

and

$$I_b - I_2 - I_3 = 0$$

$$I_a + \frac{V_b - V_a}{R_x} - \frac{V_a}{R_w} = 0$$

and

$$I_b - \frac{V_b - V_a}{R_x} - \frac{V_b}{R_w} = 0$$

Thus:

$$I_a = V_a \frac{(R_x + R_w)}{R_x R_w} - \frac{V_b}{R_x}$$

and

$$I_b = V_b \frac{(R_x + R_w)}{R_x R_w} - \frac{V_a}{R_x}$$

So there is a negative crosstalk component in the emitter currents. If the source resistance R_e is taken into account the equations become rather complicated, but if R_e' is very large and the load resistance can be neglected, then application of Kirchoff's law at the collectors gives,

$$I_a - I_4 - I_6 = 0$$

and

$$I_b - I_5 + I_6 = 0$$

Adding,

$$I_a + I_b = I_4 + I_5$$

Therefore,

$$V_b' = -V_a' - \frac{R_z}{R_w}(V_a + V_b)$$

Substitution, manipulation and rewriting give,

$$V_a' = -mp(V_a + nV_b)$$

and

$$V_b' = -mp(V_b + nV_a)$$

where m is a constant, equal to the circuit gain when n is zero, i.e. when $R_x R_z = R_w R_y$. With the component values of the practical circuit (Fig. 2)

$$m = 1 \text{ and, } R_w = 2{\cdot}4 \text{ k}\Omega$$
$$R_x = 1{\cdot}2 \text{ k}\Omega$$
$$R_y = 2x \text{ k}\Omega$$
$$R_z = (3 - x) \text{ k}\Omega,$$

where x is the fractional rotation of the control (between 0 and 1).

Fig. 4 shows the predicted characteristics of p and n. It is a simple matter to arrange for the circuit to have gain. For a gain of m, the collector components R_6, R_7, R_{13} and R_{14} should all be multiplied in value by m. Alternatively the emitter components R_5, R_{10}, R_{16} could all be divided in value by m. Obviously the biasing should be recalculated to ensure efficient usage of the rail voltage.

Variable Capacitance Diode

The variable-capacitance diode, or varactor as it is often called, is now quite widely used for tuning purposes, but little information about it seems to have been published. The capacitance of any semiconductor junction diode which is reverse biased varies with the magnitude of the reverse bias, the capacitance decreasing with the applied voltage. In ordinary diodes the capacitance is associated with quite high resistive losses, but in the special varactor diodes these losses are sufficiently reduced for them to be very useful devices for tuning purposes.

One example of the varactor is the Motorola 1N5145A. At 4V reverse bias this has a capacitance of 27pF ± 1.3pF and a nominal capacitance ratio of 3.4 (minimum ratio 3.2) when the applied bias is changed to the maximum rated value of 60V. The nominal minimum capacitance is thus 7.85pF. In practice one cannot achieve quite such a small minimum capacitance because it is necessary to restrict the reverse bias to less than 60V in order that 60V is not exceeded under worst-case conditions. The Q is 200 at 50MHz which is a good deal higher than that of the average inductor with which it will be associated.

The law of variation with voltage is, approximately, an inverse square-root one. However, series fixed capacitance is usually needed to allow the application of the reverse bias and a tuned circuit always has shunt capacitance so that the law of variation of frequency with voltage is quite a complex expression. It turns out in practice, however, that frequency is almost exactly proportional to the logarithm of the voltage.

Fig. 1 shows the circuit of an oscillator in which the frequency is controlled by a varactor diode. The circuit is basically that of a Colpitt's oscillator in which the 6.8-pF capacitor forms one of the split capacitors and the base-emitter capacitance of the transistor forms the other.

Fig. 2 shows the measured frequency of oscillation plotted against the reverse bias voltage V_d. The amplitude of oscillation was about 1.1V peak. It must, of course, be less than the minimum reverse bias to prevent the varactor from conducting during part of the r.f. cycle. It should be much less to minimize capacitance variations during the cycle. It can be seen from Fig. 2 that only three of the points lie slightly off the straight line drawn through the other 10 points and it is probable that this is because of experimental errors.

This law of frequency variation will hold for any mid-band frequency as determined by the inductance, as long as the circuit continues to oscillate with the capacitance values given.

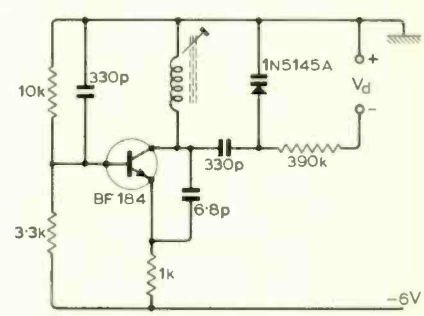


Fig. 1 Circuit of a transistor oscillator using a varactor diode

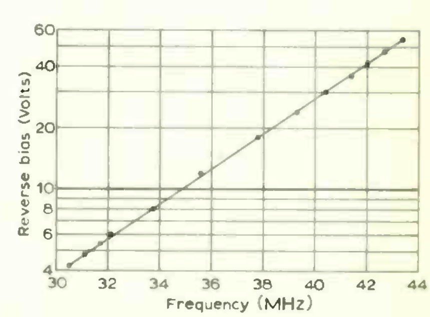


Fig. 2 Variation of oscillator frequency with varactor bias

Wireless World Logic Display Aid

8: Some demonstration circuits. Using a large screen oscilloscope

*designed by B. S. Crank**

In this, the last article in the series, a few circuits will be described that may be used with the *Wireless World* Logic Display Aid to demonstrate various logic functions. Also a modification to the blanking arrangements allowing the instrument to be used with large, slow-scan demonstration oscilloscopes, will be discussed (See also "Letters to the Editor", p. 519, November issue).

AND—OR demonstration unit

This unit consists of a box containing 32 switches arranged as per Fig. 91. The switches are grouped in sets of eight and are labelled A, B, C, D, $\overline{A}$, $\overline{B}$, $\overline{C}$, $\overline{D}$. The variables represented by the switches in a particular group will be "ANDed" together when the appropriate switches are operated. For instance, if S_1, S_6, S_3 and S_8 are operated the display aid will show the function $A\overline{B}C\overline{D}$. The TRUE variables are allocated red switches and the complements have black switches.

Switches operated in different groups will be "ORed" together. The exclusive OR function would be set up as follows:

$$\text{exclusive OR} = A\,\overline{B} + \overline{A}\,B$$
$$= S_1S_6 \quad S_{13}\,S_{10}$$

Because there are four groups of switches Boolean expressions consisting of four sets of AND terms can be "ORed" together. Some examples are the binary SUM and CARRY equations:

$$\text{SUM} = A\overline{B}\overline{C} + \overline{A}\overline{B}C + \overline{A}B\overline{C} + ABC$$

$$\text{CARRY} = AB\overline{C} + A\overline{B}C + \overline{A}BC + ABC$$

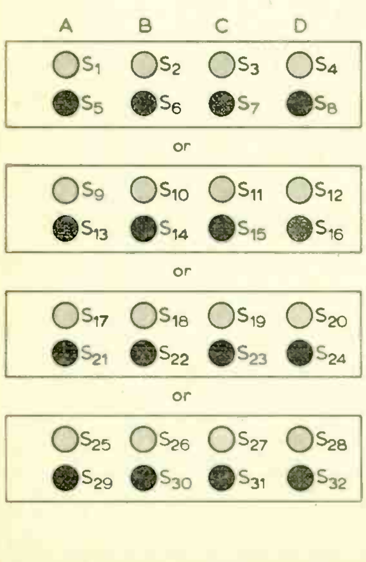


Fig. 91. Front panel layout of the AND—OR demonstration unit.

Basic facts like $A\overline{A} = 0$ and $A + \overline{A} = 1$ can be instantly demonstrated using the demonstration unit. It can also be used to demonstrate minimization ($ABC\overline{D} + ABCD = ABC$. etc.)

The switches used are miniature two-pole change-over types obtainable from G. W. Smiths. A 10% reduction on the catalogue price can be obtained if 32 are purchased.

Fig. 92 shows part of the circuitry of the demonstration unit. One four-input gate, expanded to nine inputs with five diodes, is used for each group of switches. The common point of the diodes is connected directly to the input node of the gate (pins 3 or 11 of ZN33OE—see Fig. 29, June issue). Operation of a switch will connect the variable represented by that switch to one of the inputs of the gate for the particular group.

Fig. 93 shows the remainder of the circuitry which earths one of the inputs to the gate for a particular group of switches when all switches in that group are open. If this were not done, then, unless at least one switch in each group is operated, the output from the demonstration unit would permanently be at logical 1.

If the black switches are taken to represent the TRUE variable and the red the complement, and if the output of the unit is connected to the $\overline{Z}$ input terminal of the display aid the unit will operate in negative logic and will therefore perform the NAND—NOR functions.

Basic logic function unit

This consists of a box, which is plugged into the output variable socket of the display aid, and has outputs corresponding to the main logic functions. The front panel is shown in Fig. 94 and in use the Z input to the display aid is connected to one of the gate outputs on the front panel.

The circuit is shown in Fig. 95 where it can be seen that the OR function is obtained by feeding $\overline{A}$ and $\overline{B}$ and $\overline{C}$ to a NAND gate. Wire-up the circuit as illustrated in Fig. 96 using two ZN362Es.

Demonstrating sequential logic circuits

The output of the sequential logic circuits can be displayed on the instrument provided the frequency of operation is low enough to be followed with the eyes. All that needs to be done is to compare the output of the sequential circuit with the output variables of the display aid in such a way as to provide a Z output when both are in the same condition. In our example of Fig. 97 we have used a two-bit binary counter which can be made to cycle continuously or operate in a single shot mode. In the prototype of this circuit which was built on a single plug-in card, a four-bit counter was employed with an extra

*Assistant editor *Wireless World*.

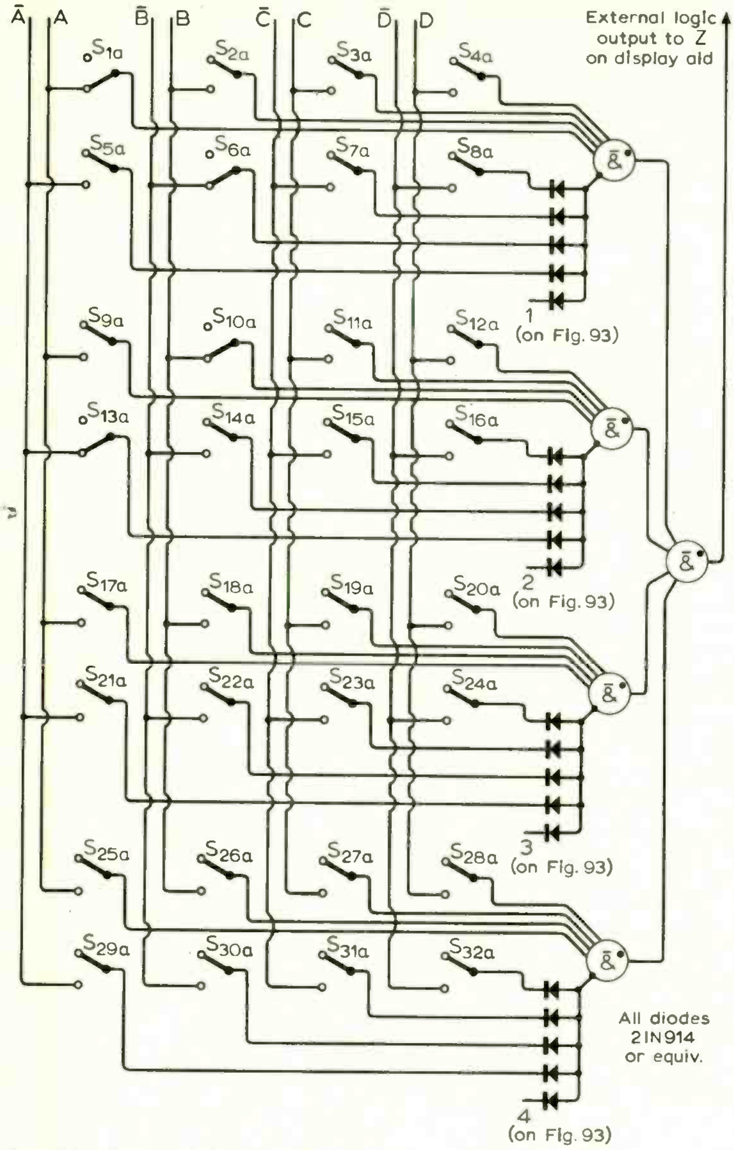


Fig. 92. Some of the switch wiring.

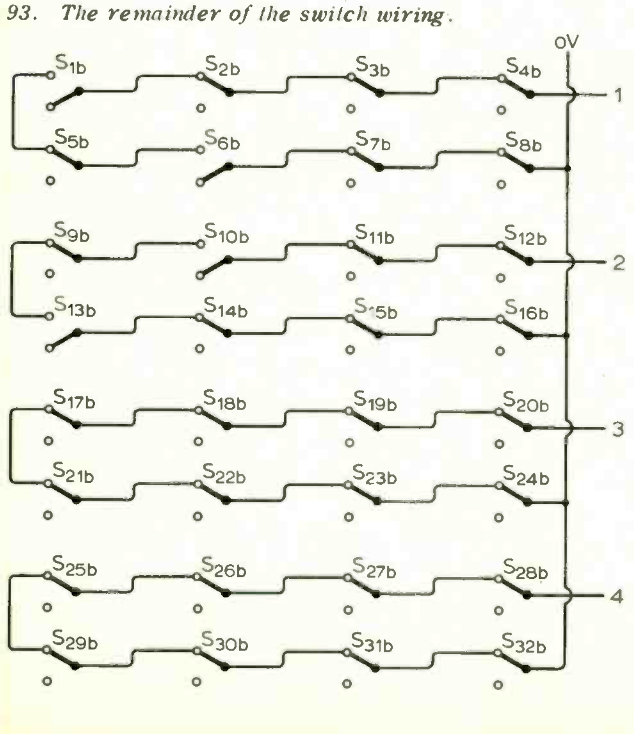


Fig. 93. The remainder of the switch wiring.

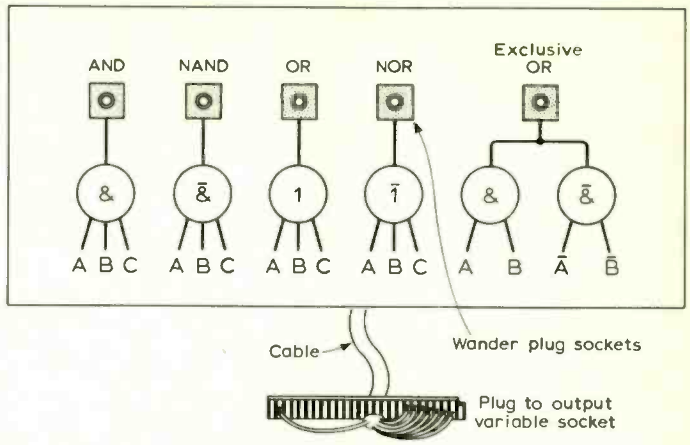
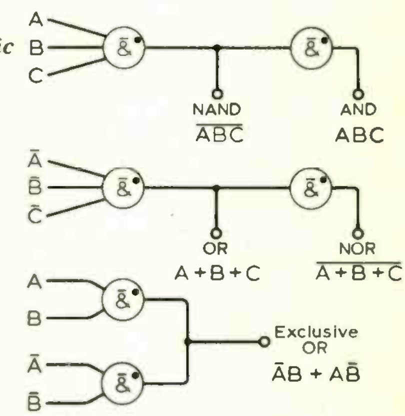
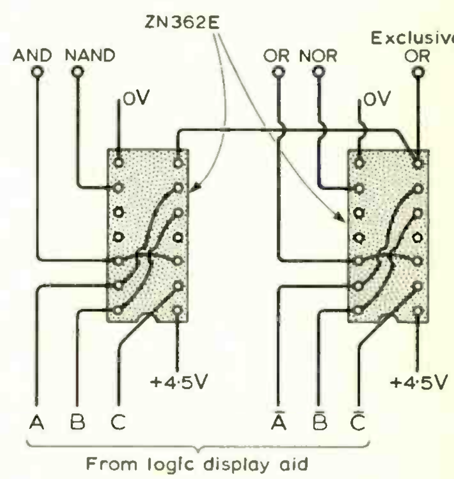


Fig. 94. Front panel of the basic logic function unit.

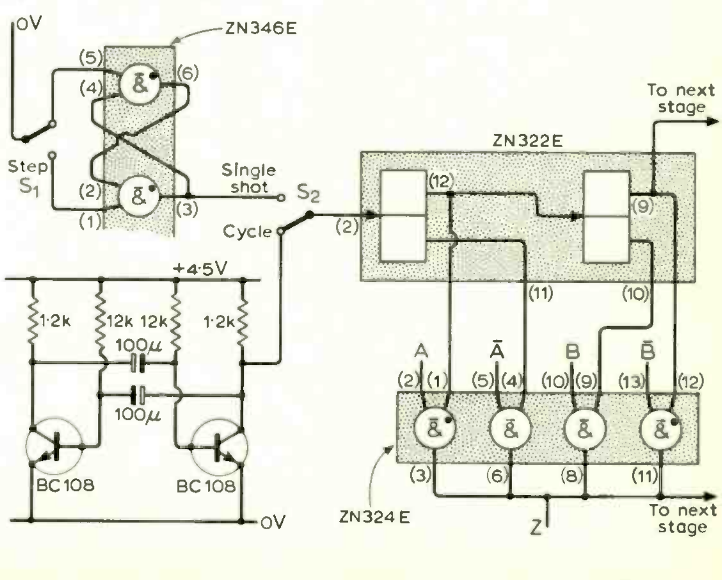
(Right)
Fig. 95. Showing how the basic logic functions are obtained with NAND gates.



(Right)
Fig. 96. Practical wiring diagram of Fig. 95.



(Below)
Fig. 97. Demonstrating sequential circuits. A two bit counter which may be extended to four or six bits, depending upon instrument type.



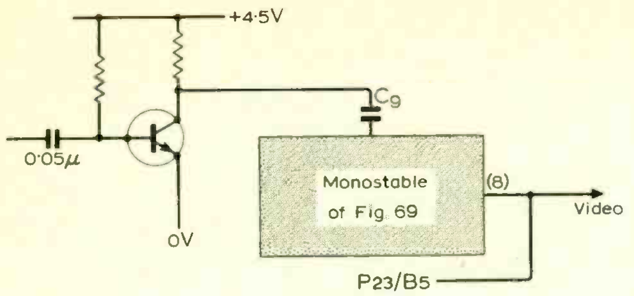


Fig. 98. Altering the blanking arrangements to give better performance and about 4V output for LAN Electronics' 19-in oscilloscope.

switch which altered the length to three bits when required. The switch S_2 allows the output of a low-frequency multivibrator for continuous operation, or a trigger circuit for single shot operation, to be selected. S_1 causes the counter to increase one count at a time when S_2 is in the single shot position.

The output of any sort of counter, be it n.b.c.d., Johnson, etc., can be displayed in this way so that all the possible states are seen in turn on the screen. The same limitations as for combinational circuits apply of course, three outputs for Venn diagrams and Truth tables or four or six outputs (depending on instrument type) for Karnaugh maps.

Using the instrument with a large oscilloscope

For a demonstration it was necessary to use a large 19-inch screen slow-scan oscilloscope. The particular instrument chosen was manufactured by LAN Electronics Ltd. An examination of the specification showed that the Z axis required a normal logic input of only about 4V for full modulation of the beam.

The circuit was altered accordingly using much the same principle as before. The blanking arrangements used in the display aid did not prove very satisfactory in this case as several of the dots appeared as lines.

The circuit of Fig. 98 was finally employed. The 60V power supply and the video amplifier were no longer required and were dispensed with. The transistor of Fig. 98 is normally held on by the base resistor. On the receipt of a negative transient from the clock generator the transistor switches off for a time determined by the 0.05μF input capacitor. The pulse at the collector is used to trigger the monostable of Fig. 69 (Sept. issue) via C_9. The video output to the large oscilloscope was taken from the junction of the output of the monostable and the video output of the logic circuits. The monostable clamps the video output of the logic circuits and therefore the necessary delay between a clock pulse and the video output signal is provided.

To revert to modification –4 in the October issue it should have been mentioned that it is necessary to reduce the size of the clock generator capacitors to 0.01μF to prevent flicker.

Announcements

"Micro-electronics applied to digital systems" is the title of a course of lectures organized by the Electrical & Electronic Engineering Department of Sunderland Polytechnic. The lectures are offered both as an evening course and a day course commencing in January.

The Yorkshire Television careers film **"I am an engineer—electrical"**, a 16mm black-and-white film lasting 20 minutes, is now available on loan from the Education Department, Institution of Electrical Engineers, Savoy Place, London W.C.2.

"Introducing metrication into your company" is the title of a one-day seminar organized by Business & Industrial Training Ltd, (161-166 Fleet Street, London E.C.4) in association with *Engineering Materials & Design* to be held at the following venues: Airport Excelsior Hotel, Manchester (December 2nd); Royal Garden Hotel, London (December 9th); Airport Excelsior Hotel, Birmingham (December 11th). The fee is £20.

Techmation Ltd are to hold an international **seminar on analytical laboratory techniques** at the Royal Garden Hotel, London W.8, from December 2nd to 4th. Tickets are available from Tachmation Ltd, 58 Edgware Way, Edgware, Middx.

Pye of Cambridge Ltd is bringing together the aviation activities of Ekco Electronics Ltd in the radar field and those of Pye Telecommunications Ltd in the airport and ground-to-air communications field. The merged facility will become the **Ekco Electronics Aviation Division** of Pye Telecommunications on January 1st. In a parallel move, Ekco Electronics instrument activity will be re-named Ekco Instruments Ltd.

Interdata Inc., of Oceanport, New Jersey, has formed a **wholly-owned British subsidiary** to market its products. The new company, Interdata Ltd, Station House, Harrow Road, Wembley, Middx, will be responsible for the sale of the parent company's range of small, real-time, on-line control computers.

Following the introduction of an all-solid-state data transmission keyboard, the American company **Ikor Inc. have opened a U.K. office** at Chiltern House, Oxford Road, Aylesbury, Bucks, to handle local manufacture and marketing of the keyboard.

A new company, **Hytron Ltd**, Park Road, Crowborough, Sussex, has been formed to manufacture and sell data communications and storage equipment. The managing director is J. Hale and marketing director A. Thomas.

Alfred Herbert Ltd, of Coventry, have announced the amalgamation of two of their operating companies, Sigma Instrument Co. Ltd and Herbert-BSA Electrics Ltd, to form a new company called **Herbert Controls and Instruments Ltd.**

Electrical Remote Control Co. Ltd, and Raymond Engineering Inc, of Connecticut, have formed a joint company, Raymond Controls Corporation, which will manufacture, import and market Elremco products in the U.S.A. and Latin America.

Racal Electronics Ltd, of Bracknell, Berks, and the **Antenna Products Company** of Texas have announced an agreement whereby Racal has exclusive representation of A.P.C. outside the American continent. A.P.C. are manufacturers of m.f., h.f., v.h.f., and u.h.f. aerials, and specialize in log periodic types.

Racal Electronics Ltd has announced that following discussions with the Ministry of Technology and the Industrial Reorganization Corporation it is selling the business and certain assets of **Airmec-AEI Ltd** (acquired when it took over the Controls & Communications group) to the Plessey Company Ltd.

Dixons, of 3 Soho Square, London, W.1, have been appointed exclusive U.K. distributors for the **Ikegami** range of closed-circuit television equipment.

Salford Electrical Instruments has signed an agreement to market in the U.K. the range of **Petercem micro switches** manufactured by Compagnie Electro-Mécanique, of France.

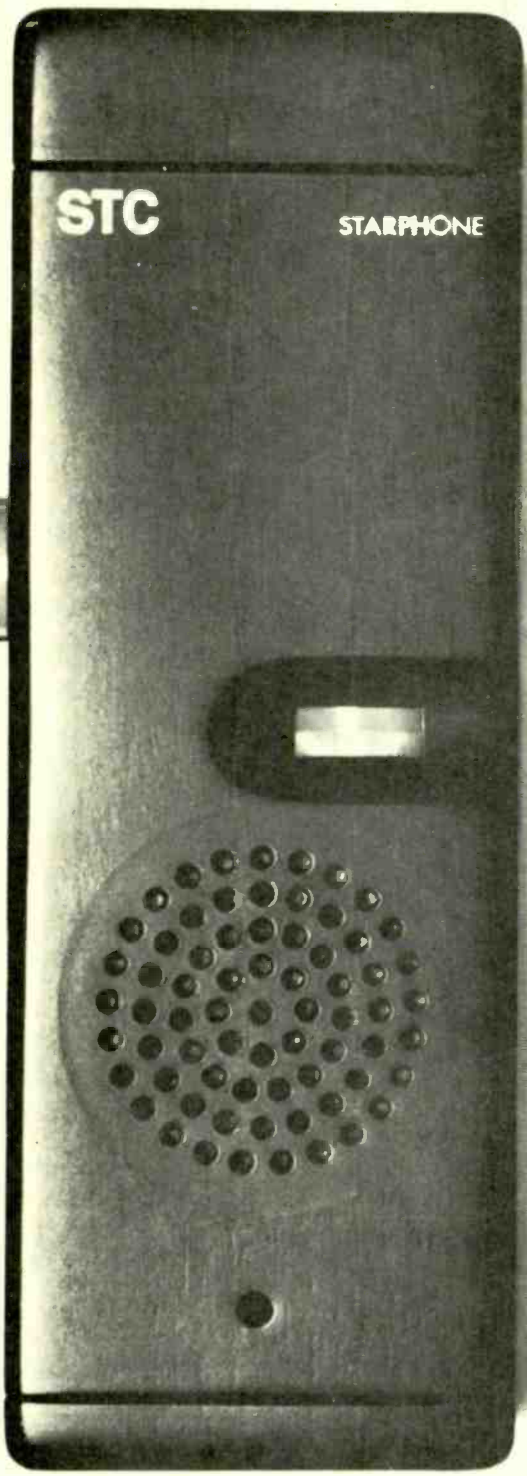
A marketing agreement has been announced between B & K Instruments Ltd and Intecole Systems Ltd, manufacturers of 'MODULOG' data logging equipment. B & K will distribute 'MODULOG' and provide full after-sales service in the U.K. and Eastern Europe.

The sale of **Eddystone Radio's** semi-domestic receivers is now concentrated through Alfred Imhof Ltd, 112-116 New Oxford Street, London W.C.1, who will act as main distributor.

Amalgamated Wireless (Australasia) Ltd, have appointed Marconi Instruments as servicing agents in the U.K. for their telecommunications test gear.

London Weekend Television have purchased five RCA **vision tape recorders,** type TR-70B, as part of their colour expansion. The contract is valued at nearly £¼M.

STARPHONE by STC



Starphone—actual size

The World's Smallest UHF Radiotelephone

The Starphone is unique.
It's the first radiotelephone designed to go in the pocket without external wires or rods. Operating on UHF, STC Starphone has an astonishing penetration of buildings and steel structures, and can give you instant two-way communication with your staff over a wide area.

Write for details to
STC Mobile Radiotelephones Limited,
New Southgate, London N.11. England.
Telephone: 01-368 1200.
Telex: 261912.

Attach your letterheading to this panel.
Please send me full details of your STARPHONE

Name............................

Position............................

WW11

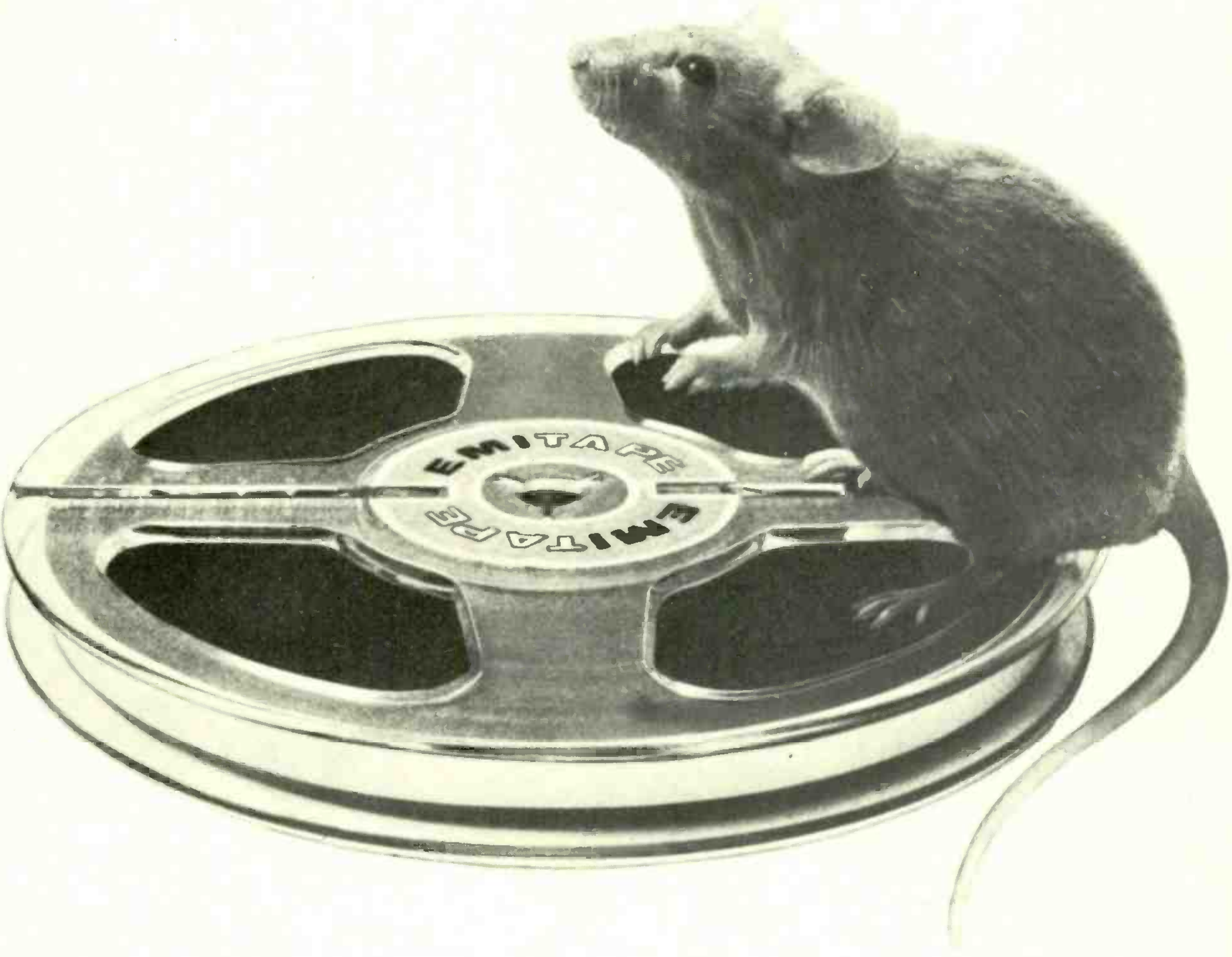
STC
Mobile Radiotelephones

An associate of
ITT

EMITAPE Afonic

low-noise recording tape

quiet as a mouse!



don't buy any tape – buy EMITAPE

THE RANGE OF EMITAPE AFONIC LOW-NOISE TAPE

88
STANDARD PLAY
The best general purpose tape, giving maximum durability at all professional speeds. Pre-stretched polyester base film of super strength.

99
LONG PLAY
50% longer recording time – specially designed for multi-track recorders – pre-stretched polyester base film of super strength.

100
DOUBLE PLAY
Twice the recording time for a given size of spool – the perfect film for low speed, multi-track recorders – superflex polyester base film.

300
TRIPLE PLAY
Maximum playing time on spools up to 5" dia. – extended dynamic range – specially suitable for battery operated recorders – extra tensile polyester base.

EMITAPE IS AN EMI GROUP PRODUCT EMI

WW—105 FOR FURTHER DETAILS

Letter from America

Japanese competition is causing some concern in American Trade Union circles and the presidents of three of the largest unions in the electrical industry recently appealed to the Nixon administration to curb imports of electrical goods. One union leader said "This rapidly rising flood of imports from Japan, Taiwan, Korea, Hong Kong and Mexico has almost eliminated U.S. domestic production in some segments of this industry". Another official stated that "More than 50% of the black-and-white TV sets sold in the U.S. during 1969 will be of foreign manufacture".

The situation is complicated by some U.S. manufacturers taking advantage of the fact that components can be sent "offshore" to be assembled and returned on a Low Value Added duty. The low wages being of course the added value. According to the Tariff Commission, about \$270 million a year of electronic products—plus some \$13 million in scientific instruments—are involved.

One area in which the Japanese are now making considerable inroads is the electronic desk calculator field. In fact, it is estimated they already have 50% of the total sales (currently assessed at 100,000 machines a year). A typical machine is the new Toshiba BC-1212 which is a 12 digit, one memory model costing less than \$500 (£210).

Super high-gain bipolar transistors will become serious rivals to f.e.ts in the near future. At the moment they are a little more expensive but they do offer some definite advantages such as lower leakage current and wider temperature ranges. National Semiconductor have used them in their new LM108 op. amp.—replacing the f.e.ts used in earlier types. It is claimed that the input error current equals the f.e.t. up to 50°C but is far superior at 125°. Robert Wedlar, the designer, said the current is so low at 125° that it could not be compared with an f.e.t.—or even a complicated chopper stabilized amplifier costing much more. The performance is limited by leakages in the printed boards, resistors and capacitors rather than the amplifier itself. These super-gain transistors operate at virtually zero voltage so it is necessary to use a bootstrap circuit in the LM108 but the offset voltage is typically less than 1mV. The low current error means that the 108 can be used with configurations not possible with more conventional amplifiers. It can operate from source resistances as high as 10MΩ, introducing less error than other units with 10kΩ sources. This high resistance allows time delays in analogue circuits of up to one hour with capacitors no larger than 1μF!

RCA have just released a new time-sharing computer (model 61) which is designed for a lease price of about \$50,000 a month—or a cool \$2¼ million cash. According to RCA's T. A. Smith, the computer revolution is only just beginning and it is destined to have a greater impact on everyone's life than originally envisaged. Some of the advances in communications expected during the next few years include students operating "teacher" computers, housewives using a special video console to order groceries and automatic car control for commuters. This last named idea is not really so far fetched and much work has already been carried out by various research organizations and highway authorities using embedded control circuits and ancillary equipment for long-distance expressways. A form of automatic control for cars was demonstrated recently by the Mellon Institute. It rejoices in the name Computerised Energy Distribution and Automatic Control, or CEDAC, and it is intended to replace automotive electrical circuitry, improve safety—and cut repair bills into the bargain! Two computers are used one to control 18 functions and the other to diagnose electrical troubles. Integrated circuits are used extensively and a driver-operated master display panel transmits signals to the central computer to perform such functions as operating door locks, windscreen washers, power windows and lighting. Capacity is provided for climate control, anti-skid devices, fuel injection and transmission and ignition sub-systems. A digital display panel can be incorporated which will provide instantaneous readout of speed, oil pressure, fuel level, engine temperature, etc. If any trouble develops, the diagnostic computer will analyse it.

A new plastic developed by Union Carbide would appear to have many advantages over existing materials. It is called Parylene and it is a better insulator than epoxys, silicones or urethanes, has a higher resistance to moisture and thermal expansion is very low. Applications include semiconductor barrier coatings, corrosion protection and encapsulation. One company—Rockwell—has been working with NASA developing techniques for vacuum depositing Parylene on complex circuit assemblies and it is claimed that tests have been very successful. Not only are electrical parameters unchanged after many hours of stringent tests but the deposited film can conform to very complex shapes.

In a new book entitled "A biography of the Watsons and I.B.M." author William Rodgers says "In all the world, one corporation dominates the future—I.B.M." The *New York Times* book reviewer thinks this is a little extravagant but concedes that I.B.M. does employ 250,000 people (more than half are college graduates) and that current stock value is more than the gold ever held in Fort Knox. According to Rodgers, I.B.M. activities "cover much of the worlds advanced technology in space, on the earth, under the seas and in thousands of industries". Although I.B.M. have a reputation of being a forward looking, enlightened company, I, for one, find the move towards larger and larger conglomerations very disquieting. Many business experts are predicting a greater and greater swing towards an international business oriented world during the next few years. For instance, Dr. Perlmutter, Professor of Industry at the University of Pennsylvania, believes that by 1985 there will be 200 or 300 super giant multi-national firms dominating the world. The National Industries Conference Board estimates that by 1975 some 25% of the gross national product of the free world outside the U.S. will come from branches and subsidiaries of U.S. companies operating abroad. Not enough people know that this is a two-way affair—last year foreign investors put over 2½ billion dollars into U.S. industry via the stock exchanges. This international business accord has been welcomed by some who feel it will help the "one world" concept. Whether people will like living in a computerized world, dominated by super-national corporations is another matter!

A great deal of interest was aroused by the new RCA Selectavision (SV) video cartridge tape recorder when it was demonstrated recently. This uses laser technology and it can be attached to any colour TV set (although the user cannot tape his own programmes). The tape is made of plastic and the recordings are made by an electron beam system. The tape or "colour encoded master" is then developed and converted by a laser to a series of holograms recorded on the tape with photoresist. After chemical treatment a nickel master is made and this is so durable that it can make many thousands of tapes without degradation. The playback equipment consists of a very low power laser tube plus a basic form of TV camera. The laser beam passes through the tape to the pick-up tube which sees the image colours as coded variations. How does the SV compare with the E.V.R. system of C.B.S.? Well, RCA see the most significant difference in the cost as they expect to market the system for less than \$400 (£167). Tape prices are believed to be around \$10 for a 30 minute programme and \$18 for 60 minutes. Some months ago C.B.S. said that the E.V.R. unit would sell for \$800 and tapes would be \$40.

G. W. TILLETT.

Operational Amplifiers

10. A triangular, square-wave generator

by G. B. Clayton, B.Sc., A.Inst.P.

The circuit to be described uses an operational integrator supplied with a constant input to generate a precise triangular wave. A schematic diagram illustrating the principle of operation is given in Fig. 8. Two amplifiers are used, one acting as an integrator (A_1) and the other (A_2) acting as a regenerative comparator. Diodes D_1, D_2, D_3 and D_4 determine the direction of current flow into the integrator. When the comparator output is at its positive level (V_0^+) diodes D_1 and D_4 are reverse biased, diodes D_2 and D_3 are forward biased and a current $+E_s/R_3$ flows through D_2 to the summing point of amplifier A_1. The output voltage of this amplifier runs down at a rate $-E_s/R_3C$ volts/sec (Fig. 9(a)). With the comparator output at its negative value (V_0^-) a current $-E_s/R_4$ flows through diode D_4 away from A_1 and A_1 output voltage runs up at a rate $+E_s/R_4C$ volts/sec (Fig. 9(b)).

The output from the integrator (amplifier A_1) is applied to the non-phase-inverting terminal of amplifier A_2 (the comparator) through the resistor R_1. The phase-inverting input terminal of amplifier A_2 is connected to earth. The comparator makes a transition between states when the voltage between the two input terminals of A_2 goes through zero. When the comparator output is in its positive state V_0^+ the transition occurs when the output from the integrator is

$$e_{01} = -\left(V_0^- \frac{R_1}{R_2}\right)$$

and when the comparator output is in its negative state the transition occurs when

$$e_{01} = -\left(V_0^+ \frac{R_1}{R_2}\right).$$

Waveforms are illustrated in Fig. 10. The frequency and the periods t_1 and t_2 are conveniently set by choice of R_3, R_4 and C.

A practical circuit giving component values is illustrated in Fig. 11. A single integrated circuit having two op. amps formed on the same silicon chip mounted in a single dual-in-line pack was selected for use. There are now several of these dual op. amps commercially available at modest cost; in fact the price of a dual amplifier is very little more than that of a single amplifier and this makes multi amplifier circuits economically attractive.

In the circuit a frequency compensating capacitor of value 4,700 pF is connected to the input lag compensating terminals of the amplifier used as an integrator. No frequency compensation is applied to the amplifier acting as the comparator. Diode clipping, using a 470 Ω resistor and four silicon diodes, is employed to accurately define the comparator output swing (V_0^+ and V_0^-).

The oscillograms (Fig. 12) show the triangular and square waveforms produced by the circuit using various values for R_3, R_4 and C. If the circuit were to be made the basis of a function generator frequency ranges could be conveniently selected by switching in different values of C and a fine control of frequency could be obtained by using potentiometers for R_3 and R_4. Unity mark-space ratio is obtained for equal values of R_3 and R_4, a variable mark-space ratio for independent variation of R_3 and R_4.

The circuit functions over a wide frequency range from very low frequencies of order 0·2 Hz to 100 kHz. The 5 kΩ potentiometer is used as a balance control to cancel integrator drift due to initial amplifier offsets; the adjustment is made at the lowest frequencies. With $R_3 = R_4$ magnitude, say 2 MΩ, and $C = 1\ \mu$F the balance control is adjusted to give a waveform with unity mark-space ratio. The effects of integrator drift are only really appreciable for the longer timing periods and if very low frequency operation is not required the

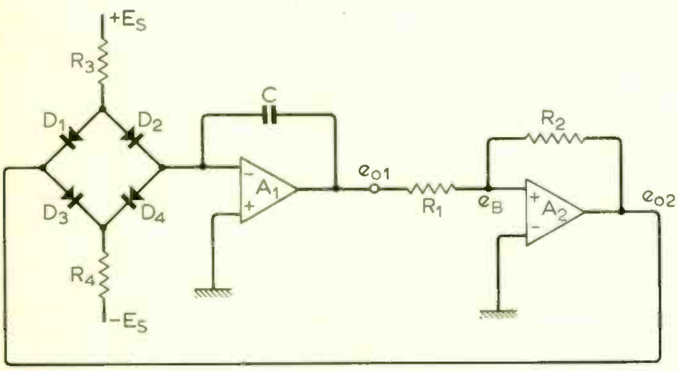


Fig. 8. Schematic for generator of triangular and square waves.

(Left) Fig. 9. Conditions for (a) positive and (b) negative levels of comparator output voltage in the Fig. 8 system.

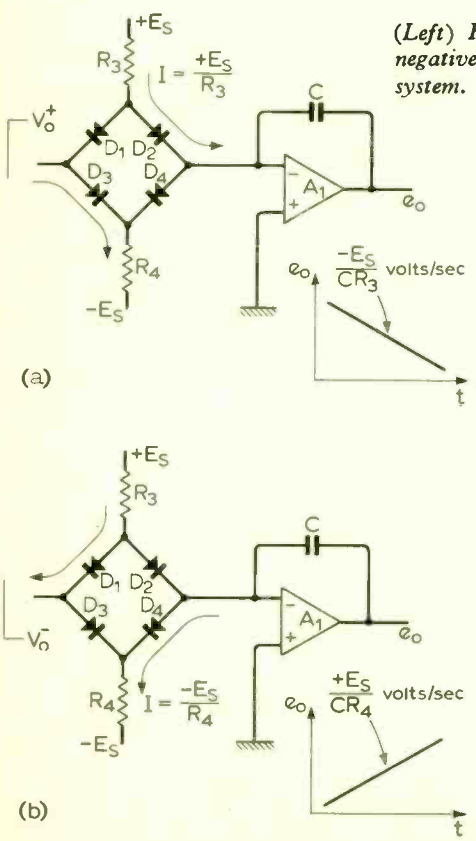
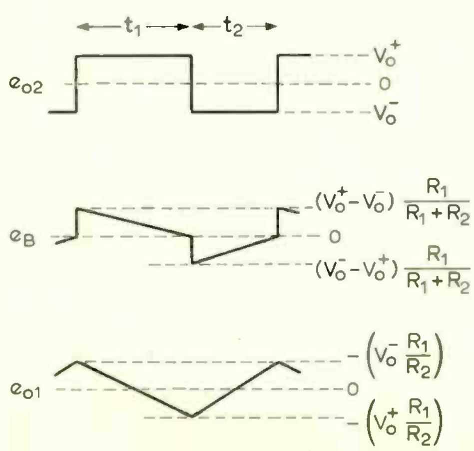


Fig. 10. Waveforms in the triangular- and square-wave generator.

$$t_1 = (V_0^+ - V_0^-)\,\frac{R_1}{R_2}\cdot\frac{CR_3}{E_s}$$

$$t_2 = (V_0^+ - V_0^-)\,\frac{R_1}{R_2}\cdot\frac{CR_4}{E_s}$$



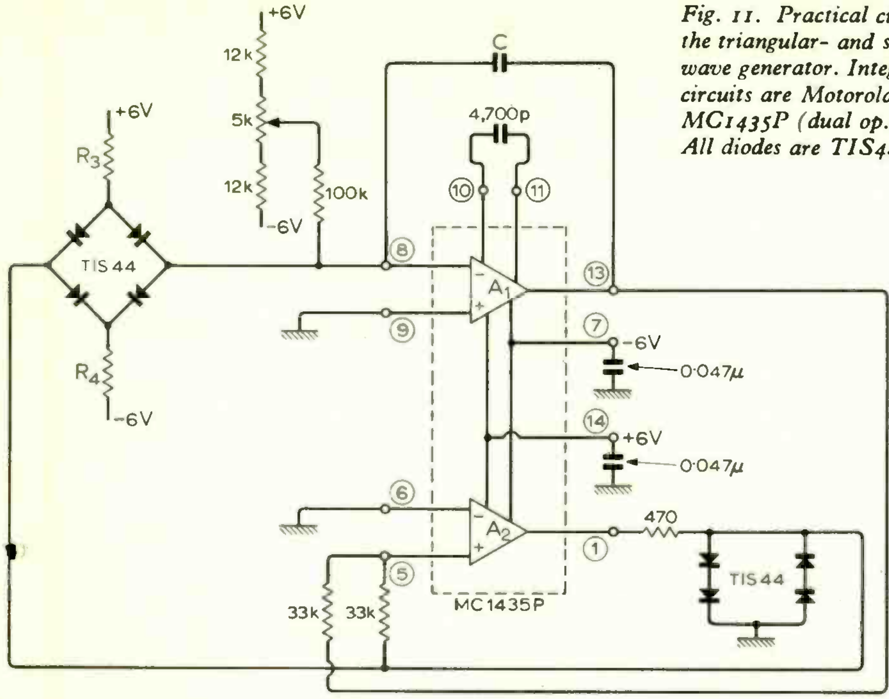


Fig. 11. Practical circuit for the triangular- and square-wave generator. Integrated circuits are Motorola MC1435P (dual op.amp.). All diodes are TIS44.

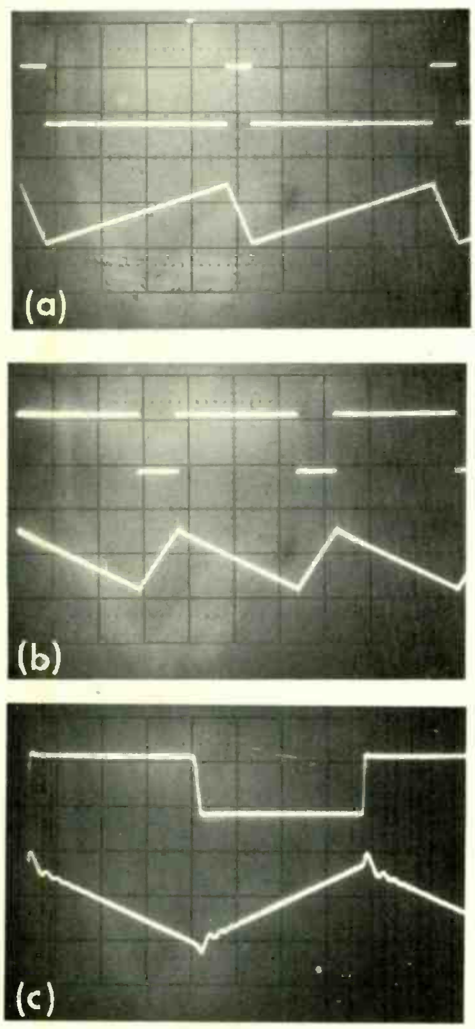


Fig. 12. Waveforms from the triangular- and square-wave generator for different values of C, R_3 and R_4. In (a) C = 1 μF, R_3 = 56 kΩ, R_4 = 680 kΩ; horizontal scale 50 ms/div. In (b) C = 0·01 μF, R_3 = 56 kΩ, R_4 = 18 kΩ; horizontal scale 0·1 ms/div. In (c) C = 220 pF, R_3 = 27 kΩ, R_4 = 27 kΩ; horizontal scale 1 μs/div. All waveforms, vertical scale 2 V/div.

integrator balance control could well be omitted from the circuit. At the higher frequencies the output triangular wave from the integrator shows marked switching transients (Fig. 12(c)).

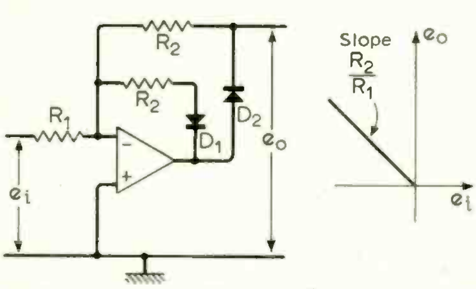
Precise rectifiers

The following section was regrettably omitted from an earlier issue. With it we conclude Mr. Clayton's series of articles on op. amps.

The forward voltage drop across a solid-state diode can cause errors when the device is used for low-signal levels in a conventional rectification or detection circuit. Op. amps can be combined with diodes and resistors to perform almost ideal rectification.

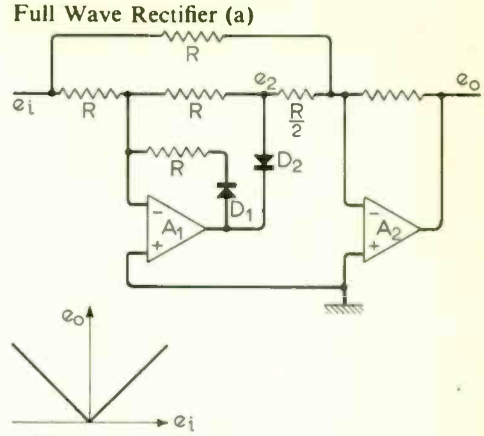
For positive input signals D_1 is forward biased and D_2 is reverse biased; the output voltage is zero with output impedance R_2.

Half Wave Rectifier



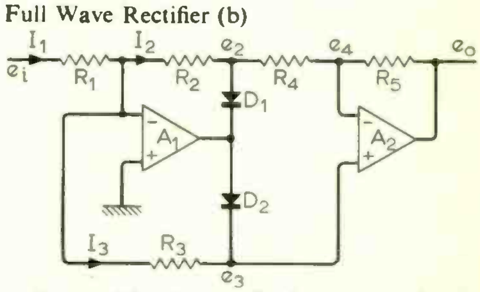
For negative input signals D_1 is reverse biased, D_2 is forward biased and the output voltage is $-e_i\,(R_2/R_1)$ with output impedance equal to the closed-loop output impedance of the amplifier. Dependent on the choice of R_2/R_1 the circuit may be used to produce gain as well as rectification. The circuit may be adapted to summation by the connection of appropriate input resistors to the amplifier summing point. In this case the amplifier will give half-wave rectification of the sum of the input signals.

Full Wave Rectifier (a)



The circuit shows an arrangement commonly used to obtain full-wave rectification. The first amplifier acts as a half-wave rectifier and the second amplifier as an adder. For negative input signals D_2 is reverse biased and $e_2 = 0$; the output from the second amplifier is thus $e_o = -e_i$. For positive input signals D_2 is forward biased and $e_2 = -e_i$. The output from the second amplifier (the adder) is thus $e_o = -(e_i + 2(-e_i)) = e_i$.

Full Wave Rectifier (b)



For positive inputs D_2 is reverse biased and the two inverting amplifiers are in cascade

$$\left|\frac{e_o}{e_i}\right| = \frac{R_2\,R_5}{R_1\,R_4}$$

For negative input signals D_1 is reverse biased and there are then two feedback paths to the summing junction of amplifier A_1, one from the output of A_1 through D_2 and R_3 and the other from the output of A_2 through R_5, R_4 and R_2.

With the usual summing point restraints we have $I_1 = I_2 + I_3$. This gives

$$\frac{e_i}{R_1} = -\left(\frac{e_o}{R_5 + R_4 + R_2} + \frac{e_3}{R_3}\right)$$

But $$e_3 = e_4 = e_o\,\frac{R_2 + R_4}{R_5 + R_4 + R_2}$$

$$\left|\frac{e_o}{e_i}\right| = -\left(\frac{R_2 + R_4 + R_5}{R_3 + R_2 + R_4}\right)\frac{R_3}{R_1}$$

Using equal value resistors throughout makes

$$\left|\frac{e_o}{e_i}\right|_+ = 1 \qquad \text{and} \qquad \left|\frac{e_o}{e_i}\right|_- = -1$$

Circuit (b) offers several advantages over (a). The current drain on the driving source is less, for in circuit (a) the input signal drives two amplifiers in parallel. All resistors may be made equal in circuit (b) and equal value resistors are easy to select for high accuracy. Circuit (b) may be adapted to summation by the connection of additional input resistors to the summing point of amplifier A_1.

World of Amateur Radio

Amateur 70-cm band coveted

British amateurs are reacting sharply to repeated demands by prominent manufacturers of mobile and personal two-way business communications equipment that the mobile u.h.f. band should be extended downwards to 420 MHz, thus threatening the entire amateur 70-cm band which currently extends in the U.K. from 425 to 429 and 432 to 450 MHz. While such proposals are usually accompanied by the rider that provision would have to be made for amateurs, no suggestions have been made as to how this could be done without seriously impairing the usefulness of this important amateur band. When the 70-cm band was released in October 1948, it was then 40 MHz wide, but over the years it has been whittled down to the present 22 MHz.

Amateurs point out that they were making effective use of these allocations for many years before the mobile services made practical use of u.h.f.; indeed, amateur development paved the way for the present increasing use of u.h.f. by the mobile services. Almost all amateur television experimental work is concentrated in this band, which is also highly suitable for investigation of tropospheric propagation and for moon-bouncing.

In Region 1 (including Europe), with a few exceptions, no provision is made in the international allocation table for mobile services in the section 430 to 440 MHz; in Region 2 (including U.S.A.) and Region 3 the entire allocation 420 to 450 MHz is shared by the radiolocation and amateur services.

A pertinent indication of the potential of these frequencies for extended distances is shown by the recent breaking of the world amateur 432-MHz record by a two-way contact over the 1,185-mile path between stations K2CBA, Petersburg, N.Y., and W0DRL, Topeka, Kansas. Similarly, an amateur in Virginia recently became the first to work 20 States on this band. European activity includes frequent contacts between the U.K. and western European countries. The present width of the band is of importance in allowing regional sub-divisions and the voluntary allocation of the top 16 MHz to video transmissions for amateur television.

Long delay echoes

The renewed interest in long delay ("cosmic") echoes reported in August in this section has already resulted in the total of useful reports of amateur experiences of this strange phenomenon rising to almost 50. Professor Mike Villard (W6QYT), of Stanford University, is convinced that this is a phenomenon "the origin of which is crying out to be understood". The reports now range in frequency from 810 kHz up to and including 50 and 144 MHz, two frequency bands not normally associated with ionospheric propagation. The period of the echoes ranges from ½-second to two reports of "super-long" delays of 5 minutes. The reports are now spaced in latitude from Canada to Peru; in longitude from Libya to the Marshall Islands; in time from 1932 to this summer. Preliminary analysis of the reports suggests that there are two main categories of echoes, one of which may be explainable in terms of retardation at the ionospheric critical frequency. The other category tends to occur at the time of opening or closing of transmission at a given frequency, when conditions are good for long distance propagation, often in times of low magnetic activity. Professor Villard (Stanford Electronics Laboratories, Radioscience Laboratory, Stanford, California) would welcome further reports from British Commonwealth amateurs.

The Young idea?

Recently a Cardiff youngster, Robert Ellis, passed his Radio Amateurs' Examination and morse test at the age of 13½ years, and thus qualified to receive his own licence at the minimum age of 14 years. (For many years, minimum British age for a full licence was 16—as your contributor who acquired an artificial aerial licence, 2BUH, at 14 and G3VA at 16 well recalls.) An F.C.C. survey of new amateur licensees in the United States has shown that over the past 20 years there have been substantial shifts to both older and younger ages for obtaining a first licence. Although the median age of newcomers is now 24.0, compared to 25.9 in 1949, 36% of them are in the age group 16 and below, compared with only 8.5% in 1949. More than half of the newcomers were found to have been introduced to amateur radio through a relative or friend who already held a licence.

During a recent 14 MHz c.w. contest, which involved an exchange of "age" in place of the usual check serial number, the majority of operators were in the late twenties and early thirties, though an overall spread of from 17 to 60 was noted during a short period of participation.

The latest (1970) issue of the R.S.G.B. Amateur Radio Call Book includes at least a few amateurs who are known to have held the original "three letter" call signs issued before the First World War; pre-1939 call signs represent about 13% of the current licences.

Royal Signals Society

The Royal Signals Amateur Radio Society—with a current membership of over 600 present and former members of the Royal Signals and the R.S. Territorial and Army Volunteer Reserve—is aiming to increase its membership to over 1000 by the end of 1970, which is the jubilee year of the Corps.

The Society, with members in many parts of the world, operates a headquarters station (G4RS and GB3RCS) at Blandford Camp, Dorset; produces a quarterly journal *Mercury*; operates a number of "nets" on several amateur bands and issues a number of awards. It also operates a QSL Bureau and acts as forum for and link between many wartime members of the Royal Signals, including the many amateurs who served in the various Special Communications Units, as well as those with much more recent experience in Army radio communications. General Secretary is: W.O.1 (F. of S.) J. Cooper (G3DPS), 15 Valley Road, Blandford Camp, Blandford Forum, Dorset.

In Brief: Overall winners of the 1969 V.H.F. National Field Day were the Mid-Essex VHF-UHF Contest Group, with the Pennine V.H.F. Group as runners-up. . . . Preparation of the Australis-Oscar V amateur satellite continues with the electronic package undergoing radio-frequency-interference, telemetry sensor calibration, vibration and thermal tests. Amsat (Radio Amateur Satellite Corporation) is seeking launch facilities for this further amateur communications satellite from the U.S. government. . . . Thailand recently withdrew its objections to amateur communication between licensed Thai stations and those in other countries. . . . French amateurs have been instrumental in securing a law which forbids proprietors of apartment buildings opposing the installation of amateur aerials. . . . The Derby society has reported its highest ever membership—654 on the nominal role, with a fully paid-up membership of 221 of whom 107 hold transmitting licences. . . . The Clifton Amateur Radio Society with a clubroom open every Wednesday and Friday at 225 New Cross Road, London S.E.14, has been planning new activities to encourage wider membership (details from R. A. Hinton, 58 Camilla Road, S.E.16). . . . A revised "band plan" for the 70, 144, 432 and 1296 MHz bands, as agreed at the 1969 I.A.R.U. Region 1 meeting at Brussels, comes into force (voluntarily) on 1st January, 1970. . . . 144 MHz contacts have been effected by means of meteor scatter between Bulgaria (LZ1BW) and Holland and Luxembourg; a French amateur, F9FT, in Rheims has contacted SV1AB of Athens on s.s.b. also by means of meteor scatter.

PAT HAWKER, G3VA

Test Your Knowledge

*Series devised by L. Ibbotson**,

B.Sc., A.Inst.P., M.I.E.E., M.I.E.R.E.

19. Electronics Fundamentals

1. When a particular bipolar-transistor amplifier is used to amplify a sinusoidal signal the collector current flows for approximately $\frac{3}{4}$ of the input signal cycle. The mode of operation of the amplifier is:
(a) class A
(b) class B
(c) class AB
(d) class C.

2. Select, from the types of amplifier circuits described below, one in which voltage phase inversion occurs:
(a) triode—common grid
(b) pentode—cathode follower
(c) bipolar transistor—common collector
(d) field-effect transistor—common source.

3. The upper "3dB point" of one stage of a multistage aperiodic amplifier occurs at the frequency at which:
(a) the reactance of the coupling capacitor is equal to the input resistance of the next stage
(b) the susceptance of the coupling capacitor is equal to the total shunt conductance (formed by the output conductance of the stage combined with the input conductance of the next)
(c) The total shunt capacitance (the combination of the output capacitance, the stray capacitance between the stages and the input capacitance of the next stage) has a reactance equal to the input resistance of the next stage
(d) the susceptance of the total shunt capacitance is equal to the total shunt conductance.

4. Considering pentodes, bipolar transistors, junction f.e.ts and m.o.s.ts, the "Miller effect" (by which the input capacitance of an amplifying device is many times larger when it is in operation than the "cold" value) is normally significant in voltage amplifiers using:
(a) any of the four
(b) bipolar transistors only
(c) bipolar transistors or junction f.e.ts but not pentodes or m.o.s.ts
(d) all except pentodes.

5. The advantage of coupled tuned circuits for linking r.f. amplifiers in cascade, compared to any other form of coupling is:
(a) the amplifying-device gain is greatest
(b) the gain frequency characteristic is nearest to the ideal
(c) unwanted feedback is reduced
(d) the transformer coupling the circuits gives extra amplification.

6. The power delivered to its load by a normal power amplifier is supplied
(a) entirely by the d.c. supply
(b) entirely by the input signal
(c) partly by the d.c. supply and partly by the input signal
(d) by the active device (valve or transistor).

7. A low-frequency power amplifier (using a pentode or transistor, with a fixed supply potential and transformer-coupled load) will, in all cases, deliver its maximum undistorted output power to a load which has a transformed value presented to the device:
(a) equal to the device output resistance
(b) equal to twice the device output resistance
(c) equal to half the device output resistance
(d) unrelated to the device output resistance

8. The use of push-pull configuration in a power amplifier has a number of advantages when compared to the use of a single-ended configuration (using in each case devices of appropriate power dissipation; the supply voltage, class of operation and power output being the same). Select from below the quoted advantage which does not apply:
(a) non-linear distortion in the output may be reduced
(b) an unbalanced input to the stage can be used
(c) the output transformer is used more efficiently
(d) the effect of variations in the supply potential is reduced.

9. Complementary-symmetry circuits can be constructed using:
(a) any of the normal range of active devices
(b) valves only
(c) bipolar transistors only
(d) bipolar transistors or f.e.ts.

10. A particular amplifying device has a dynamic transfer characteristic (mutual characteristic) of which the slope increases as the output current increases. If it is used in a large-signal amplifier, over a range in which this characteristic can be regarded as parabolic, the harmonic distortion produced will:
(a) be negligible
(b) consist predominantly of even harmonics
(c) consists predominantly of odd harmonics
(d) include equal amounts of even and odd harmonics.

11. The application of negative feedback to an amplifier always results in:
(a) an increase in input impedance
(b) an increase in output impedance
(c) an increase in signal-to-noise ratio at the output
(d) a decrease in the harmonic distortion produced by the amplifier.

12. An emitter-follower circuit is generally used to match a high impedance output to a low impedance load. In addition it imposes on the signal:
(a) a voltage and a current gain
(b) a voltage gain but a current loss
(c) a current gain but a voltage loss
(d) a loss of both current and voltage

13. When an *LC* sinusoidal oscillator is operating in its steady-state condition, the loop gain at the oscillating frequency must be:
(a) unity
(b) minus unity
(c) greater than unity
(d) positive, and less than unity.

14. An active device with an a.c. negative resistance characteristic is connected in shunt with a parallel tuned circuit. Oscillations of finite amplitude will occur provided the maximum value of the magnitude of the negative resistance of the device for the particular bias used is:
(a) zero
(b) greater than the dynamic impedance at resonance of the tuned circuit
(c) equal to the dynamic impedance at resonance of the tuned circuit
(d) less than the dynamic impedance at resonance of the tuned circuit.

15. The open-loop gain of an ideal operational amplifier should be:
(a) zero
(b) unity
(c) 3 dB
(d) infinity.

16. The most common fault in the operation of directly-coupled amplifiers is:
(a) drift
(b) variation in the gain
(c) a tendency to oscillate
(d) excessive noise generation

Answers and comments, page 597

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

Personalities

John M. Groocock, Ph.D., recently appointed director of quality control for the European area by the International Telephone and Telegraph Corporation, has been with Standard Telephones and Cables (an I.T.T. associate) since 1958 where for three years he was concerned with transistor design. In 1961 he was appointed quality assurance manager for Transistor Division and later assumed responsibility for quality and reliability at both the Harlow and Footscray semiconductor manufacturing plants. In his new appointment Dr. Groocock will assume overall responsibility for the quality and reliability of all products leaving I.T.T. factories in the European area, including the UK. Prior to joining S.T.C. he spent seven years with the Ministry of Supply after undertaking research at Imperial College for his Ph.D.

M. H. Easy, director of development at Decca Radar Ltd, has been awarded the annual trophy of the Radar and Electronics Association for his "outstanding contribution to the radar and electronics industry". Mr. Easy joined the Decca Navigator Company from the Royal Air Force in 1945, transferring to Decca Radar Ltd at the company's inception in 1949. As a Squadron Leader during the war Mr. Easy was responsible for the ground stations of the "OBOE" blind-bombing system which was used so successfully by "Pathfinders".

Anthony S. Pudner, M.B.E., F.I.E.E., F.I.E.R.E., engineer-in-chief of the Cable & Wireless Group for the past four years has been appointed a director. Educated at the Imperial Service College, Windsor, Mr. Pudner, who is 52, joined C. & W. in 1934. His overseas service included two years (1950/2) in Korea in charge of the company's field telegraph unit. He recently became a vice-president of the Institution of Electronic and Radio Engineers. Cable & Wireless have also announced the appointment of **Peter A. McCunn** as a director. He is 46 and has been traffic manager for the past four years.

J. C. Akerman, commercial product manager for all semiconductor devices within Mullard's Industrial Electronics Division since 1966 and a director of Associated Semiconductor Manufacturers Ltd, has been appointed head of Mullard's Consumer Electronics Division in succession to **K. O. Rees** who has left the company. **N. Weisbloom** has become commercial product manager for all semiconductor devices in the Industrial Electronics Division. Since 1966 Mr. Weisbloom has held a similar position in the Consumer Electronics Division. The company has also announced the following appointments in the Consumer Electronics Division. **T. Jacobs**, B.Sc., who has been with Mullard since 1953, has become technical commercial manager of the division. Latterly Mr. Jacobs has been manager of the technical services department of the division. **L. B. Johnson**, B.Sc., M.I.E.E., becomes commercial product manager for all semiconductor devices in the division. He joined the company in 1942 and was at one time manager of the quality and reliability laboratory at Mullard, Southampton, and latterly was commercial product manager for i.cs in the Industrial Electronics Division.

Wilfrid John Fry, M.I.E.R.E., has been appointed managing director of the Electronic Instrumentation Group of Bell & Howell Ltd. Mr. Fry, who is 42, joined the company in 1962, having previously spent thirteen years with the Solartron Electronic Group.

P. J. N. Collaro has joined E.M.I. as marketing director for the electronics and industrial operations and is responsible for the direction and development of marketing policy for all the companies and divisions within the organization: S.E. Laboratories (Holdings), Precision Electronic Terminations (E.M.I.), Nickols Automatics (E.M.I.), Ardente, Tape Manufacturing Co., E.M.I. Tape, Feriel Organization, and the six divisions of E.M.I. Electronics. Before joining E.M.I. Mr. Collaro was the marketing director for Leasco and was previously managing director of the European division of K.L.H. Research and Development Corp.

Welwyn Electric of Bedlington, Northumberland, has announced the appointment of **G. R. Latham**, B.Sc., F.I.E.E., as divisional manager of its newly formed Interconnections Division. Mr. Latham has latterly been working for the Plessey Co. where he was employed as engineering manager, microelectronics, at their Swindon factory. Prior to that he was with Ferranti Ltd., for fourteen years. In his new capacity Mr. Latham will be responsible for implementing the agreement recently signed between Welwyn and Sanders Associates Inc. of New Hampshire, U.S.A., under which Welwyn will produce the range of flexible, rigid and multi-layered circuit boards developed by the Flexprint Division of Sanders.

A. L. Dow, B.Sc.(Hons), has joined Coutant Electronics Ltd as a development engineer in the Power Supply Division. Prior to joining Coutant Mr. Dow worked for two years in the Micro-electronics Division of E.M.I. From 1962 to 1967 he undertook a 1-3-1 year sandwich course spending the middle three years at Southampton University studying for his degree in electronic engineering.

Michael G. Shortland, M.Sc.Tech., who is 35, and a graduate of Manchester University where he took first class honours in electrical engineering in 1956 and received his Master's Degree the following year, has been appointed manager of the Control and Automation Division of the Electrical Research Association. In 1963 he joined BISRA (now the Inter Group Laboratories of the British Steel Corporation) from the U.K.A.E.A., Winfrith. At BISRA he first headed the Control Dynamics Section but in 1964 took charge of the newly formed Automatic Control Section. In May 1967 he was additionally appointed chief engineer (automation).

Kenneth O. Rees, who recently resigned his directorship with the Mullard Company (which he joined in 1947), has been appointed director of marketing in the Plessey Components Group. Mr. Rees, who is 46, is currently chairman of the British Radio Valve Manufacturers' Association and is the Association's representative to the Conference of the Electronics Industry.

Jack Hale, B.Sc.(Eng.), M.I.E.E., appointed managing director of Hytron Ltd, of Crowborough, Sussex, served his apprenticeship with B.T.H. from 1948-53 and rejoined B.T.H. as project engineer following his service in the R.N.V.R. From 1959-64 Mr. Hale was with PE Consulting Group Ltd, as a management consultant, before joining Feedback Ltd as production manager. In 1965, he became production director and in 1968, was appointed a director of Feedback Inc., U.S.A. Hytron also announces the appointment of **Arthur Thomas**, M.Inst.M.C., as marketing director. He was for some time with Muirhead & Co. Ltd, as sales engineer and then spent six years as sales manager of Muirhead Inc., in Canada and the U.S.A. In 1967 he became the European manager of Telautograph Inc. of Los Angeles. **G. P. Gates** has also joined the board as director of development. Mr. Gates was a founder of Hytec Corporation, Los Angeles, consulting engineers and manufacturers of control equipment. He remains a director of Hytec Corporation, although he has moved to England to supervise the development of Hytron's new range of handwriting transmission systems and computer peripherals.

R. M. A. Jones has been appointed to the central management of Pye of Cambridge Ltd, as director of planning and administration. He joined Pye in 1933 and became managing director of Pye Group (Radio & Television) Ltd and chief executive of the Consumer Products Division in 1966. Throughout the war he served in the Royal Corps of Signals and was at the time of demobilization Lt.Col. on the staff of the Chief Signals Officer of the 1st Corps. Mr. Jones is also appointed chairman of Pye Group (Radio & Television) Ltd, thus retaining his link with this activity. In succession to Mr. Jones, **J. T. Griffiths**, joint managing director of TV Manufacturing Ltd, has been appointed managing director of Pye Group (Radio & Television) Ltd and chief executive of the Consumer Products Division.

K. P. Kenny is appointed marketing manager of the Marine Division of Dymar Electronics Ltd, of Watford. After service at sea and ashore for a major shipping line Mr. Kenny has spent five years with Cossor Electronics Ltd.

Obituary

Raymond Dorrington Bangay, who retired from the Marconi Company in 1957 after over 54 years' service with the company died on October 29th. Born in 1883, he joined Marconi in 1902 and later that year went to America to help with the installation of radio stations. On his return to England in 1907, he started his study on the military uses of wireless, which included the first experiments in air-to-ground communications. From 1921 to 1925 he was chief of designs. Subsequently, he changed his orientation from design to exporting and from 1935 until his retirement was foreign manager.

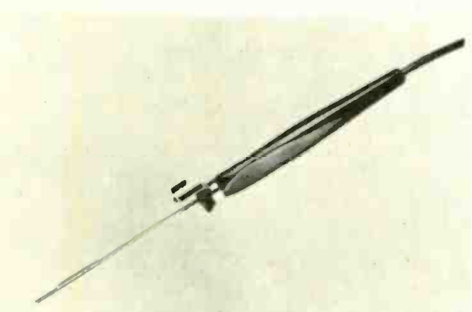
New Products

Sub-miniature Power Supplies

A Belclere sub-miniature encapsulated stabilized power supply is now available from Electronic Component Services (Worcester) Ltd. The new hermetically sealed unit is designed for printed-circuit mounting and has a low ripple voltage. There are four types available, with a maximum ripple voltage of 500μ V. r.m.s.—P.S. 2009 (output 9V at 40mA), P.S. 2012 (output 12V at 30mA), P.S. 2015 (output 15V at 20mA) and P.S. 2020 (output 20V at 15mA). Overload point is at 5mA above rated output. Voltage drop at rated load is less than 150mV. Output voltages are $\pm 5\%$. Dimensions of the supplies are 60mm long by 37mm wide by 25mm high. Typical prices are: 1–9 at £3 5s each or, quantities from 50–99 at £2 9s 6d each. Non-standard types of these power supplies can be made to order. Electronic Component Services (Worcester) Ltd, 63-66 Foregate Street, Worcester.
WW309 for further details

Lightweight Soldering Iron

A low-voltage lightweight soldering iron, the Tip-Touch is available from Midland Electronics. This 6W iron requires 6V a.c. or d.c. and maximum bit temperature is 320°C. Three sizes



of interchangeable bits are available with diameters of $\frac{1}{16}$, $\frac{3}{32}$, and $\frac{5}{32}$in. The shaft is stainless steel. Lead length is five feet. Midland Electronics Ltd, Cogenhoe, Northampton.
WW317 for further details

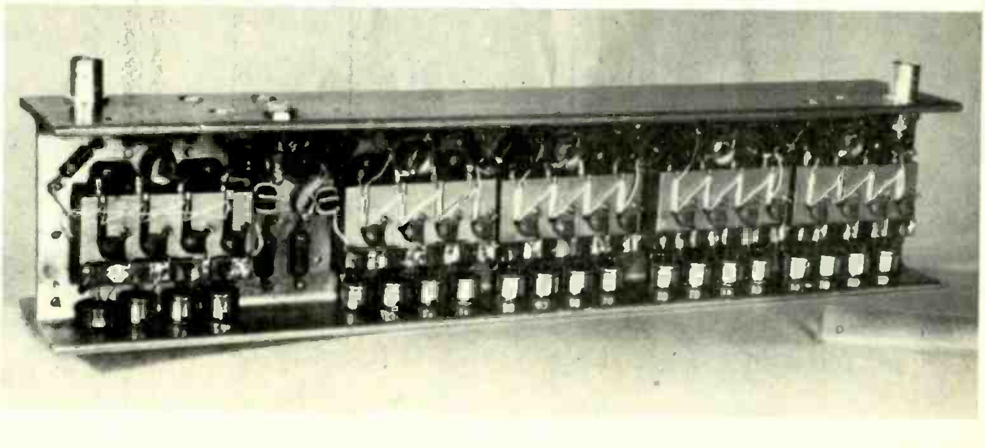
Portable A.F. Power Meter

A portable battery operated a.f. power meter, type 85, has been designed by Dymar Electronics to provide a wide power measuring range, wide frequency response and high accuracy both of the terminating impedance and measured power. Twelve power ranges in 1, 3, 10 sequence give full-scale readings from 100μ to W 30W and an

auxiliary dB scale allows direct readings in dBm (0dBm—1mW) from −20dBm to +45dBm. A feature of the instrument is a temperature compensated "square law" detector which gives true power reading irrespective of waveform. There is a choice of 30 input impedances arranged in three decades from 1.25Ω to 1,000Ω each one being accurate to 2% and capable of dissipating 50 watts. The frequency range is 30Hz—30kHz; accuracy is 3% between 100Hz and 10kHz. The integral power supply is monitored by a press-button switch on the front panel. The batteries are two PP1 power packs which give a typical operating time of 800 hours. The U.K. price, including batteries, is £125. Dymar Electronics Ltd, Colonial Way, Radlett Road, Watford, Herts.
WW301 for further details

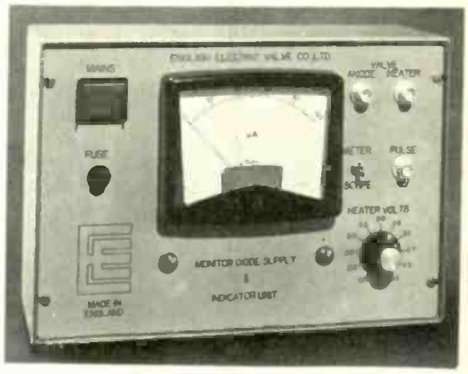
100-watt Broadband Linear Amplifier

A modular solid-state 100-watt broadband linear amplifier which operates in the 2-32MHz range and weighs only 1kg has been developed by E.M.I. Electronics Canada Ltd. Units can be used singly or combined in parallel for power outputs of from 100 watts up to many kilowatts. Power required is −24V d.c. 11A. Each unit is compatible with the h.f. transmitter used with the "Manpack" system, as well as with transmitters used in mobile, airborne and fixed ground stations. The complete amplifier is contained in a single module measuring approx. 300 × 60 × 50 mm. Receptacles for power and r.f. input and output are located on the face of the module. The rear panel is used to dissipate heat, and various methods of heat dissipation may be used. These include water or air cooling for large systems and pannel or plate mounting for Smaller systems. E.M.I. Electronics Canada Ltd, P.O. Box 1005, Dartmouth N.S., Canada.
WW319 for further details



Monitor Diode Supply

For monitoring the r.f. output of radar transmitters operating in the 1—12MHz band the English Electric Valve Co. has produced the type BS600 monitor diode supply and indicator unit. Provision is made for monitoring either by a built-in meter which gives a reading proportional to the mean r.f. power input to the diode, or by feeding the demodulated r.f. pulse envelope to an external oscilloscope, in order to read the peak power accurately. Supplies for the diode anode and heater are taken from sockets on the front



panel of the instrument. A heater-voltage control, also on the front panel, provides for adjustment of the diode heater-voltage for all conditions of r.f. input. The correct diode load-resistance is built into the unit. English Electric Valve Co. Ltd, Chelmsford, Essex.
WW302 for further details

Circuit Board Faultfinder

A low-cost unit for production-line testing of circuit boards and many types of electrical and electronic sub-assemblies, and known as Testmatic TM60, is being produced by Wayne Kerr. It makes up to 59 measurements in 4 seconds and gives unskilled operators a clear indication of 'O.K.', 'High' or 'Low' together with the location of any defective test point. Programming is quick and easy, the board for this serving also as the test jig. All checks can be pre-set for acceptance within any limits from $\pm 1\%$ to $\pm 50\%$. The basis of the

tests is d.c. voltage checks and any subsidiary signals, circuits or supplies can be fed into the TM60 at the rear of the unit or embodied in the programme board.

Intermittent faults can be detected by switching the instrument to a continuous repetition of the test programme, with an audible warning device operating when the defect arises. Outputs are provided for operating external alarms, sorting or counting mechanisms. Price is £695. Wayne Kerr Co. Ltd, New Malden, Surrey.
WW318 for further details

Wet Tantalum Capacitors

A range of wet tantalum capacitors is available from General Instrument (UK). The capacitors have low leakage current, long life and small physical size. Capacitance values range from 1.7 to 560.0μ F and working voltages from 6 to 125V. The operating temperature range is −55°C to +85°C at the full-rated voltage or +125°C at 65% of nominal voltage. Surge voltage can be 115% of rated voltage. The capacitors will withstand at least 2,000 hours' operation at the rated temperature and d.c. voltage and meet MIL-C-3965/D and 4F, DEF 5134-A5, AEC and SEN specifications. Three different cylindrical case sizes are used throughout the range of electrical specifications. General Instrument (U.K.) Ltd, Industrial Components Division, Stonefield Way, Victoria Road, South Ruislip, Middx.
WW307 for further details

V.L.F. Frequency Analyser

Aim Electronics have announced a third-octave frequency analyser (TOF 260A) with a frequency range extending from 0.5Hz up to 100kHz and covering any eight octaves in this frequency range. The octaves covered are pre-set to customer requirements. The unit consists of twenty-four filters, each covering one-third of an octave, designed in accordance with B.S.2475:1964 (which recommends centre frequencies and equivalent bandwidths of the filter elements). Each filter may be attenuated by 0-100% by adjustment of a ten-turn calibrated potentiometer. The outputs from all the filters may be selected by adjustment of the attenuators. Typical applications include extraction of third-octave information from unknown waveforms and simulating the characteristic noise

of any low-frequency excitation (e.g. vibrations) by selective filtering of white noise. Price: £600. Aim Electronics, Bar Hill, Cambridge.
WW316 for further details

Variable Temperature Soldering Iron

The W-TCP-2 variable-temperature soldering pencil from Weller Electric, is a small lightweight 20-watt iron that can be run at any temperature range from 200°F (93°C) to 450°F (233°C). The required temperature is selected on a control unit

which gives a 24-volt feed into the iron from a 230-volt mains input. Price, including the continuously-variable temperature-controlled soldering pencil, the control unit and one tip is £23. Extra tips are 8s each. Weller Electric Ltd, Redkiln Way, Horsham, Sussex.
WW306 for further details

Plastic Encapsulated A.F. Transistors

Two pairs of plastic encapsulated silicon transistors for use in 20W and 35W complementary audio amplifiers have been introduced by Motorola. The four transistors are encased in a compact Thermopad package (Motorola case 90) for easy mounting and efficient heat transfer. The n-p-n MJE205 and p-n-p MJE105 are 5A transistors for use in complementary audio amplifiers delivering up to 20W. They have a V_{ceo} of 50V, power dissipation of 65W and high current gain of 25 to 100 at a collector current of 2A. The n-p-n MJE2801 and p-n-p MJE2901 are 10A devices for use in complementary audio amplifiers with outputs of up to 35W. They have a V_{ceo} of 60V, P_d of 90W and high current gain of 25 to 100 at a collector current of 3A. Application notes AN433 and AN427 are available, describing respectively a 20W and a 35W amplifier using these transistors. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx.
WW335 for further details

Plug-to-Jack "T" Adaptor

The r.f. components division of Sealectro have introduced a new 75 Ω sub-miniature "T" adaptor. Designated Conhex 50-185-0019 it is designed for screw-on mating engagement and will permit two cable-mounted plugs to be connected

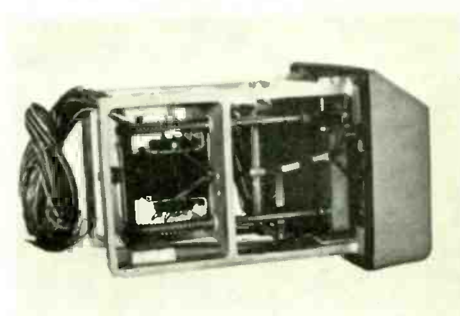
in series—the third leg accommodating a cable mounted jack. This third leg employs a knurled coupling nut in place of the usual hexagonal arrangement and allows repeated disconnections. The adaptor has a gold plated body and contacts, and Teflon insulators. Sealectro Ltd, Farlington, Portsmouth, Hants.
WW303 for further details

Encapsulated Power Supplies

Philbrick/Nexus Research offers two encapsulated power supplies with 0.01% regulation for either 115V a.c. or 230V a.c. power lines. Model 2203 has a ±15V ±100mA output, the 2204 a ±15V ±50mA output. These power supplies have 0.005% load regulation and less than ±40 p.p.m/°C temperature coefficient. The unit is short-circuit protected and has automatic overload tracking. The units are capable of output trimming (optional) to ±15.00 V or without trimming the units will put out ±15V ±0.03V. Model 2203 costs £30 (1–9) and model 2204 £23 (1–9). Philbrick/Nexus Research, 81a North Street, Chichester, Sussex.
WW308 for further details

Card Programmed Switching Matrix

The Sealectro SCR1010 is a multiple switching device which can be programmed in seconds by the insertion of a pre-punched plastic card. The device contains 100 individually operated single-pole switches which, prior to insertion of a card are at an open setting. Any number of cards may be

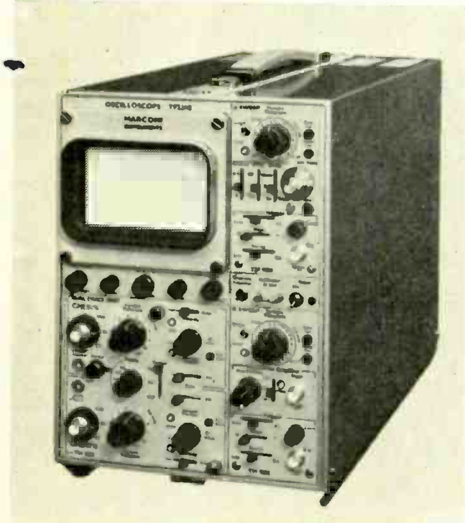


programmed by pre-punching with up to 100 holes, corresponding to the switch positions, and stored ready for use. When a particular programme is chosen, the appropriate card is inserted in a slot in the switching device which then automatically senses the card and closes the switches corresponding to the punched holes. Interlocks prevent operation from an incorrectly punched or misorientated card

The switches are rated at 250mA 50V d.c., and the complete unit has a guaranteed life in excess of 1,000,000 operations. Programming Division, Sealectro Ltd, Walton Road, Farlington, Portsmouth, Hants. PO6 1TB.
WW327 for further details

Wideband Oscilloscope

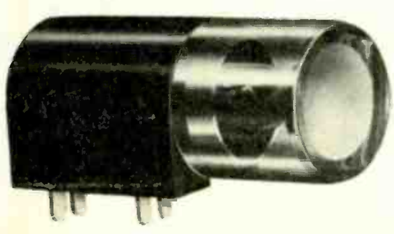
Features of the Marconi TF 2210 wideband oscilloscope include dual timebase, delayed sweep facility, dual trace with internal triggering from either of two identical Y channels and sensitivity of 50mV/cm from d.c. to 100MHz. In conjunction with the two identical timebase generators, the delayed



sweep facility can be used for detailed examination of virtually any part of any waveform. The same waveform can be displayed for examination on a fast delayed sweep or a slow delaying sweep or examined simultaneously in both fast and slow sweep forms on separate traces. By means of a dual trigger delay, a controlled double image can be displayed for comparison of one part of a waveform with another. With long delay times, jitter can be obviated completely by use of gated delay. Combination of the dual timebase facility with the dual trace Y input system allows two different waveforms to be viewed at two sweep speeds. The result is a highly informative display comprising four separate traces. Marconi Instruments Ltd, St. Albans, Hertfordshire.
WW325 for further details

Signal Lamp

Designed for mounting directly onto a printed circuit assembly, a recently introduced Bulgin signal lamp has four mounting pins on 0.1 × 0.3in (2.54 × 7.6mm) centres and thus fits proprietary boards having a 0.1 in standard matrix. The



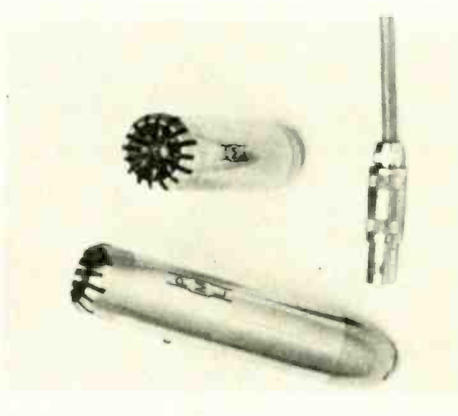
lamp body has a maximum working rating of 30V at 0.5A and accepts two different lens types—domed end or flat end (as shown in accompanying illustration). Both types of lens are a push fit on the body and are available in a choice of five transparent colours, red, amber, green, blue and water clear, and five translucent colours, red, orange, green, blue and white. The lamps have order numbers D965 (transparent) and D966 (translucent) for flat lens, D967 (transparent) and D968 (translucent) for domed lens. A. F. Bulgin & Co. Ltd, Bye-Pass Road, Barking, Essex.
WW330 for further details

Miniature V.H.F. Paging Receiver

Weight, including rechargeable cells, of the crystal-controlled Type CO.442 Tele-Tracer v.h.f. pocket receiver is just over 100g ($3\frac{1}{4}$ ounces). Four different paging facilities can be supplied: tone only; tone and light; light only; tone and speech. A prefocused lamp of special design enables the light signal to be seen in daylight. Three types of power supply are available: a rechargeable cell which is automatically recharged when the receiver is placed in a charging rack; a throw-away mercury battery; a slide-in rechargeable battery cassette which can be recharged whilst detached from the receiver. The receiver conforms with the new G.P.O. regulations for v.h.f. pocket paging systems which come into force in January 1970, and is made by Cass Electronics Ltd, White Hart Yard, Guildford Street, Chertsey, Surrey.
WW328 for further details

Miniature Condenser Microphone

A miniature microphone manufactured in Sweden by the Pearl Microphone Laboratory weighs 40g, is only 75mm long × 18mm diameter and incorporates an f.e.t. amplifier. A supply of 0.5 to 0.8mA at 67.5V is required but because of the wiring



arrangements used only a 2-core flexible cable is required. Frequency response is from 30Hz to 20kHz, dynamic range is 126dB and sensitivity, at 1dyne/cm^2 100mN/m^2 is −50dB. The case and cartridge are designed so that noise is not produced by the microphone rubbing against clothing. This microphone is available with an omni-directional response pattern (Type DC-20) or a cardioid pattern (Type DC-21). Both types are supplied with a 20ft cable and a stand adaptor. Jagor Interelectric Ltd, Mercury House, Hanger Green, Ealing, London W.5.
WW326 for further details

Resistivity Bridge

The battery operated Radley MkIII resistivity bridge is designed to measure the resistivity of semiconductor materials in the range 10^{-2} to 10^{4} ohm-cm. Integrated circuit operational amplifiers are used with a pulse counting phase discriminator for accurate null detection. The null indicator—a centre zero microammeter—is

driven by the phase discriminator operating in a digital mode so that directional proximity of the null is also indicated. Bridge accuracy of ±1% is claimed. A simple four-in-line configuration is used in the probe system for which low cost replaceable contacts are available. Soil resistivity may also be measured by changing the probe head for an array of earth spikes. The bridge costs £245. J. A. Radley (Laboratories) Ltd, 220 Elgar Road, Reading, Berks.
WW331 for further details

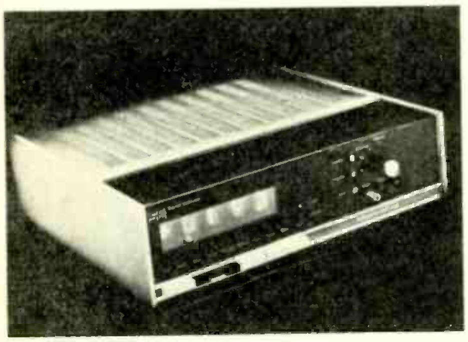
100-W Audio Amplifier

A feature of the Centurion audio amplifier is that its power output of 100W r.m.s. across 4Ω may be open- or short-circuited without adverse effect. Four input channels are provided, each with an individual volume control and suit a wide range of signal source levels from 1mV to 20V. The input channels are electronically mixed by separate circuits, and the final output may be adjusted with treble, bass and master

volume controls. Overall frequency response is 20Hz to 20kHz ± 1dB. Signal-noise ratio is less than 70dB and harmonic distortion at 1W and 100W is less than 0.1% and 1%, respectively. The Centurion is listed at £99 and is available from Adastra Electronics Ltd, 167 Finchley Road, Swiss Cottage, London N.W.3.
WW324 for further details

Digital Voltmeter

The SM212 digital voltmeter has a full scale indication of ±9999 and measures up to 1kV in five steps: 100mV, 1V, 10,V 100V and 1kV. Resolution is 10μV at the 100mV step. The first three steps up to 10V are direct reading and the input impedance is more than 1000MΩ. The input voltage at the other two steps is attenuated and input



impedance is 10MΩ ±0.1%. Accuracy on the direct steps is ±0.01% ±1 digit, and on the attenuated steps it is ±0.015% ±1 digit. Digitization time is 30ms and the display consists of four in-line side view numerical indicator tubes with integral decimal points, and one side view polarity indicator. The SM212 which has a common mode rejection of more than 140dB is available from SE Laboratories (Engineering) Ltd, North Feltham Trading Estate, Feltham, Middlesex.
WW323 for further details

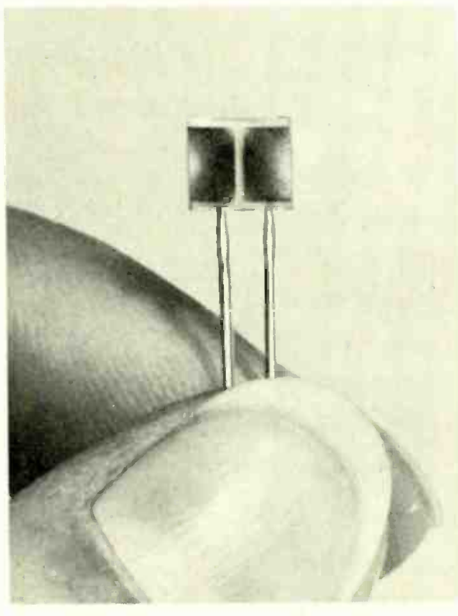
Storage Cathode-ray Tube

The Type E714B direct view storage c.r.t. introduced by E.E.V. is intended for use in oscilloscopes, and incorporates the electrostatic method for flood-gun and writing-gun focus and for deflection. The tube has a robust storage layer and uses an aluminized P31 screen. In the storage mode, typical light output is 175 ft-lamberts. Variable persistence gives a choice of storage time from several minutes to less than one second. With the flood gun switched off and provided no further writing is applied, storage time extends to several days. The

tube has a writing speed in the storage mode of 0.5cm/μs, a deflection sensitivity of approximately 12V/cm in both axes, at a writing beam voltage of 1.5kV, a typical line width of 0.4mm in the c.r.t. mode. The English Electric Valve Co. Ltd, Chelmsford, Essex.
WW329 for further details

A.C. Microvoltmeter

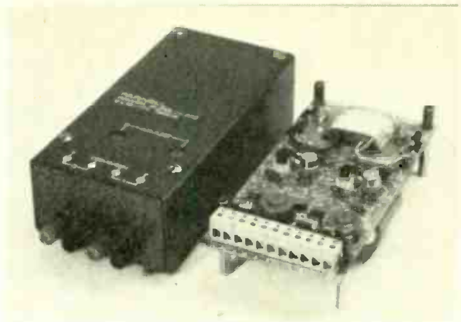
The Comark a.c. microvoltmeter type 1251 has a maximum sensitivity of 30μV f.s.d. with a resolution of 0.30μV per scale division on a scale length of 120mm with d.c. output. The instrument has 12 fixed calibration ranges covering 100μV f.s.d. to 30V f.s.d. Sensitivity is continously variable up to a maximum of × 3 on all ranges. The variable sensitivity control does not affect the calibration of the instrument on fixed ranges. The input impedance is greater than 5MΩ in parallel with 20pF on the most sensitive ranges, increasing to 10mΩ in parallel with 20pF on the less sensitive ranges. Response is flat from 10Hz to 20kHz on 100μV range, 10Hz to 50kHz on 300μV range, and 3Hz to 200kHz on the remaining ranges with −3dB points at 50, 200 and 500kHz respectively. Accuracy is given as ±3% of f.s.d. and the instrument, which measures average value, is calibrated to indicate the r.m.s. value of sine waves. A d.c. output, proportional to meter reading, of 1V for f.s.d. at 2mA is provided, permitting the instrument to be used as an a.c./d.c. converter for digital voltmeters, etc. Comark also produces a similar a.c. millivoltmeter type 1241 but this has no



variable sensitivity. It covers the range from 1mV f.s.d. to 300V f.s.d. in 12 ranges with a flat response from 3Hz to 200kHz (−3dB 1Hz to 500kHz). The normal response time is less than 0.1s extending to approximately 2s for low-frequency measurement. Both instruments are battery powered. Comark Electronics Ltd, Brookside Avenue, Rustington, Littlehampton, Sussex.
WW304 for further details

Op. Amp. Power Supply

Farnell's A15 power supply has two nominal outputs arranged to provide 15V–0–15V at 100mA. Each output can be varied over the range 12V to 17V. Alternatively, the outputs may be connected in series to obtain



24V to 34V. Two separate controls are provided and effect both ganged adjustment and independent variation of one output. Stability during zero to full load variation and ±10% mains change is better than 2mV. Ripple and noise content is less than 1mV p-p. Protection is afforded by means of cut-back and current limiting circuitry and mains fuse. The unit may be purchased as a printed circuit card at a price of £18 or as a modular sub unit with cover, mains lead and terminals for £20. Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorkshire.
WW322 for further details

Plastic S.C.Rs

Transiiron Electronic Ltd has introduced a range of low-cost silicon planar s.c.rs in a particularly rugged TO-92 plastic package. These devices are ideally suited to lamp and solenoid driving, sensing and timing applications and for motor control and other industrial and consumer switching problems. Designated 2N5060–64, there are 30V, 60V, 100V, 150V and 200V types with peak pulse currents up to 40A and extended blocking voltage capability up to 300V. Other versions with tightened or relaxed specifications for gate-trigger current are also available. Moisture resistance is to Military Standard 202C (Method 106B) and the packages are tested for thermal and mechanical stress, including constant acceleration to 40,000g on each axis for 32 hours, vibration shock and simulated fall, and corrosion resistance. Transitron Electronic Ltd, Gardner Road, Maidenhead, Berks.
WW320 for further details

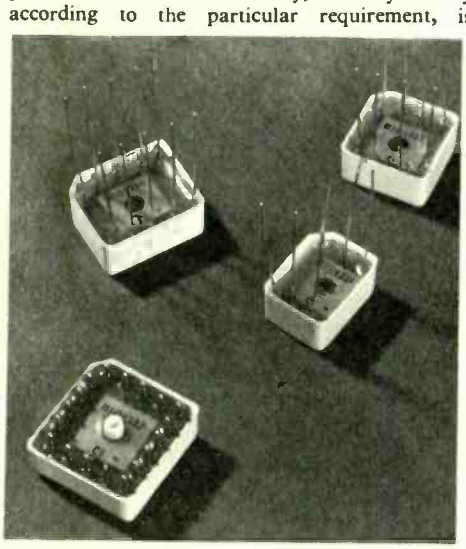
Signal Generator-Synthesizer

The French Adret Codasyn 201 combines the functions of a signal generator (modulation, attenuation and sweep) with the accuracy of a synthesizer (digital frequency selection and coherent spectrum derived from a crystal controlled oscillator) and is intended for use as an exceptionally accurate and stable coherent frequency source over the range 0.1Hz to 2MHz. The instrument incorporates a very stable crystal oscillator in a proportionally controlled oven followed by a phase locked harmonic generator and digital circuits using what is claimed to be a unique frequency synthesis design. Digital dividers provide a spectrally pure output whose frequency stability is $\pm 1 \times 10^{-7}$/day. Higher stability of $\pm 2 \times 10^{-9}$/day is optional. Output frequency is controlled by eight digital dials with resolution to 0.1Hz. In addition, a calibrated search or interpolation oscillator provides smooth

frequency control between all digital steps up to 100kHz. Resolution and stability of this oscillator permit a meaningful setting of 0.001Hz. A separate calibrated variable oscillator covers the band 0.1Hz to 2MHz without range change. High level output voltage is +13dBm ±0.5dB (1V r.m.s.) into 50 Ω for c.w. and f.m. modes, or +7dBm ±0.5dB (0.5V r.m.s.) into 50 Ω for the a.m. mode. Attenuated output is −1dBm ±0.5dB (0.2V r.m.s.) into 50 Ω for c.w. and f.m., or −7dBm ±0.5dB (0.1V r.m.s.) into 50 Ω for a.m. Frequency response is within ±0.5dB over the entire frequency range. The Adret Codasyn 201 is marketed in the U.K. by Racal-Electronics Ltd, Western Road, Bracknell, Berkshire.
WW321 for further details

Ferrite Packages

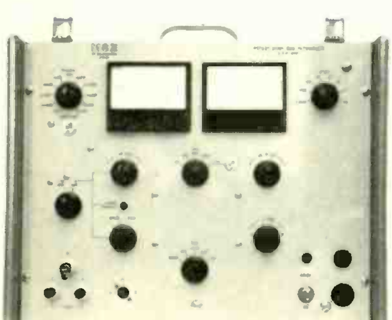
A range of packages for handling and mounting small and awkward shaped pieces of ferrite has been developed by the Industrial and Electronic Components Division of Plessey. The packages—'Maxi Packs'—can be used where circuit-board area and space are not at a premium. The ferrite circuitry, built by Plessey according to the particular requirement, is



encapsulated in a resin block which is finally enclosed in a plastic box. As the electrical contacts to the component are made via either terminal spills or printed-circuit termination pins, all of which are on one face of the box, mounting in either the upright or inverted positions is easy. They are available in ten sizes. Plessey Co. Ltd, Swindon, Wilts.
WW312 for further details

Transistor and Diode Tester

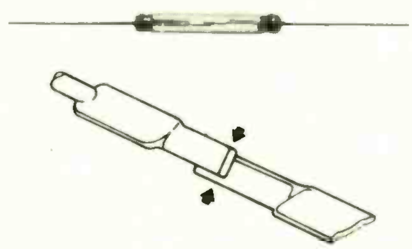
Model RK66 is another tester in the range supplied by K.S.M. Electronics Ltd, and



the instrument has the following specification. *Transistor measurements:* leakage current, 1 nA and above; collector current, 1 nA to 2A f.s.d.; collector voltage, 0-12V; base current, 0-150mA; and h_{fe} (1kHz); 0-1500. *Diode measurements:* forward voltage drop (at 2A) 0-12V d.c.; reverse voltage, 0-1kV d.c. f.s.d.; and reverse current, 10 nA and above. K.S.M. Electronics Ltd, Bradmore Works, Bradmore Green, Brookmans Park, Herts.
WW332 for further details

Novel Reed Switch

A magnetic reed switch manufactured by the Gordos Corporation of the U.S.A., and marketed in the U.K. by B & R Relays, contains blades twisted from their normal planes which open and



close using a sliding or wiping action. This wiping action maintains low contact resistance, and contact bounce is reduced to some 70µs (compared to a standard time of about 1ms) giving increased life. Contact resistance of 100mΩ remains relatively stable throughout the life of the switch which is in the region of more than 10^8 operations. Maximum operating time is 50µs and maximum contact rating is 0.5A at 150V d.c. Two models are available, designated MR 1148 and MR 1348. Both have a nominal coil-power requirement of 50mW and identical specifications. The difference is in diameter of the glass container. MR 1148 is 2.67mm and MR 1348 is 3.2mm. Length is the same at 53mm. B & R Relays Ltd, Temple Fields, Harlow, Essex.
WW310 for further details

V.H.F. Tetrodes

Two new, air-cooled, high-power, ceramic-metal tetrodes (types YL1470 and YL1480) are announced by Mullard. They have a high gain (greater than 300) that enables them to be used with solid-state drive circuits that are simpler than those needed with other high-power output valves. With a drive input of 22W the YL1470 gives an output of 6.6kW at frequencies up to 110MHz; up to the same frequency, the YL1480 requires a drive of 40W to produce an output of 12.5kW. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW305 for further details

Sensitive Cadmium Sulphide Cell

A sub-miniature cadmium sulphide photocell is now available from Mullard. Type RPY58, it is made by a new 'monograin' construction technique that gives the cell high sensitivity and virtual freedom from initial zero drift. Other electrical parameters remain within 40% of their original values during life even when the cell is operated at maximum dissipation. The cell is encapsulated in a transparent plastic. The electrodes are very close together—about

40µm—and have a large area of contact. Hence, the resistance is much less than that of a conventional cadmium sulphide cell, a typical value being 600Ω at 50 lux from a light source with a colour temperature of 2700°C. The RPY58 has a maximum permissible dissipation of 200mW and an ambient temperature operating range extending from −40 to +70°C. It measures approximately 6 × 6 × 2mm without its flexible leads, which are 37mm long and spaced for standard printed-circuit grids. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW311 for further details

Non-polarized Tantalum Capacitors

A range of non-polarized solid tantalum capacitors is announced by General Instrument (UK). Designated NPMCS, the capacitors range from 0.034 to 160 µF and standard tolerances are ±20% and ±10%, but ±5% types are available. Typical capacitance variation with temperature is −4% at −55°C and +85°C referred to 25°C. Full rated operating voltage can be applied throughout the temperature range −55 to +85°C and surge voltage over this range of temperatures can be 130% of rated voltage. These capacitors are basically two (MCS) capacitors connected cathode-to-cathode in a bakelite case. They are particularly suitable for use in circuits where the reverse voltage is too high for polarized types. General Instrument (UK) Ltd, Stonefield Way, Victoria Road, South Ruislip, Middlesex.
WW314 for further details

Power Regulator Module

Emihus Microcomponents have introduced a d.c. power regulator module, measuring approx. 60 × 30 × 25 mm, which is adjustable over the range 3.5V to 30V and which will supply a load circuit of 0.6A over this voltage range without any derating. The load current may be extended up to 20A by means of external transistors. Both positive and negative types are available. The regulator is designed to withstand very large variations of input voltage and the stabilization factor is typically 1100:1 at V_{out} = 10V. The operating temperature range is 0 to 100°C and the total power dissipation of the module in standard form is 6W at 40°C. Temperature coefficient is typically 0.02%°C and recovery time 50ms (for a 250mA change in load current recovering to 50mV). Emihus Microcomponents Ltd, Glenrothes, Fife, Scotland.
WW315 for further details

December Meetings

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

LONDON

1st I.E.E.—Discussion on "Wideband techniques and the local telecommunications network of the future" at 17.30 at Savoy Pl., W.C.2.

2nd I.E.R.E.—"The design of active filters" by Dr. A. G. J. Holt at 18.00 at 9 Bedford Sq., W.C.1.

4th I.E.E.—"The commercial exploitation of research and development" by J. C. Duckworth at 17.30 at Savoy Pl., W.C.2.

4th I.E.R.E.—"Computer-based telemetry systems for distribution management" by R. A. F. Smythers at 18.00 at 9 Bedford Sq., W.C.1.

5th I.E.E.—Discussion on "Measurements using c.r.t. displays" at 17.30 at Savoy Pl., W.C.2.

8th I.E.E./I.Meas. Control.—"The Concorde's flying control system" by I. L. Rye at 17.30 at Savoy Pl., W.C.2.

10th I.E.R.E.—"Computer-aided instruction" by Inst. Captain G. Huggett, R.N., at 18.00 at 9 Bedford Sq., W.C.1.

10th B.K.S.T.S.—"The acoustics of the Royal Albert Hall" by K. Shearer at 19.30 at the Colour Film Services, Portman Close, Baker St., W.1.

11th I.E.R.E./I.E.E.—Third lecture on "Physiology for engineers" at 18.00 at St. Bartholomew's Medical College, E.C.1.

11th I.E.R.E.—"Passive satellite communications" by R. L. Harris at 18.00 at 9 Bedford Sq., W.C.1.

11th R.T.S.—"New large-screen television projector" by I. Lake at 19.00 at I.T.A., 70 Brompton Rd., S.W.3.

15th I.E.E.—Discussion on "Gallium arsenide lasers" at 17.30 at Savoy Pl., W.C.2.

16th I.E.R.E./I.E.E.—Discussion on "Non-magnetic digital recording techniques" at 18.00 at 9 Bedford Sq., W.C.1.

17th I.E.E.—Discussion on "Electron-optical design techniques" at 14.30 at Savoy Pl., W.C.2.

17th I.E.R.E.—Discussion on "More engineers in management?" at 18.00 at 9 Bedford Sq., W.C.1.

18th I.E.E.—Discussion on "Radio interference measurements" at 17.30 at Savoy Pl., W.C.2.

BATH

10th I.E.R.E.—"Noise in transistor circuits" by P. J. Baxandall at 19.00 at the Technical College.

BIRMINGHAM

11th I.E.R.E.—"Quasars: the most powerful transmitters in the universe" by Dr. P. J. S. Williams at 19.15 at the University.

BOURNEMOUTH

2nd I.E.E.—"Electromagnetic levitation" by R. B. Owen at 18.30 at the College of Technology.

3rd I.E.E.T.E.—R. Aero. Soc.—"Automatic flight control" by A. J. Colwell at 20.00 at the Anglo Swiss Hotel.

BRISTOL

16th I.E.E.T.E.—"Electrics & electronics in heavy industries" by A. R. S. Gough at 19.30 at Queens Bldg., the University, University Walk.

CAMBRIDGE

9th I.E.E.—"Electromagnetic levitation" by H. Bolton at 19.30 at Cambridgeshire College of Arts and Technology.

11th I.E.E./I.E.R.E.—"Circuit optimization by digital computer" by J. S. Reynolds at 20.00 at Engng. Labs, Trumpington St.

CARDIFF

10th I.E.E./I.E.R.E.—"Electronics in the nation's economy" by I. Maddock at 18.30 at U.W.I.S.T.

12th S.E.R.T.—"High-fidelity and public address" by J. Davies at 19.30 at Llandaff Technical College.

17th R.T.S.—"Loudspeakers—their history and development" by R. L. West at 19.00 at B.B.C. Llandaff.

COVENTRY

4th I.E.E./I.E.E.T.E.—"Satellite communication" by J. M. Brown at 18.30 at Herbert Art Gallery.

EDINBURGH

9th I.E.E./I.E.R.E.—"Project planning and control" by J. Brennan at 18.00 at the Carlton Hotel, North Bridge.

EVESHAM

9th I.E.R.E.—"The Post Office Tower" by S. G. Young at 19.00 at the B.B.C. Club.

GLASGOW

8th I.E.E./I.E.R.E.—"Project planning and control" by J. Brennan at 18.00 at the University of Strathclyde.

19th S.E.R.T.—"Transistors in logical circuits" by G. Roberts at 19.30 at 70 Bothwell St., C.2.

IPSWICH

16th I.E.E.—"Automatic landing of aircraft" by A. W. Jolliffe at 18.30 at Great White Horse Hotel.

LEEDS

2nd I.E.E.—"The management of major electronic projects" by J. W. Sutherland at 18.30 at the University.

9th I.E.E.—"Radar data processing techniques with application to air traffic control" by Dr. P. J. C. Child at 19.00 at the University.

LEICESTER

9th R.T.S.—"Decca Navigator" by R. S. Trevelyan at 19.30 at Vaughan College, St. Nicholas Circle.

LETCHWORTH

1st I.E.E.—"Colour television" by P. L. Mothersole at 15.00 at the College of Technology.

LIVERPOOL

10th I.E.R.E.—"Information theory and code design" by S. B. Wilson at 19.00 at the University.

MANCHESTER

3rd I.E.E.—"Computers and communications" by Prof. R. L. Grimsdale at 18.15 at U.M.I.S.T.

4th S.E.R.T.—"Ferguson colour television receiver" by K. Harris at 19.30 at the Renold Bldg., U.M.I.S.T.

11th I.E.R.E.—"Pulse code modulation" by G. H. Bennett at 19.15 at the Renold Bldg., U.M.I.S.T.

NEWCASTLE-UPON-TYNE

10th I.E.E./I.E.R.E.—"Hybrid integrated circuits" by T. D. Towers at 18.00 at the Polytechnic.

NOTTINGHAM

16th I.E.E.—"Concorde electronics" by H. Hill at 18.30 at the University.

PORTSMOUTH

10th I.E.R.E.—"Stripline circuits in microwave equipments" by J. M. H. Chambers at 19.00 at Highbury Technical College, Cosham.

READING

11th I.E.R.E.—"Solid state displays" by L. H. Lea at 19.30 at the University, Whiteknights Park.

RUGBY

2nd I.E.R.E.—"Application of electronics to aero engine design" by D. R. Foulds at 18.30 at the College of Engineering Technology.

RUGELEY

4th I.E.R.E.—"Loudspeakers" by Dr. A. R. Bailey at 19.00 at Shrewsbury Arms.

SHRIVENHAM

2nd I.E.E./I.E.R.E.—"Impact of micro-electronics for circuit design" by C. S. Den Brinker at 18.15 at R.M.C.S.

SOUTHAMPTON

2nd I.E.E.T.E.—"Engineering education & training for the 1970s" by R. Bray at 19.30 at the British Legion Centre, Cumberland Place.

ST. HELENS

18th S.E.R.T.—"Amateur radio opertion" by E. H. Lewis at 20.00 at the Technical College.

TREFOREST

2nd I.E.E.—"The electronic wattmeter" by P. C. Joslin at 19.00 at Glamorgan College of Technology.

WORCESTER

10th B.C.S./I.Prod.E.—"Computer aided design" by K. Thompson at 19.30 at the Technical College, Deansway.

Late November Meetings

ABERDEEN

26th I.E.E.—"Large scale integration—why, where and when?" by D. D. Jones at 19.30 at Robert Gordon's Inst. of Technology.

BELFAST

25th I.E.R.E.—"Audio frequency hi-fi amplifiers" by I. Hardcastle at 18.30 at the Ashby Inst., Queens University, Stranmillis Rd.

DUNDEE

27th I.E.E.—"Large scale integration—why, where and when?" by D. D. Jones at 19.00 at the University.

DURHAM

26th I.E.E.T.E.—"Modern techniques of air-traffic control" by J. Henderson at 19.30 at the University's Science Labs., South Road.

FAREHAM

27th I.E.E. Grads.—"Brain cell to micro-circuit—pattern recognition" by Dr. I. Aleksander at 19.00 at H.M.S. Collingwood.

INVERNESS

25th I.E.E.—"Large scale integration—why, where and when?" by D. D. Jones at 19.30 at the Technical College.

LEEDS

25th I.E.E.—"Use of satellites in long-distance communication" by H. Stanesby at 18.30 at the University.

NOTTINGHAM

20th R.T.S.—"The design of colour video tape recorders" by W. Silvie at 19.30 at the B.B.C. Studios, Wilson House, Derby Road.

READING

24th I.E.E.—"Hi-fi" by J. Moir at 19.30 at the J. J. Thomson Laboratory, the University, Whiteknights Park.

25th I.E.R.E.—"Automatic test equipment" by O. H. Davie at 19.30 at the J. J. Thomson Laboratory, the University, Whiteknights Park.

SOUTHAMPTON

25th I.E.E.—Faraday Lectur "People, communications and engineering" by J. H. H. Merriman at 10.30 and 14.30 (students) and 18.30 (public) at the Guildhall.

Answers to "Test Your Knowledge"—19

Questions on page 589

1. (*c*)

2. (*d*) Valves, bipolar transistors and f.e.ts are broadly analogous in their use in most basic amplifier circuits. Phase inversion occurs in the device only when the cathode, emitter or source respectively is the common electrode in the circuit.

3. (*d*) At mid-band frequencies in a properly designed amplifier this shunt capacitance has much too small a susceptance to draw significant current. As the frequency is increased the capacitive current increases, the output voltage falls, and additional phase shift is introduced.

4. (*d*) In a pentode the screen grid reduces the control-grid/anode capacitance to such an extent that in normal circuits the Miller effect is insignificant.

5. (*b*) By adjusting the degree of coupling so that "double-humping" just starts to occur the output is almost constant in amplitude over a band of frequencies and drops rapidly outside that band.

6. (*a*) The input may take power, as in the case of a bipolar transistor amplifier, but this power is dissipated in the transistor.

7. (*d*) The optimum load causes the output current and voltage to swing up to the "knee" of the most extreme characteristic which may be reached (this will be determined by limitations which depend on the particular device), and down almost to cut-off. It appears that the maximum power transfer theorem is violated here, but this is not so because the input signal amplitude, and hence the value of the Norton equivalent current generator at the output, is not a fixed parameter.

8. (*b*) The inputs to the two devices must be balanced about the supply common line.

9. (*d*) Complementary symmetry circuits use devices requiring supply potentials of opposite polarities; i.e., n-p-n and p-n-p bipolar transistors; n-channel and p-channel f.e.ts.

10. (*b*)

11. (*d*) The input impedance, the output impedance and the signal-to-noise ratio each may be increased or decreased depending on the details of the circuit.

12. (*c*)

13. (*a*) When the oscillations are building up the loop-gain must be greater than unity, but the output amplitude will stabilize at a value at which non-linearity reduces the gain to unity.

14. (*d*) The power absorbed by a resistor of value R, when the voltage across it is V, si V^2R. If R is negative power is given out by the resistor. So long as the negative shunt resistance is smaller than the positive shunt resistance more power is delivered to the circuit than is absorbed. As oscillations build up non-linearity in the device characteristic reduces the mean a.c. resistance until it is equal in magnitude to the dynamic impedance at resonance of the tuned circuit.

15. (*d*)

16. (*a*)

Literature Received

ACTIVE DEVICES

A TTL series 74N Cross Reference Guide, listing 13 manufacturers' devices in cross reference with National's TTL line, is available from Marketing Services Department, National Semiconductor Corporation, 2975 San Ysidro Way, Santa Clara, California 95051 .... WW401

Farnell Instruments Ltd, Sandbeck Way, Wetherby LS22 4DH, Yorkshire, list their digital logic components with prices, in publication F21 .... WW402

"Gunn effect devices and their applications", an 8-page article originally published in *Mullard Technical Communication*, is now available as a reprint. I.E.D./Valve Sales, Mullard Ltd., Torrington Place, London W.C.1. WW422

HARDWARE

A descriptive sheet is available from Jidenco Ltd, Vale Road, Windsor, Berks, on their reflow solder machine, model J.P.2, suitable for the attachment and removal of flat pack i.cs to and from p.c. boards WW419

INSTRUMENTS

Dana Electronics Ltd, Bilton Way, Dallow Road, Luton, Beds, have produced the following publications:

- Series 7000 Digiphase Synthesizer—very accurate frequencies to 11MHz in 1Hz increments WW403
- Amplifier data sheets 789-791 .... WW404
- Series 2600 data amplifiers WW405
- Digital voltmeters WW406

Type 422 precision v.l.f.-l.f. signal generator, having a frequency range of 0.005Hz-50kHz, frequency accuracy of ± 2 parts in 10^5, and sine, square and triangular wave outputs is described in a leaflet from Airmec Instruments Ltd, High Wycombe, Bucks WW407

Two leaflets have been received from Telequipment Ltd, 313 Chase Road, Southgate, London N.14:

- Oscilloscopes WW408
- S54A Single-beam Solid-state Oscilloscope WW409

An 8-page technical manual on electronic tachometers, which describes their application to flow rate, r.p.m. and linear speed measurement, is available from Dynalco Corporation, 4107 N.E. 6th Avenue, Ft. Lauderdale, Florida 33308, U.S.A. WW410

The Wayne Kerr Co. Ltd, New Malden, Surrey, have published a catalogue of their range of electronic measuring instruments WW411

Tektronix Inc. has published a 40-page catalogue on oscilloscopes and associated instruments which is available from Tektronix U.K. Ltd, Beaverton House, Harpenden, Herts WW412

Two short-form catalogues are available from Bell & Howell Ltd, Lennox Road, Basingstoke, Hants:

- Tape & Graph Recording WW413
- Transducer products WW414

A short catalogue discussing Brüel & Kjaer electronic measuring equipment is available from B&K Laboratories Ltd, Cross Lances Road, Hounslow, Middx WW415

B & K Instruments Ltd, 59 Union Street, London S.E.1, have produced a folder containing details of instruments made by Krohn-hite Corporation, Brush Clevite, Chronetics, Benrus, Jerrold and Radiometer WW416

A short-form catalogue describing their range of electronic measuring instruments is available from Avo Ltd, Avocet House, Dover, Kent WW417

S.E. Laboratories (Engineering) Ltd, North Feltham Trading Estate, Feltham, Middx, have produced a folder of leaflets and catalogues describing their various products WW418

GENERAL INFORMATION

No.38 (August/September 1969) of the house magazine "News from Rohde & Schwarz" is available from Rohde & Schwarz, 8000 Munchen 80, Muhldorfstrasse 15 .... WW420

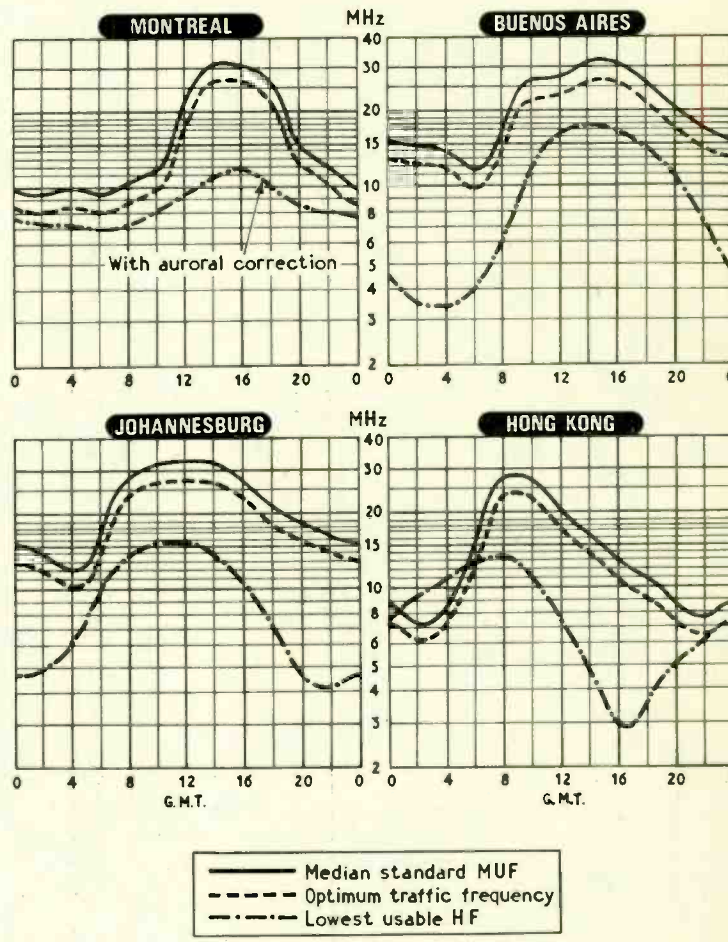
The British Standards Institution, 2 Park Street, London W1Y 4AA, has produced PD64 36: "A guide to the BS9000 scheme", price 12s.

The handbook "Printed Wiring & Printed Circuit Techniques", revised by the Electronic Engineering Association, is available from *Design Electronics*, Dorset House, Stamford Street, London S.E.1. Price 40s, post free.

A 16-page "guidance manual" on how to optimize circuit designs for their most economical production as hybrid i.cs has been produced by Newmarket Transistors Ltd, Exning Road, Newmarket, Suffolk WW421

Those readers looking for an introduction to logic circuits will not go far wrong with "It's the Logic that Counts" which is a book published by Marconi Instruments Ltd, Marketing Services Department, St. Albans, Herts. Costing £2 the book uses the "programmed learning" approach.

H.F. Predictions—December



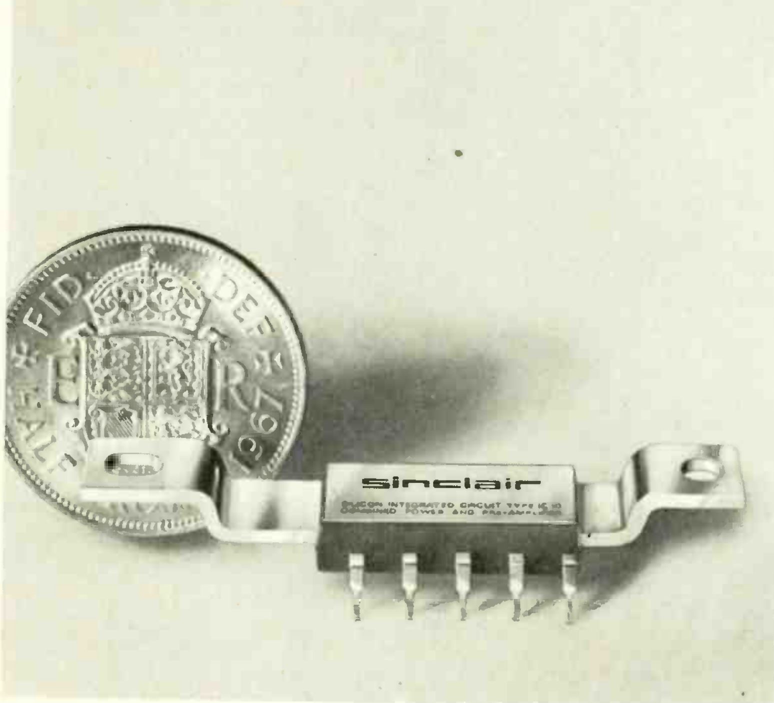
Sunspot numbers for recent months show the expected start of a steady decline in solar activity which will continue until 1975. F2 layer daytime MUFs for routes predominantly in the northern hemisphere are at their peak in December, F1 and E layer MUFs, however, are at their lowest and have little or no effect on circuit operation. Night-time F-layer MUFs on the other hand are also lowest during winter months which, coupled with declining solar activity, seriously reduces the usable spectrum.

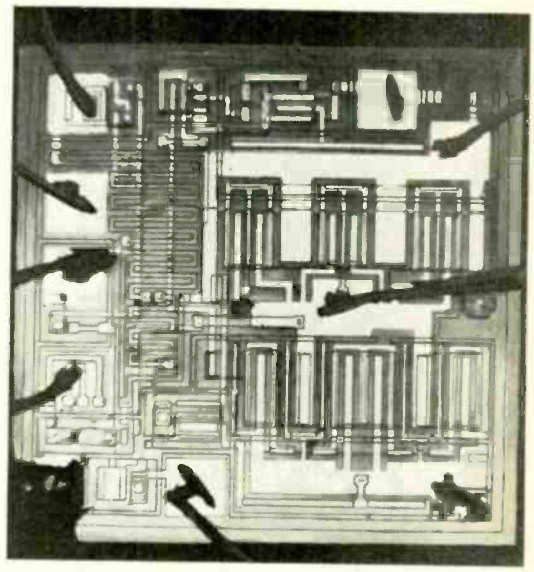
Fade-outs and disturbances should continue as at present, that is relatively frequent but of low intensity.

The northern auroral zone passes through Alaska, Hudson Bay, Iceland and northern Norway; radio paths crossing this zone are subject to periods of high attenuation lasting several days.

SINCLAIR IC-10

MONOLITHIC INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMP





A 13 transistor circuit measuring only one twentieth of an inch square by one hundredth of an inch thick!

the world's most advanced high fidelity amplifier

The Sinclair IC-10 is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself, a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, has 5 watts R.M.S. output (10w. peak). It contains 13 transistors (including two power types), 2 diodes, 1 zenor diode and 18 resistors, formed simultaneously in the silicon by a series of diffusions. The chip is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is not only more rugged and reliable than any previous amplifier, it also has considerable performance advantages. The most important are complete freedom from thermal runaway due to the close thermal coupling between the output transistors and the bias diodes and very low level of distortion.

The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of the usual tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout), etc. Once proven, the circuits can be produced with complete uniformity which enables us to give a 5-year guarantee on each IC-10, knowing that every unit will work as perfectly as the original and do so for a lifetime.

■ SPECIFICATIONS

Output:	10 Watts peak. 5 Watts R.M.S. continuous
Frequency response:	5 Hz to 100 KHz ± 1dB
Total harmonic distortion:	Less than 1% at full output.
Load impedance:	3 to 15 ohms.
Power gain:	110dB (100,000,000,000 times) total.
Supply voltage:	8 to 18 volts.
Size:	1 x 0.4 x 0.2 inches.
Sensitivity:	5mV.
Input impedance:	Adjustable externally up to 2.5 M ohms.

■ CIRCUIT DESCRIPTION

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from cross-over distortion at all supply voltages, making battery operation eminently satisfactory.

■ APPLICATIONS

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

MORE SINCLAIR DESIGNS ON PAGES FOLLOWING

SINCLAIR IC-10 *with IC-10 manual and 5-year guarantee Post free.* **59/6**

sinclair

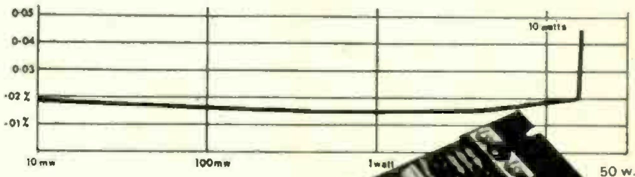
SINCLAIR RADIONICS LTD. 22 NEWMARKET ROAD, CAMBRIDGE
Telephone: 0223 52731

Z-30 TWENTY WATT R.M.S. (40 WATT PEAK) POWER AMPLIFIER

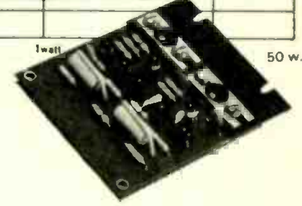
The Z-30 is a complete power amplifier of very advanced design employing 9 silicon epitaxial planar transistors. Total harmonic distortion is incredibly low being only 0.02% at full output and all lower outputs. As far as we know, no other high fidelity amplifier made can match this specification, no matter what the price. Thus you can be utterly certain that your Project 60 system will do full justice to your other equipment however good it may be. The Z-30 is unique in that it will operate perfectly, without adjustment, from any power supply from 8 to 35 volts. It also has sufficient gain to operate directly from a crystal pickup. So in addition to its use in a high fidelity system you can use a Z-30 to advantage in your car or a battery operated gramophone for your children, for example. These, and many other applications of the Z-30, are covered in the Project 60 manual.

APPLICATIONS

High fidelity amplifier; car radio amplifier; record player fed direct from pick-up; intercom; electronic music and instruments; P.A., laboratory work, etc. Full details of these and many other applications are given in the manual supplied with your Z.30.



Power versus distortion curve of Sinclair Z.30.



SPECIFICATIONS

Power output—15 watts R.M.S. (30 watts peak) into 8 ohms using a 35 volt supply; 20 watts R.M.S. (40 watts peak) into 3 ohms using a 30 volt supply.

Output—Class AB.

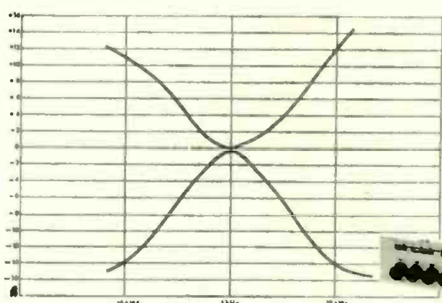
Frequency response:	30 to 300,000 Hz ± 1dB.
Signal to noise ratio:	better than 70dB unweighted.
Distortion:	0.02% total harmonic distortion at full output into 8 ohms and at all lower output levels.
Size:	3½ x 2¼ x ½ inches.
Input sensitivity:	250mV into 100 Kohms.
Damping Factor:	>500.
Loudspeaker impedances	3 to 15 ohms.
Power requirements:	8 to 35 V.d.c.

Z.30

Ready built, tested and guaranteed, with Z.30 manual. **89/6**

STEREO SIXTY PREAMPLIFIER AND CONTROL UNIT

The Stereo 60 is a stereo preamplifier and control unit designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout and great attention has been paid to achieving a really high signal-to-noise ratio and excellent tracking between the two channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs. The tone controls are also very carefully designed and tested.



Treble and bass control curves

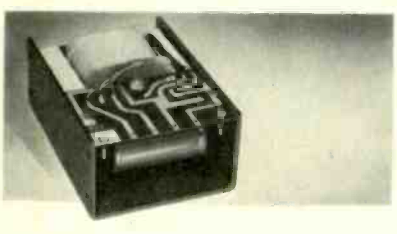
SPECIFICATIONS

- Input sensitivities—Radio—up to 3mV; Magnetic Pickup—3mV Correct within ± 1dB on R.I.A.A. curve. Ceramic Pickup—up to 3mV; Auxiliary—up to 3mV.
- Output—1 volt.
- Signal-to-noise ratio—better than 70dB.
- Channel matching—within 1dB.
- Tone Controls—TREBLE + 15 to − 15dB. at 10 KHz; BASS +15 to −15dB at 100 Hz.
- Power consumption 5mA.
- Power requirement—PZ.5 or PZ.6.
- Finish—brushed aluminium front panel with black knobs.
- Mounting—on cabinet front by spindle bushes and adjustable brackets.

STEREO SIXTY

Ready built, tested and guaranteed **£9.19s.6d.**

SINCLAIR POWER SUPPLY UNITS



PZ-5 30 volts unstabilised—sufficient to drive two Z-30's and a Stereo 60 for the majority of domestic applications.

Price: £4. 19s. 6d.

PZ-6 35 volts stabilised—ideal for driving two Z-30's and a Stereo 60 when very low efficiency speakers are employed.

Price: £7. 10s. 6d.

GUARANTEE

If at any time within 3 months of purchasing Project 60 modules from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter.

SINCLAIR RADIONICS LIMITED
22 NEWMARKET ROAD, CAMBRIDGE
Telephone 0223 52731

sinclair

To: SINCLAIR RADIONICS LTD., 22 NEWMARKET RD., CAMBRIDGE

Please send ....

NAME ....

ADDRESS ....

for which I enclose cash/cheque money order

WW1269

Z AND I AERO SERVICES LTD

ZAERUX BRAND

INTEGRATED CIRCUIT AMPLIFIERS

CA3005 RF Amplifier with 100mc/s bandwidth. Max. dissipation 26mW. For use as RF amplifier, balanced mixer, product detector or self-oscillating mixer. 27/-

CA3012 Wide Band Amplifier (up to 20mc/s), suitable as IF Amplifier for VHF/FM receivers. 22/-

CA3020 General Purpose Audio Amplifier of 550mW output. 30/-

CA3036 Buffer Amplifier consisting of two "super-alpha" pair of transistors suitable for stereo pick-up systems. 19/-
The above four I.C's are in TO5 encapsulation.

PA222 Audio Amplifier providing a max. output of 1.2 watts. 65/-

PA234 Audio Amplifier providing a max. output of 1 watt. 27/6

PA237 2 watts Audio Amplifier. 40/-
The above three I.C's are in epoxy moulded double four-in-line package.

MC1709CG General Purpose operational amplifier in TO-99 case. 40/-

TAA263 3-stage direct coupled amplifier for use from DC to 600kc/s; 70mW dissipation. Output 10mW into 150 Ω load. 15/-

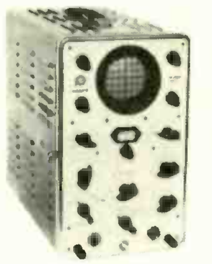
TAA293 3-stage amplifier with connection brought out to the individual leads. Bandwidth 600kc/s. 160mW dissipation. Output 10mW into 150 Ω load. 20/-

TAA320 MOST input stage followed by a bi-polar transistor stage. 200mW dissipation. 13/-

TAD100 All active components required for an A.M. Receiver, comprising mixer, oscillator, i.f. amplifier, a.g.c. and pre-amplifier stages. To build complete receiver only coils, capacitors and resistors are required and output stage for which one of the above described I.C.s can be used. Dual seven-in-line package. 45/-
Data sheet available for all the above I.C.s.

NEW OSCILLOSCOPE FROM RUSSIA

CI-5 SYNCHROSCOPE



Bandwidth 10mc/s. Triggered and free-running time base. Pulses from .1 to 3,000 microseconds can be observed. Max. overshoot of 1 microsec. pulse 5%. Built-in time base calibrator and amplitude calibrator. Sensitivity from .3 to 25 Vrms/mm. Telescopic viewing hood.

NOW AT NEW REDUCED PRICE OF £39
Full servicing facilities available

WESTINGHOUSE EPOXY ENCAPSULATED WIRE ENDED MINIATURE RECTIFIERS

1N5399, 1,000 p.i.v., 1·5 amps D.C.; Max. surge 50A. Diameter ·140in. Overall length (with leads) 2·3in. 4/6.
1N5408, 1,000 p.i.v., 3 amps D.C.; max. surge 200A. Diameter ·210in.; overall length (with leads) 2·875in. 6/3.
25% DISCOUNT FOR QUANTITIES OF 20 OR OVER

SILICON 'LOCKIT' TRANSISTORS

BC147	4/6	BC148	4/6
BF194	7/-	BF195	4/6

SPECIAL INTRODUCTORY OFFER:
12 TRANSISTORS OF ANY OF THE ABOVE TYPES
£2.5.0 POST PAID

SPECIAL OFFER OF PNP GERMANIUM TRANSISTORS

AC154, large signal type, suitable for class 'B' output and oscillator applications. Max. collector-base voltage —26V. Max dissipation 200mW. Audio power output per pair 400mW free air or 1·1W on heat sink. Price, per pair. 6/-
AC169 PNP Bias Stabilizing, Diode-connected, Transistor. Max dissipation 60mW. Max. collector-base voltage —2V. Max collector current 30mA. Price, each 2/-

SILICON MATCHED DIODE PAIRS

1N4951 Two diodes in common TO92 epoxy case. Separate anode leads and joint cathode. Diodes are statically and dynamically balanced. Max. reverse voltage 20V. Max. dissipation 200mW. Suitable for TV horizontal phase discriminators and similar applications. Price 3/- each. Considerable discount for quantities.

MULTIMETERS TYPE 108-IT

4-range precision portable meter. 5,000 o.p.v. D.C. Volt 2.5-10-50-250-500-2500V. A.C. Volts: 10-50-100-250-500-2500 V. D.C. current 0.5-5-50-500 mA. Resistance: 2,000-20,000 ohms-2-20 megohms. Power output calibration for 600 ohms line. £6/5/-. P.P. 7/6. Dimensions: 7½in. × 6in. × 3½in. Weight 3½lb.

TYPE MF16

D.C. Voltage range 0-0.5-10-50-250-500V.
A.C. Voltage range 0-10-50-250-500V.
D.C. current ranges: 500μA-10-100mA.
Resistance ranges: 100M Ω-1M Ω. The meter is also calibrated for capacity and output level measurements. Sensitivity 2000 Ω V. Accuracy ±2.5% for D.C. and ±4% for A.C. measurements. Dimensions: 4½in. × 3½in. × 1½in. Price £4/5/-.

WHEN ORDERING BY POST PLEASE ADD 2/6 IN £ FOR HANDLING AND POSTAGE.
NO C.O.D. ORDERS ACCEPTED
ALL MAIL ORDERS MUST BE SENT TO HEAD OFFICE AND NOT TO RETAIL SHOP.

FULLY GUARANTEED ZAERUX BRAND FIRST QUALITY VALVES

Valve	Price
OA2	6/6
OA3	9/-
OA4G	22/-
OB2	6/6
OB3	10/-
OC2	17/-
OC3	7/-
OD3	6/6
1A3	5/-
1A5GT	5/6
1A7GT	7/6
1B3GT	7/6
1B24A	80/-
1C5G	6/-
1G4GT	8/6
1G6GT	7/6
1H5GT	7/6
1L4	3/6
1N5GT	8/6
1Q5GT	10/-
1R4	7/-
1R5	7/-
1S2	6/6
1S4	5/6
1S5	5/-
1T4	4/6
1T5GT	8/-
1U4	6/-
1U5	9/6
1V2	9/-
1X2B	7/6
1Z2	25/-
2A3	7/-
2C26A	10/-
2C39A	140/-
2C40	65/-
2C51	8/6
2C53	75/-
2CW4	12/-
2D21	6/6
2E22	38/-
2E24	50/-
2E26	30/-
2X2	7/-
3A3	11/-
3A4	4/-
3A5	10/-
3A8GT	10/-
3B24	30/-
3B28	42/6
3C45	65/-
3D6	3/3
3D21A	50/-
3E29	65/-
3Q4	8/-
3Q5GT	8/-
3S4	7/-
3V4	8/-
4-125A	160/-
4-250A	230/-
4-400	300/-
4B32	80/-
4CX250B	260/-
4HA5	9/6
4THA	8/-
5AR4	11/-
5C22	320/-
5D21	80/-
5R4GY	11/-
5U4G	6/-
5U4GB	7/6
5V4G	8/-
5Y3GT	6/-
5Z3	9/-
5Z4G	7/6
5Z4GT	8/-
6/30L2	15/-
6A8G	6/6
6AB4	6/6
6AC7	4/6
6AF4A	9/6
6AG5	4/-
6AG7	7/6
6AH6	10/-
6AJ8	5/9
6AK5	6/-
6AK5W	8/-
6AK6	11/6
6AK7	6/6
6AL3	8/6
6AL5	3/3
6AM5	5/-
6AM6	4/6
6AQ5	6/6
6AQ6	10/-
6AR5	6/6
6AR6	6/6
6AS5	7/-
6AS7G	16/-
6AT6	5/-
6AU6	5/-
6AV5GTA	13/-
6AV6	6/-
6AW8A	11/-
6AX4GTB	9/-
6AX5GT	13/-
6B4G	16/6
6B7	7/6
6B8G	3/-
6BA6	4/6
6BE6	5/-
6BF5	16/-
6BF6	9/-
6BG6G	12/-
6BH6	8/6
6BJ6	8/6
6BK4	21/-
6BK7A	10/-
6BL7GTA	12/-
6BN4	13/-
6BN6	8/-
6BQ5	5/-
6BQ6GTB	13/-
6BQ7A	7/6
6BR7	17/-
6BR8	13/-
6BS7	26/-
6BW6	16/-
6BW7	13/6
6BX6	5/-
6BX7	14/-
6BZ6	6/6
6C4	6/-
6CB6	5/6
6CD6GA	23/-
6CG7	9/-
6CH6	11/-
6CL6	10/-
6CU6	13/-
6CW4	12/6
6CY5	8/-
6CY7	12/-
6D3	8/-
6DC6	13/6
6DK6	8/6
6DQ6B	12/-
6DS4	15/-
6EA8	11/-
6EH7	6/6
6EJ7	7/-
6F6	14/-
6F6G	5/-
6F11	6/6
6F13	7/-
6F14	12/-
6F15	11/-
6F17	9/-
6F18	8/-
6F22	6/6
6F23	15/6
6F24	13/6
6F25	15/-
6F28	14/-
6GH8	11/-
6GK6	12/-
6J4	9/6
6J5GT	6/-
6J7	8/6
6K6GT	10/-
6K7	6/6
6K8G	6/-
6K23	10/-
6K25	15/-
6L6GT	9/-
6L7	6/6
6L18	6/-
6LD20	6/6
6N7GT	7/-
6P1	12/-
6P28	12/6
6Q7	7/6
6R7G	7/-
6S2	8/-
6S4	11/-
6SA7	7/6
6SC7	13/-
6SG7	6/6
6SH7	5/-
6SJ7	7/6
6SK7	6/6
6SL7GT	6/6
6SN7GT	6/-
6SQ7	8/-
6SR7	7/6
6SS7	4/-
6T8	6/6
6U4GT	12/6
6U8	7/-
6V6GT	6/6
6X4	5/-
6X5GT	5/6
6X8	11/-
6Y6G	12/-
6Z4	5/6
7B5	12/-
7B6	12/6
7B7	7/6
7C5	15/-
7F8W	17/6
7Y4	12/-
7Z4	8/6
9A8	6/6
9BW6	8/6
10C2	10/-
10D1	8/-
10D2	8/-
10F1	18/-
10F9	10/-
10F18	8/-
10L1	8/-
10LD11	11/-
10P13	11/-
10P14	20/-
10Y	20/-
11D3	8/-
11D5	8/-
11E2	40/-
11E3	70/-
12AB5	10/-
12AC6	7/6
12AD6	7/6
12AH7GT	5/-
12AL5	8/-
12AQ5	8/-
12AT6	5/-
12AT7	6/6
12AU6	5/6
12AU7	6/-
12AV6	6/-
12AV7	9/-
12AX4GTB	9/-
12AX7	6/-
12AY7	13/6
12B4A	10/-
12BA6	6/6
12BA7	6/6
12BE6	6/6
12BH7	6/6
12BY7	10/-
12C8	6/-
12CU6	15/-
12E1	26/-
12E14	55/-
12J5GT	4/-
12J7GT	8/-
12K5	10/-
12K7GT	7/-
12K8	10/-
12Q7G	5/-
12SC7	5/-
12SG7	7/-
12SH7	5/-
12SJ7	5/-
12SK7	8/-
12SL7GT	8/-
12SN7GT	8/-
12SQ7	8/-
12SR7	6/6
1487	16/-
20CV	62/6
20D1	9/-
20L1	20/-
20P1	10/-
20P3	12/-
20P4	20/-
20P5	20/-
25C5	9/-
25L6GT	7/6
25Z4G	6/-
25Z6GT	12/-
30A5	8/-
30AE3	8/-
30C1	6/6
30C15	15/-
30C17	16/-
30C18	15/-
30F5	17/-
30FL1	15/-
30FL12	18/6
30FL13	18/6
30FL14	15/6
30L1	7/-
30L15	17/-
30L17	17/-
30P12	16/-
30P18	7/-
30P19	15/-
30PL1	15/6
30PL13	18/-
30PL14	17/-
35A3	10/-
35A5	11/-
35B5	13/-
35C5	7/-
35D5	13/-
35L6GT	9/6
35W4	5/-
35Z3	11/-
35Z4G	5/-
35Z5GT	7/-
42	8/-
50A5	13/-
50B5	7/-
50C5	7/-
50CD6G	35/-
50L6GT	8/-
52KU	7/6
53KU	16/-
75B1	9/-
75C1	8/-
80	9/-
83A1	14/-
85A1	25/-
85A2	7/6
85A3	9/-
90AG	48/-
90AV	48/-
90C1	12/-
90CG	25/-
90CV	25/-
108C1	6/6
150B2	12/-
150B3	11/-
150C4	11/-
310A	27/6
311A	37/6
328A	40/-
329	20/-
329A	35/-
715B	70/-
715C	80/-
805	100/-
807	9/6
811A	30/-
813	75/-
829B	60/-
832A	57/6
833A	340/-
837	15/-
866A	14/-
872A	57/6
884	10/-
927	55/-
955	4/-
4378	25/-
5544	120/-
5545	150/-
5551A	320/-
5654	8/-
5670	10/-
5751	12/-
5796	280/-
5814A	12/-
5894	110/-
6080	27/6
6146	30/-
6146B	47/6
6267	6/6
6360	25/-
6550	33/-
6883	47/6
6922	12/6
6939	42/-
7199	15/-
7586	25/-
7895	25/-
8005	135/-
9002	6/6
9003	10/-
A1834	16/-
A2293	23/-
AC/HL/DD	9/-
AC/TH1	8/-
C1A	90/-
C1K	80/-
CBL1	16/-
CBL31	17/-
CL4	12/-
CL33	17/6
DAF41	10/-
DAF91	5/6
DAF92	9/6
DAF96	7/9
DC90	9/-
DCC90	10/-
DF91	4/6
DF92	3/6
DF96	7/9
DH76	6/6
DH81	11/-
DH101	10/-
DK40	10/-
DK91	7/-
DK92	9/-
DK96	8/-
DL66	25/-
DL68	13/-
DL69	35/-
DL91	5/6
DL92	7/-
DL93	4/-
DL94	8/-
DL95	8/-
DL96	7/6
DM70	6/6
DM160	11/6
DY70	12/-
DY86	6/6
DY87	7/-
DY802	10/-
E55L	55/-
E80CC	21/-
E80CF	29/-
E80L	18/-
E81L	22/-
E83F	20/-
E84L	9/6
E88C	24/-
E88CC	12/6
E90CC	9/-
E91H	10/-
E130L	90/-
E180F	19/-
E188CC	16/6
E280F	42/-
E283CC	40/-
EA50	4/-
EAF42	10/-
EAF801	9/6
EB34	3/-
EB91	3/3
EBC33	9/-
EBC41	10/6
EBC81	6/6
EBC90	5/-
EBC91	6/-
EBF80	8/-
EBF83	8/6
EBF89	6/6
EBL31	25/-
EC53	10/-
EC86	12/-
EC88	12/-
EC90	6/-
EC92	6/6
EC93	9/6
ECC34	8/-
ECC40	11/-
ECC70	17/-
ECC81	6/6
ECC82	6/-
ECC83	6/-
ECC84	6/-
ECC85	5/6
ECC86	9/6
ECC89	8/-
ECC91	4/-
ECF80	7/-
ECF82	7/-
ECF83	15/-
ECF86	12/6
ECF804	30/-
ECH35	12/-
ECH42	13/-
ECH81	5/6
ECH83	8/6
ECH84	9/-
ECL80	9/-
ECL81	8/6
ECL82	6/6
ECL83	12/6
ECL84	11/-
ECL85	10/6
ECL86	8/6
EF9	9/-
EF39	9/-
EF40	10/-
EF41	12/6
EF42	14/-
EF55	13/-
EF80	5/-
EF83	10/-
EF85	7/-
EF86	6/6
EF89	5/6
EF91	4/6
EF92	7/6
EF93	4/6
EF94	5/-
EF95	5/-
EF96	4/-
EF97	10/-
EF183	6/6
EF184	7/-
EF800	20/-
EF804	20/-
EF811	15/-
EF812	15/6
EF814	13/6
EK2	15/-
EK90	5/-
EL5	11/-
EL34	10/6
EL36	9/6
EL41	11/-
EL42	11/6
EL81	10/-
EL83	7/6
EL84	5/-
EL85	8/6
EL86	8/6
EL90	6/-
EL91	5/-
EL95	7/-
EL360	23/-
EL803	17/-
EL821	11/-
EL822	18/-
ELL80	15/-
EM34	16/-
EM71	12/6
EM80	8/-
EM81	8/6
EM84	7/6
EM87	11/-
EN10	70/-
EN11	70/-
EN32	30/-
EN91	6/6
EY51	8/-
EY80	9/-
EY81	8/-
EY83	11/-
EY84	10/-
EY86	8/-
EY87	8/6
EY88	8/6
EZ35	5/6
EZ40	7/6
EZ41	9/-
EZ80	5/6
EZ81	5/6
EZ90	5/-
FG17	90/-
FW4/500	13/6
GC10B	37/-
GC10D	55/-
GN4	30/-
GR10M	30/-
GS10D	55/-
GS10H	40/-
GS129	67/6
GS47X	55/-
GU50	35/-
GY501	16/-
GZ30	7/6
GZ31	6/-
GZ32	9/6
GZ33	16/-
GZ34	11/-
HABC80	8/6
HBC90	5/-
HBC91	6/-
HF93	6/6
HF94	5/6
HK90	6/6
HL23	7/6
HL23DD	7/6
HL42DD	9/-
HL92	7/-
HL94	8/-
KT8	40/-
KT33C	17/-
KT36	20/-
KT44	8/6
KT45	30/-
KT66	27/6
KT71	8/-
KT76	8/-
KT88	33/-
KTW63	6/-
LL4	9/-
LP2	8/-
ME91	8/-
ME1400	28/-
MH4	8/-
MHL4	8/-
ML4	9/-
ML6	8/-
MSPEN/T	10/-
MT17	90/-
MU12/14	10/-
N78	21/-
NSP1	70/-
NSP2	70/-
PABC80	8/-
PC86	11/6
PC88	13/-
PC97	8/6
PC900	9/6
PCC84	7/-
PCC85	8/-
PCC88	12/-
PCC89	10/6
PCC189	11/-
PCC805	17/-
PCC806	17/-
PCE800	15/-
PCF80	6/6
PCF82	6/9
PCF84	9/-
PCF86	11/-
PCF87	16/-
PCF800	15/-
PCF801	10/-
PCF802	10/-
PCF805	15/-
PCF806	13/-
PCF808	15/6
PCH200	14/-
PCL81	10/-
PCL82	7/9
PCL83	13/-
PCL84	8/9
PCL85	9/6
PCL86	9/6
PCL88	17/-
PCL800	18/-
PCL801	15/6
PD500	30/-
PE06-40N	80/-
PEN4DD	8/-
PEN36C	13/6
PEN45	7/-
PEN45DD	15/-
PEN46	7/6
PEN383	10/-
PEN384	10/-
PEN453DD	11/-
PF86	11/-
PF818	17/-
PFL200	11/-
PL33	7/-
PL36	11/-
PL81	9/6
PL82	9/-
PL83	8/-
PL84	7/-
PL302	15/-
PL500	15/-
PL504	16/-
PL508	17/6
PL509	30/-
PL801	16/-
PL802	14/-
PLL80	11/-
PM84	9/-
PX4	30/-
PX25	30/-
PY31	5/-
PY32	11/-
PY33	12/6
PY80	6/6
PY81	6/-
PY82	6/-
PY83	7/6
PY88	8/-
PY500	20/-
PY800	10/-
PY801	10/-
PZ30	7/-
QQV02-6	42/-
QQV03-10	25/-
QQV03-20A	105/-
QQV06-40A	110/-
QS83/3	7/6
QU37	30/-
QV03-12	13/-
QY3-125A	160/-
QY4-250A	230/-
QY4-400A	300/-
R10	20/-
R18	9/-
RG3-250A	14/-
RL18	10/-
S130	35/-
S130P	35/-
SP2	9/-
SP4	9/-
SP41	7/-
SP42	12/-
SP61	7/-
TP22	11/-
TP25	6/-
TT21	48/-
TT22	50/-
U17	10/-
U18/20	13/6
U19	50/-
U20	13/6
U25	15/-
U26	15/-
U31	9/-
U33	30/-
U37	30/-
U50	6/-
U52	6/-
U76	5/-
U78	5/-
U81	13/-
U191	14/-
U201	7/-
U281	8/-
U282	8/-
U301	11/6
U403	10/-
U404	7/6
U801	20/-
UABC80	6/9
UAF41	10/-
UAF42	10/6
UB41	11/-
UBC41	9/6
UBC81	8/-
UBF80	7/3
UBF89	7/-
UBL1	10/-
UBL21	12/-
UC92	6/6
UCC85	8/-
UCF80	10/6
UCH21	11/-
UCH42	13/-
UCH43	12/-
UCH81	6/6
UCL81	11/-
UCL82	7/-
UCL83	12/-
UD143	15/-
UF9	11/-
UF11	10/-
UF41	10/-
UF42	12/-
UF43	11/-
UF80	7/6
UF85	8/-
UF89	7/-
UL41	12/-
UL84	6/6
UM4	5/6
UM84	4/-
UU5	10/-
UY1N	10/-
UY11	11/-
UY21	11/-
UY41	8/-
UY82	10/-
UY85	6/-
VLS631	38/-
VP23	6/6
VP41	7/-
VP133	15/-
VR75/30	9/-
VR105/30	7/-
VR150/30	6/6
VU33	10/-
VU39A	10/-
VU111	10/-
VU120	15/-
VU133	10/-
W76	8/-
W107	8/-
W729	12/-
X65	10/-
X66	10/-
X76M	9/-
XC11	15/-
XC12	6/6
XC12T	8/-
XC15	4/6
XC15T	7/-
XC23	17/-
XC25	7/-
XR1-1600	280/-
XR1-3200	120/-
XR1-6400	150/-
Z309	10/-
Z319	55/-
Z329	17/-
Z520M	30/-
Z700U	8/-
Z700W	15/-
Z719	5/-
Z729	6/6
Z749	15/6
Z800U	30/-
Z801U	30/-
Z803U	17/6
Z900T	13/-

Head Office:
44a WESTBOURNE GROVE, LONDON, W.2
Tel.: **PARK 5641/2/3**
Cables: **ZAERO LONDON**
Retail branch (personal callers only)
85 TOTTENHAM COURT RD., LONDON W.2. Tel: LANgham 8403

A.R.B. Approved for inspection and release of electronic valves, tubes, klystrons, etc.

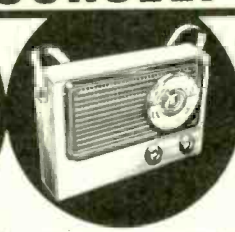
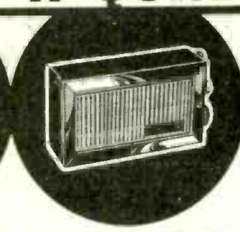
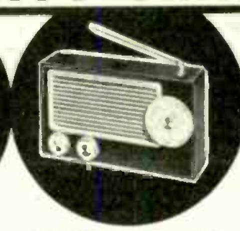
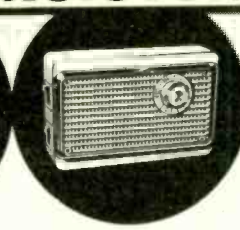
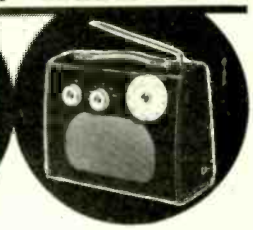
OUR NEW 1969/1970 CATALOGUE IS NOW READY.
PLEASE SEND QUARTO S.A.E. FOR YOUR FREE COPY

WE WANT TO BUY:

723A/B; 2K25; 4C35—50/- paid subject to test. Please offer us your special valves and tubes surplus to requirements.

TELEX 261306

BUILD YOURSELF A QUALITY TRANSISTOR RADIO !

NEW! ROAMER EIGHT Mk 1 WITH TONE CONTROL SEVEN WAVEBANDS—MW1, MW2, LW, SW1, SW2, SW3 AND TRAWLER BAND. 8 transistors and 3 diodes. Ferrite rod aerial and telescopic aerial. Socket for car aerial. 7 x 4 in. Speaker. Airspaced ganged tuning condenser. Earpiece socket and earpiece. Selectivity switch. Size 9 x 7 x 4 in. **Total Building Costs £6.19.6.** P & P 7/6. Plans and Parts list 5/- (free with parts).

ROAMER SIX, 6 WAVEBANDS—MW1, MW2, SW1, SW2, LW AND TRAWLER BAND. 6 transistors and 2 diodes. Ferrite rod and telescopic aerials, speaker. Size 7½ x 5½ x 1½in. **Building Costs 79/6.** P. & P. 4/6. Plans and Parts list 2/- (free with parts). Carrying Strap 1/6 extra.

POCKET FIVE, MED. AND LONG WAVES & TRAWLER BAND to approx. 50 metres **WITH SPEAKER AND EARPIECE.** 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, moving coil speaker, etc. 5½ x 1½ x 3½in. **Total Building Costs 44/6.** P. & P. 3/6. Plans and Parts list 1/6 (free with parts).

NEW! TRANSEIGHT 6 WAVEBANDS. MW, LW, 3 SHORT WAVES AND TRAWLER BAND. 8 improved type transistors and 3 diodes. Ferrite rod and telescopic aerials. 3in. speaker. Push pull output. Size 9 x 5½ x 2¾in. **Total Building Costs 89/6** P & P 5/6. Plans and Parts list 5/- (free with kit). Personal earpiece with switched socket for private listening 5/- extra.

TRANSONA FIVE MED. AND LONG AND TRAWLER BAND to approx. 50 metres **WITH SPEAKER AND EARPIECE.** 5 transistors and 2 diodes, ferrite rod aerial, moving coil speaker. 6½ x 4½ x 1½in. **Total Building Costs 47/6.** P. & P. 3/9. Plans and Parts list 1/6 (free with parts).

ROAMER SEVEN Mk 4. 7 WAVE-BANDS—MW1, MW2, LW, SW1, SW2, SW3, AND TRAWLER BAND. 7 transistors and 2 diodes. Ferrite rod aerial and telescopic aerial. Socket for car aerial. 7 x 4in. speaker. Airspaced ganged tuning condenser etc. Size 9 x 7 x 4in. **Total Building Costs £5/19/6.** P. & P. 7/6. Personal earpiece with switched socket for private listening 5/- extra. Plans and Parts list 3/- (free with parts).

RADIO EXCHANGE CO. LTD. Dept WW. 61 High Street, Bedford. 'Phone 0234 52367

● Open 10-1, 2.30-4.30. Sat. 9-12.

KING OF THE PAKS Unequalled Value and Quality

SUPER PAKS — NEW BI-PAK UNTESTED SEMICONDUCTORS

Satisfaction **GUARANTEED** in Every Pak, or money back.

Pak No.		
U1	120 Glass Sub-min. General Purpose Germanium Diodes	10/-
U2	60 Mixed Germanium Transistors AF/RF	10/-
U3	75 Germanium Gold Bonded Diodes sim. OA5, OA47	10/-
U4	40 Germanium Transistors like OC81, AC128	10/-
U5	60 200mA Sub-min. Sil. Diodes	10/-
U6	40 Silicon Planar Transistors NPN sim. BSY95A, 2N706	10/-
U7	16 Silicon Rectifiers Top-Hat 750mA up to 1,000V	10/-
U8	50 Sil. Planar Diodes 250mA OA/200/202	10/-
U9	20 Mixed Volts 1 watt Zener Diodes	10/-
U11	30 PNP Silicon Planar Transistors TO-5 sim. 2N1132	10/-
U12	12 Silicon Rectifiers EPOXY BY126/127	10/-
U13	30 PNP-NPN Sil. Transistors OC200 & 2S104	10/-
U14	150 Mixed Silicon and Germanium Diodes	10/-
U15	30 NPN Silicon Planar Transistors TO-5 sim. 2N697	10/-
U16	10 3-Amp Silicon Rectifiers Stud Type up to 1000 PIV	10/-
U17	30 Germanium PNP AF Transistors TO-5 like ACY 17-22	10/-
U18	8 6-Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	10/-
U19	30 Silicon NPN Transistors like BC108	10/-
U20	12 1.3-amp Silicon Rectifiers Top-Hat up to 1,000 PIV	10/-
U21	30 A.F. Germanium alloy Transistors 2G300 Series & OC71	10/-
U22	10 1-amp Glass Min. Silicon Rectifiers High Volts	10/-
U23	30 Madt's like MAT Series PNP Transistors	10/-
U24	20 Germanium 1-amp Rectifiers GJM up to 300 PIV	10/-
U25	25 300Mc/s NPN Silicon Transistors 2N708, BSY27	10/-
U26	30 Fast Switching Silicon Diodes like IN914 Micro-min.	10/-
U28	Experimenters' Assortment of Integrated Circuits, untested Gates, Flip-Flops, Registers, etc., 8 Assorted Pieces	20/-
U29	10 1 amp SCR's TO-5 can up to 600 PIV CRSI/25-600	20/-
U30	15 Plastic Silicon Planar trans. NPN 2N2924-2N2926	10/-
U31	20 Sil. Planar NPN trans. low noise Amp 2N3707	10/-
U32	25 Zener diodes 400mW D07 case mixed Volts, 3-18	10/-
U33	15 Plastic case 1 amp Silicon rectifiers 1N4000 series	10/-
U34	30 Sil. PNP alloy trans. TO-5 BCY26, 2S302/4	10/-
U35	25 Sil. Planar trans. PNP TO-18 2N2906	10/-
U36	25 Sil. Planar NPN trans. TO-5 BFY50/51/52	10/-
U37	30 Sil. alloy trans. SO-2 PNP, OC200 2S322	10/-
U38	20 Fast Switching Sil. trans. NPN, 400Mc/s 2N3011	10/-
U39	30 RF Germ. PNP trans. 2N1303/5 TO-5	10/-
U40	10 Dual trans. 6 lead TO-5 2N2060	10/-
U41	30 RF Germ. trans. TO-1 OC45 NKT72	10/-
U42	10 VHF Germ. PNP trans. TO-1 NKT667 AF117	10/-

Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

BI-PAK SEMICONDUCTORS

(DEPT. WW.)

TESTED SCR'S

PIV	1 A	7A	16A	30A
25	—	7/6	—	30/-
50	7/6	8/6	10/6	35/-
100	8/6	10/-	15/-	45/-
200	12/6	15/-	20/-	55/-
300	15/-	20/-	25/-	—
400	17/6	25/-	35/-	80/-
500	30/-	40/-	45/-	95/-
600	—	40/-	50/-	—

SIL. RECTS TESTED

PIV	750mA	3A	10A	30A
50	1/-	2/9	4/3	9/6
100	1/3	3/3	4/6	15/-
200	1/9	4/-	4/9	20/-
300	2/3	4/6	6/6	22/-
400	2/6	5/6	7/6	25/-
500	3/-	6/-	8/6	30/-
600	3/3	6/9	9/-	37/-
800	3/6	7/6	11/-	40/-
1000	5/-	9/3	12/6	50/-
1200	6/6	11/6	15/-	—

FULL RANGE OF ZENER DIODES
VOLTAGE RANGE 2-16V.
400mV (DO-7 Case) 2/6 ea.
1-5W (Top-Hat) .. 3/6 ea.
10W (SO-10 Stud).. 5/- ea.
All fully tested 5% tol. and marked. State voltage required.

BRAND NEW TEXAS GERM. TRANSISTORS
Coded and Guaranteed

Pak No.			EQVT
T1	8	2G371A	OC71
T2	8	2G374	OC75
T3	8	2G3744A	OC81D
T4	8	2G381A	OC81
T5	8	2G382T	OC82
T6	8	2G344A	OC44
T7	8	2G345A	OC45
T8	8	2G378	OC78
T9	8	2G399A	2N1302
T10	8	2G417	AF117

All 10/- each

2N2060 NPN SIL. DUAL TRANS. CODE D1699 TEXAS. Our price 5/- ea.

120 VCB NIXIE DRIVER TRANSISTOR. Sim. BSX21 & C407. 2N1893 FULLY TESTED AND CODED ND120. 1-24 3/6 each. To-5 N.P.N. 25 up 3/- ea.

OTHER MONOLITHIC DEVICES

BP424. Zero voltage switch. 8/6 each.
This device is a monolithic I.C. that acts a combined threshold detector and trigger circuit for controlling a triac. It is designed to pulse the gate of a thyristor at the point of zero supply voltage, and therefore eliminate radio frequency interference when used with resistive loads.

D13D1 Silicon Unilateral switch 10/- each.
A Silicon Planar, monolithic integrated circuit having thyristor electrical characteristics, but with an anode gate and a built-in "Zener" diode between gate and cathode. Full data and application circuits available on request.

CA3020 RCA (U.S.A.) LINEAR INTEGRATED CIRCUITS
Audio Power Amplifier, 30/- each.

FREE
One 10/- Pack of your own choice free with orders valued £4 or over.

PLEASE NOTE. To avoid anyfurther increased Postal Charges to our Customers and enable us to keep our "By Return Postal Service" which is second to none, we have re-organized and streamlined our Despatch Order Department and we now request you to send all your orders together with your remittance, direct to our Warehouse and Despatch Department, postal address: **BI-PAK SEMICONDUCTORS,** Despatch Dept., P.O. Box 6, **WARE, HERTS.** Postage and packing still 1/- per order. Minimum order 10/-.

INTEGRATED CIRCUITS

BI-PAK MONOLITHIC DIGITAL CIRCUITS
(10 lead TO-5)

BP305A, 6-Input AND gate, 9/6 each.
BP314A, 7-Input NOR gate, 9/6 each.
BP315A, Dual 3-Input NOR GATE. 9/6 each.
BP316A, Dual 2-Input NOR gate (expandable), 9/6 each.
BP320A, J-K-Binary element, 11/6 each.
BP332A, Dual 3-Input OR gate, 9/6 each.

BI-PAK MONOLITHIC AMPLIFIERS
(TO-5 8 lead)

BP709C. Operational amplifier, 15/- each.
BP701C, Operational amplifier (with Zener output), 12/6 each.
BP702C, Operational amplifier (with direct output), 12/6 each.
BP501, Wide band amplifier, 18/- each.
BP521, Logarithmic wide band amp., 14/- each.
BP210C, General purpose amplifier (TO-5 8 lead). (voltage or current amp.), 12/6 each.

FAIRCHILD (U.S.A.) RTUL MICROLOGIC INTEGRATED CIRCUITS
Epoxy case TS-5 lead temp. range 15°C. to 55°C.
UL900, Buffer, 10/6 each.
UL914, Dual two-input gate, 10/6 each.
UL923 J-K-flip-flop, 14/- each.
Complete data and circuits for the Fairchild I.C.'s available in booklet form priced 1/6.

MULLARD I.C. AMPLIFIERS
TAA243. Operational amplifier, 70/- each.
TAA263. Linear AF amplifier, 18/6 each.
TAA293. General purpose amplifier, 21/- each.

QUALITY-TESTED PAKS

6	Matched Trans. OC44/45/81/81D	10/-
20	Red Spot AF Trans. PNP	10/-
16	White Spot RF Trans. PNP	10/-
5	Silicon Rects. 3 A 100-400 PIV	10/-
2	10 A Silicon Rects. 100 PIV	10/-
2	OC1 140 Trans. NPN Switching	10/-
1	12 A SCR 100 PIV	10/-
3	Sil. Trans. 2S303 PNP	10/-
4	Zener Diodes 250mW 3-12V	10/-
3	200 Mc/s Sil. Trans. NPN BSY26/27	10/-
3	Zener Diodes 1W 33V 5% Tol.	10/-
4	High Current Trans. OC42 Eqvt.	10/-
2	Power Transistors 1 OC26 1 OC35	10/-
5	Silicon Rects. 400 PIV 250mA	10/-
4	OC75 Transistors	10/-
1	Power Trans. OC20 100V	10/-
10	OA202 Sil. Diodes Sub-min.	10/-
2	Low Noise Trans. NPN 2N929/30	10/-
1	Sil. Trans. NPN VCB 100 ZT86	10/-
8	OA81 Diodes	10/-
4	OC72 Transistors	10/-
4	OC77 Transistors	10/-
4	Sil. Rects. 400 PIV 500mA	10/-
5	GET884 Trans. Eqvt. OC44	10/-
5	GET883 Trans. Eqvt. OC45	10/-
2	2N708 Sil. Trans. 300 Mc/s. NPN	10/-
3	GT31 LF Low Noise Germ Trans. PNP	10/-
6	IN914 Sil. Diodes 75 PIV 75mA	10/-
8	OA95 Germ. Diodes Sub-min. IN69	10/-
3	NPN Germ. Trans. NKT773 Eqvt. AC130	10/-
2	OC22 Power Trans. Germ.	10/-
2	OC25 Power Trans. Germ.	10/-
4	AC128 Trans. PNP High Gain	10/-
4	AC127/128 Comp. pair PNP/NPN	10/-
3	2N1307 PNP Switching Trans.	10/-
7	CG62H Germ. Diodes Eqvt. OA71	10/-
3	AF116 Type Trans.	10/-
12	Assorted Germ. Diodes Marked	10/-
4	AC126 Germ. PNP Trans.	10/-
4	Silicon Rects. 100 PIV 750mA	10/-
3	AF117 Trans.	10/-
7	OC81 Type Trans.	10/-
3	OC171 Trans.	10/-
5	2N2926 Sil. Epoxy Trans.	10/-
7	OC71 Type Trans.	10/-
2	2S701 Sil. Trans. Texas	10/-
3	12 Volt Zeners 400mW	10/-
2	10 A 600 PIV Sil. Rects. IS45R	10/-
3	BC108 Sil. NPN High Gain Trans.	10/-
1	2N910 NPN Sil. Trans. VCB 100	10/-
2	1000 PIV Sil. Rect. 1.5 A R53310 AF	10/-
3	BSY95A Sil. Trans. NPN 200 Mc/s.	10/-
3	OC200 Sil. Trans.	10/-
2	Sil. Power Rects. BYZ13	15/-
1	Sil. Power Trans. NPN 100mc/s. TK201A	15/-
6	Zener Diodes 3-15V Sub-min.	15/-
1	2N1132 PNP Epitaxial Planar Sil.	15/-
3	2N697 Epitaxial Planar Trans. Sil.	15/-
4	Germ. Power Trans. Eqvt. OC16	15/-
1	Unijunction Trans. 2N2646	15/-
2	Sil. Trans. 200 Mc/s. 60Vcb ZT83/84	15/-
1	Tunnel Diode AEY11 1050 Mc/s.	15/-
2	2N2712 Sil. Epoxy Planar HFE225	15/-
8	BY 100 Type Sil. Rects.	20/-
25	Sil. and Germ. Trans. Mixed, all marked, New	30/-

BI-PAK GUARANTEE SATISFACTION OR MONEY BACK

4-STATION INTERCOM

Our Price Only **£7/15/0**

Solve your communication problems with this new **4-Station Transistor Intercom** system (**1 master** and **3 subs**), in de luxe plastic cabinets for desk or wall mounting. Call/talk/listen from **Master** to **Subs** and **Subs** to **Master.** Operates on one 9 v. battery. On/off switch. Volume control. Ideally suitable to modernise Office, Factory, Workshop, Warehouse, Hospital, Shop, etc., for instant inter-departmental contacts. Complete with 3 connecting wires, each 66ft. and other accessories. Nothing else to buy. P. & P. 7/6 in U.K.

INTERCOM/BABY ALARM

OUR PRICE ONLY **3 gns.**

Same as 4-Station Intercom for two-way instant conversation from MASTER to SUB and SUB to MASTER. Ideal as Baby Alarm and Door Phone. Complete with 66ft. connecting wire. Battery 2/6. P. & P. 4/6.

7-STATION INTERCOM

(1 MASTER & 6 SUB-STATIONS) in strong metal cabinets. Fully transistorised. 3½in. Speakers. Call on Master identified by tone and Pilot lamp. Ideally suitable for Office, Hotel, Hospital and Factory. Price **27 gns.** P. & P. 14/6 in U.K.

Transistor TELEPHONE AMPLIFIER

59/6

Why not increase efficiency of Office, Shop and Warehouse with this incredible De-Luxe Portable Transistor **TELEPHONE AMPLIFIER** which enables you to take down long telephone messages or converse without holding the handset. A useful office aid. A must for every telephone user. Useful for hard of hearing persons. On/off switch. Volume Control. Operates on one 9 v. battery which lasts for months. Ready to operate. P. & P. 3/6 in U.K. Add 2/6 for Battery.

Full price refunded if returned in 7 days.

WEST LONDON DIRECT SUPPLIES (W.W.), 169 Kensington High Street, London, W.8

2½kW FAN HEATER

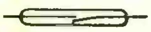
Three position switching to suit changes in the weather. Switch up for full heater (2½kW), switch down for half heat (1¼kW), switch central blows cold for summer cooling—adjustable thermostat acts as auto control and safety cut-out. Complete kit **£3.15.0**. Post and ins. 7/6. Made-up model **£4.15.0**. Post and ins. 7/6.

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. **19/6**. Kit E—65 w. **19/6**. Kit MF1 is for 6in., 9 in. and 12in. miniature tubes. **19/6**. Postage on Kits A and B 4/6 for one or two kits then 4/6 for each two kits ordered. Kits C, D and E 4/6 on first kit then 3/6 for each kit ordered. Kit MF1 3/6 on first kit then 3/6 on each two kits ordered.

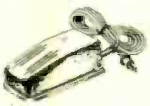
BECKASTAT

This is an instant thermostat, simply plug your appliance into it and its lead into wall plug. Adjustable setting for normal air temperatures. 13A loading. Will save its cost in a season. **19/6**. Post and ins. 2/9



REED SWITCHES

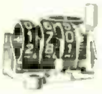
Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types:
Miniature. 1in. long × approximately ⅛in. diameter. Will make and break up to ½A up to 300 volts. Price **2/6** each. **24/-** dozen.
Standard. 2in. long × 3/16in. diameter. This will break currents of up to 1A, voltages up to 250 volts. Price **2/-** each. **18/-** per dozen.
Flat. Flat type, 2in. long, just over 1/16in. thick, approximately ⅛in. wide. The Standard Type flattened out, so that it can be fitted into a smaller space or a larger quantity may be packed into a square solenoid. Rating 1 amp 200 volts. Price **6/-** each. **£3** per dozen.
Small ceramic magnets to operate these reed switches **1/3** each. **12/-** dozen.



15A FOOT SWITCH

Suitable for Sewing Machine Motor, Drilling Machine or in fact to switch any job where both hands are to be left free. Rated at 13 amps, 250 volts. Price **22/6**.

3 DIGIT COUNTER



For Tape Recorder or other application re-settable by depressing button. Price **8/6**.

TRANSDUCER

Made by Acos, reference No. I.D.1001. For measuring vibration, etc., to be used in conjunction with "G" Meter. Regular price £5. Our price **49/6**. Brand new and unused.

ISOLATION SWITCH

20 Amp D.P. 250 Volts. Ideal to control Water Heater or any other appliance. Neon indicator shows when current is on, **4/6**. **48/-** per dozen.

LIGHT CELL

Almost zero resistant in sunlight increases to 10 K. Ohms in dark or dull light, epoxy resin sealed. Size approx. ⅛in. dia. by ⅛in. thick. Rated at 500 MW. wire ended. **8/6** with circuit.

FLEX BARGAINS

Screened 3 Core Flex. Each core 14/0076 Copper PVC insulated and coloured, the 3 cores laid together and metal braided overall. Price **£3.15.0** per 100 yds. coil
15A 3 Core Non-kink Flex. 70/0076 insulated coloured cores, protected by tough rubber sheath, then black cotton braided with white tracer. A normal domestic flex as fitted to 3kW fires. Regular price 3/6 per yd. 50 yd. coil **£4.10.0**, or cut to your length 2/6 per yard.
10A 3 Core Non-kink Flex. As above but cores are 28/0076 Copper. Normal price 2/6 per yd. 100 yd. coil **£7.10.0**, or cut to your length **1/9** yd.
6A 2 Core Flex. As above, but 2 cores each 23/0076 as used for Vacuum Cleaners, Electric Blankets, etc. **39/6** 100 yd. coil.

3-CORE WATERPROOF FLEX

6A, 23/0076 circular PVC covered as fitted to electric drills and most portable appliances, ideal extension lead. Regular price 1/6 per yard, our price **79/6** for 100 yard coil. Post 6/6.

Elliot Sealed Contact Reed Relay. Three circuits closed by 3 volt or 100MA. **9/6** each.

Slim Tubular Microphone. For hand holding or frontal suspension—lever switch—high impedance with lead and plugs for cassette tape recorder but suitable for most amps. **19/6**.

500MA Moving Coil Meter. 2in. flush mounting round meter ex-Government but unused and perfect. **17/6**.

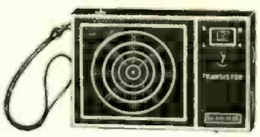
6, 12 OR 24 VOLT SOLENOID

For energizing Reed Switches, etc., size approx. 1in. long by 1in. diameter. Hole through Solenoid approx. ⅛in. **8/6** each.

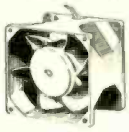
5A 3-PIN SWITCHED SOCKETS

An excellent opportunity to make that bench dis board you have needed or to stock up for future jobs. This month we offer 6 British made (Hicraft) bakelite flush mounting shuttered switch sockets for only **10/-** plus 3/6 post and insurance. (20 boxes post free.)

'GLADIATOR' 2 WAVEBAND TRANSISTOR RADIO



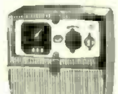
7 transistor, 2 wave band (medium & long) pocket radio with carrying handle and ear-plug. These radios use a ferrite slab aerial and a conventional superhet circuit with built-in moving coil speaker. Completely built up, ready to play. Offered at less than importer's price due to bankrupt purchase. A remarkable bargain.
39/6 plus 3/6 post and insurance.



MINIATURE EXTRACTOR FAN

Beautifully made by famous German Company. PAPST System. 230/240 A.C. Mains operated, size 3⅛in. × 3⅛in. × 2in. Made for instrument cooling but ideal to incorporate in a cooker hood, etc. **65/-** P. & p. 2/9.

BUY TIME SLOT METERS



If you hire out equipment such as TV sets by the hour then these slot meters are what you require. We have 3 types. 8d. an hour, 1/- an hour and 1/6 an hour. Brand new. Made by the famous Weston Company. Price **£3.19.6**, post and ins. 6/6

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**.

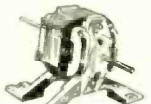
DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs. Supplied complete with 6 feet of heavy cable and 13 amp plug. Similar panels advertised at £5. Our price **39/6**, plus 3/6 post and insurance.

THIS MONTH'S SNIP

24 HOUR TIME SWITCH

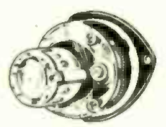
Mains operated. Adjustable Contacts give on/off per 24 hours. Contacts rated 20 amps, repeating mechanism so ideal for shop window control, or to switch hall lights (anti-burglar precaution) while you are on holiday. Made by the famous Smiths Company. This month only **39/6** complete with perspex cover, new and unused, plus 3/6 postage and insurance, a real snip which should not be missed.



DOUBLE ENDED MAINS MOTOR

On feet with holes for screw-down fixing. To drive models, oven, blower heater, etc. **10/-** each, plus 3/6 post and insurance. 6 or more post free.

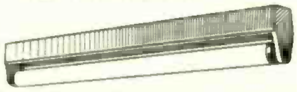
INSTRUMENT MOTOR WITH GEAR BOX



Made by the famous Smiths Company. This motor has an 8-gear train in perspex gear box. Approximate dimensions, motor 1⅛in. × 1⅛in. diameter, gear box ⅝in. × 2⅛in. diameter. Although only 2 watt motor this is really powerful and impossible to stop by hand. Mains operated and available with the final speeds 1 rpm, 4 rpm, 30 rpm, 60 rpm and 1 rev. per hour. **35/-**.
SIMILAR MOTOR, but approximately half the size and mains operated, final shaft, 2 revs. per min. Price **17/6**.

ATLAS SLIMLINE FLUORESCENTS

THE TWENTYLITE



A Fluorescent lighting unit made by the famous Atlas company, with super silent polyester filled choke and radio suppressed starter. The tube springs in and out and the whole unit is beautifully made and finished white enamel. Amazingly economical. If left on all the time costs only one penny per day (uses ½ unit). Measures 2ft. long. Is ideal Kitchen, Bedroom, Hallway, Porch, Loft, etc. Don't miss this amazing offer, **39/6** with tube. Assembled ready to install. 4 ft. twin model **59/6**. Post and ins. 6/6 extra.

1 WATT AMPLIFIER & PRE-AMP

5 transistors—highly efficient made for use with tape-head G4 but equally suitable for microphone or pick up. Limited quantity **29/6**. Full circuit diag. also shows tape controls 5/-.

VARYLITE

Will dim incandescent lighting up to 600 watt from full brilliance to out. Fitted on M.K. flush plate, same size and fixing as standard wall switch so may be fitted in place of this, or mount on surface. Price complete in heavy plastic box with control knob **£3.19.6**.

HI FI BARGAIN

FULL F1 12 INCH LOUDSPEAKER. This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi load and Rhythm Guitar and public address.
Flux Density 11,000 gauss—Total Flux 44,000 Maxwells—Power Handling 15 watts R.M.S.—Cone Moulded fibre—Freq. response 30-10,000 c.p.s.—specify 3 or 15 ohms—Main resonance 60 c.p.s.—Chassis Diam. 12in.—12⅜ over mounting lugs—Baffle hole 11in. Diam.—Mounting holes 4, holes—⅜in. diam. on pitch circle, 11⅝in. diam.—Overall height 5⅛in. A £6 speaker offered for only **£3.9.6** plus 7/6 p. & p. Don't miss this offer. 15in. 30 watt **£7.19.6**. 18in. 100 watt **£24.10.0**.

TAGENTIAL HEATER UNIT

Winter is coming but act today and you won't dismay. This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only. Units complete, wired ready to fit into cases, i.e. motor, impeller, 3 kW. heater switching 1, 2 and 3 kW. and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only need on/off switch. **79/6**. Postage and insurance 6/6. Don't miss this.

Where postage is not stated then orders over £3 are post free. Below £3 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at **3/6** each, **36/-** dozen, your assortment.

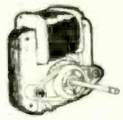
WATERPROOF HEATING ELEMENT
26 yards length 70W. Self-regulating temperature control. **10/-** post free.

AC FAN

Small but very powerful mains motor with 5½ in. blades. Ideal for cooling equipment or as extractor. Silent but very efficient. **17/6**, post 4/6. Mounts from back or front with 4BA screws.

DRILL CONTROLLER

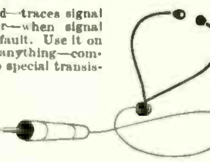
Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions **19/6**, plus 2/6 post and insurance. Made up model also available **37/6** plus 2/6 p. & p.



MAINS MOTOR

Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at **9/6**. Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

RADIO STETHOSCOPE



Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece **29/6**—twin stetoset instead of earpiece **7/6** extra—post and insurance 2/9.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **16/6**, plus 3/6 postage.

PHILIPS TRIMMER

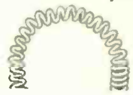
0-30pf an old design but one which has never been bettered. **1/-** each. **10/-** doz. **£4.0.0** per 100.

MOTOR WITH GEARBOX

Very powerful 7 r.p.m., operates from standard A.C. mains. **29/6**, plus 3/6 P. & P.

230 VOLT SOLENOID

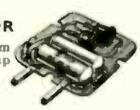
⅝in. stroke. Size 2⅛in. × 2in. × 1⅛in. **14/6**, postage 2/9.



SPRING COIL LEADS

as fitted to telephones, 4 core **2/6** each, 3 core **2/-** each.

PP3 BATTERY ELIMINATOR



Run your small transistor radio from the mains—full wave circuit. Made up ready to wire into your set and adjustable high or low current. **8/6** each.

INSTRUMENT BUZZER

6-12 volts, adjustable tone, a very neat metal cased U.S.A. made unit approx. 1⅛in. × 1in. × ⅝in. thick. **6/6** each.

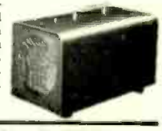
PANEL LAMPS

In neat plastic cases, available in several voltages as follows: 4v., 6v., 12v., 24v., 36v., 48v., 60v., 110v., 220v., 380v. Note all below 110v. are fitted with lamps. 110v. and above are neons. Price **3/-** each, **30/-** dozen.

APPLIANCE THERMOSTAT

This is a skeleton Type control intended for building into oven, for baking, curing, pottery, etc. 2 models, one pre-set for screwdriver control. The other has a shaft for knob control. Approximate operating temperature. Note only high temperature insulation used in these stats. Price **12/6** each.

5 K.W. PORTABLE HEATER



For workshop — stores — greenhouse, etc. Uses twin balanced motors for silent operation and reliability, three position switch gives 'max. heat,' 'half heat,' and 'blow cold.' A really fine heater. Price **£9.19.6**, plus 10/6 post and insurance.

ELECTRONICS (CROYDON) LTD

Dept. WW, 266 London Road, Croydon CRO-2TH
Also 102/3 Tamworth Road, Croydon

BETTER BARGAINS SERVICE FROM T.R.S.

Amplifier Kits

Styled and kitted by T.R.S., using quality components, including valves or transistors and excellent instructions. Backed by T.R.S. service.

MULLARD 5-10. Mono. Basic kit (requires pre-amp). Input Sensitivity—40 mV; Response 20Hz-15KHz + 1dB; Output 10 watts R.M.S. at 3 or 15 ohms. **KIT £10.10.0; BUILT £13.0.0** (*Carr. either, 7/6*).

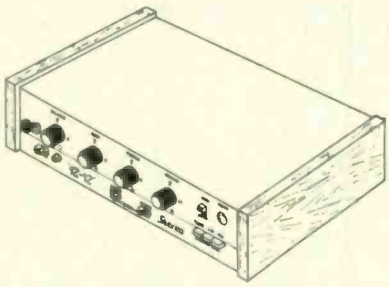
MULLARD 2-VALVE PRE-AMP with switching for 5 inputs; bass/treble/volume controls, etc. Sensitivity at input—4mV max. into 80K-1 Megohm; Response 20-25,000 Hz +1dB. **KIT £6.19.6; BUILT £9.10.0** (*Carr. either, 5/6*).

MULLARD 10-10 STEREO AMPLIFIER. Input sensitivity—210 mV per ch.; Response 12 Hz—35KHz + 3dB: 10 watts R.M.S. output per channel into 3 or 15 ohms. **KIT £18.10.0; BUILT £22.10.0** (*Carr. either, 12/6.*)

2+2 STEREO PRE-AMP similar to Mullard 2-valve pre-amp, but doubled with gang controls and balance. **BUILT £13.19.6** (*Carr. 7/6*).

T.R.S. 4+4 STEREO AMP
Low cost transistor amplifier based on Mullard modules. 4+4 watts output. For 3-15 ohms speakers. Input switching, etc. Bass and treble controls. Simple module assembly. Amp and pre-amp with front panel and knobs.
Kit **£7.19.6** (*Carr. 3/6*); Teak sided cabinet **£1.17.6** (*Carr. 2/6*); 24V. Power pack **£2.5.0** (*Carr. 2/6*); Complete kit inc. OIN plugs and sockets **£12.10.0** (*Carr. 7/6*).

THE NEW T.R.S. P.W. 12-12



T.R.S. have produced their own kit version of this outstandingly good combined stereo amp and pre-amp. It conforms precisely to Practical Wireless's excellent circuit but is styled for a flatter, more conventional cabinet which will be shortly available. Kit includes two-tone front panel and control knobs.
Inputs—Mag. P.U. (R.I.A.A.) 2.5mV into 68 Kohms; Ceramic—Radio: Response—20Hz to 30KHz +1dB. Output—12 watts per ch. R.M.S. into 15 ohms.

Complete Kit of parts less cabinet (carr. 7/6) **£24.10**

MODULES

SINCLAIR Z.30—New power amplifier, as advertised **£4.9.6**
SINCLAIR STEREO SIXTY Pre-amp/tone control **£9.19.6**
SINCLAIR PZ.5 power supply unit **£4.19.6**
SINCLAIR IC-10 integrated circuit amplifier and pre-amp **£2.19.6**
SINCLAIR "MICROMATIC" MIDGET RADIO RECEIVER—smaller than a matchbox. Kit **49/6**; Built **59/6**.

TUNERS

T.R.S. 6 VALVE AM/FM TUNER

With power supply, valves, large illuminated station-named scale. Push button on-off and wave change, "magic eye" indicator. Tunes Med. waves and F.M. Diode output for tape.

Kit with power unit **£12.10.0** (*Carr. 7/6*).

Kit less power unit **£11.11.0** (*Carr. 7/6*).

T.R.S F.M. TUNER
Assemblies from modules obtainable separately. Features interstation suppression, A.F.C., etc. Modules and chassis, scale and tuning drive come to **£15.15.0** (*Carr. 7/6*); Mains power unit **£2.5.0** (*Carr. 3/-*); Cabinet to match "4+4" **£1.17.6** (*Carr. 2/6*); Decoder **£10.10.0** (*Carr. 2/6*).

GRAMO UNITS, PLINTHS, ETC.

GARRARD SP.25 Mk. II
10½ in. die-cast t/table, cueing device and counterbalance. Less cartridge. In maker's carton **£11.19.6** (*Carr. 7/6*)

GARRARD LM.2025
With Sonotone 9TA/HC cartridge and lift control **£10.19.6** (*Carr. 7/6*)

PLINTHS
Garrard WB.1 **£3.7.6** (*Carr. 5/-*)

Garrard Clearview Cover SCP.1 **£3.5.0** (*Carr. 4/6*)
Garrard Scandinavian Type **£5.5.0** (*Carr. 5/-*)

CARTRIDGES
When bought together with playing units. Decca Deram, **£5.5.0**; BSR TC8/H (Stereo compatible), **25/-**; BSR Stereo TC.85, **28/6**; Sonotone 9TA/HC, **60/-**; Acos GP.93-1, **30/-**.

ALWAYS IN STOCK
Resistors in all valves and types: Volume controls, mono and stereo; Capacitors; Electrolytics; Vinair; Bondacoust; Veroboard; Cir-Kit; Enamelled wire; Tinned copper wire; Plugs and sockets.
S.a.e. brings lists.

T.R.S. FOR TRANSFORMERS.
Mains and output supplied to spec. for single or short production runs. Also comprehensive service in replacement line O/P transformers. Enquiries invited. S.A.E. from private individuals please.

T.R.S. RADIO COMPONENT SPECIALISTS

70 BRIGSTOCK RD., THORNTON HEATH, SURREY

Open Saturday all day. Wednesday 1 p.m.

More than a Christmas Present!

. . . a stepping stone to a career for electronically minded teenagers.

New...Unique... **RADIONIC X30**
Radio and Electronic Construction Kit.

An educational hobby-set comprising:—
Over 30 fascinating experiments, including a printed-circuit transistor radio—which works !—Burglar-alarm, Morse Code, etc. Completely safe, battery operated. Easy to build with detailed, fully illustrated instruction manual. Radionic is used in over 2000 schools. Special cash price direct from manufacturer £7.19.6 inc. P.T. Post Free. Dispatch before Dec. 15th guaranteed for orders received before Dec. 10th.

Send cheque or P.O. to:
RADIONIC PRODUCTS LTD. Dept. W
St. Lawrence House, Broad Street, Bristol 1

WW—116 FOR FURTHER DETAILS

SPEED CHECK!

Revs per Minute or anything else per minute—

P.I. ELECTRONIC TACHOMETER

Type P.I/L with light probe
Type P.I/M with magnetic probe

- ★ **Imposes no load**
- ★ **No mechanical connection required**
- ★ **Ideal for inaccessible places**
- ★ **Lightweight for easy movement**

External D.C., Battery, and Marine engine speed versions available from—

NECO ELECTRONICS (EUROPE) LTD.,

WALTON RD., EASTERN RD., COSHAM, HANTS.
COSHAM 71711/5

LONDON OFFICE: NORTH ST., CLAPHAM, LONDON, S.W.4
TEL: 01-622 0141/3 & 3211/5

WW—117 FOR FURTHER DETAILS

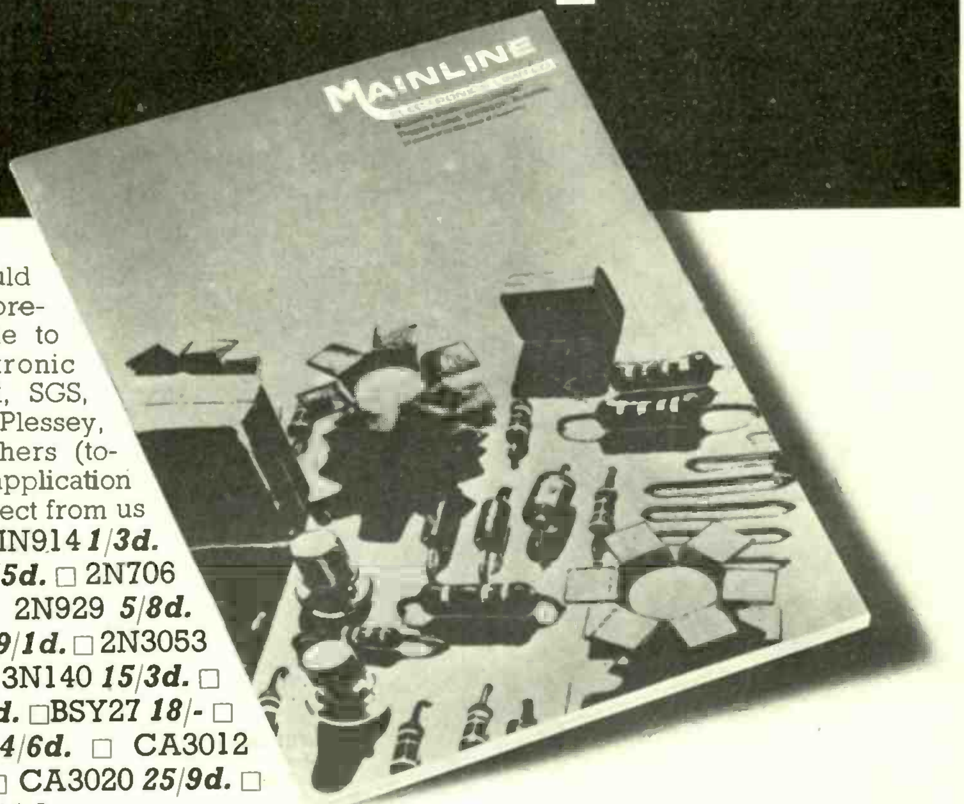
W.H.M.

WOW AND FLUTTER METER (R.M.S) MODEL 111

SYDNEY HOUSE, 35 VILLIERS ROAD, WATFORD WDI-4AL

WW—118 FOR FURTHER DETAILS

4/- brings you a mountain of components at manufacturers' prices



The serious amateur should never be without this comprehensive price list and guide to semiconductors and electronic components from RCA, IR, SGS, Emihus, Semitron, Keyswitch, Plessey, Morganite, Litesold and others (together with manufacturers' application data) which you can buy direct from us at *manufacturers' prices* e.g. IN914 ***1/3d.*** □ IN916 ***1/11d.*** □ 2N697 ***4/5d.*** □ 2N706 ***2/3d.*** □ 2N706A ***2/9d.*** □ 2N929 ***5/8d.*** □ 2N1613 ***4/8d.*** □ 2N3011 ***9/1d.*** □ 2N3053 ***6/2d.*** □ 2N3055 ***15/9d.*** □ 3N140 ***15/3d.*** □ BFY50 ***4/8d.*** □ BFY51 ***3/9d.*** □ BSY27 ***18/-*** □ BSY95A ***3/3d.*** □ C407 ***4/6d.*** □ CA3012 ***18/3d.*** □ CA3014 ***25/6d.*** □ CA3020 ***25/9d.*** □ OA200 ***1/9d.*** □ OA202 ***1/11d.***

Build the NEW Mainline Audio Amplifier kits – UP TO 70 WATTS

The result of the combined resources of SGS and RCA, these quasi circuits set new standards in quality and performance. Each kit is complete with circuit diagram, all semiconductors, resistors, capacitors and printed circuit board.

12A	**£7. 0. 0.**
25A	**£8. 5. 0.**
40A	**£9. 0. 0.**
70A	**£10.10. 0.**

Any two will make an outstanding stereo equipment.

To: Mainline Electronics Limited, Thames Avenue, Windsor, Berkshire

I enclose 4/-. Please send me your price list and guide □

I am interested in .... Amp Mainline Audio Amplifier Kits. Please send me full data □

I am interested in receiving data on preamplifier & power supply kits □

NAME__________ ADDRESS__________

(A member of the ECS Group of Companies)

WW/1269

R+TV

RADIO & TV COMPONENTS (Acton) LTD
21a High Street, Acton, London, W.3.
also 323 Edgware Road, London, W.2.
Goods not dispatched outside U.K. Terms C.W.O. All enquiries S.A.E.

Complete stereo system – 28 gns.

The new Duo general-purpose 2-way speaker system is beautifully finished in polished teak veneer, with matching vynair grille. It is ideal for wall or shelf mounting either upright or horizontally.
Type 1 SPECIFICATION.
Impedance 10 ohms. It incorporates Goodmans high flux 6" × 4" speaker and 2½" tweeter. Teak finish 12" × 6¾" × 5½". **4 guineas** each. 7/6d. p. & p.
Type 2 as type 1. Size 17½" × 10¾" × 6¾". Incorporating 10½" × 6½" bass unit and 2½" tweeter. 3 ohms impedance **5½ guineas** plus 7/6d. p. & p.
Garrard Changers from £7.19.6d. p. & p. 7/6d.
Cover and Teak finish Plinth £4.15.0d. 7/6d. p. & p.

Duetto Integrated Transistor Stereo Amplifier **9GNS.** plus 7/6d. p. & p.

The Duetto is a good quality amplifier, attractively styled and finished. It gives superb reproduction previously associated with amplifiers costing far more.
SPECIFICATION:
R.M.S. power output: 3 watts per channel into 10 ohms speakers
INPUT SENSITIVITY: Suitable for medium or high output crystal cartridges and tuners. Cross-talk better than 30dB at 1Kc/s.
CONTROLS: 4-position selector switch (2 pos. mono and 2 pos. stereo) dual ganged volume control.
TONE CONTROL: Treble lift and cut. Separate on off switch. A preset balance control.

These 5 Items can be purchased together for 28gns + £1.10p. & p.

The Classic

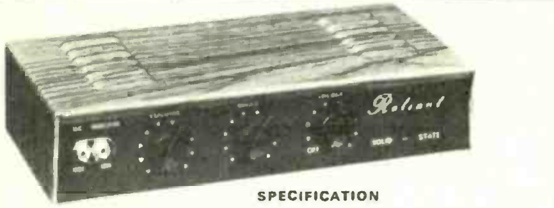
TEAK FINISHED CASE
8½ GNS.
plus 7/6 p. & p.
Built and tested.

SPECIFICATION
Sensitivies for 10 watt output at 1 KHz into 3 ohms. Tape Head: 3mV (at 3¾ i.p.s.). Mag. P.U.: 2 mV. Cer. P.U.: 80 mV. Tuner: 100 mV. Aux. 100 mV. Tape/Rec. Output: Equalisation for each input is correct to within ±2dB (R.I.A.A.) from 20 Hz to 20KHz. Tone Control Range: Bass ±13 dB at 60 Hz. Treble ±14 dB at 15 KHz. Total Distortion: (for 10 watt output) < 1.5%. Signal Noise: < −60dB. AC Mains 200-250v. Size 12½" long. 4½" deep. 2¾" high.

The Viscount

INTEGRATED HIGH FIDELITY TRANSISTOR STEREO AMPLIFIER
13½ GNS. + 7/6 p. & p.
SIZE: 12½" x 6" x 2¾" in teak-finished case.
Built and tested.

SPECIFICATION
OUTPUT: 10 watts per channel into 3 to 4 ohms speakers (20 watts) monoral.
INPUT: 6-position rotary selector switch (3 pos. mono and 3 pos. stereo). P.U. Tuner. Tape and Tape Rec. out Sensitivities: All inputs 100 mV into 1.8M ohm.
FREQUENCY RESPONSE: 40Hz-20KHz ± 2DB.
TONE CONTROLS: Separate bass and treble controls. TREBLE 13dB lift and cut (at 15KHz) BASS: 15dB lift and 25dB cut (at 50Hz).
VOLUME CONTROLS: Separate for each channel. AC MAINS INPUT: 200-240v. 50-60Hz.
Viscount Mark II for use with magnetic pick ups specification as above. Fully equalised for magnetic pick ups. Suitable for cartridges with minimum output of 4mV/cm/sec. at 1kc. Input Impedance 47k. **15 gns** plus 7/6 p.&p.



THE RELIANT MK.II

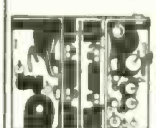
Solid State
General Purpose Amplifier
In teak-finished case
6½ GNS.
+ 7/6 p. & p.

SPECIFICATION
OUTPUT: 10 watts into a 3 ohms speaker.
INPUTS: (1) for mike (10 m.v.). Input (2) for gram. radio (250 m.v.) individual bass and treble control.
TRANSISTORS: 4 silicone and three germanium.

MAINS INPUT: 220/250 volts.
SIZE: 10½" x 4¾" x 2½".
MIKE TO SUIT (CRYSTAL): 12/6d. 1/6d. p. & p.
8" x 5" speaker 14/6d. + 3/- p. & p.
Mk. 1 5½gns. + 7/6d. p. & p. less Teak-finished case.

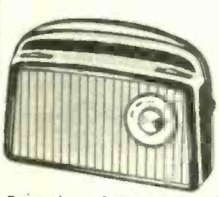
X101 10w. SOLID-STATE HI-FI AMP

With Integral Pre-amp.



Specifications: Power Output (into 3 ohms speaker) 10 watts. Sensitivity (for rated output): 1mV into 3K ohms (0.33 microamp) Total Distortion (at 1 KHz): At 5 watts 0.35%: At rated output 1.5%. Frequency Response: Minus 3 dB points 20 Hz and 40 KHz. Speaker: 3-4 ohms. (3-15 ohms may be used). Supply voltage: 24v D.C. at 800 mA. (6-24v may be used).

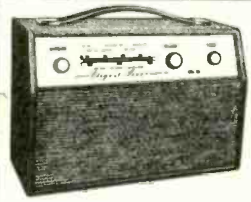
69/6 plus 2/6 p. & p.
CONTROL ASSEMBLY: (including resistors and capacitors). 1. Volume: Price 5/-. 2. Treble: Price 5/-. 3. Comprehensive bass and treble: Price 10/-. The above 3 items can be purchased for use with the X101. **POWER SUPPLIES FOR X101:** P101 M (mono) 35/- p. & p. 4/6: P101 (stereo) 42/6 p. & p. 4/6.



THE DORSET

(600mW Output)
£5.5.0
plus 7/6 p. & p.
Circuit 2/6. FREE WITH PARTS
MAINS POWER PACK KIT: 9/6 extra.

7-transistor fully tunable M.W.-L.W. superhet portable—with baby alarm facility. Set of parts. The latest modulized and pre-alignment techniques makes this simple to build. Sizes: 12" x 8" x 3".

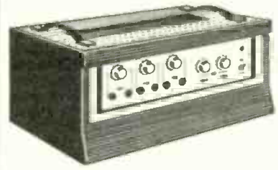


ELEGANT SEVEN MK. III

(350mW Output)
£4.9.6
plus 7/6 p. & p.
Circuit 2/6. FREE WITH PARTS
MAINS POWER PACK KIT: 9/6 extra.

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.

50 WATT AMPLIFIER



AC MAINS 200-250V
27 gns.
plus 20/- p. & p.

An extremely reliable general purpose valve Amplifier—with six electronically mixed inputs. Suitable for use with: mics, guitars, gram, tuner, organ, etc. Separate bass and treble controls. Output impedance 3, 8 and 15 ohms.

CYLDON 2 TRANSISTOR U.H.F. TUNER

Brand new. Complete with circuit diagram.
£2.10 + 1/- p. & p.

STEREO PRE-AMPLIFIER

Inputs—6 position rotary switch (3 position mono, 3 position stereo). Tuner 150 mV into 680k. Magnetic pick-up fully equalised and suitable for magnetic cartridges with minimising output of 4mV/cm/sec. Load 47k. Ceramic pickup 150 mV into 680k. Sensitivities taken for 200mV output. Controls—separate volume controls for each channel. Twin ganged bass. 12dB lift and 15dB cut at 60c/s. Twin ganged treble. 10dB lift and 15dB cut at 10kc/s. Voltage required 23-30v DC at 5mA. Size 12½" x 3½" x 2¾". In teak finished case, complete with front panel and knobs. Built and tested £7.7.0 plus 5/- p. & p.

SPECIAL OFFER

Complete stereo systems comprising BALFOUR 4 speed auto player with stereo head 2 DUO speaker systems size 12 x 6¾ x 5¾. Plinth (less cover) and the DUETTO stereo amplifier. All above items
19 GNS. plus 20/- p. & p.

L.S.T. ELECTRONIC COMPONENTS LTD.

AA119	2/-	BC142	15/-	BYY25	31/9	NKT217	13/-	OC24	10/-	2G302	3/9	2N2369	5/6
AAY11	2/1	BC143	15/-	BYY142	3/9	NKT218	5/3	OC25	6/9	2G339A	5/-	2N2369A	6/-
AAZ12	17/6	BC147	4/7	BYZ10	9/-	NKT221	5/6	OC26	12/-	2G374	5/-	2N2432	58/4
AC107	14/6	BC148	3/3	BYZ12	6/-	NKT222	4/-	OC28	12/-	2G381	5/-	2N2477	18/-
AC126	6/6	BC149	4/7	BYZ13	5/-	NKT223	6/-	OC29	15/-	2G371	4/-	2N2484	14/-
AC127	6/-	BC154	12/-	C106F1	9/-	NKT223A	3/6	OC35	9/6	2G371B	3/-	2N2613	8/3
AC127Z	8/6	BCY10	7/6	C111	18/-	NKT224	4/6	OC36	13/-	2N174	24/-	2N2614	7/6
AC128	4/-	BCY12	7/6	C111E	12/-	NKT225	3/6	OC41	3/6	2N301	8/-	2N2646	10/-
AC151	8/8	BCY30	7/2	C400	9/-	NKT226	10/-	OC42	4/-	2N109	13/6	2N2894	13/9
AC176	7/6	BCY31	9/2	C426	8/3	NKT227	5/6	OC43	4/-	2N217	7/6	2N2904A	15/6
AC187	12/-	BCY32	20/5	CG6E	4/-	NKT228	6/-	OC44	3/-	2N352	15/-	2N2924	5/-
AC188	12/-	BCY33	4/11	CG63	2/-	NKT261	4/3	OC45	3/-	2N386	12/-	2N2925	5/6
ACY17	5/9	BCY34	6/6	D13T1	10/-	NKT270	3/6	OC70	3/-	2N384	17/-	2N3036	39/2
ACY18	3/6	BCY38	8/-	EA403	3/6	NKT271	5/-	OC71	3/-	2N385A	15/-	2N3053	8/-
ACY19	4/5	BCY39	28/-	EC401	5/-	NKT272	5/-	OC72	4/6	2N388A	15/-	2N3054	15/-
ACY20	3/7	BCY40	16/-	EC402	4/8	NKT273	4/-	OC73	3/-	2N370	15/-	2N3055	15/-
ACY21	4/-	BCY42	4/-	EB383	3/6	NKT274	5/-	OC75	5/-	2N404	4/2	2N3394	6/-
ACY22	2/11	BCY43	4/-	GET102	6/-	NKT275	5/-	OC76	2/6	2N410	6/-	2N3702	3/6
ACY30	9/-	BCY54	17/4	GET103	4/6	NKT276	3/6	OC77	9/3	2N456A	20/-	2N3703	3/3
AD140	15/-	BCY70	4/4	GET104	5/-	NKT279A	2/6	OC81D	3/-	2N458A	33/-	2N3704	3/9
AD149	11/8	BCY71	8/8	GET105	8/-	NKT281	5/-	OC81	4/6	2N511A	50/3	2N3705	3/4
AD161	6/-	BCY72	4/8	GET114	5/-	NKT301	16/-	OC82	4/6	2N513A	118/5	2N3706	3/10
AD162	6/-	BCY87	86/9	GET875	6/-	NKT302	11/2	OC82D	3/-	2N514B	192/-	2N3707	4/-
ADT140	12/6	BCZ11	10/8	GET573	7/6	NKT303	10/2	OC83	4/-	2N599	12/-	2N3708	2/5
AF102	18/-	BD119	15/-	GMO290	13/5	NKT304	9/8	OC84	4/-	2N601	5/-	2N3709	3/9
AF114	4/4	BD121	18/6	GMO378	11/-	NKT351	8/-	OC123	7/-	2N657	15/4	2N3710	3/10
AF115	4/4	BD123	23/6	GEX45/1	4/-	NKT352	7/6	OC139	8/-	2N696	5/3	2N3711	3/3
AF116	4/4	BD124	15/-	K8/15	4/-	NKT402	24/-	OC140	12/-	2N697	5/3	2N3819	8/-
AF117	4/4	BF152	13/6	K8/30	9/-	NKT403	16/-	OC169	6/-	2N698	4/6	2N3820	18/9
AF118	16/6	BF154	9/-	K3/50	8/3	NKT404	13/8	OC170	4/-	2N706	3/-	2N3826	6/-
AF124	6/-	BF159	15/-	MAT100	5/-	NKT405	15/-	OC171	6/-	2N706A	3/-	2N3906	7/6
AF126	3/9	BF163	9/-	MAT101	5/6	NKT451	13/8	OC200	6/3	2N708	4/-	2N4058	7/9
AF127	4/-	BF167	6/6	MAT120	5/-	NKT452	13/4	OC201	10/-	2N711	7/6	2N4284	3/-
AF139	8/-	BF173	6/2	MAT121	5/6	NKT453	12/-	OC202	18/10	2N711A	7/6	2N4285	3/-

PRICES FOR QUANTITIES IN EXCESS OF 100 PIECES ON APPLICATION

FIRST GRADE + FAST SERVICE

When enquiring for types not listed please enclose a STAMPED ADDRESSED ENVELOPE

AF181	12/-	BF178	14/-	ME4103	6/-	NKT674	6/-	OC203	8/3	2N715	7/6	2N4286	3/-
AF186	11/-	BF179	12/-	MJE520	15/-	NKT675	5/-	OC204	8/-	2N716	7/6	2N4287	3/-
AF239	12/-	BF180	6/-	MPF102	9/-	NKT676	5/-	OC205	9/-	2N718	7/2	2N4288	3/-
AFZ11	14/-	BF181	7/-	MPF103	9/-	NKT677	5/-	OC206	10/6	2N743	5/-	2N4289	3/-
AFZ12	11/9	BF184	7/6	MPF104	9/-	NKT703	8/-	OC207	7/6	2N744	5/6	2N4290	3/-
ASY26	4/5	BFX13	4/10	MPF105	9/-	NKT713	7/6	ORP12	9/6	2N753	5/-	2N4291	3/-
ASY27	6/-	BFX29	8/-	MPS3638	6/-	NKT773	6/-	ORP60	8/-	2N863	12/-	2N4292	3/-
ASY28	4/5	BFX44	6/5	MJ480	21/-	NKT774	5/4	ORP61	8/-	2N911	7/6	2N4303	15/-
ASY29	6/-	BFX87	6/-	MJ481	27/-	NKT0013	12/6	ORP63	9/-	2N914	4/3	2N4871	6/9
ASZ21	11/-	BFY50	4/6	MJ491	30/3	NKT10419	13/-	ORP93	24/-	2N918	15/-	2S002	15/-
ATZ10	40/-	BFY51	3/9	NKT121	10/11	NKT10519	12/6	OC309	12/-	2N929	5/6	2S004	23/-
AUY10	39/6	BFY52	4/6	NKT122	7/9	NKT10339	10/3	P346A	6/-	2N930	6/8	2S017	15/-
AFY19	16/10	BFY53	3/2	NKT123	6/2	NKT10429	11/3	RAS310AF	6/-	2N1131	9/6	2S018	12/6
BA110	6/-	BSX20	3/4	NKT124	9/8	NKT20329	12/6	RAS508AF	15/-	2N1132	7/6	2S020	15/-
BA111	6/-	BSX21	8/-	NKT125	6/2	NKT16229	11/-	ST2	9/9	2N1143	26/2	2S024	25/-
BA112	18/-	BSY27	4/-	NKT127	5/8	OA5	3/8	ST140	3/-	2N1177	14/-	2S034	12/6
BA115	2/8	BSY95A	3/4	NKT128	6/-	OA10	6/-	ST141	5/-	2N1302	4/6	2S102	10/-
BA130	3/-	BTX39/		NKT129	5/10	OA47	1/6	TIS44	1/7	2N1303	4/6	2S104	12/6
BAY31	2/6	600R	120/-	NKT141	6/11	OA70	1/6	TIS43	6/9	2N1304	5/-	2S301	7/7
BAY38	3/-	BTX40/		NKT142	5/10	OA73	1/6	U23AAA	5/-	2N1305	5/-	2S302	6/-
BC107	2/9	600R	120/-	NKT143	5/4	OA79	1/6	V405A	9/3	2N1306	6/6	2S304	15/-
BC108	2/9	BTY87/		NKT144	8/-	OA81	1/6	XA102	6/-	2N1307	6/6	2S320	12/6
BC109	2/9	150R	31/-	NKT152	3/4	OA85	1/6	XA702	15/-	2N1308	8/-	2S322	8/-
BC113	5/-	BTY91/		NKT161	5/8	OA90	1/6	ZT22	19/-	2N1309	8/-	2S701	10/-
BC114	7/5	300R	47/-	NKT162	5/8	OA91	1/6	ZT86	27/6	2N1507	4/8	2S702	12/-
BC115	7/11	BY100	5/-	NKT163	5/4	OA95	1/6	ZT2270	19/6	2N1613	6/6	2S711	23/3
BC116	9/-	BY125	3/6	NKT164	5/4	OA200	2/-	IN23A	20/-	2N1496	34/6	2S712	30/3
BC118	5/-	BYX10	3/-	NKT165	5/8	OA202	2/-	IN34A	4/-	2N1711	7/6	2S733	9/9
BC125	12/-	BYX36/150	2/6	NKT211	6/-	OA210	6/4	IN60	4/-	2N2147	17/-	40361	13/3
BC126	12/-	BYX36/300	2/10	NKT212	6/-	OA211	9/-	IN64	4/-	2N2148	12/6	40362	16/3
BC134	5/-			NKT213	6/-	OC19	5/-	IN82A	9/6	2N2160	14/9		
BC136	7/11	BYX36/600	3/8	KNT214	4/-	OC20	33/-	IN87A	4/6	2N2218	12/-	ZT22	19/-
BC137	8/6	BYY21	25/-	NKT215	4/-	OC22	13/-	IN191	5/-	2N2243	23/7	ZT86	27/6
BC138	12/-	BYY23	26/3	NKT216	10/5	OC23	15/-	IS44	1/6	2N2368	6/6	ZT2270	19/6

COMPONENTS

RESISTORS ¼ or ½ Watt 5% **LOW NOISE CARBON FILM.** 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 ohms and decades (×10, ×100, ×1,000, ×10,000) 1 Meg etc. to 8.2 Megohms (10% tolerance). PRICES: 1-25 **4d**, 26-99 **3d**, 100+**2d** (your selection ¼ and/or ½ Watt mixed).

SKELETON PRESET POTS. 20% Tol. Linear. Low noise. Available in sub-miniature or standard size, horizontal or vertical. 100, 250, 500, 1k, 2.5k, 5k, 10k, 25k, 50k, 100k, 250k, 500k, 1 Meg, 2.5 Meg, 5 Meg. NEW PRICE: 1/- each or any selection of 12 pieces 10/-.

ELECTROLYTIC CAPACITORS (Mullard). -10% to +50% tol. Subminiature (all values in μF).

4V	8	32	64	125	250	400
6.4V	6.4	25	50	100	200	320
10V	4	16	32	64	125	200
16V	2.5	10	20	40	80	125
25V	1.6	6.4	12.5	25	50	80
40V	1	4	8	16	32	50
64V	0.64	2.5	5	10	20	32
Price	1/6	1/3	1/2	1/-	1/1	1/2

MIN. POLYESTER CAPACITORS. Printed circuit type 250 Vdc working. 0.01, 0.015, 0.022, **7d** each; 0.033, 0.047, **8d** each; 0.068, 0.10, **9d** each.

VEROBOARD 0.15" Matrix FLUX COATED 2½ × 3¾", 3/3. 2½ × 5", 3¾ × 3¾", 3/11. 3¾ × 5", 5/6. 3¾ × 18", 18/-. BARGAIN PACK of 36 square inches all good size pieces only 10/- pack.

VEROBOARD 0.1" Matrix, 3¾ × 2½", 3/9.

VEROPINS for 0.15", 36 pieces 3/-.

VEROCUTTER 9/- (including free sample pieces).

S-DeCs Single "DeC" with accessories and project manual .. 29/6
"2-DeC" kit contains two "DeCs" component tray accessories, instruction book, all packed in attractive plastic box 69/6
"4-DeC" kit contains four "DeCs", accessories, manual, etc. 117/6

BOOKS FROM STOCK
General Electric Transistor Manual, 660 pages of data and circuits 29/6
RCA Transistor Manual, 554 pages, includes SCR circuits 28/-
Designers' Guide to British Transistors. Excellent data book lists over 1,000 common types plus Computer-selected substitution chart 25/-
(ADD 2/6 POST & PACKING FOR ALL BOOKS)

NEONS
Signal neons for many types of circuit, type "N" Price 1/6 each or 16/- dozen.

HEATSINKS. Suitable for 2 × OC35, etc. As used in commercial equipment. Type 10D 6/-

ALUMINIUM CHASSIS
6 × 4 × 2½" with reinforced corners 6/9 each (P & P 1/6). Ally panel to fit 1/6. Paxolin panel to fit 2/-. Many other sizes in stock up to 12 × 8 × 2½" (see catalogue).

ZENER DIODES. 400mW 10%. Tolerance. Complete range preferred values 3 volt to 30 volt, each .. 3/6

SOLAR CELLS
B2M 0.2–0.4 volts @ 2mA Selenium type 12/6
B3M 0.2–0.4 volts @ 1½–2½mA Selenium type .. 15/-
S1M 0.3–0.4 volts @ 10–16mA Silicon 19/-
S4M 0.3–0.4 volts @ 25–40mA Silicon 33/6

2N3819 Texas FET **8/-**
25+6/9 100+5/9

2N4871 MOTOROLA Unijunction **6/9**
25+5/9 100+4/9

μ LOGIC

These are new Prices.

	1-6	7-11	12+
uL900	9/9	9/-	8/-
uL914	9/9	9/-	8/-
uL923	13/-	12/-	11/-

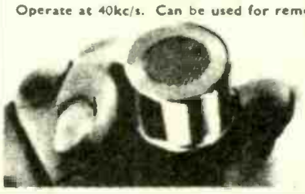
Five Page Data and Circuits article . 2/6
Larger quantity prices (100+ and 1,000+) on application.
Plastic Spreaders 1/6

SILICON RECTIFIERS

PIV	200mA	750mA	2 Amp	10 Amp
50	6d	1/-	2/3	—
100	9d	1/6	2/3	4/6
200	1/3	2/-	2/9	5/-
400	—	2/6	4/-	8/-
600	—	3/-	4/6	9/6
800	—	3/9	5/-	11/3
1000	—	6/-	6/6	14/-

ULTRASONIC TRANSDUCERS

Operate at 40kc/s. Can be used for remote control systems without cables or electronic links. Type 1404 trans-ducers can transmit and receive.



FREE: With each pair our complete transmitter and receiver circuit.
PRICE £5.18.0 Pair
(Sold only in pairs)

2N3055 115 WATT POWER **15/-**
25+13/- 100+11/-

BF180 MULLARD UHF AMPLIFIER **6/-**
25+4/11 100+4/3

THYRISTORS-SCRs

PIV	1A	3A	10A	30A	100A
50	7/6	9/-	7/6	25/-	20/-
100	—	10/-	10/-	30/-	22/-
200	8/6	—	12/6	42/-	35/-
300	—	11/-	—	51/-	—
400	9/6	12/6	15/-	60/-	45/-
600	—	—	20/-	84/-	120/-
800	—	—	—	—	—

56CAY Gallium Arsenide Infra-Red emitter
29/6 each. (Incl. data)

2N2614 RCA LOW NOISE AUDIO **4/9**
25+4/- 100+3/-

Prices quoted are current at time of going to press and may be subject to variation.
Semiconductors offered bear Manufacturers' original markings and are subject to our full replacement guarantee if not to published specifications.
WE DO NOT offer "Re-marked" Semiconductors.
Our 1969/70 Catalogue is available FREE on request.
Please enclose a stamped addressed envelope with any queries.
Quantity Prices on application.
Retail: Cash with order, please.
Trade: Please furnish usual references if Credit facilities required.

Post & Packing 1/- per order (FIRST CLASS).

BC107/8/9 Planars 2/9

CRS3/40AF STC/ITT Thyristor 12/6
400piv 3Amp
25+11/- 100+10/3

NEW SPECIAL ITEMS!!

40602— Dual Gate MOS-FET 9/- each
L14B— Photo-Darlington Amplifier 26/6
MGA100—Gallium Arsenide Infra Red Light Source 35/-
31F2— Infra Red Detector Diode 28/6
3N84— Silicon Controlled Switch 29/6
TAA320—Monolithic IC with MOS-FET input followed by Bi-Polar transistor 13/6
Datasheets 1/- on request—free with above items.

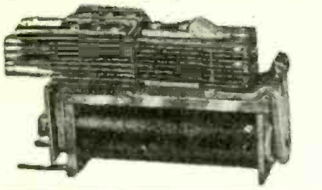
TAA263 MULLARD LINEAR IC **17/6**

2N2926 LOW COST NPN PLANAR **2/-**
25+1/8 100+1/6

SC41D GE Triac
400piv 6amp **37/6**

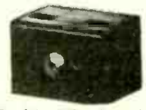
MAIL ORDER DEPT. & RETAIL SHOP:—
LST, 7 Coptfold Road, Brentwood, Essex
Telephone: 226470/1 (Sales Department)
EXPORT ENQUIRIES PARTICULARLY WELCOME
GIRO No. 388-3159

Wilkinsons FOR RELAYS



P.O. TYPE 3000 AND 600

BUILT TO YOUR REQUIREMENTS—QUICK DELIVERY
COMPETITIVE PRICES—VARIOUS CONTACTS
DUST COVERS—QUOTATIONS BY RETURN
LARGE STOCKS HELD OF MINIATURE SEALED RELAYS



EQUIPMENT WIRE P.V.C. covered 80/- per 1,000 yds. 7/.0076, 1/.024, 14/.0048 type 1 and 2, all colours. 14/.0076 type 11 Red and Natural £15 per 1,000 yds. 140,000 yds. available.

MINIATURE SILVER ZINC ACCUMULATOR. 1.5 volt, 1.5 ampere. Size 2×1.13×0.63in. Weight 1¼ oz. Ideal for model work, 12/6 each. 120/- doz., post 1/6.

STROBOSCOPE FORK. 125 cycles. P.O. No. 5, 30/- each, post 2/6.

LEDEX ROTARY SOLENOIDS AND CIRCUIT SELECTORS. SIZE 5s. 4 pole, 11 way and off 110/-, 4 pole, 12 way 110/-, 24 pole, 11 way and off 210/-, 54 pole On/Off 150/-.

N.S.F. SOLENOIDS type 3E 115.2 ohms 48v. D.C. 17/6 ea.

CERAMIC AND PAXOLIN WAFER SWITCHES available from stock at keen prices, send for list. 24 way Double Pole Pax Wafer Switches 12/6 each, post 2/6.

P.O. STANDARD RACKS 6ft. U channel sides drilled for 19in. panels heavy angle base, 150/-, cge 20/-. Desk Units for Racks 30/-, cge 7/6.

MINIATURE BUZZERS. 12v. with tone adjuster. 7/6.

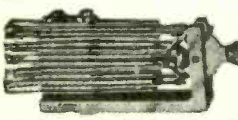
PLASTIC-FILM CONDENSERS TMC S125017LM 0.9+0.1 mfd. 500v. also 1 mfd. 1%. 150v. TCC 20/- each.

AIR BLOWERS. 200/250 volt. A.C. cylindrical 7in.—7in. suitable for intake or extraction. 1/50th h.p. £10. 1/15th h.p. £11. 1/10th h.p. £14.

ELCOM STUD SWITCHES. 12 pole 2 way or 3 way types on 3 Banks, break before make action, 50/- each.

GEARED MOTORS. 1 r.p.m. or 3 r.p.m. 4 watts very powerful, reversible 24v. A.C. 35/-, post 2/6, can be operated from 230v. with our 20/- Transformer. Post 5/-.

VACUUM GAUGES. 2in. scaled. 0/30 inches of mercury, 20/- each, post 2/6.



STANDARD LEVER KEYS, 3 POSITION 4C lock/4C lock 17/6 each. Stop/6C 15/6 each. 2C 2M non-lock/2C 2M non-lock 14/6 each. 4C non-lock/6C lock 20/- each.

ONE HOLE FIXING. Stop/4 C.O. non-locking 2 position 10/6. 6 C.O. lock/2 C.O. lock 3 position 17/6.

TRANSFORMER. 200/240v., tapped 6.3v., 8.3v., 10.3v. at 17 amps 5kv. wkg., 70/-, post 6/-.

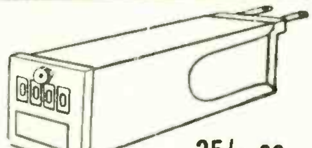
LAMP HOUSES with pair of 6in. lenses mounted in a 9in. square case. Ideal spotlight 70/- each, post 10/-.

BATTERY CHARGERS at special price made by Westinghouse, worth £35. Input 200/250v. A.C. output 6v. 15 amps D.C. with ammeter, fuses; regulated by a 4-position switch and sliding resistance. **OUR PRICE 170/-.** Cge. 15/-.

MINIATURE DIGITAL DISPLAY SERIES 661 Counting Insts. Ltd., an assembly of five units each displaying 11 messages in numbers with decimal point, and letters £25 complete, send for details.

HIGH SPEED COUNTERS

3¼ × 1in., 10 counts per second with 4 figures. The following D.C. voltages are available, 6v., 12v., 24v., 50v. or 100v.



35/- ea.

SUB-MINIATURE Microswitch Honeywell S.P.D.T. type 11 SMI TN 13 size ⅝in. × ⅜in. × ¼in. 6/6 each, or mounted in fives for 22/6 post free.

JACK PLUGS. 2 Point with screw-on cover, 2/6, post 9d. PO 201 on headphone cord 3/-, post 1/6.

PLUG-IN RELAYS. Londex 4 change-over HD contacts 28v. D.C. or 240v. A.C. with base and cover, 35/- each.

RELAYS, 24 volt D.C., 4 make, 4 break heavy duty contacts with dust cover, 12/6 each, quantities available.

UNISELECTOR DIGIT SWITCHES 8 level 12 outlets 3 bridging 5 non-bridging 50 volts. £8/10/-.

STABILIZED POWER UNITS RACAL. Inst. type PU 156C, A.C. Input 200/250v. D.C. output positive HT 200/300v. stabilized Load current 250 mA negative HT 150v. stabilized 15 mA. £45.

ROOM THERMOSTAT. Adjustable between 45 and 75 deg. Far., 250v. 10 amp. A.C. ideal for greenhouses, 35/- Post 4/6.

TERMINAL BLOCKS. 2 way 5C/430 or 3 way 5C/432 50/- per 100 or £20 per 1,000. (As illustrated.)

ROBUST AIRCRAFT PUSH. 5C/898 of bakelite barrel type construction, with 1¾in. square hole fixing top with actual push below the level of a 1in. bakelite circle to prevent it being used accidentally. Samples 5/- each large quantities available.

MAGNETIC COUNTERS. Veeder Root with zero reset. 800 counts per minute, counting to 999,999, 110 or 125 volts A.C. or 110 volts D.C. 65/- each, post 3/-.

VACUUM CONDENSERS, 25 pf., 32 KV, 27/6, post 3/-.

METERS GUARANTEED. Complete list available.

Microamps 0/500 2in. MC	25/-
Microamps 0/500 2½in. MC	37/6
Milliamps 0/50 2½in. MC	35/-
Milliamps 0/500 3½in. MC	54/-
Amps 50-0-50 2in. MC	17/6
Amps 0/5 2in. MC	42/6
Volts 5/0/5 2½in. MC	25/-
Volts 0/20 2in. MC	42/6
Volts 0-40 2in. MC	42/6
Volts 0/10 A.C. 3½in. MCR	70/-

MICROAMPS 0/50 scaled in Rontgens 2½in. MC 45/-.

PORTABLE VOLTMETERS 0/250 Moving Iron A.C./D.C., 6in. scale, in polished wood case, £7/10/-.

ONE HOLE FIXING SWITCHES DOUBLE POLE ON/OFF

3 amp 250 volt A.C. 1¼in. × ⅞in. × ⅞ in. 30/- per dozen, 200/- per 100. Post 3/- per dozen, 6/- per 100.

MASTER CONTACTOR. Precision made. Contacts making and breaking twice per second in sound proof case, thermostat controlled heating. 12 or 24v. 18/6, post 6/-.

VISCONOL-CATHODRAY" CONDENSERS. .001 mfd. 10 kV, 5/-; .002 mfd. 15 kV, 9/-; .02 mfd. 10 kV, 10/-; .025 mfd. 2.5 kV, 5/-; .05 mfd. 5 kV, 9/-; 0.1 mfd 4 kV, 9/-; 6 kV, 17/6; 0.5 mfd. 2.5 kV, 17/6; 1 mfd. 2 kV. 17/6.

RESISTORS, wire wound or carbon, potentiometers, condensers, quantities ex-stock at low prices.

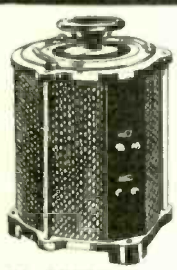
BRIDGE MEGGER series 1. With resistance box 1,000 volts, range 0/100 megohms-infinity, usual price £189, our price £60.

L. WILKINSON (CROYDON) LTD.
LONGLEY HOUSE LONGLEY RD. CROYDON SURREY

Phone : 01-684-0236 Grams: WILCO CROYDON

NO EXCUSES! NO DELAYS! FROM STOCK!

VARIABLE VOLTAGE TRANSFORMERS



50 AMPS

1 AMP.

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.

BRAND NEW. Keenest prices in the country. All Types (and spares) from ½ to 50 amp. available from stock.

0–260 v. at 1 amp.	£5	10	0
0–260 v. at 2·5 amps.	£6	15	0
0–260 v. at 5 amps.	£9	15	0
0–260 v. at 8 amps.	£14	10	0
0–260 v. at 10 amps.	£18	10	0
0–260 v. at 12 amps.	£21	0	0
0–260 v. at 15 amps.	£25	0	0
0–260 v. at 20 amps.	£37	0	0
0–260 v. at 37·5 amps.	£72	0	0
0–260 v. at 50 amps.	£92	0	0

20 DIFFERENT TYPES AVAILABLE FOR IMMEDIATE DELIVERY.

Double Wound Variable Transformers

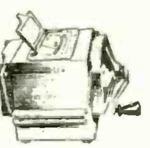
Fully isolated, low tension Secondary winding. Input 230 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.

0-36 v. at 5 amp. £9.12.6— p. & p. 8/6

0-36 v. at 20 amp. £21.0.0— 15/- p. & c.

These fully shrouded Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.

INSULATION TESTERS (*NEW*)



Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8in., W. 4in., H. 6in. Weight 6lb.

500 VOLTS, 500 megohms. Price **£28** carriage paid.

1,000 VOLTS, 1,000 megohms, **£34** carriage paid.

5Amp.AC/DC VARIABLE VOLTAGE OUTPUT UNIT

Input 230 v. A.C. Output 0-260 v. A.C. Output 0-240 v. D.C. Fitted large scale ammeter and voltmeter. Neon Indicator, fully fused. Strong attractive metal case 15in.× 8¾in.×6in. Weight 24 lb. Infinitely variable, smooth stepless voltage variation over range. **Price £38 plus 30/- p. & c.** Similar in appearance to illustration below.

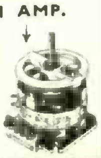
OPEN TYPES

Designed for Panel Mounting.
Input 230 v. A.C. 50/60
Output variable.
0-260 v.

½ amp	£3 10 0
1 amp.	£5 10 0
2½ amp.	£6 12 6

P. & P. 7/6

½ AMP. 1 AMP.



VAN DE GRAAF ELECTROSTATIC GENERATOR

fitted with motor drive for 230 v. A.C. giving a potential of approx. 50,000 volts. Supplied absolutely complete including accessories for carrying out a number of interesting experiments, and full instructions. This instrument is completely safe, and ideally suited for School demonstrations. Price £7/7/-, plus 4/- P. & P. L't. on req.

CONSTANT VOLTAGE TRANSFORMER

Input 185-250 v. A.C. Output constant at 230 v. AC. Capacity 250 watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17lbs. Price **£11/10/-,** P. & P. 10/-.

LATEST TYPE SOLIO STATE VARIABLE CONTROLLER

Ideal for lighting and heating circuits, compact panel mounting. Built in fuse protection. CONTINUOUSLY VARIABLE.
Input 230v AC output 25-230v AC
5 amp model **£8. 7. 6**
10 amp model **£13. 5. 0**

SPEEDIVAC HIGH VOLTAGE HIGH FREQUENCY GENERATOR

Input 100/110 volts or 200/250 volts AC/DC Output 19KV variable. Ideal for testing insulation, vacuum, leakage path, gas discharge lamps, neon etc. A useful ozone and HF supply. Manufactured by Edwards High Vacuum Ltd. Brand new in maker's polished wooden carrying case. Offered at fraction of maker's price. £10.0.0 plus 7/6 p. & p.

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit

INPUT
220/240 v. A.C.
OUTPUT
CONTINUOUSLY VARIABLE 0-36 v.

Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £55 plus 40/- p. & c.

SERVICE TRADING COMPANY

NEW PRICES ON NEW COMPONENTS

RESISTORS
High stability, carbon film, low noise. Capless construction, molecular termination bonding.
Dimensions (mm.): Body: ¼W: 8 × 2·8
½W; 10 × 4·3
Leads: 35
10% ranges; 10 Ohms to 10 Megohms (E12 Renard Series).
5% ranges; 4·7 Ohms to 1 Megohm (E24 Renard Series).
Prices—per Ohmic value.

		each	10 off	25 off	100 off
¼W	10%	2d.	1/6	3/3	10/4
¼W	5%	2½d.	1/9	3/8	11/8
½W	10%	2½d.	1/9	3/8	11/7
½W	5%	3d.	2/-	4/-	12/10

CAPACITORS
Subminiature Polyester film, Modular for P.C. mounting. Hard epoxy resin encapsulation. Radial leads.
±10% tolerance. 100 Volt working.
Prices—per Capacitance value (μF)

	each	10 off	25 off	100 off
0·001, 0·002, 0·005, 0·01, 0·02 ..	6d.	4/3	8/4	30/-
0·05	8d.	6/-	12/6	41/8
0·1	10d.	7/1	15/6	51/-
0·2	1/2	10/-	20/10	68/6

Polystyrene film, Tubular, Axial leads. Unencapsulated ±5% or ±1pf tolerance, 160 Volt Working.
Prices—per Capacitance value (μμF)

	each	10 off	25 off	100 off
10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82, 100, 120, 180, 220, 270, 330, 390	5d.	3/7	7/9	24/-
470, 560, 680, 820, 1,000, 1,500	6d.	4/-	8/8	26/8
2,200, 3,300, 4,700, 5,600 ..	7d.	5/-	10/10	33/4
6,800, 8,200, 10,000, 15,000 ..	8d.	6/-	13/-	40/-
22,000	9d.	6/9	18/-	45/4

POTENTIOMETERS (Carbon)
Superior grade enclosed controls. Low rotational noise. Body dia., 1in. Spindle, 2in. × ¼in. Tolerance, 20%.
Linear: 1K to 2M. (¼W at 40°C).
Logarithmic: 5K to 2M. (¼W at 40°C).

	each	10 off	25 off	100 off
Prices per ohmic value	2/-	18/4	41/8	150/-

GANGED STEREO POTENTIOMETERS (Carbon)
¼W at 70°C. Long Spindle.
Logarithmic and Linear: 5k + 5k to 1M + 1M.

	each	10 off	25 off	100 off
Prices per ohmic value	8/-	70/-	162/6	575/-

SKELETON PRE-SET POTENTIOMETERS (Carbon)
High quality pre-sets suitable for printed circuit boards of 0·1in. P.C.M. 100 ohms to 5 Megohms (Linear only). Miniature: 0·3W at 70°C. ±20% below ½M. ±30% above ½M. Horizontal (0·7in + 0·4in. P.C.M.) or Vertical (0·4in. × 0·2in. P.C.M.). Subminiature: 0·1W at 70°C. ±20% below 2·5M. ±30% above.

Prices—per ohmic value	each	10 off	25 off	100 off
Miniature (0·3W)	1/-	8/9	18/9	66/8
Subminiature (0·1W)	10d.	7/1	14/7	46/8

ELECTROLYTIC CAPACITORS (Mullard.) —10% to +50%.
Subminiature (all values in μF)

4V	8	32	64	125	250	400
6·4V	6·4	25	50	100	200	320
10V	4	16	32	64	125	200
16V	2·5	10	20	40	80	125
25V	1·6	6·4	12·5	25	50	80
40V	1	4	8	16	32	50
64V	0·64	2·5	5	10	20	32
Price	1/4	1/3	1/2	1/-	1/1	1/2

Small (all values in μF)

4V	800	1,250	2,000	3,200
6·4V	640	1,000	1,600	2,500
10V	400	640	1,000	1,600
16V	250	400	640	1,000
25V	160	250	400	640
40V	100	160	250	400
64V	64	100	160	250
Price	1/6	2/-	2/6	3/-

POLYESTER CAPACITORS (Mullard)
Tubular 10%, 160V: 0·01, 0·015, 0·022μF, **7d.** 0·033, 0·047 μF, **8d.** 0·068, 0·1 μF, **9d.** 0·15 μF, **11d.** 0·22 μF, **1/-.** 0·33 μF, **1/3.** 0·47 μF, **1/6.** 0·68 μF, **2/3.** 1 μF, **2/8.**
400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, **6d.** 6,800pF, 0·01, 0·015, 0·022 μF, **7d.** 0·033 μF, **8d.** 0·047 μF, **9d.** 0·068, 0·1 μF, **11d.** 0·15 μF, **1/2.** 0·22 μF, **1/6.** 0·33 μF, **2/3.** 0·47 μF, **2/8.**

SEMICONDUCTORS: OA5, OA81, **1/9.** OC44, OC45, OC71, OC81, OC81D, OC82D, **2/-.** OC70, OC72, **2/3.** AC107, OC75, OC170, OC171, **2/6.** AF115, AF116, AF117, ACY19, ACY21, **3/3.** OC140, **4/3.** OC200, **5/-.** OC139, **5/3.** OC25, **7/-.** OC35, **8/-.** OC23, OC28, **8/3.**

SILICON RECTIFIERS (0·5A): 170 P.I.V., **2/9.** 400 P.I.V., **3/-.** 800 P.I.V., **3/3.** 1,250 P.I.V., **3/9.** 1,500 P.I.V., **4/-.** (6A): 200 P.I.V., **3/-.**, 400 P.I.V., **4/-.** 600 P.I.V., **5/-.** 800 P.I.V., **6/-.**

PRINTED CIRCUIT BOARD (Vero).
0·15in. Matrix: 3¾in. × 2½in., **3/3.** 5½in. × 2½in., **3/11.** 3¾in. × 3¾in., **3/11.** 5in. × 3¾in., **5/6.**
0·1 Matrix: 3¾in. × 2½in., **4/-.** 5in. × 2½in., **4/6.** 3¾in. × 3¾in., **4/6.** 5in. × 3¾in., **5/3.**

SEND S.A.E. FOR 1969 CATALOGUE

DUXFORD ELECTRONICS
97/97A MILL ROAD, CAMBRIDGE

Telephone: CAMBRIDGE (0223) 63687

(Visit us at our new Mail Order, Wholesale and Retail Premises)
MINIMUM ORDER VALUE 5/- C.W.O. Post and Packing 1/6

LATEST RELEASE OF

RCA COMMUNICATION RECEIVERS AR88

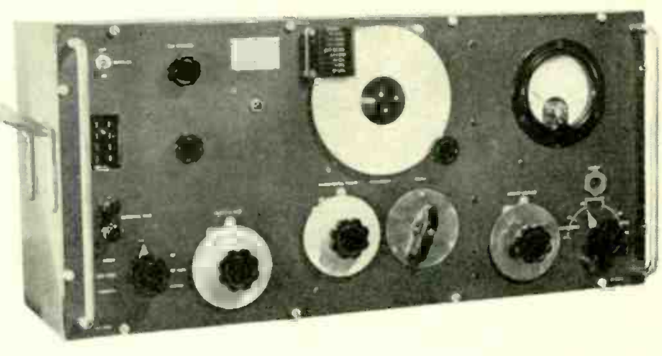
BRAND NEW and in original cases—A.C. mains input. 110V or 250V. Freq. in 6 bands 535 Kc/s-32 Mc/s. Output impedance 2.5-600 ohms. Complete with crystal filter, noise limiter, B.F.O., H.F. tone control, R.F. & A.F. variable controls. Price **£87/10/-** each, carr. £2.

Same model as above in secondhand cond. (guaranteed working order), from **£45 to £60,** carr. £2.

***SET OF VALVES:** new, **£3/10/-** a set, post 7/6; **SPEAKERS:** new, **£3** each, post 10/-. ***HEADPHONES:** new, **£1/5/-** a pair, 600 ohms impedance. Post 5/-.

AR88 SPARES. Antenna Coils L5 and 6 and L7 and 8. Oscillator coil L55. Price 10/- each, post 2/6. RF Coils 13 & 14; 17 & 18; 23 & 24; and 27 and 28. Price 12/6 each. 2/6 post. By-pass Capacitor K.98034-1, 3 × 0.05 mfd. and M.980344, 3 × 0.01 mfd., 3 for 10/-, post 2/6. Trimmers 95534-502, 2-20 p.f. Box of 3, 10/-, post 2/6. Block Condenser, 3 × 4 mfd., 600 v., £2 each, 4/- post. Output transformers 901666-501 27/6 each, 4/- post.

* *Available with Receiver only.*



MARCONI SIGNAL GENERATORS

TYPE TF-144G

Freq. 85Kc/s-25Mc/s in 8 ranges. Incremental: +/— 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV-1 volt-52.5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements: 19¼ × 12¼ × 10 in. The above come complete with Mains Leads, Dummy Aerial with screened lead, and plugs. As New, in Manufacturer's cases, £40 each. Carr. 30/-. DISCOUNT OF 10% FOR SCHOOLS, TECHNICAL COLLEGES, etc.

S.A.E. for all enquiries. If wishing to call at Stores, please telephone for appointment.

W. MILLS
3-B TRULOCK ROAD, TOTTENHAM, N.17
Phone: Tottenham 9213

HRO RECEIVER. Model 5T. This is a famous American High Frequency superhet, suitable for CW, and MCW, reception crystal filter, with phasing control. AVC and signal strength meter. Complete HRO 5T SET (Receiver, Set of 5 Coils & Power Unit) for £27/10/-, carr. 30/-.

COMMAND RECEIVERS; Model 6-9 Mc/s., as new, price £5/10/- each, post 5/-.

COMMAND TRANSMITTERS, BC-458: 5.3-7 Mc/s., approx. 25W output, directly calibrated. Valves 2 × 1625 PA; 1 × 1626 osc.; 1 × 1629 Tuning Indicator; Crystal 6,200 Kc/s. New condition—£3/10/- each, 10/- post.
(Conversion as per "Surplus Radio Conversion Manual, Vol. No. 2," by R. C. Evenson and O. R. Beach.)

AIRCRAFT RECEIVER ARR. 2: Valve line-up 7 × 9001; 3 × 6AK5; and 1 × 12A6. Switch tuned 234-258 Mc/s. Rec. only **£3** each, 7/6 post; or Rec. with 24 v. power unit and mounting tray **£3/10/-** each, 10/- post.

RECEIVERS: Type BC-348, operates from 24 v D.C., freq. range 200-500 Kc/s, 1.5-18 Mc/s. (New) **£35.0.0** each; (second hand) **£20.0.0** each, good condition, carr. 15/- both types.

MARCONI RECEIVER 1475 type 88: 1.5-20 Mc/s, second-hand condition **£10.0.0** each. New condition **£25.0.0** each, carr. 15/-.

RACAL EQUIPMENT: RA. 17 Outer Metal case for receiver available, as new, **£10** each, carr. £1. Frequency Meter type SA20: **£35** each, carr. £1. Frequency Counter type SA21: **£65** each, carr. 30/-. Diversity Switching Unit type MA168: **£35** each, post 10/-. Converter Frequency Electronic VHF Type SA.80 (for use with the SA.20): 25 Mc/s-160 Mc/s, **£40** each, carr. £1.

ROTARY CONVERTERS: Type 8a, 24 v D.C., 115 v A.C. @ 1.8 amps, 400 c/s 3 phase, **£6/10/-** each, 8/- post. 24 v D.C. input, 175 v D.C. @ 40mA output, **25/-** each, post 2/-.

CONDENSERS: 150 mfd, 300 v A.C., **£7/10/-** each, carr. 15/-. 40 mfd, 440 v A.C. wkg., **£5** each, 10/- post. 30 mfd, 600 v wkg. D.C., **£3/10/-** each, post 10/-. 15 mfd, 330 v A.C. wkg., **15/-** each, post 5/-. 10 mfd, 1000 v, **12/6** each, post 2/6. 10 mfd, 600 v, **8/6** each, post 5/-. 8 mfd, 1200 v, **12/6** each, post 3/-. 8 mfd, 600 v, **8/6** each, post 2/6. 4 mfd, 3000 v wkg., **£3** each, post 7/6. 2 mfd, 3000 v wkg., **£2** each, post 7/6. 0.25 mfd, 2Kv, **4/-** each, 1/6 post. 0.01 mfd. MICA 2.5 Kv. Price **£1** for 5. Post 2/6. Capacitor: 0.125 mfd, 27,000v wkg. **£3.15.0** each, 10/- post.

AVO MULTIRANGE No. 1 ELECTRONIC TEST SET: £25 each, carr. £1.

OSCILLOSCOPE Type 13A, 100/250 v. A.C. Time base 2 c/s.-750 Kc/s. Bandwidth up to 5 Mc/s. Calibration markers 100 Kc/s. and 1 Mc/s. Double Beam tube. Reliable general purpose scope, **£22/10/-** each, 30/- carr.
COSSOR 1035 OSCILLOSCOPE, £30 each, 30/- carr.
COSSOR 1049 Mk. 111, £45 each, 30/- carr.

RELAYS: GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., **£2** each, 6/- post.
12 Small American Relays, mixed types £2, post 4/-.
Many types of American Relays available, i.e., Sigma; Allied Controls; Leach; etc. Prices and further details on request **6d.**

GEARED MOTORS: 24 v. D.C., current 150 mA, output 1 r.p.m., **30/-** each, 4/- post. Assembly unit with Letcherbar Tuning Mechanism and potentiometer, 3 r.p.m., £2 each, 5/- post.

Actuator Type SR-43: 28 v. D.C. 2,000 r.p.m., output 26 watts, 5 inch screw thrust, reversible, torque approx. 25 lbs., rating intermittent, price £3 each, post 5/-.

SYNCHROS: and other special purpose motors available. British and American ex stock. List available **6d.**

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price 25/-, post 5/-.

AUTOMATIC PILOT UNIT Mk. 2. This complex unit of diodes and valves, relays, magnetic clutches, motors and plug-in amplifiers, with many other items, price £7/10/-, £1 carriage.

FOR EXPORT ONLY: B.44 Trans-ceiver Mk. III. Crystal control, 60-95 Mc/s. **AMERICAN EQUIPMENT:** BC-640 Transmitter, 100-156 Mc/s., 50 watt output. For 110 or 230 v. operation. ARC 27 trans-ceivers, 28 v. D.C. input. Also have associated equipment. BC-375 Transmitter. BC-778 Dinghy transmitter. SCR-522 trans-ceiver. Power supply, PP893/GRC 32A; Filter D.C. Power Supply F-170/GRC 32A: Cabinet Electrical CY 1288/GRC 32A; Antenna Box Base and Cables CY 728/GRC; Mast Erection Kits, 1186/GRC; Directional Antenna CRD.6; Comparator Unit, CM.23; Directional Control CRD.6, 567/CRD and 568/CRD; Azimuth Control Units, 260/CRD. Test Set URM.44, complete with Signal Generator TS.622/U.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, £2/10/- each post 6/-.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps., £2/10/- each, carr. 12/6.

AUTO TRANSFORMER: 230-115 v.; 1,000 w. **£5** each, carr. 12/6. 230-115 v.; 300VA, **£3** each, carr. 10/-.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 2.6 ohms at 4 amps. Price (either type) £2 each, 4/6 post each.

POWER SUPPLY UNIT PN-12B: 230 v. A.C. input, 395-0-395 v. output @ 300 mA. Complete with two × 9H chokes and 10 mfd. oil filled capacitors. Mounted in 19in. panel, £6/10/- each, £1 carr.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, £4/10/- each, 15/- carr.

POWER UNIT: 110 v. or 230 v. input switched; 28 v. @ 45 amps. D.C. output. Wt. approx. 100 lbs., **£17/10/-** each, 30/- carr. **SMOOTHING UNITS** suitable for above **£7/10/-** each, 15/- carr.

DE-ICER CONTROLLER MK. III: Contains 10 relays D.P. changeover heavy duty contacts, 1 relay 4P, C/O. (235 ohms coil). Stud switch 30-way relay operated, one five-way ditto, D.C. timing motor with Chronometric governor 20-30 v., 12 r.p.m.; geared to two 30-way stud switches and two Ledex solenoids, 1 delay relay etc., sealed in steel case (4 × 5 × 7 ins.) £3 each, post 7/6.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. £7/10/- each, 15/- carr.

ADVANCE TEST EQUIPMENT: VM78 A.C. Millivoltmeter (transistorised) **£55** each; TT1S Transistor Tester (CT472) **£37/10/-** each; VM77C Valve Voltmeter **£40** each. Carr. 10/- extra per item.

NIFE BATTERIES: 4 v. 160 amps, new, in cases, **£20** each, £1 10/- carr.

FUEL INDICATOR Type **113R:** 24 v. complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in a 3in. diameter case. Price 30/- each, postage 5/-.

UNISELECTORS (ex equipment): 5 Bank, 50 Way, 75 ohm Coil, alternate wipe, **£2/5/-** each, post 4/-.

FREQUENCY METERS: BC-221, meter only **£30** each, BC-221 complete with stabilised power supply **£35** each, carr. 15/-. LM13, 125-20,000 Kc/s., **£25** each, carr. 15/-. TS.175/U, **£75** each, carr. £1. TS323/UR, 20-450 Mc/s., **£75** each, carr. 15/-. FR-67/U: This instrument is direct reading and the results are presented directly in digital form. Counting rate: 20-100,000 events per sec. Time Base Crystal Freq.: 100 Kc/s. per sec. Power supply: 115 v., 50/60 c/s., **£100** each, carr. £1.

CT.49 ABSORPTION AUDIO FREQUENCY METER: freq. range 450 c/s-22 Kc/s., directly calibrated. Power supply 1.5 v.-22 v. D.C. **£12/10/-** each, carr. 15/-.

CATHODE RAY TUBE UNIT: With 3in. tube, colour green, medium persistence complete with nu-metal screen, £3/10/- each, post 7/6.

APNI ALTIMETER TRANS./REC., suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. 3 relays, 11 valves, price **£3** each, carr. 10/-.

TEST EQUIPMENT

MARCONI	TF-1274	VHF Bridge Oscillator	**£75 each**
	TF-1275	VHF Bridge Detector	**£75 each**
	TF-1067/1	Heterodyne Frequency Meter	**£85 each**
	TF-899	Valve Millivoltmeter	**£35 each**
	TF-978	VHF Admittance Bridge	**£85 each**
	TF-894A	Audio Tester	**£55 each**
	TF-329G	Circuit Magnification Meter	**£45 each**
	TF-428/2	Valve Voltmeter	**£12/10/- each**
	TF-428/1	Valve Voltmeter	**£8/10/- each**
	TF-726C	UHF Signal Generator	**£65 each**
	TF-934	Deviation Test Meter	**£35 each**
	6075A	Deviation Test Meter	**£65 each**
	TF-987/1	Noise Generator	**£20 each**
	TF-956	(CT.44) A.F. Absorption Wattmeter	**£20 each**
FIRZ HILL	V.200	Sensitive Valve Voltmeter	**£35 each**
	B.810	Incremental Inductance Bridge	**£75 each**
SOLATRON	CD-513	Oscilloscope	**£45 each**
	CD-513-2	Oscilloscope	**£47/10/- each**
	AW-553	Power Amplifier	**£30 each**
AIRMEC		Type 701 Signal Generator	**£50 each**
PHILLIPS		Type GM-6008 Valve Voltmeter	**£35 each**
DAWE		Type 402C Megohm Meter	**£12 each**

CANADIAN C52 TRANS/REC.: Freq. 1.75-16 Mc/s on 3 bands. R.T., M.C.W. and C.W. Crystal calibrator etc., power input 12V. D.C., new cond., complete set **£50.** Used condition working order **£25.** Carr. on both types **£2/10/-.** Transmitter only **£7/10/-** (few only) Carr. 15/-. Power Unit for Rec., new **£3/5/-.** Used power units in working order **£2/5/-.** Carr 10/-.

AVOMETERS: Model 47A, **£10** each, 10/- post. Excellent secondhand cond. (meters only).

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each 0.9 ohms. Tolerance ±1% **£3** each, 5/- post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ±1% **£3/10/-** each, 5/- post.

TELESCOPIC ANTENNA: In 4 sections, adjustable to any height up to 20 ft. Closed measures 6 ft. Diameter 2 in. tapering to 1 in. **£5** each + 10/- carr. Or **£9** for two + £1 carr. (brand new condition).

COAXIAL TEST EQUIPMENT: COAXWITCH—Mnftrs. Bird Electronic Corp. Model 72RS; two-circuit reversing switch, 75 ohms, type "N" female connectors fitted to receive UG-21/U series plugs. New in ctns., **£6/10/-** each, post 7/6. CO-AXIAL SWITCH—Mnftrs. Transco Products Inc., Type M1460-22, 2 pole, 2 throw. (New) **£6/10/-** each, 4/6 post. 1 pole, 4 throw, Type M1460-4. (New) **£6/10/-** each, 4/6 post.

PRD Electronic Inc. Equipment: FREQUENCY METER: Type 587-A, 0.250-1.0 KMC/SEC. (New) **£75** each, post 12/6. FIXED ATTENUATOR: Type 130c, 2.0-10.0 KMC/SEC. (New) **£5** each, post 4/-. FIXED ATTENUATOR: Type 1157S-1, (new) **£6** each, post 5/-.

ALL GOODS OFFERED WHILST STOCKS LAST IN "AS IS" CONDITION UNLESS OTHERWISE STATED

CALLERS BY TELEPHONE APPOINTMENT ONLY

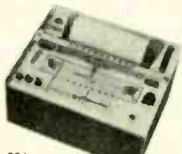
W. MILLS

3-B TRULOCK ROAD, TOTTENHAM, N.17
Phone: Tottenham 9213

ELECTRONIC BROKERS

MEASURING INSTRUMENTS AND RECORDERS

NEW AMERICAN 5" CHART RECORDER



Good general purpose potentiometric recorder. Suitable for research and laboratory work. Range 0-10 m.v. Variable zero set, Zenor divide reference. Input Inpedance. Max 100 Kohms.
Price £69.10.0. P.&P. 30/-.

PORTABLE AC/DC PEN RECORDER

A most versatile pen recorder. Produces a trace on a curvilinear 3½ in. strip chart. Two speeds 1 in. and 6 in./hr. Limiting contacts to give alarm, and limits the current when it exceeds the high and/or low preset values. Range: 0 - 1MA D.C. Meter Resistance 400 ohms; 0 - 1MA A.C. Meter Resistance 1800 at 50 Hz; —10 to + 5 dB into 600 n Impedance Source. Chart speed: 1 in. and 6 in./hr. Chart width: 3½ in. curvi-linear. Power supply: 230V 50 Hz driving Synchronous Motor.
Price: £52.10.0. Postage and packing £1 5s. 0d.

KENT STRIP-CHART INDICATING RECORDER

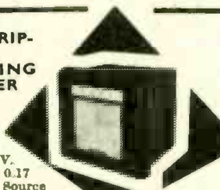
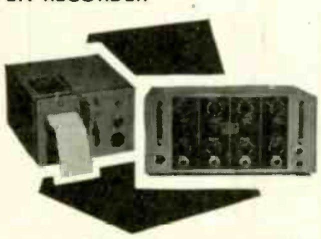


Chart width 9½ in. 10 mV. Sensitivity ± 0.17 of full scale. Source impedance 100 ohms. Speed of operation 33 sec. for full-scale travel. Chart speed ½ in., 3 in., 6 in. per hour. Single point. £49.10.0. P. & P. 30/-.

RECORDER SP 20 Series

General Purpose Single Pen potentiometric instrument for continuous recording for any input signal from 0 - 10mV D.C. Suitable for use with Spectrophotometer and other laboratory instruments. Chart speed 0.5 to 8.4 cm/min. Linearity ±0.25%. Fully transistorised. Chart width 200 mm. Input impedance 10K ohms max. Available S.P. 20 Plain Linear. S.P. 21 Flat Bed. S.P. 22 Linear/Log. £135 each. P. & P. 40/-.

PEN RECORDER



Portable 1, 2 and 4 channel pen recorders by Kelvin Hughes. General purpose recorders providing clear instantaneous and permanent records of phenomena with comparatively high rates of change. The torsion-strip suspension of the moving-coil renders the instrument immune to the effects of vibration and accelleration.
Six possible chart speeds, chart width 55 mm. length 150 ft., linearity 8 v. at 3 m.A. response D.C. to 100 c/s. Single pen with amplifier £99; 2 pen with amplifier £125. 4 pen with amplifier £149. Also 5 pen recorder complete with amplifiers, specification as above but housed in cabinet £225. P. & P. extra.

A.F. GENERATOR TYPE H MODEL I.

High impedance, output from 20V. R.M.S. to 200 micro volts. Frequency Range 15c/s to 50kc/s. Distortion less than 1%. Square wave output 800 micro volts to 80 volts peak.

PULSE AMPLITUDE ANALYSER £105

LOW OHM SAFETY METER

12 milli-amps 5 ohms. suitable for testing circuits where currents must be limited £12/10/- p. p. 17/6.

6 Pen Event Recorder. 6 in. Chart width. Available in wide range of chart speeds. Rack mounted £79/10/0 Case to suit extra.

ULTRA VIOLET RECORDER

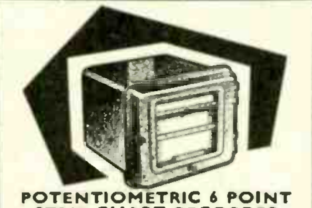
12 Channel NEP 1050 with 6 galvanometers £280.

ULTRA VIOLET PHOTOGRAPHIC RECORDER

12 Channel mirror Galvanometer Honeywell 1000 with 6 galvos £280.
24 Channel Siesmic Recorder by Film & Equipments £325. Carriage extra.

NEW PORTABLE RECORDING AMMETER

Specification. Type: Moving Coil, D.C. Range: 0-5 amp. D.C. Chart Width: 100 mm. Scale Length: 127 mm. Chart Speeds: 20, 60, 180, 600, 1800 and 5400 mm/hr. Dimensions: 180h × 163 w × 245mm. Weight: 5.5kg. List price £65. Our price £35.



POTENTIOMETRIC 6 POINT STRIP CHART RECORDER BRAND NEW

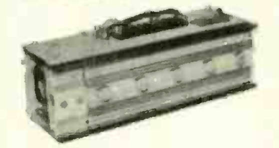
For use with thermocouplers, pyrometers and other e.m.f. sources. 6 point. Range (—100) —0—(+100) mV; 0—1,600 deg. C. 6½ in. chart width; pen speed 8 secs. Accuracy ±0.5%; 10 chart speeds 20-720mm/hr. Tropicalised. Including tools and spares. Listed at over £200. Our price £79.10.0. Also available 0-100mW F.S.D. £89.10.0.

POWER SUPPLIES

AIRMEC 698B KLYSTRON POWER SUPPLY

Rack mounted (19 in.). Mains operated. Cathode volts from 1.0 to 2.4 kv. negative. Grid Volts, 0 to 220V negative. Reflector Volts, 0 - 500V negative. Cathode Current, 0.18mA max. Heater 4V at 1.5A. Internal Modulation—Square wave 2 - 4 KHz 7V p-p. Saw Tooth 150 - 600 Hg 0 - 30V peak. Price £45. P. & P. 40/-.

★ HIGH PRECISION ★ FULLY STABILISED TRANSISTORISED LOW VOLTAGE POWER SUPPLIES



incorporating
- S.C.R. Panel for overload projection.
- OVERLOAD & CIRCUIT BREAKER WITH MANUAL RESET button.
- RIPPLE belter, better than 3000 : 1.
- CHOKE OF CAPACITOR transistorised 120/130 volt A.C. INPUT.

Available in the following types:

6 Volt 9 Amp	£12.10.0
6 Volt 12 Amp	£17.10.0
6 Volt 16 Amp	£22.10.0
12 Volt 8 Amp	£22.10.0
12 Volt 16 Amp	£25. 0.0
12 Volt 22 Amp	£25. 0.0
20 Volt 16 Amp	£25. 0.0
24 Volt 4 Amp	£22.10.0
30 Volt 8 Amp	£18.10.0
56 Volt 7 Amp	£25. 0.0

Ex-equipment but fully tested in our laboratory. Carr. 30/-

ADVANCE TRANSISTORISED DC POWER UNITS

	Input Volts	Output Volts	Amps	Price
DC 4	200-245±15%	12	4	£17/10/-

METERS

2 in. dia. mounting A.C. voltmeter 0-300 V. A.C. £1.15.0. Carriage 6/-.
3½ in. dia. Electrostatic Kilo Voltmeter in wooden case. £2.15.0. Carriage 10/-.
Precision A.C. & D.C. Wattmeter. Model S.67 certificated. Accuracy to ½% up to 133 c/s. Range 250/450 V. and 0.5 to 1 A. £29.10.0. Carriage 30/-.

D.729 B.M. PHASEMETER AND SUPPLY UNIT

May be used as a Voltmeter, distortion of waveforms, "Q" meter, in phase and quadrature components. Gives indication of phase angle 0°-360°. Frequency range 2 c/s-100 Kc/s. £225. P. & P. extra.

BRAND NEW S.E. LABORATORIES TRANSDUCER

complete with encapsulated Amplifier/demodulator S.E. 441/2
Frequency D.C.—60 c.p.s.
Available in the following ranges:
SE150, SE50 or SE165A.

0 - 25 p.s.i.	0 - 350 p.s.i.	0 - 2000 p.s.i.
0 - 50 p.s.i.	0 - 500 p.s.i.	0 - 3000 p.s.i.
0 - 200 p.s.i.	0 - 750 p.s.i.	0 - 4000 p.s.i.

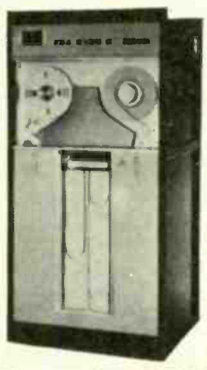
Also available differential types ± 5 p.s.i., ± 10 p.s.i.
List price £70+ Our price £15

COMPUTOR AND PERIPHERAL EQUIPMENT

7 TRACK DIGITAL MAGNETIC TAPE STORAGE DECK

These machines originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay heads encased in one common unit. Low resistance heads. Frequency response approximately 30 Kc/s. to 50 Kc/s. Bit density 557 b.p.i. ½ in., 10½ in. spools 230 V. to 380 V. A.C. Capstan Motor speed 1,500 r.p.m. 48 V. D.C. Rewind motors complete with vacuum Assembly. Finished in brush aluminium and matt-black. Size 27 in. × 26 in. × 8 in. Weight 90 lb. Price £72.10.0. Carriage extra.

MODEL 72 MAGNETIC TAPE DATA STORAGE UNIT



This unit consists of ½ in. 8 channel read-write heads. Can be used to record any 6 bit code. Data can be read in either a forward or backward direction plus giving search facilities. The unit consists circuits for receiving and storing instruction signals. Recording density 250 characters per inch. Tape speed 100 in. per second, price £190. Excellent condition.

½" 7 TRACK

Ex-computer record/replay head complete with guides. Little used. Price £12.10.0 Carriage 15/-.

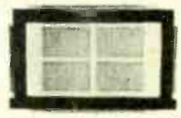
BRAND NEW

Gresham Lion 1 in. 1 + 7 track record/replay heads. Of the highest professional quality. Cost £100 plus price £12.10.0. Carr. 15/-.

9 TRACK 1 in. Record/replay heads with sprocket drive, driven by synchronous motor. Mounted with integrated head assembly eliminating alignment problems. This can be fitted to any suitable type of transport system. Price £8.10.0. Carriage 15/-.

PROGRAMME BOARDS BY SEALECTRO

These boards are basically a multi pole multi throw switch device consisting of a X-Y Matrix with two contact decks in the Z Plane running at 90 degrees to each other. Contact is made by either, shorting or plugging in pins. Ideal for prototype work, etc. Boards available in 24 × 60 2 plane £12.10.0. Pins available 1/3 each.



MEMORY PLANES

Ferrite core memory planes with wired Ferrite cores. Used for building your own computor or as an interesting exhibit in the demonstration of a computer. Mounted on plastic material, frame 5 × 8 in. Consisting of matrices 40 × 25 × 4 cores each one individually addressable and divided into 2 halves with independent sense and inhibit wires. £8.10.0. P. & P. 3/-.

MULLARD MATRIX CORE STORE STACKS

A.W. 510 5 planes 8×16 cores/per plane	£12/10
A.W. 511 5 planes 18×32 cores/per plane	£25
A.W. 534 20 planes 64×64 cores/per plane	£89/10
A.W. 597 8 planes 32×32 cores/per plane	£55
Single plane 40×25×4	£8/10
Flexi-writer 7 hole punch and keyboard	£199/10

MEMORY STORE

M. M. 1044 complete with logic circuits mounted in Imhof cabinet £400

COMPUTERS

Burroughs E 201 225 word store. £450

SYNCHRONOUS MOTORS

Model 87. 1-rev. per hour. Self starting complete with gearing shaft ½" dia. ½" long. 200/250 V 50 Hz. New Condition Ex. Equipment. 30/-. P. & P. 3/-.

BRAND NEW COMPUTER TAPES AND EMPTY SPOOLS

Made by well known manufacturers

½ in. certified 2,400 ft. 800 b.p.i.	£8.10.0
½ in. 2,400 ft.	£6.10.0
½ in. Highest grade 2,400 ft.	£3. 0.0
½ in. 10½ in. dia. spool and cassette	£1.10.0
½ in. 8½ in. dia. spool and cassette	£1.10.0
1 in. metal 10½ in. dia. spool and cassette	£2.10.0
½ in. N.A.B. centres 10½ in. spool only	£1. 0.0

TAPE PUNCH MODEL 25 7 HOLE

A multiwire tape punch designed for general application involving the conversion of parallel wire electrical impulses into punched papertape at 33 characters per second. Unit complete; self-contained requiring only motor power and signal supplies. Price £45.

7 HOLE NON PARITY TAPE PUNCH

New condition £45.

LOW SPEED 7 HOLE TAPE PUNCH

60 characters per second by well-known manufacturer. Price £45.

TELETYPE 8 HOLE PAPER PUNCH MU27 PRICE £75.

Also available 5 hole punch BRPE2 as above. This model has interchangeable heads. Complete with spooler. Price £35.

HIGH SPEED 5/7 HOLE OPTICAL READER

20 characters per second. £19.10.

CARD READERS

80 column 1500/80 model, punch
80 column 1400/80 model verifier. } £325
Excellent condition.

HOLLERITH 80 COLUMN CARD PUNCH TYPE HO29 & VERIFIER H129 £225.

DECODER 4 DIGIT READOUT

Can be used in constructing frequency counter or Digital Voltmeter. Consists of 4 transistorised cards each containing 10 NOR gates £19.10.0. Circuits supplied with Decoder. 5 Digit £25. P. & P. 15/-

TRANSFER CASE

For sending data by personal carrier, GPO post, passenger train, etc. ideal. Suitable for despatching tape 20/-. P. & P. 5/-.

8 HOLE OPTICAL READER PRICE £35

CANCELLED EXPORT ORDER

90 Column card sorter and punch type 425/0 price on application.

SPOOLERS 1" and ½"

Both hand and motor drives available at £3.0.0 and £5.0.0 respectively.

BRAND NEW TAPE SPOOLER

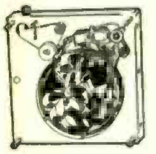
Suitable for 1 in., ½ in. and ¼ in. tapes. Fully self-contained £99.10.0.

5" TAPE PUNCH

Suitable for machine control complete with 50 reels of tape £35.

LOW COST ELECTRONIC AND SCIENTIFIC EQUIPMENT AND COMPONENTS

CONTINUOUS TAPE CASSETTE

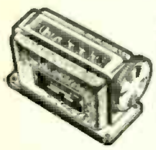


Suitable for sleep-learning, teaching programmes, programming machine tools, telephone answering etc. Complete with replay/record head and separate erase head. ¼" tape twin track. Speed 3¾" per sec. Length of tape 88 feet, but will hold three times this amount. £3-9-6 p. & p. 7/6.

SINGLE SPEED TAPE DECK

Driven by 240v 50 Hz power supply. Speed 3¾in. per sec. Remote control operation, 3 motors, record/replay heads with separate erase head. Fast erase facilities and counter. Price £2/19/6 p & p 10/-

VEEDER ROOT 6 DIGIT COUNTER

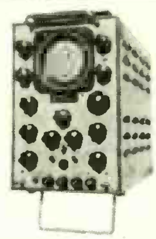


Suitable for counting all kinds of production runs, business machine operation. Mechanically driven Type KA1337. Reset manual knob. Ex-equipment but new condition. Special price 25/- plus 5/- p. & p.

MINIATURE SQUARE COUNTER 6 DIGIT

by Veeder Root. Rotary ratchet type, adds 1 count for each 36° movement of shaft 9/6 + 2/6 p. & p.

OSCILLOSCOPES



Cossor 1035. £25.
Cossor 1035 Mk. III. £35.
Cossor 1049 Mk. III. £40.
Solartron AD 513.2 L.F. & Servos & CD 5238.2 Long Persistent Tube. £49.10.
Furzehill 0.100. £25.
Airmec 249. £25.
Solartron AD 557 Pulse & Radar Field. £55.
Solartron CD 7118.2 Double Beam DC.7 Mtg. £65. Calibration extra.
Mullard L101 Double Beam £96.10.
Airmec 723. £19.10.

MOTORS

HYSTERESIS REVERSIBLE MOTOR

Incorporating two coils. Each coil when energised will produce opposite rotation of output shaft. 240V 50 Hz. ¼ r.p.m., ½ r.p.m., 1/6 r.p.m., 120V 50 Hz, 1/10 r.p.m., 6 r.p.m. 30/- each. P. & P. 3/-.

HIGH TORQUE INDUCTION MOTOR.

3-30 oz/inch. Available in the following speeds only 240V 50 Hz ½ r.p.m., 1 r.p.m., 2 r.p.m. 120 V 50 Hz 20 r.p.m. 30/- each. P. & P. 3/-.

LOW TORQUE HYSTERESIS MOTOR MA23

Ideal for instrument chart drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting torque enable relative high inertia loads to be driven up to 6-oz/in. Available in the following speeds and ranges: 240V 50 Hz 15 r.p.m., 4 r.p.m. 2 r.p.m., 1½ r.p.m., 1 r.p.m., ½ r.p.m., ¼ r.p.m., 1/3 r.p.m., 1/5 r.p.m., 1/6 r.p.m., 1/10 r.p.m., 1/12 r.p.m., 1/40 r.p.m., 1/60 r.p.m., 1/75 r.p.m., 1/120 r.p.m., 1/180 r.p.m., 1/360 r.p.m., 1/720 r.p.m., 1/1440 r.p.m., ¼, 1/20, 1/45 r.p.m.; 120V 50 Hz 1/6 r.p.m., 1/5 r.p.m., 1/15 r.p.m., 1/16 r.p.m., 1/20 r.p.m., 1/30 r.p.m., 1/60 r.p.m., 1/120 r.p.m., 1/240 r.p.m., 1/300 r.p.m., 1/720 r.p.m. 25/- each. P. & P. 3/-.

HYSTERESIS CLUTCH MOTOR

with integral clutch allowing the motor to drop out of engagement with the gear train, thereby facilitating easy resetting when used in timers or in conjunction with a light spring. 6 oz. torque at 1 r.p.m. 240 v., 50 c/s. L=left, R=right. 15 r.p.m. L. 8 r.p.m. R & L. 6 r.p.m. L. 4 r.p.m., ½, ¼ r.p.m. L. 1/5 r.p.m., 1/6 r.p.m.. R & L. 1/10 r.p.m.. 1/12, 1/15 r.p.m. L. Also 120 v. 50 c/s 2, 1/6, 1/12, 5/12, 4/11, 1/10 r.p.m. 25/-. P. & P. 3/-.

HIGH PRECISION MAINS MOTOR

230V 50 Hz 1/8 h.p. continuously rated. 3000 r.p.m. Made by Croydon Engineering Model KA 60 JFB. Suitable for capstan motor. Size 8 in. long, 4½ in. diameter with 6 in. diameter flange and 4 fixing holes. £4.10.0 each. £1.5.0 postage and packing.

HI-SPEED QUICK RESET ELECTRO MAGNETIC COUNTERS

Push button reset 6 digits. 48 v. D.C. 3.5 watts. 20 counts per second. Size 3.875 × 2.625 in. Panel mounting. List £8. Our price 59/6.

PRECISION POTENTIOMETERS

TEN TURN 3600° ROTATION BRAND NEW

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
100/100/100		Beckman	A	160/-
100	0.5	Beckman	A.8	60/-
200	0.5	Beckman	A	60/-
500	0.1	Beckman	8	70/-
500		Colvern	2501	45/-
500		Foxes	PX4	40/-
500		Colvern	2610	50/-
2K	0.5	Beckman	8A1101	60/-
2K		Beckman	7216	60/-
2K		Reliance	GPM15	40/-
10K	0.5	Beckman	A	60/-
10K	0.1	Beckman X	A	70/-
15K		Foxes	GPM15	50/-
18K		Beckman	A	60/-
20K	0.5	Beckman	A	60/-
30K		Colvern	2402	30/-
30K		Beckman	8A95C	60/-
30K	0.1	Beckman	A.88	70/-
30K	0.5	Beckman	8A 1692	60/-
30K	0.25	Beckman	8A 1692	65/-
50K		Reliance	07.10	45/-
50K			07.5	45/-
50K		Colvern	2503	45/-
50K	X	Foxes	PX4	45/-
50K	0.5	Beckman	A	60/-
50K	0.1	Beckman	A	70/-
100K/100K		Ford	A	100/-
100K	0.1	Beckman	A	70/-
100K	0.5	Beckman	A	60/-
100K		Colvern	2501	45/-
100K		Colvern	2610	50/-
298K	0.1	Beckman	8A3902	70/-
300K	0.1	Beckman	A	70/-

THREE TURN 780° ROTATION

100/100	0.5	Beckman	A	60/-
300		Beckman	9303	45/-
10K	0.5	Beckman	C.ss	45/-
20K/20K	0.1	Beckman	C.8	60/-
10K/10K	0.1	Beckman	C	60/-
50K	0.5	Beckman	C.8	35/-

FIFTEEN TURN 5400° ROTATION

25K/25K	Beckman B	10 watts	£6.10s
46/K/46K	Beckman B	10 watts	£6.10s

TWENTY TURN 7200° ROTATION

250 ohms	General Controls	PXM130	80/-
1 Meg	General Controls	PXM130	80/-
50K Reliance			40/-

156 TURN 56, 160° ROTATION

460 ohms....Kelvin Hughes......KTP0701... £9.10s.

FIVE TURN 1800° ROTATION

500 ohms	Colvern	CLR 2505	40/-
U1.5K	Colvern	CLR 2605	40/-

SINE COSINE

Kelvin & Hughes 8CP5	14·4K	£17.10.0
Colvern 8601	30K	£17.10.0
CLR 9602—Cam Corrected	25K	£17.10.0
8CP4	32K	£17.10.0
8CP1	35K	£17.10.0

PRECISION BECKMAN 40 TURN 14,400° ROTATION

Wirewound Precision Potentiometer. 8E 107A 20 watts at 40°C. 3 1/16" Diameter. Servo Mounting. 200 K. Brand New £12.10s. List Price £30.

GENERATORS

SIGNAL GENERATOR

T.F. 801A Sine Wave, Square Wave Generator. Frequency Range: 10-310 M.c/s. Output Voltage (maximum) 200 mini-volts ± 2db. Output impedance 75 ohms. Mark/Space Ratio 50/50 on square wave. Price £120. Packing and carriage £2.

SIGNAL GENERATOR

T.F. 517F/1 Sine Wave, Square Wave Generator. Frequency Range: 120-300 M. C/s. Auxiliary 18-58 Meg. c/s. Output Voltage 0.2 Volts. Output impedance 75 ohms.

MARCONI T.F. 144G

Frequency Range 85 k.c/s. 25Mc/s.
Output voltage 1 micro-volt to 1 volt.
Output impedance 1 micro-volt. 100 milli-volt, 10 ohms. 100 milli-volts to 1 volt. 52.5 ohms. £75 + £2 carriage.

AVO SIGNAL GENERATOR

Frequency Range 50 kc/s—80Mc/s.
Output 0.5 Volts.
Price £15. Carriage £1/10s.

SQUARE WAVE GENERATOR

Frequencies: 1M. 100kc/s 10kc/s 50c/s
Load impedance 75 ohms.
Output Voltage 10V. 75 ohms.
0-18 volts into 2000 ohms.
Rise time from 30-50 Milli micro seconds at 1 meg. Cycle.

MARCONI VALVE VOLTMETER TF 428B/1

Frequency response on probe 10Kc/s/3-100Mc/s. Five separate Voltage Ranges. Overload Protection 100-250 A.C.I.P. Input 1MΩ Acc. ±2 % or 00.2V. Size: 10 × 16½ × 9in.—15lb. £5/19/6.

VOLSTAT

Advance
CVN500A. Input 190-260v. 50 Hz. Output 240v. R.M.S. 500 watt P.S.I. £25
CV500/27. Input 95-130v. 60 Hz. Output 85v. R.M.S. Load 4 amps P.S.I. £8/10/0
CV25E. Input 190-260v. 50 Hz. Output 6v. 25 watts £9/10/0
CV50J. Input 190-260v. 50 Hz. Output 230v. 50 watts £12/10/0
Carriage extra 15/-.

OSCILLATORS

MUIRHEAD D729 PHASE-METER AND POWER SUPPLY

Gives direct indication of phase angle 0°-360° and difference in level between two sinusoidal voltages (transfer function) over the frequency range 2 cycles per sec. to 100 Kc/s. £275 Carriage £2.

TORQUE MOTOR 225 by ELLIOTT

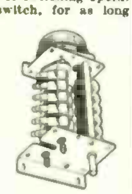
Originally designed to operate hydraulic valves or motors under extreme environmental conditions. The torque motor is practically unaffected by vibration or sudden shock. It consists of a moving iron rotor with a travel of 7° either side of centre. Min. torque 500g per centimeter. Current 45 mA. £9/10/0 p & p 5/-.

DAWE 444C AUTOMATIC L.F. SWEEP OSCILLATOR (NEW)

Amplitude 0 - 10V. Frequency Range 5Hz-5 KHz ±2% ±0.5 Hz. 18 Sweep Rates of 10 octaves/min. Frequency Response 0.5 dB. £89.10.0. Carriage extra.

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.

REPEAT CYCLE TIMERS



These timers repeat a set cycle of switching operations via a cam and micro switch, for as long as the motor is energised. Single Cam RB 21 in 2 min., 4 min., 5 min., 6 min. cycles @ 45/-. Twin Cam RD 22 in 1 min., 2 min., 3 min., 4 min., 5 min. cycles @ 55/-. 4 Cam RD 24 in 4 min., and 5 min. cycles @ 75/-. 6 Cam RD 26 in 1 min., 2 min., 3 min., 4 min., 5 min. cycles @ 95/-. 8 Cam RD 28 in 2 min., 3 min., 4 min., 5 min. cycles @ 115/-. All + p. & p. 5/-.

UNISELECTOR

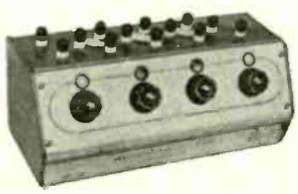
8 and 4 Banks, 25 contact per bank, 2 sets of wipers 2 in. radius. Complete with surge capacitor. 25/- and 45/- respectively.

MINIATURE DIGITAL DISPLAY

Operates on a rear projection 6.3 pilot lamp. The lamp projects the corresponding digit on the condensing lens through a projector lens, on to the viewing screen at the front of the unit. 1 in. width. 3 5/16 in. deep. 1 5/16 in. high. Weight 3½ oz. Character size ½ in. high, 0.9 with 8 right hand decimal point and degree. Available to special order, words and other characters or colour, at cost of artwork or plates. List price 6 gns. Our price 49/6.

BRAND NEW LABORATORY TEST EQUIPMENT—*AT LESS THAN HALF PRICE*

HIGH VALUE RESISTANCE BOX TYPE R.7003



Specification. Range: 0.01–111 Meg. in 0.01 Megohm divisions. Accuracy: 0.05%. Maximum power rating: 0.1W per step. Case: Hammer finished stove enamel.
List price £60. Our price £22/10/-.

PORTABLE WHEATSTONE BRIDGE

Specification. Type: Moving Coil Galvanometer. Ranges: 1. 0.05 to 5 ohms. 2. 0.5 to 50 ohms. 3. 5 to 500 ohms. 4. 50 to 5,000 ohms. 5. 500 to 50,000 ohms. Scales: Switched. Slidewire: 0.5 to 50. Galvanometer Scale: 10-0-10. Case: Moulded plastic. Internal Source: 4V. Dry battery. Dimensions: 200 × 110 × 65mm. Weight: 0.9 kg.
List price £25. Our price £9/19/6.

PORTABLE MULTIRANGE METER

Specification.
Ranges: 0-60 & 0-300μA. D.C. 0-3, 0-30 & 0-120mA. D.C. 1.2 & 12 amps D.C. 0.6-3 & 6-30 mA. A.C. 24-120 mA. A.C. 0.24-12A, A.C. 3-12-30-300-600-1,200 & 6,000 V, D.C. 0.6-3, 2.4-12, 6-30, 60-300, 120-600, 240-1,200 & 1,200- 6,000 V. A.C. 3-333 ohms, 0.3-30 Kohms, 0.03-3 megohms D.C. Resistance —12 to +78 Decibels. Frequency: 50 cps. Input Resistance D.C.: 20,000 ohms/volt. Input Resistance A.C.: 2,000 ohms/volt. Dimensions: 255 × 215 × 170 mm. Weight: 8 kg. Supplied with 2 voltage dividers, H.V. leads, spare rectifiers, 1.5 & 22.5 V. battery.
List price £25. Our price £12.19.6. P. & P. 15/-.

MUTUAL INDUCTANCE BOX TYPE R.7005

Specification Range: 0 - 11.100 mH in 0.002 mH divisions. Accuracy: $\pm(0.3 \times \frac{0.012}{M})\%$ where M=value of mutual inductance in mH set on the box. Frequency range: 0 - 2.5 Kc/s for all decades except X1=0 - 15 K/cs. Maximum current: 0.5A for decades 1A for variometer (both primary and secondary dingings). Case: Polished teak. List price £65. Our price £26.10.

MUTUAL INDUCTANCE COIL TYPE R.7006

Specification. Value: 0.001 H. Accuracy: ±0.3%. Operating Frequency: 5 Kc/s, 10 Kc/s. Maximum current: 1A, 3A. Resistance of coils: 4 ohm, 1 ohm. Case: Moulded plastic. List price 8 gns. Our price 50/-.

★ ILLUSTRATED LEAFLETS AVAILABLE ★

ELECTRONIC BROKERS LTD., 49-53 PANCRAS ROAD, LONDON, N.W.1. Tel: 01-837 7781/2 Cables: SELELECTRO

ELECTROVALUE

EVERYTHING BRAND NEW AND TO SPECIFICATION • LARGE STOCKS
CATALOGUE WITH FULL TECHNICAL DATA—1/6d.

30 WATT BAILEY AMPLIFIER COMPONENTS

MJ481, MJ491 } matched pair output 59/- 40361 12/6, BC125 12/-, BC107 3/6, 40362 16/9, BC126 12/-, BC109 3/6

40361, 40362 } matched pair drivers .. .. 30/3 Main amp PC board free with each transistor set.

Total for one channel £7.9.6 list, with 10% discount only £6.14.6.
Total for two channels £14.19.0 list, with 15% discount only £12.14.0.
Complete power supply kit £4.14.6 mono or stereo, subject to discount.
Complete regulated power supply kit **£9.5.0** subject to discount. Further details on application.

2N2926 PLASTIC range Silicon NPN, 120MHz fT:
Red spot β = 55 to 110 .. .. .. 2/3
Orange spot β = 90 to 180 .. .. .. 2/3
Texas Silect range, TO92
30V, 600mA NPN
2N3704 β = 90 to 330 .. .. .. 3/9
2N3705 β = 45 to 165 .. .. .. 3/5
25V 200mA PNP
2N3702 β = 60 to 300 .. .. .. 3/6
2N3703 β = 30 to 150 .. .. .. 3/3
Small signal NPN
2N3707 low noise 4/-
2N3711 β = 180 to 660 .. .. .. 3/11

Yellow spot β = 150 to 300 .. .. .. 1/9
Green spot β = 235 to 470 .. .. .. 2/3
BC107 series and plastic equivalents
300mW 300 MHz fT, TO18
BC107 β = 125 to 500, 45V 3/6
BC108 β = 125 to 900, 20V 3/-
BC109 β = 240 to 900, 20V 3/6
180mW 300MHz fT, TO92 plastic
BC167 β = 125 to 500, 45V 2/3
BC168 β = 125 to 900, 20V 2/-
BC169 β = 240 to 900, 20V 2/3
BC109 and BC169 are low noise.

FETS n-channel — Low cost general-purpose type 2N5163, 25V 5/- only. Audio/r.f. Texas 2N3819, 25V 9/-.

NEW PLESSEY INTEGRATED CIRCUIT POWER AMPLIFIER TYPE SL403A
Operates with 18V power supply. Sensitivity 20mV into 20M.ohms. 3·0 watts into 7·5 ohms. Only 57/- net.
PRACTICAL ELECTRONICS NOV. 69 STEREO AMP KIT, less metalwork .. £13.0.0

ZENER DIODES
3V to 27V 5% 400mW. All preferred voltages. each 4/6

SINCLAIR IC.10 INTEGRATED CIRCUIT AMP. & PRE-AMP.

This remarkable monolithic integrated circuit amplifier and pre-amp is now available for dispatch from stock. It is the equivalent of 13 transistor/18 resistor circuit plus 3 diodes and the first of its kind ever. It is D.C. coupled and applicable for an unusually wide range of uses, all of which are detailed in the manual provided with it. Sinclair IC.10 as advertised, post free .. ..

59/6 NETT

PEAK SOUND AMPLIFIER KITS
The new Englefield Kits

Build it 12+12 or 25+25

Brilliant new styling and available in two forms:

STEREO 15 WATTS PER CHANNEL
Supplied in kit form with complete amplifier and pre-amplifier modules and power supply components. Output per channel into 15Ω—13 watts R.M.S. **Price £38.4.0 Net**

STEREO 25 WATTS PER CHANNEL
Supplied in kit form with complete amplifier, pre-amplifier and regulated power supply modules. Output per channel into 15Ω—28 watts R.M.S. **Price £58.15.0 Net**

Specifications on these amplifiers in accordance with the Specifications in Guarantee published in Peak Sound advertisements.

Inputs:

Magnetic, RIAA	3·5mV
Ceramic	35mV
Tape	100mV
Radio	100mV

Signal to noise ratios: Better than 60dB all inputs.

ENGLEFIELD CABINET to house either above assemblies (as illustrated) **£6.0.0.**

Other Peak Sound Products as advertised.
Mainline Kits as advertised.

BARGAINS IN NEW TRANSISTORS
All power types supplied with free insulating sets

2N696	5/6	2N2147	18/9	2N4289	2/11	AF118	16/6	BCY31	12/6	BSX20	4/6
2N697	6/-	2N2369A	6/9	2N4291	2/11	AF124	7/6	BD121	18/-	MJ480	21/-
2N706	3/5	2N2646	9/6	2N4292	2/11	AF127	7/-	BD123	24/3	NKT211	5/8
2N1132	13/-	2N2924	4/3	40406	16/3	AF139	8/-	BD124	16/-	NKT214	4/2
2N1302	4/-	2N2925	5/3	40408	14/6	BA102	6/6	BF115	7/6	NKT217	12/-
2N1303	4/-	2N3053	5/6	AC126	6/6	BC147	4/3	BF167	8/6	NKT274	4/3
2N1304	4/-	2N3054	15/6	AC128	6/-	BC148	3/3	BF178	10/6	NKY403	14/10
2N1305	4/-	2N3055	16/6	AC176	6/3	BC149	4/3	BF180	12/-	NKT404	14/6
2N1306	6/9	2N3391A	5/6	ACY22	3/3	BC157	3/6	BF194	7/-	NKT405	15/-
2N1307	6/9	2N3708	2/9	ACY40	3/6	BC158	3/3	BFX29	12/3	NKT713	5/5
2N1308	8/9	2N3904	9/-	AD140	19/-	BC159	3/6	BFX85	8/3	NKT773	5/3
2N1309	8/9	2N3906	9/-	AD149	17/6	BC177	6/-	BFX88	7/9	NKT781	6/-
2N1613	6/6	2N3794	2/11	AD161 }	14/- pr.	BC178	5/3	BFY50	4/9	P346A	5/9
2N1711	7/4	2N4286	2/11	AD162 }		BC179	5/9	BFY51	4/3	V405A	7/9

METAL OXIDE RESISTORS
Electrosil type TR5, 2%, ½ watt rating. Very low noise, low temperature coefficient, low drift. A Professional resistor! All E24 preferred series of values from 10Ω to 1 MΩ. Price: 1 to 24, **10d.** each; 25 to 99, **9d.** each; 100 up, **8d.** each. (Resistance values may be mixed to obtain quantity reductions.)

POTENTIOMETERS
Carbon track. Long plastic spindles: each
Single gang linear: 220Ω, 470Ω, 1K, etc. to 2·2MΩ 2/6
Single gang log: 4K7, 10K, 22K, etc. to 2·2MΩ 2/6
Dual gang antilog: 10K only 8/6
Dual gang linear: 4K7, 10K, 22K, etc. to 1MΩ 8/6
Dual gang log: 4K7, 10K, 22K, etc. to 1MΩ 8/6
Dual gang log/anti-log: 10K, 47K, 1MΩ only 8/6
Any type with ½ amp double pole mains switch: extra 2/3.

CARBON SKELETON PRE-SETS
Small high quality, type PR: Linear only, 100Ω, 220Ω, 470Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1MΩ, 2M2, 5M, 10MΩ vertical or horizontal mounting, 1/- each.

CAPACITORS CERAMIC DISC
Hi-K, all ±20% tolerance: 1,000pF, 2,000pF, 5,000pF, 500V; 0·01μF, 0·02μF, 0·05μF, 50V, **4d.** each.

LARGE CAPACITORS
High ripple current types: 2,000μF 25V, **7/-**; 2,000μF 50V, **9/3**; 5,000μF 25V, **10/3**; 5,000μF 50V, **17/6.**

S-Dec, **30/6**; 2-DeC DeCstore, **69/6**; 4-DeC, **119/6.**

MEDIUM RANGE ELECTROLYTICS
Axial leads. Values (μF/V): 50/50, **1/6**; 100/25, **1/6**; 100/50, **2/-**; 250/25, **2/-**; 250/50, **3/3**; 500/25, **3/3**; 1,000/10, **4/-**; 220μ 25V, **1/9**; 470μ 10V, **2/-**.

MULLARD C426 SERIES ELECTROLYTICS
Sub-miniature axial leads. Values: (μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·5/64; 4/10; 4/40; 5/64; 6·4/6·4; 6·4/25; 8/4; 8/40; 10/2·5; 10/16; 10/64; 12·5/25; 16/40; 20/16; 20/64; 25/6·4; 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; 160/2·5; 200/6·4; 200/10; 250/4; 320/2·5; 320/6·4; 400/4; 500/2·5. All 1/3 each.

MINIATURE (μF/V): 5/10; 10/10; 25/10; 50/10, **9d.** each. 25/25; 50/25; 100/10; 200/10, 1/- each. 50/50; 100/25, 1/6 each. 100/50; 250/25, 2/- each.

- **COMPONENT DISCOUNTS**
  10% on orders for components for £3 or more.
  15% on orders for components for £10 or more.
  (No discount on NET items.)
- **POSTAGE AND PACKING**
  Free on orders for £1 and over.
  Please add 1/- if order under £1.
  Overseas orders welcome: carriage charged at cost.
- **CATALOGUE** price 1/6 (U.K. post free)
  Our catalogue contains technical data on many of our stock semi-conductors and other components and as such is a useful reference book.

ELECTROVALUE DEPT. WW.12, 28 ST. JUDES ROAD, ENGLEFIELD GREEN, EGHAM, SURREY.
Hours: 9-5.30 daily; 1.0 p.m. Saturdays. ***Telephone: Egham 5533 (STD 0784-3)***

ALL GOODS GUARANTEED

CONVERTOR/BATTERY CHARGER. Input 240v 50 c/s. output 12v 5 amp DC. Input 12v DC. output 240v AC. 170 watt max. With fuse and indicator lamps. Size 9¼ × 10 × 4½in. Weight 19lb. An extremely compact unit that will give many years' reliable service. Supplied with plug and lead. Only **£4/10/-**. P. & P. 15/- extra.
As above—fully serviceable—perfect interior but soiled exterior cases. £3. P. & P. 15/- extra.

RACAL EQUIPMENT
One KiloWatt Linear PA complete with power supplies in 6 ft. enclosed cabinet. 1.5 to 25 meg cycles requiring 100 milli watt drive. In brand new condition. Complete with spares. Full details on request. **£550.**
Digital Frequency Counters SA20; SA21B; SA28. Prices **£30 ; £45 ; and £65.**

G.M. TUBES. Brand new. G24/G38/G60 at **27/6** ea. G53/1. brass cased. **£6** ea.
PHOTOMULTIPLIERS. 6097B at **£5** ea. EMI 6097X at **£8/10/-** ea.
SOLARTRON stab. P.U. type AS516 300v 50mA. **£3/10/-**; AS517 300v 100mA. **£6**. P. & P. 10/- extra.
TRANSISTOR OSCILLATOR. Variable frequency 40 c/s to 5 kc/s. 5 volt square wave o/p. for 6 to 12v DC input. Size 1⅞ × 1¼ × 1⅛in. Not encapsulated. Brand new. Boxed. **11/6** ea.
TIMER UNIT. Standard primary transformer giving 18V 4 amp.. G.E.C. bridge rectifier in bench or wall mounting case 10 × 10 × 5in. Complete with internal one second timer sub-chassis. Checked and tested **£2/15/0.** P. & P. 15/-.
COUNTENAY TIMER sub-chassis with 2-12AU7. transistor. relay etc. Requiring 12V. A.C. or D.C. to operate 22/6.

OSCILLOSCOPES
Cossor DB 1035. **£20**; 1035 Mk. 2. **£25**; 1035 Mk. 3. **£32/10/-**; 1049. **£22/10/-**; 1049 Mk. 3. **£30**; CT52. **£15**; **HARTLEY** 13A. **£18/10/-**.
All scopes carefully serviced and in excellent condition. Carriage 30/- extra.
Miniature Scopes type 1200B. Ideal TV Servicing. etc. Checked and tested. **£10**. P. & P. £1.
ADVANCE Signal generator type D.1. 2mc/s to 190mc/s. Sine and square mod. With original charts. Excellent condition. **£12/10/-**. P. & P. £1.

RELAYS
50 Watt AUDIO AMPLIFIERS by GEC—4KT 66's 4/8/25 or high impedance inputs 15 ohm out. Standard mains in; metered output etc. No electrolytics. Absolute reliability **£20** only. Carr. 30/-.
AMPLIFIERS. Compact unit by Parmeko—rated 17 watts. capable of double. 2-KT66/2B254M; ECC81; 2-EF86; 5U4. matching to 15 ohms. High impedance or transformer input. Size 14½ × 8¾ × 8½in. high. Standard mains input. Fully tested **£8/10/-**, including carriage.
Omron/Schrack octal based plug-in relays. 2 pole c/o 5A. 230v and 6v. State which. Brand new. Boxed. **12/6** ea.
G.E.C. 4 pole c/o 6/12v operation 180 ohms. Platinum contacts. Brand new. Boxed **12/6** ea.
Min. VARLEY type VP4. 4 pole c/o 430 ohm or 15 K/ohm. Brand new **6/6** ea.
S.T.C. sealed 2 pole c/o 48V. 2,500 ohm **3/6** ea.
CARPENTERS polarised Single pole c/o 20 and 65 ohm coil as new, complete with base **9/6** ea. Single pole c/o 680. 1.110 and 1,570 ohm coil. As new **6/6** ea. Synchronous chopper AEI type CK4. As new **17/6** ea. Top connector **2/6** ea.
COLVERN Pots. Brand new. 10; 50; 100; 250; 500 ohms; 1; 2.5; 5; 10; 25; 50k all at **2/6** ea. Special Brand new **MORGANITE** 250K Lin. sealed. Normal price 9/-, our price **3/6** ea.
INSTRUMENT POTENTIOMETERS. 3" Colverns. 5, 25, 50, 100 ohms; 2·5, 25K. All at **7/-** ea.
HIGH RESOLUTION Potentiometer. 25K. 80 turns. Complete with knob. **6/6** each.
COLVERN 50K Ten Turn pots complete with dial **£1** ea. P. & P. 2/6.
ALMA precision resistors. 100K; 400K and 998K 0.1%. **5/6** each.
3.25 K 0.1% **4/-** ea.
DUBILIER Electrolytic Capacitors. 32mfd 350v. DC. Brand new, **1/9** ea.
EL84 VALVES. Ex. eq. Tested. **7/-** pair.
PANEL SWITCHES. high quality DP 2w. **2/6** ea.
RACAL stabilizer unit 24V. raw DC in 20 volts 1amp stab and 12V. 5 MA Zener stab out. Brand new condition complete with circuit diagram. **35/-** ea.
Geared Motors. 240v 50c/s synchronous. Geared down to 60 r.p.m. Brand new. **50/-** ea. P. & P. 7/6 ea.
DIODES 1N914. Brand new. **1/3** ea.; **12/-** doz.; **£4** 100; **£25** 1,000.
Photocells, equivalent OCP 71. **2/6** ea.
E.H.T. Condensers. 7·5kV working. 0·25 mfd. **8/6** ea. Brand new 5kV 0·25mfd at **10/6** ea.; 10kV 0.05mfd **7/6** ea.
VISCONOL E.H.T. Condensers. Brand new. 0·002 15kV. **8/6** ea.; 0·0005 25kV. **16/-** ea.
BURGESS Micro Switches V3 5930. Brand new **2/6** ea.
BULGIN panel mounting Lamp holders. Red. Brand new **2/3** ea.
Brand new **PLESSEY** plugs and sockets. Mark 4 and 7. Your requirements please.
MINIATURE SPEAKERS 15 ohm 100 MW 2in. diameter. Brand new **10/6.**
MAINS FREQUENCY METERS with large 270 deg. Dial calibrated 45 to 65 cycles 4in. diameter. In original service carton. **£3/10/-**. P. & P. 7/6.
TRANSISTOR Stabilised Power Unit. 48v. 4 amp. Manufactured by E.M.I. Open chassis. Brand new. Highest quality. Size 10½ × 5¼ × 6½in. high. **£6** ea.
AMERICAN TX tuning units. TU7B 4·5—6·2 Mc/s TU8B 6·2—7·7 mc/s. Only **35/-** ea. Carriage 7/6 extra
VALVE VOLTMETERS. Marconi TF899, **£7/10/-**, carriage 10/-; TF428B. **£3/15/-**, carriage 10/-;

DIGITAL VOLT METER type BIE 2114. 1 MV to 1 KV DC. Auto Decimal Change. Excellent condition **£65.**

AVO Generator type TFN AM/FM 5 mc/s to 220 mc/s. In excellent condition. **£45.**
AVO Generator CT 368 2/225/mc/s. New condition. **£50.**
AVO Meter 471A. Transistorized. 11 range DC/AC 12 micro A-1·2 Amp 11 ranges DC/AC 12 MV-1200V; 25 c/s to 50 kc/s; 5 ranges 40 MV to 4V, 20 kc/s to 500 mc/s extended with X 100 multiplier; 8 ranges 12 ohm to 120 m ohms. Input imped. 100 m/ohm per volt on 1·2 V. range. Brand new **£75** each.

19in. Rack Mounting **CABINETS.** 6ft. high. 2ft. deep. Side and rear doors. Fully tapped; complete with base and wheels. Excellent condition. **£12/10/-**. Carriage at cost.

SOLARTRON Storage Oscilloscope type QD910. Exceptional condition. Carefully checked. **£175** each.

SPECIAL OFFER
V.H.F. Receiver. type 715 by BCC. Complete tested and working (less crystal). 12v DC input. Ideal conversion 2 and 4 meters. In good condition. Supplied with conversion data. Only **£3/10/-**. P. & P. 7/6 ea.

LABORATORY OSCILLOSCOPE. Solartron CD 643. 5in. tube. DC. 12Mc/s. Rise time 30 M Micro/s. TG 100 M sec/cm to 0·1 Micro/s/cm with no expansion; with expansion 20 M Micro/s/cm. Fine condition. NOW only **£80.**

SOLARTRON EQUIPMENT
D.B. Oscilloscope. Type CD 7118.2. **£55.**
S.B. Oscilloscope. Type CD 513. **£35.**
Pulse generator. Type OPS 100C. 50 c/s to 1 Mc/s. **£25.**
Laboratory Amplifier. Type AW851A. 15c/s to 350 kc/s. **£40.** Stabilised P.U. Type SRS 152. **£12/10/-.**

MIC-O-VAC type 22 (CT54) Volts; Current; Ohms. DC to 200mc/s with probe. leads etc. As new **£8.10.0.** P. & P. 10/-. Plug-in **MAINS PACK** for Mic-o-vac type CT54. **£2/10/-**. P. & P. 6/-.

CINTEL Microsecond Counter Chronometer. 6 digit. Start-stop terminals. In fine condition **£20.** Carr. 25/-.
CINTEL Transistorized Nucleonic Scalers with adjustable discriminator. count of 10 to the 5. In as new condition. **£37/10/-** each. Carr. 15/-.
AIRMEC Counter type 865. 6 decades; bright vertical display; gate facilities. Very good condition. **£30.** Carr. 25/-.
MULLARD Transistorized Analogue to Digital Convertor Model L 281. As new. **£30.** Carr. 15/-.
SUNVIC DC Chopper Amplifier type DCA 1. Superb condition. **£22/10/-** each. Carr. 20/-.
ELLIOTT Dynamometer Model 5999. Accuracy 0.5 fsd. Perfect condition. **£12/10/-** ea. P. & P. 15/-.
Special discount to Universities. Schools, etc.

MARCONI Audio Frequency Absorption Wattmeter type TF956 (CT44). Large 6" scale. 1 micro watt to 6 watt. Excellent condition. **£15.** P. & P. 10/-.
MARCONI TF 886A. Magnification meter. **£45.**
MARCONI TF 762C UHF Generator 200 to 400 MC/s. **£40.**
MARCONI TF 995 AM/FM Generator 1·5 to 200 mc/s. **£120.**
MARCONI TF 936 (No. 5). Impedance Bridge **£75** ea.
MARCONI TF 144G Generator 85 kc/s to 25 mc/s. Tested and in excellent condition. **£18.** Carr. 35/-.
BC221 Frequency Meter. **£17.10.0**; with built-in Stab. P.U. **£22.10.0.** Carriage 15/-. With Charts.

METERS
SIGNAL GENERATOR/WAVEMETER type 61. 90 to 160 mc/s. Built in crystal markers. Standard mains input. Excellent condition **£12/10/-**. Carr. 30/-.
SIGNAL GENERATOR type CT 478 by W. H. Sanders. Freq. range 1·3 kmc/s to 4·2 kmc/s. Output power calibrated dbm. New **£40.** Carr. £2/10/-.
AM/FM OSCILLATOR Type 1 CT 212. 85 kc/s to 32 mc/s. As new **£40.**
TAYLOR 100-0-100 micro amp. Scale size 4 × 2in. Internal lamp scaled —6 —0 —6. **£2** ea.
E.H.T. Electrostatic. Ernest Turner, etc. 0/750v. **£2** ea. 0/5kV. **£3/10/-** each. 0/7·5kV. **£4/5/-** ea.
GRIFFEN & GEORGE. 3in. round. In sloped open-ended case with terms. AC 50 c/s. 3 types available: 0/20; 0/100; and 0/250v. **£1** ea.

TRANSFORMERS. All standard inputs.
18v 6 amp and 12v ½ amp. Sep. windings, **18/6** ea.
18v 12 amps at **£3** ea.
3kV 4·5mA, 4v 0·5 amp × 2, 4v 1·1 amp. Brand new. **£5** ea., ex. eq., **£3/10/-** ea. 350-0-350 75mA, 5v 2 amps × 2, **21/-** ea.
Gardners 6·3v 2A; 6·3v 1·5A; 6·3v 0·1A. Size 3 × 1⅞ × 4⅛in. As new. **14/-** ea.
Gardners. Potter. Multi 6·3's combine to give 48v at 4 amps or 6·3 at 45A. With 350-0-350 at 50mA. As new. **£2/10/-** ea.
Parmeko/Gardners. Potted. 475-60-0-60-475 at 160 mA; separate winding 215-0215 at 45mA; 6·3v 5A; 6·3v 0·75A; 5v 3A. As new. **£3** ea.
Gardners 400-350-0-350-400 at 250MA; 0/4/6·3v 4 amp × 2; 0/4/6·3 2 amp; 0/4/5 3·5A. In original boxes. **£4/10/-** inc. post. Gardiners 2kV 10MA. As new. **£3** incl. postage. Gardiners 2kV 10MA and 4 volts × 2. **£4/10/-** ea incl. postage.
Parmeko 6·3v at 2 amp × 4. **22/6** ea.
Parmeko 65v 1 amp. Separate 0-18-24v at 0·5 amp. **30/-** ea.
Gard/Parm/Part. 450-400-0-400-450. 180 MA. 2 × 6.3v. **£3** each.
CHOKES. 5H; 10H; 15H; up to 120mA. **8/6** ea. Up to 250mA **12/6** ea.
Large quantity LT. HT. EHT transformers. Your requirements. please.
SERVOMEX. Stabilized D.C. Power supplies type DC3. 0-30 Volts. 0-7 amps. Separate voltage and current meters. **£40.** Type 38. bench mounting. 0-15 Volts. 0-2.5 amps. Separate voltage and current meters **£30**
Bulk **TAPE ERASE** unit 1 or 2in. video tape 14in. diameter. As new **£15.** Carr. 25/-.
E.H.T. Brand new 5kV 5MA with rectifier heater winding. Size 3 × 3 × 3½in. **27/6** ea.

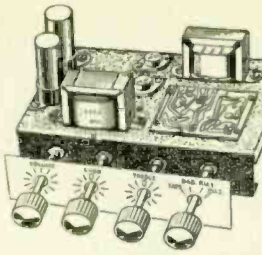
Cash with order. Post paid over 10/-

FOR CALLERS. Always a large quantity of components, transformers, chokes, valves, capacitors, odd units, etc., at 'Chiltmead' prices. Callers welcome 9 a.m. to 10 p.m. any day

CHILTMEAD LTD.

22 SUN STREET · READING · BERKS,
Off Cumberland Road (Cemetery Junction) Tel. No. Reading 65916 (9 a.m. to 10 p.m.)

NEW ! HSL.700 Mono Transistor Amplifier



A really high fidelity monaural amplifier with performance characteristics to suit the most discriminating listener. 6 transistor circuit with integrated preamplifier assembled on special printed sub panel. AD-161-AD162 operating in symetrical complementary pair. Output transformer coupled to 3 ohm and 15 ohm speaker sockets. Standard phono input sockets. Full wave bridge rectifier power supply for A.C. mains 200-240 v. Controls: Bass, Treble, Volume/on/off. Function selector for PU1, PU2, Tape, Radio. The HSL.700 is strongly constructed on rigid steel chassis, bronze hammer enamel finish. size 9½ in. × 5 in. × 4½ in. high. Performance figures:
Sensitivity—PU1-50 m/v., 56K input impedance.
PU2-110 m/v, 1 meg. input inpedance.
Tape—110 m/v, 1 meg. input impedance.
Radio—110 m/v, 1 meg. input impedance.
Output power measured at 1 Kc-6.2 watts RMS into 3 ohms, 5.8 watts RMS into 15 ohm. Overall frequency response 30 c/s-18 Kc/s: Continuously variable tone controls; Bass, + 8db to 12 db at 100 c/s. Treble, + 10 db to – 10 db at 10 Kc/s.
The HSL.700 has been designed for true high fidelity reproduction from Radio Tuner, Gramophone deck and Tape Recorder pre amp but is also capable of being used in conjunction with a guitar by connecting to PU1 socket and the peak output power will then be in the region of 15 watts.
Supplied ready built and tested, complete with knobs, attractive anodised aluminium front escutcheon panel, long spindles (can be cut to suit your housing requirements), full circuit diagram and operating instructions. OUR SPECIAL PRICE **£7/19/6.** P. & P. 7/6.

BRAND NEW!
PARMEKO MAINS TRANSFORMERS
Primary 110v-250v Secondary 330-0-330v. 100mA and 6.3v. at 2 amps. 6.3v. at 2 amps and 6.3v. at 1 amp. Conservatively rated. Fully impregnated. Electrostatic screen. Suitable for vertical or drop through mounting. Overall size 4½in. × 3½in. × 3½in. Weight 8lbs. Limited number only at 37/6 P. & P. 8/-.

Transistor Stereo 8+8 Mk. II
Now using Silicon Transistors in first five stages on each channel resulting in even lower noise level with improved sensitivity. A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors giving 8 watts push pull output per channel (16W, mono), integrated pre-amp, with Bass, Treble and Volume controls.* Suitable for use with Ceramic or Crystal cartridges. Output stage for any speakers from 3 to 15 ohms. Compact design, all parts supplied including drilled metal work. Cir-Kit board, attractive front panel knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief Specification: Freq. response ±3dB, 20-20,000 c/s. Bass boost approx. to +12dB. Treble cut approx. to —16dB. Negative feedback 18dB. over main amp. Power requirements 25V. at .6 amps.
PRICES: Amplifier Kit £10/10/0; Power Pack Kit £3/0/0; Cabinet £3/0/0. ALL POST FREE.
Circuit diagram, construction details and parts list (free with kit) **1/6** (S.A.E.).

SPECIAL OFFER!
HI FI CELESTION SPEAKER UNIT. Size 6in. × 4in. Powerful 11,000 line magnet with specially treated cone surround. 10-12 ohm impedance. Few only at 20/- P. & P. 3/6.

QUALITY RECORD PLAYER AMPLIFIER MK. II
A top-quality record player amplifier employing heavy duty double wound mains transformer. ECC83, EL84, EZ80 valves. Separate bass, treble and volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 3in. d. × 6in. h. Ready built and tested. **PRICE 75/-**. P. & P. 6/-.
ALSO AVAILABLE mounted on board with output transformer and speaker ready to fit into cabinet below. **PRICE 97/6.** P. & P. 7/6.

DE LUXE QUALITY PORTABLE R-PLAYER CABINET MK. 2
Uncut motor board size 14½ × 12in., clearance 2in. below, 5½in. above. Will take amplifier above and any B.S.R. or GARRARD Autochanger or single Player Unit (except AT60 or SP25). Size 18 × 15 × 8in. **PRICE 79/6.** Carr. 9/6.

3-VALVE AUDIO AMPLIFIER MODEL HA34 MK. II

Designed for Hi-Fi reproduction of records. A.C. mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. × 4in. d. × 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker. Separate volume control and now with improved wide range tone controls giving bass and treble lift and cut. Negative feed-back line. Output 4½ watts. Front-panel can be detached and leads extended for remote mounting of controls. The HA34 has been specially designed for us and our quantity order enables us to offer them complete with knobs, valves, etc., wired and tested for only **£4/15/-**. P. & P. 6/-.

10/14 WATT HI-FI AMPLIFIER KIT

A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up: 2 EL84s, ECC83, EF86, and EZ80 rectifier. Simple instruction booklet 1/6 (Free with parts). All parts sold separately. ONLY **£7/9/6.** P. & P. 8/6. Also available ready built and tested complete with standard input sockets. **£9/5/-**. P. & P. 8/6.

HARVERSON SURPLUS CO. LTD.

170 HIGH STREET, MERTON, LONDON, S.W.19
Telephone: 01-540 3985
S.A.E. all enquiries.
Open all day Saturday (Wednesday 1 p.m.)
PLEASE NOTE: P. & P. CHARGES QUOTED APPLY TO U.K. ONLY. P. & P. ON OVERSEAS ORDERS CHARGED EXTRA.

NEW 4th EDITION

THE SEMICONDUCTOR DATA BOOK

by Motorola

60/- Postage 5/-

TRANSISTOR AUDIO AND RADIO CIRCUITS by Mullard. 30/-. Postage 1/-.

TELECOMMUNICATIONS AND THE COMPUTER by James Martin. 140/-. Postage Free.

SERVICING WITH THE OSCILLOSCOPE by Gordon J. King. 28/-. Postage 1/-.

THE HI-FI AND TAPE RECORDER HANDBOOK by Gordon J. King. 40/-. Postage 1/6.

TRANSISTOR MANUAL by General Electric Company. 21/-. Postage 1/6.

DISCRETE AND INTEGRATED SEMICONDUCTOR CIRCUITRY by L. J. Herbst. 38/-. Postage 1/-.

SCR MANUAL by General Electric Company. 25/-. Postage 1/6.

TRANSISTOR POCKET BOOK by R. G. Hibberd. 25/-. Postage 1/-.

THE MODERN BOOK CO.

BRITAIN'S LARGEST STOCKIST
of British and American Technical Books

19-21 PRAED STREET,
LONDON, W.2

Phone PADdington 4185
Closed Sat. 1 p.m.

High grade of stability of electric parameters
Resistance and durability
Long operational life

Polish

electronic tubes for radio receiver sets
electronic tubes for TV receiver sets
and
electronic components

are offered by

UNIVERSAL

Foreign Trade Enterprise
Warszawa, Al. Jerozolimskie 44, Poland
P.O. Box Warszawa 1 No. 370.
Telex No. 81437

To persons interested we forward detailed information, catalogues and tenders.

WANTED—
Redundant or Surplus stocks of Transformer materials (Laminations, C. cores, Copper wire, etc.), Electronic Components (Transistors, Diodes, etc.), P.V.C. Wires and Cables, Bakelite sheet, etc., etc.
Good prices paid
J. BLACK
44 Green Lane, Hendon, N.W.4
Tel. 01-203 1855 and 3033

GLASS FIBRE OPTIC
FLEXIBLE LIGHT PIPE, now available in any length. 150+ glass fibres with three times lower loss than plastic fibre. P.V.C. sheath 0.080 in. dia.
Used like wire but to convey light to remote or inaccessible positions for inspection, panel indicators, photo-electric and other applications. Prices per ft. (post free): 1-9, 5/-; 10-49, 4/-; 50-249, 3/-. Enquiries S.A.E.
SYSTEM 696 & CO.
15 BELL ROAD • EAST MOLESEY • SURREY

PRINTED CIRCUITS
Small quantities are not expensive, we have full artwork and assembly facilities.
Let us quote you for any quantity.
OFRECT ELECTRONIC SYSTEMS LTD.
Hookstone Park, Harrogate
Harrogate 86258
Telex 57962

NEW LOW COST

Oscilloscope Camera-Type p

Setting a new standard combining lower purchase and operating costs with superior performance, the Telford Type P meets requirements where smaller or standard oscilloscopes are employed.

SIMPLE OPERATION—ATTRACTIVE APPEARANCE—LIGHTWEIGHT—ECONOMY SIZE POLAROID FILM TYPE 20

LENS
High-quality Dallmeyer F4.5 2.4" (61 mm) lens provides a reproduction of trace and graticule with good linearity. The object/image ratio is 1:0.7 (nom).

SHUTTER SPEEDS
Three modes of operation are provided, including fixed exposure 1/25 sec. (nom.), time and brief.

ADAPTERS
Comprehensive range of adapters are available to fit most popular oscilloscopes.

TELFORD PRODUCTS LTD.

4 Wadsworth Road, Greenford, Middlesex. Telephone: 01-998 1011

THE DAVALL PHOTO OPTICAL COMPANY OF THE BENTIMA GROUP

"OSCILLOSCOPES"

Double Beam, Single Beam and Differential Types Available Now

	Price
Telequipment D55	£95
E.M.I. WM8. DC–15 MHz	£100
Naggard Model 311 DB	£225
Hewlett Packard 130 A	£95
Marconi TF 1277	£105
Solartron CD 5235	£49
Solartron CD 711	£55
Solartron CD 7115/2	£75
Mullard 140/3	£125
Furzhill Model 0–100	£22
Hartley 13A DB	£22
Cossor 1049 DB	£35
Cossor 1035 DB	£25
Lavoie 05–73 DC–35 MHz	£150
Solartron CD 514	£40
Cossor 1065	£35
Telequipment 520	£18

Please write for further details

"SPECIAL OFFER"

SOLARTRON HIGHLY STABILISED P.S.U. MODEL SRS 151A

Output 20–500 v. in two ranges. Positive line at 300 mA. Variable output 170 v. fixed; 0–170 v. variable. Two A.C. outputs at 6·3 v. A.C. are provided.

These units are offered in first-class condition. For A.C. mains. 200–250 v. A.C. Overall case dimensions 20 × 16 × 10 ins. approx.

Price £35. Packing and carriage 30/-.

Handbook available with P.S.U.

* TRANSISTORISED STABILISED * LOW VOLTAGE P.S.U. TYPE 4D

3–30 v. D.C. at 3 amps. Fully variable.
Current limiting control.
Sensing facilities for remote operation.
Protected and fused for 110/250 v. A.C. mains.
Small size only: 5½ × 5 × 11 ins. deep.
Stability: 1000–1.
Ripple: 1 mV. max. Weight: 16 lbs.

These units are built to high present-day standards and are offered BRAND NEW BOXED at £20 inclusive of post and packing.

ALSO AS ABOVE 1 AMP MODEL. TYPE 4B

Size: 4 × 3½ × 7 ins. Weight: 6 lbs.
Price £13.10.0 inclusive of post and packing.

R.D.O. UHF/VHF RECEIVERS

This is an I.F. (300 Mc/s) five-stage amplifier followed by A.F. and video stages. R.F. tuning is provided by interchangeable Tuning Heads or Units which cover frequency range of 38 to 4,000 Mc/s. Receiver . . . I.F. sensitivity is 15µV. approx. for an output of 6 mW. I.F. bandwidth is 4 Mc/s. Audio response can be set at 150–10,000 c/s (broad) or 320–1,950 c/s (narrow). Provisions are made for connecting the receiver to a Panoramic Adaptor (for observing frequency spectra) or to a Pulse Analyser. Power requirements—115 v. A.C. PRICE, fully overhauled and guaranteed, complete with Tuning Units TN1B, TN2B and TN3B to cover frequency range from 40 to 1,000 Mc/s.... £110 0 0

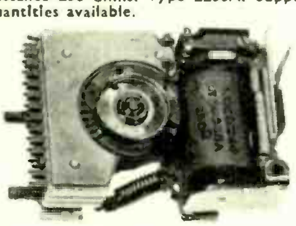
Packing and carriage 50/-.

PORTABLE 12 v. BATTERIES

Non-spillable lead acid type. Rating: 12 v. 4 amp. hours, will withstand heavy overloads without damage.
Size: 4 × 4 × 4 ins. Weight: 4 lbs.
Supplied fully sealed/charging instructions.
BRAND NEW BOXED 45/-. Post and packing 4/6.
Ideal for Model Boats and Photo Floods, etc.

A.E.I. MINIATURE UNISELECTORS

Coil resistance 250 ohms. Type 2200A. Supplied with base. Quantities available.



Price £4.19.6

VIBRATING REED FREQUENCY METERS

Range 55–75 c/s in 2 scales, having total length of 10 ins. for 110 v. (or 240 v. with transformer).
Manufacturer: Trub Tauber, Zurich. **Price £12.10.0.**

NIFE BATTERIES—NICKEL IRON

We have for disposal complete sets comprising 2 batteries to a total of 12 v. at 180 amp/hours. Supplied filled as NEW CONDITION.
Price £45 per set. Carriage extra.

DAWE STOBOFLASH TYPE 1200C

Fully calibrated in r.p.m. for 240 v. A.C. mains operation, these instruments have many uses especially in the field of engineering, enabling operators to view reciprocating and revolving machinery under actual conditions and determining speeds of motors, fans, etc. Offered in good condition at only **£27.10.0**

CREED MOTORS—REF. 522

Originally intended for teleprinters. Will make ideal light duty grinders/buffers, etc. Series wound 4,200 r.p.m. 125 v. A.C. or D.C. 42 watts. BRAND NEW. Spare brushes. 35/6. Post and packing 4/6.

R.F. ATTENUATORS TYPE A38

These attenuators are contained in a screened cast case and are suitable for the audio to VHF range up to 300 Mc/s. Input level 0·5 watts max. Impedance 75 ohms. Attenuation 80 dB in steps of 20 dB. Weight: 9 oz. Panel mounting. List price £10. Special offer price 85/- post paid.

BURNDEPT R.F. PLUGS

These difficult-to-obtain plugs, suitable for Londex aerial, C/O relays and other types of equipment, are supplied NEW EX CABLES at 4/6 each or 3 for 12/-. Post and packing 6d.

HIGH VOLTAGE TRANSFORMER

A.I grade. Input 240 v. tapped down to 200 v. Output 2,560 and 2,820 v. at 1 amp. Offered at only **£15.** Weight: 75 lb. Post and packing 25/-.

EDDYSTONE DIE-CAST BOXES

Contains sensitive amplifier originally intended for amplification of P.E. cells. C/W input socket, fuse, signal lamp P.S.U. (mains) amplifier, fully transistorised. BRAND NEW 32/6. Post and packing 2/6.

LEDEX ROTARY SWITCHES

Standard wafer size: 1⅞ ins. Single-pole 12-way, 3-bank flange mounting. 48 v. D.C. coils. Minimum voltage 30 v. D.C. Supplied BRAND NEW 45/-.
Similar to above but one wafer with long spindle to enable user to make up to own requirements.
Coil voltages: 30–48 v. D.C. BRAND NEW 35/-.

PLESSEY HIGH-SPEED SWITCHING RELAYS

Ideally suitable for transistor circuits. Coil 12 v. 3,100Ω. Single pole change over. Fully sealed. Small size. BRAND NEW. Only 15/-. Post and packing 1/-.

IMHOFS INSTRUMENT CASES

Finished in mottled grey stove enamel with satin finish trim. Size width for standard 19 in. equipment. Height: 10 ins. Depth: 15 ins. With front panel and ventilated rear panel.
Supplied BRAND NEW **£4.10.0 each.** Carriage 10/-.

COMMUNICATIONS RECEIVERS

Redifon R50M. 16·5 Kc/s–32 MHz in 8 bands. These well-known receivers are in world-wide use. Especially built to marine specifications. Price as new £105. Used model reconditioned to specification **£85.** Supplied with mains 240 v. A.C. P.S.U.

"PERISTALTIC PUMPS" TYPE MHRE 721. WATSON MARLOW LTD.

These very versatile units have facilities for two feed lines and are highly suitable for corrosive liquids and chemicals. Operating voltage 200/250 v. A.C. These are standard type without variable speed control. Offered BRAND NEW at only **£24.10.0.** Post and packing 10/-.

HIGH VALUE RESISTANCE BOX TYPE R.7003

Specification. Range: 0·01–11·10 Megohm in 0·01 Megohm divisions. Accuracy: 0·05 per cent. Maximum power rating: 0·1 watt per step. Case: Hammer finished stove enamel.
List price £60. Our price **£22.10.0.**

"TEKTRONIX" OSCILLOSCOPE 515A

D.C. to 15 MHz. Rise time 23 NS.
As new condition. Offered at a little over half Price. **£260.** Guaranteed.

REMSCOPE DOUBLE-BEAM STORAGE OSCILLOSCOPE

With two plug-ins. Type 741/1 and 741/2. As new condition. **Please write for further details.**

PORTABLE MULTIRANGE METER

Specification. Ranges: 0–60 and 0–300 µA, D.C. 0–3, 0–30 and 01–120 mA, D.C. 1·2 and 12 amps D.C. 0·6–3 and 6–30 mA, A.C. 24–120 mA, A.C. 0·24–12 A, A.C. 3–12–30–300–600–1,200 and 6,000 v. D.C. 0·6–3, 2·4–12, 6–30, 60–300, 120–600, 240–1,200 and 1,200–6,000 v. A.C. 3–333 ohms, 0·3–30 Kohms, 0·03–3 megohms D.C. Resistance: —12 to +78 Decibels. Frequency: 50 cps. Input Resistance D.C.: 20,000 ohms/volt. Input Resistance A.C.: 2,000 ohms/volt. Temperature Range: —10 to +50 deg. C. Dimensions: 255 × 215 × 170 mm. Weight: 8 kg. Supplied with 2 voltage dividers, H.V. leads, spare rectifiers, 1·5 and 22·5 v. battery.
List price £25. Our price £12.19.6.

BRADLEY D.C. CALIBRATOR TYPE 126

This instrument is essential for the accurate calibration of meters/oscilloscopes and provides accurate voltages up to 2,500 v. D.C. For lab. use at 2 mA. Ripple 0·05%. Accuracy ±0·5%. Range 0–2,500 v. in 50 v. steps. Polarity positive or negative with respect to earth. Percentage deviation ±5% of output voltage (calibrated control). Supplied in perfect condition at **£60.**

BOONTON SIGNAL GENERATOR TS 497/B/URR

Attenuation 0·1 micro v.–100 mV.
Supplied in very good condition.
Frequency coverage: 2–400 MHz.

SCHOMANDLE FREQUENCY METER FD1 with Type FDM1 Adaptor

Range: 30–900 MHz.
Approved by G.P.O. as standard for mobile communications equipment, etc.

MARCONI DIGITAL FREQUENCY METER TF 1325/2

Range, with plug-in, up to 220 MHz.
Supplied AS NEW **£325** with plug-ins.

ADVANCE FREQUENCY COUNTER TIMER—TYPE TC 1A

6 digit in line read out.
List price £390. Our price **£95.**

FLUKE DIFFERENTIAL V.T.V.M. MODEL 821A

Range: 0–500 v. and 001–10 v. as null detector.

ENGLISH ELECTRIC INSULATION TESTERS

Fully variable to 10 kV. Metered output on voltage and current for 240 v. A.C. operation.
Supplied AS NEW at **£35** each.

DIGITAL VOLTMETERS!

*** A.C. AND D.C. ***

Digimeter Type B.I.E. 2123 is a fully transistorised multi-range instrument possessing the following distinctive features:

Electrical characteristics:
D.C. Ranges: 10 mv to 400 volts in four ranges (1,000 volts for positive voltages).
Accuracy: the greater of ±0·1% of ±1 digit.
A.C. Ranges: 100 mV to 250 volts RMS in three ranges.
Brand new with handbook £92.10.0.

LAST FEW TO CLEAR ONLY £70 EACH

P. F. RALFE *10 Chapel Street London N.W.1*

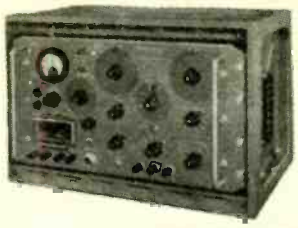
Phone 01-723 8753

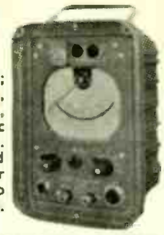
VALVES

Type	Price
CY31	7/6
DAF96	7/9
DF96	7/9
DK92	9/-
DK96	7/6
DL92	6/6
DL94	6/6
DL96	8/-
DM70	6/-
DM71	7/6
DY86	6/-
DY87	6/6
DY802	9/9
EABC80	6/6
EAF42	10/-
EB91	2/-
EBC33	8/-
EBC41	10/6
EBC81	9/-
EBF80	7/6
EBF83	8/6
EBF89	6/-
ECC81	6/-
ECC82	5/9
ECC83	5/6
ECC84	6/-
ECC85	5/6
ECC86	9/-
ECC88	7/-
ECC189	9/9
ECC804	12/6
ECF80	6/6
ECF82	6/6
ECF83	15/6
ECF801	12/6
ECF802	12/6
ECH35	11/-
ECH42	13/-
ECH81	5/9
ECH83	8/6
ECH84	7/6
ECH200	12/6
ECL80	9/-
ECL82	12/6
ECL83	16/6
ECL86	8/6
EF36	3/6
EF37A	8/-
EF39	6/-
EF40	10/-
EF41	12/6
EF42	14/6
EF80	5/-
EF83	9/7
EF85	6/6
EF86	6/3
EF89	5/3
EF91	3/-
EF92	2/6
EF95	5/-
EF183	6/6
EF184	7/-
EF800	21/-
EF812	15/6
EFL200	15/6
EH90	7/6
EL34	10/6
EL41	11/6
EL42	11/6
EL84	4/9
EL85	8/-
EL91	5/-
EL95	7/-
EL500	17/-
EL8035	17/-
EM31	5/-
EM80	7/6
EM84	7/-
EM87	11/-
EY51	8/-
EY86	7/6
EY88	8/6
EZ40	8/3
EZ41	8/6
EZ80	5/-
EZ81	5/-
GZ34	10/6
KT66	26/-
KT88	32/-
N78	25/-
OA2	6/-
OB2	6/-
PABC80	7/6
PC97	9/-
PC900	9/6
PCC84	6/9
PCC89	9/6
PCC189	11/6
PCE800	15/-
PCF80	6/6
PCF82	6/9
PCF84	9/3
PCF86	10/-
PCF200	15/6
PCF201	15/6
PCF801	9/9
PCF802	9/9
PCF805	14/6
PCF806	13/-
PCF808	14/6
PCH200	12/6
PCL81	9/6
PCL82	7/6
PCL83	13/-
PCL84	8/6
PCL85	9/3
PCL86	9/-
PFL200	12/-
PL36	10/9
PL81	8/9
PL82	8/-
PL83	7/3
PL84	6/6
PL500	14/9
PX4	14/-
PX25	12/6
PY33	12/-
PY80	6/6
PY81	5/6
PY82	5/6
PY83	7/-
PY88	7/6
PY800	9/6
PY801	9/6
PY802	13/6
QQVO3-10	25/-
QQVO6-40	85/-
QQVO6-40A	100/-
R17	8/-
R19	7/6
U25	14/6
U26	14/6
U27	8/-
U191	14/-
U404	6/-
U801	20/-
UABC80	6/6
UAF42	10/6
UBC41	9/6
UBF80	7/-
UBF89	7/-
UCF80	10/-
UCH42	12/6
UCH81	7/-
UCL82	7/6
UCL83	12/-
UF41	10/6
UF80	7/3
UF89	6/9
UL41	11/6
UL84	6/6
UU5	7/-
UY41	7/-
UY85	5/9
VR105/30	6/-
VR150/30	6/-
Z800U	29/-
Z801U	25/-
Z900T	12/-
1L4	2/6
1R5	6/-
1S4	5/-
1S5	4/6
1T4	3/-
1X2A	7/6
1X2B	7/6
3A4	4/-
3D6	3/-
3Q4	7/6
3S4	6/9
3V4	8/-
5B254M	36/-
5B/255M	35/-
5R4GY	10/6
5U4G	5/6
5V4G	7/6
5Y3GT	6/-
5Z4	14/-
5Z4G	7/7
6AB7	4/-
6AC7	3/-
6AH6	11/6
6AK5	5/-
6AK8	6/-
6AL5	3/-
6AL5W	7/-
6AM5	5/-
6AM6	3/-
6AN5	20/-
6AN8	10/-
6AQ5	6/-
6AQ5W	9/-
6AS6	6/-
6AS7G	16/-
6AT6	4/6
6AU6	5/-
6AX4	8/-
6AX5GT	13/-
6B7	5/6
6BK7	8/-
6BA6	4/6
6BA7	12/6
6BE6	5/-
6BG6G	11/-
6BJ6	8/6
6BJ7	7/-
6BL7GTA	11/-
6BQ7A	6/9
6BR7	16/-
6BW6	16/-
6BW7	13/-
6C4	5/9
6C6	4/-
6CH6	7/-
6CL6	9/9
6D6	3/-
6EA8	9/-
6EU7	7/-
6F23	15/-
6F33	20/-
6H6M	3/-
6J4WA	12/-
6J5	7/-
6J5GT	5/-
6J6	3/6
6J7G	5/-
6J7M	8/-
6K6GT	8/-
6K7	6/6
6K7G	2/-
6K7GT	4/9
6K8G	4/-
6K8GT	7/3
6K25G	14/-
6L6	14/6
6L6GA	9/6
6P25	12/6
6SA7	7/-
6SA7GT	6/6
6SC7	7/-
6SC7GT	5/-
6SG7	6/-
6SJ7	6/-
6SJ7GT	6/6
6SJ7Y	6/6
6SK7	7/-
6SL7GT	6/6
6SN7GT	6/-
6SQ7GT	7/9
6V6G	3/6
6V6GT	6/3
6V6M	8/-
6X4	4/9
6X5G	5/-
6X5GT	5/6
6-30L2	14/-
6Z4	5/-
7C5	14/6
7C6	6/-
7H7	5/6
7Y4	9/3
9D6	2/6
11E2	30/-
12AT6	4/6
12AT7	4/-
12AU7	5/9
12AV6	5/6
12AX7	6/-
12BA6	6/-
12BE6	6/-
12BH7	3/6
12C8	3/-
12E1	17/-
12K5	10/-
12K7GT	7/6
12K8GT	7/6
12Q7GT	5/6
12SG7	4/6
1487	15/-
19AQ5	5/9
19G3	60/-
19G6	20/-
19H4	70/-
20P4	20/6
25L6GT	7/3
30C15	15/-
30C17	16/-
30C18	15/-
30F5	16/9
30FL1	15/-
30FL12	19/-
30FL13	9/3
30FL14	15/6
30L15	17/-
30L17	17/-
30P12	16/-
30P19	14/-
30PL1	14/-
30PL13	18/6
35W4	5/-
42	5/-
50C5	6/-
50CD6G	27/6
50EH5	12/-
75	5/6
76	5/-
78	5/-
80	7/6
807	9/-
813	75/-
832A	45/-
866A	15/-
954	4/6
955	2/6
956	2/-
957	5/-
991	6/-
1622	17/-
2051	5/-
3505	13/-
5676	10/-
5678	10/-
5726	7/-
5933	22/6
6057	10/-
6060	7/6
6064	7/-
6065	8/-
6080	27/6
6146	28/-
9001	3/-
9002	4/6
9003	8/6
9004	2/6
9006	2/6
C.R. Tubes	
09J	75/-
VCR97	32/6
VCR517	50/-
VCR517B	55/-
VCR517C	45/-
5FP7	26/7
Photo Tubes	
GS16	12/6
CMG25	45/-
931A	62/6
6097C	350/-
Special Vlvs.	
ACT6	£8
ACT9	£16
CV1031	70/-
CV2339	£20
K301	£4
K305	£12
K308	£12
K337	£12
KRN2A	70/-
2J22	£2/10/-
WL417A	30/-
3J/92/E	£37/10/-
5C22	£15
714AY	£4
723A/B	130/-
725A	£10

P. C. RADIO LTD.
170 GOLDHAWK RD., W.12
01-743 4946

MARCONI TEST EQUIPMENT





VALVE VOLTMETER TYPE TF 958. Measures AC 100mV; 20 c/s to 100 mc/s, DC 50mV to 100V, multiplier extends ac range to 1·5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. **£32.10.0.**

IMPEDANCE BRIDGE TYPE TF 369 (No. 5). Measures L & C at 80Hz, 1kHz, 10kHz. Ranges:—L: 1μH-100H. C: 1mF-100μF. R: 0.1ohms 100mohms. AC Bridge volts monitored and variable. Automatic detector sensitivity control. **£105.** Carriage 30/-.

FM DEVIATION METER TYPE TF 791B. Frequency range: 4-250MHz, deviation 1-75kHz. Specification and price on application.

SIGNAL GENERATOR TF 801/A. 10-300 Mc/s. in 4 bands. Internal at 400 c/s. 1 kc/s. External 50 c/s to 10 kc/s. Output 0-100 db below 200 mV from 75 ohms source. **£85.** DITTO but **801/A/1** with additional high level output. **£89.** Both P. & P. 20/-, including necessary connectors, plugs, and instruction manual.

DISTORTION FACTOR METER TYPE TF 142E. Frequency range: 100-8,000Hz in four ranges. Distortion range: 0.05 to 50%. Input impedance 600Ω, attenuation 0-60db continuously variable. Sensitivity 1mW. **£42.10.0.** Carriage 20/-.

PULSE GENERATOR TYPE TF 675F. Repetition frequency: 50Hz to 50kHz. Pulse duration: 0.15 to 100Ω sec; built in 0.1 and 0.5μ sec delay lines. **£40.10.0.** Carriage 20/-.

CIRCUIT MAGNIFICATION METER TYPE TF 329F. Frequency range: 50kHz to 50MHz. Magnification 10 to 500 Q, Tuning Capacitor: 40 to 450pF with ±3pF vernier. Fully overhauled and calibrated, **£70.** Carriage 30/-.

TF 899 VALVE VOLTMETER, 10mV to 2V, **£17.10.0.** Carriage 30/-.

F.M. DEVIATION METER TF 934, £57.10.0. Carriage 30/-.

VIDEO OSCILLATOR TF 885A & 885A/1, £55 and **£85** resp. Carr. 30/-.

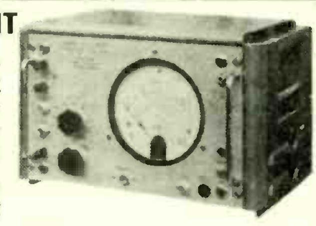
HEWLETT-PACKARD TEST EQUIPMENT

MODEL 524B ELECTRONIC COUNTER WITH MODEL 525B PLUG IN UNIT. Basic counter measures frequencies from 10Hz to 10MHz and time from 0 to 10 kHz. Automatic positioning of decimal point, eight place registration. Full self check facility from built in frequency standards. Plug in unit extends frequency range of basic counter to 100 to 220MHz. Full specification and price on request.

MODEL 400D VALVE MILLIVOLTMETER. Voltage range: 1mV to 300v F.S.D. in 12 ranges. Frequency range: 10Hz to 4MHz. Input impedance 10MΩ and 15pF. Accuracy 2%. **£38.10.0.** Carriage 12/-.

MODEL 430C MICROWAVE POWER METER. Power range: 0.1 to 10mW F.S.D. in five ranges, also calibrated in DBM from —20 to +10. Frequency range: 10MHz to 'R' Band, depending on Bolometer mount. **£58.10.0.** Carriage 30/-.

SOLARTRON EQUIPMENT



VF 252 VALVE VOLTMETER. Voltage range: 1.5mV to 15v F.S.D. in nine ranges. 10:1 attenuator input; accuracy 1%. Frequency range: 10Hz to 100kHz. Input impedance: Greater than 50MΩ with 20pF. Full specification upon request. **£33.10.0.** Carriage 15/-.

Regulated and stabilised **P.S.U. SRS 151A,** 20 to 500V positive at 300mA in two ranges. Variable and fixed 170V negative output, **£35.** Carriage 20/-.

CD 711S.2. Double beam, DC to 7MHz 'scope, **£85.** Carriage 30/-.

CD 643.2. Single beam Laboratory Model, DC to 14MHz price upon application.

QD 910. Storage Oscilloscope, as new. Price on request.

ENGLISH ELECTRONIC INSULATION TESTERS 0-10KV with built-in ionisation amplifier, **£35.**

AIRMEC INSULATION TESTER O-15KV with built-in ionisation amplifier, **£28.**

KELVIN & HUGHES PEN RECORDERS £35. Carriage 15/-.

END OF RANGE ITEMS in 'as seen' condition: CR 100—£10; H.R.O.—£10; Coils at 15/-; AR 88, less case, £12.10.0; TF 144 Signal Generator (Rack Models) £20; Furzehill VTVM 10mV to 100V—£15.

GAUMONT KALEE (RANK STUDIO) MODEL 1740 WOW & FLUTTER METER. £105. Carriage 7/6.

BOONTON SIGNAL GENERATOR TS 497/B/URR, 2-400MHz. £95. Carriage 30/-.

TS 418 B/U SIGNAL GENERATOR, 400-1000MHz. £105. Carr. 30/-.

AVO SIGNAL GENERATOR CT 378, 2-225MHz. £58.10.0. Carr. 18/-.

TELEPHONE ENQUIRIES relating to **TEST EQUIPMENT** should be made to 01-748 8006 Extension 23.
To view **TEST EQUIPMENT** please phone for appointment

TRANSISTORS, ZENER DIODES etc.

Type	Price
OA5	2/6
OA10	3/-
OA70	2/-
OA71	2/-
OA79	1/9
OA81	1/6
OA200	1/9
OA202	2/-
OA210	7/6
OA211	9/6
OAZ200	11/-
OAZ201	10/-
OAZ202 to OAZ206	8/6
OAZ207	9/6
OAZ208 to OAZ213	6/6
OAZ223 to OAZ225	10/-
OC16	15/-
OC22	10/-
OC25	7/6
OC26	5/-
OC28	12/6
OC29	15/-
OC35	10/-
OC38	8/6
OC44	4/-
OC45	2/6
OC71	2/6
OC72	4/6
OC73	11/-
OC75	6/-
OC76	5/-
OC81	4/-
OC81D	3/-
OC81DM	3/-
OC82	5/-
OC82DM	3/-
OC83	4/6
OC83B	3/-
OC139	6/6
OC140	9/6
OC170	5/-
OC171	6/-
OC172	7/6
OC200	7/6
IN21	3/6
IN21B	5/-
IN25	12/-
IN43	4/-
IN70	4/-
2N1306	6/6
2N1307	6/6
2S303	10/-
AC126	6/6
AC127	7/6
AC128	6/6
AC176	7/6
ACY28	4/-
AD140	13/-
AD149	16/-
AF117	5/-
AF118	10/-
AF124	7/6
AF127	5/-
AF139	10/-
AF178	12/6
AFY19	22/6
ASY26	5/6
ASY28	5/6
BC107	3/6
BFY51	4/6
BFY52	4/6
BSY27	5/-
BYZ13	5/-
BYZ16	15/-
CR81/10	5/-
CR81/20	9/6
CR81/30	10/-
CR81/35	11/6
CR81/40	12/6
CR83/05	6/-
CR83/20	10/-
CR83/30	11/6
CR825/025	15/-
CR83/40	12/6
GET103	4/-
GET115	9/-
GET116	8/-
MPF102	11/-
MPF103	9/6
MPF104	10/-
MPF105	10/6
Z Range Zener diodes	3/6 ea.
Z2A range	7/6 ea.
Z3B range	5/- ea.
ZL range	5/- ea.
Z8 range	7/6 ea.

MANY OTHERS IN STOCK include Cathode Ray Tubes and Special Valves. U.K. P. & P. up to 10/- 1/-; to £1 2/-; over £1 2/- in £, over £3 post free. C.O.D. 4/- extra.

Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.

TELEMETRY STATION

We are able to offer, one only. Telemetry Station of very recent American manufacture. Comprising Helical Antenna, oscilloscope receiver and associated units, Ampex tape recorder and power supply for the entire installation. Interested clients with a knowledge of this type of equipment are invited to phone or write for further particulars.

PRECISION VHF FREQUENCY METER TYPE 183. 20-300 Mc/s with accuracy 0.03% and 300-1,000 Mc/s with accuracy 0.3%. Additional band on harmonics 5.0-6.25 Mc/s with accuracy $+ -2 \times 10^{-6}$. Incorporating calibrating quartz 100 kc/s $+ -5 \times 10^{-5}$ 120/220v. A.C. mains. **£85.** Carr. **£2.**

PYE EQUIPMENT

4 CHANNEL H.F. TRANSMITTER RECEIVER STATION. Comprising PTC 941 Crystal-controlled Receiver 1.6-14 mcs. Sensitivity 1 microvolt for 1W, output at all frequencies at 10Db S/N and PTC 931 60W Transmitter for RT, CW and MCW operation with push-button control for selection of any one of four pre-set channels. Full details and specification on request.

PYE RANGER F.M. MOBILE RADIO TELEPHONE. Transmitter output 7-10W; double superhet receiver, 12v DC positive or negative earth. Full details and specification on request. **£45.0.0.** Carriage 30/-.

4, 5 and 8 bank 25 way uniselectors, 24V, guaranteed perfect, **£3.15.6; £4.10.0; £6.17.6** respectively.

FOR EXPORT ONLY

53 TRANSMITTERS. All spares available. COLLINS TCS. Complete installations and spare parts. 62 WIRELESS SETS. Complete installations and spare parts. P.S.U. for C42 & C45 12v and 24v R.C.A. TRANSMITTERS ET 4336. Complete installations and all spares. BC 610E & I TRANSMITTERS. Complete installations and all spares. No. 19 WIRELESS SETS. H.P. SETS and all spares R.210 RECEIVERS with all necessary accessories.

VOLUME METER (VU). 20-0-+3 internal resistance 3900 ohms at "O" VU, 3½in. square, flash **£10,** post paid.

SPARES FOR AR.88D. RECEIVERS. Ask for your needs from our huge selection.

DC MOVING COIL METERS 50μA 2½in. Sq. panel. **32/6.** 200μA 2½in. rd. panel. **27/6.** 1mA 2½in. rd. panel. **22/6.** 100mA 2½in. rd. panel. **19/-.** 25 amp. 3½in. rd. proj. **27/6.** 100v. 4in. rd. panel. **25/-.** FULL LIST OF OUR VERY LARGE STOCK OF METERS ON REQUEST.

29/41FT. AERIALS each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag, £3/9/6. P. & P. 10/6.

HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.

FIELD TELEPHONE TYPE "F". Housed in portable wooden cases. Excellent for communication in and outdoors for up to 10 miles. Pair including batteries, fully tested. **£6.10.0,** or with 220 yds field cable in drum **£7.10.0.**

To:—**COLOMOR ELECTRONICS**
170 Goldhawk Rd., London, W.12.

Please send me your full list of Test Equipment .... Meters .... Valves .... Tick as required.

Name..

Address..

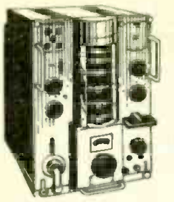
....

....

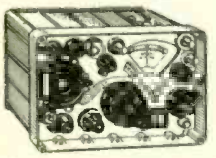
All overseas enquiries & orders please address to:

COLOMOR (ELECTRONICS LTD.)
170 Goldhawk Rd., London, W.12
Tel. 01-743 0899

ADMIRALTY B.40 RECEIVERS High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s-30 Mc/s. I.F. 500/Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½ × 13½ × 16in. Weight 114lb. Offered in good working condition. **£22/10/0**, carr. 30/-. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. £17/10/-. Carr. 30/-.

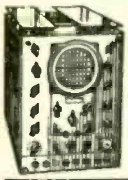


R209 Mk. II COMMUNICATION RECEIVER

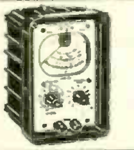


11 valve high grade communication receiver suitable for tropical use. 1-20 Mc/s. on 4 bands. AM/CW/FM operation. Incorporates precision vernier drive. B.F.O. Aerial trimmer, internal speaker and 12v. D.C. internal power supply. Supplied in excellent condition, fully tested and checked. **£15.0.0** Carr. 20/-.

TYPE 13A DOUBLE BEAM OSCILLOSCOPES BARGAIN



An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kc/s. Bandwidth 5.5 Mc/s Sensitivity 33 Mv/cm. Operating voltage 0/110/200/250 v. A.C. Supplied in excellent working condition. **£22/10/-**. Or complete with all accessories, probe, leads, lid, etc. **£25**. Carriage 30/-.



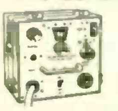
MARCONI CT44 TF956 AF ABSORPTION WATTMETER

1 µ/watt to 6 watts. **£20**. Carr. 20/-.

SOLARTRON CD. 1016. OSCILLOSCOPE

Double beam. D.C. To 5 Mc/s. Excellent condition. **£55** each. Carr. 20/-.

CLASS D. WAVEMETERS



A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition **£5.19.6** Carr. 7/6. Or brand new with accessories **£7.19.6** Carr. 7/6.

CLASS D WAVEMETERS No. 2

Crystal controlled. 1.2-19 Mc/s. Mains or 12v. D.C. operation. Complete with calibration charts. Excellent condition **£12/10/0**. Carr. 30/-.

EDDYSTONE V.H.F. RECEIVERS

770R. 19-165 Mc/s. **£150.** Both types in excellent condition.

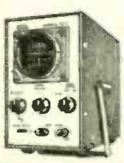
LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

0-20 Kc/s. Output 5K or 500 ohms. 200/250 v. A.C. Offered in excellent condition, **£12/10/-**. Carriage 10/-.

RACAL MA.168 TRANSISTORISED DIVERSITY SWITCH

Brand new condition **£15**. Carriage 10/-.

TO-2 PORTABLE OSCILLOSCOPE



A general purpose low cost economy oscilloscope for every-day use. Y amp. Bandwidth 2 CPS—1 MHZ. Input imp. 2 meg Ω. 25 PF. Illuminated scale. 2" tube. 115 × 180 × 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. **£22/10/-**. Carr. 10/-.

TO-3 PORTABLE OSCILLOSCOPE. 3" TUBE

Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps—1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. .9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook. **£35/-/-**. Carr. 10/-.

SOLARTRON MONITOR OSCILLOSCOPE TYPE 101

An extremely high quality oscilloscope with time base of 10 µ/sec. to 20 m/sec. Internal Y amplifier. Separate mains power supply, 200/250 V. Supplied in excellent condition with cables, probe, etc., as received from Ministry. **£8/19/6**. Carr. 30/-.

FIELD TELEPHONES TYPE L. Generator ringing, metal cases. Operate on 2 1.5 v. batteries (not supplied.) Excellent condition. **£4.10.0** per pair. Carr. 10/-.

UNR-30 4 BAND COMMUNICATION RECEIVER

Covering 550 Kc/s-30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/240 v. A.C. Supplied brand new, guaranteed with instructions. **13gns.** Carr. 7/6.

HAMMARLUND SP600 JX COMMUNICATION RECEIVER

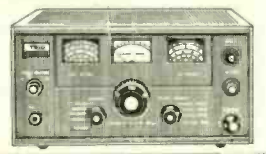
Frequency range 540 Kc/s to 54 Mc/s in 6 Bands. Few available in excellent condition, tested and checked. **£100** each.

LAFAYETTE SOLID STATE HA600 RECEIVER

5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE. 150 kc/s-400 Kc/s AND 550 Kc/s-30 Mc/s. F.E.T. front end ● 2 mechanical filters ● Huge dial ● Product detector ● Variable BFO ● Noiselimiter ● S Meter ● 24½in. Bandspread ● 230 v. A.C./12 v. D.C. neg earth operation ● RF gain control. Size 15in. × 9½in. × 8½in. Wt. 18 lbs. EXCEPTIONAL VALUE **£45**. CARR. 10/-. S.A.E. FOR FULL DETAILS.

TRIO COMMUNICATION RECEIVER MODEL 9R-59DE

4 band receiver covering 500 Kc/s to 30 Mc/s, continuous and electrical bandspread on 10-15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter. ● Sep. Bandspread dial ● IF 455 Kc/s ● audio output 1.5 w. ● Variable RF and AF gains controls. 115/250 v. A.C. mains. Beautifully designed. Size 7 × 15 × 10in. With instruction manual and service data. **£42**. Carriage paid Trio Communication Type Headphones. Normally £5.19.6. Our price **£3.15.0** if purchased with above receiver.



TRIO TS 510 AMATEUR TRANSCEIVER with speaker and mains P.S.U. £212. IN STOCK!

TRIO JR-500SE 10-80 Metre AMATEUR RECEIVER

Covers all the amateur bands in 7 separate ranges between 3.5 and 29.7 Mc/s, 7 valves, 2 transistors and 5 diodes plus 8 crystals: output 8 and 500 ohm and 5,000 ohm phone jack, Crystal controlled oscillator. Variable BFO. VFO. AVC. ANL. S meter. SSB-CW. Stand-by switch. Special double gear dial drive with direct reading down to 1 kHz. Remote control socket for connection to a transmitter. Audio output 1 watt. 115/250 v. A.C. mains. Superb modern styling. Size 7 × 13 × 10in. with instruction manual and service data. **£69.10.0**. Carr. Paid.

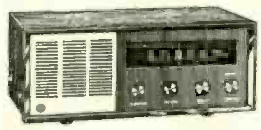
TRIO JR-310 NEW AMATEUR BAND 10-80 METER RECEIVER IN STOCK £77.10.0

RCA COMMUNICATIONS RECEIVERS AR88D

Latest release by ministry BRAND NEW in original cases. 110-250v. A.C. operation. Frequency in 6 Bands. 535 Kc/s—32 Mc/s continuous. Output impedance 2.5-600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price **£87.10.0**. Carr. £2.

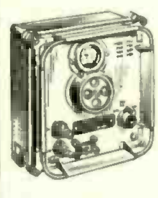
LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER

A completely new transistorised receiver covering 152-174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built-in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75 Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. **£37/10/-**. Carr. 10/-.



SOLARTRON CD711S.2. DOUBLE BEAM OSCILLOSCOPE

An extremely high quality oscilloscope originally costing £400. Switched beam. Identical Y1, Y2 Amplifiers D.C. to 9 Mc/s. Sensitivity 3mV/CM to 100 V/CM. Time base 10µ/sec. to 10 M/secd. Calibrator. X amplifier D.C. to 2.5 Mc/s. Z Modulation. 110/250 v. A.C. Supplied in good working order. **£65**. Carriage 50/-.

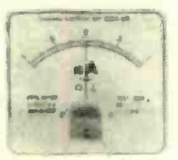


CRYSTAL CALIBRATORS NO. 10

Small portable crystal controlled wavemeter. Size 7in. × 7½in. × 4in. Frequency range 500 Kc/s—10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. **89/6**. Carr. 7/6.

SEW PANEL METERS

Type **MR.38P.** 1 21/32in. square fronts.



50µA	40/-	50mA	27/6	100V. D.C.	27/6
50-0-50µA	37/6	100mA	27/6	150V. D.C.	27/6
100µA	37/6	150mA	27/6	300V. D.C.	27/6
100-0-100µA	35/-	200mA	27/6	500V. D.C.	27/6
200µA	35/-	300mA	27/6	750V. D.C.	27/6
500µA	30/-	500mA	27/6	15V. A.C.	27/6
500-0-500µA	27/6	750mA	27/6	50V. A.C.	27/6
1mA	27/6	1 amp	27/6	150V. A.C.	27/6
1-0-1mA	27/6	2 amp	27/6	300V. A.C.	27/6
2mA	27/6	5 amp	27/6	500V. A.C.	27/6
5mA	27/6	3V. D.C.	27/6	S meter 1mA	32/-
10mA	27/6	10V. D.C.	27/6	VU meter	42/-
20mA	27/6	20V. D.C.	27/6		

FULL RANGE OF OTHER SIZES IN STOCK—SEND SAE FOR LEAFLET

LAFAYETTE STEREO AMPLIFIER MODEL STEREO 10

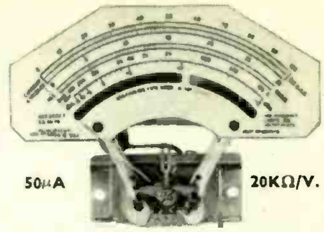
Completely transistorised 5 watts per channel I.H.F. music power. Inputs for gram and tuner. Separate volume controls and variable tone control for Bass and Treble. A compact size, big performance stereo amplifier ideal for limited space systems. Beautifully finished in grey and aluminium. Size 7½in. × 2 15/16 in. × 5½in. AC. 220/240v.

Price **£11.19.6** Carr. 7/6.

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing. ¼in. dia. shafts. Bulk quantities available.
25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. 14/6. P. & P. 1/6.
50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms, 21/-. P. & P. 1/6.
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms, 27/6. P. & P. 1/6.

AVOMETER MOVEMENTS



50µA 20KΩ/V.

Spare movements for Model 8 or 9. (Fitted with Model 9 scale) or basis for any multimeter. Brand New and Boxed **69/6** P. & P. 3/6

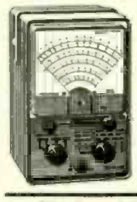
AVP 48A

Perfect order with set of shunts and resistances. **£12.10.0**. P. & P. 7/6.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels −40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. **£17/10/-**. Carr. 5/-.

TE-65 VALVE VOLTMETER

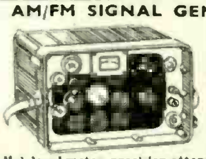


High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions **£17/10/0**. P. & P. 6/-. Additional Probes available; R.F. 35/- H.V. 42/6.

COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

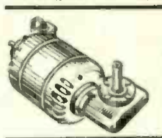
D.C. coupled. Band width 1 Kc/s. Perfect order. **£25**. Carr. 30/-.

AM/FM SIGNAL GENERATORS



Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1µV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 8½ x 9in. Supplied in brand new condition complete with all connectors, fully tested. **£45**. Carr. 20/-.

GEARED MAINS MOTOR

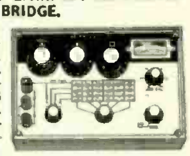


Parslux type SD19 230/250 v. A.C. Reversible. 30 r.p.m. 40 lb. ins. Complete with capacitor. Excellent condition. **99/6**. Carr. 10/-.

TE-16A TRANSISTORISED SIGNAL GENERATOR

5 Ranges 400 KHZ-30 MHZ. An inexpensive instrument for the handy-man. Operates on 9v. battery. Wide easy to read scale. 800 KHZ modulation. 5½" × 5½" × 3½". Complete with instructions and leads. **£7/19/6**. P/P 4/-.

TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.



A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1 Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1µH—111 HENRIES. 6 Ranges — 2%. C. 10PF ± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100µA. Meter indication. Attractive 2 tone metal case. Size 7½" × 5" × 2". **£20**. P. & P. 5/-.

AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded
150 W. **42/6**. P. & P. 3/6
300 W. **59/6**. P. & P. 4/6
500 W. **£4/10/0**. P. & P. 6/6
1,000 W. **£6/10/0**. P. & P. 7/6
1,500 W. **£7/19/6**. P. & P. 8/6
7,500 W. **£15/10/0**. P. & P. 20/-.

G. W. SMITH & Co. (Radio) Ltd.

ALSO SEE OPPOSITE PAGE

ARF-100 COMBINED AF-RF SIGNAL GENERATOR

AF. SINE WAVE 20-200,000 cps. Square wave 20-30,000 cps. O/P HIGH IMP. 21 v. P/P 600 Ω 3.8 v. P/P. R.F. 100 kc/s-300 Mc/s. Variable R.F. attenuation. Int./Ext. Modulation. Incorporates dual purpose meter to monitor. AF output and % mod. on R.F. 220/240 v. A.C. **£30.** Carr. 7/6.

VOLTAGE STABILISER TRANSFORMERS.

180-260v. input. Output 230v. Available 150w or 225w. **£12.10.0.** Carr. 5/-.

TE-20RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 kc/s-260 Mc/s. on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions. **£15.**

P. & P. 7/6. S.A.E. for details.

PEAK SOUND PRODUCTS

Full range of Amplifiers, kits, Speakers in stock.

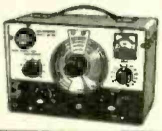
TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 30 kc/s. Output impedance 5,000 ohms. 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads. **£16.10.0.** Carr. 7/6.

MARCONI TF885 VIDEO OSCILLATORS

0-5 mc/s Sine Square Wave **£45.** Carr. 20/-.

LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER

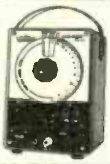


2 pf-2,000 mfd. 2 ohms-200 megohms. Also checks impedance turns ratio insulation. 200/250 v. A.C. Brand New, **£17.10** Carr. 7/6.

MARCONI TF.142E DISTORTION FACTOR METERS

Excellent condition. Fully tested **£20.** Carr. 15/-.

TY75 AUDIO SIGNAL GENERATOR



Sine Wave 20 CPS—200 Kc/s. Square Wave 20 CPS—30 Kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts A.C. Brand new with instructions. **£16.** Carr. 7/6. Size 210 × 150 × 120 mm.

MARCONI TF195M BEAT FREQUENCY OSCILLATORS

0-40 kc/s. **£20.** Carr. 30/-.

TE-20D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 Kc/s—500 Mc/s on 6 bands. Directly calibrated. Variable RF. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. **£15.** Carr. 7/6. Size 140 x 215 x 170 mm.

ADVANCE TEST EQUIPMENT

Brand new and boxed in original sealed cartons.

VM.76. VALVE VOLTMETER. R.F. measurements in excess of 100 Mc/s and D.C. measurements up to 1000 v. with accuracy of ±2%. D.C. range 300 MV to 1 KV. A.C. range 300 MV to 300 V RMS. Resistance 0.02—500 M. Price **£72.**

VM.79. UHF MILLIVOLT METER. Transistorised. A.C. range 10 Mv—3V. D.C. current range 0.01/A—0.3 Ma. Resistance 1 ohm—10 megohms. **£125.**

H1B. AUDIO SIGNAL GENERATOR. 15 c/s—50 Kc/s, sine or square wave. Price **£30.**

J1B. AUDIO SIGNAL GENERATOR. 15 c/s—50 Kc/s. Price **£30.**

TT1S. TRANSISTOR TESTER. **£37/10/-.** Carriage 10/- per item.

MODEL ZQM TRANSISTOR CHECKER

It has the fullest capacity for checking on A, B and Ico. Equally adaptable for checking diodes, etc. Spec.: A: 0.7-0.9967. B: 5-200. Ico: 0/50 micro-amps. 0.5 mA. Resistance for diode 200Ω + 1 MEG. Supplied complete with instructions, battery and leads. **£5/19/6.** P. & P. 2/6.

Latest Catalogue

The latest edition giving full details of a comprehensive range of HI FI EQUIPMENT, COMPONENTS, TEST EQUIPMENT and COMMUNICATIONS EQUIPMENT.... Nearly 200 pages, fully illustrated and detailing thousands of items—many at bargain prices. FREE DISCOUNT COUPONS VALUE 10/-.

SEND NOW—ONLY 7/6 P&P1/-

GARRARD

Full current range offered brand new and guaranteed at fantastic savings

SRP22 Stereo	£5.19.6	•SP25 MKII	£11.19.6
•1025 Mono	£7.10.0	•SL55	£11.19.6
•1025 Stereo	£7.15.0	A70 MKII	£12.10.0
•2025 Stereo	£7.19.6	•SL65	£14.14.6
•2025T/C Mono/Stereo	£8.17.6	AP75	£17.17.0
•3000 Stereo	£9.19.6	401	£28. 7.6
		SL75	£28.10.0

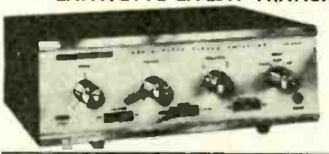
Carriage/insurance 7/6 extra any model.

WB4 Bases £3/19/6. Perspex cover £3/10/0.

•Special offer base and cover available for these models at £4.15.0. Carr. 5/-.

Full range of Garrard accessories available

LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER



19 transistors, 8 diodes, IHF music power 30 watts at 8 ohms. Res. 30-20,000 ±2 dB at 1 w. Distortion 1% or less. Inputs 3 mV and 250 mV. Output 3-16 ohms. Separate L and R volume controls. Treble and bass controls. Stereo phone jack. Brushed aluminium, gold anodised extruded front panel with metal case. Size 10½in. × 3 ⅛ in. × 7 ¾ in. Operation 115/230 volt A.C. **£28.** Carr. 7/6.

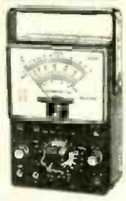
Variable Voltage TRANSFORMERS

Brand new, guaranteed and carriage paid.
High quality construction. Input 230 v. 50-60 cycles.
Output full variable from 0-260 volts. Bulk quantities available.
1 amp.—£5/10/-; 2.5 amp.—£6/15/-; 5 amp.—£9/15/-;
8 amp.—£14/10/-; 10 amp.—£18/10/-; 12 amp.—£21; 20 amp.—£37

MULTIMETERS *for EVERY purpose!*

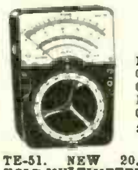
TE-900 20,000Ω/VOLT GIANT MULTIMETER Mirror scale and overload protection. 6in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0/25/12.5/10/50/250/1,000/5,000 v. D.C. 0/50μA/110/100/500mA/10 amp. D.C. 02K/200K/20 MEG. OHM. **£15/-/-.** P. & P. 5/-.

MODEL AS-100D. 100KΩ/Volt. 5in., mirror scale. Built-in meter protection 0/3/12/60/120/300/600/1,200 v. D.C. 0/6/30/120/300/600 v. A.C. 0/10μA/6/60/300MA/12 Amp. 0/2K/200K/2M/200MΩ. —20 to +17dB. **£12/10/-.** P. & P. 3/6.



MODEL TE-90 50,000 O.P.V. Mirror scale overload protection. 0/3/12/60/300/600/1,200 v. D.C. 0/6/30/120/300/1,200 v. D.C. .03/6/60/600 MA. D.C. 16K/160K/1.6/16 MEG Ω. —20 — + 63db. **£7/10/0.** P. & P. 3/-.

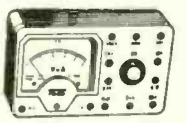
MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/30μA/3/30/300mA. 0/16K/160K/1.6M/16 MegΩ. **£5/10/-.** P. & P. 3/-.



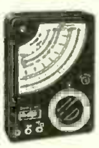
MODEL TE-80. 20,000 O.P.V. 0/10/50/100/500/1,000 v. A.C. 0/5/25/50/250/500/1,000 v. D.C. 0-50μA. 5/50/500mA. 0/6K/60K/600K/6 meg. **£4/17/6.** P. & P. 3/-.

MODEL TE-12. 20,000 O.P.V. 0/0.6/6/30/120/600/1,200/3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/60μA/6/60/600 mA. 0/6K/600K/6Meg./60 Meg.Ω. 50 PF. .2 MFD **£5/19/6.** P. & P. 3/6.

TE-51. NEW 20,000Ω/VOLT MULTIMETER, with overload protection and mirror scale, 0/6/60/120, 1,200 v. A.C. 0/3/30/60/300/600/3,000v. D.C. 0/60μA/12/300m A.D.C. 0/60K/6 meg. ohm. **92/6.** P. & P. 2/6.



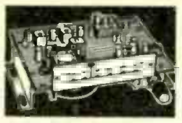
MODEL PT-34. 1,000 O.P.V. 0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K Ω **39/6.** P. & P. 1/6.



MODEL TE-10A. 20kΩ/Volt 5/25/50/250/500/2,500 v. D.C. 10/50/100/500/1,000 v. A.C. 0/50μA/2.5 mA/250 mA D.C. 0/6K/6 meg. ohm. —20 to +22 dB. 10-0, 100 mfd. 0.100-0.1 mfd. **69/6.** P. & P. 2/6.

LAFAYETTE 57 Range Super 50KΩ/V. Multimeter. D.C. volts 125mv—1000v. A.C. volts 1.5v—1000v. D.C. Current 25μA—10 Amp. Ohms 0—10 MegΩ. D.B.—20 to +81 db. Overload protection. **£12/10/-.** P. & P. 3/6.

TRANSISTOR FM TUNER



6 TRANSISTOR HIGH QUALITY TUNER SIZE ONLY 6in. × 4in. × 2½in. 3 I.F. stages. Double tuned discriminator, ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money. **£6/7/6.** P. & P. 2/6.

STEREO MULTIPLEX ADAPTORS, 99/6.

SINCLAIR EQUIPMENT

Z12. 12 watt amplifier **89/6.**
PZ4. Power supply Unit **89/6.**
STEREO 25, Pre-amplifier **£9/19/6.**
Q.14 Speakers **£7/19/6.**
Micromatic Radio Kit **49/6.** Built **59/6.**

NOW AVAILABLE IC10 . 59/6

ALL POST PAID.

SPECIAL OFFER

2 Z12 amps. PZ4 Power Supply, Stereo 25, Preamplifier	£22
or with two Q.14 Speakers	£37

NEW SINCLAIR 2000 SYSTEM

35 watt Integrated Amplifier, **£29.** Carr. 5/-. Self-powered FM Tuner, **£25.** Carr. 5/-.

ECHO HS-606 STEREO HEADPHONES

Wonderfully comfortable. Lightweight adjustable vinyl headband, 6ft. cable and stereo jack plug, 25-17,000 cps., 8Ω imp. **67/6.** P. & P. 2/6.

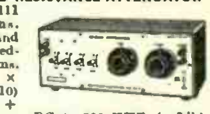
HOSIDEN DH04S 2-WAY STEREO HEADPHONES

Each headphone contains a 2½in. woofer and a ½in. tweeter. Built in individual level controls. 25-18,000 c.p.s. 8Ω imp. with cable and stereo plug. **£5/19/6.** P. & P. 2/6.

TRANSISTORISED TWO-WAY TELEPHONE INTERCOM

Operative over amazingly long distances. Separate call and press to talk buttons. 2-wire connection. 1000's of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets. **£6/19/6** pair. P. & P. 3/6.

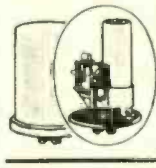
TE111 DECADE RESISTANCE ATTENUATOR



Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db × 10) + (1 db × 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db). Accuracy: 0.05 db. + indication db × 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch, Brand new **£27/10/-.** P. & P. 5/-.

CAR LIGHT FLASHERS

Heavy duty light flasher employs a condenser discharge principle operating on electro mechanical relay. (As inset.) Housed in strong plastic case. Flashing rate between 60-120 per minute. 12 volt D.C. operation. Maximum load 6 amps. Size 2 ½ in. dia. by 4in. Supplied brand new at a fraction of original cost. **6/6 each,** P. & P. 2/6. **(3 for 17/6.** P. & P. 4/6.)



RECORDING HEADS

Cosmocord ¼ track heads: Post extra.

Record/replay. High imp.	65/-
Erase. Low imp.	20/-
Marriott ¼ track heads. Post extra.	
Record/Playback, high imp.	65/-
Erase, low imp.	20/-

AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities. Postage 2/-. Over £3 post paid.

3in. 225ft. L.P. Acetate	3/6
3¼in. 600ft. T.P. Mylar	10/-
5in. 600ft. Std. plastic	8/6
5in. 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/-

MAXELL TAPE CASSETTES

C60—10/3; C90—14/3; C120—19/6. Post extra.

G.W. SMITH & CO (RADIO) LIMITED

3 and 34, LISLE STREET, LEICESTER SQ., LONDON, W.C.2 01-437 8204 01-437 9155
311, EDGWARE RD., LONDON, W.2 01-262 0387

(ALL MAIL ORDERS TO:— 3, LISLE STREET, LEICESTER SQUARE, LONDON, W.C.2)

OPEN
9 a.m. to 6 p.m. every day Mon. to Sat. (Edgware Rd. ½ day Thurs.) Trade supplied.

POWER TRANSISTORS Ex Eqpt. Sim. to OC28. 4 for 10/- p. & p. 1/-. 100 for £10. Post free

750µH inductors 5/- doz.
THERMOSTATS. ½" × ½" × 1½". O.C. above 120°F. 1½a. 250v. 5/- ea.

DESK TELEPHONES

Not new but workable. Suitable for all applications. Only 19/6 each, p. & p. 5/-. Two for 39/6 post free. Four for 70/- post free.

REED SWITCHES
Glass encased, switches operated by external magnet—gold welded contacts.
Miniature. 1in. long × approximately ¼in. diameter. Will make and break up to ½A, up to 300 volts. Price 2/6 each. 24/- dozen.

MINIATURE GLASS NEONS 12/6 doz.

TRIM POTS on 2" × 4" bds. + Ta. caps. and other components. 100Ω, 500Ω, 15K, 20K. Please state requirements. 5 for 10/- + 2/- p. & p.

THIS MONTH'S SNIP
9 OA5, 3 OA10, 3 Pot Cores, 26 Resistors, 14 Capacitors, 3 GET 872, 3 GET 872B, 1 GET 875. All long leaded on panels 13" × 4". 2 for 10/- p. & p. 1/6d. 4 for 20/-. Post free.

LARGE CAPACITY ELECTROLYTICS. 4½in., 2in. diam. Screw terminals. Top quality German manufacture. Will withstand short circuit discharge.
4,000µF 72V d.c. wkg. 7/6
6,300µF 72V d.c. wkg. 7/6
16,000µF 12V d.c. wkg. 6/-
1½" × 4½" screw terminals—
2,500µF 55V d.c. wkg. 6/- ea.

COMPUTER PANELS 2in. × 4in. 10 for 10/- + 1/6 p. & p. Min. 35 transistors; 25 for £1 p. & p. 3/6, min. 85 transistors; 100 for 65/-, p. & p. 6/6, min. 350 transistors; 1,000 for £30 + carr.

GIANT PANELS 5½" × 4" min. 20 transistors 9 × 56 µH. Inductors, resistors, capacitors etc. 3 for £1 + 2/- p. & p.
As above, only 21 transistors, 70 diodes, 62 min. 1/10thW resistors, 3 for 25/-, p. & p. 2/-

0.22 MFD 250V POLYESTERS 5/- doz.
2.2 MFD 50V TANTALUM 10/- doz.

NEW PLESSEY CAPS
1" × 3" 2000µF 25V d.c. 6/- each.
1½" × 4½" 500µF 55V d.c. wkg. 8/- each.

250 Resistors ¼ and ½ watt. 12/6
150 Hi-Stab Resistors, ¼, ½ and 1 watt 12/6

QUANTITIES AVAILABLE
EXTRACTOR/BLOWER FANS
(Papst)
100 c.f.m. 4½ × 4½ × 2in. 2800 r.p.m. 240v. A.C. Precision made in West Germany by Papst. These Fans are the best available. Genuine bargain at 50/- each. List price.

DIODES EX EQPT SILICON
150 PIV 10Amp 4 for 10/-
150 PIV 20Amp 4 for 20/-

KEYTRONICS,
52 Earls Court Rd., London, W.8
Tel. 01-478 8499
MAIL ORDER ONLY. Retail and Trade supplied. Export enquiries particularly welcome.
S.A.E. FOR LIST

computer engineering

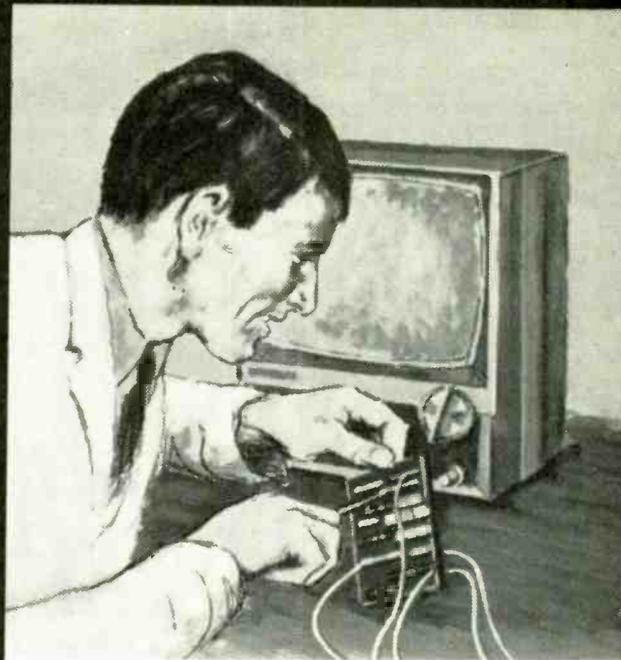
NCR requires additional ELECTRONIC, ELECTRO MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.

Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.

Starting salary will be in the range of £900/£1,250 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.

Excellent holiday, pension and sick pay arrangements. Please write for Application Form to
Assistant Personnel Officer
NCR, 1,000 North Circular Road,
London, NW2
quoting publication and month of issue.

Plan your future with NCR



Train for tomorrow's world in Radio and Television at The Pembridge College of Electronics.

The next full time 16 month College Diploma Course which gives a thorough fundamental training for radio and television engineers, starts on 1st January 1970.

The Course includes theoretical and practical instruction on Colour Television receivers and is recognised by the Radio Trades Examination Board for the Radio and Television Servicing Certificate examinations. College Diplomas are awarded to successful students.
The way to get ahead in this fast growing industry—an industry that gives you many far-reaching opportunities—is to enrol now with the world famous Pembridge College. Minimum entrance requirements: 'O' Level, Senior Cambridge or equivalent in Mathematics and English.

To: The Pembridge College of Electronics (Dept.WW11), 34a Hereford Road, London, W.2
Please send, without obligation, details of the Full-time Course in Radio and Television.

NAME ....

ADDRESS ....

....

....

APPOINTMENTS VACANT

DISPLAYED SITUATIONS VACANT AND WANTED: £7 per single col. inch.
LINE advertisements (run-on): 8/- per line (approx. 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 1/-.
SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to DECEMBER 5 for the JANUARY issue, subject to space being available.

REDIFFUSION

COLOUR TELEVISION FAULTFINDERS & TESTERS

We have a number of vacancies in our Production Test Departments for experienced faultfinders and testers.

Knowledge of transistor circuitry and experience with Colour Receivers together with R.T.E.B. Final Certificate or equivalent qualifications required.

These will be staff appointments with all the expected benefits.

Applications to:

Works Manager,
Rediffusion Vision Service Ltd.,
Fullers Way South,
Chessington, Surrey (near Ace of Spades).
Phone: 01-397 5411

83

Telecommunications Engineer

The above vacancy exists in the Scottish division of a large engineering company operating a number of establishments in the West of Scotland, in addition to factories throughout the United Kingdom. The successful candidate, who will operate from the Glasgow office, will be responsible to the Chief Electrical Engineer for planning, implementing and maintaining the rapidly expanding communications network throughout the Scottish factories.

Applicants should have experience in the operation and maintenance of H/F carrier systems, automatic telephone exchange installations and switching networks. A knowledge of data, facsimile and teleprinter transmission and P.A. systems would be an advantage.

Qualifications required are a degree, H.N.C., or C. & G. Full Technological Certificate in Telecommunications.

All applications are confidential and will be acknowledged. If already employed by our client applicants name will not be divulged without permission. Applicants should indicate any company to whom they do not wish their applications forwarded. Please give details of age, experience and qualifications to Ref. 13186/53.

Name and address in block capitals please.

S & M SELECTION, 216 BOTHWELL STREET, GLASGOW, C.2.

2610

ELECTRONIC ENGINEERS

Vacancies exist in the Test Gear Department at West Leigh for Electronics Test Gear Engineers capable of full design responsibility, manufacture and delivery to the production floor. Products include sophisticated airborne communication equipment, automatic production test equipment and equipment employed in testing many of the Company's electronic components.

Qualifications should include H.N.C. but consideration will be given to applicants with equivalent experience.

Please apply in writing giving full particulars to the Personnel Officer, The Plessey Company Limited, Martin Road, West Leigh, Havant. Hampshire quoting ref. HAV/180/6

2634

An immediate vacancy occurs at

THE WIRELESS COLLEGE
COLWYN BAY, NORTH WALES

for an additional instructor to assist in preparing students for P.M.G./M.P.T. examinations. The primary responsibility will be the practical instruction on modern marine radio equipment. Applicants must hold a P.M.G. Certificate and should have a sound technical knowledge. Recent marine operating and/or teaching experience is desirable but not essential.

Write in the first instance to the Principal. 2622

BBC

TRANSMITTER PLANNING AND INSTALLATION DEPARTMENT

requires

ENGINEER

for work in connection with the planning, installation and commissioning of VHF and UHF transmitting stations. Duties will include assisting in the preparation of specifications, negotiations with manufacturers, liaison with other BBC Departments and acceptance tests on equipment.

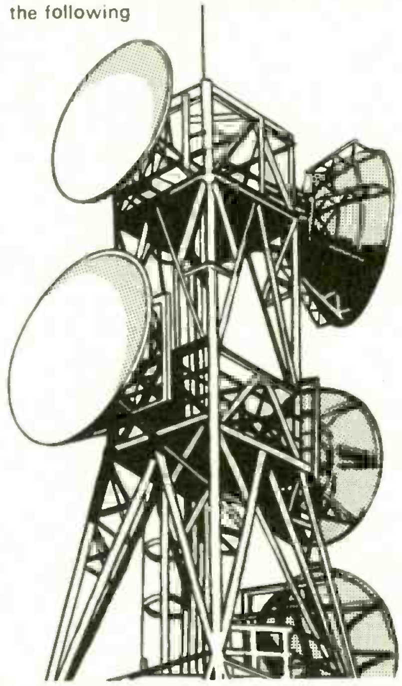
The successful candidate may be a member of a team of several engineers each dealing with a particular aspect of a project or projects or he may be directly responsible for smaller projects. He may, alternatively, be responsible for supervising the work of installation technicians and/or transmitter mechanics.

Candidates must be qualified engineers and have had several years' experience of work on UHF and VHF transmitters. They should preferably be Chartered Engineers and a university degree or equivalent would be an advantage.

Commencing salary £2,030 p.a. to £2,238 p.a. in a scale having a maximum of £2,550 p.a. Request for application form to The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA quoting reference 69.E.2287 W.W. 2620

CONTINUOUS EXPANSION

Standard Telephones & Cables, Microwave and Line Division based at Basildon are growing fast. In order to keep pace with this consistent growth rate we require the following



Installation Engineers Technicians & Testers

Ref. 25720

To test and commission Multiplex, Co-axial Line and Microwave Radio Systems.

Ideal candidates will be less than 45 years of age with practical experience on some of the above equipment. These challenging posts call for drive, initiative and common sense. It is necessary for applicants to be prepared to work anywhere in the U.K.

Test Technicians

Ref. 27221

The diversity of products manufactured at the Basildon Plant demands experienced testing staff for work on complex transmission systems.

Candidates should hold an ONC in electrical engineering and be able to offer considerable practical experience in the field of testing and fault clearing all types of land-unit, pcm and microwave equipment.

Applications should be addressed to
The Personnel Officer,
STC Chester Hall Lane,
Basildon, Essex.

STC

91

R/F TEST ENGINEERS

Engineers are required for final test of Solid State R/F prototype and pre-production equipment operating at U.H.F. and microwave frequencies.

These positions would be ideally suitable to ex service radio/radar personnel or test engineers with experience in the use of R/F/Microwave test equipment and a knowledge of transistorised circuitry.

The Company offers first class holiday, sick payments and welfare facilities including an excellent group pension and insurance scheme.

Please apply in writing to:

Personnel Officer,

Ether Engineering Ltd

Park Avenue, Bushey, Herts. Phone: Watford 28566.

2655

GOVERNMENT OF ZAMBIA

REQUIRES

GROUND ENGINEER
{Radio/Electrical}

for the Government Flight Department, Ministry of Power, Transport and Works, on contract for one tour of 36 months in the first instance. Commencing salary according to experience in scale Kwacha 3408 rising to Kwacha 4056 a year (approx. £Stg. 1988 – 2366), plus an Inducement Allowance of Kw. 1002 – 774 (approx. £Stg. 585 – 452) a year. A Direct Payment of £291 is also payable direct to the officer's bank in the U.K. Gratuity 25% of total salary drawn. Both Gratuity and Direct Payment are normally TAX FREE. Free passages. Quarters at moderate rental. Children's education allowances. Liberal leave on full salary or terminal payment in lieu.

Candidates, preferably under 50 years of age, must have the minimum qualification of Radio 'A' licence. Preference will be given to candidates holding electrical 'X' group 9. 1, with experience on American V.H.F. VOR. H/F, and possessing a Radio 'B' licence.

The officer will be required to work on Piper Aztec type aircraft and to carry out the maintenance of the radios of the Government Communication Flight Aircraft.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1, for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference M2Z/680906/WF

2651

V.H.F. TELEVISION RELAY & COMMUNAL AERIAL SYSTEMS

We are planning a considerable expansion of our activities and have the following vacancies:

I. A SENIOR ENGINEER

to have control of all aspects of systems design, planning, estimating, installation and commissioning.

II. ENGINEERS

capable of undertaking either:
(*a*) System planning and estimating.
(*b*) control of installation work.
or (*c*) test and commissioning duties.

Candidates for these appointments must have a good background of practical experience in this field of work, and an up-to-date knowledge of techniques and equipment.

Applications, which will be treated in strict confidence, should be sent to:

BRITISH RELAY

**The General Manager,
Special Services Division,
British Relay House,
41, Streatham High Road, S.W.16**

2654

HENRY'S RADIO LTD.
303 EDGWARE ROAD, LONDON, W.2
HAVE THE FOLLOWING VACANCIES IN THEIR ORGANISATION

SALES ASSISTANTS
Young man with good general knowledge of electronic components required for our retail sales dept. Please telephone 723-1008/9 ext. 1.

SALES ASSISTANTS
Young man with a good general knowledge of HIGH FIDELITY EQUIPMENT required for our retail HI-FI SALES DEPT. Please contact MR. STEVENS, Telephone 723-6963.

2585

The Middlesex Hospital Medical School
Cleveland Street, London W1

Department of Physiology

ELECTRONIC TECHNICIAN

required for maintenance and further development of wide range of electronic equipment for medical teaching and research. Well equipped electronic workshop, opportunities for developing own ideas.

Salary scale: £1025-£1285.

Applications stating age, qualifications, experience and availability for interview, to the Secretary, Department of Physiology, The Middlesex Hospital Medical School, London W1P 6DB.

2632

SUPERINTENDENT AVIONICS

This is a new appointment in the Component Overhaul Division with responsibility to the Divisional Manager for the administration and technical control of the avionics section. This section comprises electrical instrument and radio overhaul workshops and it is desirable, therefore, that candidates have a minimum of 10 years' experience in the avionic components industry, preferably in a supervisory capacity. H.N.C. or equivalent in an appropriate discipline. Age range 30-40.

The Company is a member of the important Air Holdings Group and has wide interests ranging from aircraft maintenance and conversions to freight and baggage handling equipment.

The salary is good with commencement open to negotiation. Benefits include Pension Scheme. Free Life Assurance and participation in a productivity bonus scheme.

Applications with brief details of experience and qualifications to:

The Personnel Officer,
Aviation Traders (Engineering) Limited,
Southend Airport,
Southend-on-Sea, Essex.

ATEL
A MEMBER OF THE AIR HOLDINGS GROUP

Glaxo

TECHNICAL ASSISTANT

Instrumentation Investigation

This position involving the maintenance and building of instruments and instrument investigation is in the physical chemistry unit of Glaxo Research Ltd.

Ideally candidates should be under 25 and have reached at least 'A' level standard in physics and chemistry. Experience in the construction of electronic devices is desirable but full training in the use of complex apparatus will be given.

There are opportunities for promotion, day release for further studies, generous pay scales, 3 weeks' holiday, sick pay and sports and social facilities.

Please write, quoting ref. ZH.39, to the Personnel Officer (MRG), Glaxo Laboratories Limited, Greenford, Middlesex.

2668

Go places as a Computer Service Engineer

Men under 35 with experience in light engineering and electronics can build excellent careers in ICL servicing computers.

We want qualified men with HNC or C & G in electronics engineering, or a Forces training in electronics. Or, perhaps, you have a similar qualification which proves you have the serious interest in the subject necessary for further specialist training.

We pay realistic salaries while you train—about six months—on ICL equipment, learning how to sort out operational problems and maintain computers in peak condition.

You will have to take responsibility for highly sophisticated and expensive equipment, so if you have a worthwhile career in mind, here is the chance to apply your expertise and initiative to the full. Career progression and promotion are limited only by your ability.

On top of your basic salary we pay generous overtime and shift rates, plus travelling expenses. Working conditions in ICL are well above the average in industry.

Write giving brief details of your career, quoting reference WW 103 C.
A. E. Turner, International Computers Limited, 85/91 Upper Richmond Road, Putney, London SW15.

International Computers **ICL**

OXLEY

Applications are invited for the position of

Assistant to the Works Director

of Oxley Developments Company Ltd., Ulverston.

Applicants must be about 30 years of age and have Higher National Certificate or a degree in Science. Preference will be given to someone with all or part of the following experience or qualifications:-

(1) Knowledge of modern manufacturing methods in electronics, small mechanical components and mechanisms.

(2) Assistant or deputy to a Works Manager in a thriving concern.

(3) Experience in dealing with people, production control, and shop floor conditions; experience in cost accounting.

Oxley Developments is a vigorous and expanding Company offering scope and opportunity for the right man. The Works are located in open countryside at the southern end of the Lake District.

Applications giving details of education, qualifications, experience and salary and including copies of two references or names and addresses of referees to be addressed to:

The Personnel Manager,

Oxley Developments Company Ltd.

PRIORY PARK · ULVERSTON · NORTH LANCASHIRE

2664

ELECTRONIC ENGINEERS

Service Engineers required for Offices, throughout the United Kingdom, of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic Electronics with experience in Electronics, Radar, Radio and T.V. or similar field. Position is permanent and pensionable. Comprehensive training on full pay will be given to successful applicants. Please send full details of experience to the Service Manager, Sumlock Comptometer Ltd., 102/108 Clerkenwell Road, London, E.C.1.

2663

ELECTRONIC TEST ENGINEERS

Experienced Engineers/Technicians urgently required for testing Variable Speed Thyristor Drives and Solid State Multi-track Tape Recorders. Candidates with H.N.C./O.N.C. preferred. Previous experience in Solid State Testing is necessary.

Salary up to £1,400 for suitable applicants. Some assistance with housing and removal expenses may be given.

Write or phone:

Chief Inspector,
SIMON ELECTRONICS LTD.,
Bond Avenue,
Bletchley, Bucks.
Bletchley 5331 (STD. 0908 2)

2640

ELECTRONICS TECHNICIAN
UNIVERSITY OF BIRMINGHAM

TECHNICIAN required for the Department of Anatomy to assist in the design and construction of electronic apparatus for neurological research, also to participate in routine experimental procedures involving animals and man. Elementary knowledge of electronics desirable, but no previous experience in the medical sciences is necessary. Applicants should be studying for H.N.C. or an equivalent qualification in electronic engineering or physics. Salary range £773-£1,077 p.a.

Apply for application form to the Assistant Secretary (Personnel), Personnel Office, University of Birmingham, P.O. Box 363, Birmingham 15, quoting reference 401/T/139.

2614

TEST ENGINEERS

Vacancies exist in our test department for junior test engineers to undertake prototype and production testing/servicing of advanced signal analysis computers.

Knowledge of modern digital and/or analogue techniques is essential.

Applications are invited from young men holding ONC or similar qualifications or having relevant practical experience.

Apply giving details of qualifications and experience to:

Mr. N. Elliott,
Data Laboratories
28 Wates Way
Mitcham, Surrey
01.648.4643.

2628

Loughborough University of Technology
LABORATORY TECHNICIANS

VACANCIES exist for TECHNICIANS/SENIOR TECHNICIANS with experience in either aeronautical or electronic fields. Duties include assistance in the construction and servicing of test equipment relating to research, student projects and general departmental work including mechanical construction and/or electronic instrumentation.

Applicants should have basic technical qualifications together with substantial practical mechanical or electronic experience preferably associated with the aircraft industry.

The surroundings and working conditions in the University are good and there are excellent leave conditions for all grades. The posts are superannuable. Salary scales:

SENIOR TECHNICIANS: £1,056-£1,311 p.a.
TECHNICIANS: £773-£1,077 p.a.

Please apply in writing, giving full details, to Professor K. L. C. Legg, Head of Department of Transport Technology, Loughborough, Leicestershire.

2613

PROTOTYPE DEVELOPMENT

I seek a firm or individual of proven competence to design and produce prototype important invention (provisional PAT.) involving Octo-Electronics, R.F., Logic, control circuits and small high speed electro-magnetic mechanism (from specialists) Box No. 2635.

join the men
who lead

Electronic Packaging Engineer

An experienced Electronic Hardware Designer is required to carry out thermal and structural designs on advanced electronic systems for guided weapons.

The engineer appointed to this job will be capable of working on his own initiative in the provision of design and data service for low power electronic assemblies. He will also be required to formulate design rules for the guidance of less skilled personnel in the optimised design of such assemblies, with particular emphasis on thermal management and structural design.

Suitably qualified engineers who have been working in these areas for the past three years at least are invited to write or 'phone for an application form, quoting Ref. 1512 to:

Eric Buckmaster,
1512 Personnel Department,
British Aircraft Corporation,
Guided Weapons Division,
Stevenage, Herts. Tel: Stevenage 2422

BRITISH AIRCRAFT CORPORATION
the most powerful aerospace company in Europe

2666

RADIO ENGINEER
FOR
UGANDA

We have a vacancy for a well trained radio engineer with a good knowledge of electrical and electronic problems.

The person we are looking for should be a good organiser, must have real interest in his work and must be willing to train local staff. There are unlimited opportunities as the successful applicant will receive on the spot training in our medical and X-ray dept. This will necessitate regular journeys to all parts of Uganda. Our terms of service are good, the climate is wonderful and the work unusual. We offer good local and overseas leave facilities.

Those interested should write to:

Twentsche Overseas Trading Co. (Uganda) Ltd.,
P.O. Box 7160,
KAMPALA,
Uganda,

giving details of previous experience, age and marital status.

2580

RESEARCH and DEVELOPMENT

ELECTRONIC ENGINEERS

...OUR WORK

Expanding exports and the increasing complexity of our products have intensified our development programmes for digital and analogue computers, linkage and special purpose computer peripherals. We wish to establish new teams of electronic engineers and if you are interested in joining us ...

...YOUR QUALIFICATIONS

should include a degree, H.N.C. or equivalent. You should have relevant experience, coupled with enthusiasm and ability and ...

...YOUR REWARDS

with Redifon will be a good salary, stability of employment, a wide range of interesting work and an opportunity to expand your experience into new fields in ...

...OUR COMPANY

We design and manufacture flight simulators and electronic teaching machines for world-wide markets. The laboratories are situated in a pleasant part of Sussex at Crawley, mid-way between London and the South Coast.

Application forms may be obtained from:

H. C. Hall, Personnel Manager,
REDIFON LIMITED,

Flight Simulator Division,
Gatwick Road, Crawley, Sussex.
Telephone: Crawley 28811

REDIFON

A Member Company of the Rediffusion Organisation

2665

Commissioning Engineers and Installers

TRANSMISSION DIVISION

In spite of an excellent response to our recent advertisement a continuing expansion projecting into the foreseeable future demands that we seek additional staff.

Opportunities exist for commissioning and installation staff with experience of carrier systems to join a well established team working on transmission contracts both in the U.K. and overseas.

The Transmission Division's growth and its heavy commitments also create openings for less experienced engineers with a good transmission background who would be prepared to accept responsibility after a period of field training.

If you meet any of the above mentioned requirements we shall be pleased to hear from you. Please telephone V. S. Klein, Installation Manager, or write stating age and giving details of qualifications and experience quoting reference number BEE/468/E to the Personnel Officer, Personnel Department, The Plessey Company Limited, Beeston, Nottingham NG9 ILA tel. Nottm. 254831 Ext. 4497.

PLESSEY

TRAINEE ELECTRONICS SERVICE ENGINEER

A vacancy for a Trainee Electronics Service Engineer has arisen at the MANCHESTER Office of a National Company marketing Electronic Desk Calculators. Applications are invited from young men aged 17/18 who should preferably have had some training or practical experience in the field of Radio, Television or Electronics servicing or who practice these or similar subject as a hobby.

Please write in the first instance to: Mr. I. Cuthbert, Regional Service Supervisor, Sumlock Comptometer Ltd., Empire House, King Edward Street, Briggate, Leeds, LS1.6AU.

2630

SENIOR LABORATORY TECHNICIAN

BBC have a vacancy for a Senior Laboratory Technician in the Radio Group of Research Department at Tadworth, Surrey. The duties consist of constructional and experimental work, carried out under the direction of Engineers, on transmitting and receiving systems including aerials and transmission lines. The post offers a variety of work in these fields. Applicants should have several years experience in laboratory work, a good basic knowledge of electrical theory and electronic devices, and possess O.N.C. or equivalent qualifications. They should have an interest in radio and television and in associated radio frequency measuring techniques.

The starting salary for this post is in the range of £1,453 to £1,609 per annum and rises by annual increments to £1,843. However, if no candidate fulfilling the above requirements is found the post may be filled at a lower grade.

Write for application form (enclosing addressed foolscap envelope and quoting reference **69.E.2303.W.W.**) to **The Engineering Recruitment Officer, BBC, London WIA IAA.**

2621

ARE YOU QUALIFIED TO MOVE.

If you are a Design Engineer or in systems test, technical sales, production engineering, field service or technical writing, let **ELECTRONICS APPOINTMENTS** help you. They are in consultation with almost 800 companies on all aspects of electronic engineering.

Among our current vacancies are the following:—

Senior Sales Engineer. H.N.C. standard, with extensive selling experience in computer or computer peripheral field.

Salary £3,000. London based.

Senior Design Engineer. H.N.D. or equivalent, as Assistant to Chief Engineer. Experience in modern digital control electronics and high speed counting.

£1,800. South Herts based.

This placement service is entirely free and confidential.

Phone (any time day or night) or write:

ELECTRONICS APPOINTMENTS LTD.

NORMAN HOUSE · 105/109 STRAND · LONDON · W.C.2
TEL · 01-836 5557

89

ELECTRONIC SERVICE ENGINEERS

The Installation and Maintenance Division of E.M.I. Electronics urgently requires engineers with drive and real ability to work when necessary on their own initiative and assist with the divisions rapidly expanding work programme.

The successful candidates will be engaged to work in one of the following areas:—

★ Servicing and calibration of a wide range of electrical instruments.

★ Installation and Maintenance of automation, numerical, digital and multiplex systems.

Applicants should have had several years' experience of the maintenance of electronic equipment, and these vacancies would appeal to engineers with industrial experience or a services background. Some travelling will be necessary for certain positions.

Excellent commencing salaries and staff benefits.

EMI CAREERS

Applications giving concise career and personal details to:–

EMI M. L. WATERS · GROUP PERSONNEL DEPT
E.M.I. LTD BLYTH ROAD · HAYES · MIDDX

WW/8/69

2653

THE UNIVERSITY OF LEEDS

PROCTER DEPARTMENT OF FOOD AND LEATHER SCIENCE

SENIOR EXPERIMENTAL OFFICER

Funds have been made available from the Sainsbury Centenary Grant for the Advancement of Research and Education in Food Science for the appointment of an experienced graduate electrical (electronic) engineer or similarly qualified person to join a research group investigating the chemistry of the substances responsible for the flavour of foods, using combined gas chromatography-mass spectrometry. His main duty would be to care for the sophisticated instruments involved and to develop the instrumentation further. He would be available also for consultation by other research groups in the Department.

The appointment is for 3 years in the first instance in the range £1,460-£1,940, the point of entry depending on qualifications and experience. Superannuation under F.S.S.U.

Applications (three copies) stating age, qualifications and experience and naming three referees should reach Dr. H. E. Nursten, Procter Department of Food and Leather Science, The University, Leeds, LS2 9JT, as soon as possible.

2633

BERRY'S RADIO requires:

(A) **ENGINEER**—fully conversant dictating machines.

(B) **RADIO ENGINEER**—practical experience Hi-Fi and radio (no TV).

(C) **COUNTER SALES**—must possess good technical knowledge.

ALSO JUNIOR ASSISTANTS REQUIRED, MINIMUM AGE 16.

Top Rates. Permanency.

Luncheon Vouchers. 5-day week.

25 HIGH HOLBORN, LONDON W.C.1

2612

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

REDIFON LTD. require fully experienced TELECOMMUNICATIONS TEST ENGINEERS and ELECTRONICS INSPECTORS. Good commencing salaries. We would particularly welcome enquiries from ex-Service personnel or personnel about to leave the Services. Please write giving full details to—The Personnel Manager, Redifon Ltd., Broomhill Road, Wandsworth, S.W.18. [26

WE HAVE VACANCIES for Four Experienced Test Engineers in our Production Test Department. Applicants are preferred who have Experience of Fault Finding and Testing of Mobile VHF and UHF Mobile Equipment. Excellent Opportunities for promotion due to Expansion Programme. Please apply to Personnel Manager, Pye Telecommunications Ltd., Cambridge Works, Haig Road, Cambridge. Tel. Cambridge 51351, Extn. 327. [77

ELECTRONICS TECHNICIAN required to assist in the development, construction and installation of electronics instruments used in biochemistry. Applicants should possess O.N.C. or equivalent and be able to construct and test equipment from circuit diagrams. Salary according to age and experience in the range of £1,025 to £1,295 per annum. Supplementary payments for certain qualifications. Superannuation scheme. Good conditions of service. Applications in writing to Departmental Superintendent, Department of Biochemistry, MRC Metabolic Reactions Unit, Imperial College, London, S.W.7. [2617

DEPARTMENT OF NUCLEAR PHYSICS, University of Oxford, has a vacancy for a senior technician to work with a group developing ion sources and very high voltage devices for the Oxford 20MV electrostatic generators. The work calls for initiative and responsibility. A qualification of H.N.C. in physics or electronics would be appropriate. Salary in the range £979 to £1,316 p.a., with children's allowances and six weeks' paid leave per year. Possibility of working for a higher qualification exists. Write to T. L. Green, Nuclear Physics Laboratory, Keble Road, Oxford, mentioning reference A111. [2618

INSTRUMENT/ELECTRONICS TECHNICIAN required to work in well equipped electrical workshop. Duties include servicing and construction of modern electronic equipment. Knowledge of workshop and circuit wiring essential and candidate must have initiative and be able to work without supervision. O.N.C. or equivalent qualification necessary. Opportunities for further study by part-time day release. Salary in the range £898-£1202 plus £125 per annum London Weighting according to age and experience. Apply in writing to the Departmental Superintendent, Department of Chemistry, Imperial College, South Kensington, London, S.W.7. [2623

ASSISTANT SOUND RECORDING AND MAINTENANCE ENGINEER. Enthusiastic and well qualified young man required in Central London. Excellent prospects for the right man willing to accept responsibility. Write giving details of qualifications and experience to Box W.W. 2624, Wireless World.

QUALIFIED ENGINEERS considering emigration to Australia 1970 required to join new and vigorous firm of communications consultants. Interviews London and Birmingham. Brief resume to Box W.W. 2627, Wireless World.

ARE YOU INTERESTED IN HI FI? If so, and you have some experience of selling in the Retail Radio Trade, an excellent opportunity awaits you at Telesonic Ltd., 243 Euston Road, London, N.W.1. Tel. 01-387 7467. [21

ARTICLES FOR SALE

BUILD IT in a DEWBOX quality plastics cabinet. 2 in. × 2½ in. × any length. D.E.W. Ltd. (W), Ringwood Rd., FERNDOWN, Dorset. S.A.E. for leaflet. Write now—Right now. [76

HOW to Use Ex-Govt. Lenses and prisms. Booklets. Nos. 1 & 2, at 2/6 ea. List Free for S.A.E. H. W. ENGLISH, 469 RAYLEIGH RD., HUTTON, BRENTWOOD, ESSEX. [87

UHF KITS and T.V. SERVICE SPARES. Suitable for Colour: Leading British Makers dual 405/625 six position push button transistorised tuners £5 5s. 0d., 405/625 transistorised sound & vision IF panels £2 15s. 0d. incl. circuits and data. P/P 4/6. Basic dual purpose 405/625 transistorised tuners incl. circuit £2 10s. 0d., P/P 4/6. UHF list available on request. UHF tuners, PLESSEY incl. valves 55/-, P/P 4/6. EKCO/FERRANTI 4 position push button type, incl. valves, leads, knobs £5 10s. 0d., P/P 4/6, SOBELL/GEC UHF tuner kit incl. valves, right angle slow motion drive assy, leads, fittings, knobs, instructions £5 18s. 6d., P/P 4/6. SOBELL/GEC 405/625 IF & output chassis incl. circuit 32/6, P/P 4/6. Ultra 625 IF amplifier plus 405/625 switch assy incl. circuit 25/-, P/P 4/6. New VHF tuners. Cyldon C 20/-, Ekco 283/330 range 25/-, Pye CTM 13 ch. incremental 25/-, P/P 4/6. Many others available incl. large selection channel coils. Fireball tuners, used good cond. 30/-. Push button tuners RGD 612/619 type used good cond. 30/-, P/P 4/6. LOPTs, Scan coils, Frame output transformers. Mains droppers etc., available for most popular makes. TV signal boosters transistorised PYE/Labgear B1/B3, or UHF battery operated 75/-. UHF mains operated 97/6, UHF masthead 85/-, post free. Enquiries invited. COD despatch available. MANOR SUPPLIES, 64 GOLDERS MANOR DRIVE, LONDON, N.W.11. CALLERS 589B, HIGH ROAD, N. FINCHLEY, N.12 (near GRANVILLE RD.). Tel. 01-445 9118. [60

AR88 MAINS TRANSFORMERS, £2/10/-. 12/24v carbon pile voltage regulator units, 30/-. 40 amp 4-way terminal blocks, 5/-. Rotax inverters, input 24v DC, output 115v, 3 phase, 400 cycles, 1·8 amps, £7/10/-. 200 amp terminals, insulated heads, 8/6. Carriage and packing extra. Also high voltage capacitors and insulators in stock. Westover Electronic, Braidley House, St. Paul's Lane, Bournemouth. Tel. 23944. [2619

ADVANCE E2 Signal Generator, 100 Kc/s, 100 Mc/s, £12. Hunts Capacity and Resistance Bridge, £12. Both in good condition. 6 Ingles, Welwyn Garden City, Herts. W/G 24887. [2625

BRAND NEW ELECTROLYTICS, 15/16 volt, 0·5, 1, 2, 5, 6, 8, 10, 15, 20, 30, 40, 50, 100, 200 mfds., 8d. Mullard 25 volt 6·4, 12·5, 25, 50, 80 mfds., 10d. Carbon Film Resistors, ½ watt, 5%, E12, series 10 ohms to 1 megohm, 1/6d. dozen; minimum order 7/6, postage 1/-. The C.R. Supply Co., 127 Chesterfield Road, Sheffield, S.8. [2604

NEW DEVICES AT LOWEST PRICES. GE PA230 Audio Preamplifier, 18/6 each. GE PA234 1W Audio Amplifier, 17/6 each. GE PA237 2W Audio Amplifier, 32/6 each. GE 2N5172 NPN 200mW Transistor, 1/9 each. IN 4820 1·5A 400V Si. Rectifier, 2/6 each. Data with Integrated Circuits. C.W.O. P. & P. 1/- per order. JEFF ELECTRONICS, York House, 12 York Drive, Grappenhall, Warrington, Lancs. Mail order only. [2605

COLOUR T.V. Large-screen Projectors. Cintel Model 20630, 6-ft. picture from RGB Video Inputs, with spare CRT's. Partly dismantled for storage. Offers. Phone 01-948 1414. [2639

COMPUTOR LINE OF SIGHT mk 3A. An Analog Device comprising 3 19" 6ft racks full of synchros, DC. motors, servo amps, gear boxes. Not working cheap for quick sale. 70 ex. equip. S.T.C. sealed relays 2 c/o contacts 48v. 2500 coyls, offers. Mr. Summers, Gainsborough 3940 evenings. [2637

TEST EQUIPMENT — SURPLUS AND SECONDHAND

SIGNAL generators, oscilloscopes, output meters, wave voltmeters, frequency meters, multi-range meters, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [64

(1) Mullard Double Beam Oscilloscope, L.101. Excellent general condition but may possibly need recalibrating. £80. (2) Marconi BFO, type TF195L. £30. (3) Avo model 7, £15. (4) Evershed Bridge Megger 500 volt, £20.—Burgess Lane & Co. Ltd., Thornton Ave. Chiswick, London W.4. [2638

MARCONI TF890A/4 Radar Test Set 8500-9680 Mc/s incorporating: Klystron Signal Generator, Thermistor Power Monitor, Spectrum Analyser, Directive Feed Assembly, brand new, makers' guarantee. 021-454 8305. [2660

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

HRO Rx5s, etc., AR88, CR100, BRT400, G209, S640, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [65

SURPLUS HANDBOOKS

19 set Circuit and Notes	6/6 p/p 6d.
1155 set Circuit and Notes	6/6 p/p 6d.
H.R.O. Technical Instructions	5/6 p/p 6d.
38 set Technical Instructions	5/6 p/p 6d.
46 set Working Instructions	5/6 p/p 6d.
88 set Technical Instructions	7/- p/p 6d.
BC.221 Circuit and Notes	5/6 p/p 6d.
Wavemeter Class D Tech. Inst.	5/6 p/p 6d.
18 set Circuit and Notes	5/6 p/p 6d.
BC. 1000 (31 set) Circuit and Notes	5/6 p/p 6d.
CR. 100/B.28 Circuit and Notes	10/- p/p 6d.
R.107 Circuit and Notes	7/- p/p 6d.
AR.88D Instruction Manual	18/- p/p 6d.
62 set Circuit and Notes	6/6 p/p 6d.

Circuit Diagram 5/- each post free. R.1116/A, R.1224/A, R.1355, R.F. 24, 25 and 26, A.1134, T.1154, CR.300, BC.312, BC.342, BC.348J, BC.348 (E.M.P.), BC.624, 22 set.

52 set Sender and Receiver circuits 7/6 post free.

Colour Code Indicator 2/6, p/p 6d.

S.A.E. with all enquiries please.

Postage rates apply to U.K. only.

Mail order only to:

INSTRUCTIONAL HANDBOOK SUPPLIES

Dept. W.W. Talbot House, 28 Talbot Gardens, LEEDS 8

GEARED MOTORS

Microswitches, Timers, Meters, Potentiometers, Capacitors, all new

6d. stamp for catalogue.

F. HOLFORD & CO.

6 IMPERIAL SQUARE, CHELTENHAM

BAILEY 30 WATT AMPLIFIER

10 Tr's as spec'd and Fibreglass Pcb £6.7.6

20 Tr's as spec'd and 2 Fibreglass Pcb's £12.10.0

BC125/126/40361 12/- 40362 16/-

MJ481 26/- MPF103 8/6 MJ491 30/-

R1-R27 (5% low noise) & P. 10/6 C1-C6 (Mullard) 7/6

Mullard C431 2500mFd/64vw with clip 15/-

Ali H/Sink (Drilled 2 × TO3) 4 × 4¾ in. 10/-

LINSLEY HOOD CLASS A AMP

Set 10 C.F. R's 5/- Set 5 Capacitors 22/6

MJ480 (Matched for <0.1% T.H.D.) per pair 42/6

MJ481 (Matched for <0.1% T.H.D.) per pair 52/6

2N3906/2N4058/2N697/2N1613 6/6 BC109 3/6

Pair of H/Sinks as spec'd for Mono 5 × 4 in. 21/-

Lektrokit Pinboard 4 × 4¾ in., pins & Layout 5/6

MJ480 16/6 Hunts KA112BT 2500mFd/50vw 12/6

1250mFd/40vw 9/- 250mFd/50vw 3/- 500mFd/50vw 5/9

A.1 FACTORS, 72 BLAKE ROAD, STAPLEFORD, NOTTS.

FOR YOUR . . .

SYNCHRO & SERVO REQUIREMENTS!

SERVO & ELECTRONIC SALES LTD.

43 HIGH ST., ORPINGTON, KENT. Tel: 31066, 33976

Also at CROYDON. Tel: 01-688 1512

and LYDD, KENT. Tel: LYDD 252

WE BUY

any type of radio, television, and electronic equipment, components, meters, plugs and sockets, valves and transistors, cables, electrical appliances, copper wire, screws, nuts, etc. The larger the quantity the better. We pay **Prompt Cash.**

Broadfields & Mayco Disposals,
21 Lodge Lane, London, N.12

RING 445 2713

445 0749

958 7624

AMERICAN

TEST AND COMMUNICATIONS EQUIPMENT

★ GENERAL CATALOGUE AN/104 1/6 ★

Manuals offered for most U.S. equipments

SUTTON ELECTRONICS

Salthouse, Nr. Holt, Norfolk. Cley 289

NEW BOOKS

OCTOBER 1969

TRANSISTOR SUBSTITUTION HANDBOOK 9th Edition
18s. net.

49 EASY ENTERTAINMENT & SCIENCE PROJECTS. Vol 1
Robert M. Brown and Tom Kneitel 24s. net.

NOVEMBER 1969

TRANSISTOR COLOUR TV SERVICING GUIDE
Robert G. Middleton 35s. net.

CLOSED CIRCUIT TV FOR ENGINEERS AND TECHNICIANS
Leonard E. Showalter 50s. net.

JANUARY 1970

UNDERSTANDING AND USING UNIJUNCTION TRANSISTORS
S. Hoberman 24s. net.

ELECTRONIC CIRCUIT DESIGN
Farl J. Waters 30s. net.

FEBRUARY 1970

LEARN ELECTRONICS THROUGH TROUBLESHOOTING
Wayne Lemons 75s. net.

FM FROM ANTENNA TO AUDIO
Leonard Feldman 30s. net.

The above are obtainable from most good bookshops or direct from the Publishers (see below) on remittance of the price plus 2/6 p & p.

FOULSHAM—SAMS TECHNICAL BOOKS
(W. FOULSHAM & CO. LTD)
YEOVIL ROAD, SLOUGH, BUCKS, ENGLAND

FANTASTIC SPEAKER BARGAIN

Famous English. 12" high flux, heavy cone. 10 watts speaker with built-in tweeter. 3 or 15 ohms. 12-month guarantee **39/6** (P. & I. 4/9)
2 for 70/- (P. & I. 6/9)

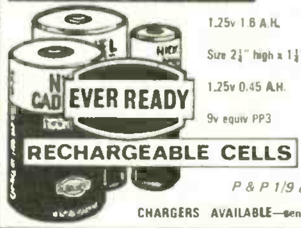
NEW RELEASE

HI-FI COLUMN SPEAKER CABINET

Beautifully made. Suitable for 7-12" speakers Rosewood finish. Screwed and glued. Attractive grey cloth front measures 24" x 13" x 10" with tweeter hole above. Mark II de luxe model (Carr. 10/-). With 12" speaker as advertised above £6/5/0 (Carr. 10/-). **95/–**

LATEST RELEASE!

Nickel Cadmium



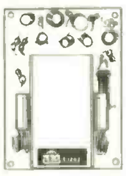
1.25v 1.8 A.H. Size 2¼" high x 1¼" dia **29/6**
1.25v 0.45 A.H. **18/–**
9v equiv PP3 **39/6**

RECHARGEABLE CELLS

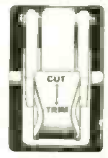
P & P 1/9 on each

CHARGERS AVAILABLE—send S.A.E. for list

4-TRANSISTOR AUDIO AMPLIFIER



(1 watt)
27/6
3⅛" × 2¼" × 1¼"
Output 8 or 16 ohms
P & P 1/9 on each



TAPE SPLICER/EDITOR 19/6
P&P 1/9 on each

ELECTRAMA Dept. WW81. 15 High St., Hailsham, Sussex

"24-hour Mail Order Service"
(Same day dispatch by 1st class mail)

PUCKA ENTERPRISES

Guaranteed Valves

CV137	4/6	EZ40	8/-	U191	15/-	6BW6	16/-
CV172	20/-	EZ41	9/-	U282	8/6	6BW7	14/-
CV189	40/-	EZ80	5/4	UABC80	6/6	6C4	5/10
CV261	20/-	EZ81	5/4	UAF42	10/2	6C5G	5/6
CV284	9/-	GZ30	7/6	UBC41	9/-	6C9	18/6
CV469	9/-	GZ32	10/2	UBF80	7/-	6CB6	11/6
CV1092	4/-	GY501	16/-	UBF89	7/6	6CH6	11/9
CV4014	8/3	KT66	21/-	UCC85	7/6	6F1	15/-
CV4025	7/6	KT88	31/6	UCF80	10/-	6F33	23/-
DAF91	4/9	MSPENT	8/-	UCH21	10/-	6H6M	3/3
DAF96	7/6	N78	30/6	UCH42	10/2	6J4W	14/-
DK91	6/5	PC86	12/-	UCH81	7/-	6J5GT	5/9
DK96	8/-	PC88	12/-	UCL83	10/3	6J6	3/8
DL93	4/3	PC97	8/6	UF41	10/3	6K6GT	9/6
DY86	6/5	PC900	9/4	UF42	10/9	6SK7GT	6/3
DY87	7/-	PCC84	6/5	UF80	7/6	6SL7GT	6/4
E90CC	9/-	PCC85	8/-	UF89	7/6	6SN7GT	6/4
EABC80	6/6	PCC88	11/10	UL41	10/2	6V6GT	6/4
EAF42	9/9	PCC89	10/3	UL84	7/-	6X4	4/9
EBC41	9/-	PCC189	10/9	UU8	16/-	6X5GT	5/3
EBC81	5/6	PCF80	7/-	UY41	7/6	7B6	11/10
ECC84	5/10	PCF84	8/7	UY85	6/6	7C6	6/10
ECC85	5/-	PCF86	9/1	OA2WA	10/-	7R7	13/6
ECF80	6/10	PCF801	9/8	OB2	6/5	12AH7GT	5/3
ECH81	5/6	PCF802	9/8	OC3	6/9	12AT6	4/9
ECL80	7/6	PCF805	15/-	OD3	6/5	12AT7	6/3
ECL82	6/4	PCF806	13/-	1A7GT	7/6	12AU7	6/-
ECL83	10/8	PCF808	15/6	1R5	6/5	12AX7	5/9
ECL86	8/6	PCL81	9/8	1S5	4/9	12SQ7GT	7/8
EF37A	8/6	PCL82	7/6	1T4	4/3	20P4	20/-
EF39	8/7	PCL83	10/2	1U4	6/5	20P5	20/6
EF40	9/9	PCL84	8/7	1X2B	7/6	25L6GT	6/9
EF41	9/9	PCL85	9/1	2D21	6/6	28D7	9/6
EF42	14/-	PCL86	9/1	2D21W	10/9	30C1	7/-
EF50	5/-	PD500	32/6	3A4	3/3	30C15	15/-
EF80	5/-	PFL200	14/-	3Q4	8/-	30C17	16/-
EF83	10/2	PL36	10/9	5CP1	80/-	30C18	15/-
EF85	7/-	PL38	19/6	5U4G	5/9	30F5	17/-
EF86	6/6	PL81	8/-	5V4G	8/-	30FL1	16/-
EF89	5/4	PL82	8/7	5Y3GT	5/9	30FL14	15/6
EF92	8/-	PL83	7/6	5Z4G	7/6	30L15	17/-
EF93	4/3	PL84	7/-	6/30L2	15/-	30P12	16/-
EF95	5/4	PL504	16/1	6AC7	3/6	30P19	15/-
EF183	6/6	PL509	35/-	6AK5	6/-	30PL13	18/6
EF184	7/-	PY31	3/6	6AK5W	8/-	30PL14	15/-
EH90	7/6	PY32	10/9	6AK6	12/6	35W4	4/9
EL34	10/2	PY33	12/6	6AL5	3/2	85A1	27/-
EL41	10/2	PY80	6/-	6AM5	5/3	85A2	8/-
EL81	9/9	PY81	5/10	6AM6	4/6	150B2	11/9
EL84	4/9	PY82	5/4	6AS6	7/6	705A	30/-
EL86	8/7	PY83	7/6	6AT6	5/-	807	9/6
EL95	5/4	PY88	8/-	6BA6	4/3	5696	7/6
EM34	16/3	PY800	9/7	6BE6W	15/-	5763	12/11
EM81	8/-	PY801	9/7	6BG6G	12/-	5933	50/-
EY51	7/6	R10	20/-	6BH6	8/6	6360	25/-
EY86	7/-	U25	15/6	6BJ6	8/6	9006	2/6
EY87	8/7	U26	15/6	6BR7	17/3		
				6BS7	27/-		

Many others in stock. S.A.E. for free price list. P. & P. 9d. per valve/2 sh. per £. Insurance extra. Terms: Cash/P.O./Cheque with order. Overseas enquiries/orders welcome.

207b Belsize Road, London, N.W.6
Telephone 01-328 6123

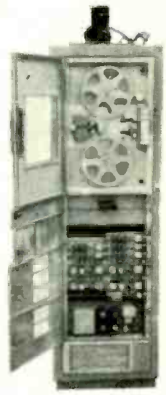
EXCLUSIVE OFFER

AMPEX

MODEL FR-100 A

DATA TAPE RECORDER-REPRODUCERS

COMPLETELY FITTED IN 6 ft. TOTALLY ENCLOSED CABINETS with recording and reproducing Amplifiers, electronic frequency control and all Power Supplies.



★SIX SPEEDS 1⅞", 3¾", 7½", 15", 30" and 60" per second.
★INTERCHANGEABLE HEADS.
★1" TAPE, 5 TRACKS.
★UP TO 14" REEL CAPACITY.
★DC-FM-PCM-NRZ SYSTEMS.
★DC to 30,000 cycles.
★UP TO 10,000 Pulse Rate.
★DRIFT FREE WITHIN 1%.
★SERVO CONTROL to 0.75 μ/s.
★TRACK TIMMING 5μ/s.
★ACCURACY 10⁶ per week.
★ELECTRONICS IN MODULES FRONT ACCESS TO ALL PARTS.
★POWER INPUT 105/125v 48 to 500 c/s.
★Made in U.S.A. these fine units cost the American Government £9,000 each before devaluation.

Full details on application.

FREE
40-page list of over 1,000 different items in stock available—keep one by you.

★E.E.8 Telephones	£3 10
★Weston 2½" DB Meters	£2 10
★Wharfdale SFB Speakers. Walnut	£14 0
★Marconi HR 110 Communications Receivers 1.5 to 31.0 m/cs	£45 0
★Candlestick microphones with push to talk switch	£2 0
★G.B.C. Plastic Punching and Binding machines	£40 0
★Lattice lightweight steel triangular Aerial Masts 12 to 16 inch sides up to 200 ft. high	According to height
★10 feet high triangular Lattice Mast Sections, galv. 6 inch sides with mating lugs for joining	£6 0
★Universal Demultiplexers	£125 0
★I.C. Testers with plug boards	£95 0
★McElroy Tape Pullers	£4 10
★Tinsley Phase-splitting Potentiometers	£75 0
★E.M.I. WM-3 Measuring Oscilloscopes	£32 10
★Marconi TF-1055 Noise Measuring Sets	£150 0
★54 inch dia. Meteorological Balloons	£1 10
★Micrometer Wavemeters General Electric 900/1530 and 1530/4000 m/cs each	£22 0
★455 k/cs Mechanical Band Pass Filters	£3 10
★7 track ½" tape head assemblies with rollers	£30 0
★½" New Magnetic Recording Tape made by E.M.I. (USA) 3600 ft on N.A.B. Spools	£5 10
★1" Used ditto "Scotch" Brand 4800 ft	£4 0
★M.E. 11 R.F. Wattmeters up to 500 m/cs	£42 10
★T.D.M.S. Sets send/receive in cabinets	£80 0
★Collins 500 w. Radio Telephone Transmitters Autotune 2 to 18 m/cs 230v. input new	P. U. R.
★8 Track Data High Speed Tape Readers	£40 0
★Mason Illuminated Drawing Tables 50" × 36"	£17 10
★Amphenol Connector Assembling Machines	£8 10
★Stelma Telegraph Distortion Monitors	£25 0
★5ft. Motorola enclosed Cabinets 19"	£12 10
★Teletype Model 14 Tape Punches	£29 10
★TS-497/URR Signal Generators 2/400 m/cs	£85 0
★Sarah Trans/Receivers and Aerials	£3 0
★Sigma 12000 ohm. DPDT Sealed Relays	£1 0
★Freiz Airport "Weather Man" Masts	£25 0
★75 foot high Lattice Triangular Wind up Masts	£285 0
★Uniselectors 10 bank 25 way ex. new	£1 15
★Precision Mains Filter Units new	£1 10
★Marconi HR.22 SSB Receivers 2/32 m/cs	£75 0
★Avo Geiger Counters new	£7 10

Carriage extra at cost on all above.
All goods are ex-Government stores.

We have a large quantity of "bits and pieces" we cannot list—please send us your requirements we can probably help—all enquiries answered.

P. HARRIS
ORGANFORD — DORSET
BH16 6ER
WESTBOURNE 65051

BAILEY PRE-AMPLIFIER

High quality pre-amplifier circuit described by Dr. A. R. Bailey in the December, 1966, "Wireless World". This is a low distortion circuit of great versatility with a maximum output of 2 volts making it suitable for driving Bailey 20W and 30W Amplifiers, Linsley Hood Class A Amplifier and many others All normal pre-amplifier facilities and controls are incorporated. A new Printed Circuit Board containing latest modifications 7in. by 3¾in. features edge connector mounting, roller tinned finish and silk screened component locations. This board is available in S.R.B.P. material or fibreglass and the complete Kit for the unit contains gain graded BC.109 transistors, polyester capacitors and metal oxide resistors where specified.

BAILEY 30W AMPLIFIER

All parts are now available for the 60-volt single supply rail version of this unit. We have also designed a new Printed Circuit intended for edge connector mounting. This has the component locations marked and is roller tinned for ease of assembly. Size is also smaller at 4½in. by 2¾in. Price in SRBP material 11/6d. in Fibreglass 14/6d.

BAILEY 20W AMPLIFIER

All parts in stock for this Amplifier including specially designed Printed Circuit Boards for pre-amp and power amp. Mains Transformer for mono or stereo with bifilar wound secondary and special 218V primary for use with CZ6 Thermistor, 35/6d., post 5/-.

Trifilar wound Driver Transformer, 22/6d., post 1/-. Power Amp., 12/6d., post 9d.

Reprint of "Wireless World" articles, 5/6d. post free.

DINSDALE 10W AMPLIFIER

All parts still available for this design.

Reprint of articles 5/6d., post free.

LINSLEY HOOD CLASS A AMPLIFIER

Parts now available for this unit including special matt black anodised Metalwork and all power supply components.

PLEASE SEND S.A.E. FOR ALL LISTS.

HART ELECTRONICS,

321 Great Western St., Manchester 14

The firm for quality.

Personal callers welcome, but please note we are closed all day Saturday.

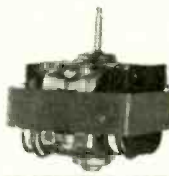
BAKER "SUPERB" 20 WATT 12in. LOUDSPEAKER

BRITISH MADE THROUGHOUT

Suitable for all Hi-Fi Systems. Provides rich clear sound recreating the musical spectrum virtually flat ±5dB, 20-17,000 cps. Latest double cone with massive "Ferroba" ceramic magnet. Flux density 16,500 gauss. Bass resonance 22-26cps. Plastic Cone Surround. Coils available 8 or 15 ohms.

Price £15 Post Free

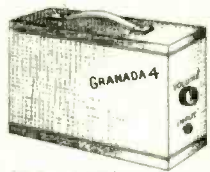
ELECTRIC MOTORS



(120v. or 240v. A.C.) Clockwise 1,200 R.P.M. off load Heavy duty 4 pole 50mA. Spindle ⅜ × 3/20 in. diameter. Size 2¼ × 2¼ × 1½ in.

BARGAIN PRICE **17/6** Post 2/6

TRANSISTOR AMPLIFIER WITH LOUDSPEAKER



A self-contained portable mini p.a. system. Many uses—Parties, Baby Alarm, Intercom, Telephone or Record Player Amplifier. Attractive rexine covered cabinet size 12×9×4 in., with powerful 7×4 in. speaker and four transistor one watt power amplifier. Uses PP9 battery. Brand new in Maker's carton with full maker's guarantee.

All for only **75/-** Post 4/6

THE INSTANT BULK TAPE ERASER AND RECORDING HEAD DEMAGNETISER

200/250 A.C. Leaflet S.A.E. **42/6** Post 2/6

EXTENSION SPEAKER

Smart plastic cabinet speaker with 20ft. lead for transistor radio, intercom, mains radio, tape recorder, etc. Size: 7¼in. x 5½in. x 3in. **30/-** Post 2/6

RETURN OF POST DESPATCH — CALLERS WELCOME
HI-FI STOCKISTS — SALES — SERVICE — SPARES

RADIO COMPONENT SPECIALISTS

337 WHITEHORSE ROAD, CROYDON. Tel: 01-684 1665

Thanks to a bulk purchase we can offer

BRAND NEW P.V.C. POLYESTER & MYLAR RECORDING TAPES

Manufactured by the world-famous reputable British tape firm, our tapes are boxed in polythene and have fitted leaders, etc. Their quality is as good as any other on the market, in no way are the tapes faulty and are not to be confused with imported, used or sub-standard tapes. 24-hour despatch service.

Should goods not meet with full approval, purchase price and postage will be refunded.

S.P.	3in. 160ft.	2/-	5in. 600ft.	6/-		
	5¾in. 900ft.	8/-	7in. 1,200ft.	9/-		
L.P.	3in. 225ft.	2/6	5in. 500ft.	8/6		
	5¾in. 1,200ft.	10/-	7in. 1,800ft.	13/-		
D.P.	3in. 350ft.	4/6	5in. 1,200ft.	12/-		
	5¾in. 1,800ft.	16/-	7in. 2,400ft.	20/-		

Postage on all orders 1/6

COMPACT TAPE CASETTES AT HALF PRICE

60, 90, and 120 minutes playing time, in original plastic library boxes.
MC 60 9/- each. MC 90 12/6 each. MC 120 18/3 each.

STARMAN TAPES

28 LINKSCROFT AVENUE ASHFORD, MIDDX.

Ashford 53020

WW—115 FOR FURTHER DETAILS

NEW GRAM AND SOUND EQUIPMENT

CONSULT first our 76-page illustrated equipment catalogue on Hi-Fi (6/6). Advisory service, generous terms to members. Membership 7/6 p.a.—Audio Supply Association, 18 Blenheim Road, London, W.4. 01-995 1661. [27

GLASGOW.—Recorders bought, sold, exchanged; cameras, etc., exchanged for recorders or vice-versa.—Victor Morris, 343 Argyle St., Glasgow, C.2. [11

TAPE RECORDING ETC.

IF quality, durability matter, consult Britain's oldest transfer service. Quality records from your suitable tapes. (Excellent tax-free fund raisers for schools, churches.) Modern studio facilities with Steinway Grand.—Sound News, 18 Blenheim Road, London, W.4. 01-995 1661. [28

TAPE to disc transfer, using latest feedback disc cutters; EPs from 22/-; s.a.e. leaflet.—Deroy, High Bank, Hawk St., Carnforth, Lancs. [70

VALVES

VALVE cartons by return at keen prices; send 1/- for all samples and list.—J. & A. Boxmakers, 75a Godwin St., Bradford, 1. [10

FOR HIRE

FOR hire CCTV equipment including cameras, monitors, video tape recorders and tape—any period. —Details from Zoom Television, Amersham 5001. [75

ARTICLES WANTED

URGENTLY REQUIRED

ALL TYPES OF RADIO TELEPHONE EQUIPMENT

ESPECIALLY PYE CAMBRIDGE AND VANGUARD MOBILES. ALSO BASE STATIONS ANY CONDITION, WORKING OR NOT. *Top prices paid.*

WE ALSO REPAIR ALL TYPES OF RADIO TELEPHONE EQUIPMENT

SOUTHERN RADIO & T.V. SERVICE

1 BACK HAMILTON STREET SALFORD 7 LANCS.

Telephone 061-792 4929 2656

WANTED, all types of communications receivers and test equipment.—Details to R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley 4986. [63

WANTED—small quantity PYE Vanguards—AM25B with connecting cables and cradles, must be clean and serviceable. Price and details please to: Raymond McAteer, Radio Engineer, Main Street, Garvagh, Co. Londonderry, N. Ireland. [2568

WANTED, televisions, tape recorders, radiograms, new valves, transistors, etc.—Stan Willetts, 37 High St., West Bromwich, Staffs. Tel. Wes. 0186. [72

WANTED GEC RELAYS, sealed, 12v, 180 ohms, four make-before-break contacts. Also tantalum Capacitors 750uF, 3v. Tel. 021-454 8305. [2657

VALVES WANTED

WE buy new valves, transistors and clean new components, large or small quantities, all details, quotation by return.—Walton's Wireless Stores, 55 Worcester St. Wolverhampton. [62

SCRAP R.F. Heating and Transmitting Valves wanted: TY5-500, TY6-800, TY7-600, ESA 1500, BR 1126. May be interested in other types. Good price paid for valves still under vacuum. Electronic Heat Co., 01-654 7172. [2606

CAPACITY AVAILABLE

AIRTRONICS, Ltd., for coil winding, assembly and wiring of electronic equipment, transistorised sub-unit sheet metal work.—3a Walerand Rd., London, S.E.13. Tel. 01-852 1706. [61

ELECTRONIC and Electrical Manufacture and Assembly. Prototypes and short production runs. East Midlands Instrument Co. Ltd., Summergangs Lane, Gainsborough, Lincs. Tel. 3260. [88

METALWORK, all types cabinets, chassis, racks, etc., to your own specification, capacity available for small milling and capstan work up to 1in bar.—PHILPOTT'S METALWORKS, Ltd., Chapman St., Loughborough. [17

PLASTIC Injection Moulding Specialists in short runs up to 1 oz. Low tooling costs.—K.T. Plastics Ltd., Dept. 10, 23 Hunters Hill, South Ruislip, Middx. 01-845 2824. [90

TECHNICAL TRAINING

BECOME "Technically Qualified" in your spare time, guaranteed diploma and exam. home-study courses in radio, TV, servicing and maintenance. R.T.E.B., City & Guilds, etc., highly informative 120-page Guide—free.—Chambers College (Dept. 837K), 148 Holborn, London, E.C.1. [16

CITY & GUILDS (Electrical, etc.), on "Satisfaction or Refund of Fee" terms. Thousands of passes For details of modern courses in all branches of electrical engineering, electronics, radio, T.V., automation, etc.; send for 132-page handbook—free.—B.I.E.T. (Dept. 152K), Aldermaston Court, Aldermaston, Berks. [13

RADIO officers see the world. Sea-going and shore appointments. Trainee vacancies during 1970. Grants available. Day and boarding students. Stamp for prospectus. Wireless College, Colwyn Bay. [80

TECHNICAL TRAINING IN Rado, TV and Electronics through world-famous ICS. For details of proven home-study courses write: ICS, Dept. 443, Intertext House, Stewarts Road, London. S.W.8. [24

TV and radio A.M.I.E.R.E., City & Guilds, R.T.E.B., certs., etc., on satisfaction or refund of fee terms; thousands of passes; for full details of exams and home-training courses (including practical equipment) in all branches of radio, TV, electronics, etc., write for 132-page handbook—free; please state subject.—British Institute of Engineering Technology (Dept. 150K), Aldermaston Court, Aldermaston, Berks. [15

TUITION

ENGINEERS.—A Technical Certificate or qualification will bring you security and much better pay. Elem. and adv. private postal courses for C.Eng., A.M.I.E.R.E., A.M.S.E. (Mech. & Elec.), City & Guilds, A.M.I.M.I., A.I.O.B., and G.C.E. Exams. Diploma courses in all branches of Engineering—Mech., Elec., Auto, Electronics, Radio, Computers, Draughts, Building, etc.—For full details write for FREE 132-page guide: British Institute of Engineering Technology (Dept. 151K), Aldermaston Court, Aldermaston, Berks. [14

KINGSTON-UPON-HULL Education Committee. College of Technology. Principal: E. Jones, M.Sc., F.R.I.C.

FULL-TIME courses for P.M.G. certificates and the Radar Maintenance certificate.—Information from College of Technology, Queen's Gardens, Kingston-upon-Hull. [18

BOOKS, INSTRUCTIONS, ETC

MANUALS, circuits of all British ex-W.D. 1939-45 wireless equipment and instruments from original R.E.M.E. instructions; s.a.e. for list, over 70 types.—W. H. Bailey, 167a Moffat Road, Thornton Heath, Surrey, CR4-8PZ. [64

BUSINESS OPPORTUNITIES

OPPORTUNITY for good TV Service Engineer with capital to invest with active participation in old established London retail business of the highest standing. Write in confidence stating age and details of experience. Box W.W. 2626, Wireless World.

EXPERIENCED technical author living in isolated country district requires writing to do at home. Could visit site anywhere in England about once a fortnight.—Box W.W.2636.

Classified copy for the

JANUARY ISSUE of WIRELESS WORLD

should arrive at this office not later than 12 p.m., Thursday, 4th Dec., 1969

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 112-122

Printed in Great Britain by Southwark Offset, 25 Lavington Street, London, S.E.1, and Published by the Proprietors, I.P.C. Electrical-Electronic Press, Ltd., Dorset House, Stamford St., London, S.E.1, telephone 01-928 3333. Wireless World can be obtained abroad from the following: Australia and New Zealand: Gordon & Gotch, Ltd. India: A. H. Wheeler & Co. Canada: The Wm. Dawson Subscription Service, Ltd.: Gordon & Gotch Ltd. South Africa: Central News Agency, Ltd.: William Dawson & Sons (S.A.) Ltd. United States: Eastern News Co., 306 West 11th Street, New York 14.

Don't risk it—use SAVBIT

ERSIN Multicore 5 CORE SOLDER

THE EXCLUSIVE MULTICORE ALLOY WHICH IS SATURATED WITH COPPER TO PREVENT ABSORBTION OF COPPER FROM COPPER WIRES, CIRCUIT BOARDS AND SOLDERING IRON BITS

When soldering fine copper wire, ordinary tin/lead solder alloys will absorb some of the copper, so that the diameter of the wire will be reduced.
Ersin Multicore Savbit Type 1 solder contains a small percentage of copper so that the solder is already 'saturated' with copper and will not absorb it from copper wire or copper laminate.
Savbit will also prolong the life of copper soldering iron bits by 10 times, thus eliminating the need for frequent resurfacing of copper bits and by keeping the copper bits in good condition, the soldering speed and efficiency are increased.
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.
Savbit Type 1 alloy with Type 362 Ersin Flux has received Ministry approval under number DTD.900/4535. It may be used for soldering processes on equipment for Services use in lieu of solder to BS.219.

FOR FACTORY USE

7 lb. REELS
Available in standard wire gauges from 10–22 swg., on strong plastic reels.

1 lb. REELS
Available in all standard wire gauges from 10–34 swg., on unbreakable plastic reels. (From 24–34 swg. only ½ lb. is wound on one reel.)

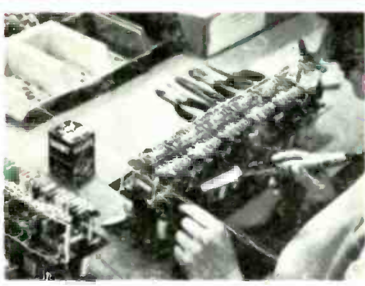
FOR MAINTENANCE AND SERVICE ENGINEERS

SIZE 1 CARTONS
In 14, 16 and 18 swg. Packed in a coil, so it can be drawn out through the top of the carton.

SIZE 5
Contains 10 ft. of 18 swg., packed in a unique handy dispenser.

SIZE 12
90 ft. of 18 swg. on a plastic reel, packed individually in a carton.

USED THROUGHOUT THE WORLD



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
MULTICORE SOLDERS LTD., HEMEL HEMPSTEAD, HERTS. Telephone: HEMEL HEMPSTEAD 3636