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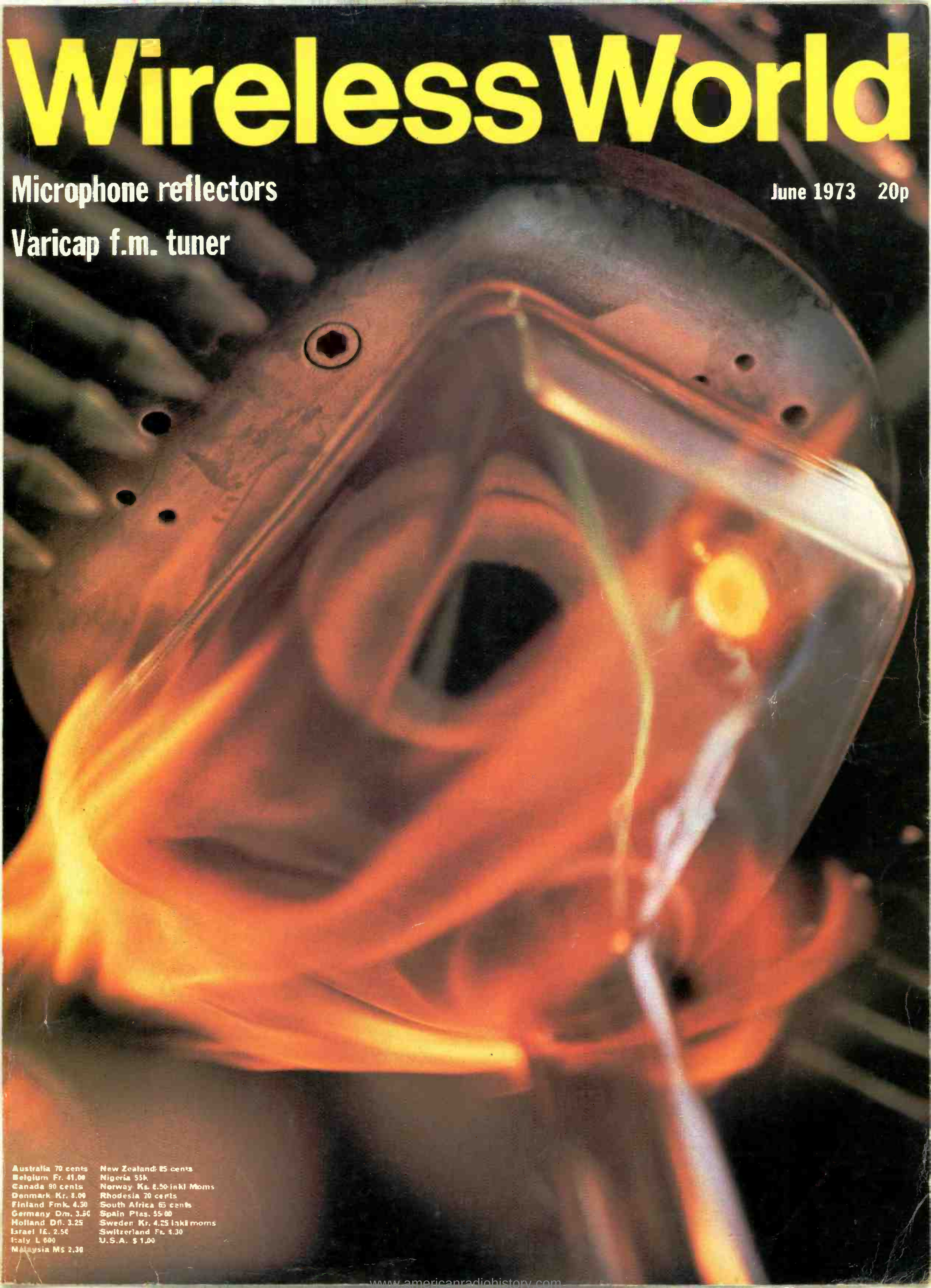

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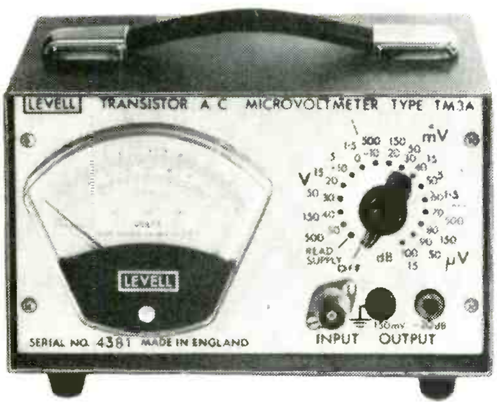

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£49 type TM3A **£63** type TM3B

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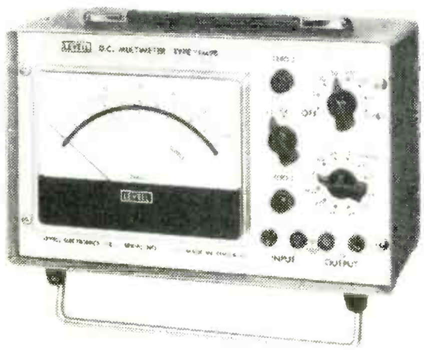
LOGARITHMIC RANGE: ± 5µV at ± 10% f.s.d., ± 5 mV at ± 50% f.s.d., ± 500 mV at f.s.d.
RECORDER OUTPUT: ± 1V at f.s.d. into > 1kΩ

£55 type TM10 (appearance similar to type TM9B)



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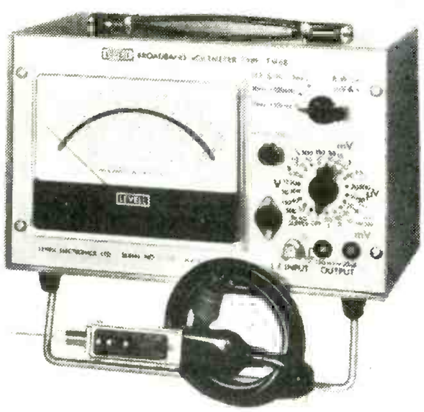

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	0.1%	0.3%	0.1%	0.3%
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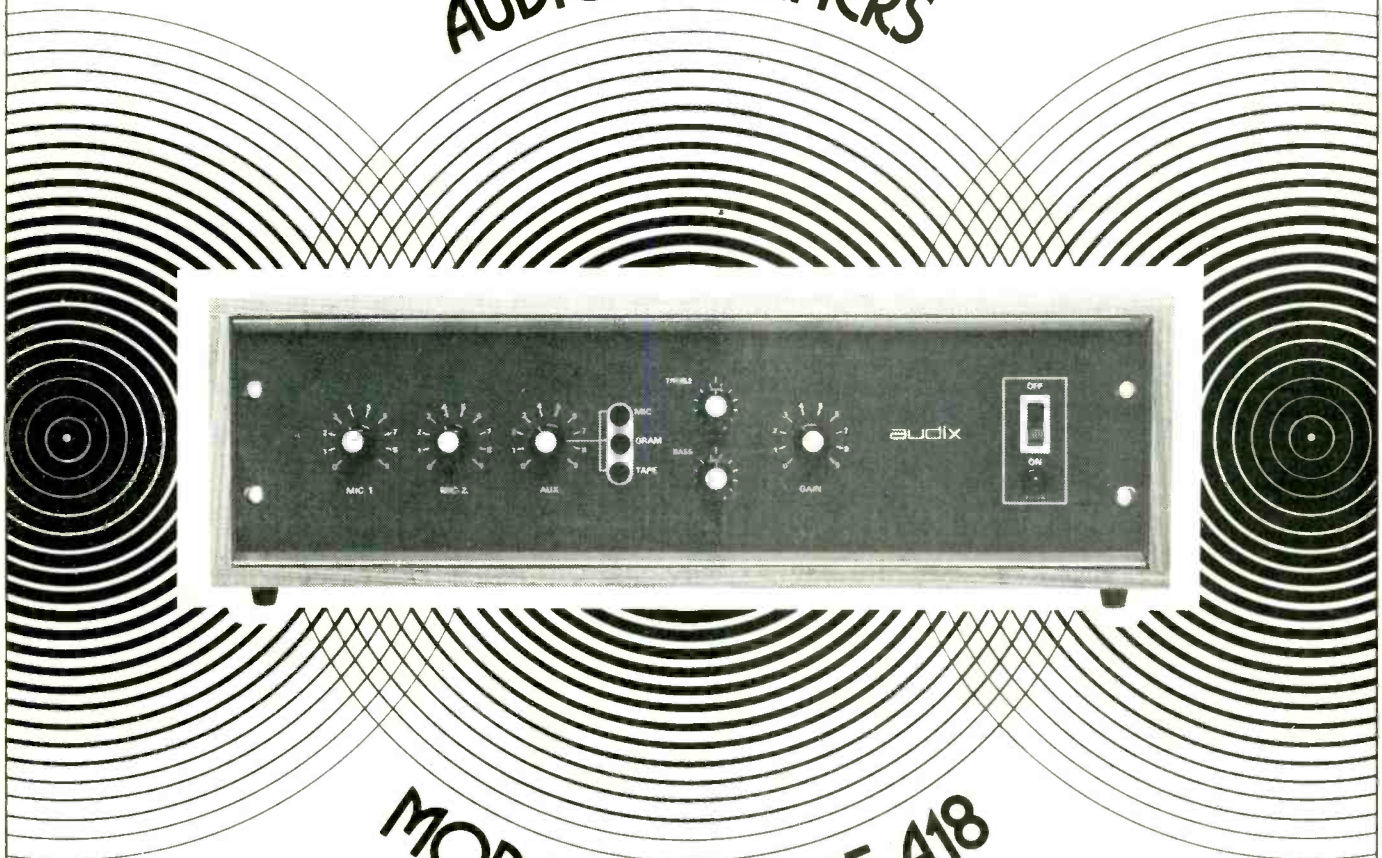

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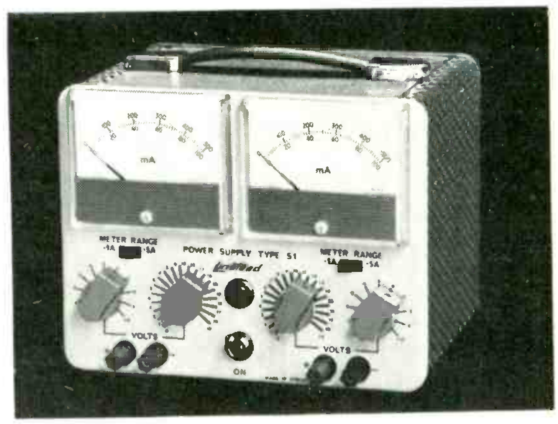

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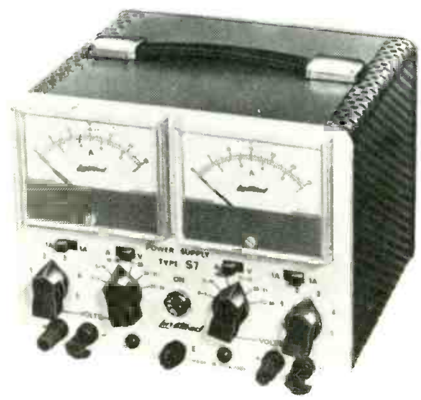

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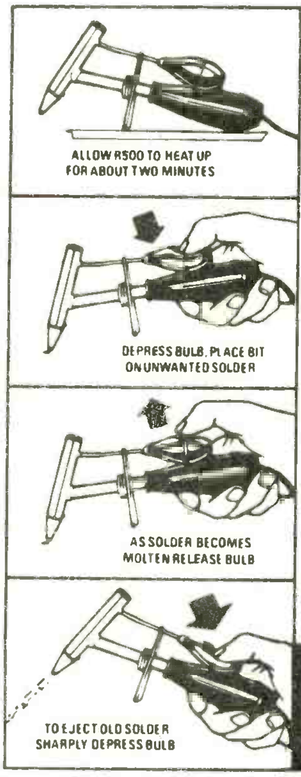

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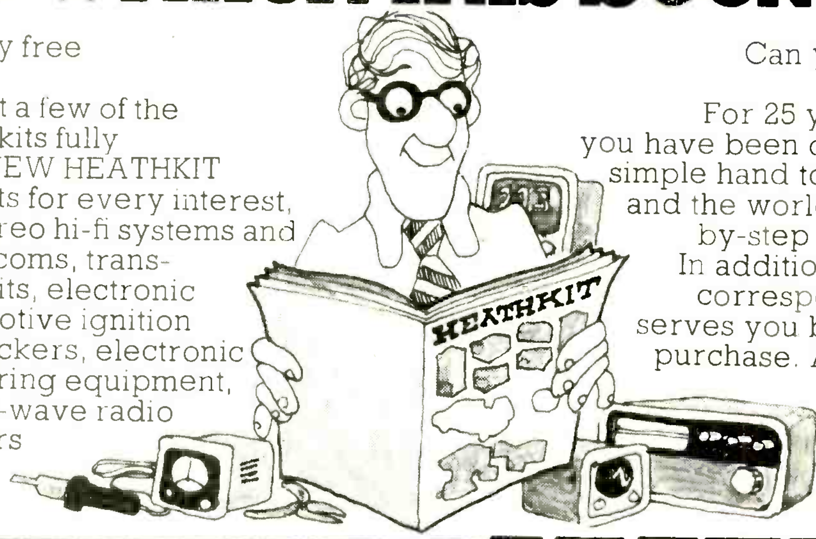

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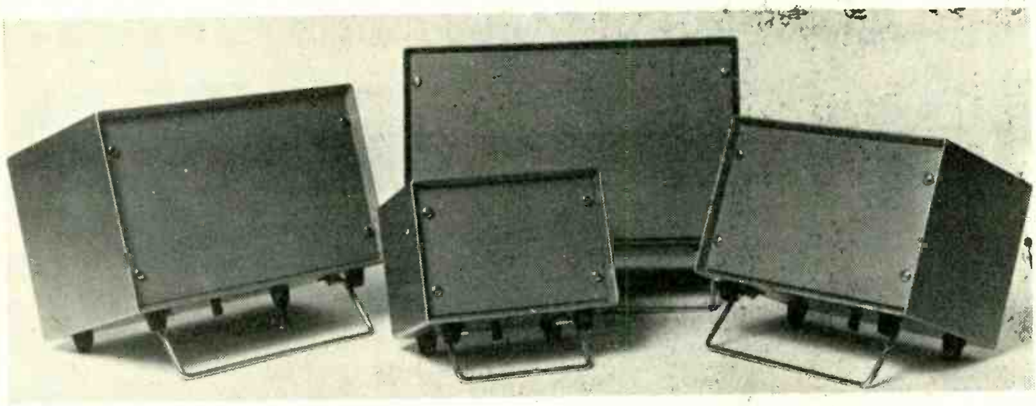

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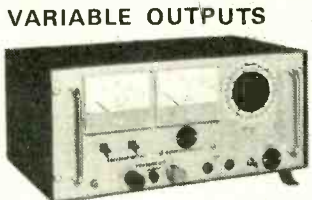

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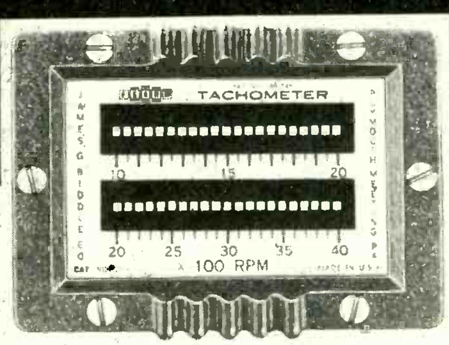

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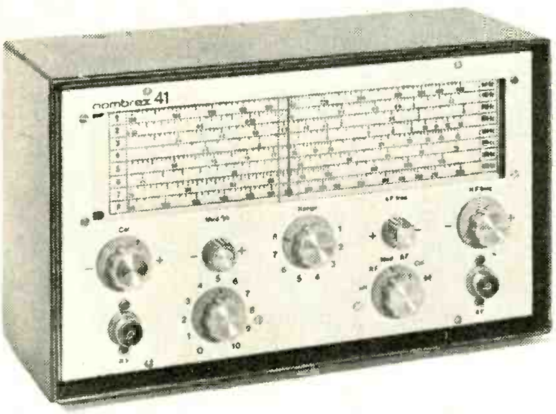

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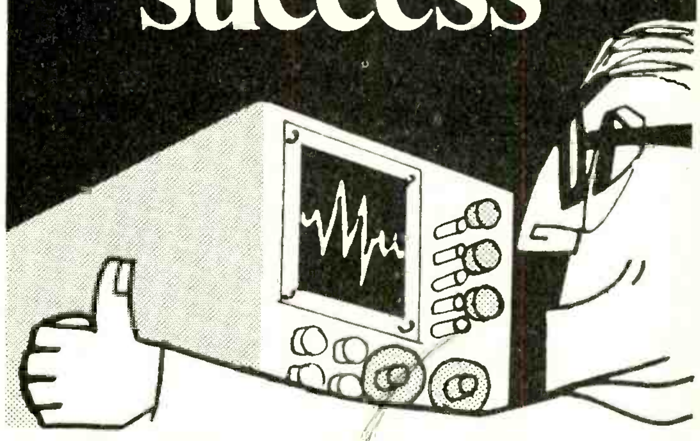

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And *you* might find it a pleasure to do business with *us*, especially as we can solve so many of your supply problems.

For instance, suppose you *did* want just a few of these or any other Cinch, Dot or FT components very quickly, we could, as stock holders, have them on the way to you the day we got your order.

Perhaps you'd like to put this promise to the test.

UNITED-CARR SUPPLIES

The single source that simplifies.

We have a remarkably comprehensive catalogue and if you can make good use of it, we shall be glad to send you one, but please state possible requirements.

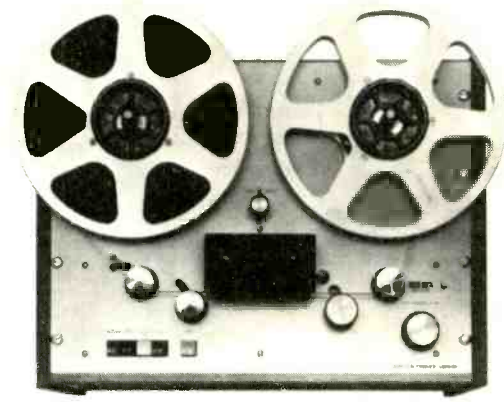
Cinch DOT FT **STOCKISTS**

United-Carr Supplies Ltd.
Clifton Works, Frederick Road,
Stapleford, Nottingham.
Sandiacre 2828 STD 0602 39 2828. Telex No. 377117. HFA1

UNITED-CARR SUPPLIES

WW—027 FOR FURTHER DETAILS

BIAS ELECTRONICS



BE1000 PROFESSIONAL RECORDER

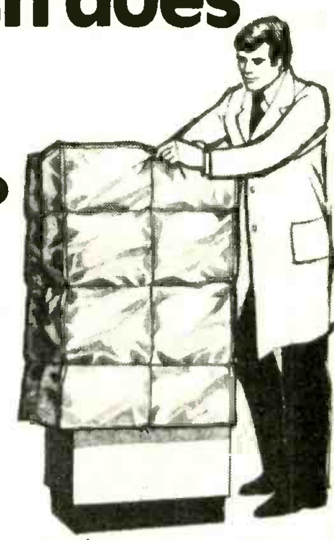
The BE1000 is a lot of tape recorder and yet does not cost a lot of money. Designed and manufactured in London it combines rugged robust construction with ease of operation and outstanding performance.
Compare its specification and facilities with machines costing hundreds of pounds more. We have a sales and service network throughout Europe.
Just ask for a demonstration and judge for yourself.

Phone or write to

BIAS ELECTRONICS LTD. 01-947 3121
UNIT 8 COOMBE TRADING ESTATE
112-120 COOMBE LANE, LONDON SW20 0BA.

WW—028 FOR FURTHER DETAILS

How much does Transit Damage cost you?



In damaged goods. In doubled delivery charges. It need not cost you a penny. Because it needn't happen. PROTECTOMUFFS are tough, padded, weatherproof, dustproof. They are tailored to fit your product. Slipped on in seconds by unskilled staff, they provide all the packing required. And because they are re-useable again and again and again, packing costs become a non-recurring item. Be like Hoover, Ferranti, Rediffusion — use Protectomuffs and show your customers you care.

PROTECTOMUFFS TRADE MARK

To JOHN EDGINGTON & CO. LTD.
47 Old Woolwich Road, Greenwich, London SE10 9PU (01-858 7014-6)

Send me details of Protectomuffs

Name ....

Address ....

....

.... W.W.

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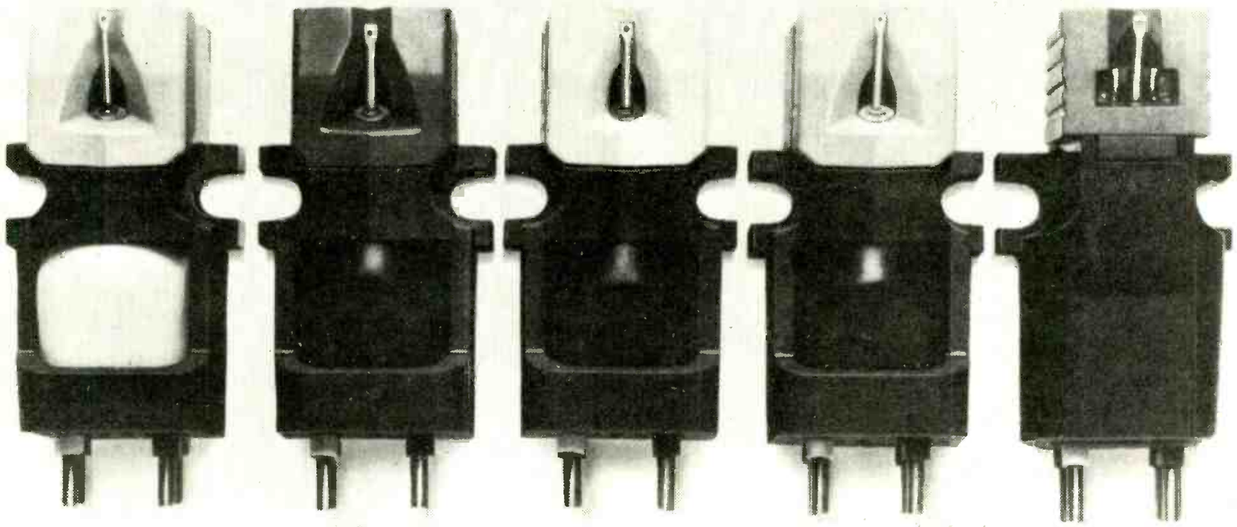
We're sensitive to everyone's needs.



Different people have very different requirements in Hi-Fi, so Goldring developed a comprehensive range of stereo magnetic cartridges that are superb in performance and realistic in price.

From the G800 Super E for those who seek perfection down to the G850 for systems on a budget, the Goldring range offers unsurpassed quality and value.

Your request will bring full details of these and other Goldring products.
Goldring Limited,
10 Bayford Street, Hackney, London E8 3SE.
Tel: 01-985 1152.

Goldring Series 800

Stereo Magnetic Cartridges.

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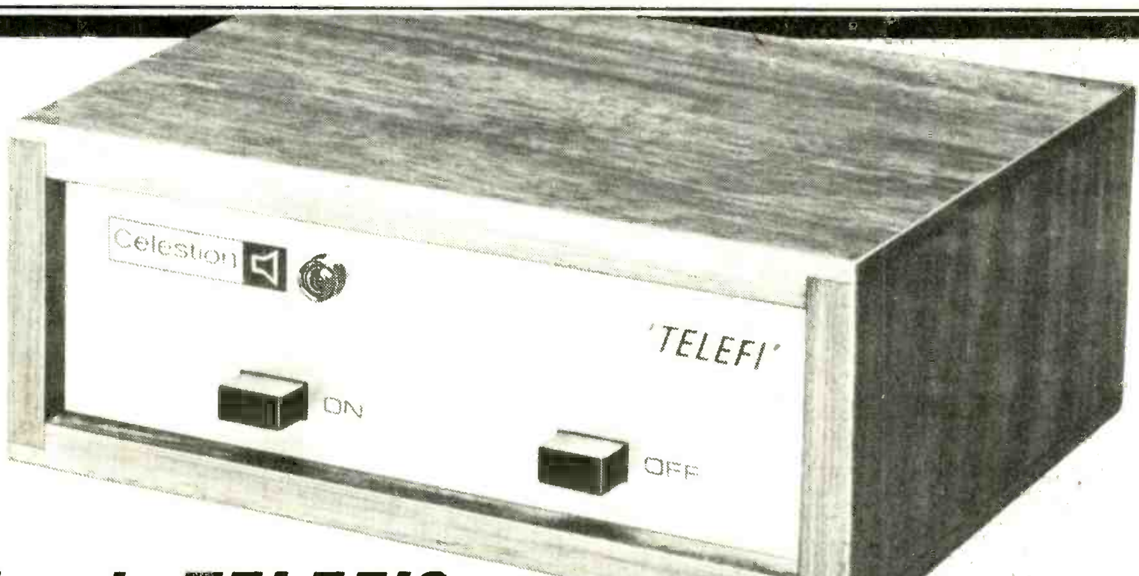

What is TELEFI?

Telefi brings you for the first time real Hi-Fi results from your existing 625 line television.

T.V. Studios transmit superb quality but skimping in the sound section of the receiver means low-fi sound.

Celestion Telefi changes all this – simply coupled to most T.V. receivers – the first T.V. music you hear through Telefi will convince you the dramatic improvement is what you have been waiting for.

Telefi a remarkable innovation exclusive to Celestion for use in conjunction with Hi-Fi and Audio systems for providing high quality television sound reproduction. No direct connection to the T.V. is required, the coupling being effected by an inductive pick-up.

Telefi is complete in a handsome natural teak veneered case $7\frac{1}{4}$" x $5\frac{1}{8}$" x $2\frac{7}{8}$" approx.

"The Telefi is a very worth while device and will give greater overall enjoyment than the T.V. manufacturers normally provide." *John Gilbert 'The Gramophone'.*

Celestion

Also send for details of the complete range of Celestion Loudspeakers

ROLA CELESTION LTD.

DITTON WORKS, FOXHALL ROAD, IPSWICH, SUFFOLK IP3 8JP

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Soft magnetic alloys

Mumetal alloys

This is the best known and widest used Telcon group of high permeability alloys. They possess low hysteresis and total losses and are available in strip, rod, bar, wire and core form. Applications include: many types of transformers, bridge ratio arms, inductors, h.f. chokes, blocking oscillators, filter circuits, magnetic amplifiers, saturable reactors, modulators, flux gate magnometers, storage circuits, shift registers, transformers, logic switching circuits and magnetic shielding.

Radiometal alloys

These high permeability alloys, with their high saturation induction and low electrical losses, are used for transformers and chokes where operating flux density is higher than is possible with Mumetal and where a higher permeability than silicon iron is required. The six grades have applications including: relay circuits, pulse and radar transformers, transductor and convertor cores, magnetic amplifiers and saturable reactors.

Permendur alloys

Permendur has the highest saturation ferric induction of all known alloys commercially available. It also has high incremental permeability at high inductions. It is used for stator laminations, telephone diaphragms, magnetic circuits of loudspeakers and equipment operating at high temperatures. Its excellent magnetostrictive properties are used in echo sounders and ultrasonic devices. Special grades, known at 'Rotelloys', which have superior mechanical properties have also been developed for high speed rotating equipment such as aircraft generators.

TELCON

Telcon Metals Ltd
Manor Royal, Crawley, Sussex
Crawley: 28800

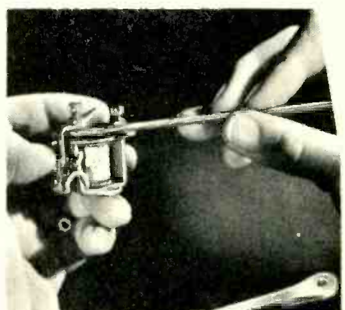
WW—032 FOR FURTHER DETAILS

WW—033 FOR FURTHER DETAILS

Keep those Contacts CLEAN

BY USING A

DIACROM SPATULA



Manufactured in France
British Patents applied for

No other cleaner has all these advantages:—

1. Only 100% pure, natural diamond grains are utilised.
2. Blades are treated with hard chrome to reinforce the setting of the diamond grains, to obviate loosening or breakaway during use. This process also prevents clogging of the diamonded surface by residues resulting from use.
3. All diamonded blades are rectified to ensure an absolutely smooth surface by eliminating diamond grains which may rise above the surface. This eliminates all excessive scratching during use.
4. All diamond grains are rigidly calibrated to ensure a perfectly uniform grain size of either 200, 300 or 400.
5. The chrome gives a very weak co-efficient of friction and the rigidity of the nylon handle is calculated to permit proper utilisation and yet pliant enough to avoid undue pressures on highly delicate relays.

- Grain size 200, thickness 55/100 mm., both faces diamonded. For quick cleaning of industrial relays and switching equipment, etc.
- Grain size 300, thickness 55/100mm., both faces diamonded. For smaller equipments, like telephone relays, computer relays, etc.
- Grain size 400, thickness 25/100 mm., one face diamonded. For sensitive relays and tiny contacts. Two close contacts facing each other can be individually cleaned, because only one face of the spatula is abrasive.

Sole Distributors for the United Kingdom
SPECIAL PRODUCTS (DISTRIBUTORS) LTD
81 Piccadilly, London W1V 0HL. Phone: 01-629 9556
As supplied to the M.O.D., U.K.A.E.A., C.E.G.B. British Rail and other Public Authorities; also major industrial and electronic users throughout the United Kingdom.

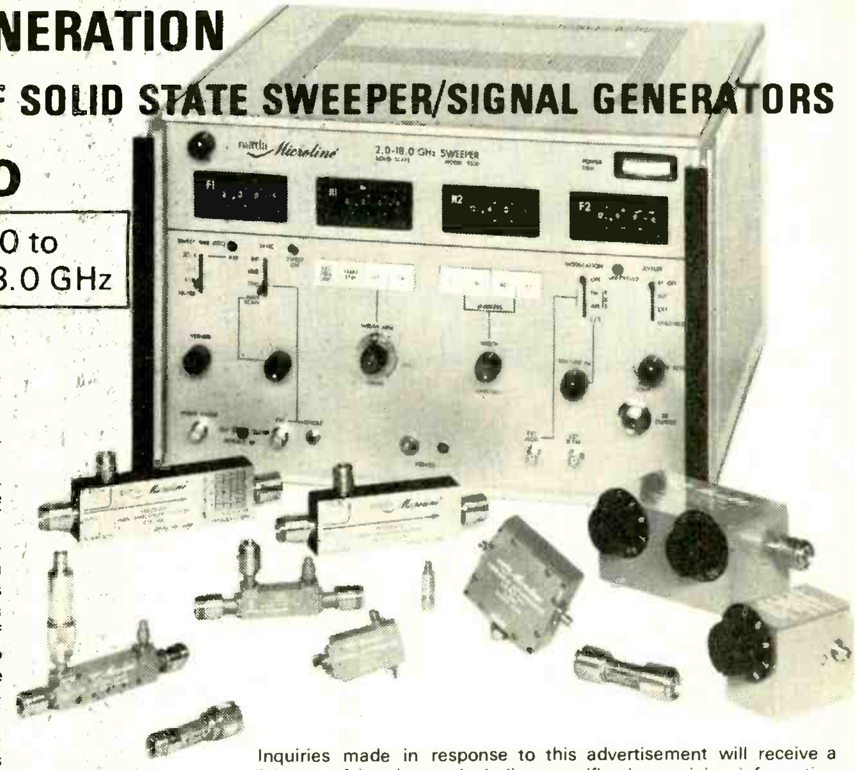
WW—034 FOR FURTHER DETAILS

our BROADBAND GENERATION

OF SOLID STATE SWEEPER/SIGNAL GENERATORS

are designed to make a Clean Sweep

1.0 to 18.0 GHz



The "Broadband Generation" product line has been designed to meet the needs raised by the advent of increasing sophistication of systems and satellite communications. All equipment in the "Broadband" product line is designed for applications from 1 to 18 GHz.
The concept of this approach is the elimination of artificial octave limitations which have restricted development of advanced "state-of-the-art" microwave systems.
These octave-band limitations and their associated problems have been eliminated by the development of the Narda 9500 series of Broadband Sweepers, which provides full sweep coverage of L, S, C, X and Ku frequency bands in a single range, self-contained instrument. This series of instruments now make it possible to use a single setup to test at all points of interest, and to sweep test over the total 1 to 12.4 GHz or 2 to 18 GHz range, or over any combinations of selected portions of these ranges.
Thus the 9500 series is ideally suited for military and commercial communications, telemetry and other applications where the assigned frequency range overlaps two different standard octaves or where the single range of interest straddles two octave bands or for ECM systems, where the operating range is subject to change.

Inquiries made in response to this advertisement will receive a full set of brochures, including specifications, giving information on the full 9500 series of NARDA MICROWAVE BROADBAND SWEEP/SIGNAL GENERATORS.

narda *Microline*

AVELEY ELECTRIC LTD.

Roebuck Road
Chessington, Surrey
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Telex: Avel London 928479

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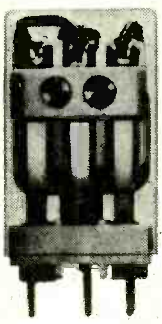
ELESTA

MINIATURE PLUG-IN RELAYS FOR INDUSTRIAL APPLICATION



High performance 3-pole & 4-pole C/O relays.

SEV tested, VDE & DEMKO Approved.

Coil Voltage: 3V to 240V AC & DC.

Contact Rating: 4A 250V AC resistive.

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MODEL U-50DX

SANWA MULTI TESTERS

USED THROUGHOUT THE WORLD. SANWA'S EXPERIENCE OF 30 YEARS ENSURES ACCURACY, RELIABILITY, VERSATILITY, UNSURPASSED TESTER PERFORMANCE COMES WITH EVERY SANWA
6 Months' Guarantee Excellent Repair Service

Model P-2-B	£6.35	Model AT-45	£20.50
Model JP-5D	£7.62	Model 380-CE	£20.81
Model 360-YTR	£10.77	Model N-101	£24.20
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THESE PRICES ARE SUBJECT TO AN ADDITIONAL CHARGE OF 10% FOR V.A.T.
Cases extra, available for most meters, but not sold separately.
Please write for illustrated leaflet of these and other specialised Sanwa meters

SOLE IMPORTERS IN U.K.

QUALITY ELECTRONICS LTD.

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Tel: 01-546 4585

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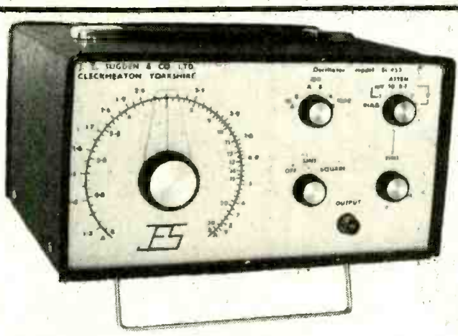

JES AUDIO INSTRUMENTATION

Illustrated the Si453 Audio Oscillator

SPECIAL FEATURES:

★ very low distortion content—less than .05%
★ an output conforming to RIAA recording characteristic
★ battery operation for no ripple or hum loop
★ square wave output of fast rise time

£40.00

also available

Si451 Millivoltmeter
★ 20 ranges also with variable control permitting easy reading of **relative** frequency response
£35.00

Si452 Distortion Measuring Unit
★ low cost distortion measurement down to .01% with comprehensive facilities including L.F. cut switch, etc.
£30.00

ALL PRICES PLUS V.A.T.

J. E. SUGDEN & CO. LTD., CARR STREET, CLECKHEATON, YORKS. BD19 5LA. Tel: 09762-2501

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Another reason why Enthoven is No.1 in solder

Superspeed solder wire

Enthoven's Superspeed soldering wire features an activated-rosin flux core and is ideal for those applications where a wide variety of different jobs must be handled with a single solder.

But don't forget the rest of the Enthoven range. It gives you a wide choice of high-quality products developed for use with modern techniques. It includes Flux Cored Solder Wires, Solder Pre-forms, Solid Solders, Selective Fluxes, solder specialities, materials for printed circuitry and for soldering aluminium.

And behind every Enthoven product stands a comprehensive advisory service that can solve your knottiest soldering problems.

Enthoven Solders Limited
Dominion Buildings, South Place
London EC2M 2RE.
Tel: 01-628 8030 Telex: 885737
Cables: ENTHOVENLONDONEC2M2RE

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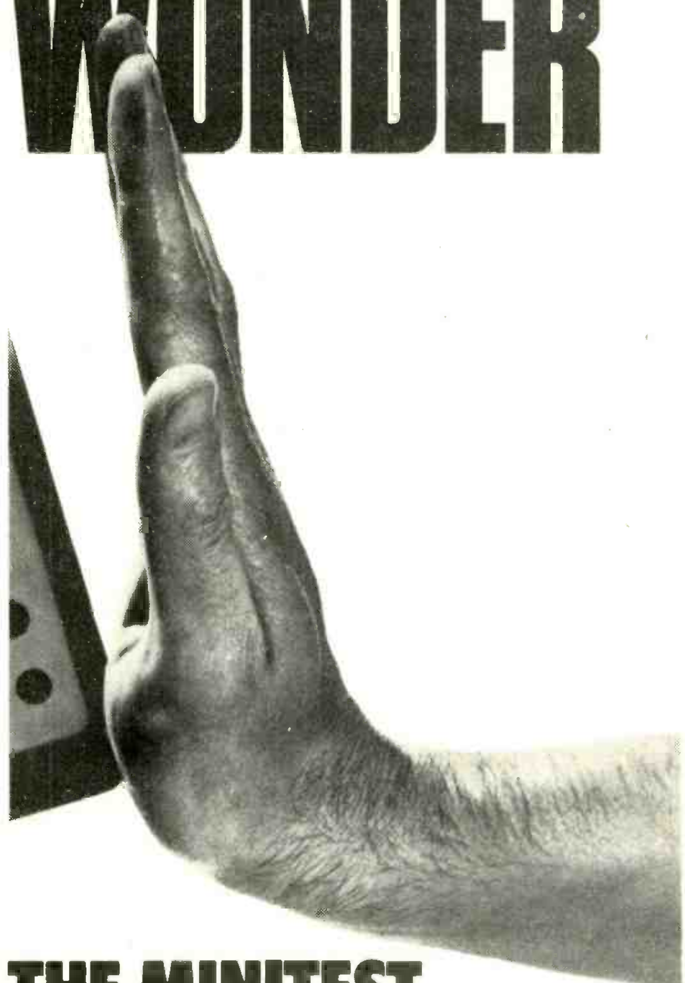
LITTLE WONDER



THE MINITEST IS PREFERRED

The SEI MINITEST has made a remarkable impact in the pocket-sized multi-range meter market, by making itself a firm favourite with discerning people in the industry. Let's look into the reasons why.

First, the appearance. Diminutive, neat, wipe-clean cycolac case with shock and magnetic field proof steel liner. Controls are simple and easy to use.

Second, the range. The Minitest measures a.c. and d.c. voltages d.c. current and resistance over 20 ranges to a sensitivity of 20,000 and 2,000 ohms per volt d.c. and a.c. respectively.

Third, high voltage probes. These extend the range to 25 or 30kV d.c.

Little wonder the Minitest is preferred!

SALFORD ELECTRICAL INSTRUMENTS LTD
Peel Works, Barton Lane, Eccles, Manchester M30 0HL.
Telephone: 061-789 5081. Telex: 667711.
A member company of GEC Electrical Components Ltd.

SEI S&C

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i.c. breadboards low cost, high performance units

All our i.c. breadboarding units are now even better value for money.

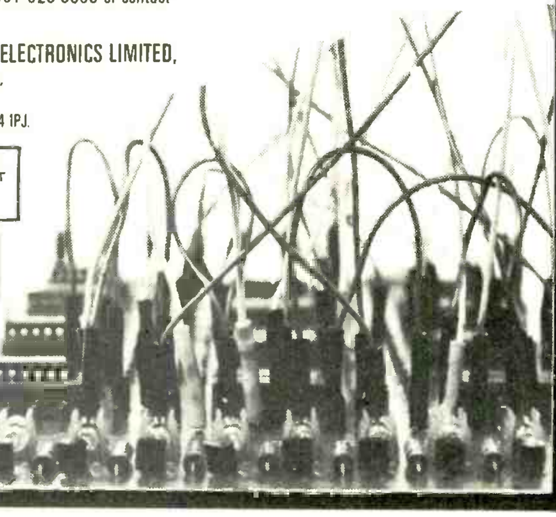
Our second-generation CK2 0020 I.C. Patchboard unit, still selling for only £50, has been completely redesigned and now has many additional features. Light-emitting diodes are used as logic indicators and a manual pulse generator and busbars have been added to ease your patching a little.

A cheaper "extension" unit, selling at only £36, will accommodate a further eighteen integrated circuits or can be used on its own for linear work.

For further information on these and other breadboarding units from Limrose, please telephone 061-928 8063 or contact

LIMROSE ELECTRONICS LIMITED,
8-10 Kingsway,
Altrincham,
Cheshire, WA14 1PJ.

PRICES SUBJECT TO V.A.T.



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Hatfield's solution to Impedance matching problems.

Our extensive range of small, robust antenna units for matching screened coaxial feeder cables to open wire receiving aerial feeders over a wide frequency range.

Fully tropical — pressurised and watertight — non corrosive construction.

Send for full details.

HATFIELD
forward thinking in electronics

HATFIELD INSTRUMENTS LIMITED
Burrington Way, Plymouth PL5 3LZ, Devon.
Tel. Plymouth (0752) 72773/4 Grams: Sigjen, Plymouth. Telex: 45592
South-East Asia: *for prompt service and deliveries, contact*:
Hatfield Instruments (NZ) Ltd., P.O. Box 561, Napier, New Zealand

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MODEL: TTR-21

Easy-handling, superb performance!!

PORTABLE VHF TRANSCEIVER

(150MHz, 1W)

FEATURES

- Three operating frequencies in any 2MHz segment of the 142—172MHz range may be selected.
- A monolithic HCM filter produced by our own crystal division is used in the IF amplifier. Performance and selectivity in this single superheterodyne set are excellent.
- A light emitting diode is used to indicate the transmit output level and condition of the battery. This approach improves reliability and allows checks under poor lighting conditions.
- Use of a posistor eliminates the troublesome fuse and alleviates maintenance requirements.

TOYOCOM
TOYO COMMUNICATION EQUIPMENT CO., LTD.

EXPORT DEPARTMENT
TOYO BUILDING NO 6 12 20 JINGUUMAE
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TEL (03) 406 3355
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Infrared FILTERS

OCLI manufacture an extensive range of Infrared Filters covering the entire 1.0 to 30 micron spectral region.

Filters in these regions present an excellent solution to filtering out high-temperature radiation without appreciably limiting the signal from the source being observed. Moreover, they have proven capability over wide operating temperatures.

OCLI I. R. Filters are made to exact Customer specifications or a range can be supplied from stock.

Typical fields benefitting from OCLI I.R. Filters include:

- GAS ANALYSERS/DETECTION SYSTEMS
- ACTIVE/PASSIVE INTRUDER ALARM
- INFRARED PASSIVE THERMAL IMAGING SYSTEMS
- FIRE DETECTION
- NON-CONTACT TEMPERATURE MEASURING
- POLLUTION DETECTION
- OPTICAL PROXIMITY FUSES
- INFRARED SPECTROSCOPY
- INFRARED PHOTOGRAPHY
- SPACE RECONNAISSANCE

Write for the new OCLI catalogue and price list of stock I.R. Filters.

OCLI OPTICAL COATINGS LTD.
Hillend Industrial Estate,
Dunfermline, Fife KY11 5JE.
Tel. Inverkeithing 3631
(STD 038-34 3631).

OC-19B

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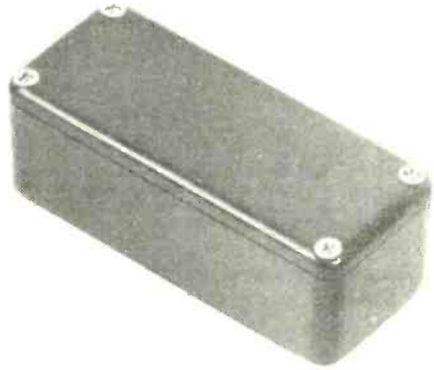
Eddystone

DIECAST BOXES



WORLD-WIDE AVAILABILITY

Diecast in aluminium alloy, BS 1490 LM2

SIX SIZES

Cat. No. 7969P— (Illustrated)	$3\frac{5}{8} \times 1\frac{1}{2} \times 1^{7}/_{32}$ in 92.1 x 38.1 x 31mm
Cat. No. 7134P—	$4\frac{3}{8} \times 2\frac{3}{8} \times 1^{7}/_{32}$ in 111.1 x 60.3 x 31mm
Cat. No. 6908P—	$4^{11}/_{16} \times 3^{11}/_{16} \times 2^{7}/_{32}$ in 119.1 x 93.6 x 56.4mm
Cat. No. 6827P—	$7^{25}/_{64} \times 4^{45}/_{64} \times 2^{7}/_{32}$ in 187.3 x 119.1 x 56.4mm
Cat. No. 6357P—	$7^{25}/_{64} \times 4^{45}/_{64} \times 3^{7}/_{32}$ in 187.3 x 119.1 x 81.8mm
Cat. No. 7970P—	$7\frac{3}{8} \times 7\frac{3}{8} \times 2^{21}/_{32}$ in 187.3 x 187.3 x 67.5mm

(Nominal outside dimensions)

Rugged. Corrosion resistant.

Self adhesive plastic strip available for mounting PCB's internally.

Easily Machined. Good Surface Finish.

Illustrated brochure and information on your local Distributor from:

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Telephone: 021-475 2231. Telex: 337081

A Member of Marconi Communication Systems Limited

LTD/ED 93

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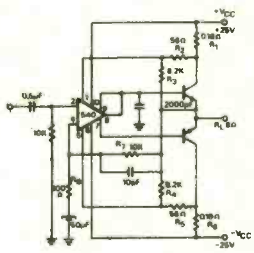
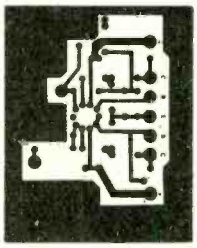
TERMS Retail mail order subject to £1·00 minimum order. Cash with order only. Trade and educational establishments M/AC on application (minimum £5·00).
Postage 10p inland, 25p, Europe.
GUARANTEE: All goods carry full manufacturer's warranty. Get in touch today for a complete run-down of devices available from SCS (include SAE).

SCS COMPONENTS, P.O. Box 26,
Wembley, Middlesex HA0 1YY
The 'Professional' Amateur Supplier

Device of the Month NE540L



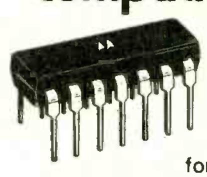
35Watt Amplifier
The Signetics 540 is a monolithic, class AB power audio amplifier designed specifically to drive a pair of complementary output transistors.



This device features: internal current limiting; low standby current; high output current capability; wide power bandwidth; low distortion – features which make this device ideal for use as an audio power amplifier.

Signetics power driver NE540L
Yours for just £1·20 + VAT
including application notes.

Compatible device MC1339P



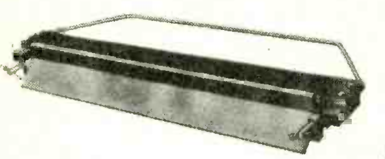
From Motorola, a monolithic dual stereo preamplifier for low noise preamplification of stereo audio signals. Just look at some of these features:

* Low audio noise
* High channel separation
* Single power supply
* High input impedance
* Built-in power supply filter
* Emitter follower output

Motorola monolithic duel stereo preamplifier only £1·20 + VAT
including applications notes.

WW—055 FOR FURTHER DETAILS

PARKER SHEET METAL FOLDING MACHINES



Forms channels and angles down to 45 degrees which can be flattened to give safe edge. Depth of fold according to height of bench.

BENCH MODEL
36" x 18 gauge capacity £35.00
24" x 16 gauge capacity £32.00
Carriage 75p

Also the well-known vice models of
36" x 18 gauge capacity ...... £17.00 Carr. 50p
24" x 18 gauge capacity ...... £12.00 Carr. 38p
18" x 16 gauge capacity ...... £12.00 Carr. 38p

One year's guarantee.
Money back if not satisfied.

Send for details:
A. B. PARKER
FOLDING MACHINE WORKS,
UPPER GEORGE STREET,
HECKMONDWIKE, YORKS.
Telephone 3997

WW—056 FOR FURTHER DETAILS

STEREO IC DECODER

HIGH PERFORMANCE PHASE LOCKED LOOP
(as in 'W.W.' July '72)

MOTOROLA MC1310P EX STOCK DELIVERY

SPECIFICATION
Separation: 40dB 50Hz-15kHz. Distortion: 0·3%
I/P level: 560mV rms O/P level: 485mV rms per channel.
Input impedance: 50kΩ. Power requirements: 8-12V at 16mA.
Will drive up to 75mA stereo 'on' lamp or LED.

KIT COMPRISES FIBREGLASS PCB (Printed and tinned), Resistors, I.C., Capacitors, Preset Potm. & Instructions. ONLY £3·50 WHY PAY MORE? post free.

LIGHT EMITTING DIODE (Red) Suitable as stereo 'on' indicator. For above with panel mounting clip and instructions ONLY 35p plus p.p.

MC1310P only £2·77 plus p.p. 6p

SPECIAL OFFER
IN4002 100V 1A RECT DIODES. Full Specification Devices. ONLY 6p each.
709' DIL 14 PIN OP AMPS. Full Specification Devices ONLY 34p each.

V.A.T.
From April 1st add V.A.T. at the standard rate to all prices

FI-COMP ELECTRONICS
BURTON ROAD, EGGINTON, DERBY, DE6 6GY

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BICC CABLEFINDER

Helsby 3171.
Brings you instant service.

A436

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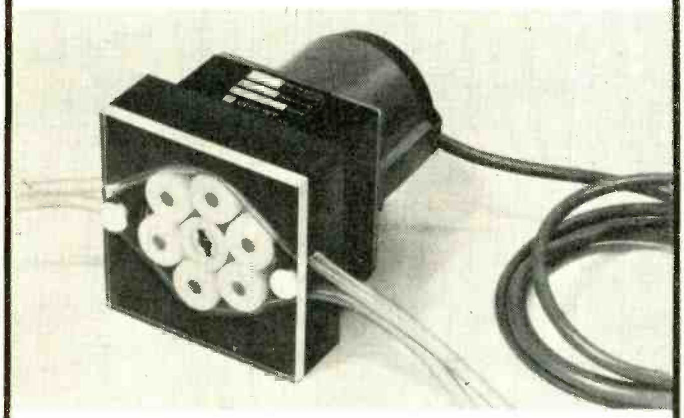
ELECTRONIC CONTROLLED PERISTALTIC PUMPS



The equipment illustrated is available as a basic pump and a low cost precision-controlled unit offering an extremely wide range of delivery rates.

The basic pump unit is available for customers wishing to incorporate it into their own systems. It can be supplied driven by stepper motor, synchronous motor or low inertia d.c. motor.

DIGITIZED SYRINGES

We are pioneering in the field of highly accurate digitized fluid delivery using electronically controlled disposable syringes, Systems are available suitable for medical, veterinary, chemical and general laboratory applications.

Facilities include: Local and remote starting. Synchronised starting of slave units. Total fluid delivered on numerical indicator during operation.

High degree of reliability.

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CONTROL SYSTEMS & COMPONENTS,
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Telephone: Crowthorne 5757/8

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You edit the tape. We edit the prices.

VIDEO TAPE AT DIXONS TECHNICAL

	RECOMMENDED PRICE	DIXONS PRICE
SCOTCH $\frac{1}{2}$" 2400 ft.	£10.80	£8.50
SCOTCH $\frac{1}{2}$" 3000 ft.	£16.82	£13.50
BASF $\frac{1}{2}$" 2400 ft.	£10.75	£8.50
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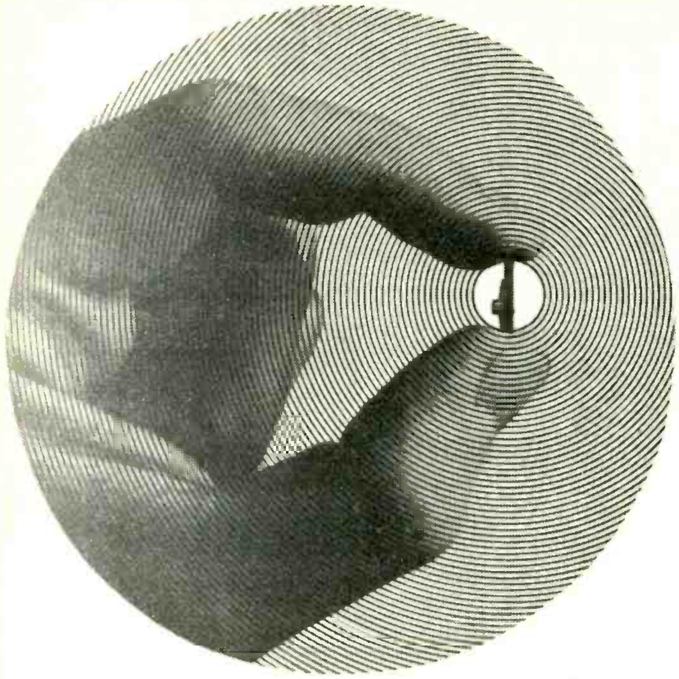

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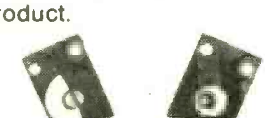

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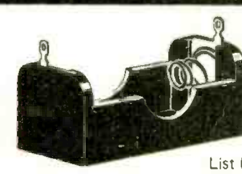

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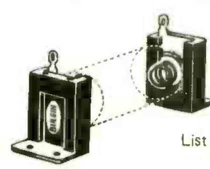

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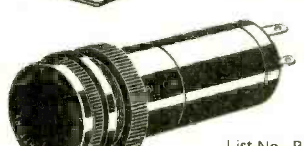

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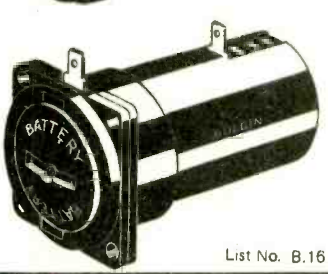

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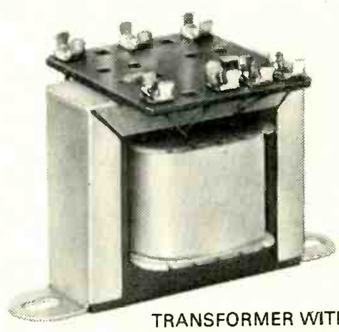

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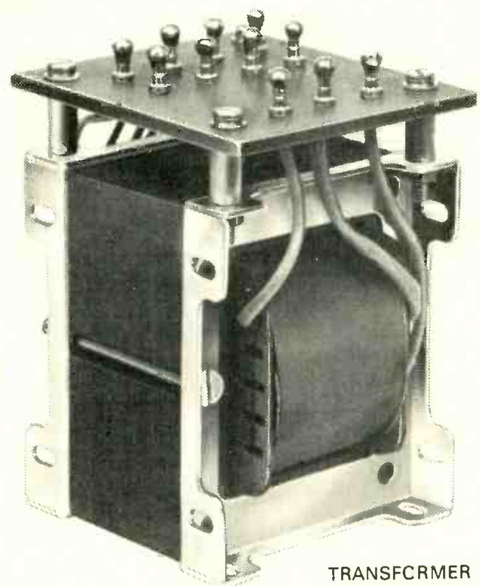

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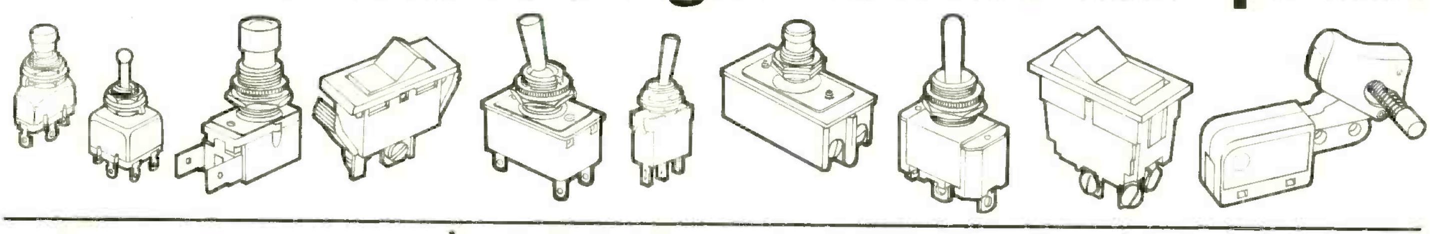

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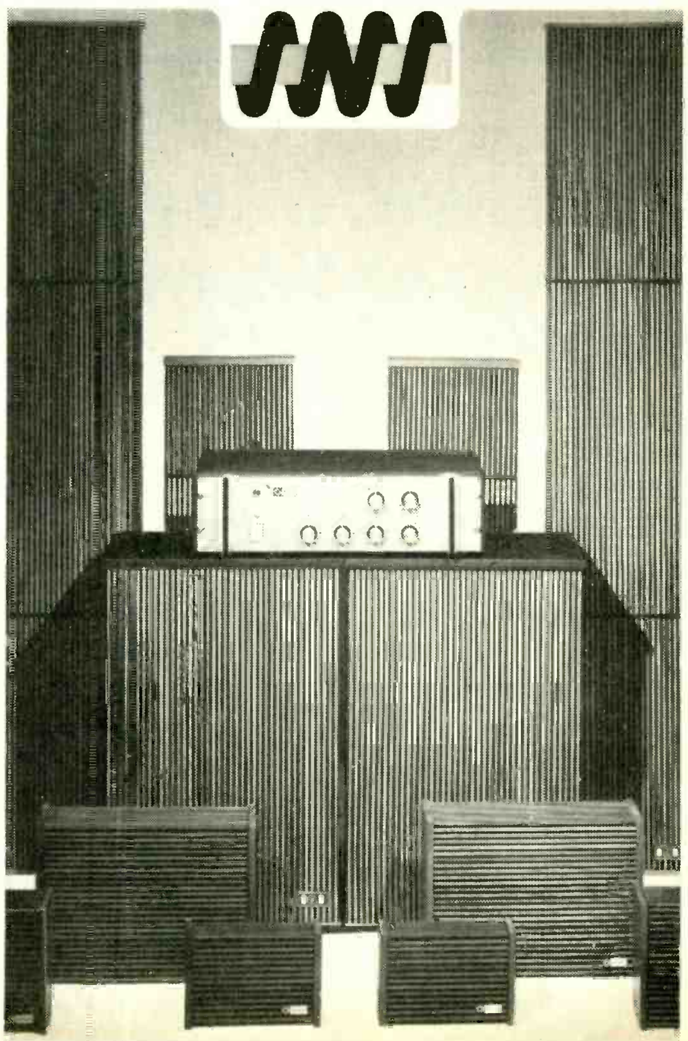

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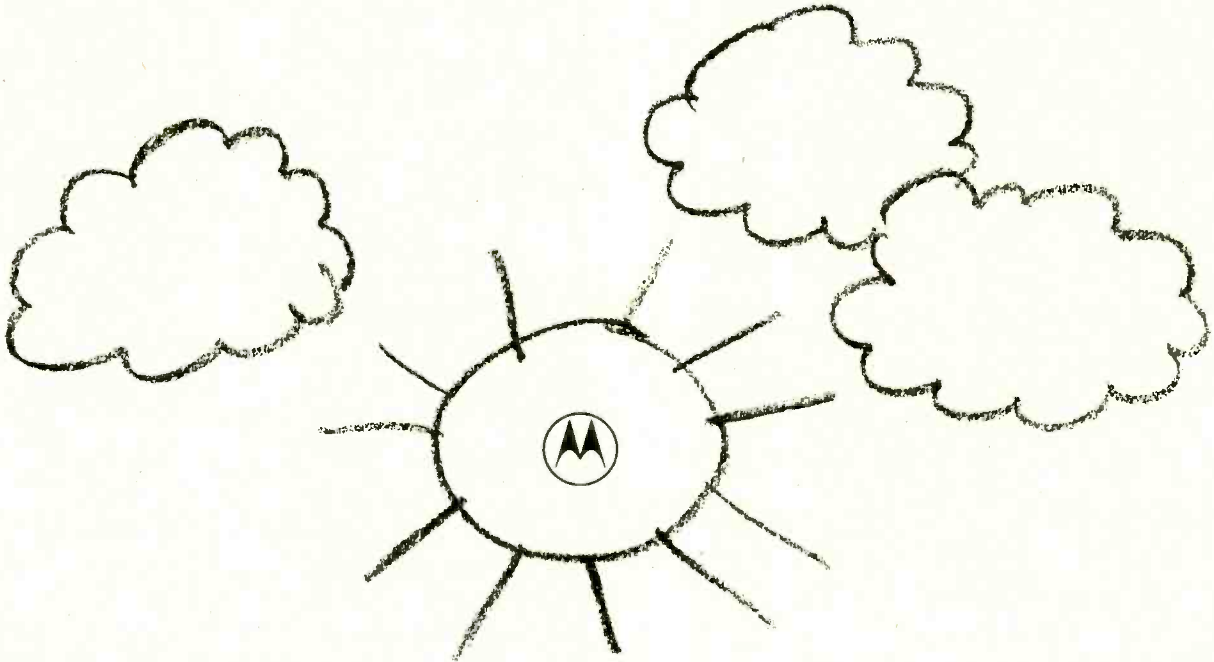

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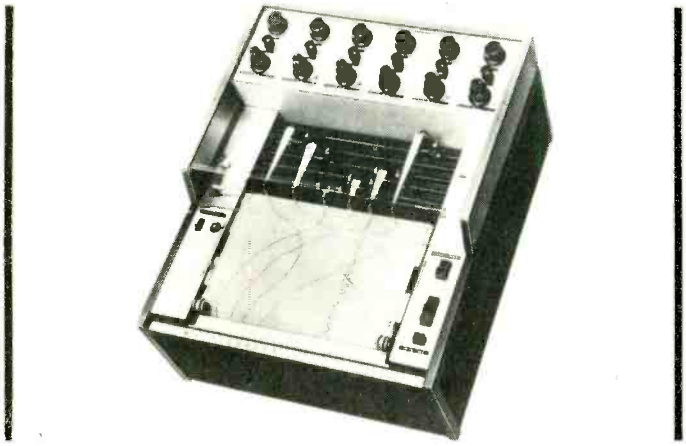

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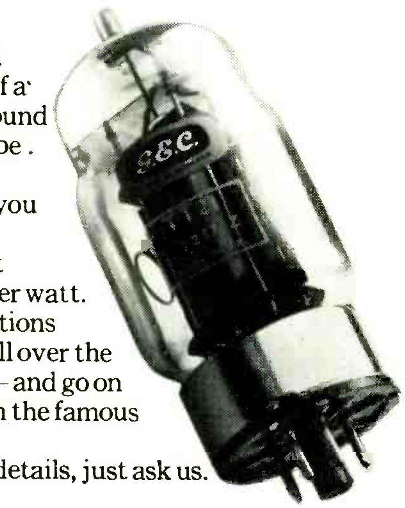

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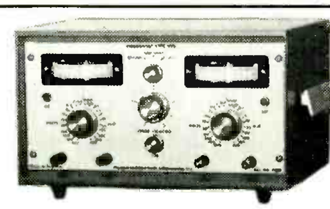

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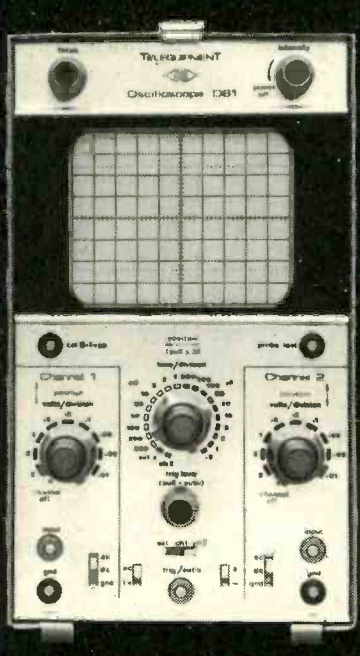

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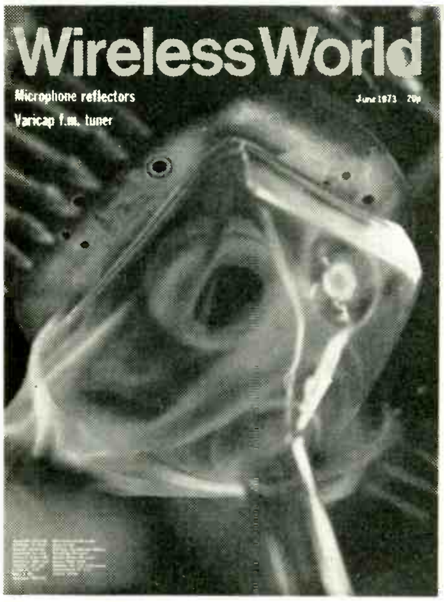
Wireless World

Electronics, Television, Radio, Audio

Sixty-third year of publication **June 1973** **Volume 79 Number 1452**



This month's cover shows the fusing together in gas flames of the parts of a cathode-ray tube envelope at Thorn-A.E.I. Radio Valves & Tubes Ltd. *(Photographer Paul Brierley)*

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Wireless World

Should integrated circuits be taught?

Pity the poor teacher! Ever since electronic engineering became a recognizable subject for instruction its teachers have had the task of not only handing on the existing knowledge acquired by man over, say, a century but imparting new knowledge which is accumulating at a staggering rate with every day that passes. At the end of his three-year course a university student finds in the outside world a technology which is markedly different from what it was at the beginning. Integrated circuits are just one of the sub-technologies — like valves, transistors and computers in their day — which have hit the course planners very hard. One cannot treat them solely as functional blocks but must explain their anatomy — the active and passive devices and the circuit techniques of which they are composed. Unquestionably the student must learn about integrated circuits, but should he be taught? Should he be taught about them *as* integrated circuits, or should the aim of the educationalists be to ensure that his fundamental knowledge of physics, chemistry, maths, circuit elements and network theory is so secure that he can cope with i.cs — and any other sub-technology which may come along (e.g. opto-electronics) — as a matter of course?

What raises this question is a combination of two facts: (a) there is a serious shortage of circuit designers in the electronics industry, and (b) electronic engineering courses in universities and polytechnics are no longer predominantly based on circuit techniques and device fundamentals but are including more and more material on systems — communication, control, computing and so on. Of course, the universities in particular can rightly claim that it is not their function to provide vocational training for circuit designers but to educate — to develop the intellectual powers of the student rather than specific mental and/or manual skills. Even so, the requirements for electronic engineering education do often coincide with the requirements for vocational training, and in fact many students want it this way because they see a degree as a meal ticket. But the main point in question is whether the shortage of circuit designers is in any way the result of the changes taking place in electronic engineering courses. To be a good circuit designer one needs the mental flexibility which can only be obtained from a fundamental knowledge of elemental devices and circuits and their possibilities in various configurations. To acquire this knowledge takes time and there is only a limited time available in a course.

It was evident from a recent conference at Hull University on teaching electronic engineering in degree courses that some educationalists, at least, consider this time well lost for the sake of integrated circuits. In one first degree course, for example, integrated circuits have largely replaced their discrete circuit predecessors and about two-thirds of the final year is spent on digital i.cs. In another, students are given the opportunity to design and evaluate their own i.cs and obtain some experience of fabrication.

Admirable as these efforts are to tackle this sub-technology, there is perhaps a danger of throwing out the baby with the bath-water. Concentration on circuits and discrete circuit elements may be thought old-fashioned in a world of systems and building blocks, but may it not in fact serve better the long-term interests of both electronic engineering and education?

Microphone Reflectors

Effects of reflector material, size, focal length and microphone size and position on amplitude and polar response

by G. N. Patchett, Ph.D., B.Sc., F.I.E.E., F.I.E.R.E., M.I.E.E.E.*

A parabolic microphone reflector is often dismissed as a device which reflects the sound waves on to the microphone and hence increases its sensitivity and makes it highly directional. Unfortunately, this is a very simplified picture of a very complex problem bringing in the effects of reflection, diffraction and interference. The normal arrangement of a parabolic reflector and microphone is shown in Fig. 1, the microphone being situated at the focal point of the reflector and facing into it. The parabola has the property that the distance AB + BC is a constant whatever the angle BC makes to the axis. Thus all sound waves travelling as a plane wave will arrive after reflection at the microphone at the same instant, i.e. in phase.

The difficulties of the reflector arise because of the large range of frequencies over which the reflector should operate e.g. 100 to 20,000Hz, a range of 200:1, and because the size of the reflector is comparable in size to the wavelength at some frequencies. Parabolic reflectors are, of course, commonly used for light and microwaves but these problems do not arise. Considering visible light, the wavelength is from, say, 400 to 700nm, a corresponding frequency range of less than 2 to 1. The wavelength of the light is, of course, extremely small compared with any normal reflector. Similarly, when dealing with parabolic aerials the range of frequencies is small and the wavelength of the radiation is small compared with the dimensions of the aerial.

There are many possible variations when dealing with the performance of reflectors, some being size of reflector, focal length, material, size of microphone and type of microphone, e.g. omnidirectional or unidirectional. Many statements have been made about the effect of some of these but I felt that scientific measurement of the effects of some of the variables would be valuable.

Unfortunately, acoustic measurements are difficult to make because there is no perfect sound source and one is troubled by reflections. Most of the tests have been done in an anechoic chamber but such chambers have their limitations, and the one used was small for this purpose. Some measurements were made in the open but then difficulties arise due to wind, noise and reflections. Some errors occurred due to difficulties of aligning the reflector accurately on to the sound source.

Before reading details of the tests and results, consider what is an ideal reflector. It should have a uniform frequency response over the range concerned, a narrow polar diagram that does not change with frequency, a good forward to backward ratio and also be as small and light as possible. These factors are largely covered by considering the frequency response and polar diagram of various reflector-microphone combinations.

Frequency response

The overall frequency response does, of course, depend on the microphone, and to eliminate the frequency response of the microphone, the results given are those obtained by subtracting the response of the open microphone from the response of the same microphone in a reflector. Thus the response curves show the *change* in frequency response of the microphone when used with a reflector. There are a number of difficulties in making these measurements and most were made in an anechoic chamber. Unfortunately, there is no perfect sound source giving a uniform response over the whole audio range.

The normal method of overcoming this difficulty, when determining the frequency response of microphones, is to use a standard microphone to control the output of the loudspeaker, so that the sound level at the standard microphone is constant. By placing the standard microphone near to the microphone on test, it can be assumed that the sound level on the test microphone is also constant. This technique cannot be used with a microphone in a reflector because the standard microphone cannot be placed near to the test microphone, as it would be upset by the reflector.

Accordingly, a standard microphone was used, with feedback to maintain a constant level at the standard microphone, but this was placed well away from the reflector. The sound level at the test microphone could not be assumed constant, but provided changes were not made in the positions of the microphones, the sound radiated in the direction of the test microphone would remain the same, with or without reflector. Hence the *change* in frequency response by adding a reflector would be correct.

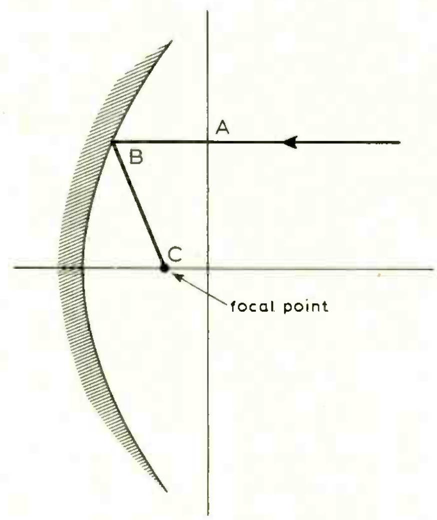


Fig. 1 The difficulty with a parabolic reflector arises because reflector size is comparable to wavelength at some frequencies.

It is common practice to use a number of speakers with crossover networks to cover the whole frequency range. It was soon realized that such a sound source would not be satisfactory, as the sound at different frequencies comes from different places and when dealing with the microphone and reflector which is highly directional this would lead to errors. Hence, eventually a Tannoy speaker was used where the tweeter is situated behind the cone and the cone is used as the horn of the high frequency unit.

The first consideration was the effect of the material of the reflector. Response curves were taken on a 24-in aluminium reflector and a 24-in fibreglass reflector, both having a 7-in focal length. These gave identical responses and it was concluded that changing the material from metal to fibreglass had no appreciable effect.

The effect of such a reflector, using a Grampian DP6 omnidirectional micro-

* University of Bradford.

phone, is given in Fig. 2, and varies greatly with frequency. The gain is poor at low frequencies because the wavelength of the sound wave is comparable to or greater than the dimensions of the reflector. At 200Hz the wavelength is about 5.6 feet and hence diffraction rather than reflection takes place. The large dip of about 7dB at 600-700Hz is thought to be due to cancellation of the reflected wave by the direct wave. As the microphone is omnidirectional, it will pick up the direct wave and the reflected wave, after travelling to the reflector and back. The difference in distance is twice the focal length, 14in, corresponding to half a wavelength at a frequency of approximately 500Hz, which does not agree exactly, probably because the microphone is not a point source.

One might expect that the gain would continue to increase at high frequencies whereas, in practice, the response drops rapidly above about 10kHz. This is assumed to be due to interference effects when the wavelength is comparable with the size of microphone. Wavelength at 10kHz is 1.3in which is of the same order as the size of the microphone. Maximum gain is about 20dB which is well worth while and occurs at about 5kHz. If the drop in response at high frequencies is due to the size of microphone, then it can be reduced by using a smaller microphone. This was confirmed by the use of a Sony ECM50 which is only about $\frac{3}{8}$in diameter and $\frac{3}{4}$in long. In this case the peak was at about 10kHz and the maximum gain was about 22dB.

The next factor to be considered was the size of reflector, and two other fibreglass reflectors were constructed exactly similar to the 24in reflector (i.e. 7in focal length) but of diameter 18 and 12in. Fig. 3 shows the change in response, using the same microphone and two reflectors. Considering first the 18in one, the gain is now less at low frequencies as would be expected but the maximum gain is not changed much. The dip occurs at the same frequency and the magnitude of the dip is approximately the same. However, due to the low gain at low frequencies, the bottom of the dip gives a response which is less than that of the open microphone. The 12in reflector results in still less low-frequency response and a response at 700Hz which is much less than that of the open microphone. The maximum response is now reduced appreciably.

The next variable to be considered was the focal length and a fibreglass reflector was made of 24in diameter and 4in focal length. This results in a much deeper reflector which is heavier and more difficult to carry. The response, using the same DP6 microphone, is given in Fig. 4. This is similar to the 7in focal length as regards low-frequency response and maximum gain but there is no appreciable dip. If the dip is caused by interference between direct and reflected waves, then it would now occur at 900Hz. There is some reduction at this frequency but nothing like the reduction which occurs with the reflectors of greater focal length.

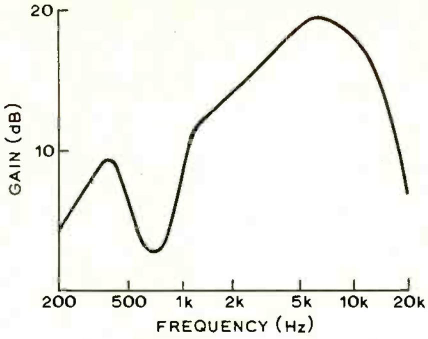


Fig. 2 Frequency response of omnidirectional DP6 microphone in 24in diameter reflector of 7in focal length.

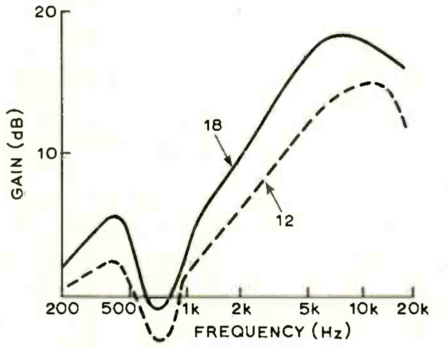


Fig. 3 Frequency response of DP6 microphone in 18 and 12in diameter reflectors of 7in focal length.

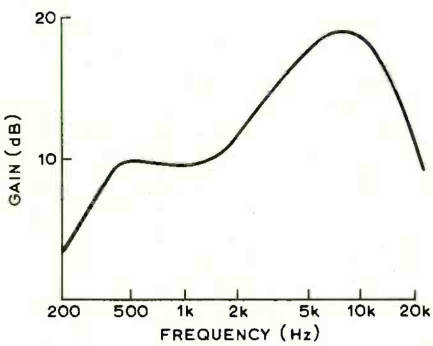


Fig. 4 Frequency response of DP6 microphone in 24in diameter reflector of 4in focal length.

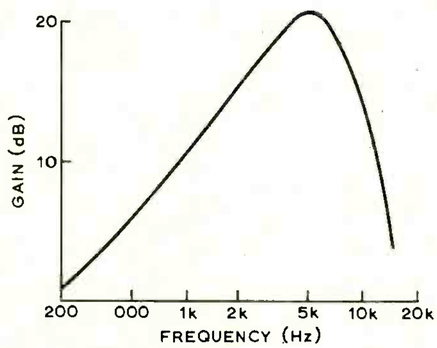


Fig. 5 Frequency response of M69 cardioid microphone in 24in diameter reflector of 7in focal length.

I do not know why. The deeper reflector therefore has the advantage of a more uniform response and it also has the advantage of protecting the microphone from the wind to a greater extent than the shallower reflector.

If the dip is due to interference between direct and reflected waves, then it should be largely removed by using a directional microphone such as one with a cardioid polar diagram. The effect of using a Beyer M69 microphone which has a cardioid polar diagram is given in Fig. 5 when used in the 24in diameter, 7in focal length reflector. The response at low frequencies is now very poor. In the case of the omnidirectional microphone, even if there are no reflected waves, the response at low frequencies will be the same as without a reflector because of the use of the direct sound waves. With the cardioid microphone the pick up of direct waves will be negligible (say −20 to −30dB) and hence the only output is that due to the reflected wave which is small. There is now no dip as there is no appreciable interference between direct and reflected waves, owing to its low response to direct waves.

The peak occurs at about the same frequency, namely 5kHz, and the maximum gain is about the same as the DP6. However, the response drops off very rapidly at high frequencies for reasons not known. The same microphone was tried in the 24in diameter, 4in focal length reflector and very similar results obtained, but with slightly greater gain at low frequencies (1 to 2dB). A Sony ECM21 (Electret) microphone, which also has a cardioid response, was tried with similar results but better at high frequencies, presumably due to its smaller size.

In all the above cases the microphone was placed at the focus of the reflector. Changing the position along the axis does not alter the frequency response appreciably but, as shown later, does alter the polar diagram. In all the above cases the sound source was on the axis of the reflector and the response changes rapidly for sources off-axis. The response of the DP6 microphone in a 24in diameter 7in focal length reflector is shown in Fig. 6 when the sound source is only

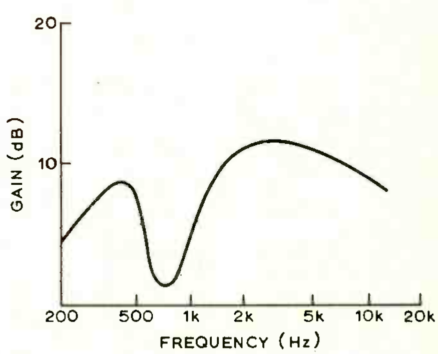


Fig. 6 Frequency response of DP6 microphone in 24in diameter reflector of 7in focal length with sound source 10° off axis.

10° off the axis. This should be compared with Fig. 2 taken on the axis under the same conditions. The response is approximately uniform apart from the dip at 700Hz. Maximum response is now less than that on the axis by some 10dB. Thus the frequency response and sensitivity obtained depend greatly on the accuracy of aiming. If the reflector is used for bird recording and there are a number of birds spaced apart, then the frequency response will be different for the different birds.

Response curves were also taken in the open air and they had the same general characteristics. However, I found it impossible to obtain steady readings at the high frequencies where the reflector is very directional. This was due to the slight wind which tilts the wavefront so that, as far as the reflector is concerned, the sound appears to be coming off-axis. In practice, if there is any wind, the frequency response will change continuously and often rapidly.

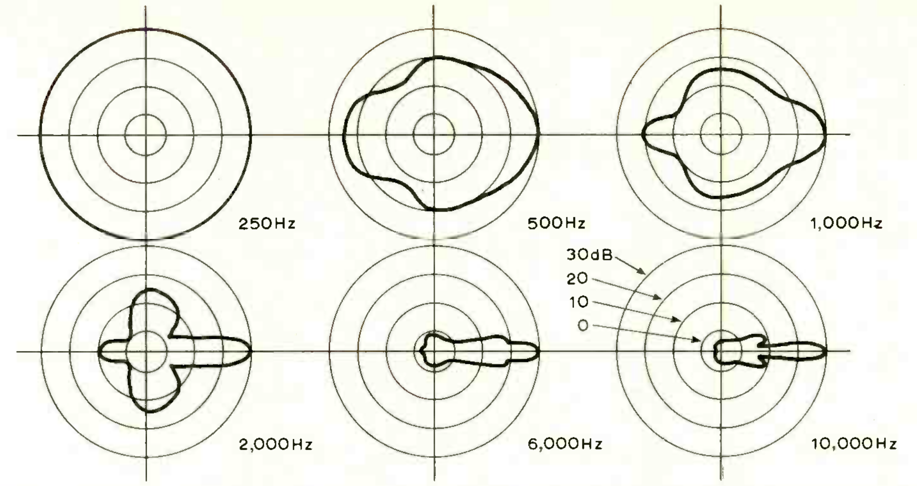


Fig. 7 Polar diagrams of DP6 microphone in 24in diameter reflector of 7in focal length.

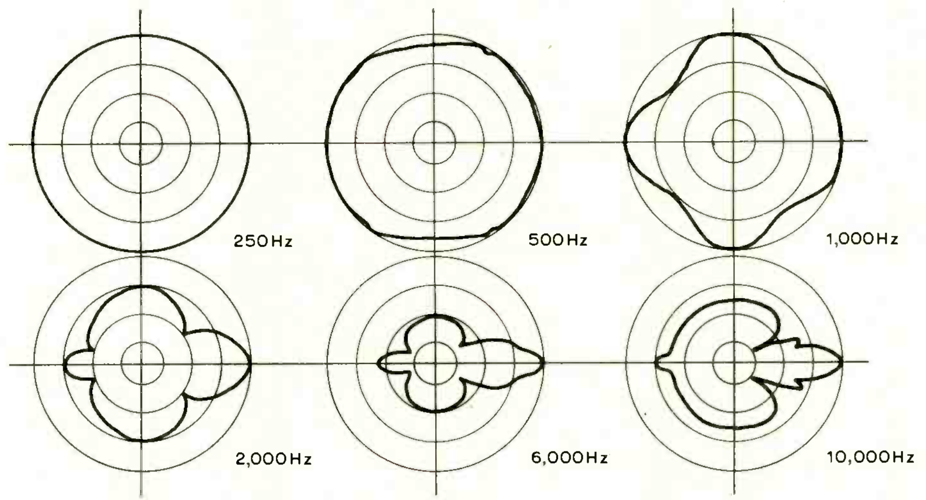


Fig. 8 Polar diagrams of DP6 microphone in 12in diameter reflector of 7in focal length.

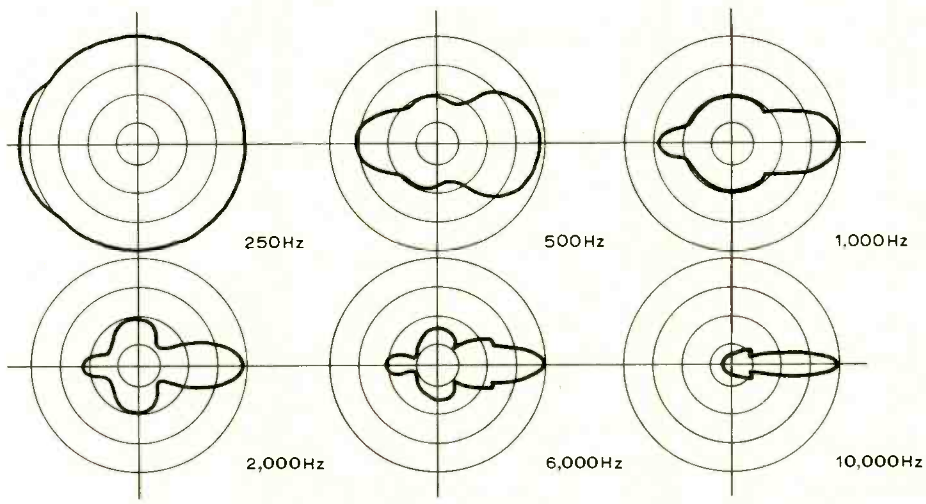


Fig. 9 Polar diagrams of M69 cardioid microphone in 24in diameter reflector of 7in focal length.

Polar diagrams

Polar diagrams were obtained using the anechoic chamber and rotating the microphone-reflector assembly. The shape of polar diagram depends very much on the frequency at which it is taken. Diagrams at a number of frequencies are given in Fig. 7 for a DP6 microphone in a 24-in diameter 7-in focal length reflector. These have been drawn with the response on axis the same at all frequencies but, of course, they will be of different amplitude according to the frequency response of the microphone. These curves are actual polar diagrams and include the effect of the microphone polar response.

With the DP6 the polar response of the microphone itself is substantially omnidirectional. At low frequencies the reflector has little effect and the response is almost omnidirectional. It is not until a frequency of, say, 2kHz is reached that the reflector-microphone combination becomes directional. At a frequency of 6kHz the response becomes highly directional and the output drops approximately 15dB when 10° off axis. There is generally an increase in response in the backward direction, relative to the sides, due to diffraction round the reflector.

A 24-in diameter reflector with a focal length of 4-in gave similar polar responses although the response in the backward direction was reduced as might be expected, the deeper reflector shielding the microphone more. The sharpness of the response in the forward direction was rather less, in general, than that of the 7-in focal length reflector. In these diagrams all the minor lobes have not been shown but have been smoothed out, as these are likely to change with small changes of frequency and, in some cases, are too numerous to draw on small diagrams.

As the size of the reflector is reduced the polar diagrams become more omnidirectional, particularly at low frequencies, and diagrams are given for the 12-in reflector of 7-in focal length in Fig. 8, using the DP6 microphone. At high frequencies the differences are not as great, but the smaller reflector does not give as great a suppression in other than the forward direction or, looking at the other way, does not give as great a gain in the forward direction. This is to be expected from the frequency response curves.

In Fig. 9 are shown the polar diagrams of a cardioid microphone (M69) in a 24-in diameter reflector of 7-in focal length. This combination gives sharper polar diagrams, particularly at low frequencies. However, at 250Hz and lower frequencies the response is greater in the backward direction than the forward. It must be remembered that the

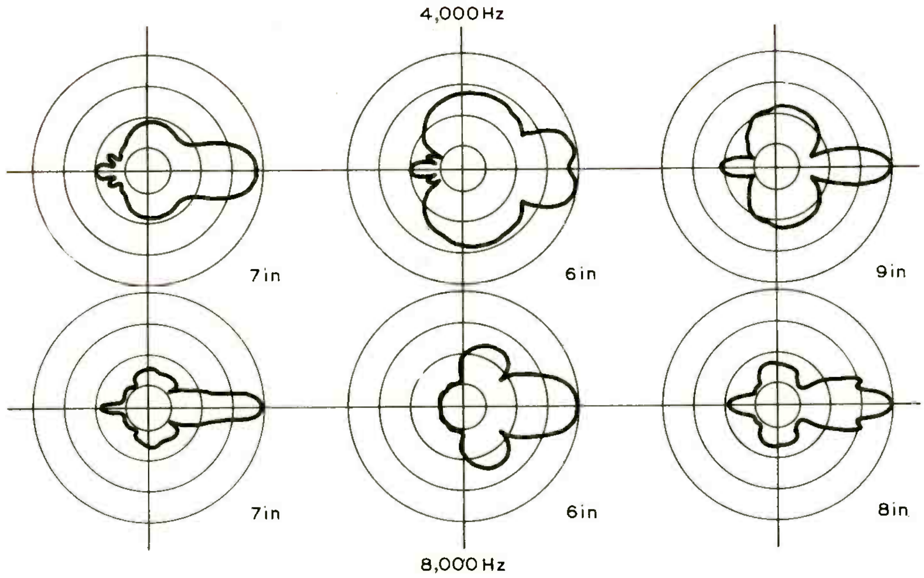


Fig. 10 Polar responses of a DP6 microphone in a 24in diameter reflector of 7in focal length with the microphone at different distances from the reflector.

microphone is pointing in the backward direction i.e. it has its maximum response in that direction. Thus at low frequencies, where the reflector has little effect, the response tends towards that of the microphone itself. This is an obvious disadvantage if there are low frequency interfering sounds at the back of the reflector. The responses of this microphone in a 24-in diameter, 4-in focal-length reflector were similar but with suppression of the response at the sides and back being rather better.

The effect of moving the microphone on the axis away from the focal point is large and is shown in Fig. 10. These are taken at 4 and 8kHz for the DP6 microphone in a 24-in diameter, 7-in focal-length reflector. If the microphone is not placed at the focal point, the sharp polar diagram is destroyed with the introduction of side lobes.

It is obvious that some distortion of the sound will occur when using a reflector, the amount depending very much on what is being recorded. Frequency distortion will be greatest when a large range of frequencies is involved, there being considerable loss of low and very high frequencies. How important this is depends on the application.

Reflectors are commonly used for wild life recording, particularly of birds. Many birds have a song at high frequencies and hence the loss at low frequencies is not so important but some harmonics may be lost due to the reduced response at very high frequencies. I did some tests to determine if the distortion was audible.

Recordings of birds were obtained using an open microphone. These were then played in an anechoic chamber, using a high-quality loudspeaker, and the resultant sounds were picked up by various microphones and microphone-reflector combinations. The difference is only slight for birds with a high-frequency song but is very noticeable in the case of birds with a relatively low-frequency song. One recording was made of a chaffinch and Canada geese. When a reflector is used, the relative levels change, the chaffinch song being increased relative to that of the geese, and the sound of the geese is appreciably changed and becomes much thinner.

It should be possible to correct for this response, say after recording, by re-recording through a filter with a response the opposite to that of the microphone-reflector combination. I tried this and an improved result is obtained, the bird sounding more natural. However, the difficulty is that any low-frequency unwanted background noise is greatly increased and unless an original recording with very low background can be obtained, the method is not very practical. Another difficulty is that the response varies greatly if the source is off axis and hence the filter used can only be correct if the sound source was accurately on the axis. Any other sounds off axis would, of course, be distorted due to the correction filter.

It is difficult to know just how much distortion is acceptable and again this depends on the application. If the recording is of a rare bird, then a recording with some frequency distortion is presumably better than nothing or one with large background noise due to the use of an open microphone.

An alternative to the microphone and reflector, and used by broadcast authorities, is the gun microphone. This has a more uniform frequency response if designed correctly. It does not have a sharp polar diagram, although the polar diagram does not change much with frequency. The microphone does not have the inherent gain of a reflector and is very expensive.

In practice, the polar response of any directional microphone will be changed by the reflection from local objects, from the ground and by the effect of the wind.

Jobs for the Grads

When looking for jobs electronic engineering graduates are increasingly coming to regard industry as a "relatively insecure second best" according to Roland G. Hirst, Careers Adviser of Hull University. Speaking at a recent conference at Hull on electronic engineering teaching* (see Leader), Mr Hirst said that until 1970-71 few graduates had had serious difficulty in obtaining jobs, and a very high proportion of students had sought employment in the electronic engineering industry. The severe recession in graduate recruitment to the industry which took place in 1970-71 and continued into 1971-72 seemed to be largely over. Large numbers of vacancies had been notified for 1972-73 graduates but a strange change seemed to have taken place. The publicity given to "rationalization", redundancies, "adjustments to research budgets" and the like seemed to have penetrated the undergraduate consciousness. The result this year was that industry was rarely mentioned as a primary career aim.

Adverse publicity and the sharply reduced number of vacancies had had a considerably greater effect on student attitudes than most employers seemed to realize, went on Mr Hirst. With a virtually static output and a steadily rising demand for electronic engineers which the present economic expansion seemed to indicate, the industry would need to positively market its career opportunities if it were to achieve its recruitment targets.

An industrialist and part-time academic, Dr P. L. Kirby of Welwyn Electric Ltd, admitted that the industry tended to take a short-term view over employment. "When things get difficult down come the shutters" he said, and sandwich courses etc. were cut. The difficulty was that industrial cycles were short-term events relative to the universities' time scales. There had in fact been an electronics manufacturing boom since Christmas, particularly in the components sector, and although there was a general atmosphere of confidence prevailing the employers were not willing to commit themselves. Employment would not go up *pro rata* with production: it was greater productivity that they wanted.

Mr Hirst maintained that the massive publicity to "graduate unemployment" was based in part on a misconception. Graduates were the only specialist group entering employment for whom figures were available. Whether graduates suffered more or less than school leavers, holders of H.N.Ds and other groups was simply not known.

*Copies of the Proceedings can be obtained from Dr F. W. Stephenson, Department of Electronic Engineering, University of Hull, price £2.50 including postage.

News of the Month

TV data service

Engineers of the Independent Broadcasting Authority have recently developed and demonstrated a new television data system, "Oracle", capable of providing a continuous public information service on conventional TV transmitting networks. With this system, the public would receive up to 50 different "pages" of information "written" on their television screens, each page containing up to 880 characters, or roughly 120 words. These messages can be displayed or superimposed on the screen of a domestic TV receiver without in any way affecting the reception of normal television programmes.

The system is similar to the B.B.C's proposed "Ceefax" system (see May issue "TV Information Service") with information transmitted within the normal TV signal. The two systems are, however, not compatible and before a nationwide service could be considered it seems desirable that a standard for the transmission of such a service should be decided upon. Experimental "Oracle" transmissions have been made on the IBA's London television broadcasting station to test the experimental receiving unit which has been assembled at the Authority's London headquarters. Any kind of written information could be sent, one page at a time, with the individual pages up-dated at regular intervals. Since it takes 1.8 seconds for the transmission of one page of this material, it is possible for the 50 pages — each perhaps representing an entirely different information service — to be up-dated or re-written in a period of less than two minutes. The viewer would also have the facility to "hold" indefinitely any page of this information.

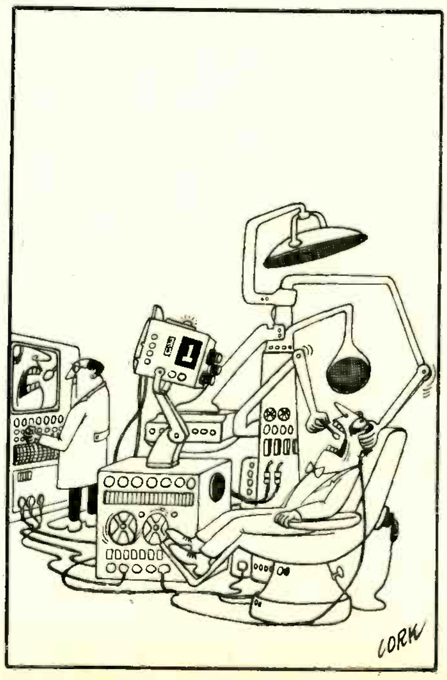
Two television line periods, during field blanking, have been set aside internationally for data transmission, although not specifically for public data transmission. Two 64-microsecond line periods repeating at the rate of 25 per second, are more than sufficient to allow the amount of data envisaged in an "Oracle" service to be transmitted. During each brief "Oracle" transmission period — that is 64 microseconds 50 times a second — one "segment" of display information representing up to ten characters, is transmitted together with its "address code". This address indicates to the receiving unit the exact position on the screen and to which page the information relates. This signal is in the form of a run-in code (5 binary digits or bits), a start code (8 bits), a line number (5 bits) and the field or page number (6 bits), and the address (8 bits).

Collision prevention for cars

RCA have developed an experimental radar designed to prevent car collisions by responding to the distance of the car ahead and sounding a warning when the separation distance becomes unsafe. The radar, mounted on the front of a car, transmits a continuous signal which is received by a "passive reflector" on the rear of the vehicle ahead. The reflector doubles the frequency of the transmitted signal and sends it back to the radar. By measuring the time required for the signal's round trip, distance to the car in front can be calculated. A warning light and buzzer indicate when the separation distance decreases below one car length for each 10 m.p.h. of speed of the car carrying the radar. Range of the radar is 100 yards.

The radar still requires testing and refinement but RCA believe that an operational system, including both the transmitting/receiving radar and the special reflector, can be mass produced within five years. Besides safety applications, the radar could also permit a smoother traffic flow and significantly decrease travel time in congested areas.

An important feature of the radar system is its rejection of false responses created by signals returned from roadside objects. This is achieved by making the radar receiver responsive only to those signals produced by the reflector at double the transmitted frequency. Since the signals reflected by the road and roadside objects are not at this second harmonic, they are ignored by the radar. The experimental radar transmitter/receiver measures $17 \times 8 \times 2\frac{1}{2}$in. It is mounted on the front bumper of the car, but an operational version could be smaller and concealed in the grillework or behind a non-metallic front licence plate. The radar beam is narrow, so that when a car moves out to pass a car ahead, the signal is not reflected and the car can pass without a warning being sounded.



Fast data link

The Harwell Electronics and Applied Physics Division of the U.K. Atomic Energy Authority have developed a novel system for interconnecting computers over inexpensive lines without the aid of repeaters. The system permits a rapid exchange of serial data at a low error rate over distances up to $1\frac{1}{2}$ miles. For example, the data transfer rate over $1\frac{1}{2}$ miles and with an error rate of 1 in 10^{10} is 880 kilobits/sec. Shorter distances allow higher bit rates and vice versa.

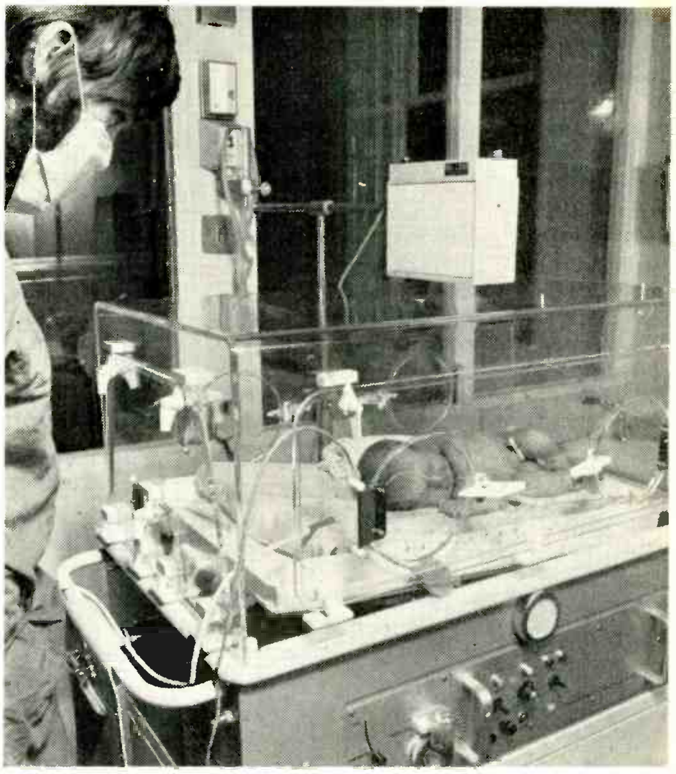
A data-link system consists of a pair of couplers, each inter-facing a computer to line, software inter-facing with the customer's programme, and the line itself. Each coupler is connected to its computer as a typical autonomous peripheral device, i.e. it can receive command words and have its status tested under programme control, and it exchanges data with the computer in autonomous mode. The transmit channel of a coupler accepts words in parallel from the computer and converts them to a serial bit-stream for transmission. The receive channel accepts a serial bit-stream and presents data as parallel words to the computer.

The software package operates in real-time, and data links time share with the customer's other programmes. Error detection and rapid recovery facilities are included. Each data link operates over two twisted-pair wires in multi-pair telephone cables.

BSI asks for industry's view

Many people have suggested that some kind of standard code for product reference numbers is desirable and investigations are being carried out in this country and abroad. Three years ago, when the British Standards Institution circulated a draft for comment, the replies showed interest in the idea of a standard but little agreement on the form of numbering to be used.

In order to find out what system of numbering will be the most suitable BSI is now circulating a second draft, with a questionnaire. This draft describes three different systems of numbering and the advantages and disadvantages of each. People responsible for the allocation and use of product reference numbers are asked to obtain copies of the draft and send BSI their views in the questionnaire. The information thus collected should show what kind of standard format is likely to be the most useful.



Based on a radar principal applied to intruder detection devices, the unit suspended above this baby provides monitoring of the life condition without any physical contact. Should movement cease, an alarm is triggered and immediate action can be taken by the nursing staff. The detector, supplied by S. E. Laboratories, is installed at the new Nottingham City Hospital baby care unit.

Queen's Award to Industry

Among companies receiving the Queen's Award to Industry are EMI, Racal-Milgo, B & W Electronics and the English Electric Valve Company.

EMI received two awards, one to the Central Research Laboratories at Hayes, Middlesex for technological innovations in the EMI-Scanner, a computerized X-ray technique for the investigation and diagnosis of brain disease. The second is to Anglo-EMI Film Distributors Ltd, the Group's film production and overseas distribution company, for export achievement. Racal-Milgo and B & W also receive their awards for export achievements in the respective fields of data communications and loudspeakers.

The award to the English Electric Valve Company is in recognition of achievement for technical innovation in ceramic hydrogen thyratrons. These are gas-filled electron tubes used as very accurate, high voltage, high current, fast operating switches which can switch powers of many millions of watts with accuracies measured in nanoseconds.

IBC '74

The fifth International Broadcasting Convention — IBC '74 — will be held in London at the Grosvenor House, Park Lane, from 23rd to 27th September 1974.

Advances in all aspects of broadcasting will be highlighted both in the technical sessions and in the exhibition of broadcasting equipment, both radio and television. Among the items to be covered in the technical sessions are: automation in broadcasting; training and management; future maintenance philosophy; propagation and service planning; receivers; recording, storage and replay; satellites in broadcasting; signal distribution systems: signal sources; sound systems — stereophonic and quadraphonic; technical aspects of international programme exchange; and transmitters, transposers and aerials.

New communications satellite

A new synchronous satellite, Intelsat IV-A, will have nearly twice the capacity of the Intelsat IVs now in global service. The International Telecommunications Satellite Organization (Intelsat) has approved a $72 million contract with Hughes Aircraft Company to build three of these high-capacity satellites for handling increasing international telecommunications traffic. Launch from Cape Kennedy of the first satellite in the new Intelsat IV-A series is scheduled for mid-1975.

An estimated 40 million overseas telephone calls will be made to and from the United States this year. The number is expected to rise to 200 million by 1980. To fulfil this accelerating growth, the larger and more powerful Intelsat IV-A will carry a new type of aerial able to re-use the same frequency aimed at different points on the globe. Use of the new aerial system will require no major changes or modifications in existing Intelsat ground stations. The spacecraft will provide capacity for 11,000 telephone circuits or 20 simultaneous colour TV channels, nearly double that of the present Intelsat IVs.

Tape news

Philips, the originators of the Compact Cassette tape system, celebrate the tenth anniversary of their invention this year. The cassette recorder was first introduced as a small battery portable machine at the Berlin Radio Fair in 1963 and since then the combined total sales of cassette machines have topped the ten million mark.

This year also marks their entry into the DIN "hi-fi" standard range with new cassette recorders. A particularly interesting feature of these machines is a clever hysteresis clutch fitted to the feed and take-up spools in place of the more conventional felt pad clutch. Philips claim that this clutch, unlike the felt pad version, requires no maintenance and will give the correct torque in braking and take-up modes under all conditions. If the claim proves to be well founded this one idea could go a long way towards reducing the common jamming problems experienced with many cassette machines.

Further to our March issue report on modern tape recorder heads, an increasing number of research and development papers have been reaching us on the topic of Sendust heads. This material first appeared in some experimental video heads made in Japan. It is an alloy of 85% iron, 5.5% aluminium and 9.5% silicon, the permeability falling midway between that of Mumetal and the ferrites currently employed for many audio heads. Sendust was first discovered in Japan over 20 years ago as a substitute for the nickel alloys but since it could only be made in powder form its use has been, until recently, confined to resin-bonded powder cores for r.f. coils and transformers. New techniques are being developed to produce a suitable form for the laminations of a head core. Its advantage over Mumetal is that it is considerably harder and suffers less from loss of magnetic properties when the usual finishing operations are undertaken. From the amount of interest being shown in this material it is felt that tape recorders with heads of this new material are likely to appear on the market this year. Its value is obvious in cassette recorder applications where chromium dioxide tape, now readily available, creates two unique problems. First, increased head wear, though some brands claim equal wear with the ferric oxide types and second, a higher coercivity which some ferrite heads cannot overcome without driving into saturation.

Seen at the Physics Exhibition

Display techniques ● c.a.d. ● function generation ● node logic

Voltage-variable colour filter

The "twisted" nematic display, a liquid crystal* cell relying for its operation on polarized light, has the attractions of negligible current consumption, low threshold voltage, high contrast ratio, and dual absorption or transmission modes (black on white or white on black displays). In this kind of display a thin film of a nematic liquid crystal, or a mixture of such materials, is sandwiched between two glass plates on which conducting but transparent electrodes have been deposited, around 10 to 50μm apart.

This type of display uses the surface of the electrodes to orient the nematic molecules (in a nematic, the ellipsoidal molecules have their long axes in the same direction) parallel to the electrodes. In a "twisted" nematic cell, *WW* May 1972 page 230, the alignments on the two electrodes are at 90° to one another, the result being that the molecular alignment is twisted and follows a quarter turn of a helix. As the helix pitch is made much larger than the wavelength of light used, the helix acts as a guide for plane-polarized light, rotating it through 90°.

Application of an electric field over a certain threshold value causes the induced electric dipole, and hence the molecule, to be parallel with the field. Being parallel to the optic axis, polarized light now passes unrotated. Thus, with the addition of a polarizer either side of the cell, the display can be switched from transmitting to reflecting or vice versa by making the alignment of the two polarizers 90° or 0°.

Work on this kind of device is going on at many laboratories and devices of this kind were shown by the Royal Radar Establishment, last year. A related device was shown by Standard Telephone Laboratories this year, that produces a voltage-variable colour display. In this one, molecules are again aligned parallel to the electrode surfaces, but the surfaces are arranged to be parallel, rather than twisted by 90°. So all the molecules are constrained by the surface forces to have their long axes parallel to, and in the plane of, the electrodes. The material resembles a uniaxial crystal with its optic axis perpendicular to the light direction.

The cell is placed between "crossed" (90-degree) polarizers, with the long molecule axis at 45° to the polarization axis of each polarizer, this giving maximum light transmission. The material is birefringent (for light not incident along the optic axis) and there is a phase difference between the ordinary and extraordinary refracted rays. Plane-polarized light is thus rotated by the crystal, the amount depending on wavelength. When the molecules are normal to the incident light, the birefringence is maximum, decreasing to zero as the applied electric field rotates the molecules to be parallel to the field, and light direction.

White plane-polarized light, transmitted by a polarizer, is rotated by the cell and only a narrow bandwidth of light, i.e. one colour, passes the second polarizer, effectively giving a voltage-controlled colour filter. The material is so birefringent that the plane of polarization is rotated by more than the 90° required for transmission through the second polarizer at low voltages. Several wavelengths are transmitted corresponding to 90, 270, 450° etc., producing mixed colours. At about 10 to 20V pure colours are obtained and at around 30 to 40V all molecules are aligned with the field, resulting in no birefringence and no transmission (polarizers crossed).

Response to voltage changes is fast and the display can be operated up to around 100kHz. High-purity material can be used because no conduction is required, which apparently greatly increases operating life. Operating temperature of such devices is -15 to $+70$°C.

*The liquid crystal state, shown in a small percentage of organic compounds, is intermediate between the melting point of a solid crystal and the isotropic liquid, with the optical and electrical anisotropy of a solid crystal but the flow properties of a liquid.

Computer-aided graphic circuit design

A system using existing circuit analysis programmes allows circuit designers to specify circuit connections graphically and maintain a record of the circuit for any subsequent changes which may be made. Called Circuit, this interactive graphical system was developed by the Applied Physical Sciences department of the University of Reading, and generates the data stream required by Racal's REDAP31 programme.

In the display mode, the designer is shown a rectangular matrix of dots and a library of component symbols on a visual display unit. The circuit is assembled by using a light pen to move components to suitable pairs of dots. Component values are entered by teleprinter. When the circuit has been completely built up in this way, a programme is called up which numbers the modes and lists the components with their values and mode numbers. Obvious errors are detected and appropriate error messages printed. Once this and any other data, for instance source and load impedances and frequencies of interest, has been filed, the designer telephones the system providing the circuit analysis programme and results of the analysis appear on the teleprinter. Hardware required by the system is a PDP 8 computer with a 20,000 word drum backing store, a simple terminal and, of course, a Datel link.

Non-volatile storage with m.n.o.s. transistors

Semiconductor memories based on bistable circuits are characterized by volatility of the stored information, i.e. if the supply fails the stored information is lost. The non-volatile property of the m.n.o.s.(metal-nitride-oxide-silicon) transistor enables information retention over several months, typically. The m.n.o.s.t. is an insulated-gate f.e.t., similar to a conventional m.o.s. transistor, whose threshold voltage may be varied between wide limits by the application to the gate of a voltage greater than a certain critical value. As the device can be switched between two distinct threshold voltages, it has the basic requirement of a memory device.

Charge is stored in deep traps within the gate dielectric so that no power is required to maintain either state. The information may be read out by sampling with a gate voltage between the two threshold voltages and detecting if the device is on or off. As long as this gate voltage is less than the critical voltage, there is no tendency to alter the storage state.

(The m.n.o.s. transistor differs from the conventional m.o.s. transistor only in the structure of its gate dielectric. In the m.o.s.t. this is a 150nm layer of thermally grown silicon dioxide, in the m.n.o.s.t. it is a two-layer structure of silicon nitride on silicon dioxide.) Retention time depends on write time; a write time of 1μs results in storage for a day, and a 10ms write time will produce storage for over a century!

The Plessey Company were showing how m.n.o.s. devices were useful in measuring electron or hole mobility in inversion layers because a charge introduced between silicon and metal electrodes remains stored indefinitely, being undisturbed by a measuring potential applied to the gate. Equipment exhibited measured effective mobility over a range of gate potentials, effected by superimposing an a.c. signal on the d.c. gate supply and monitoring the transconductance. The mobility-gate potential curve is displayed directly on an x-y recorder.

Waveform synthesis — 1

Analogue techniques to produce simple waveforms such as sinusoidal, rectangular, triangular and ramp shapes while being straightforward, do not lend themselves easily to generating *any* waveshape. A new instrument by Prosser Scientific Instruments enables the synthesis of any waveform using digital methods and with a keyboard data input, while at the same time allowing analogue control over the signal outputs.

The instrument is addressed from a keyboard, (alternatively from punched tape, resistive probe or an electrical analogue signal via an a-to-d converter) and is coded by providing rectangular cartesian co-ordinates of the designed waveform. In practice, the waveform is fed into the keyboard from a tabulation of co-ordinates derived either by calculation or by reading from a previously plotted graph. Only the y co-ordinate is fed in, the instrument

Prosser Scientific Instruments digital waveform synthesizer with keyboard data input.

automatically advancing to the next x space. An m.o.s. random access memory is clocked at one step intervals, a numerical display showing the current x position. Correction of wrong entries is facilitated by the register being made to clock backwards. When the entry is complete each pair of co-ordinates can be checked on the display. The generator is then ready to recall the programme waveform by emptying the store through a d-to-a converter.

In capturing natural events, the transducer would feed the a-to-d converter and the event would then be stored in the memory, to be played back at any chosen repetition rate. As the literature on the PSI3000 instrument says of this mode, it's a bit like a tape recorder with continuous tapes that can be played back at any speed. The effect of modifying the event in some way can then be investigated using the keyboard.

The waveform can be repetitively displayed at any desired rate, amplitude or phase. An additional output is available with variable delay useful for autocorrelation and possibly in other applications. One suggestion is in simulation of road surface profiles in testing vehicles — the synthesized output representing the displacement to the vehicle's front wheels and the delayed waveform representing the back wheel displacement. The two signals would then serve as inputs to a vibration simulator.

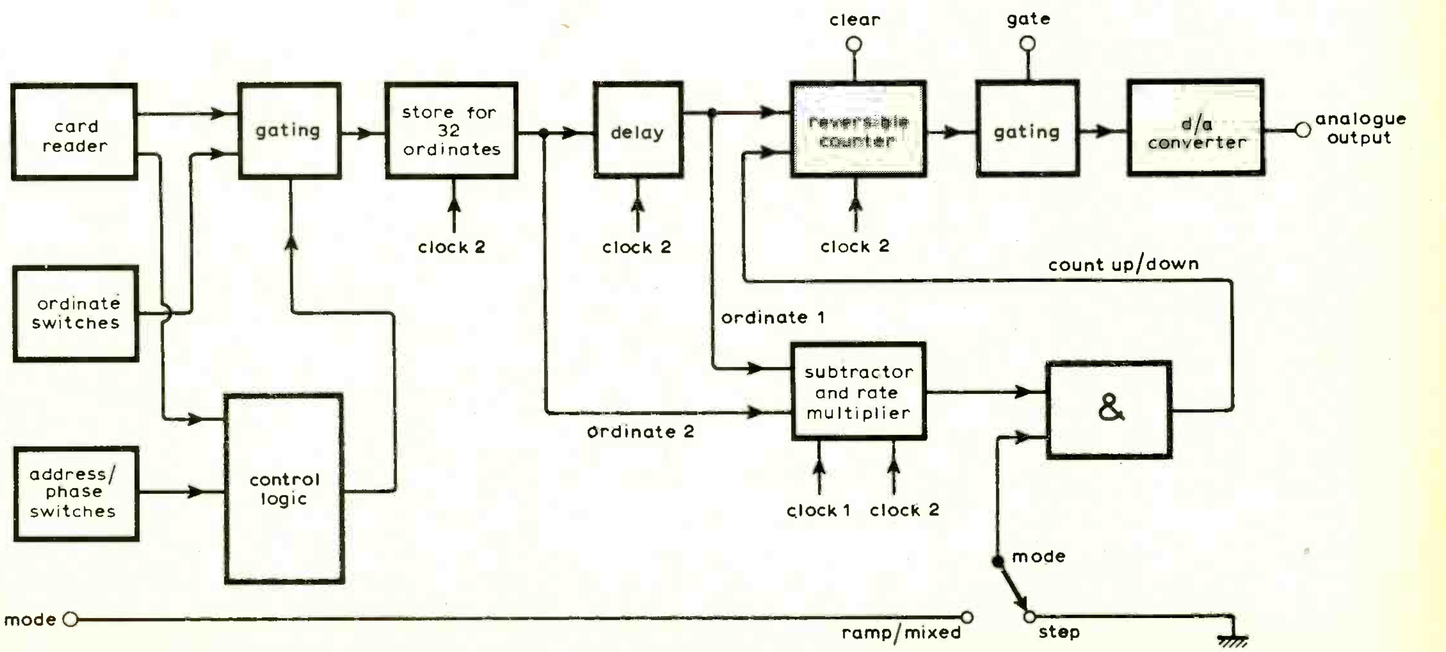
Waveform synthesis — 2

In another digital function generator, developed at the City of Leicester Polytechnic, the input ordinate information can be fed in by an inexpensive card reader or by specifying the address or number of the ordinate and its binary/octal value on two sets of switches. The operation is different in that output waveform is constructed in a ramp mode (in control engineering parlance, a first-order hold process) in which successive ordinates, taken from a 32 × 8 bit m.o.s. store, are connected by a staircase approximation to a straight line (see block diagram). The difference between two successive ordinates is fed to a rate multiplier whose output operates a reversible register counting up or down at a rate proportional to the difference between the two ordinates. When the second ordinate of a pair is reached, the difference is then taken between the next two. Information is stored in 8-bit form, the output range of ±5V being quantized into 256 levels, spaced by about 40mV.

In another mode, the pulse (or zero-order hold mode), the output is held constant at the last ordinate value between any pair of ordinates. This is specially suited to generating pulse sequences with differing, well-defined amplitudes.

External mode control and clear inputs are provided and a phase-locked trigger can be used to move the starting point along the waveform.

As there is no lower frequency limit of the instrument it can be used for precision v.l.f. measurement and control applications. Upper frequency limit is 1kHz. As the 8-bit precision chosen corre-



One way of generating waveforms digitally, proposed at Leicester Polytechnic, which can be used with an inexpensive pencilled-card reader.

sponds to a maximum of 256 steps between ordinates, the clock drive frequency is 32 × 256 times the output frequency, or about 8MHz in this case.

New technique in driving solid-state displays

New drive circuitry for solid-state displays that needs only one character generator for any number of characters, while at the same time being static, requiring only two signal leads to the display and eliminating current-limiting resistors, has been developed by ITT Central Applications Laboratory. The function of so-called drive circuits is to provide signals at the right voltage and current levels to operate the display, to route input information to the required output device, to convert binary-coded input data to the appropriate form, store the input, and to synchronize the system with a clock. These functions are currently implemented either in a static or in a dynamic, multiplexed way.

With the traditional static technique, all the functions are duplicated for each character, and with alphanumeric displays this can be costly. Further, the decode/drive i.c. would be specific to a display and different circuits would be needed for different kinds of display.

Time sharing methods need only one decoder, the character generator and drive functions being shared among characters by multiplexing, but suffer from a lack of "modularity" or flexibility and because the displays are switched there are brightness and peak current problems, making integration complex. (With liquid crystal devices there may also be operating speed limitations.)

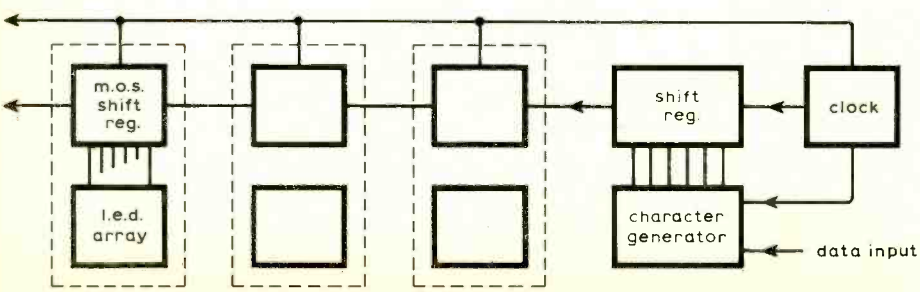
The new concept is to mount an m.o.s. serial-in parallel-out shift register on a substrate together with, say, the gallium arsenide phosphide elements, each output of the register being connected to one of the display. The system has the advantatage of requiring only one character generator for producing coded signals for the shift registers, which are connected in series. The output resistance of the m.o.s. circuit can be designed to provide current limiting for the l.e.ds, and outputs can be paralleled if more current is needed. Liquid crystals displays can be driven from the same i.c.

The system operates as follows. Coded data of the first digit is fed to the character generator where it is decoded and passed to the first shift register by a train of clock pulses applied to both units. Data for the second digit are then fed into the generator and the next sequence of clock pulses shifts the information from the first register into the second and the new data into the first. With each sequence of pulses information is shifted to the left as new information is fed in from the right. When all the information has been fed into the shift registers a static display is given requiring no external memory.

By suitable choice of the number of bits, a shift register i.c. can be developed so that two chips can drive a 7x5 dot matrix and one chip with its output paralleled in pairs can drive a seven- or nine-segment numeric display.

In use each character is completely modular and, apart from supplies, the only connections required are a single input and output and a clock input. Any number of characters can be strung in series and both liquid crystal and diode displays can be mixed. There are also other applications, for instance the solid-state analogue display, described elsewhere. Seven-segment numeric displays are in production and 35-dot alphanumeric displays are expected to be available in September from ITT Components Group, (STC) Brixham Road, Paignton, Devon TQ4 7BE.

Serial-in parallel-out shift registers enable display modules to be connected with only data wires.



Solid-state analogue readout

Although the solid-state digital readout using light-emitting diodes has undoubted advantages in many situations that demand high accuracy, and high reliability in the presence of vibration, it is not the answer to everybody's display problem. Where accuracy is not of prime importance, analogue readouts enable information to be read off instruments much more quickly. This is especially so in automotive and aeronautical situations, and where a large number of variables are being displayed simultaneously, as in process control plant. In these situations the robustness of solid-state systems would be beneficial.

A solution to this was presented on the Standard Telephone Laboratories' stand, where a solid-state analogue display is achieved by arranging l.e.ds in a column or row, say 50 for 2% resolution. The measured variable in the form of an analogue voltage is first converted into digital form. Then a serial-in parallel-out shift register is used to feed each dot or diode on the array. The control circuits are arranged to feed this shift register with an appropriate pulse and clock sequence to produce the right indication. In one example seen, "writing" takes 3ms followed by 30ms of display, the input voltage being sampled and displayed 30 times a second. The m.o.s. shift register chip is that used in the display modules, described elsewhere (see "Driving solid-state displays"). The circuit arrangement permits only two signal wires to the display unit ("data" and "clock" lines), apart from power lines. The unit lends itself to low-profile fabrication, which should attract the motor manufacturers' interest, as the cost of panel cut-outs would be avoided.

Node logic

Node logic elements have been developed at the University of Reading, which are suitable for directly implementing the logic on a state diagram. The state diagram provides a method of describing the behaviour of a sequential logic system. On the state diagram, each state that the system can or must assume is represented by a node. Each transition from state to state is signified with an arrow from node to node which is labelled with the signal that causes this particular transition. Using the available range of logic elements, it is often difficult to design a reliable electronic implementation of a system although it may be quite easily defined by a state graph.

To simplify this process, a logic element has been designed which directly simulates the node on a state graph. The wiring between elements is in one-to-one correspondence with the "connections" on the state diagram, which is itself the logic diagram of the circuit implementation. In the development stage, the logic elements have been built on conventional printed circuit plug-in boards.

The state graph simulator is arranged so that the node element terminals are brought out onto patch panels allowing the direct "plug-up" of a state graph. On the patch panel, each node has a set of input sockets, a set of stimulus sockets and appropriate output sockets. To represent a state graph arrow, a jumper lead is plugged between a node output and the following node input. The stimuli which cause a state change from a node are plugged into its stimulus input sockets. The machine can then be operated by switching the stimuli as logic levels or pulses.

Should a fault occur due to the disconnection between nodes or a node malfunction then the "present state" node cannot execute its state transition procedure on receipt of a stimulus. It therefore puts a signal to a fault bus-line causing an indication. Acknowledgement of this indication by operation of a switch causes the last operative node indicator light to come up, indicating the last state the machine was in. This is helpful to an operator plugging up a system but in addition gives the challenging possibility of a system which detects its own faults and bridges them out with a spare element or circuit, a kind of "self-healing" logic system.

F.M. Tuner Design — Two Years Later

Varicap diode tuning and lower gain modifications

by L. Nelson-Jones, F.I.E.R.E.

Many readers have asked the author for details of a modification to the f.m. tuner published in April and May 1971 (and April 1972) which will enable it to be voltage tuned. The variable-capacitance diode design subsequently produced and described in this article covers the same tuning band of 87.5 to 108MHz. Also described is a simple modification to reduce the gain of the original tuner.

In recent years a number of types of silicon variable-capacitance diodes have appeared on the market, some having very high ratios of minimum to maximum capacitance. These diodes make use of the capacitance of the depletion layer in a reverse biased diode. All semiconductor diodes exhibit a voltage dependence of reverse biased capacitance, but the degree of variation and loss factor depend on the construction of the diode. Normal signal diodes, although exhibiting the effect, do not have a sufficient variation for tuning the f.m. band. The 87.5-108MHz band needs a minimum capacitance change of the order of 3:1. This apparently large ratio is necessary because of the relatively high stray capacitances in the circuit. In a tuner designed solely for varicap tuning these strays can be reduced somewhat, but here we are concerned with replacing a normal tuning capacitor without altering the layout.

For the design described below the BB103 diode has been chosen and the capacitance/voltage relationship for these diodes is shown in Fig 1. A wide capacitance range can be covered by the diodes (almost 5:1) if the bias can be allowed to drop to a value of some -0.3 volts. However, the range required can be obtained between approximately -2 and -27V. A low reverse bias has to be avoided in a tuner using f.e.ts since the oscillator voltage injected is high compared with a bipolar design. The diodes must not be allowed to conduct or the law will be spoilt in the oscillator tuning section by the resultant build up of charge at the low frequency end of the band where the diode bias is lowest. To assist in the application of the bias and to obtain a suitable value of capacitance, two diodes are used in each tuning section (see Fig. 2) The diodes are "back-to-back" and the bias is applied to the centre point. In the case of the oscillator and aerial input tuned circuits, the whole circuit is at ground potential and therefore only a high value feed resistor is needed to supply the centre point of the diodes with the necessary reverse bias. The value of the resistor must be high enough to avoid unnecessary reduction of the Q of the tuned circuits. A value of from 100k to 1MΩ is suitable. The tuned circuit coil in the drain circuit of Tr_1 is at the drain potential and a blocking capacitor has therefore to be added in this circuit. This in turn means the addition of a second high value resistor to ensure that the bias is applied to both diodes.

The varicap diodes and associated components are assembled on a small p.c.b. which takes the place of the tuning capacitor. The components are all mounted on one side of the board in the usual manner together with connection leads of 22s.w.g. tinned copper wire and the p.c.b. is then mounted on spacers. Components on the underside use the original mounting holes provided for the tuning capacitor. An external lead from this sub-board is then taken to the tuning control unit,

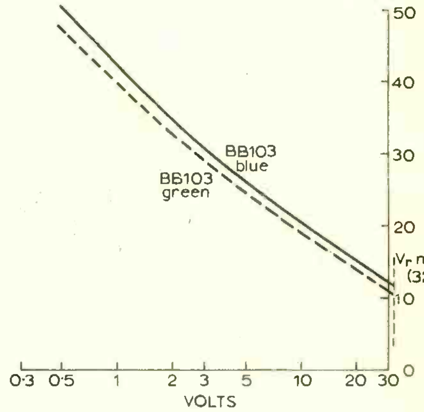
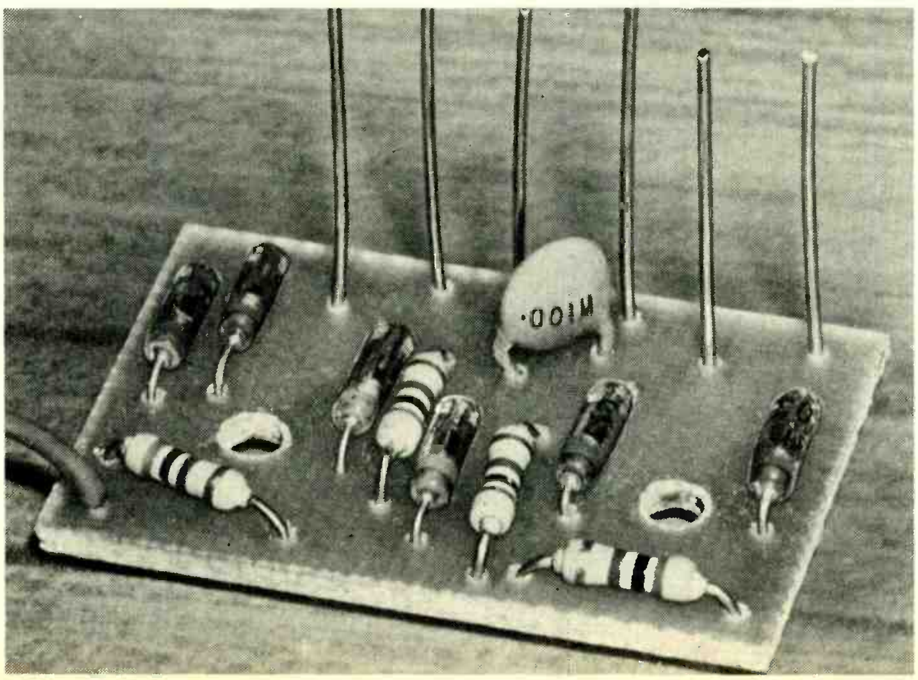


Fig.1. Capacitance versus voltage relationship for the variable-capacitance diode alternatives.



Varicap board showing the diodes, resistors and capacitor, together with the connecting wires. The diode cathodes face away from the six connecting wires.

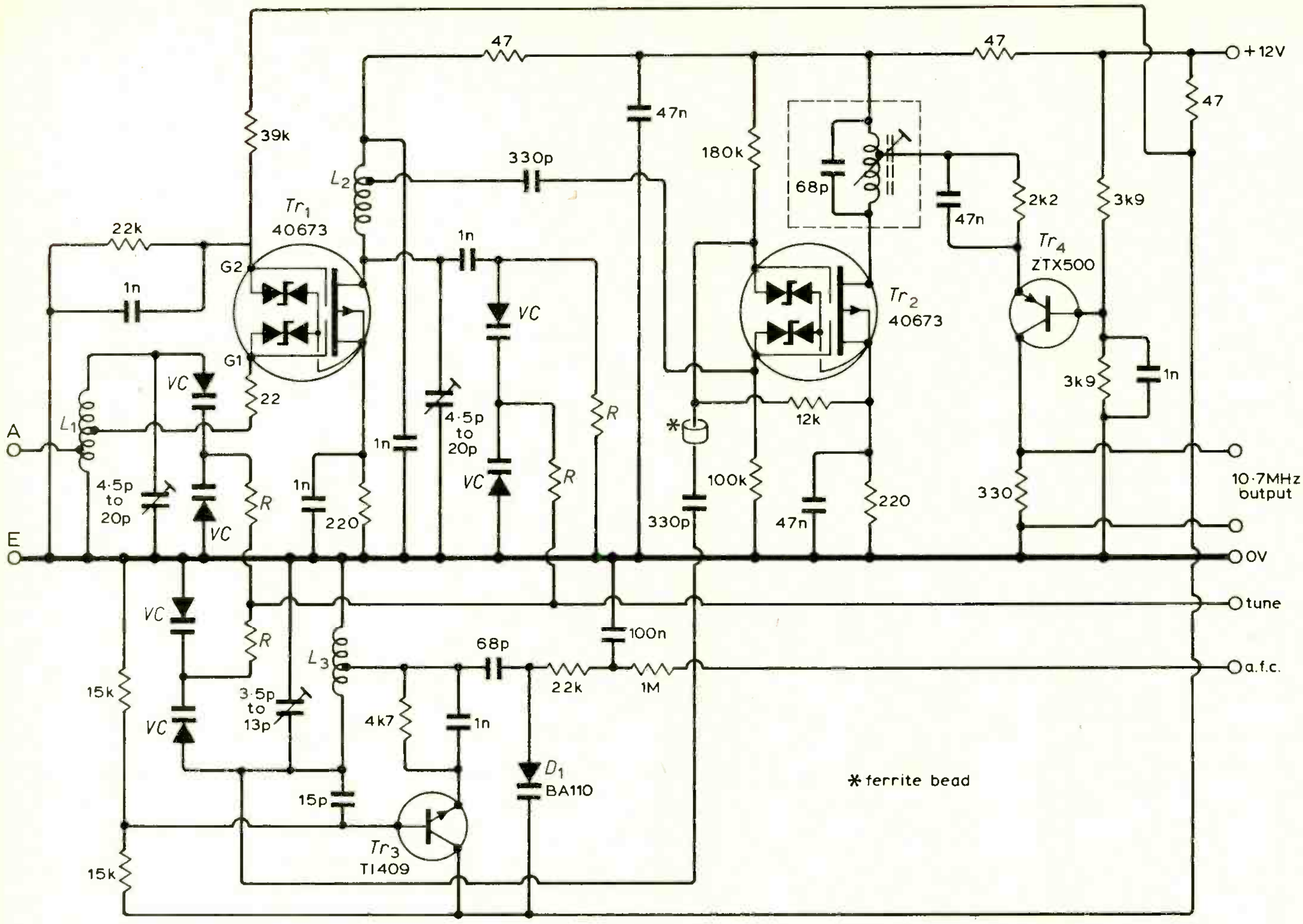
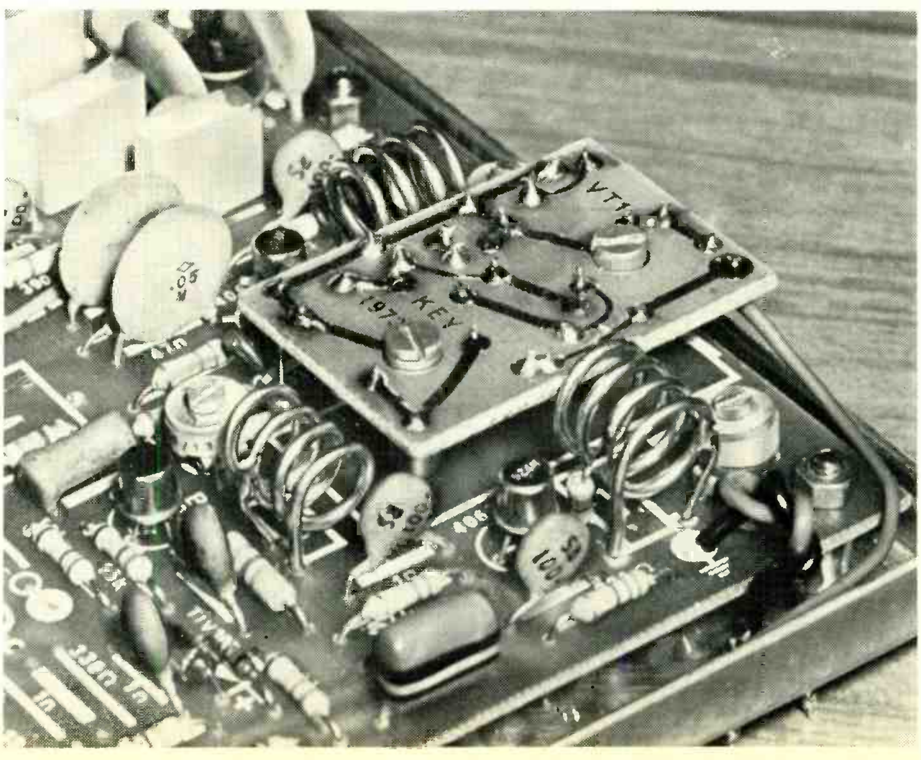


Fig.2. *Revised front end of the tuner showing the replacement of tuning capacitors by varicap diodes which provide voltage tuning.*

which is described below. This new p.c.b. is shown mounted on a tuner. A photograph shows the underside of the board before mounting on the tuner.

The only other changes needed to the tuner for varicap diode tuning is that the coils need to be replaced with slightly modified versions (shown in the photograph). The coils are all made from 18 s.w.g. tinned copper wire, but L_1 and L_2 are of a different diameter to the original coils. These two coils are now wound on a $\frac{5}{16}$in former. Inductor L_1 is otherwise as the original design, but on L_2 the tap has been moved to the end turn nearest the supply, and physically adjacent to the 100kΩ resistor. This change reduces the interaction between the tuning of the mixer and oscillator tuned circuits when trying to "track" the tuner, and although not great this reduction in interaction does make tracking much easier. Gain is not affected to any noticeable degree. The oscillator coil L_3 remains at $\frac{1}{4}$in internal diameter, but differs in construction. The direction of winding has been reversed, giving approximately an extra half turn. A 22Ω anti-parasitic resistor prevents the front-end "taking-off" at u.h.f.[1] This "vertical" resistor replaces the tap connecting L_1 to *G1* of Tr_1 and is shown in the photograph just behind the 0.001μF capacitor in the foreground. Coils are 0.1in from the surface of the board as in the

General view of the varicap board fitted to the tuner.



original design. It must be emphasized that these new coil designs only apply to the varicap design.

Tuning control units

A tuner control unit is used with the varicap tuner which is similar to those now being fitted to most single standard u.h.f. television sets.

This particular unit has six selector buttons. Pressing any button releases the previously selected button, and turning the selected button adjusts the tuning. In these units six potentiometers with graded tracks are wired with all tracks in parallel, but with the sliders selected by the action of pushing a button. The grading of the track is such that an approximately linear relationship between potentiometer movement and frequency is achieved when used with a varicap tuner. Various manufacturers fit other extra facilities; for instance the tuning control unit has a switch made when any button is held fully in, so that when tuning a station by rotation of the control knob, and pressing it at the same time, the a.f.c. control can be shorted out. The method of connection of this switch to the tuner is shown in Fig. 3. Many of these tuning control units have such a switch, though not necessarily ganged to the selector mechanism. It is often an additional button at one end. Various values of total resistance are available but a common value is 100kΩ per track, giving a six-button unit a resistance of around 16kΩ with the six tracks in parallel.

Power supplies

The varicap tuner needs a highly stable noise free supply of around 30V to supply the tuning control unit, and the author has therefore devised a suitable circuit, Fig. 4, giving regulated supplies of 30V (nominal), and 12V. An optional 6V supply (stabilized) is also included for use with the Portus and Haywood decoder[2]. The Motorola MC1310 integrated circuit decoder also works well with the tuner and may be run off the stabilized 12V rail. The circuit of the 30V stabilizer uses the SGS TBA271 regulator, which is itself an integrated circuit, but is equivalent to a low temperature coefficient high voltage zener diode. For as good a regulation as possible the device is fed by a constant-current circuit, consisting of a transistor with emitter resistor and the base-emitter voltage stabilized by a zener diode. The temperature coefficients of the forward bias of the transistor and the zener diode are approximately equal and therefore cancel. The use of this constant current feed together with the low slope resistance of the TBA271 gives the main smoothing action of the supply, but this is augmented by the addition of a capacitor to reduce still further the ripple and noise. This capacitor is used together with the series impedance of one of the two pre-set potentiometers (used to set the span of the tuning control voltage) as a simple *RC* filter. The result is a supply with less than 100μV pk-to-pk noise. The 12V supply uses an SGS TBA625B integrated circuit series regulator. This gives a very simple circuit and is current overload protected above 100mA load.

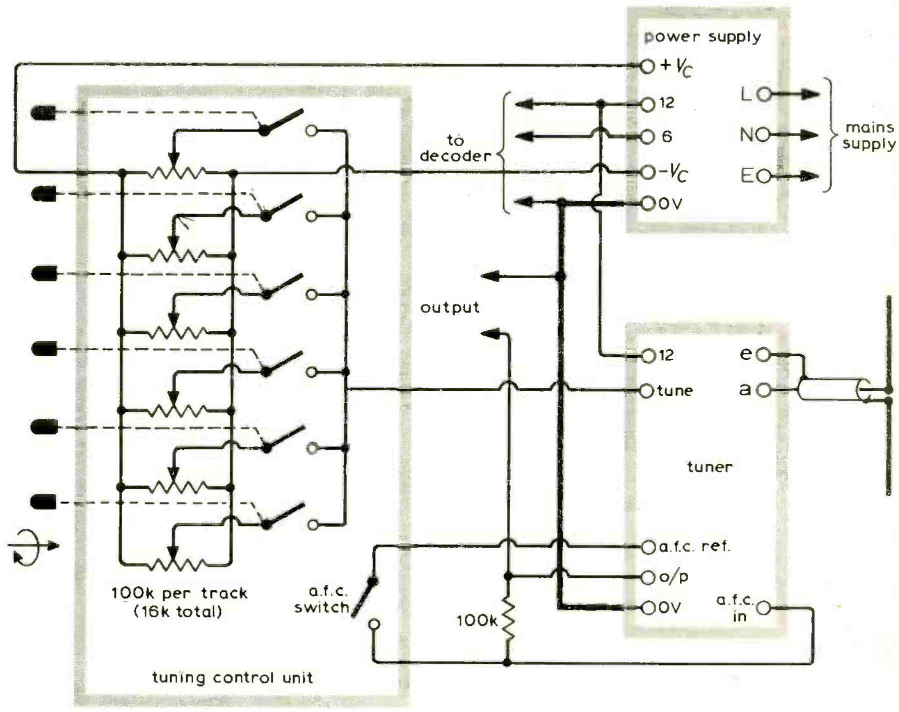
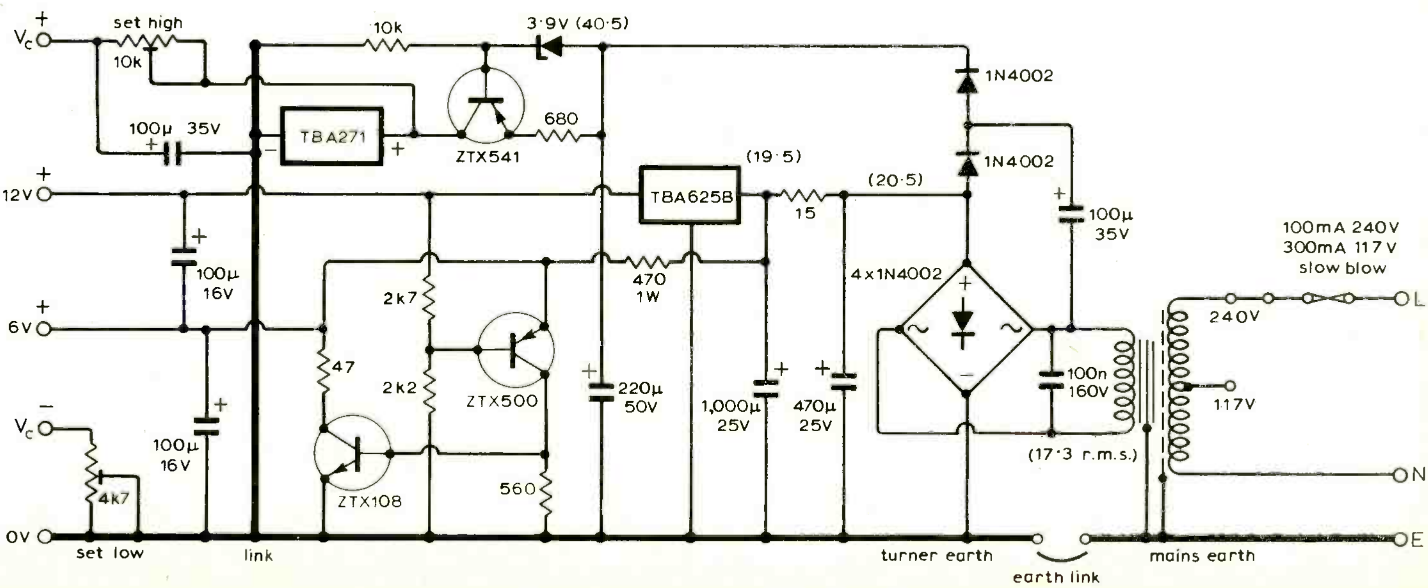


Fig.3. Method of connecting the switches of the tuner control unit to the tuner.

Fig.4. Stable noise free power supply giving regulated 30V and 12V and an optional stabilized 6V supply. Voltage levels in volts are shown in brackets at appropriate points on the diagram.



The rectification circuit for the 30V supply may seem a little odd at first until it is realized that it is a simple voltage doubler but "hung" on top of the rectified supply for the 12V regulator. The voltage doubler only gets half-wave pulses from the side of the bridge rectifier to which it is connected, but the output of the doubler (when added to the main supply) results in a supply approximately twice that of the main supply, without the added complexity of an additional winding on the transformer.

If the 6V supply is omitted then the capacitor between the 6V output and the 0V line should be omitted and replaced by a wire link so that the upper 100μF capacitor is connected to the 0V line.

Varicap setting-up procedure

The first stage in this procedure is to reduce the number of variables by setting the voltage limits of the tuner unit. The limits are set using the two variable resistors of the power supply circuit "set low" and "set high". The two controls interact to some extent and the adjustment must be repeated several times until both are correct. The "set low" control is set for a potential of +2.2V with respect to the 0V line at the bottom extreme of the tuner, and the "set high" control is set for +27.0V at the upper extreme of the tuner control unit. (If BB103-Blue diodes are used in the tuner then the "set low" should be set to +2.7V and the "set high" to +29.0V.)

Following this step the normal alignment procedure is followed, and this is easiest if the first two buttons of the tuning control unit are set to the two extremes of voltage. With the lowest voltage selected the inductors are set, and with the highest voltage selected the trimmer capacitors are set. Initially, it is easier to set the oscillator range in this way and then concentrate on the aerial and r.f. tuning, followed by a final check of all three tuned circuits.

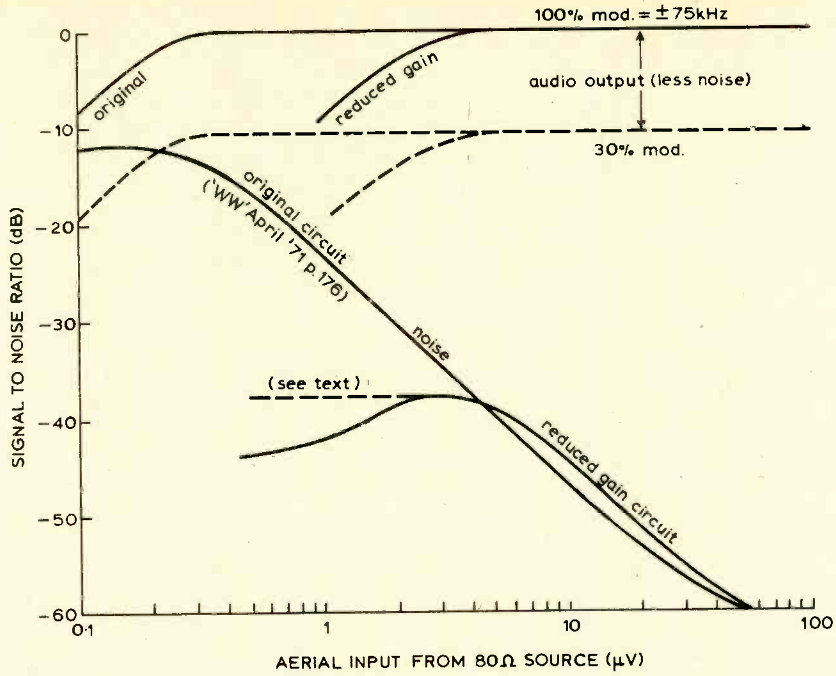


Fig. 7. Noise performance of the modified receiver compared with the original curves of the April 1971 article.

It is important to state that in some tuning control units on the market there is a fixed resistor in series with the low voltage end of the potentiometers. It is therefore important to check the voltage actually available from the tuning control unit at the actual extremes of travel.

The relationship between voltage and frequency is shown in Fig.5, the voltage being plotted on a logarithmic basis.

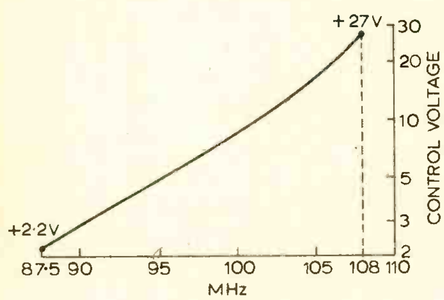


Fig.5. Voltage available from the tuning control unit as a function of frequency.

Performance

Measurements on the prototype tuner indicate that the change to varicap tuning has had no effect on sensitivity or signal to noise ratio, though since the alterations were not made to the original prototype, it is not possible to be absolutely firm on this point. Certainly the performance is well up to the expected level and differs little from the original.

Components

Varicap diodes	Siemens type BB103 Green or Blue (all six diodes must be of the same colour selection. With this proviso matching should not be necessary).
Resistors *(R)*	any value between 100k and 1MΩ $\frac{1}{8}$ or $\frac{1}{4}$W carbon film.
Capacitor	0.001μF ceramic disc, preferably 500V low leakage type.
Mounting	$\frac{3}{8}$in 6 BA spacers (2) and $\frac{3}{4}$in × 6 BA cheese head screws (2) plus washers and nuts (2 each).

All components for tuning board, control unit and power supplies, are available from Integrex Ltd, P.O. Box 45, Derby, DE1 1TW. S.A.E. for details.

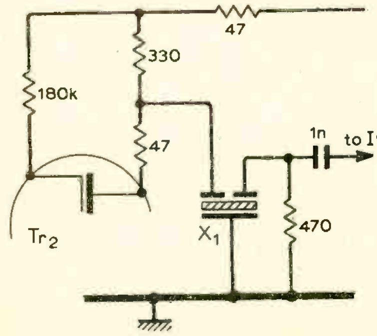


Fig.6. Arrangement after removal of the first stage of the i.f. amplifier for the lower gain version.

Lower gain version

The author has had a number of enquiries regarding the sometimes very high noise level on some tuners when tuning between stations. The optimum level of overall gain practical in a tuner with a given noise factor has been investigated. The conclusion has been that, although helpful to the long distance listener, the full gain of the original tuner does not add greatly to the practical usefulness of the receiver for listening to normal broadcast programmes at reasonable signal strength. Removing the first i.f. stage and coupling the mixer directly to the first i.f. filter provides the necessary simple modifications.

The actual noise level of a receiver is related not only to the noise factor of the receiver, but also to its gain, as even the quietest receiver will be noisy if it has sufficient gain. This is because the "noise factor" is merely a measure of the ratio of the noise output of the actual receiver, compared to that of an ideal receiver. This ratio is expressed usually in decibels. The source in both cases is resistive, and equal to the normal source impedance (in the case of this receiver an 80Ω source).

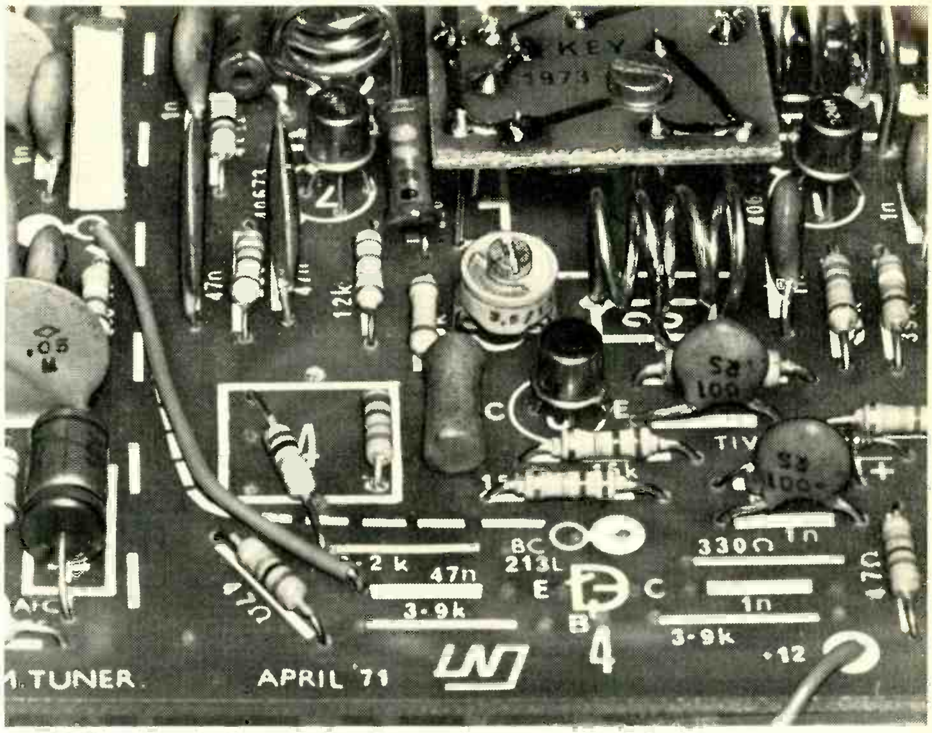
Since the tuner has a number of stages all subject to normal tolerances, it has been found (not unexpectedly) that some receivers are relatively quiet and others almost reach limiting on their own noise. Only ±1dB variation per stage means a variation of overall gain between receivers of 4 : 1, and ±2dB (roughly) ±20%)

will give about 16 : 1 so the apparent differences in noise are hardly surprising.

A "noisy" receiver (but with a noise factor of approximately 3dB), was therefore taken and the first stage of the i.f. amplifier (Tr_4) was removed leaving the arrangement shown in Fig.6. The actual modification is shown (see photograph) where the blank component locations are clearly seen together with the two added resistors and the new link between r.f. and i.f. sections (now only a single wire). The 47Ω resistor lies diagonally across the location of the previously fitted L_4 and the 330Ω resistor is on the right of the outline of L_4.

The noise performance of the modified receiver is shown in Fig.7 which also shows the original curves of the April 1971 article. The curves should merge, but it must be remembered that the figures were measured on two different receivers, and the 2dB difference in the noise levels between 5 and 50μV is therefore quite a good agreement between measurements taken nearly two years apart. The noise level below 3μV should flatten off, not drop as shown. The reason for this is that a slight offset in the i.f. amplifier demodulator stages can result in one sided clipping of low noise levels and this is evident in the output waveform without any injected signal. The effect disappears as soon as the signal level rises appreciably above the basic noise level.

It has been found in this reduced gain version that the interaction between the tuning of the mixer and oscillator tuned circuits is greater though the reason is not immediately obvious. The effect is reduced to normal proportions by moving the tap on L_2 by one turn to the end turn nearest the 100kΩ resistor and Tr_2, as recommended in the varicap tuned version of the receiver. The curves of Fig.7 were taken with this change to L_2.



View of the area where the missing and additional components are located in the lower gain version.

The actual 30dB quieting level of the modified receiver is lower than that of the original receiver according to the curves of Fig.7 (about 1.1μV against 1.9μV), which only proves that anything taken out of context can prove almost anything. The performance should be more than adequate for all normal listening, and the author has received RAD10 Bristol in Bournemouth fairly regularly on a simple loft mounted dipole.

References

1. Letters to the Editor, *Wireless World*, July 1972, p.318.
2. Portus, R. T. and Haywood, A. J. "Phase-locked Stereo Decoder", *Wireless World*, Sept. 1970, pp.418-422.

Experiments with Operational Amplifiers

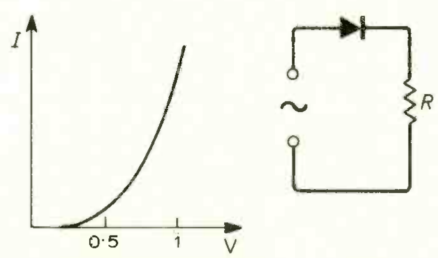
10. Precise rectification with an op-amp and diode combination

by G. B. Clayton, B.Sc., F.Inst.P.

Semiconductor diodes show pronounced non linearity at low forward voltages; in the case of a silicon diode no appreciable conduction takes place through the diode until the forward voltage across it exceeds about 0.5V. As a result of this non linearity diodes give rise to appreciable errors when used to rectify small signals in a conventional rectification circuit. The point is illustrated by the input and output waveforms for a simple diode half-wave rectifier shown in Fig. 10.1.

A circuit which can be used to demonstrate the way in which an operational amplifier diode combination overcomes the effect of diode non linearities is illustrated in Fig. 10.2.

Typical waveforms for the circuit are shown in Fig. 10.3 in which the upper trace is a sinusoidal input voltage, the middle trace is the amplifier output voltage and the lower trace is the rectified output signal.



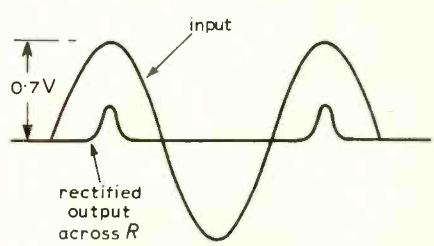


Fig. 10.1. Simple diode rectifier.

The offset voltage potentiometer is adjusted so as to obtain the symmetrical amplifier output waveform shown when a small amplitude input signal is applied. The input amplitude is less than 0.2V in Fig. 10.3; a simple diode rectifier would give no measurable output with such a small amplitude input signal. In the circuit of Fig. 10.2 the diode D_1 is connected in the feedback path of the amplifier so that the initial forward voltage drop required to make the diode conduct is supplied by the amplifier output voltage. Before diode conduction starts the amplifier acts virtually open loop so that the signal required at the input to cause diode conduction is very small, $\frac{0.5}{A_{VOL}}$V. Once the diode D_1 is conducting the effect of its non linearities on the rectified output is effectively divided by the loop gain.

The second feedback path through diode D_2 is included in the circuit to prevent amplifier output saturation on the input half cycles for which D_1 is reverse biased. Note that the circuit can be used to produce gain as well as rectification, dependent upon the ratio R_2/R_1.

Precise rectifier as a.c. millivoltmeter

An operational amplifier, a diode bridge and a d.c. microammeter can be used as the basis for a precise a.c. millivoltmeter. A circuit which can be used to investigate the action and limitations of such an arrangement is given in Fig. 10.4.

The a.c. input signal is applied to the non phase-inverting input terminal of the amplifier. Feedback through the diode bridge forces the voltage across the resistor R to follow the input voltage. A current e_i/R must pass through the bridge, and this current, rectified by the bridge, passes through the d.c. meter. The reading of the meter indicates the average value of the full-wave rectified current. If e_i is the r.m.s. value of the sinusoidal input signal the rectified current through the d.c. meter is

$$\frac{2\sqrt{2}}{\pi} \cdot \frac{e_i}{R}$$

In investigating the action of the circuit it is convenient to measure the d.c. current with a multirange current meter. The meter is initially set to one of its less sensitive ranges, the input to capacitor C is earthed and the offset balance potentiometer is adjusted for minimum current through the meter. The sensitivity of the meter is increased while making this adjustment.

An a.c. signal, of frequency say 120Hz, is now applied. Its value is increased in steps and the reading of the d.c. meter is recorded for each value of the a.c. input signal. Suitable values for the input signal are 2mV, 4mV, 6mV, 8mV, 10mV, (r.m.s. values) and so on through increasing decades.

The linearity of the system can now be assessed. In making this assessment don't forget possible errors or non linearities in the test instruments. Pronounced non linearity, of course, occurs when the amplifier output saturates. The signal at the output of the amplifier should be monitored with an oscilloscope in order to detect the onset of such saturation.

The frequency response of the system may be investigated by applying an input signal of fixed amplitude, say 50mV, and increasing the frequency until the reading of the d.c. meter falls. The reason for this fall in response at the higher frequencies will be obvious if the output waveform of the amplifier is monitored. Amplifier output waveforms for frequencies of 50Hz and 5 kHz are shown in Fig 10.5.

The steps in the upper, 50Hz waveform occur as the amplifier output voltage takes up the diode forward voltage drops. When the frequency is increased to 5kHz (lower trace) the time taken by the amplifier output to overcome the diode forward voltage drops is an appreciable fraction of the period of the waveform and so the average value of the rectified current falls. The system response at the higher frequencies is thus limited by amplifier slewing rate.

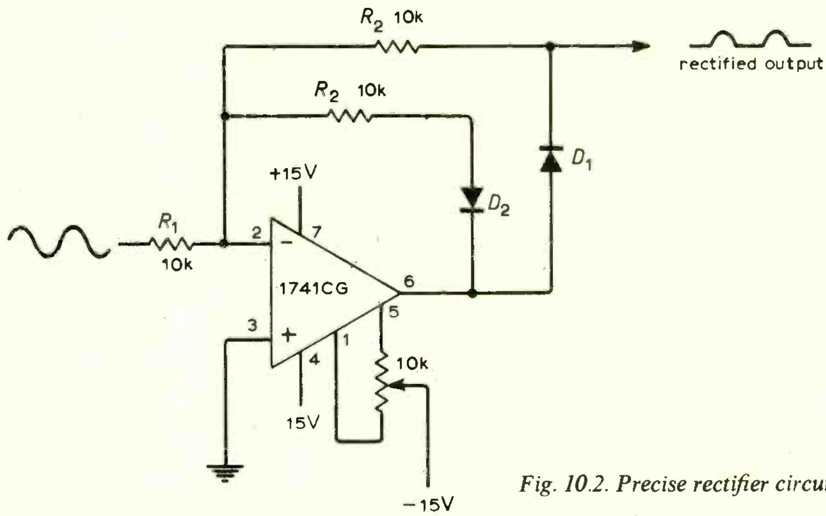


Fig. 10.2. Precise rectifier circuit.

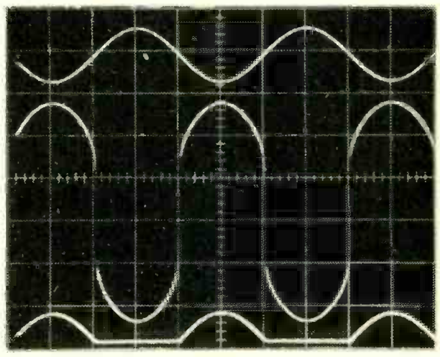


Fig. 10.3. Waveforms for precise rectifier in Fig. 10.2. Horizontal time scale, 1ms/div; vertical scale, 0.2V/div.

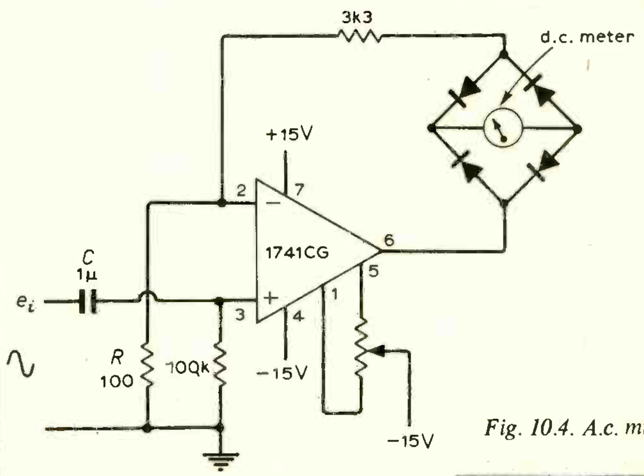


Fig. 10.4. A.c. millivoltmeter.

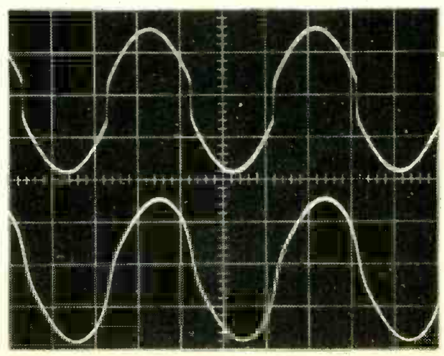


Fig. 10.5. Amplifier output waveforms. Upper trace time scale, 5ms/div; lower trace time scale, 50µs/div. Vertical scale, 2V/div.

25-watt Transistor Transmitter for 20 metres

by S. A. Money, G3FZX

The circuit, forming a basic transmitter, contains three stages operating respectively as crystal controlled oscillator, frequency doubler and power amplifier, and is designed primarily for c.w. transmission.

For many amateurs a major interest of the hobby is that of working stations in distant countries. This can be more readily achieved by using the h.f. bands such as 14 or 21MHz. In order to make one's signal heard above the general din on the bands in their present crowded state, it is highly desirable that the transmitter used should have a power input to the final r.f. amplifier of at least some 20–30W. With an efficient aerial system such a transmitter can provide contacts with stations in all parts of the world.

Choice of p.a. transistor

R.f. power transistors capable of operating at powers of up to 100W have become available in the past few years. These devices are expensive, at prices varying from £30 to £60 each, and are primarily intended for use in military and commercial equipment. Transistors of this type are not readily available to the amateur so the design of this transmitter was based on the use of cheaper and more easily obtainable types.

Many power transistors have a maximum collector voltage rating V_{ceo} of 60 to 80V. When class B or C operation is used, the collector voltage can rise to twice the supply voltage due to the flywheel action of the collector tuned circuit. To allow an adequate margin of safety the supply rail should not be more than 24 to 28V.

If we assume a power input of 25W, the mean d.c. collector current will need to be about 1A with a 25V supply. In class B, the peak collector current will be roughly three times the mean d.c. value. For class C, the peak current may be as high as four times the mean value. Under these conditions therefore the p.a. transistor used must be capable of handling peak values of collector current up to 3 or 4A.

Assuming that the efficiency of the p.a. stage will be about 60%, the transistor must be capable of dissipating about 10W. This requirement rules out transistors in TO5 cans and implies the use of TO3, TO66 or other high power dissipation types.

In order to have reasonable power gain and to maintain stable operation, the transition frequency (f_T) should be at least five times the frequency at which the amplifier operates. For 14MHz operation this requires an f_T of at least 70MHz.

The transistor chosen for this stage of the transmitter was the Mullard type BD123, which has a V_{ceo} of 80V. Its maximum peak collector current is 5A and the f_T is 85MHz. The BD123 is mounted in a TO3 can and will dissipate up to 35W safely if it is mounted on a sufficiently large heat sink.

Power amplifier design

The final stage of the transmitter Tr_3, Fig. 1, runs at 25W input with a BD123 transistor operating in the class B mode. Class B operation was chosen because, although it is less efficient, it produces lower harmonic output and needs less drive power than an equivalent class C stage.

To obtain optimum power transfer, this

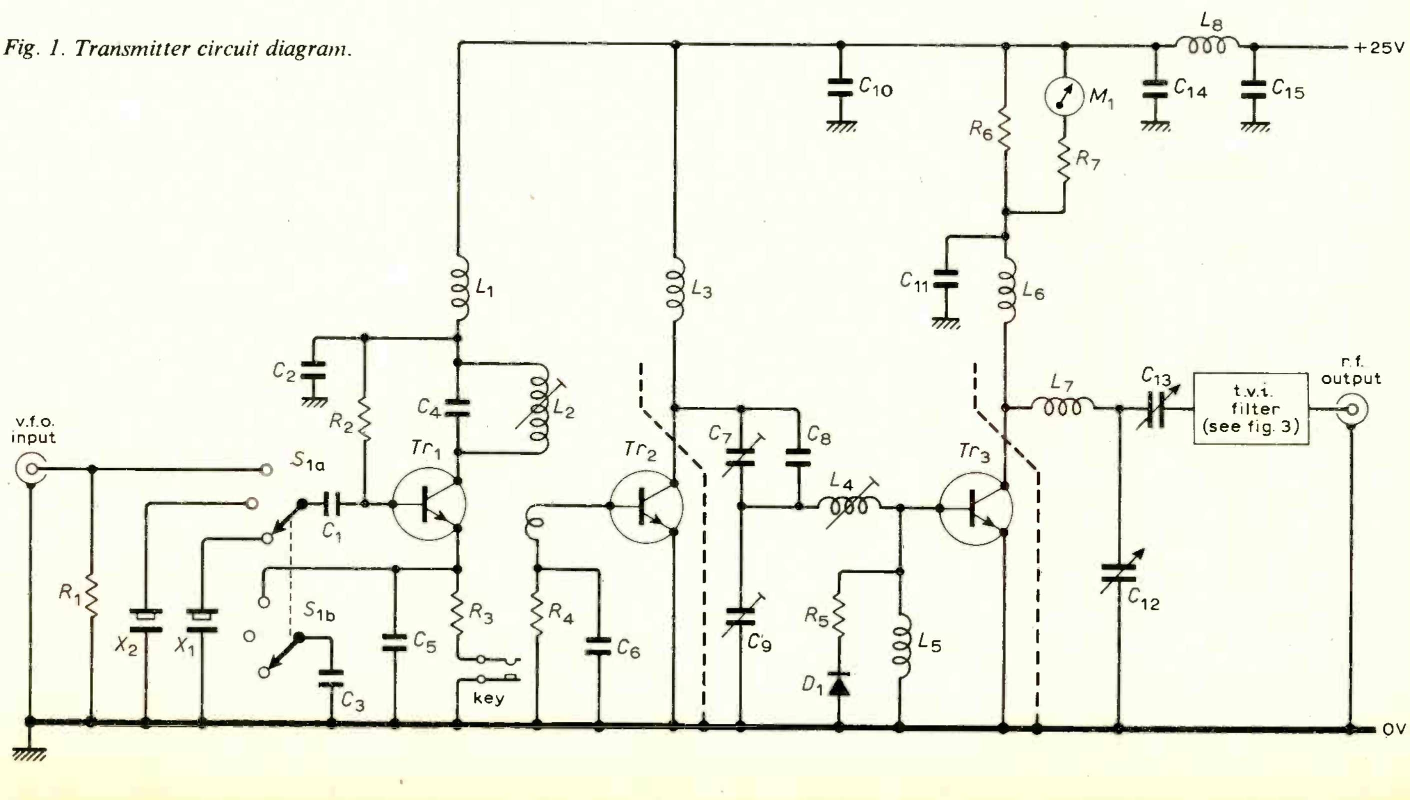


Fig. 1. Transmitter circuit diagram.

stage must be correctly matched to the load. The output impedance of this transistor is made up of a resistive component R_p in parallel with a capacitive component X_p representing the collector capacitance and circuit strays.

The value of R_p can be calculated from the formula,

$$R_p = \frac{V_s^2}{2P_o}$$

where V_s is the d.c. supply voltage and P_o is the power output from the stage. The value for the power output is assumed to be about 60% of the power input since this is a reasonable value for the efficiency of a class B stage. With V_s at 25V and P_o at 15W this gives a value of roughly 20Ω for R_p. The capacitance of the transistor and circuit strays is about 100pF which, at a frequency of 14MHz, represents a reactance of approximately 125Ω.

The matching network used to couple this amplifier stage to the load must not only match the two impedances but also provide sufficient selectivity to reduce the output of harmonics to an acceptable level. A good compromise can be obtained between power transfer and harmonic output by designing the matching circuit to have a loaded Q value somewhere between 10 and 15. In this transmitter it was decided to aim for a Q value of 12.

In many transmitters using valves for the output stage, the matching to the load is achieved by using a low-pass Pi section network. Unfortunately this type of network is only effective if the ratio between the source and load impedances is fairly high. If the two impedances to be matched are similar in value it becomes impracticable to design a Pi network which will have the required value of working Q. In the output stage of this transmitter, the impedance ratio is only about 3:1 if we assume that the load is a normal 70Ω aerial feeder cable properly terminated.

It would be possible to match this ratio of impedances by using two Pi networks in cascade with one network having a very low Q value. However, a more attractive solution is to use the T type network shown in Fig. 2. This particular type of circuit is most suitable for transistor transmitters because it easily matches two similar impedances.

The equivalent circuit of the transistor is shown as an impedance represented by series resistance R_s and capacitive reactance X_s. As a first step in the design of the network the parallel impedance values R_p and X_p must be converted into their equivalent series form by using the two equations

$$R_s = \frac{R_p}{1+(R_p/X_p)^2}$$

and

$$X_s = \frac{R_s R_p}{X_p}$$

For the BD123 stage the value for R_s will be about 20Ω and the value for X_s will be around 4Ω. At this point the value of the series inductance L_1 can be calculated from:

$$XL_1 = QR_s + X_s$$

If we are designing for a Q of 12 then XL_1

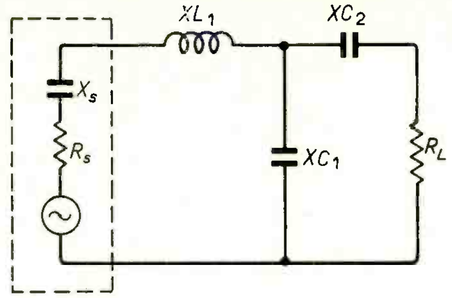


Fig. 2. A "T" matching network.

will be 240Ω which at 14MHz represents an inductance of 2.7μH. A coil to give this inductance consists of 16 turns of 16 s.w.g. enamelled wire close wound with a diameter of ¾in. The coil length will be about 1¼in and the coil should be completely self supporting.

In order to find the values for the tuning and loading capacitors C_1 and C_2 two constants A and B must be calculated from

$$A = R_s(1+Q^2)$$

and

$$B = \sqrt{(A/R_L)-1}$$

where R_L is the load impedance which is assumed to be a pure resistance. If R_L is taken as 70Ω then the value of A will be 2900 and B will be 6.4.

At this point the reactance values for the tuning and loading capacitors can be found from:

$$XC_1 = \frac{A}{Q-B}$$

and

$$XC_2 = BR_L$$

which give values of XC_1 = 480Ω and XC_2 = 448Ω. The corresponding capacitors will have values of 24pF and 25pF respectively at a frequency of 14MHz. In the actual transmitter these capacitors C_{12} and C_{13} are 50pF air-spaced variable types. In the prototype transmitter 100pF variable capacitors were used with 100pF fixed capacitors in series to reduce the maximum value and to make the tuning adjustment easier. It should be noted that both the stator and the rotor of capacitor C_{13} are live and this capacitor must therefore be insulated from the panel which is grounded. These two capacitors may be of the preset type since the tuning adjustment will remain correct over most of the 14MHz band.

Since the output is taken off in parallel from the collector of the power amplifier stage an r.f. choke L_6 is required to feed the d.c. supply voltage to the collector. This choke has an inductance of about 15μH and consists of 100 turns of 28 s.w.g. enamelled wire close wound in one layer on a 2in length of ⅜in diameter s.r.b.p. rod. A similar choke L_5 is used from base to ground but in this case the winding consists of 120 turns of 30 s.w.g. wire wound in one layer on a ¼in diameter rod.

Diode D_1 and resistor R_5 are included in the base circuit of the transistor to protect it during the half cycle when the base is reverse biased. For a BD123 the reverse base to emitter breakdown voltage is only 5V whereas the unloaded base drive signal may exceed 10V peak unless a diode limiter circuit is used. It was found that the addition of a diode limiter actually tended to increase the base drive current to the p.a.

It is essential that the inductance of the emitter to ground lead from the p.a. transistor should be kept as low as possible to prevent instability. The actual wire should be as short as practicable and of heavy gauge. All other earth returns for this stage should be connected to the chassis at the same point as the lead from the emitter.

Frequency doubler and oscillator

For the frequency doubler stage Tr_2 a second BD123 transistor is used. This stage is operated in class C to obtain maximum harmonic output.

The p.a. stage has an effective power gain at 14MHz of about 10dB. This means that it requires an input drive signal of some 1.5W from the doubler stage. Since the efficiency of the doubler stage is not likely to be better than 25%, its d.c. collector input power will need to be 6 to 8W in order to produce the required drive power. The mean d.c. collector current drawn by this transistor is between 250 and 300mA.

Matching between Tr_2 and Tr_3 is via a T network similar to that used at the p.a. collector. The inductance of L_4 needs to be 3μH which is obtained by winding 20 turns of 26 s.w.g. wire in a single layer on a ⅜in diameter former. This former is of the type used for television i.f. coils and is tuned by a 6mm dust core. This dust core is adjusted in conjunction with variation of C_7 and C_9 to give correct tuning and matching. The r.f. choke L_3 is made in the same way as L_6 in the p.a. stage.

The 7MHz drive signal from the oscillator stage Tr_1 is link coupled to the base of Tr_2. Resistor R_4 and capacitor C_6 give the reverse bias needed for class C operation.

In the interests of simplicity a crystal controlled oscillator is used for frequency control. The value of the emitter bypass capacitor C_5 is chosen so that a large phase shift is produced in the emitter circuit. Positive feedback then occurs, the quartz crystal ensuring stable oscillation.

A switch S_1 has been included to enable one of two alternative crystals to be selected, allowing transmitter frequency to be easily changed. Since the average amateur tends to have a collection of crystals in different types of holders, it is convenient to make sockets available for two different types.

Unless a wide selection of crystal frequencies is available, operation of the transmitter would normally be limited to one or two frequencies. To allow greater flexibility of operation, therefore, provision has been made to drive the transmitter from an external v.f.o. With S_1 set in its third position, the v.f.o. input is applied to Tr_1 which acts as a straightforward amplifier.

To ensure stable operation of Tr_1 as an amplifier, the base circuit is shunted by a low resistance R_1 and the emitter bypass capacitor is increased to 0.047μF.

Keying of the transmitter is carried out by simply breaking the d.c. feed to the emitter of Tr_1. When the stage is operating as a crystal oscillator, keying is quite clean with no "chirp" or key clicks. When the oscillator is keyed-off, no drive signal is applied to the doubler and p.a. stages so that they both remain cut-off.

Harmonic filter

In common with other amateur band transmitters this unit can cause quite severe harmonic interference on nearby television receivers unless some form of low pass filter is included in the output circuit. Details of a t.v.i. filter used in this transmitter are given in Fig. 3 which is a five section filter with constant *k* middle sections and *m* derived half sections at the ends to give better impedance matching. Nominal roll-off frequency of this filter is 20MHz and its characteristic impedance is 70Ω.

Without a filter the transmitter harmonic radiation caused complete wipe out of Band 1 signals on a television receiver 15ft from the aerial. With the filter in the circuit, interference was reduced to a slight pattern.

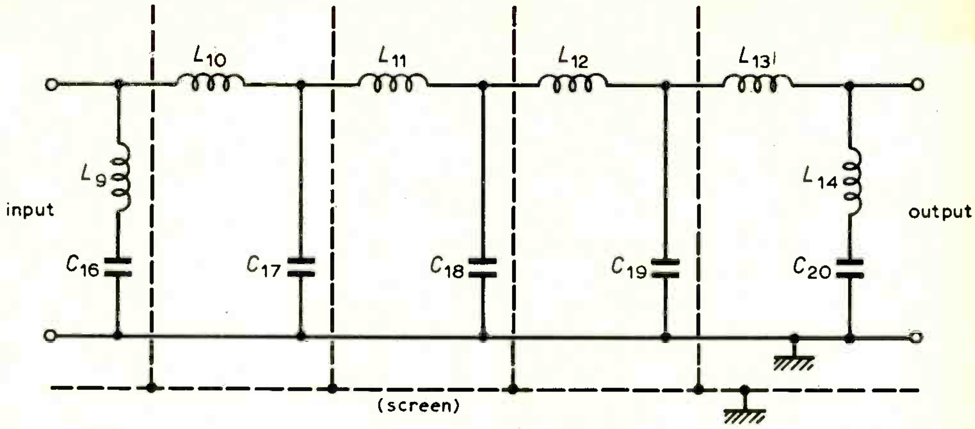


Fig. 3. Harmonic suppression filter to prevent television interference.

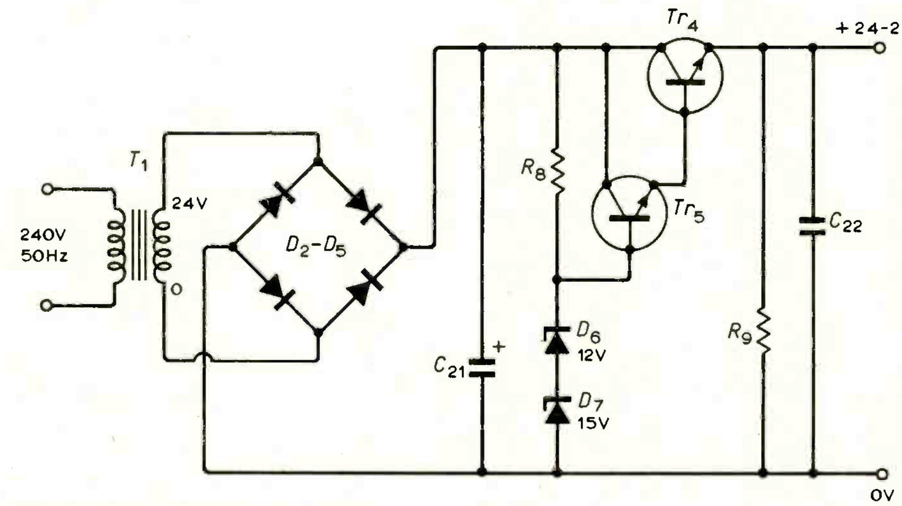


Fig. 4. Power supply circuit diagram.

Construction

Layout of the transmitter does not seem to be very critical, provided that normal r.f. construction techniques are used such as keeping leads short and making use of single point earth returns for each stage.

The transistors used in the p.a. and doubler stages are required to dissipate a few watts of power when the transmitter is radiating, and to avoid overheating they must be mounted on some form of heat sink.

To avoid unwanted feedback and possible instability, it is a good idea to mount a screen between the base and collector circuits of each of the stages. It is convenient to make these screens perform a dual function as both screen and heat sink for the transistors. Mica washers are used to insulate the transistors from the screen whilst allowing conduction of heat.

To obtain good heat conduction the screens must be made of aluminium at least $\frac{1}{16}$in thick. In the prototype transmitter the screens used were 4 × 2 inches of 16 s.w.g. aluminium and were solidly connected to the chassis and case of the transmitter to improve heat transfer. Under normal keyed operation, the p.a. transistor heat sink will run slightly warm after a long period of transmission.

If it is desired to run the transmitter with continuous carrier output, such as for n.b.f.m. working, the heat sink used for the p.a. stage must be made larger. A standard finned type heat sink giving about 4° C/W should however be large enough for use under these conditions.

The t.v.i. filter must be mounted in the same case as the transmitter. Individual sections of the filter must be screened from one another to prevent direct coupling of harmonics. This is indicated in Fig. 3. To avoid mutual coupling coils in adjacent sections of the filter are mounted at right angles to one another.

Power supply

An external 24 to 28V power supply is used for the transmitter. This supply must be either stabilized or regulated to handle the large variations in current drawn by the transmitter. With the key down the current drawn from the supply will be about 1.5A, whereas with the key up the current will be virtually zero.

An r.f. filter comprising L_8, C_{14} and C_{15} (Fig. 1) is included at the point where the power supply lead enters the case of the transmitter. This filter is intended to prevent leakage of r.f. signals into the power supply leads which could cause unwanted radiation.

A circuit of a suitable power supply for use with the transmitter is given in Fig. 4. A 2N3055 transistor Tr_4 is used as a series regulator. The output voltage is set by the two zener diodes D_6 and D_7 which drive the base of the series transistor via the emitter follower Tr_5. The 2N3055 transistor will need to be mounted on a heat sink since it will have to dissipate about 4 to 6W when the transmitter is radiating.

While carrying out initial tests with the transmitter it is useful to be able to supply only 12V, which reduces the possibility of destruction of transistors due to mistuning or overloading. By tapping the base of Tr_5 at the junction of the two zener diodes, an output of about 12 to 15V is obtained.

Testing and tuning

Monitoring of the collector current to the p.a. stage is provided by measuring the voltage drop across the 1Ω resistor R_6 using a 1mA meter in series with a 1kΩ resistor R_7.

A 70Ω dummy load will be needed when setting up. This can easily be made up from four 68Ω carbon, or other non-inductive type, resistors which are wired in series/parallel to give a total value of 68Ω. Each of these resistors must be rated at 2 or 3W.

To give a visible indication of the power output a 2.5V, 0.3A torch bulb is connected in series with the dummy load. At full power output from the transmitter the current in the dummy load will be about 0.5A. Since this level of current will overload and possibly burn out the lamp it is advisable to connect a low value resistor across the lamp during the later stages of testing.

Before starting any tests the transmitter wiring should be checked for any possible errors. Capacitors C_7, C_9, C_{12} and C_{13} should all be set at roughly half their maximum value. At this point the supply, set to 12V, may be applied. With the key circuit open no current should flow.

To check the oscillator stage connect a voltmeter across R_4 with the positive lead connected to ground. A 7MHz band crystal is now plugged in the circuit and the key closed. Adjust L_2 until a voltage is obtained across R_4 which indicates that the oscillator is running and drive is being applied to the doubler stage.

There should at this point be some current flowing in the output stage. Adjust L_4 to produce the maximum current on the meter M_1. The capacitors C_{12} and C_{13} may now be adjusted to obtain maximum current into the dummy load.

With power being delivered to the load

and the p.a. and doubler stages roughly tuned to resonance, the full supply voltage can be applied. The network L_4, C_7 and C_9 are adjusted together to produce maximum p.a. collector current which should be about 0.9 to 1.0A. Adjust C_{12} and C_{13} again to produce maximum brilliance on the dummy load indicator lamp. These adjustments will be found to be interdependent, but as a rough guide C_{13} adjusts the load coupling and C_{12} is used to tune the circuit to resonance. It will be found that if C_{13} is made too large or too small there will be a fall off in the maximum achievable output. The capacitors should be adjusted to give an optimum between these states. The settings will be fairly broad and, once set up, they should hold over a large part of the 14MHz band.

Performance

Over the past two years two versions of this solid state transmitter have been used on the 14MHz band. One transmitter was only run at 12W input whilst the later unit was run at the full 25W. In both cases the aerial used was a rather inefficient indoor dipole running NE to SW.

Contacts with all parts of Europe were found to be easily made and consistent reports of signal strengths from S-7 to S-9 were obtained. Working stations in Asia, Africa and North America is naturally a little harder but reports averaging S-5 to S-8 are regularly received during contacts with the U.S.A. and Canada. So far it has not been possible to contact Australia but this is probably due to the orientation of the aerial which does not favour Australia and the Pacific area.

Components list

Resistors

R_1	100Ω	R_6	1Ω 3W
R_2	33kΩ	R_7	1kΩ
R_3	100Ω	R_8	330Ω
R_4	330Ω	R_9	4.7kΩ
R_5	10Ω		

All resistors ½W unless otherwise stated

Capacitors

C_1	0.002μF	paper
C_2	4700pF	ceramic
C_3	0.047μF	polyester or paper
C_4	330pF	mica
C_5	330pF	mica
C_6	1000pF	ceramic
C_7	3–40pF	tubular trimmer
C_8	22pF	mica
C_9	3–40pF	tubular trimmer
C_{10}	0.047μF	polyester or paper
C_{11}	0.047μF	polyester or paper
C_{12}	50pF	air spaced variable
C_{13}	50pF	air spaced variable
C_{14}	0.047μF	polyester or paper
C_{15}	0.047μF	polyester or paper
C_{16}	68pF	mica
C_{17}	220pF	mica
C_{18}	220pF	mica
C_{19}	220pF	mica
C_{20}	68pF	mica
C_{21}	10,000μF	36V
C_{22}	0.47μF	polyester or paper

Semiconductors

Tr_1	BFY51	D_1	1N4001
Tr_2	BD123	D_2–D_5	3A, 100–1000 p.i.v. silicon diodes
Tr_3	BD123		
Tr_4	2N3055	D_6	12V, 400mW zener diode
Tr_5	2N2219		
		D_7	15V, 400mW zener diode

Inductors

L_1	2.5 mH r.f. choke
L_2	Primary—14 turns 26 s.w.g. enamelled Secondary—4 turns 26 s.w.g. enamelled, wound at d.c. supply end of primary Former—Neosid 8mm diameter with dust core
L_3	100 turns 26 s.w.g. enamelled, close wound on ⅜in diameter s.r.b.p. rod
L_4	20 turns 26 s.w.g. enamelled Former—Neosid 8mm diameter with dust core
L_5	120 turns 30 s.w.g. enamelled, close wound Former—¼in diameter s.r.b.p. rod
L_6	Same as L_3
L_7	16 turns 16 s.w.g. enamelled, close wound ¾in diameter, self supporting 1¼in long
L_8	20 turns 18 s.w.g. enamelled, close wound ¼in diameter self supporting
L_9	12 turns 18 s.w.g. enamelled, close wound ¼in diameter self supporting
L_{10}	18 turns 18 s.w.g. enamelled, close wound ¼in diameter self supporting
L_{11}	Same as L_{10}
L_{12}	Same as L_{10}
L_{13}	Same as L_{10}
L_{14}	Same as L_9

T_1	50Hz mains isolation transformer with secondary winding of 0–24V, 2–3A

Microwaves at the Physics Exhibition

Impatt diode applications

The Impatt diode is challenging the travelling-wave-tube in many respects. An amplifier shown by S.T.L. provides an output of 1W c.w. at 8GHz, and requires 120V d.c. supply, a great advantage over currently available t.w.ts. The amplifier comprises four cascaded stages, circulator coupled, and each stage is provided with its own constant-current and transient protection circuits allowing the simplest of external d.c. supplies to be used. A novel design for each amplifier circuit is used so that each of the four stages can use the same type of matching circuit to provide the optimum gain and bandwidth characteristics with reduced manufacturing problems. Overall, it provides a bandwidth of 250MHz at 8GHz — prototype centre frequency — with 40dB of gain but this can be increased to 400MHz by overdriving to a reduced gain of 30dB. Silicon Impatt diodes used in the prototype yield better than 70% operating efficiency but work is now going on to replace these with the more efficient gallium arsenide devices, around 15%. (Overdriven Impatt diode amplifiers are necessarily non-linear and obviously not suitable for a.m. systems.)

Phase switching, usually performed by p-i-n diodes at a loss in microwave phase modulation systems, can be achieved with Impatt diodes with the advantage of power gain, as demonstrated by the Services Electronics Research laboratory. An Impatt diode, forming the termination of a transmission line, reflects signals that are incident with magnitude and phase depending on the values of the real and imaginary parts of the diode terminal admittance. Under conditions of reverse bias, where avalanche current is flowing, the diode conductance can appear negative over a wide range of frequencies and therefore can provide signal gain where the reflected wave is greater than that of the incident wave. The magnitude of the reflected wave basically depends on the real or conductive components of the diode equivalent circuit whereas the phase is associated with the imaginary or shunt reactance part of the model.

A situation can arise where at or near the avalanche transit-time frequency, the conductance component can be equal at two different levels of diode current, but because the series inductance element is a function of this current the phase delay at these two currents is different. In the demonstration, the diode current was switched alternatively between two values, chosen to give the same amplifier gain, providing phase switching of up to 180° with small-signal gains of about 10dB with very little amplitude modulation. For further details, see *Electronics Letters,* vol.8 no. 19.

Q-band communications

A lightweight Q-band communications link capable of handling data rates of up to 1Mbit/sec has been developed by Decca Radar Ltd. Designed for short-distance communications of up to 5km, the link can be tuned to any frequency in the 26.5 to 40GHz band. The demonstration link was operated with a Gunn device transmission source providing a c.w. power output of around 7 to 10mW at approximately 34GHz, pulse modulated at 1MHz with a p-i-n diode circuit. The Gunn devices are apparently operating in the $n\ \lambda/2$ mode in full-height waveguide and it is claimed that little trouble has been found with moding or hysteresis. Aerial gain is greater than 30dB with parabolic reflectors of around 25-cm diameter and the hardware is mounted in the case space behind the box-shaped aerial mounting.

The receiver uses a similar Gunn oscillator, suitably attenuated, to drive the Q-band mixer which, it is said, maintains its sensitivity figure over at least a 6dB variation in local oscillator power — very useful for long-term gain stability. The overall noise factor, with 50MHz i.f. bandwidth, of <12.5dB allows good link range, easy tuning and a minimal drift problem.

Unusual forms of Analogue Modulation

A discussion of the importance of a.g.c.

by R. C. V. Macario, B.Sc., Ph.D., M.I.E.E.*

Some time ago the writer questioned the merits of simple diode detection and suggested that more complicated detector circuits could have advantages in the design of radio receivers.[1] Many such designs have been appearing, especially in broadcast receiver technology[2,3] and in mobile radio communication equipment.[4,5,6]

There is no doubt that these more complex circuits can perform some remarkable signal recovery, but one soon discovers an interesting feature in that automatic gain control (a.g.c.) prior to signal detection takes on a new importance. It is interesting to note that hardly any of the above references discuss the a.g.c. problem, yet it is an unfortunate fact that many of the detection circuits described do not operate in a practical environment unless well controlled automatic gain control is available. The great merit (or one of them at least) of the diode detector is that it provides its own a.g.c., at least on full carrier a.m. modulation.

The great merit of frequency modulation is likewise, that it provides its own form of a.g.c. by limiting, and system equipment designers are much more tempted to stay with systems where some of the circuit problems are automatically eliminated.

Other forms of modulation

If, however, a restriction is placed on channel bandwidth, or the maximum range for a given primary power is a priority, other forms of modulation become of interest. In particular the transmission of speech is considered since this, in the main, possesses the large amplitude fluctuations which are so difficult for the automatic gain control circuits to cope with in a completely satisfactory manner. The speech bandwidth can take two values, (a) broadcast quality, say 40Hz to 4000Hz, and (b) communication quality, say 300Hz to 3000Hz, and this can be a restriction which may have to be noted.

The modulations to be described fall into three categories:

1. The speech signal to be transmitted is completely amplitude suppressed so that it no longer possesses any amplitude fluctuation and so a.g.c. is hardly necessary.
2. The speech signal is amplitude suppressed as in (1), but an additional coded signal is transmitted so that some of the speech amplitude fluctuations can be recovered and reinstated.
3. The speech signal is not suppressed (more than usual) but a variable carrier is transmitted so that the total signal has more or less a constant amplitude — rather like f.m.

All of these systems need a more complicated transmitter processor and a more complicated receiver detector circuit, but in all cases the a.g.c. can act on the average signal and retain the old envelope detector simplicity.

Category 1. Completely amplitude suppressed speech is identified with the infinitely clipped speech experiments of Licklider and Pollack[7] who showed that the speech intelligence is maintained under these conditions. A direct and efficient method of achieving this form of speech is shown[8] in Fig. 1. The speech signal, category (b), is converted to a single sideband signal and then infinitely clipped by a limiter. The residual carrier is adjusted so that during speech pauses the remaining carrier constitutes the output and suppresses the noise.[9] A simple filter, following the limiter, suppresses the harmonics of the clipped r.f. waveform.

If one listens directly (via a converter back to audio of course) the speech "quality" is surprisingly good, and one finds the improvement in talk power is at least ± 10dB. However, if one listens to the system after transmission through a radio system with some attendant distortion, the "quality" is degraded very rapidly. This appears to be a fundamental disability of infinitely clipped speech, but improvements have been reported. For in-

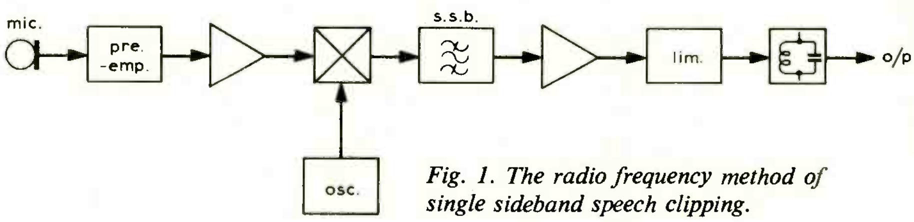


Fig. 1. The radio frequency method of single sideband speech clipping.

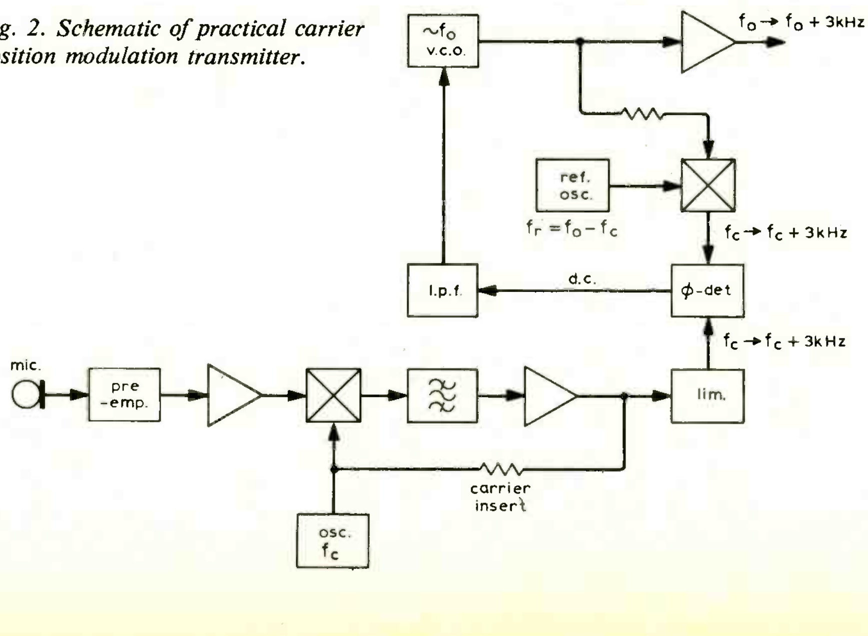


Fig. 2. Schematic of practical carrier position modulation transmitter.

stance James and Daley[10] report a significant improvement if the speech band is split up into a number of smaller channels, clipped individually and then reconstituted then the quality is indeed quite remarkable.

Applied to a radio communication system this form of modulation seems to appear under two names. Thus in amateur radio circles[11] it is known as infinitely-clipped phase-locked s.s.b. (p.l.s.s.b.), which is, as far as one can ascertain, identical to a General Electric mobile radio system known as carrier position modulation — c.p.m.[12]. The transmitter arrangement for both methods may be shown as Fig. 2. It will be seen in this diagram that the speech processor of Fig. 1 precedes the carrier phase lock circuits, which in turn can be followed by class C r.f. amplifiers. During periods of speech a constant-amplitude suppressed-carrier signal is transmitted, during speech pauses a full carrier is transmitted; whence the name carrier position modulation, since a change only in frequency occurs, not in amplitude.

Now the main advantage from the point of view of the present discussion of carrier position modulation, or phase-locked single sideband, is that a.g.c. in the receiver is now a simple matter, if indeed necessary at all, since there is no amplitude information to be recovered from the received signal. However the "quality" of the signal under practical conditions would need careful study.

The efficiency of this form of modulation with regard to transmission range, bearing in mind class C operation of stages can be employed and it also only occupies approximately a 3kHz signal bandwidth, is noted in Fig. 3.

This graph[12] plots measured word intelligibility against received signal level in receivers having the same front end noise figure and optimum bandwidth for the modulation concerned — which is noted. Bearing in mind that +6dB would also be equivalent to raising a transmitter power from 25W to 100W, the advantage of c.p.m. is noteworthy. The curve for the narrow band f.m. signal is actually some 3dB above the theoretical[13] achieved by pre-emphasis and slight bandwidth clipping.

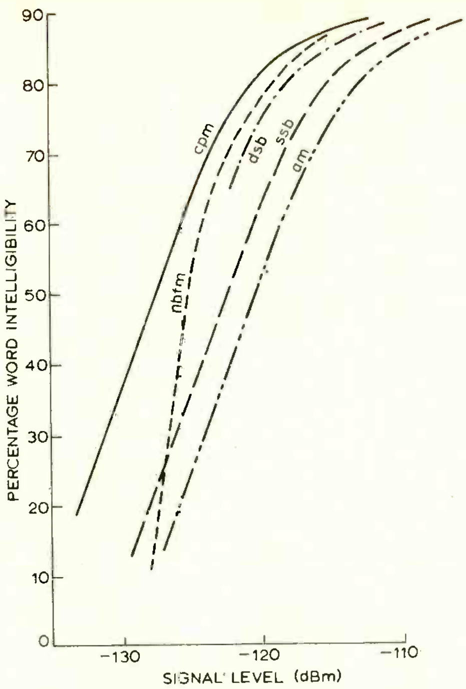


Fig. 3. Threshold intelligibility performance of amplitude modulation, single sideband, double sideband suppressed carrier, narrow band frequency modulation and carrier position modulation.

Category 2. As mentioned, infinitely-clipped speech works well until there is some attendant distortion in the transmitter-receiver link. Therefore a number of modulation systems have been "invented" which overcome this fact by restoring amplitude information to the received signal from information received in a pilot signal transmitted alongside the main signal.

The best known system in this class of modulation is of course "Lincompex"[14], and since this has been very well described no more will be said about it here.

An earlier family of similar systems are the "Frena" and "Frenac" systems[15] of speech transmissions. The primary purpose of these systems is to improve performance under adverse signal-to-noise conditions, and an estimate of this fact is attempted in Fig. 4. In this diagram, which has the same ordinate as Fig. 3, are superimposed the intelligibility results given by Jagger and Greefkes for their "Frena" system. Their method of assessing intelligibility employed recognizable sounds, whereas the more recent tests (scale of Fig. 3) employ words, so one would expect a difference between the two methods especially with regard to the fall-off in intelligibility. But this does not hide the significant feature that the "Frena" system does demonstrate the wanted improvement.

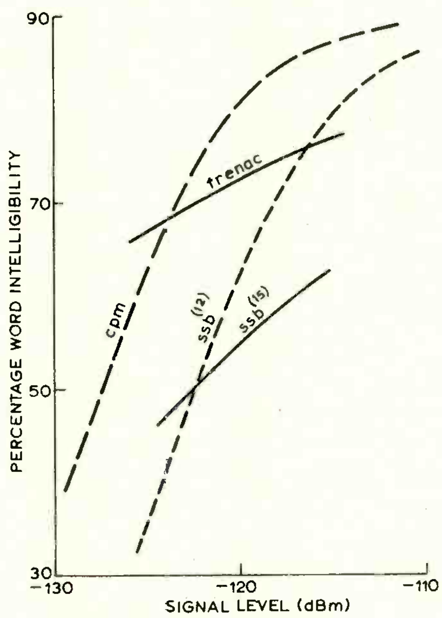


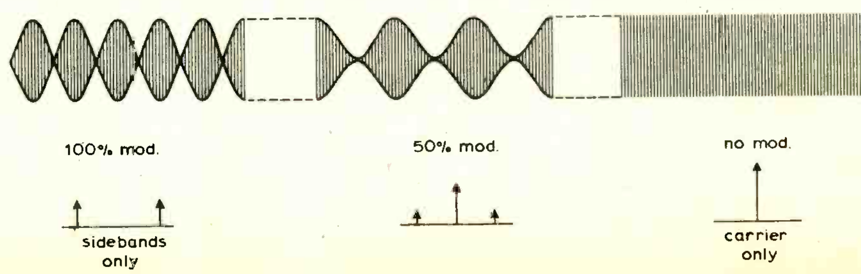
Fig. 4. Estimated threshold intelligibility performance of "Frena" compared to single sideband and carrier position modulation.

The feature of main interest to the discussion, however, is the question does the system assist the a.g.c. problem? The answer is yes, if the control tone (amplitude information) is an f.m. signal and the main speech channel has a constant amplitude. The total signal transmitted is then of constant amplitude. Of even greater interest is to note the nature of the "Frenac" system. Here the control tone is pulse modulated, and it is arranged that "the pilot signal has a certain constant value when speech is absent, and is zero when it is present. This amounts to saying that the frequency signal and the amplitude signal are transmitted in turn, and the obvious course is to transmit them at the same amplitude. The carrier of the single-sideband signal in the frequency channel can profitably be made to act as pilot signal."

It would therefore appear that "Frenac" p.l.s.s.b. and c.p.m. are in reality the same form of modulation, possibly constructed in different ways, but providing the same meritorious features.

Category 3. In the final category, the speech waveform is less severely processed and the systems lie between the previous systems and straightforward single sideband and double sideband suppressed carrier. Now it is common practice to provide voice operated a.g.c., especially for s.s.b. (A3J telephony) which works very well in the main if the a.g.c. circuit is sufficiently sophisticated, i.e. Plessey device SL621, but if the detector has to establish synchronization before an audio waveform is generated, as in the case of double sideband suppressed carrier[4,13], this form of a.g.c. is unworkable. An a.g.c. voltage can be derived by envelope detecting the incoming signal (out of the i.f. stages), but here again the correct choice of time constant is difficult if this detector is to distinguish between, say, rapid fading and a speech waveform. Therefore systems have

Fig. 5. The waveform and spectrum of double sideband controlled carrier.



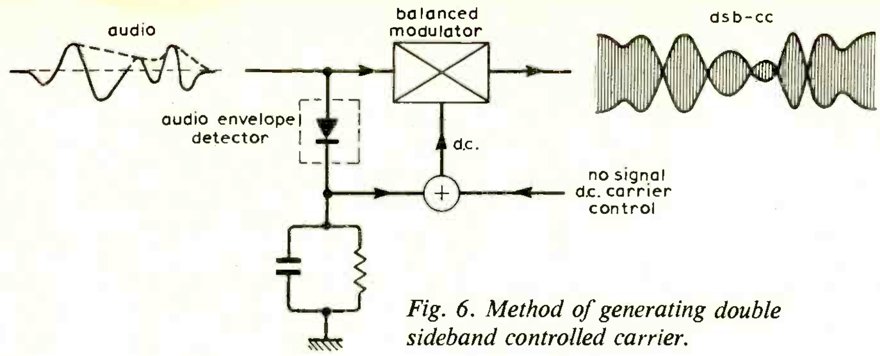


Fig. 6. Method of generating double sideband controlled carrier.

been proposed in which the carrier amplitude is made to vary inversely as the sideband amplitude[16].

Fig. 5 illustrates the action of the controlled carrier on a double sideband controlled carrier signal. It will be seen that there is a gradual take over of the signal energy by either the carrier or the sidebands, depending on the amplitude of the sidebands. The waveform would be similar for two tone single sideband controlled carrier. In either example this contrasts to the almost snap change-over action of the carrier position modulation, phase locked single sideband or "Frenac" system.

A means of generating d.s.b.-c.c. is shown in Fig. 6. In effect the quick acting envelope detector of the receiver has been removed to the transmitter, allowing a slow acting envelope derived a.g.c. to be placed in the receiver. Note also that the waveform envelope of the signal is now completely constant as in modulation categories 1 and 2, as is to be expected since, as explained, this category is an intermediate system. Also, because the carrier is amplitude modulated it will have instantaneous sidebands on either side of it at a frequency spacing dependent on the time constant chosen for the carrier control. This will necessitate restricting the audio signal bandwidth to commercial quality, as indeed needs to be the case for the previous modulation systems.

Finally, it is of interest to note a form of modulation which so intermingles the audio waveform sidebands and a carrier that a constant amplitude phase shift keyed waveform results, which of course can be transmitted with constant amplitude. In this system[17] the conditioned speech waveform (the amplitude variation is restricted using pre-emphasis and compression) is converted to a suppressed clock pulse duration modulation (s.c.p.d.m.) which in turn is fairly easily converted to phase shift keying at the required r.f. frequency. Without going into details of the transmitter modulator and the receiver demodulator, the latter needing two phase lock loop detectors, the point of interest is again the avoidance of a.g.c. problems by placing more complication in the transmitter, and thereby radiating a constant amplitude signal. The only penalty paid by this particular system, however, for being able to not to have to use infinitely clipped speech, is that the bandwidth of the signal has to be between four and eight times the audio baseband width.

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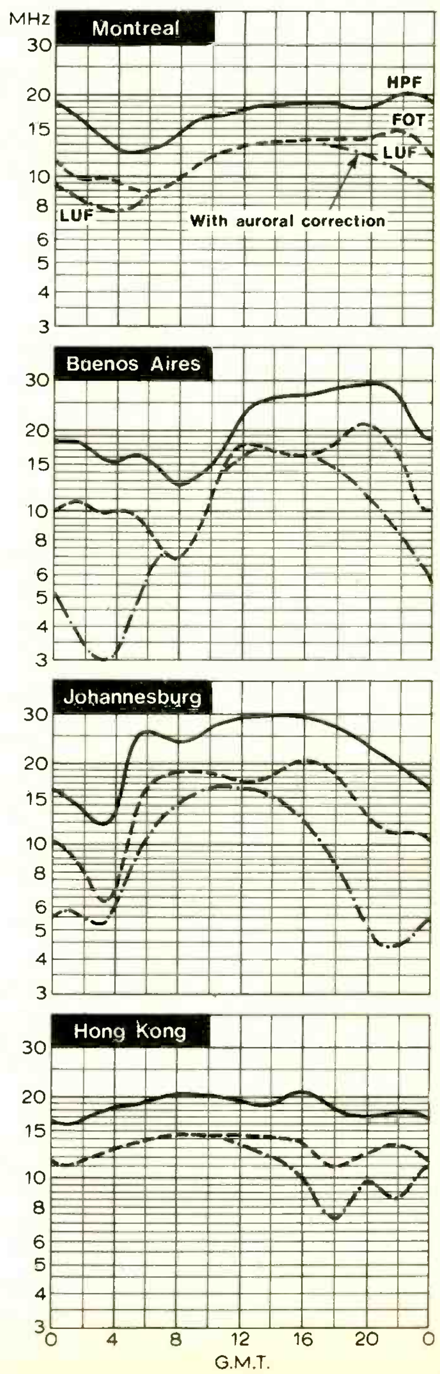
H.F. Predictions for June

Conditions have been generally poor in recent months and there is no prospect of rapid improvement. In fact the lower daytime MUFs of summer season coupled with present magnetic and solar activity levels look like producing the worst month so far this year. The most favourable periods are the first and last five days of the month. LUF calculations assume that ionospheric reflections will occur at all frequencies, thus the contradiction of LUF exceeding FOT (LUF curves discontinued for this condition) often arises. This does not mean that communication is impossible; the value of MUF minus LUF is an indication of ease of communication at frequencies around FOT.

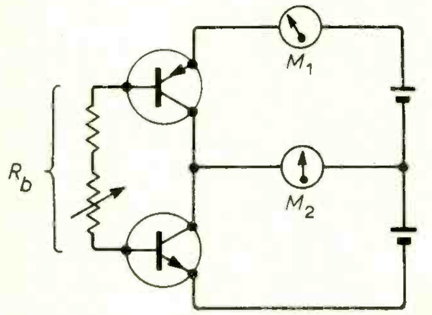


Circuit Ideas

Concise descriptions of new circuits are invited for Circuit Ideas, for which £5 is paid on publication. Contributors should say how their circuit is an improvement over existing circuits, preferably in the first sentence.

D.C. matching of complementary pairs

The emitter current at which matching is required is set up by adjusting R_b. Current meter M_1 indicates this. Centre-zero meter M_2 now displays the difference between the collector currents of the two transistors. The direction of deflection of M_2 shows which transistor



has the higher h_{FE}. If the base-emitter drops can be allowed for R_b may be calibrated in base current: this is useful information when the matched pair is transferred to a working circuit.

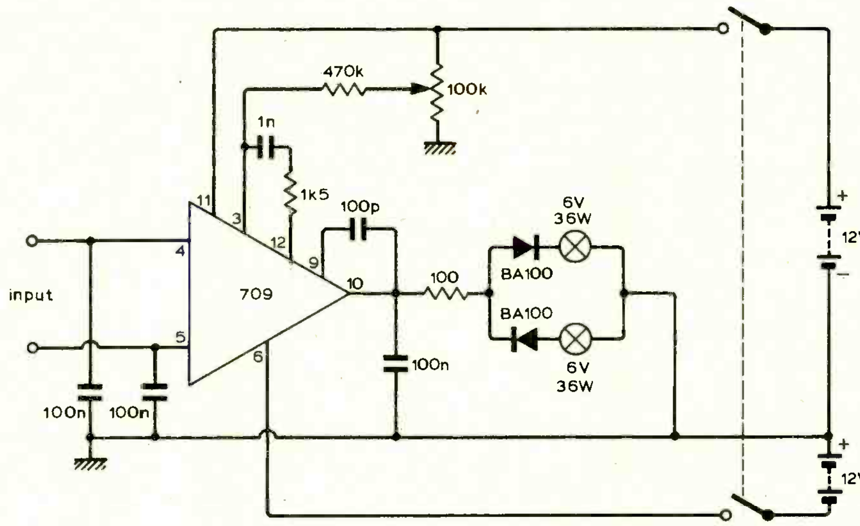
G. W. Short,
South Croydon,
Surrey.

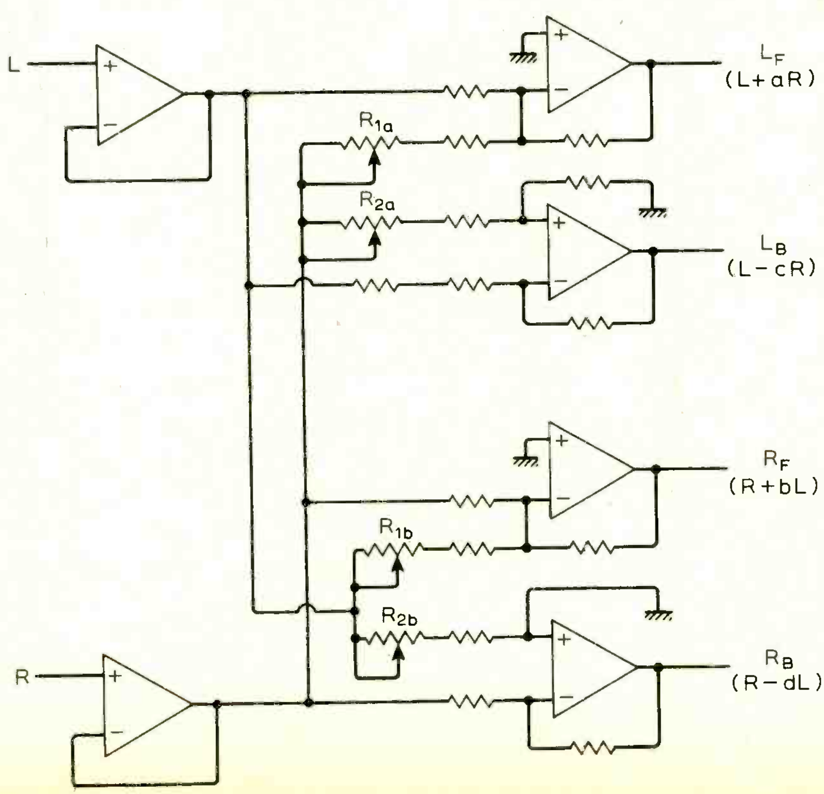
Miniature null indicator

This circuit provides good sensitivity, while having the advantages of small size and ruggedness (as compared with a moving-coil indicator). The amplifier, a 709 type, is driven open loop. This means that a small change in the input voltage — about one mV — will cause the output to switch from one rail to the other. This output state is indicated by one of the bulbs. The null is indicated by both bulbs being extinguished, the initial null having been set by shorting the input and adjusting the potentiometer.

If desired, the diodes can be l.e.ds and the bulbs dispensed with. In this case the series resistance may need altering.

Brian P. Cowan,
University of Sussex,
Brighton.





Surround sound with 741s and variable crosstalk

An alternative to the TA7117P matrix i.c. mentioned by Geoffrey Shorter in the March issue (page 116) uses 741 i.cs and differs from the circuit on page 3 of the January 1972 issue in that crosstalk is variable.

In the circuit shown left fixed resistors are 1kΩ and ganged variable resistors 250kΩ. As in the TA7117P the two inputs are added and subtracted in varying proportions depending on the setting of the two variable resistors. The added signals $L + aR$ and $R + bL$ feed the front channels and the subtracted pair feed $L - cR$ and $R - dL$ feed the rear channels.

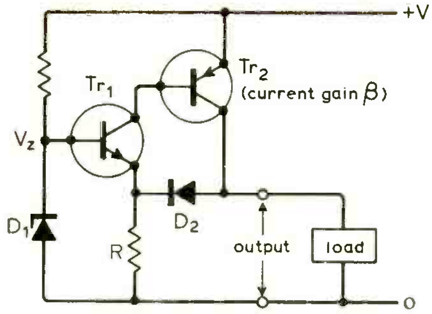
With the values as shown above, $a = b$ and $c = d$, and the crosstalk ratio will be 1/(1 + wiper resistance) and therefore can be varied between 1 and 0.0004.

M. D. Bamforth,
Oldham,
Lancs.

Simple current-limited stabiliser

This simple circuit fits in the gap between the simplest emitter follower stabilizer and the more expensive series stabilizers with current limit protection.

Emitter followers with zener diode stabilized input voltage are often used to provide simple stabilization and ripple reduction on transistor equipment power supplies. A simple modification can be made to provide a current-limit action, using the circuit shown. Diode D_2 is added to the complementary transistor emitter follower and at low currents does



not affect the circuit other than to provide some temperature compensation for V_{be} changes in Tr_1. The maximum Tr_1 collector current is $\approx V_z/R$ giving a maximum Tr_2 collector current of $I_{max} \approx \beta\, V_z/R$, where β is the d.c. current gain of Tr_2. If the load impedance becomes too low diode D_2 becomes reverse biased and the current is limited to I_{max}. No component values are given as the circuit will work with a wide range of components to suit the particular application. Transistor Tr_2 should preferably be a silicon transistor, both from the point of view of heat sink requirements and of improved current-limit characteristic.

A. E. T. Nye,
Cranleigh,
Surrey.

Voltage-controlled two-phase sawtooth oscillator

The oscillator described is a design I am working on to investigate its possibilities for providing a waveform of any desired frequency and phase as soon as these quantities are specified. The interest of the problem lies in specifying phase, for which one voltage line is perhaps not enough while two are perhaps too many. The oscillator is a sawtooth type but at a fixed amplitude outputs can be shaped to give a sinewave. (See for example New techniques in function generation under "Notes from the Physics Exhibition", *W.W.* May 1972 p. 236). It is based on the fact that the sine and cosine functions of an angle each cross the zero line whenever the other reaches a peak or trough. For sine and cosine the sum of their squares is constant but for the two-phase sawtooth oscillator the arithmetical sum of the outputs is constant.

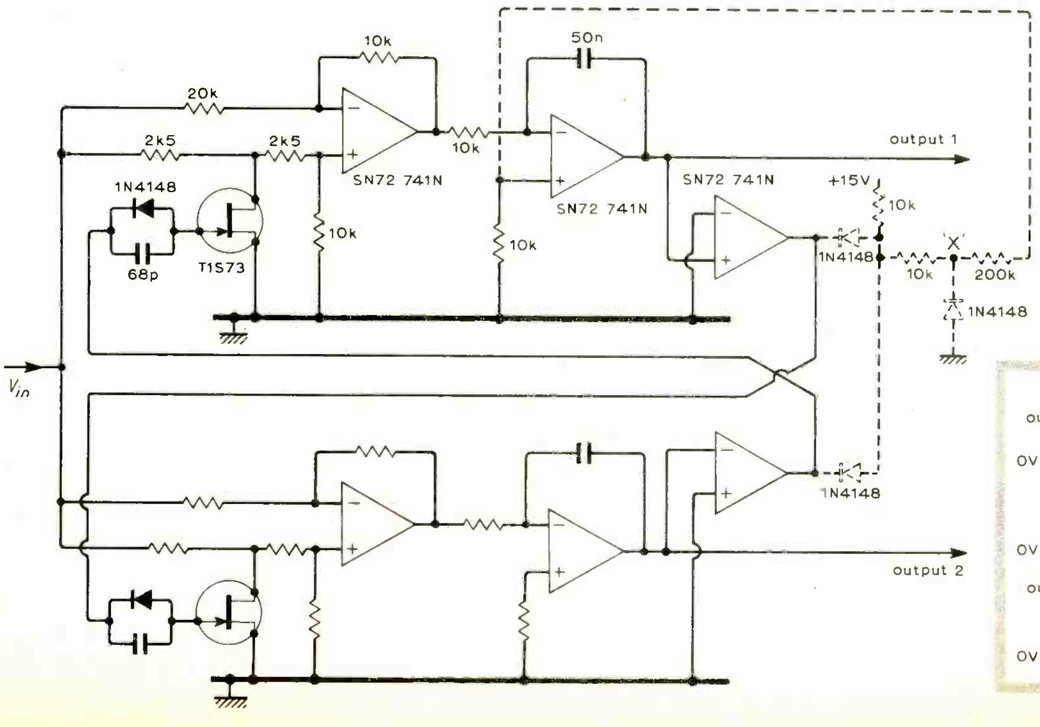
Assume a direct voltage V_{in}; this is amplified as $\pm\frac{1}{2}V_{in}$ by each of the two amplifiers at the left of the diagram, depending on whether the f.e.t. is off or on in each case. Each output is integrated to give a rising or falling ramp by the two following integrators. The polarity of the two resulting outputs is monitored by the last two operational amplifiers, which switch rapidly between the limits of their outputs. The top one has positive gain, the lower one negative gain. Each controls the switching f.e.t. at the beginning of the other channel. The generator has similarities in each channel with R. J. Tidey's version of G. B. Clayton's generator (*W.W.* May 1972 p. 239), but instead of discrimination at two definite voltage levels to trigger a bistable circuit, leading to reversal of the polarity of the input to the integrator, this reversal is caused by the zero crossings of the other channel.

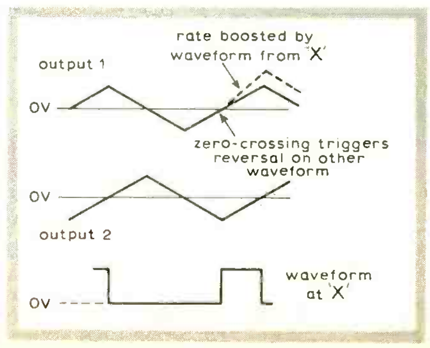
Once oscillation is established, the output of one integrator is travelling toward zero, and the output of the other is travelling away from zero, with the same or opposite polarity. When the first output crosses zero the discriminator switches the f.e.t. in the input amplifier of the other channel. This reverses the polarity of the voltage to the integrator so that its output now travels toward zero. But the first output, having passed through zero, is now travelling away from it. Each channel is now in the situation the other channel started off in, so the second channel passes through zero output from its integrator, whereupon its discriminator switches the f.e.t. in the first channel, and the action is self-perpetuating.

The Q of the system is nominally infinite, i.e. oscillations once started continue at the same level for some time, not that there is any provision for starting them. Provisionally, I would add some gating from the outputs of the two discriminator 741s to boost the slope of one sawtooth in one quadrant, using the components shown in broken lines.

All this is happening on a time scale determined by V_{in}, assumed constant. If V_{in} is reversed in polarity the oscillator repeats its past performance backwards, like a film projector switched from forward to reverse; this is "negative frequency". If V_{in} becomes zero the output voltages freeze at constant values. Modulating V_{in} modulates the output frequency. This may be more useful if the outputs are shaped into sinewaves.

F. B. Jones,
Crosfield Electronics Ltd,
London.





Realm of Microwaves

3. Modern circuitry

*by M. W. Hosking** M.Sc.

The general summaries in the preceding article of the various types of transmission line treated them simply as carriers of electromagnetic waves. No attention was given to the ways in which a transmission line can be locally modified to influence the field. As part remedy, this article commences with a description, not of the many and varied components such as frequency, power and attenuation measuring devices, but of the basic reactive elements from which they are constructed. Progress can then be made towards a description of distributed-element, microwave integrated circuits using the microstrip form of transmission line. Finally, a worked example is given of the design of a microwave receiver.

Transmission-line distributed elements

A distributed element is an inductance, capacitance, or resistance, the exact value of which is a function of frequency, and where the *L, C* or *R* is formed by a discrete length of the transmission line itself. To appreciate the significance of this, consider a few further transmission line properties. Derivation and proof of these statements is elementary, and are not given space in this text.

Firstly on the periodic nature of the line: an impedance or admittance occurring at a particular point will be repeated in value all the way down the line at half line-wavelength, $\lambda_g/2$ intervals. For example, if a shunt inductance is formed across the line at A and, say, five half-wavelengths further along at B, a shunt capacitance is placed, then the input admittance sees B superposed on A or, equivalently, A superimposed on B. The input is thus susceptive, having a value equal to the normal sum of the inductive and capacitive susceptances of the two elements.

The second important property is that a quarter line-wavelength interval acts as an impedance inverter. That is, an impedance $a + jb$ looks like an admittance $1/(a + jb)$ at all points which are odd multiples of a quarter line-wavelength away.

*British Aircraft Corporation.

Strictly speaking, these two statements are true only if the transmission line has zero loss, but in most practical cases, the loss per wavelength is small enough to give negligible error. One use of these periodic relationships might be a requirement to introduce some reactance, say, at a point in a system which is not directly accessible. By choosing a part of the transmission line some distance from the required point and inserting the appropriate component value, the required effect can be produced. Again, this is strictly true at only one frequency and approximations or trade-offs have to be made if a wider bandwidth is required.

To achieve any particular value of reactance, capacitive or inductive, use is often made of the properties of an open-circuited or short-circuited length of line. No matter what form of transmission line is used, be it waveguide, coaxial or other, the following properties apply. Suppose a length of transmission line is to be short circuited at one end and the input impedance to be noted at different distances from the short. Then, at the short circuit itself, the impedance is zero but, on moving away down the line, the input impedance will appear as an inductive reactance, increasing in value until it reaches infinity at a quarter wavelength from the short. At this point the reactance reverses sign and becomes capacitive, decreasing in value from infinity to zero and then repeating. (This is also true for a purely open-circuited line, but with a quarter wavelength phase difference; that is the first quarter wavelength is capacitive instead of inductive.)

Thus, any value of reactance can be produced from a suitably terminated length of transmission line, that is, a distributed element. Such elements can then be placed in series or parallel with the main line to influence the flow of power and can be dealt with, computationally, in the same way as for normal a.c. theory. To those brought up on dielectric capacitors, it is interesting to point out that a capacitance produced in the above fashion is not necessarily a d.c. open circuit. An example of a series T-junction in microstrip is shown in Fig. 1 and here it is possible to influence the e.m. field travelling down the main line by the impedance of the series arm; by the length of the series arm; and by the way in which the series arm is terminated.

There are really two effects at a junction like this. By the definition of "distributed" the line dimensions are comparable in size to the wavelength, the junction actually appears as a physical discontinuity to the field in the main line and will disturb it. This disturbance is equivalent to the effect of a reactance across the main line. Impedance of microstrip is a function of linewidth; the narrower the strip, the higher the impedance. This governs the value of X_c. On top of the basic junction reactance is superposed the impedance of the series arm itself and its termination and herein

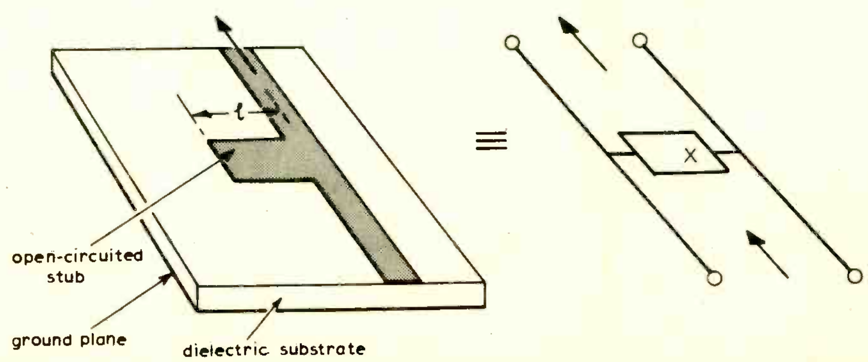


Fig. 1. Illustrating a T-junction in microstrip transmission line. Reactance X is a function of the stub length and can be made to vary between zero ohms and infinity.

lies great scope for influencing and controlling the transmission properties of the main line.

By way of illustration, suppose the length of the series arm was made a half microstrip-wavelength long and formed as in Fig. 1. Leaving radiation effects from the end to the dedicated reader, this is an open-circuited strip and the terminating impedance (in this case infinity) will be repeated in value at half-wavelength intervals. Thus, there will be an infinite impedance (open circuit) across the junction and the main power flow will be uninterrupted. If now the open-circuited stub is gradually shortened, the impedance presented at the junction appears as a gradually decreasing inductive reactance. At the point when the line length becomes a quarter wavelength long, the impedance-inverting property applies and the open circuit is transformed into a short circuit, effectively blocking the transmission line.

A simple application of such a quarter-wave open-circuited stub is as a band-stop filter such as is often used in a superhet circuit adjacent to the mixer diode. Here, the requirement is to let the intermediate frequency (say tens of MHz) through to the rest of the circuit and suppress the signal frequency (say thousands of MHz). If the stub is made a quarter-wave long at the signal frequency, then it goes virtually unnoticed at i.f. but appears as a short circuit to the signal.

As an additional example, use can be made of this transmission line principle to construct a simple switch or modulator. The half-wave stub can be terminated in a semiconductor diode which, depending on whether forward or reverse bias is applied to it, can have a high (open circuit) or low (short circuit) impedance. The periodic nature of the half-wavelength stub then transforms the impedance across the main line and one has a simple on/off switch. In practice, the stub length can be made slightly greater or less than a half wavelength and the reactance due to this deviation can be used to compensate for the electrical discontinuity introduced by the diode itself.

The foregoing illustrates one of the basic differences between the design of microwave circuits and those at lower frequencies and is worthwhile reiterating; a simple inductance or capacitance can be produced by using a physical length of the transmission line itself. Whether an element is termed inductive or capacitive depends on the way it affects the phase relationship between the electric and magnetic fields (or voltage and current); such elements can be produced by a variety of other means. In fact, any abrupt change in the dimensions of any of the transmission line forms, or any external object brought close enough to perturb the fields, will act as a reactive device.

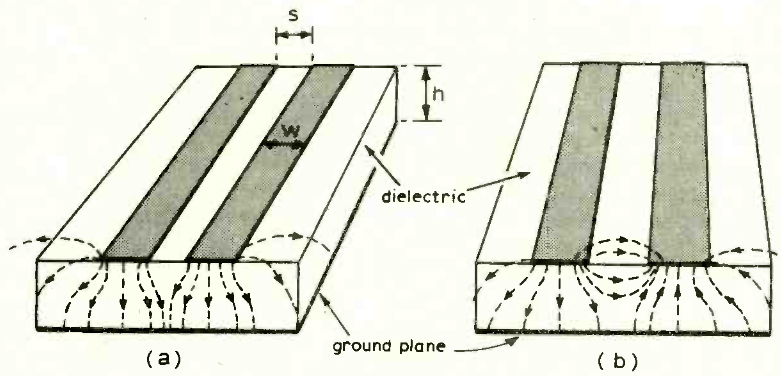


Fig. 2. Coupled microstrip lines showing the electric field distributions for the two analytical modes. Coupling is a function of the spacing and is much stronger for the odd-mode, making the characteristic impedance less than that of the even-mode case.

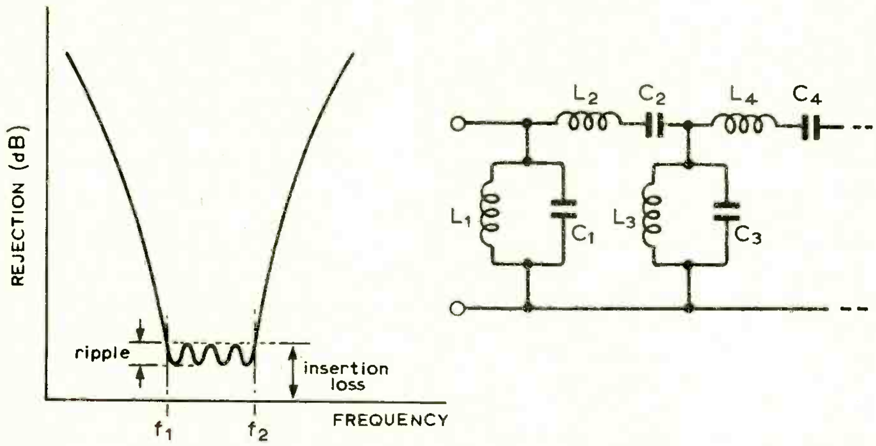
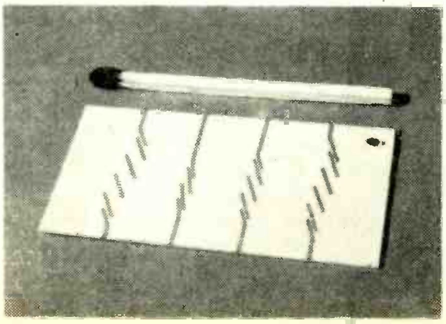


Fig. 3. Trade-offs can be made between the width of the pass-band, ripple amplitude and stop-band rejection for the characteristic of (a). Shown in the photograph are four microstrip bandpass filters, each having the same centre frequency but different pass-band shapes. Each filter consists of a number of half-wavelength resonators with mutual electromagnetic coupling as shown idealistically in (b).

(c)



Coupled transmission lines

If instead of using some localized element to perturb the fields a second transmission line itself were brought into close proximity with the first, so that the fringing fields could overlap, then a portion of the power could be coupled from one line into the other. Used mainly in stripline and microstrip form, coupled lines comprise a major feature of microwave integrated circuit design. Although this effect has been known ever since these circuit forms have been used, it has not been until very recently that, particularly for microstrip, the mathematical analysis has overtaken the empirical approach in the design of circuits. Even now, there is no comprehensive set of equations giving explicit values of circuit parameters, and design problems must either be left in synthesis form for computer studies or worked out using graphical solutions for the coupled lines.

To determine the properties of a section of coupled line, the overall field configuration can be resolved into two separate patterns. Each of these represents a travelling wave and are called the even and odd modes of the coupled junction. The electric field patterns are as shown in Fig. 2 with the even mode having the same field polarity on each conductor and the odd mode having opposite polarities. There is much stronger field coupling between the conductors for the odd mode.

Having thus split up the overall field, it is possible to define a separate impedance for each mode, the even mode always having a higher value than the odd. The overall impedance of the coupled section is equal to the geometric mean value of the even and odd mode impedances. In similar fashion to the single microstrip line, the mode impedance is a function of w/h increasing as w gets narrower. But, now, it is also dependent on the line spacing, s/h and the impedance of the even mode increases as the spacing becomes closer, while that of the odd mode decreases. Also, as the spacing between lines changes, so too does the amount of power that is coupled from one to the other.

Making use of the properties of coupled transmission line sections are two very important and widely used types of component: filters and directional couplers. Virtually any microwave integrated circuit will use one or both of these. The most common filter type to be based on the coupled line is the bandpass filter having the general characteristic of Fig. 3 (a) and an equivalent circuit shown in Fig. 3 (b). Basically, such a filter consists of a number of parallel resonant sections, coupled together with series resonant sections. Modifications are usually made to this simple circuit to improve the response, but that is another story. The width and shape of the passband, together with the stopband rejection and rate of cut-off are all functions of the number and type of resonators and of the inter-resonator coupling.

In microstrip or stripline form, the resonators are produced with open-circuited sections of transmission line. Such a section of line will resonate at the frequency for which it is a half-wavelength long. For instance, if the example used in part 2 is continued and we require a 50-ohm impedance microstrip line on 0.025-in thick alumina, for which $\epsilon_r = 9.7$, to be resonant at 3GHz; then the free space wavelength is 10 cm and the microstrip wavelength is 4 cm. So the strip will resonate at 3GHz if it is 2 cm long.

In practice, slight corrections would have to be made to this length to compensate for fringing capacitances from the open ends. For practical convenience, open-circuited strips are used, but the foregoing would apply just the same to a half-wavelength short-circuited strip. As such, this example may also serve to illustrate the difference in size between microstrip and waveguide. To propagate 3GHz standard waveguide has internal cross-sectional dimensions of 7.2 cm × 3.4 cm and the guide wavelength will be 13.85 cm giving a resonant length of just under 7 cm. The ratio in volume of just the resonators is, thus, about 2,000 : 1.

Having chosen the resonator length, the filter itself can be constructed as in Fig. 3 (c). Each resonator has input and output coupling to it from adjacent resonators, the coupling length being a quarter wavelength. The amount of overlap of the fringing fields between strips governs the bandwidth and rate of cut-off. This is a photograph of a range of filters, designed for operation at 9GHz and having various passband characteristics.

In similar fashion to the filter, it is possible to tap-off power from the main transmission line into a secondary line. Such a device is called a directional coupler and is one of the most commonly used microwave components. There are many possible designs suitable for stripline and microstrip, the simplest being that of Fig. 4. Here, the main transmission line includes the section 1-2 with the secondary line 3-4 brought into close proximity. The length of the coupling section is a quarter wavelength and the amount of power tapped-off depends on the spacing between the two lines. With the input at 1, say, the main output will be at 4 with the coupled output at 2 and a 90° phase difference between both of them. Ideally, no power should appear at 3.

Directional couplers are classified in terms of their coupling factor: defined as the ratio of the power in arm 2 to that in arm 1 and this is usually expressed in decibels. Thus, coupling is $10\log_{10}(P_3/P_1)$ and is a negative number. The sign is usually ignored and one talks of a 3dB, 10dB, 20dB coupler, meaning that $\frac{1}{2}$, 1/10, 1/100 of the mainline power is coupled into arm 3. The particular type of coupler shown is most suitable for what is termed the "loose" coupling of power: generally 1/10th or less. For "tighter" coupling, the gap must be narrower and becomes impractically small. As an example, still using the 0.025-in standard alumina and 50-ohm microstrip transmission line, an equal power split of 3dB would require a line spacing of about one tenth of a thousandth of an inch; a 10dB coupler would require a spacing of 0.007in and a 20dB coupler, one of 0.033in. The gap required for the 3dB coupler is not achievable using the conventional microstrip etching or deposition techniques and in any case the surface finishes available on alumina would preclude such fine definition. The current practical limit on linewidth and spacing is about 0.001in.

There are many occasions when an equal power split is required and the 3dB directional coupler is probably the most widely used of all. It is possible to use coupled lines, but not in the form shown and not by methods which are particularly convenient in the microstrip type of circuit. Instead, the design shown in Fig. 5 is almost invariably used. The first is the hybrid ring coupler, sometimes called a "rat-race", and can also be built in waveguide or coaxial form. For an input at one arm, there is an equal power split between the two adjacent arms and ideally no output from the fourth. Suppose for instance that power enters arm 1; it will divide equally at the junction with the ring and the two halves will flow in opposite directions. Power arriving at arm 2 will have travelled a distance $3\lambda_g/4$ in each direction and will be in phase and combine to give an output. Similarly, power at arm 4 will have travelled $\lambda_g/4$ one way and $5\lambda_g/4$ (which is equivalent to $\lambda_g/4$) the other and will combine in phase. At arm 3, however, there will be a $\lambda_g/2$ phase difference and no combination will take place. In practice, this decoupled arm is typically isolated by about 20dB from the output arms in microstrip. One further point of design is that, to provide a good match, the impedance of the line forming the ring is made $1/\sqrt{2}$ of that of the arms.

The branch-line coupler of Fig. 5 (b) works in similar fashion to the hybrid ring, an input at arm 1 producing outputs at 2 and 3. By adjusting the impedances of the branch arms it is possible to produce unequal outputs. Also, this coupler can be made to operate over a wider frequency band than the hybrid ring by increasing the number of branch arms.

Both of these couplers are readily produced in stripline or microstrip form and are used extensively. A common application is a balanced mixer circuit where, if the branch line coupler was used, the two mixer diodes would be attached to the output arms 2 and 3 and the signal and local oscillator to arms 1 and 4. In this way each diode receives an equal amount of signal and oscillator power and the signal source and oscillator are well isolated from each other.

An example of microstrip coupler

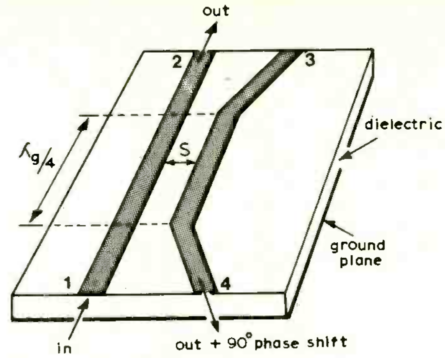


Fig. 4. Coupled-line microstrip directional coupler. An input at 1 produces a main-line output at 2 with a coupled output at 4. The output at 4 is a function of the spacing.

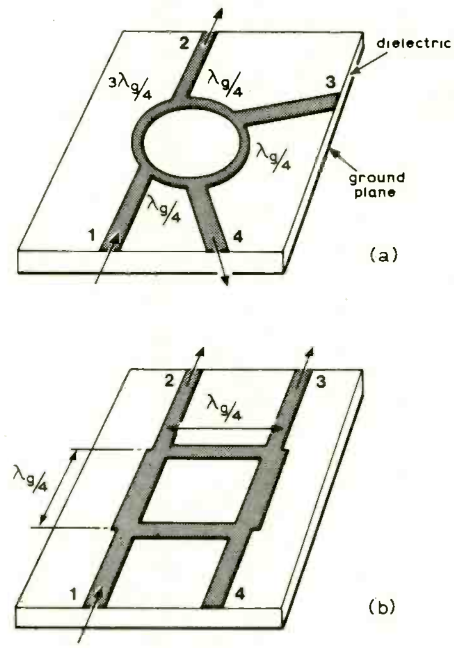


Fig. 5. Two examples of microstrip directional coupler, invariably used to produce an equal power split. There is always a 90° phase difference between the two outputs due to the different path lengths involved.

circuits appeared in the Doppler radar article by K. Holford in the November 1972 issue of *WW* (Fig. 1, page 535). A coupled-line type can be seen at the upper left — probably 10dB from the text — and two hybrid ring couplers appear at the centre.

To complete this article and to demonstrate how the various components can be used a worked example follows on the design of a microwave receiver. This is one of the basic units common to all radar and communication systems and its presentation here should enable useful comparisons to be made by those readers acquainted with receiver design at more "do-like" frequencies.

Microwave receiver design

The type of receiver will be a superheterodyne one for increased sensitivity, using a balanced mixer and we will arbitrarily choose a signal frequency at the centre of X-band of 10GHz. The microwave circuitry will be in the microstrip form of transmission line and the complete circuit, as it would appear in practice, is shown in Fig. 6. The signal input would be coupled to the receiver by an external aerial and there might be the need for an impedance-matching section. Not detailed is the intermediate frequency amplifier which would be fed directly from the r.f. filter output and might need a matching section.

In detail then: the first parameter to be settled for the receiver is the i.f., as this influences the design of the local oscillator, input filter, output filter and i.f. amplifier. Most of all, it concerns the input filter, the main purpose of which is to cut out spurious signals at the image frequency. If a low i.f., say 1MHz, was chosen, one would be asking the filter to provide an attenuation of perhaps 30-50dB at a frequency 2MHz from 10GHz and implying *Q*-factors of several thousand. Such a design is not really practicable, especially in microstrip and would also pose stability problems. Therefore a high i.f. is preferable — another benefit being that fewer filter sections will be needed, as the cut-off rate is reduced and so the losses in the filter itself will be smaller. At the other end of the scale, the higher the frequency, the higher the amplifier noise figure; although with small-signal transistors currently giving only 3.5dB or less noise figure at 4GHz, this is not the problem it once was. It is almost always the i.f. amplifier which defines the noise bandwidth of the receiver by either an input filter or preferably by using tuned stages. Thus, an i.f. very large compared with the bandwidth presents tuning and stability problems.

So having a free hand let us choose an i.f. of 500MHz and a 3dB amplifier bandwidth of 50MHz, necessitating *Q*-factors of up to 10 and put the image frequency at $(10{,}000 - 2 \times 500) = 9\text{GHz}$ with the oscillator frequency at 9.5GHz. Finally, assume that an extensive survey of the r.f. environment has indicated that 30dB of image rejection is required. The parallel-coupled bandpass filter at the input to the receiver can now be designed. Its characteristic will be that of Fig. 3 (a) and it is only necessary to define the bandwidth for the number of sections to be determined. The bandwidth cannot be lower than 50MHz and the maximum width will depend on the variation of the signal frequency; let us choose it as 100MHz.

When several tuned circuits are coupled together, as is the case in the filter, it is possible to vary the coupling to produce a passband response which is either a smooth curve or is rippled. In particular, the ripple amplitude can be made to vary as some mathematical function and a "trade-off" made between ripple and rate of cut-off. Our requirement for cut-off rate is not particularly stringent, so we shall specify a very small allowable ripple of 0.1dB. In this case, the 100MHz bandwidth is measured to the 0.1dB points at the band edges. Graphs and tables exist for determining the filter design details and from these two resonant sections will provide the 30dB image rejection. Using high-purity alumina substrate with a 10 microinch surface finish and gold metallization, the passband insertion loss of this filter will be less than 1dB.

The last article showed that the microstrip line impedance was a function of the strip width w to substrate thickness h ratio. If we adopt the usual 50-ohm impedance then Fig. 5 of that article shows that a w/h value of unity is required. We will use standard 0.025-in thick alumina and so the input and output lines to the filter will be this width. Because not all of the microwave field is confined to the alumina, there is an effective dielectric constant, ϵ_{eff} which is lower than the material value ϵ_r. From Fig. 4 of Part 2: ϵ_{eff} in our case is 6.7, for $\epsilon_r = 9.7$ and each half-wavelength resonator is 0.228-in long ($\lambda_0/2\sqrt{\epsilon_{eff}}$).

Fringing fields from the ends of these resonators make them seem electrically longer and to compensate for this effect they must be shortened. In this case, the correction would be about 0.019in from each end, making the lengths 0.190in. If this were not done, then the filter passband would be at a lower frequency than required.

The signal, after passing through the filter, reaches one input of a 3dB directional coupler where it divides equally and arrives at the two mixer diodes. Each section of the coupler is made $\lambda_g/4 = 0.114$in long, only two shunt arms being required as the operating bandwidth is fairly narrow. The impedance of the series arms in the coupler is made $1/\sqrt{2}$ times that of the input and shunt arms which means a value of 35.4 ohms and Fig. 5 of part 2 requires $w/h = 1.85$, giving a linewidth of 0.046in. The other input to the coupler, which would be isolated from the signal input by typically 15dB to 20dB, carries the local oscillator signal which divides equally to the mixer diodes.

The oscillator will be a Gunn effect device, with an output power of perhaps 50mW. Such a device is typically 2% efficient, requiring a d.c. input of 9V, 280 mA for full output. With 2.5W being dissipated, good heat-sinking is essential and for this reason the Gunn device will be shunt-mounted across the microstrip line as in Fig. 7 (a). Many oscillator designs are possible in microstrip, the one chosen here being the Gunn device terminating a half-wavelength section of line which, as explained for the filter, will be resonant at the oscillator frequency. In this case adjustments to the line-length must take into account the equivalent circuit of the Gunn device and in particular the parasitic reactions of the package. The simple equivalent circuit will be as in Fig. 3(b) of Part 1.

In this example the resonant line is split into two nominal $\lambda_g/4$ sections and a varactor diode inserted between them. The capacitance of this diode is a function of bias voltage and so the apparent electrical length of the gap between the two sections can be varied. Under reverse bias, the diode capacitance decreases as the reverse voltage increases, thereby shorten-

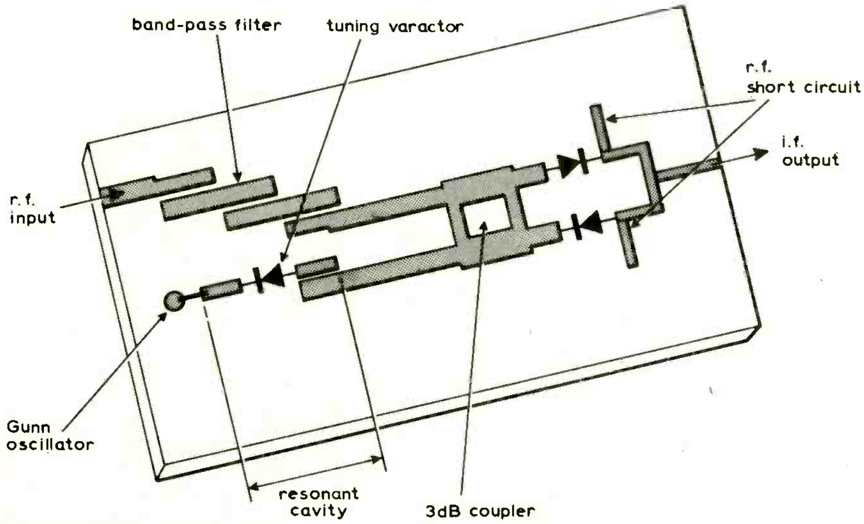


Fig. 6. Microstrip receiver with integrated local oscillator, approximately four times full size. Even when packaged, size and weight are many times smaller than waveguide circuitry.

ing the electrical length of the line and increasing the resonant frequency. The diode could be mounted in similar fashion to the oscillator diode but as no heat sinking is required it is preferable to do away with the complicating package and use a chip diode. Series mounting also gives a slightly greater tuning range than shunt. The output from an a.f.c. loop would be connected to the varactor which, with careful design, could provide ± 3% frequency tuning.

Output from this complete oscillator section is conveniently taken by means of a parallel-coupled length of line and might tap-off about 10mW of power. There are inherent power losses in the system, some power being radiated from the Gunn end of the cavity, some lost in the bias circuitry, some dissipated in the varactor and more lost in the coupling section and 3dB Coupler.

On arrival at the two mixer diodes, the signals combine to produce the i.f., image frequency and an infinite series of intermodulation products. Most of the output power is split between the i.f. and image and the efficiency of the mixer system is considerably influenced by the way in which the image power is dealt with. If nothing were done to prevent it, the image would be reflected back from the diodes and would be lost through the oscillator and signal input lines. By reflecting this power back again into the mixer with the correct phase, the conversion efficiency can be improved. This job is done in part by the signal input filter, which looks like a short circuit to the out-of-band image. By adjusting the distance between the filter and the coupler, this short circuit can be transformed to the diodes themselves by the periodic property of the line described previously.

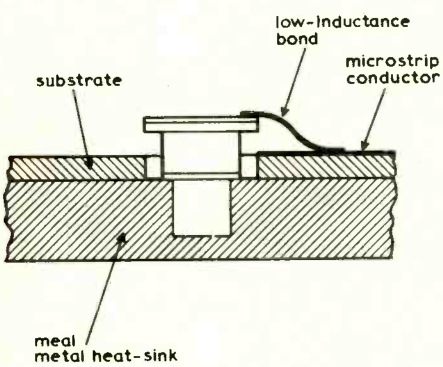
The type of diode most commonly used now at these frequencies is the Schottky barrier or hot carrier diode. This is a metal/semiconductor junction device which is essentially free of charge-storage restrictions, resulting in more efficient rectification and lower noise. For microstrip applications, the diode is conveniently packaged in the beam-lead style of mount shown in Fig. 7 and thermo-compression-bonded into place. In common with other types of mixer, there is an optimum oscillator power level for lowest conversion loss, in this case about 1 to 3mW per diode. The i.f. impedance is also a function of oscillator power, decreasing as the power increases and at the optimum level is around 180ohm. On combining the mixer outputs, though, the diodes appear in parallel to the i.f. and so the impedance presented to the amplifier is 90ohm, which is compatible with typical low-noise input stages.

One main advantage of the balanced mixer is the suppression it provides of the a.m. components of oscillator noise. These appear in phase at each diode while the two i.fs are out of phase; therefore the diodes are inserted with opposite polarities so that on summing the outputs the noise cancels. Finally, the $\lambda_g/4$ open-circuited stubs mentioned previously are placed after the mixers to appear as short-circuits to the input r.f. signal at these points.

In practice, the complete circuit would be packaged in a metal box, the final problem being to ensure that the sides and top of this enclosure do not interfere with the microstrip fringing fields.

Having established the design and determined the components, an estimate can be made of the sensitivity of the receiver. The minimum signal that can be detected is limited by the electronic thermal noise background, given by $S = kTB$, where k is Boltzmanns constant $= 1.38 \times 10^{-23}$ joule/K, T the receiver temperature (Kelvin) and B_n the noise bandwidth (not the 3dB bandwidth B). Taking $T = 290$K and $B_n = 1.16B$ (this assumes a three-stage amplifier), $S = 2.32 \times 10^{-13}$W for the ideal case. Practically, this figure is degraded by losses in the system which we can estimate as: 2dB circuit losses in filter and coupler, 4dB mixer noise figure and 2dB mismatch and i.f. amplifier loss; giving a total of 8dB. This means that the sensitivity is decreased by 6.3 times the above thermal noise power to a value of about 1.5×10^{-12}.

A receiver such as this employs a large number of individual microwave components, both active and passive and provides a good example of microwave circuit design. Although quite commonly constructed in waveguide, the modern type of circuitry is hybrid microstrip as illustrated here and is particularly suited to compact light-weight installations in aircraft and missiles.



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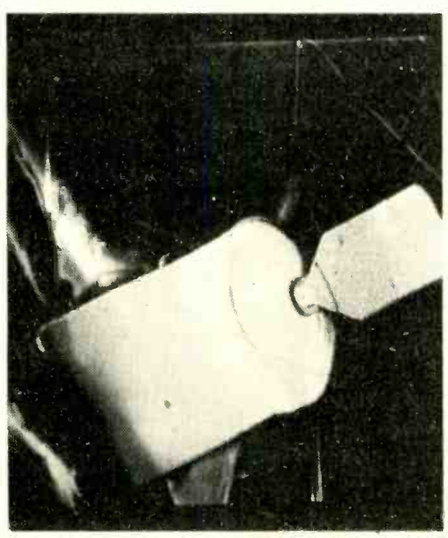

Fig. 7(a). Shunt-mounted Gunn diode in microstrip. Series mounting cannot be used at even moderate power levels because of the heat-dissipation problem. Photograph shows beam-lead Schottky barrier mixer diode 77 times full size. Smaller tap is about 0.005in wide by 0.002in thick.

Announcements

"Components and Small Devices" is one of a series of three-day courses dealing with production in the electronics industry. The course is to be held at Twickenham College of Technology, Egerton Road, Twickenham, Middlesex TW2 7SJ from the 5th to 7th June.

MSL Calibration Centre of Hunting Gate, Hitchin, Hertfordshire announce a new **calibration service.** This covers a range of instrumentation including oscilloscopes, pulse generators, frequency counters, digital voltmeters and a comprehensive range of multimeters and associated prime standards.

Henri Picard & Frere Ltd have moved to 357/359 Kennington Lane, London SE11 5HY. The company supplies precision hand and special-purpose tools for electronics production and servicing, micro-assembly, and laboratory use.

The Ministry of Defence has approved the **Muirhead-Vactric Test House** at Garth Road, Morden, Surrey for Part III Approval. The main facilities cover conditions simulating altitudes up to 100,000ft, temperature variations between -80°C to 350°C and humidity to 95%. Other conditions available are salt spray, water percolation, dust, vibration and bump tests.

The Broadband Marketing Department of Pye Telecommunications has extended its broadband u.h.f. and microwave activities by the recent award of a number of contracts, from the Post Office, for **multi-channel telephony** and **colour television** systems. These are to expand a communication system between Plymouth and the Goonhilly Satellite Earth Station.

The **Midlands Electricity Board,** Northen Area, has placed an order worth £125,000 with Pye Telecommunications Ltd, Newmarket Road, Cambridge, for a radio communications network which will cover North Shropshire and North Staffordshire. The order includes five of the Pye Telecommunications L300 point to point radio links in the 1.5GHz band.

Emihus Microcomponents Ltd, Clive House, 12/18 Queens Road, Weybridge, Surrey, have acquired the connector business of the Belgian company Sabca who have been manufacturing connectors under licence from Hughes Aircraft Co.

Light Soldering Developments Ltd, 28 Sydenham Road, Croydon CR9 2LL, manufacturers of the Litesold range of soldering irons have appointed Lugton & Co. Ltd, of London, as their distributor for London and the South East.

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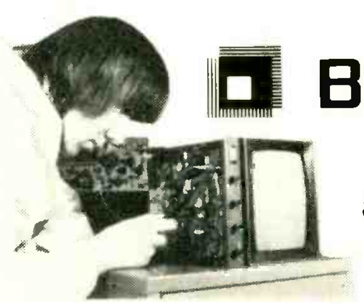

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WW 6/73

Circards — 7

Power amplifiers

Efficiencies ● matching ● "rms" power

*by J. Carruthers, J. H. Evans, J. Kinsler & P. Williams**

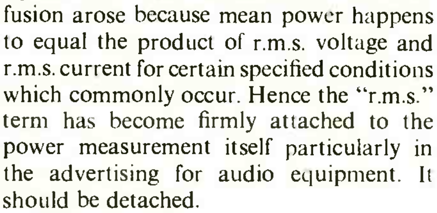
All amplifiers are power amplifiers in that the power delivered to the load is greater than that drawn from the source. Few are power amplifiers in the same sense that an operational amplifier with feedback may be said to be a voltage amplifier or a current amplifier. Thus in Fig. 1 the load voltage is defined for a given input signal and the load power is proportional to the conductance of R_L. For Fig. 2 feedback defines the load current while the corresponding power developed in the load is proportional to the resistance of R_L.

This suggests that as many power amplifiers use shunt-derived feedback to define their output characteristics, they could properly be regarded as voltage amplifiers which just happen to be capable of delivering large powers to a load of sufficiently low resistance. Operating these amplifiers from a constant supply voltage in the usual way fixes an upper limit on the load voltage. Practical imperfections in the transistors together with current limiting resistors or other protective circuitry reduce this upper limit but still leave the peak output voltage broadly proportional to the supply.

Output power depends equally on the maximum current that can be supplied to the load. The mean value of this power over a complete cycle for a sinusoidal output voltage and resistance load is $\hat{V}\hat{I}/2$, where $\hat{V}$ and $\hat{I}$ are the peak instantaneous values of voltage and current, and as $\hat{V} = \hat{I}R_L$ and $V_{rms} = \hat{V}/2$, alternative expressions are $V_{rms}.I_{rms} = \hat{V}^2/2R_L = I^2R_L/2 = V^2_{rms}/R_L = I^2_{rms}R_L$.

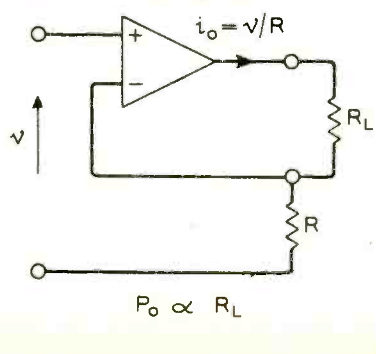
At this point, you might be asking: "what about r.m.s. power?". This, unfortunately, is on a level with the equivalent enquiry after the well-being of the workers. It can be answered in various ways none of which are useful. To interpret it properly it must be realized that, while the power developed in the load varies from instant to instant, it is the mean or average value of that power that determines, for example, the loudness of the sound produced by a given loudspeaker. The r.m.s. value of the power can be defined mathematically in the same manner as the r.m.s. value of the voltage, but it has no comparable physical significance, i.e. it would require the instantaneous power to be squared, integrated to obtain the mean value of the "power squared", and then the square root taken of the result. The confusion arose because mean power happens to equal the product of r.m.s. voltage and r.m.s. current for certain specified conditions which commonly occur. Hence the "r.m.s." term has become firmly attached to the power measurement itself particularly in the advertising for audio equipment. It should be detached.

While the voltage term in the output power is fixed by the supply voltage, the current term is a property of the amplifier. Consider first the amplifiers based on a single transistor as shown in Fig. 3. In each case the transistor is assumed to be dealing with an a.c. signal which has equal positive and negative magnitudes, e.g. a sine wave. Thus the transistor must be biased to some quiescent voltage/current setting which will allow positive and negative-going output swings. If distortion is to be avoided the transistor must remain conducting throughout the cycle, i.e. neither the current nor the p.d. across the transistor shall fall to zero. This mode of operation, class A, may be defined in terms of the "angle of conduction", being the full 360° of the cycle. In class B each device conducts for precisely 180° or half the cycle and in class C conduction is for $< 180°$.



$P_o \propto 1/R_L$

Figs. 1 and 2. In a voltage amplifier and a current amplifier, load voltage or current is defined for a given input signal and load power is proportional to the conductance of R_L (Fig. 1 above) or the resistance of R_L (Fig. 2 below), suggesting that power amplifiers using shunt-derived feedback could be looked on as voltage amplifiers, but capable of handling large powers.



$P_o \propto R_L$

In Fig. 3 (a) if the direct current is permitted to flow in the load, equal positive and negative excursions occur for a voltage across the transistor equal to half the supply voltage (assuming an ideal transistor). Thus the peak of the a.c. component of load voltage is $\hat{V} = V/2$. Hence the a.c. power in the load is $(V/2)^2/2R_L = V^2/8R_L$. In the absence of signal the current drawn from the supply is $V/2R_L$ giving a supply power $V^2/2R_L$. This shows an efficiency of 0.25. The quiescent power splits 50/50 between transistor and load resistance.

It is possible to do still worse. In Fig. 3 (b) the load is capacitively coupled to the amplifier to eliminate the direct current in the load. A collector resistor is still required to allow the flow of current in the transistor, establishing the quiescent conditions for class A operation. Now the total a.c. power is split between R and R_L and the maximum efficiency is reduced to 0.125.

The situation can be retrieved if the collector resistor can be replaced by some constant-current stage as in Fig. 3 (c). The positive peak current in the load can then equal the quiescent current even when the collector approaches the supply voltage (assuming a constant-current stage that can function with a p.d. falling towards zero). Hence the load can have a maximum current swing simultaneously with a maximum voltage swing. In Fig. 3 (b) when the transistor current falls to zero, R and R_L are effectively in series and the p.d. across R limits that across R_L.

The constant-current stage may consist of an inductor whose reactance is high compared to the resistance of the load at all frequencies of interest; an ideal transformer that also allows the use of arbitrary load resistance by proper choice of turns ratio; a transistor biased to deliver a constant current. The disadvantage of (d) and (e) is that the amplitude-frequency response is limited unless bulky and expensive inductor/transformers are available. They do offer the possibility of higher efficiency than any of the other circuits. For example, Fig. 3 (f) allows the peak current in the load to equal the quiescent current, and the peak voltage to equal the transistor quiescent voltage,

*All at Paisley College of Technology

i.e. half the supply voltage for the best operating conditions. Thus load power is $(I_{dc}V/2)/2$ while supply power is $V.I_{dc}$, giving an efficiency of 0.25 bringing the efficiency back to the level of Fig. 3 (a) but with the d.c. component removed from the load. In Fig. 3 (d), the peak current in the load is still equal to the quiescent current, but the inductance allows the collector voltage to swing positive with respect to the supply line as the transistor current falls—a load peak voltage equal to the supply voltage being available. The a.c. power in the load then becomes $VI_{dc}/2$ for the same supply power VI_{dc}, and maximum efficiency is 0.5. This is the highest efficiency possible in class A and the transformer-coupled circuit of Fig. 3 (e) has the same capabilities. It is common for practical circuits using small transformers to have efficiencies in the region of 0.25 to 0.4.

The low efficiencies attained by these single-device circuits lead to the investigation of multiple transistor circuits. Simply operating transistors in parallel may increase the quiescent power they can dissipate and hence the available output power, but the method offers only second-order improvements in efficiency by reduction of saturation voltage etc. Before turning to other classes of amplifier, consider the natural extensions that are possible of the circuit of Fig. 3 (f). Replace the transistor used as a current source by one receiving a signal as in Figs 4 (a) to (d). The signals to the two transistors depend on the configuration used, but the aim in each case is to cause one transistor to decrease its current by the same amount as the other increases it, still assuring class A operation for each transistor individually. In this way the peak current in the load may equal twice the circuit quiescent current: at the point when the current in one transistor reaches zero the other has doubled. The peak load voltage remains at half the supply voltage when the output is biased to the supply mid-point for maximum undistorted output.

So far the term "matching" has been avoided. For low-level amplifiers, input impedance is frequently matched to that of the source; this is the condition for minimum noise. To maximize the power gains of following stages the output and input impedances may be matched, i.e. made equal. This remains the practice in r.f. amplifiers, but at lower frequencies deliberate mismatch is more common as it allows for better control over the gain.

A fallacy that is based on the experience with these low-level stages, and derives from the maximum power-transfer theorem is often extended to power amplifiers. For each of the class A stages described earlier there is a value of load resistance that maximizes the output power without clipping the waveform peaks. As shown for each individual case there are separate limits for both peak voltage and peak current, and the optimum load will have a resistance given by the ratio of these peaks. This load resistance has nothing to do with the output resistance of the transistor.

Consider Fig. 5 which represents the operation of Fig. 3 (d). Draw the load line representing the load resistance through the quiescent point; the maximum output power without distortion is achieved for the slope giving symmetrical voltage and current swings in the positive and negative directions. Such a line intersects the V, I axes at $2V_c$ and $2I_c$ respectively and the slope of the line is the same as that joining the V_c, I_c points on the axes. This optimum load is thus confirmed as depending on the quiescent conditions with the slope of the transistor characteristics (the true output resistance) playing no part. Life is rarely that simple in practice, and the results are modified by saturation effects as well as by the various non-linearities, but not sufficiently to disturb the principle, which applies equally to the circuits of Fig. 4.

Hence for Fig. 4 (c) when used as a class A amplifier the quiescent current (I_s) may be calculated from the supply voltage (V_s) and the intended load resistance. Peak voltage in load is $V_s/2$; peak current in load is $2I_s$; therefore optimum load resistance is $V_s/4I_s$. Resulting mean load power is $(V_s/2)2I_s/2 = V_sI_s/2$, corresponding to an efficiency of 0.5 for ideal transistors.

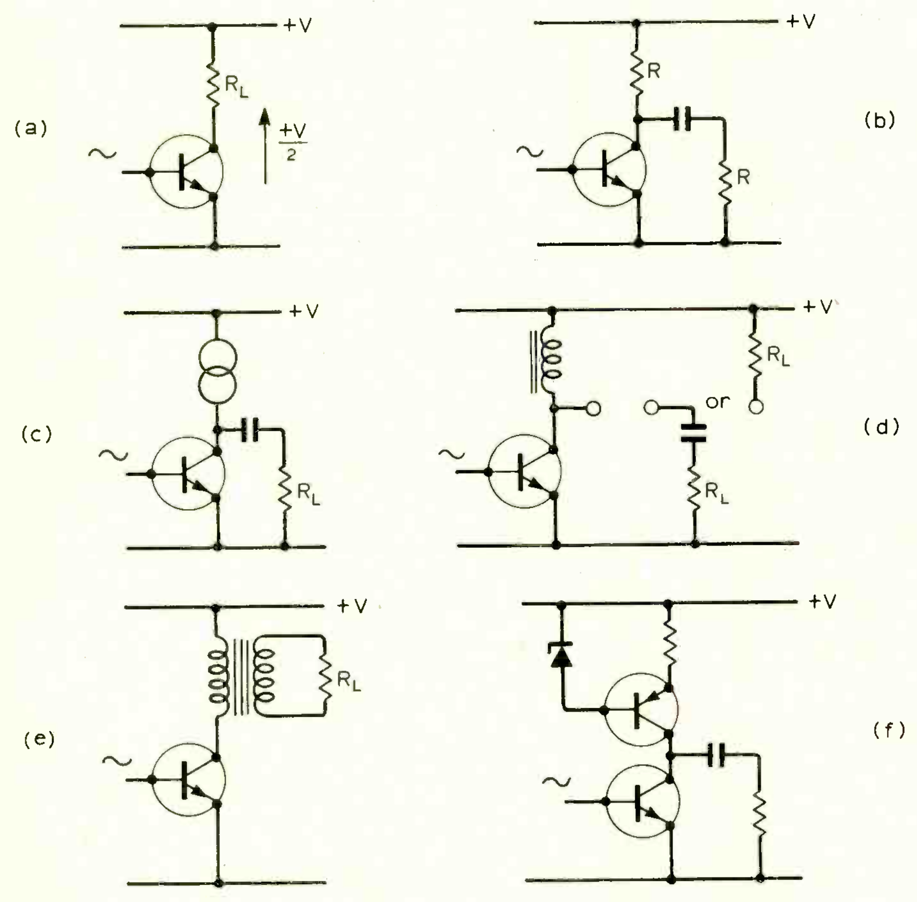


Fig. 3. In a resistive-load class A amplifier (a) efficiency is only 25%; with a capacitatively-coupled load efficiency could be 12½% for equal values of resistor shown (b). Replacing collector resistor by a constant-current circuit (c) means the peak load current can equal the quiescent current. Examples of constant-current circuits are a simple inductor (d) or transformer (e) both giving maximum possible efficiencies of 50%, or at (f) using an additional transistor, efficiency 25%.

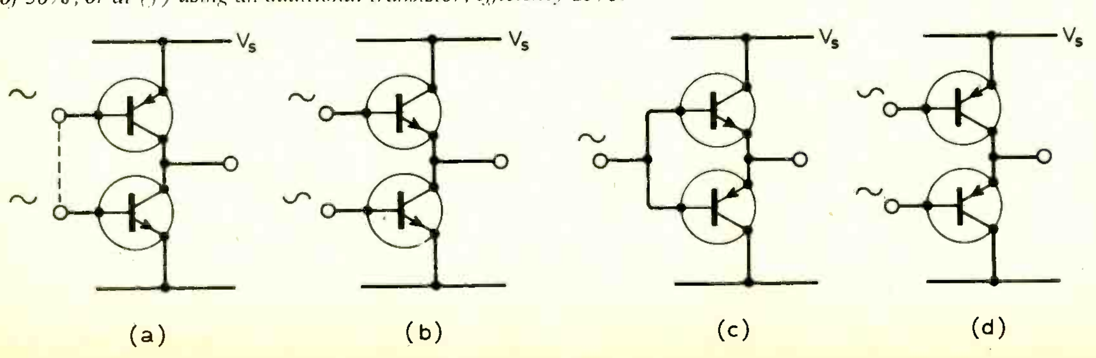


Fig. 4. Using a second for signal handling enables the peak load current to equal twice the quiescent current, with efficiencies of up to 50%.

These circuits are not restricted to class A operation. Indeed they are more commonly used as push-pull class-B amplifiers in which the bias network (not shown) is adjusted to bring both transistors to the edge of conduction. Each transistor then conducts during one half-cycle, there being no quiescent current. There is no comparable limit to the peak current that may be provided; class B simply demands that conduction takes place in a device for 180° in the cycle. A limit will be imposed in any particular design by the current/power limitations of the transistors/power supply. In principle any basic design for a class B power amplifier using configurations such as those of Fig. 3 (c) and (d) may be extended to higher current levels by replacing the output transistors with Darlington pairs, complementary pairs etc. Thus 100W and 100mW amplifiers may be surprisingly similar in configuration. At high power levels the importance of protection and of maintaining stable bias leads to the addition of circuits monitoring and/or controlling the current in the output stage.

To minimize the distortion due to device non-linearity at low currents (cross-over distortion) the bias networks are set to provide some quiescent current, setting the operation intermediate between true class B and class A—often called class AB and further subdivided into AB_1, AB_2 according to the fraction of the cycle for which each device is non-conducting. The design of low-distortion power amplifiers is a highly specialized subject that will warrant separate treatment in a later series though outline design procedures and practical examples of simple and economical circuits are given in this series of Circards.

Quiescent power in class B is zero. Maximum output power with ideal transistors (Fig. 6) is $\hat{V}^2/2R_L$ where $\hat{V}$ is $V_s/2$. Therefore $P_{L\,max}$ is $V_s^2/8R_L$.

Under these conditions, the mean current drawn from the supply is $V_s/2\pi R_L$. This is because the current is drawn from the supply only during the positive half-cycle; the negative half-cycle results in charge being withdrawn from the large coupling capacitor, which charge is restored during the next positive half-cycle. The mean power drawn from the supply is $V_s I_{dc} = V_s^2/2\pi R_L$ and the corresponding efficiency is

$$\frac{P_L}{P_s} = \frac{V_s^2}{8R_L}\cdot\frac{2\pi R_L}{V_s^2} = \frac{\pi}{4}$$

or 78.5%.

As the load power is proportional to the square of the output voltage while the supply power is proportional to the voltage it follows that efficiency is proportional to output voltage. It is also true that at some intermediate level of output, the load power having fallen faster than the supply power, the power in the transistors passes through a maximum. For sine wave drive the maximum dissipation in each transistor is at an output voltage where $\hat{V}$ is V_s/π, and the dissipation is then about one fifth of the maximum output power derived above, i.e. a 10W amplifier could theoretically be constructed using a pair of transistors with power ratings of only 2W each.

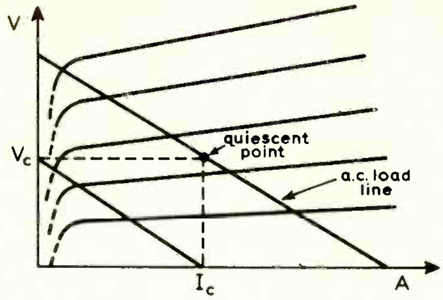


Fig. 5. Optimum load for maximum signal handling is represented by load line cutting axes at $2V_C$, $2I_C$, for Fig. 3 (d) or (e) and depends on the quiescent condition and not transistor output resistance. In general optimum load can be calculated from peak voltage/peak current.

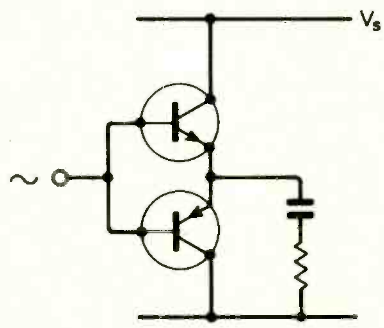


Fig. 6. In this typical class B stage, text shows maximum efficiency to be 78.5%.

Class C amplifiers are normally restricted to tuned amplifier systems, conduction taking place for only a small part of a cycle, and the recovery of a sinusoidal waveform then demands a high-Q circuit. The exception is the power-control circuits such as controlled rectifier and triac circuits in which only the mean value of voltage/current/power is of interest and waveform shape is non-critical. These differ from conventional class C circuits in that the conduction has a controlled starting angle but always finishes near the end of a half-cycle; class C r.f. amplifiers are biased such that the conduction angle is symmetrical about the peak of the drive waveform.

A further difference is that the power control devices are operated as nearly as possible as perfect switches, while at the high frequencies normally associated with class C stages, a very detailed design procedure is required to cope with transistor parameters. This will normally include complex conjugate matching to source and and load, to optimise performance. Efficiency can exceed that for class B, though power losses in the passive components involved in the tuning/matching processes are inevitable. A further application of class C power amplifiers is in frequency multiplication where the output circuit is tuned to a harmonic of the input frequency. These aspects are germane to more detailed later studies of r.f. circuits.

Class D is the generic term for switching circuits in which the active devices are switched multiply in and out of conduction during a single cycle of the input signal. They are also power realizations of pulse modulation systems, the theory for which can be used to determine the spectral components of the output. As one example, circuits such as those of Fig. 4 may have their signal drive replaced by high-speed pulse waveforms whose widths are modulated by the received signal. If the load is fed via an LC filter, the pulse frequency terms can be removed and the output transferred to the load is proportional to the signal.

For ideal transistors the switching process allows for zero power dissipation; at all times either the transistor p.d. or its current tend to zero. If the unwanted terms are to be well outside the band of frequencies that it is required to amplify, then the pulse frequency may have to be so high that serious power losses occur during the instants of switching, while charge storage in either of the transistor base-emitter junctions can lead to excessive current spikes through the series path then provided by the two transistors. The principle is more readily applicable to small servo-motor systems than to audio amplifiers as the electromechanical properties of the load do not require very high switching frequencies. In some cases efficiencies may exceed 90% with 100% as the theoretical upper limit.

In all the above circuits an ever-present problem is that of protecting both the circuit and its load from excessive current flow. Much time and energy is expended on systems for protection against faults, but inevitably accidents happen, so often after some improvement or embellishment has been added. One can only wonder if such thoughts may have been in the mind of William Wordsworth when he wrote

I have submitted to a new control;
A power is gone which nothing can restore;
A deep distress hath humanized my soul.

A cry from the heart that will speak to all designers of power amplifiers.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Transmitting aerial design

I would like to suggest the possibility of another method of reducing interference in addition, or alternative, to frequency allocation or use of suppressed carrier systems on the medium waves. This is associated with aerial design.

Many wavelengths from an aerial, all that is left of the composite field is a transverse one, in which the electric and magnetic vectors are perpendicular to the line of propagation, and the inverse square law applies to this radiation. However, closer to the aerial we find radial components of radiation which die away more rapidly than as r^2. Would it not be possible to design an aerial with strong radial components and small transverse component, so that the fields which die away inversely as r^4 and above are used for local communication; while the field which dies away inversely with r^2 is of sufficiently small amplitude not to cause interference over long distances at night?

Guy S. M. Moore,
University of London King's College,
London W.C.2.

Current flow symbology

Over the years your journal, through its articles and correspondence columns, has played an important part in tidying-up thinking, terminology and conventions in our industry. I wonder if a really basic convention could be discussed and possibly one of the alternatives chosen as *Wireless World* policy?

I refer to the direction of current flow. Some people, I am one of them, regard electron flow *as* current and indicate on circuit diagrams the direction of electron flow by arrows. Other people prefer to refer to "conventional current" and indicate its direction by arrows pointing +ve to −ve.

A brief survey of educational books showed other variations. One showed steady current flowing +ve to −ve but signal currents flowing −ve to +ve. In another, the "two" currents are called electric current and electron current. In another, electron current is called "negative current". So long as it is made clear in the text of articles which convention is used I suppose it does not matter very much to experienced engineers, but it does seem rather a waste of effort and it must cause confusion, particularly to students.

Pneumatic and hydraulic engineers manage without a theory which needs the belief in a "conventional" air or water current flowing in the opposite direction to the flow of air or water particles.

Is there any serious objection to dropping "conventional" current and dealing only with electron flow, calling the flow "current" or "electron current" and indicating its direction on circuit diagrams by arrows pointing −ve to +ve?

C. H. Banthorpe,
Northwood,
Middlesex.

Measuring displacement

I was interested to read the article on "Displacement and position" in Richard Graham's series on Industrial Electronics, and in particular his comments on the susceptibility of the incremental moiré fringe counting system to miscounted pulses and mains transients (April issue).

Modern chrome-on-glass or stainless steel gratings, housed in a sealed channel to prevent contamination, will provide signals of good amplitude and waveform which virtually preclude errors due to miscounting, provided that the maximum permissible speed of counting is not exceeded. Unfortunately, the effects of vibration, a fairly common hazard with machine tools in particular, can give rise to instantaneous very high counting rates and hence to counting errors.

The problem of mains transients is more serious than is commonly imagined; operation of arc welding equipment, overhead cranes, and even nearby machine tools, can cause momentary "spikes" in the mains supply and hence counting errors. Furthermore, complete failure of the mains supply, although only for a second's duration, can result in the scrapping of complex and expensive components.

One method of eliminating this problem is to power the reading heads, interpolation circuitry and counters from a "floating" battery supply: a Ni-Cd or other storage battery, with voltage stabilizer, continuously trickle-charged from the mains. This solution not only caters for gross breaks in the mains supply, but also smooths out even the most extreme mains transients.

An additional point, regarding radial gratings, is that any eccentricity in the rotation of the grating will frequency-modulate the output pulse train, giving rise to angular reading errors. The conventional way of avoiding this "eccentricity error" is to employ two diametrically opposed reading heads (or occasionally four heads at 90° spacing) and to combine the in-phase and quadrature signals from these heads in operational amplifiers. However, this technique is of use only when the grating eccentricity is less than one-eighth of a line spacing. For very fine gratings (64,800 or 72,000 radial lines) this means that the bearing must have an eccentricity of only a few micro-inches, and that the grating must be mounted to a similar accuracy — both requirements possible only on equipment of the very highest accuracy.

A recent development by the Cranfield Unit for Precision Engineering is a form of digital eccentricity-reducing circuit, acting in combination with a phase-division circuit giving typically 20 equi-spaced pulses for each prime fringe. The Cranfield circuit accepts signals from two diametrically opposed reading heads, and reduces the effects of any eccentricity present by the same factor as the phase-division circuit, e.g. 20 times. The circuit will accept signals from gratings with any amount of eccentricity, and in particular a small modification enables a continuous display of the eccentricity present to be made *even while the grating is stationary*. This feature has reduced the time required to centralize gratings and bearings to a few minutes.

Finally, position servo systems have been developed at Cranfield using moiré fringe measurement, with positioning resolutions of 0.5μm (linear) and 0.9 arc-seconds (rotary).

J. Dinsdale,
Cranfield Unit for Precision Engineering,
Bedford.

"Biamplifier" loudspeakers

I notice in Mr Peter Hiscocks' letter on "Loudspeaker parameters" (March) he mentions the Biamplifier approach.

Some fifteen years ago at Philco we marketed such a system. The amplifiers were quite modest with the ratio of their respective power capabilities arranged to coincide with their section of the audio spectrum. Additionally, the loudspeakers were designed into the filter characteristics. The overall aural effect certainly demonstrated a low level of intermodulation and even a direct comparison with the standard high fidelity equipment of the day failed to prove any marked inferiority, even though the price differential was very considerable.

The disastrous sounds associated with overdrive of the high feedback amplifier was of course absent and the impression was of almost unlimited power from the

system. The low-pass filter action of the bass/mid-range loudspeaker contributes to the low aural distress. Also, unlike the passive cross-over, no distortion products of mid-frequency overload are diverted into the treble loudspeaker; this remains clean until treble components of the programme material themselves overload the treble amplifier.
H. D. Garland,
Romford,
Essex.

Distortion reducer

The article "Distortion Reducer" by D. Bollen (*W.W.* Feb. 1973, pp. 54-57) describes a useful method of reducing distortion in power amplifiers. Since the article gives no references to earlier work in this field, it is worth pointing out that exactly the approach used by Bollen for distortion reduction has been described in detail much earlier (J. R. Macdonald, *Proc. I.R. E. 43*, 808, 1955). This scheme, termed active-error feedback, preferentially makes use of a feedback, amplified error signal. Bollen shows in his Fig. 1 a realization with unity gain in the feedback path (amplifier *C* has unity gain), but his actual experimental circuit (Fig. 4) and text involve an error signal path with greater than unity gain, as described in 1955 and perhaps even earlier. The current availability of inexpensive i.c. operational amplifiers now makes the active error approach extremely easy to implement, but the usual precautions appropriate for negative feedback amplifiers must be observed.
J. Ross Macdonald,
Dallas,
Texas, U.S.A.

Old headphones needed

I hope you will be kind enough to allow space for this begging-letter. I need a few old headphones for children's Science lessons. The 'phones need not even be good enough to emit readable speech, so long as they "crackle" when a faint voltage is passed through their leads and diaphragms.

If headbands are present, they will be a marvellous bonus, but we do want some earpieces and leads that respond to a voltage of about 0.5V.

My problem is that we have no money to pay for these. Your readers already know that teachers in primary schools these days ungrudgingly spend quite a bit of their own pay in supplementing their fellow ratepayers' contribution. In the present case I am saving for a secondhand 4-channel mixer so that some less-articulate children may be encouraged to help make a "radio play" on my (1958 model) tape-recorder; we are therefore stumped for cash for headphones for Science.
John R. Gibson,
Sudbury Junior Mixed Primary School,
Watford Road,
Sudbury,
Middlesex.

Mechanical television

I am trying to revive interest in mechanical television for recording and line-transmission, using the most modern electronic devices that have appeared since the demise of the mechanical system, *circa* 1934.

I feel sure that many *W.W.* readers with a knowledge of mechanics and optics would be interested in taking part in such work as an unusual inter-disciplinary project, particularly those of a younger generation to whom the ideas are virtually unknown. I have already felt considerable warmth of enthusiasm from the older workers in this field to whom this subject has a naturally nostalgic appeal.

Having received most courteous help from the I.T.A. and the B.B.C., not to mention the local radio station, I am moved to make a wider appeal, and the use of your pages would be a great help.
D. B. Pitt,
Wollaton,
Nottingham.

Magnetic pickup loading

The origin of the myth that the 47kΩ load resistor specified for most magnetic cartridges results in a h.f. cutoff is one that has always mystified me, and to see it perpetuated in the latter part of Mr Fison's letter (*Wireless World* March issue) puzzles me even more. It is perfectly true that if we consider a typical magnetic cartridge to be almost a pure inductive source, then a termination with the usual 47kΩ load would create a simple 1st-order low pass filter, with the −3dB point obtaining when $R_L = X_L$ and thereafter increasing to the anticipated 6dB/octave slope (Fig. 1).

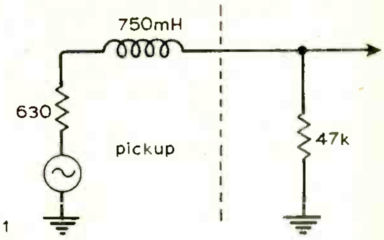


Fig. 1

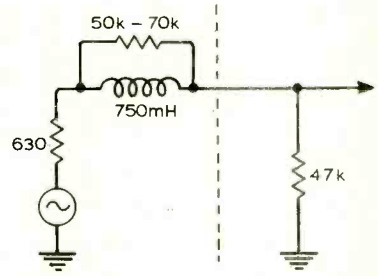


Fig. 2

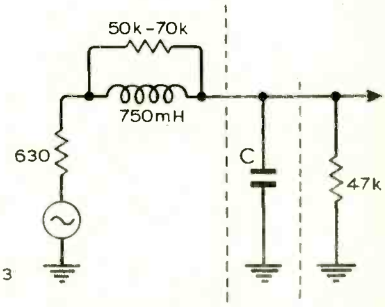


Fig. 3

But, of course, in a real circuit, this would be an incorrect assumption. The inductive component in, for example, the pickup referred to is heavily damped and a quick measurement in my lab suggests that Fig. 2 would be much nearer to the equivalent circuit. I am sure that it will be agreed that now the h.f. fall-off will be very small within the audio passband and, indeed, hardly worth working out. Let's now take the example a stage farther. It is a fact that there will certainly be a shunt *C* component in our equivalent circuit (Fig. 3) and, if one assumes that the amount of coupling lead is not less than 1 metre of low capacitance screened cable, then the value of the shunt *C* will not be less than 100pF and may be as much as 250pF (although this is far from desirable).

Without R_L the equivalent circuit now looks like an unterminated basic ½-section low pass filter and, as one might expect, there will now be a *rise* at the h.f. end, reaching a well damped peak somewhere between 10kHz and 20kHz and dependent, naturally, upon the source inductance and the shunt capacitance. This is where the optimum load comes in, and, as we know already, the cartridge parameters are normally tailored by the cartridge designer for an optimum load of 47kΩ. Please note, I have not taken into account at all the inevitable mechanical resonances in the pickup such as that which arises from the stylus mass and the compliance of the record material. These will almost certainly contribute to an additional rise in amplitude at the h.f. end of the passband.

Incidentally, if I might be permitted a little aside? It might be rather interesting to discover how many of my colleagues, entrusted with the task of evaluating commercial amplifiers for the popular hi-fi press, take the precaution of inserting a simulated cartridge into the signal path when checking the characteristics of the "magnetic pickup" input stage? The results can often be quite revealing, since one must not overlook the fact that this reactive signal source is usually in the n.f.b. path of the input stage as well.
Reg Williamson,
Norwich.

Loudspeaker loading

As a student of electroacoustics I have taken interest in your articles and letters on loudspeakers. It is my opinion that instead of trying to eliminate all resonances to produce systems working on one single loading principle, one should make deliberate use of as many as possible (suitably damped of course) to extend and improve bass response. After having tried out most of the available methods in my own systems, I have finally arrived at a very satisfactory design based on t.l.s., reflex and tuned pipe principles at the same time, the effects occurring at different frequencies below about 100Hz. This has enabled me to get a good, clean and strong response to about 30Hz from a modest elliptical unit costing about £4 in this country mounted in a 2 cu.ft cabinet.

I would also like to add to Telfer's and Greenbank's letters on horns that I feel the ability to produce reasonably plane waves at low frequencies (also mentioned by "Toneburst" if my memory serves me right) is essential in the correct reproduction of spatial information, especially when illusions of distance are necessary. This accounts for the obvious superiority of a good horn in reproducing large orchestral works etc. Listening to chamber music or music where direct sound plays a minor role, e.g. an organ, or sitting at a distance from the speaker in a large room, all tend to reduce this difference. The only real disadvantage of the hornloaded speaker seems to be bulk, which should not be much greater than conventional systems of comparable quality in both extended response and handling capability, though the latter is hard to achieve in direct radiators.

Peik Borud,
Trondheim,
Norway.

Electronics in psycho-kinesis

An apparatus used in a psycho-kinesis experiment performed in the U.S.A. is shown in the accompanying diagram (a). It consists of a solenoid, a conventional magnetic compass, a battery and a current-limiting resistor R. The combination of the solenoid and the compass provides a sensitive galvanometer. The experiment was performed by Professor E. M. Monahan, a parapsychology teacher at Georgia State University, Atlanta, Georgia. Professor Monahan is a well-known "psychic" or "sensitive", with many remarkable accomplishments to her credit, discussed in current magazine articles (*Newsweek* August 28th 1972, *Atlanta Magazine* August 1972).

In the author's design of the psycho-kinesis (p.k.) apparatus, the following four aims were pertinent. To prove that the "sensitive", in this case Professor Monahan, could (1) deviate a magnetic needle by p.k. energy, (2) similarly rotate a magnetic needle, thus for a short time providing a "mind-driven motor", (3) symbolically, at least, employ p.k. energy to inject "stimulance" (negative resistance or negative conductance) in an electric circuit, and (4) establish "energy conversion" — the fact that in this experiment mind energy can be converted to mechanical energy, electrical energy, and heat.

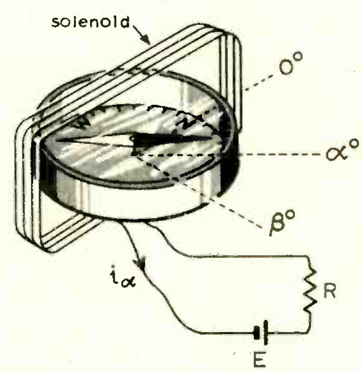
The circuit diagram of the complete apparatus is shown in (b), where r is the resistance of the solenoid. With the switch in position "a", the circuit is open. When the switch is in position "b", the situation shown in (a) is established, the current i_α being just sufficient to cause a small deflection $\alpha°$. When the switch is in position "c", the solenoid is connected to a load resistor, provided with output terminals for the connection of a sensitive d.c. voltmeter. Experiments (1) and (2) have been performed before, and today it is a fact that "sensitives" can employ p.k. energy to deviate and rotate a magnetic needle. During October 1972, Professor Monahan successfully performed experiments (1), (2) and (3). The research model used by her did not have the particular switch arrangement with a load resistor, and experiment (4) was therefore never performed, but there is no need to perform it since Maxwell's equations assure us that rotation of the magnetic needle results in an alternating current in the load resistor.

In experiment (3) the needle moves because the p.k. force combines vectorially with the earth's magnetic field force in agreement with Newton's laws. While the "sensitive" did not change anything in the electrical circuit, the fact remains that a deflection β obtains, with a current i_β in excess of the current i_α, determined by Ohm's law. Mathematically, therefore, we may satisfy the equations by introducing a negative resistance R_N, writing

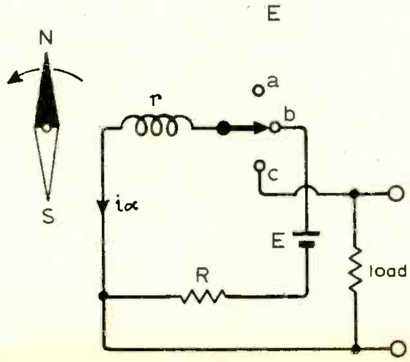
$$i_\alpha = \frac{E}{r+R}; \quad i_\beta = \frac{E}{r+R+R_N};$$

$$R_N = \frac{E}{i_\beta} - (r+R) = (r+R)\left(\frac{i_\alpha}{i_\beta} - 1\right)$$

We are now measuring the mind action in the international unit ohm, and, as an example, $R_N = -100$ ohm. For an experiment of this nature to actually contribute "stimulance", the p.k. action must be extended to the current carriers in the proper electrical circuit rather than being applied to a magnetic needle. Whenever a carrier is deviated from its trajectory in an electric or magnetic field, as described by Maxwell's equations, the potentiality for an increased or decreased loss exists, contributing possibilities for the design of new kinds of amplifiers, oscillators, s/n ratio enhancers and similar devices, and it is hoped that such experiments will attract the interest by research workers in the communications field. The most valuable contribution that can ever come out of such research is an apparatus for storing of p.k. energy.



(a)



(b)

Among future research apparatus contemplated is a p.k. power meter, in which a wheel of known mass and weight is rolled up a slope by p.k. energy. The mind energy is then measured directly in the unit joule, and the mind power in watt. Professor Monahan has already succeeded to rotate a wheel by p.k. power, and to make a paper clip move on a table top. It moves in little jumps. There is a great need for refined test equipment in this new field. Of special interest is a recently developed research apparatus in which p.k. energy is applied to material or living tissues inside the capacitor of an oscillator, so that the mind action can be measured in the international unit hertz.

Harry E. Stockman,
Arlington,
Mass., U.S.A.

Audio amplifier design

With reference to the letter from Messrs Vereker and Mornington-West in your May issue, I would like to point out that the amplifier unit of my design to which Mr Vereker refers, and on which he made his published measurements, was one which I had lent to him for experimental purposes and in which the harmonic distortion performance was below specification. Moreover, I had informed Mr Vereker on this point at the time.

This circumstance arose because of the unsatisfactory characteristics of the output transistor pair with which it had been fitted (these were the only pair I had spare at the time). This particular phenomenon, worsening of the t.h.d. at higher frequencies, will inevitably occur in any power amplifier design in which the h.f. and l.f. negative feedback loops are divided (which is necessary to meet the Otala transient intermodulation criterion[1]) if the output transistors are badly matched or if their h.f. parameters are poor, since the t.h.d. characteristics at frequencies above that of the operating range of the main l.f. feedback loop depend on the effectiveness of output stage emitter follower action. If this phenomenon is found, this cause should be suspected.

For the record, when the output devices were changed (a reasonably well matched, ± 20%, pair of Sescosem BDY56s was used) the harmonic distortion of the same unit was lower than that of my reference standard signal generator at frequencies up to 20 kHz, i.e., better than 0.05% at 10 kHz and better than 0.1% at 20 kHz. I take the point that a shunt feedback design might be better still, but common mode failure was not the cause of the phenomenon observed

J. L. Linsley Hood.
Taunton,
Somerset.

1. Otala. M., *Trans. I.E.E.E.*, Sept. 1970.

Paris Components Exhibition

New semiconductors seen at the Sixteenth International Salon

The romantic picture of Paris in the Spring fell some way short of accuracy this year, at least during the exhibition. Rain and wind were present in full measure, although the exhibition attendance did not seem to suffer as a result.

Exhibitors were about 11% down in number on last year's figure, but the effect on the leg muscles was hardly noticeable. To report on 910 stands is impossible and we have concentrated on the subject which we thought would provide the most innovation — semiconductor devices and circuits. If we are right in this assumption, we can only say that new components in the other categories must have been very thin on the ground indeed. In the opinion of many people we spoke to, manufacturers have been caught unprepared by the welcome resurgence in the electronics industry and are having a hard time supplying the demand for established components without developing new ones. This can only be a very short-lived situation and one would expect future shows to be as fruitful in novelty as previous ones have been.

Integrated circuitry continues to develop at a remarkable rate. Equipment that was "mini" even a few months ago can now be "micro" and an equipment manufacturer who rushes into hardware with his new calculator, for instance, confident in the knowledge that his latest integrated circuit is the ultimate in l.s.i., is likely to be informed otherwise rather rapidly.

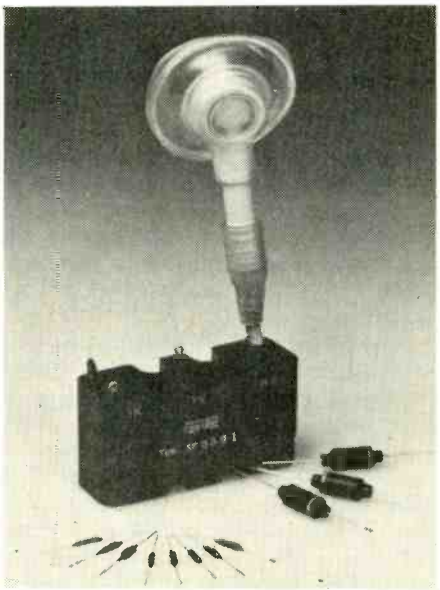
Fairchild Semiconductor, for example, have brought one stage nearer the ideal of the "computer on a chip" with the PPS25 system. They have taken the low-cost m.o.s. l.s.i. technology, which has revolutionized the design of calculators and, with an expected upsurge of interest in mind, have applied it to the realization of minicomputers and data-processors. A family of integrated processing units has been designed to form the nucleus of programmable digital processing systems, removing the cost barrier and making possible the development of computing equipment for use with small systems. Fairchild say that the PPS25 (programmed processor system) fills the gap between calculators and minicomputers. A basic system would consist of an arithmetic/logic unit to provide timing and supervision in addition to arithmetic functions, a memory, consisting of three 25-digit shift registers, a read-only memory for programme storage and input/output units — all on six chips, costing less than £25. The PPS25 uses single-polarity silicon-gate m.o.s. techniques and is compatible with t.t.l. circuitry at all interfaces.

A particularly elegant application of integrated m.o.s. circuits is the Bizerba price-computing counter weighing machine, using a pair of Siemens integrated circuits specially designed for this purpose. The arithmetical process is the reverse of that used in the count-by-weight machine used in industry to count large numbers of small items, and performs the multiplication of two quantities. The weight of the goods for sale is transduced into electrical form by means of a coded, transparent disc mounted on the spindle of the mechanical weighing machine. Lamps and phototransistors continuously record the weight information, which is passed to the electronics. The price per unit weight is entered by means of a ten-digit keyboard, and the two m.o.s. packages multiply the weight by the unit price to give selling price, which is displayed digitally. Siemens point out that one of the more significant benefits of l.s.i. is the reduction in soldered joints and ensuing increase in reliability. The use of these two packages has reduced the number of joints from about 4000, using t.t.l. and r.t.l., to 48.

The improved C-550 calculator chip produced by General Instrument SpA offers the facilities required to make an 8-digit, 4-function, display calculator dissipating only 150mW at 14V. No under or overflow indication is provided, the lack of a decimal point in the calculated result implying that the whole number consists of more than eight digits. The exponent (up to the 79th) is obtained by dividing the result by powers of 10 until the decimal point appears.

The same company were also showing their read-only memory ic — the RO-5-5184 — which is an m.o.s. character generator for needle mosaic printers. It contains a 64 × 9 × 9 matrix and an internal counter with forward/reverse control. The outputs are tri-state.

Large-scale integration is primarily for large-scale application, or, at least, it has been until now. The high cost of



E.h.t. rectifiers and multipliers for solid-state colour television in silicon by General Instrument Europe (left) and in selenium by ITT.

development of these ics has limited the use of purpose-designed units to long-run manufacture. In an effort to overcome this limitation, several firms are now making life easier for the small user by the introduction of circuits which contain a large number of finished, but unconnected, active and passive devices. The French firm of Sintra have given the name Monochip to their design, which comes in three versions, and which contains from 197 to 352 components (14 to 24 outputs). Bipolar transistors of p-n-p and n-p-n types are provided, with a maximum current capability of 200mA, and resistors are between 200Ω and 90kΩ in value. In addition, Schottky diodes are provided with the n-p-n transistors and a Hall-effect device is included to enable an external magnetic field to initiate operation. The user specifies the interconnection pattern which the manufacturer applies.

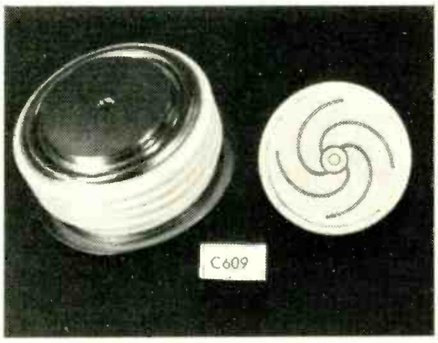
Ferranti have called their approach to this problem of cost reduction the uncommitted logic array (u.l.a.). Using their recently developed collector diffusion isolation process which produces a component density in the bipolar technology comparable to that of m.o.s. techniques, they have developed an array of 187 three-input gate cells which are complete except for the fifth mask, which is the pattern for the aluminium interconnection layer, specified by the customer. Each cell can be connected to operate as either a logic element or as part of a linear circuit such as an operational amplifier or oscillator. Gate delays are typically 35ns and power dissipation is 2.5mW per cell.

Motorola introduced their 1024-bit read-only memory, which is claimed to be the largest production memory in this technique. This is a complementary m.o.s. memory which is programmed by the user with the aid of punched cards or a truth table. The use of c.m.o.s. confers the benefit of extreme tolerance to power supply variations, the range 3 to 18V being usable. The MCM14524 can therefore, be used not only in all c.m.o.s. systems but will interface with bipolar elements. Access time is 70ns.

Also using c.m.o.s., National Semiconductor have introduced their 54C/64C/74C series of logic circuits performing the same functions as the well-established 54/74 series of t.t.l. units. The two series are compatible, and low-power t.t.l. and d.t.l. can also be interfaced with the "C" series. The advantages of c.m.o.s. are low power dissipation (dependent on supply voltage and clocking frequency), high noise immunity (45% of supply voltage), reasonably short transition times (50ns) and a propagation delay of about 25 to 50ns.

A clearly evident trend is the recognition by a number of firms of the need for electronics in motoring. AEG-Telefunken, for instance, showed an ic, the SAJ150, which can be used to control direction indicators and hazard warning lights, as well as providing a timing function for other on-car equipment with independently variable on and off periods. ITT presented their power pulse generator ic which serves as a central timer for direction and hazard indicators and timed wipers, and will provide an excess-speed warning signal. Both these devices indicate the presence of a lamp failure by increasing flashing speed. Thomson-CSF also had a device on show which provides the timing and warning functions, and have developed the ESM16 transistor for use in electronic ignition systems.

Industrially, special-purpose integrated circuits are now being presented, the technique of integration enabling sensors and controls to be made which, while exceeding the reliability of electromechanical devices, are lower in cost. Siemens presented a series of three units, the TCA105, TCA345 and 5059 which are inductive, light-operated and magnetic switches. The TCA105 consists of a flexible input stage, operating as either oscillator or Schmitt and includes a voltage regulator. Applications include phototransistor output level detection and proximity detectors using inductively coupled oscillators. Anti-phase outputs are provided, giving currents of up to 50mA. The TCA345 is also a level detector and is notable for its low power consumption (1.8V at 800μA quiescent). It is primarily intended for use in photographic camera control circuitry. The SO59 is a Hall-effect circuit with Hall generators on the chip. An output is obtained in a field of 600 gauss which is t.t.l.-compatible. Application in typewriter keyboards and calculators is envisaged.



The C609 inverter thyristor from General Electric, rated at 1kHz and 1200A. The involuted cathode structure permits a rating of 850A at 5kHz, long-term di/dt of 500A/microsecond and minimum dv/dt of 400V/microsecond.

The National Semiconductor LX1600 absolute pressure transducer is capable of measuring pressure in the range 0-3 atmospheres at temperatures of $-40°C$ to $+105°C$, is temperature-compensated and is chiefly contained in one thick-film integrated circuit. A piezo-resistive bridge with a vacuum reference, and a diaphragm are integrated on thick film, while the amplifiers are on a separate chip in the same package. The unit is, in effect, a simple potentiometer which is free from the loading problems imposed by an ordinary resistive type. Loading impedance is in the order of megohms, while the output is from a few kilohms. The input is over-voltage protected and the output is not damaged by shorts to earth. Applications include medical investigations, meteorological work and process control.

SGS Ates SpA mounted a working demonstration of their new voltage-and-temperature-protected amplifiers TBA810S and TC940. The former, in a 12-lead quad-in-line package with heat-sink tabs, will deliver 6W at 14.4V into 4Ω, at which point it is completely immune to short circuits and overloads. A rise in junction temperature automatically limits output power.

The highlight of the Plessey display was their collection of Process III Bipolar circuits including the remarkable SP600 high-speed frequency divider series which is t.t.l.- or e.c.l.-compatible. This is capable of dividing a frequency of 1GHz by four and 100MHz by 32, while using only 10mA. Process III linear products include the SL360 matched transistor pair and the SL3145 array, exhibiting an f_T of 2.5GHz The low-noise SL362 has a noise figure of 4dB between 30 and 200MHz at 50 ohms, while SL645 is a square-law device for communications use. The devices in this series exhibit f_T of more than 2GHz due to the extreme thinness of the epitaxial layer (4 microns) and the emitter/base and base/collector junctions (0.25 and 0.5 microns). Plessey claim them to be the fastest monolithic integrated circuits in the world.

ITT's new v.h.f. transistors include the BFT13A, which is a low-noise beam-lead type useful up to 5.5GHz, while the BFT16 will deliver 200mW at 3.5GHz. Their Schottky diode rectifier is capable of putting out 30A of rectified current with a repetitive p.i.v. of 20V, while dropping only 400mV.

AEG-Telefunken introduced four new l.i.d. silicon diodes for use in microwave integrated circuits. One of these is intended for use in up-converters up to 12GHz, while the other three are frequency multiplication types at 2GHz, 7GHz and 11GHz, exhibiting rise times of 0.2ns, reverse voltage of 36V and junction capacitances of 0.4pF to 2pF.

Twelve complementary pairs of TO220 power transistors were shown by Sescosem, ranging from 36 to 75W at up to 90V, and intended for medium power switching with inductive loads and servo motor applications. They also had four complementary Darlington pairs, giving between 50 and 75W at 80V.

ITT claim a major breakthrough with their new thermistor (HT103/750) which is in probe form and which can be used up to 1000°C. It is a negative temperature coefficient type, offering a resolution better than 100 ohms and a cooling time constant of three seconds. The device is much simpler to use than other high-temperature devices, such as gas and liquid-in-metal thermometers and thermocouples.

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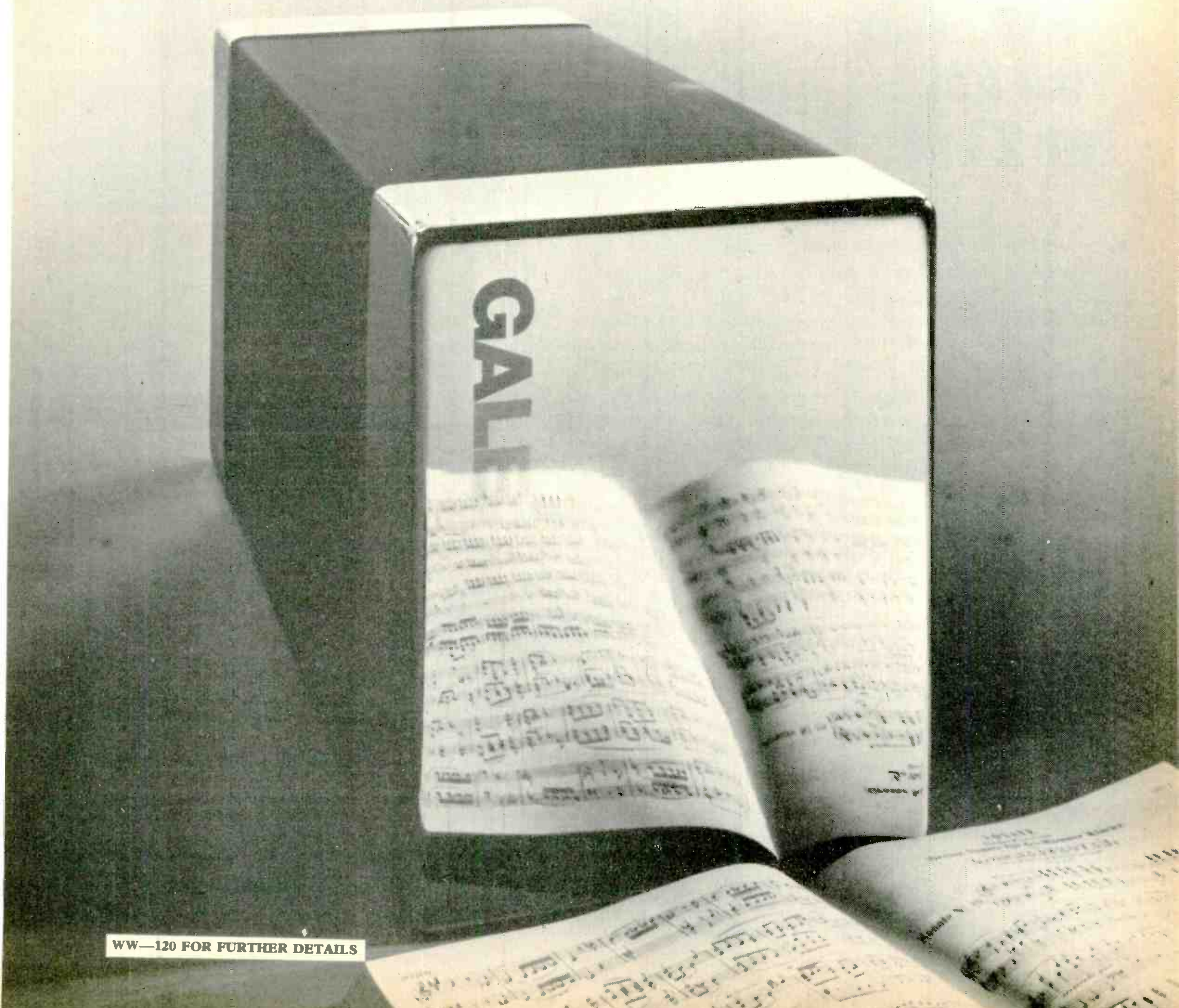

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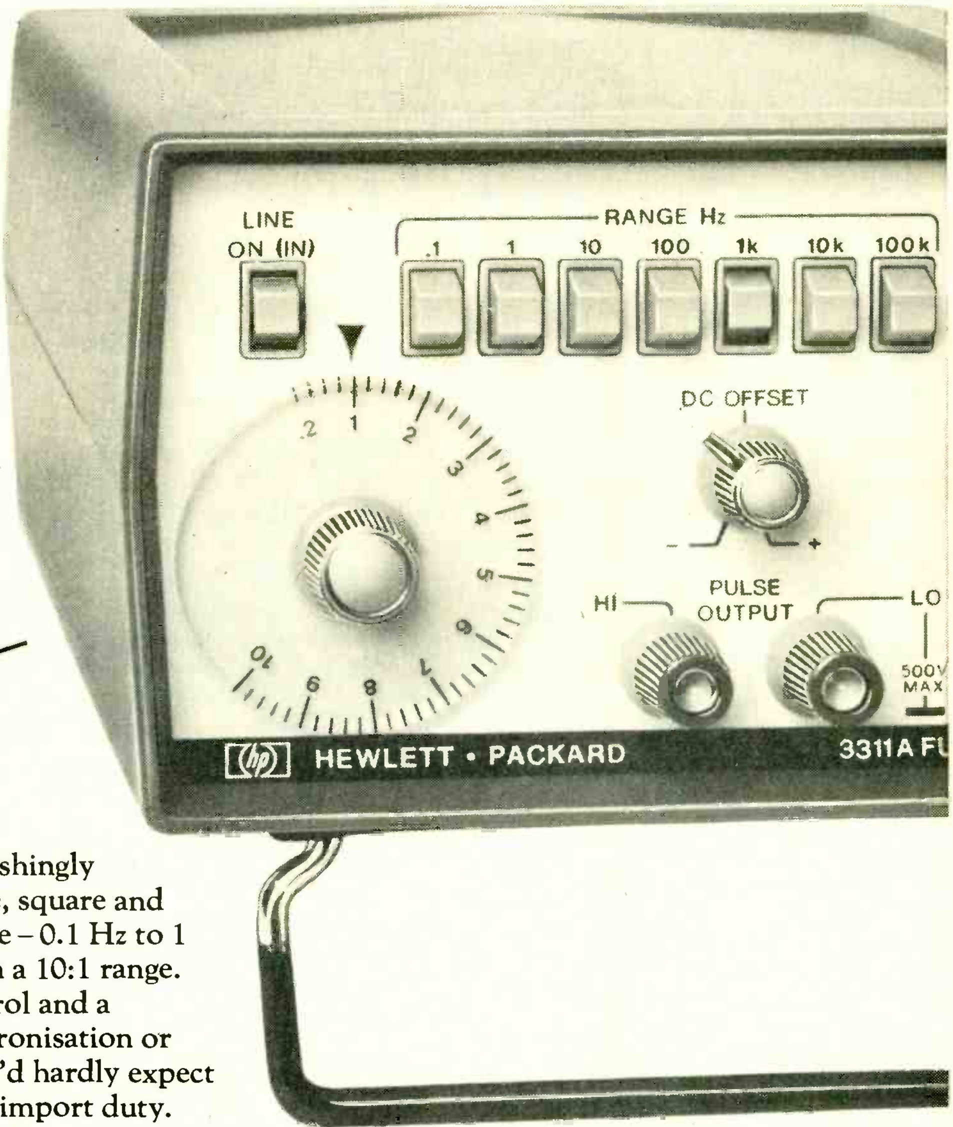

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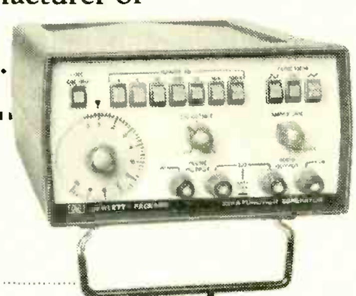

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Magnetism and Magnetic Units

The measurement of the intensity of magnetization and its units

by M. McCaig, Ph.D., F.Inst.P.

In the January issue of *Wireless World*, "Cathode Ray" accused the Sheffield manufacturers of permanent magnets of blocking the introduction of SI (formerly known as m.k.s.) units. Actually the Permanent Magnet Association, comprising all the important Sheffield magnet manufacturers, published nearly twenty years ago a booklet listing permanent magnet properties in m.k.s. as well as c.g.s. units. Since then this practice has been continued in the majority of P.M.A. publications. Until recently, however, very few others have copied their example. The majority of papers on magnetism, published throughout the world, have used c.g.s. units. In 1968 I wrote a paper for a journal of international repute in the field of magnetism and electronics. The only important comment by the referee was "What does SI mean?"

I think one of the reasons for the neglect of SI units by those working in magnetism has been the tardiness of those working out the system to provide a unit and symbol for one of the most fundamental magnetic qualities. I refer to what in c.g.s. units is called the intensity of magnetization, and is usually represented by the symbol J, although some writers have used I or M. "Cathode Ray" still ignores the need for this unit. In his terms it is a measure of the number of aligned electrons circulating in orbit or spinning within the material. Practically, this quantity can be defined by the torque that unit volume of the material experiences in an external field, and it is most important not to confuse this quantity with the flux density B. If a magnetization curve J versus H is plotted, J eventually reaches a constant maximum value, the saturation magnetization; B on the other hand, continues to increase indefinitely, because it includes a component due to the applied field H. The difference between B and J is even more striking in permanent magnets. In an ideal permanent magnet it is possible to reverse the direction of B, while the magnet remains fully magnetized with J unchanged in the original direction. Many modern permanent magnet materials come surprisingly close to this ideal behaviour. The first extensive exploitation of this property was for field measuring devices using Silmanal. This is an alloy of silver, manganese and aluminium, which is only slightly magnetic, but requires a very high field to change its magnetization. Its intrinsic coercivity, the field necessary to reverse J, is at least ten times its ordinary coercivity, the field that just reverses B. Platinum cobalt, some grades of ferrite and the new rare-earth cobalt alloys can also exist with their magnetization and flux density opposed.

Even in the c.g.s. system, workers in permanent magnetism did not find the unit provided for intensity of magnetization very convenient. They usually plotted $4\pi J$ rather than J itself, and were in this way able to use the same scale as for B. Perhaps unwittingly, they were forestalling rationalization, which is a feature of SI units discussed by "Cathode Ray".

Publishers of textbooks as distinct from scientific journals often urged authors to use m.k.s. or later SI units. As no unit had been recommended for intensity of magnetization, the authors had to invent one. Not surprisingly, they invented two different units; some authors expressed intensity of magnetization in tesla, others in Am^{-1}. Furthermore, some authors used the symbol J others M, and all four permutations of these units and symbols have been used.

My colleagues and myself in the Permanent Magnet Association were unanimous in preferring tesla, but had an open mind on the symbol. For some years we used J and then believing we were following the consensus decided to change to M. Shortly afterwards the various international committees that consider units made a pronouncement. Both units were to be recognized with different names and symbols: thus we may speak of the polarization with symbol J and unit tesla or the intensity of magnetization with symbol M and unit Am^{-1}. In the circumstances, this was a sensible compromise, but inevitably there are many books in circulation in which these conventions are not observed.

Some misconceptions about magnetic quantities have arisen from a false belief that measuring a physical quantity in a different unit with different dimensions made it into a different physical quantity. The dimensions of a physical quantity give us very little information about the nature of that quantity. Rather they often tell us which of several alternative methods we have chosen to measure that quantity. Specific gravity is dimensionless, density has the dimensions of mass per unit volume and its numerical value depends on the units we use for mass and volume. Whether we speak of specific gravity or density and whatever units we use, the value we assign to copper is a little over three times that of aluminium. Specific gravity and density are different ways of measuring the same physical quantity.

On the other hand, the height of a mountain or building can obviously be varied independently of its horizontal dimensions, but we are quite happy to measure both in the same unit, say metres or feet. We do this in spite of the fact that when we climb a mountain we realize that altitude does have a different physical significance from horizontal distance. If the same principle that some people think should apply to electrical and magnetic units had been applied to architecture and cartography, we should probably measure heights in joules per kg, the work required to raise unit mass.

SI units provide two units for what we may in general terms call magnetic fields. A distinction is made between the flux density B measured in tesla and the magnetizing force H measured in Am^{-1}. In free space, one of these quantities is redundant, because we always find that $B \equiv \mu_o H$, where μ_o the magnetic constant or permeability of free space $= 4\pi \times 10^{-7}$ henry per metre (Hm^{-1}). In free space it does not matter whether we work with B or H, provided we are quite clear which we are using. Actually, all calculations from the current flowing in a coil lead directly to H in Am^{-1} and all measurements for example by means of a coil and fluxmeter lead naturally to B in tesla.

When we deal with magnetic materials we require not two but three independently variable quantities. Actually, no less than five quantities can be distinguished, but relations between them mean that only three can be varied independently. In the above statement, I should make it quite clear that I am counting the polarization J and intensity of magnetization M as only one quantity because $J \equiv \mu_o M$.

Perhaps it will be clearer if I enumerate these quantities. There are:

(i) B the flux density in the material which can be measured in tesla by means of a coil and fluxmeter.

(ii) The polarization J or intrinsic magnetization M of which we have already spoken.

(iii) The externally applied field that can exert a torque on the sample. If we use the polarization J this external field should be H_e in Am^{-1} and if we use M the external field should be B_e in tesla. In other words a torque must be a product of one quantity in tesla and one in Am^{-1}, but we can choose which is which.

(iv) The self demagnetizing field H_d; this depends on J and the shape of the sample. For the moment we will assume that it is expressed in Am^{-1}, but sometimes we have to multiply it by μ_o to convert it to tesla.

(v) The magnetizing force H in Am^{-1} which determines the state of magnetization of the material and which we require for the X axis of a hysteresis loop.

The relations between these quantities to which I have referred are:

$$H = H_d + H_e$$

and

$$B = J + \mu_o H = J + \mu_o(H_d + H_e)$$

or if we use M

$$B = \mu_o(M + H)$$

It should be noted that all the quantities in these equations are vectors and some of them will often need to be treated as negative.

Now I realize this may seem rather complicated, and to some extent the complications are unavoidable. Some of the complications are, however, due to trying to press the subject into a straight jacket of units that just does not fit. The idea that every quantity ought obviously to be measured in tesla or Am^{-1} just as a mass is measured in kg and a length in metres does not work. In some cases the decision is arbitrary and often we have to treat the same quantity sometimes in one unit and sometimes the other.

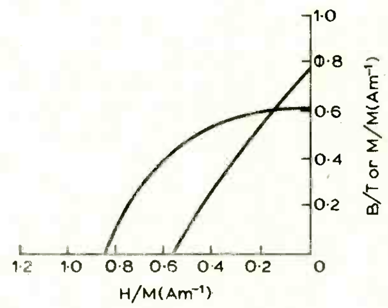
As I am sceptical about the deep philosophical significance of some of the schisms within the adherents of SI units (there is a battle of almost religious fervour between those who wish to use J/tesla and those who believe in M/Am^{-1}) I prefer to be guided by convenience. People will only change over to SI units if they are flexible enough not to entail a large amount of extra work.

If one is measuring the hysteresis loop of an anchor ring of soft magnetic material, there is no problem. H is naturally calculated in Am^{-1} and B is naturally measured in tesla. The area of the hysteresis loop obtained gives the energy loss per cycle in joule m^{-3}.

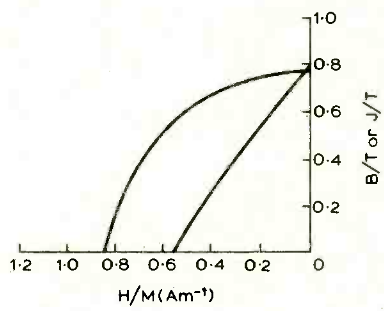
With permanent magnets the situation is less simple; H is nowadays unlikely to be calculated; more probably it will be equated to measurement of B made just outside the magnet and the manufacturer will have calibrated the instrument in tesla or possibly gauss, but certainly not in Am^{-1}. It is also likely that the polarization J (or magnetization M) as well as B will be required; J may be deduced from B and H by calculation or by remeasurement with certain modifications to the apparatus. An inconvenient choice of units can be very expensive in time and money.

To illustrate the advantages and disadvantages of the various possibilities, Fig. 1 shows the curves for a typical rare-earth cobalt magnet plotted (a) with B in tesla, M in Am^{-1} against H in Am^{-1} (b) with B in tesla and J in tesla against H in Am^{-1} and (c) with B in tesla J in tesla plotted against $\mu_o H$ also in tesla.

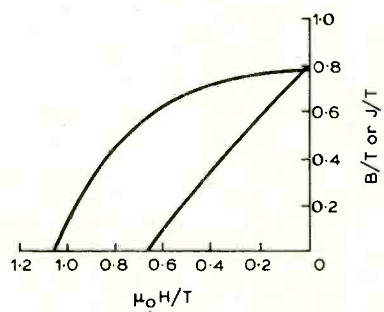
Method (a) is extremely inconvenient. In many cases today, the final output is an XY recorder, using standard graph paper. To record B in tesla and M in Am^{-1} directly would involve an expensive modification to standard equipment. Alternatively it can be done by laborious calculations. Method (b) is certainly an improvement although there are still difficulties if one has to use existing equipment calibrated in tesla or gauss to measure H and to calculate B from J or vice versa still involves multiplying each value of H by $4\pi \times 10^{-7}$. Method (c) was used by several contributors to the seventeenth Conference on Magnetism and Magnetic Materials and published by the American Institute of Physics in March 1972.



(a)



(b)



(c)

Fig. 1. (a) Demagnetization curve with B in tesla and M and Am^{-1} against H in Am^{-1}. (b) With B in tesla and J in tesla against H in Am^{-1}. (c) With B in tesla, J in tesla against $\mu_o H$ in tesla. The left curve in each case is that of $B - \mu_o H$.

Using a product of two quantities rather than a single quantity as the unit for one of the co-ordinate axes of a graph is a practice accepted in many branches of science and technology. There should, therefore, be no objection to using $\mu_o H$ for the X axis in this case, and since both μ_o and H are in SI units it in no way conflicts with the spirit of SI units. I believe that this method should be used when it is found to be convenient. It is more convenient in the following circumstances—

(i) If it is necessary to use equipment already calibrated in tesla or gauss to measure H. The factor 10^4 gauss = 1 tesla being a simple power of 10 causes little difficulty.

(ii) If it is desired to calculate B knowing J or J knowing B, only a simple addition or subtraction of the X co-ordinate value $\mu_o H$ is involved.

(iii) It is easy to see whether the value of $\mu_o H$ which brings J to zero is greater or less than B_r. If it is greater the magnet can be treated as a "hard" permanent magnet. It is suitable for applications such as repulsion devices and certain types of motors and generators, in which other materials with μ_o times the intrinsic coercivity less than B_r, would be demagnetized. It is also possible to make design calculations with the assumption that the permanent magnet is uniformly magnetized.

The objection to plotting B against $\mu_o H$ is that it may be necessary to divide by μ_o to obtain the $(BH)_{max}$ product in Jm^{-3}. This division has only to be performed once for each curve. In any case, I advocate this course only as an optional procedure when it is clearly more convenient. The decision concerning J/tesla or M/Am^{-1} is much more important. Obviously agreement is desirable, but I am convinced that those working with permanent magnets would find J much more convenient.

Paul Dirac, O.M.

Professor Paul Dirac has been awarded the Order of Merit for intellectual achievement. When he was 31, Professor Dirac gained the Nobel Prize for his work on what was then the new planetary theory of atomic structure. He devised a set of equations which required the existence of negative energy for all possible results to be true; accordingly, he predicted a new sub-atomic particle, the the short-lived positron or anti-electron, which is a positively-charged electron. A few years later, the positron was experimentally discovered by Dr Carl Anderson in America, Professor Dirac's theory thereby being substantiated. In 1930, he published his book "Quantum Mechanics", in which he asserted that nature can never be completely defined in terms of space-time happenings, as the observation required to specify natural events imposes artificial constraints upon them. This philosophy became known as the uncertainty principle of Heisenberg and Dirac.

Audio Power Amplifier

by P. L. Taylor, M.A.*

In this article the author puts forward a proposal for a transistor power output stage which does not claim the best possible performance but provides an economic configuration to achieve acceptable results. A circuit diagram for a 30W main amplifier with 0.1% distortion and a hum level of −50dBW is presented together with a description of the design philosophy.

The current-voltage relationship of a semiconductor junction is basically an exponential form. This curve has the property that moving it horizontally along the voltage axis is equivalent to a simple change of the scale of the vertical or current axis. There is an unfortunate consequence when it comes to trying to adjust two exponential curves back-to-back to make a class B output stage, Fig. 1. No matter how one juggles the two curves relative to each other the resultant, shown dotted, always has the same shape; it merely changes in scale. It is a hyperbolic sine and is far from linear. Semiconductor junctions are evidently bad starting material for a class B design.

Matters are somewhat better if a fixed resistance R is included in series with each junction. A few moments' work with pencil and paper shows that, for the nearest approach to a linear resultant characteristic, the resistance should have a value equal to the slope resistance of the junction at the standing or quiescent current. What happens when it does not have this value has been graphically illustrated by Gibbs[1].

There is an important practical consequence. If I_0 is the standing current and V_0 the corresponding voltage drop across the base-emitter junction, then the general equation relating current I and voltage V is,

$$I = I_0 \exp\{K(V - V_0)\}.$$

The slope resistance is dV/dI, and when $I = I_0$, takes on the value $1/KI_0$. If the series resistance has this value we get the particularly simple result that the standing voltage drop across it must be $I_0 \times 1/KI_0 = 1/K$. So if I_0 is firstly chosen, the value of resistance follows and the circuit must be designed to maintain $1/K$ volts across the resistance under quiescent conditions.

Now $K = q/kT_j$ where q is the charge on an electron, k is Boltzmann's constant and T_j is junction temperature. It is the same for all transistors n-p-n or p-n-p, germanium or silicon, and has the value $40V^{-1}$ at room temperature. Hence there is a universal rule which defines that, for class B operation of any transistor, the standing voltage drop across each series resistor should be 25mV at room temperature†. Here lies the practical difficulty. The 25mV is in series with the much larger, and variable, 550mV, or so, voltage drop V_0 across the junction. It is small wonder that temperature compensating diodes and preset adjustments are required in class B designs. Added to this are the difficulties that the adjustment is critical[2], K is temperature-dependent (so that strictly the series resistance should vary with junction temperature) and the series resistance must include the internal emitter resistance of the transistor—about ½Ω for type BD121. Therefore, only part of the 25mV is available outside the transistor for monitoring the standing current. All in all, it is surprising how well class B stages have been made to perform.

Class AB is a little better. Typical values are $R = 1\Omega$ and $I_0 = 100$mA, so that the standing voltage drop is 100mV. This voltage is still rather small compared with 550mV but unfortunately it cannot be increased much above this figure because, as I_0 is increased, there are problems of power dissipation in the transistors. On the other hand R is in series with the load so that if this resistance is increased, the peak voltage drop across it reduces the peak power available in the load. That is, R ideally should be small compared with the resistance of the load.

The new circuit to be described attempts to overcome these difficulties by putting the current monitoring resistor outside the main feedback loop.

†By a similar argument one obtains another universal rule which defines the transfer conductance of all transistors to be 40mA/V per mA of emitter current at room temperature. It is strange that not many textbooks mention this valuable and easily-remembered fact.

*University of Salford.

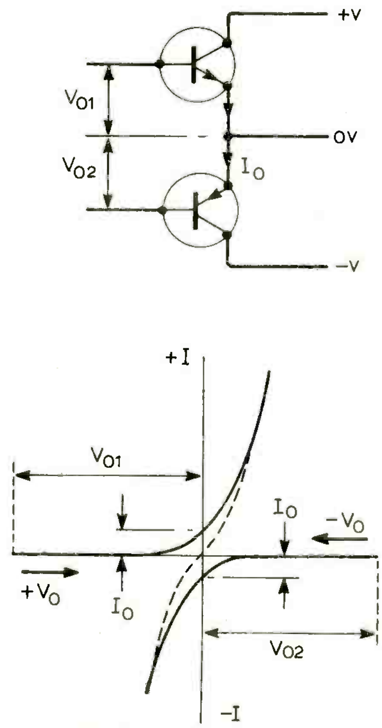


Fig. 1 (left). Class B cross-over characteristics constructed from two curves of exponential form.

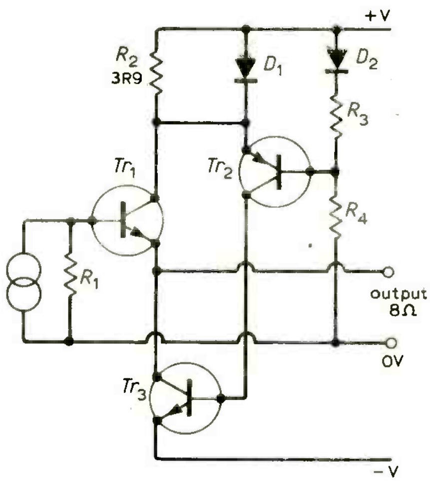


Fig. 2. Basic configuration of power output stage.

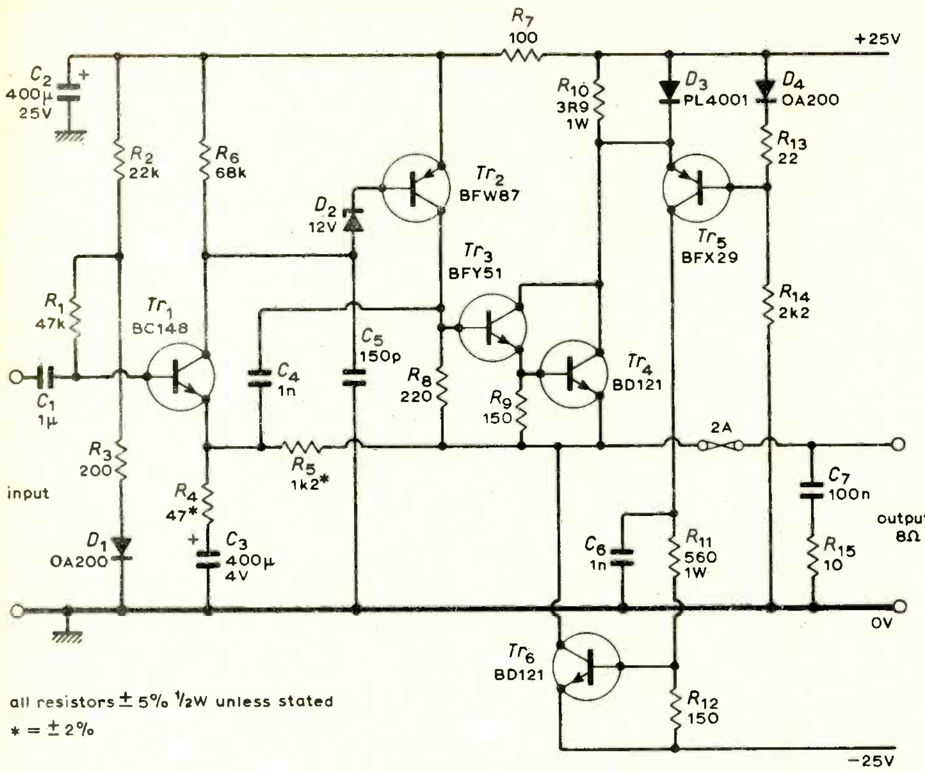


Fig. 3. Diagram of a 30W main amplifier utilizing the described technique.

Circuit operation

The basic circuit[3], shown in Fig. 2 has one of the output transistors, Tr_1, acting as a straightforward emitter follower. The current generator and the resistance R_1 represent a transistor driving Tr_1 and R_2 is a collector current monitoring resistance. In the absence of signal the standing current through Tr_1 is chosen to be 100mA so the voltage drop across R_2 is 390mV. The polarity and magnitude of this voltage is arranged to make diode D_1 partially conduct, but not sufficiently to pass appreciable current.

Ignoring D_1 for the moment, there is seen to be negative feedback round the loop Tr_2-Tr_3-Tr_1. The standing current through Tr_1 and Tr_3 (the second output transistor) is fixed in terms of the voltage drop across R_2, which is applied to the emitter of Tr_2, and the fixed voltage applied to the base of this transistor from the chain D_2-R_3-R_4. The diode D_2 is included to compensate for variations in the base-emitter voltage of Tr_2 and the voltage across R_3 is therefore approximately equal to the desired standing voltage drop across R_2.

Now suppose Tr_1 is driven by a signal. Over positive half-cycles Tr_1 passes more current from the positive supply to the load. The voltage drop across R_2 rises, reducing the collector-emitter current in Tr_2 and hence Tr_3. This does not matter if the conditions are correct because Tr_1, provided it has sufficient drive, should be capable of supplying all the current required by the load. What is important, however, is that R_2 has a value which is comparable with an 8Ω loudspeaker load and, if measures were not taken to counteract the voltage drop, the peak output current would severely reduce the voltage at the collector of Tr_1 and would consequently restrict the positive excursions of output voltage available across the load. In this circuit the voltage drop across R_2 is limited to about 600mV, when D_1 fully conducts. Obviously D_1 must be a small power type to carry the peak current.

Over negative half cycles Tr_1 passes less current which reduces the voltage drop across R_2 so that Tr_2 passes more current and Tr_3 conducts more to supply the required load current from the negative supply. Current through Tr_1, which is maintained by the negative feedback, still flows through the load. Thus Tr_3 supplies the load current on negative half-cycles but Tr_1 remains in conduction operating as an emitter follower to control the output voltage at all times.

Thus the circuit permits the use of a much higher current monitoring resistance than in a typical class AB amplifier, the resulting voltage drop under quiescent conditions being high enough to permit pre-set adjustments to be dispensed with, but because this resistance is outside the main amplifier feedback loop the peak voltage can be limited by a shunt diode.

Distortion

The distortion produced by this circuit is basically even-order and may be estimated as follows. In practice Tr_1 is a Darlington pair with a current gain of about 2500. On positive half-cycles, when Tr_3 is inoperative, an 8Ω load is therefore presented as a resistance of about $8 \times 2500 = 20k\Omega$ across R_1. On negative half-cycles the extra gain round the Tr_2-Tr_3 loop makes the reflected resistance much higher. Therefore, assigning a value of 10kΩ to R_1 creates the condition where on negative half-cycles the current generator works into approximately 10kΩ and on positive half-cycles it works into 10kΩ in parallel with 20kΩ, which is 6.7kΩ. The magnitudes of positive and negative half-cycle output voltage therefore differ by 33% and second-harmonic distortion is approximately half this value or 17%. A loop gain of 170 round the main amplifier loop would reduce this to the target figure of 0.1%.

A practical audio amplifier incorporating the new output stage is shown in Fig. 3. It provides 30W into an 8Ω load and performance is as expected. Distortion is 0.1% at maximum output and is mainly second harmonic. Full output is available up to 15kHz with an input voltage of 600mV r.m.s. With conventional power supplies the hum is less than 10μW with a load of 8Ω.

The following points may be of interest. A minor extravagance seems to be the use of a zener diode D_2 to couple Tr_1 to Tr_2. This has the effect of defining accurately the voltage drop across R_6 and hence the current flowing through Tr_1 and R_5. In turn, this defines the voltage drop across R_5 which reduces variations in the output d.c. voltage to less than 100mV—without any pre-set adjustment. If the loudspeaker has a d.c. resistance of 8Ω, an output coupling capacitor can be eliminated. It appears that the use of D_2 is not such an extravagance after all.

An additional point is that Tr_2 does not need a collector load resistance connected to the negative supply. This eliminates not only a potential source of hum, but also the usual "bootstrapping" capacitor. This means that this type of output stage is ideally suited for applications requiring an output down to d.c., such as control and servo drive systems.

References

1. Gibbs, D. S. Letter to the Editor, *Wireless World*, August 1970, pp. 387–8.
2. Blomley, P. "A new approach to class B amplifier design", *Wireless World*, Feb. 1971, pp. 57–61; March 1971, pp. 127–131.
3. Patent applied for.

Sixty Years Ago

The problems of obtaining what is now the basic function of a transmitter —the production of a continuous wave — were, sixty years ago, so formidable that many people were of the opinion that they just were not worth the trouble. In his evidence to the Postmaster-General's Advisory Committee, G. Marconi said ". . . there has never been submitted here or elsewhere one scintilla of evidence to prove that the continuous or undamped waves have any advantage over intermittent or feebly-damped waves for long-distance working in radio-telegraphy." In an article on methods of obtaining these waves using rotary machines, Hubert Dodell mentioned the difficulty of maintaining a constant frequency, the speed of the machine being affected by the loading due to Morse modulation. "So serious is this difficulty, that the full load is kept permanently on the machine, and the dots and dashes are produced by varying the aerial wavelength so that at times it is in tune with the receiver, and at others it is so much out of tune that the receiver is not affected."

Multiphonic Organ

Switching system permits use of a small number of generators (six) with a four-octave keyboard

by J. H. Asbery, B.Sc., M.I.E.R.E.

The first electronic organs to be built consisted of a single generator in which the value of one of the components was controlled by the keyboard. Fig. 1 is a block diagram of part of the usual system. If key C is pressed RV_1 is connected to the generator. RV_1 is adjusted during tuning so that the generator frequency is that of note C. If key B♭ for example is pressed RV_3 is connected to the generator and RV_3 is adjusted during tuning so that the generator pitch is that of B♭. If two notes are pressed at the same time only the highest note is operative. These organs are very simple and are still sold and in use today. They are called "monophonic".

In order to overcome the limitation of the monophonic organ the "polyphonic" organ was developed. Fig. 2 is a block diagram of part of a typical polyphonic organ. For each note there is an oscillator that is tuned to the pitch of that note. When any key is pressed the output of the oscillator is connected to a "busbar". The busbar is connected via filters, which shape the wave and control the tone to the amplifier. In a typical organ there may be, for example, 49 generators. This system is not only expensive but wasteful, as many organists do not use more than about four or six notes at any one time.

The "multimonophonic" organ, which is abbreviated to "multiphonic", is a compromise between the simple and cheap but very limited monophonic organ and the versatile but expensive and complicated polyphonic organ. The principle is that of the monophonic organ, but repeated with more than one generator. In circuit diagrams of multiphonic organs change over switches are not shown as in Fig. 3(a) with the contacts at the corners of a triangle but as in Fig. 3(b) with the contacts at three of the four corners of a square. This makes the diagrams easier to follow and tidier. The principle of the multiphonic organ is shown in Fig. 4 which is part of an organ shown with keys B and A♭ pressed. Variable resistor RV_2 is connected to generator number 1 which therefore oscillates at the pitch of B and RV_5 is connected to generator 2 which therefore oscillates at the pitch of A♭. Generator 3 is not connected to any resistor and therefore does not oscillate. A thickened line is used to show the connection path to each generator.

The keyboard switches must be of the break-before-make type to avoid connecting a generator to two resistors at the same time during changeover. Two types of switches are available: (1) Discrete 3-pole changeover switches. With these it is necessary to connect fixed contacts of the poles together and to wire between switches as shown on the Fig. 5 circuit diagram. (2) Integrated switching systems

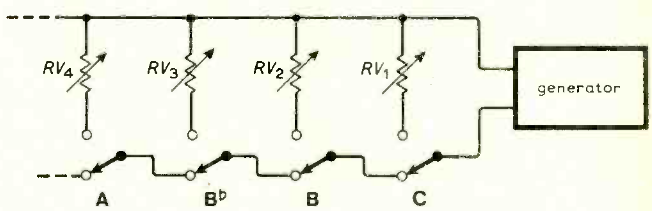


Fig. 1. Principle of monophonic organ. The pitch of the single generator is changed by switching in different resistors.

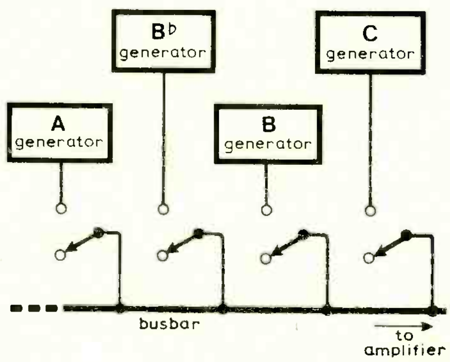


Fig. 2 (left). The polyphonic organ has a generator, individually tuned and switched, for each note.

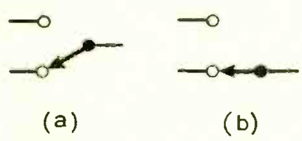


Fig. 3. Conventions for change-over switch symbols: (a) conventional switch; (b) multiphonic organ switch.

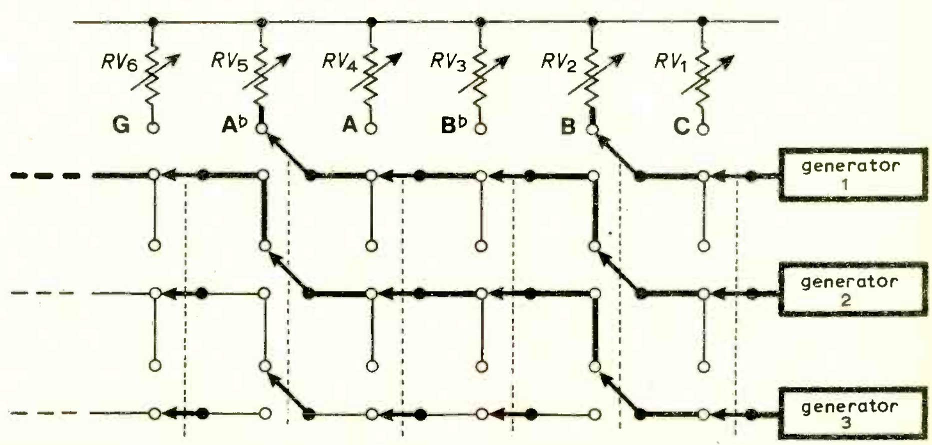


Fig. 4. Part of a multiphonic organ with two keys, A♭ and B, pressed simultaneously. The connection paths between the variable resistors and the generators are shown by the thickened lines.

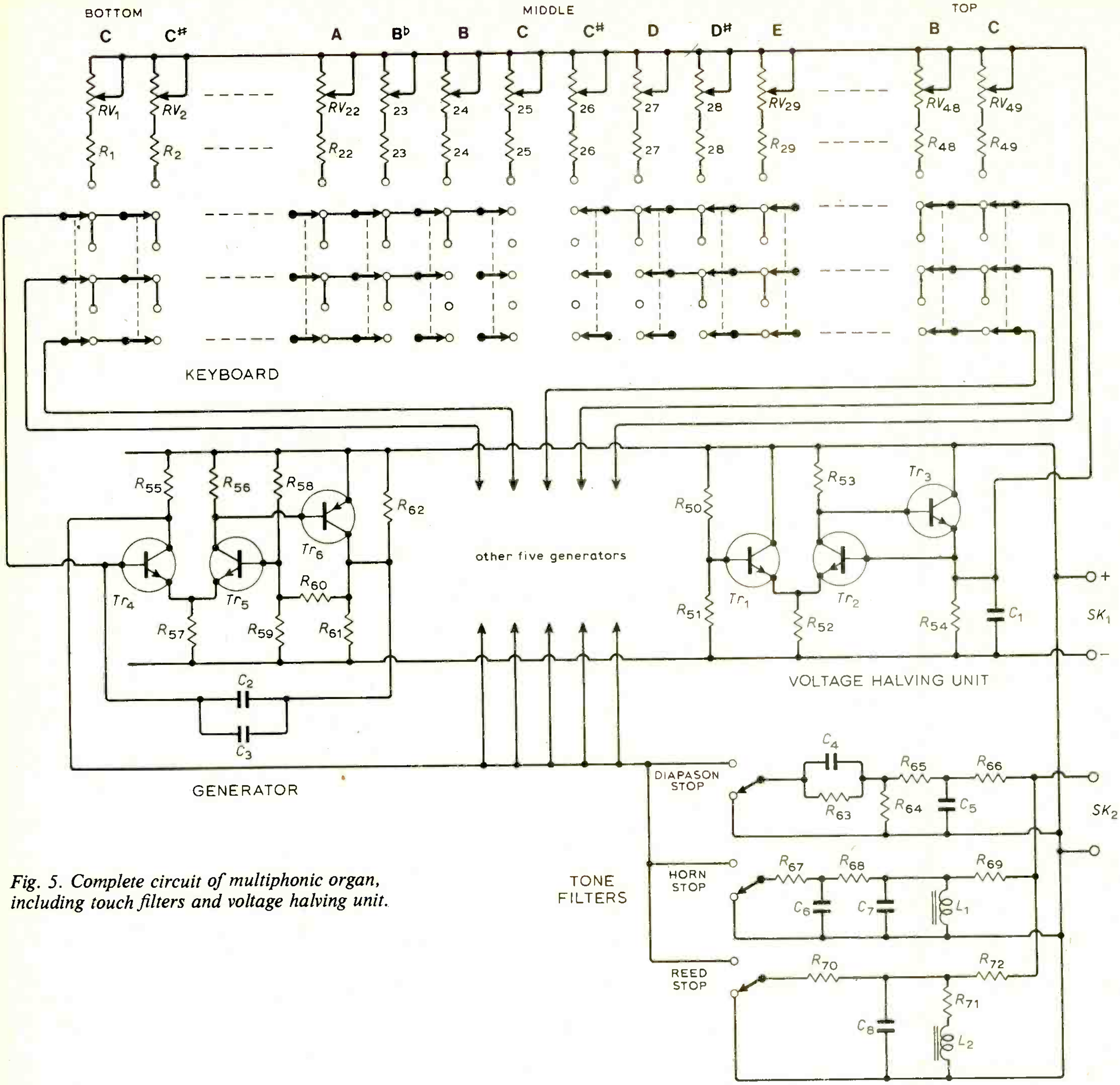


Fig. 5. Complete circuit of multiphonic organ, including touch filters and voltage halving unit.

in which the normally open contact of one pole, the normally made contact of the next pole of the same switch and the changeover contact of same pole of the next switch is one piece of gold plated wire. This eliminates all wiring between poles of each switch and between switches.

If desired, better long term stability and finer tuning can be achieved by replacing each tuning variable resistor by a fixed resistor of about 90% of the required value and a variable resistor of about 20% of the required value.

In the organ circuit of Fig. 5 the three highest keys pressed in the right-hand half of the keyboard "speak" and the three lowest keys pressed in the left-hand half of the keyboard also "speak". If more than six keys are pressed at the same time the extra ones simply do not "speak". There are no undesirable side effects.

The generators have been designed for long term stability and for accuracy of tracking; that is, a given value of resistor will cause different generators to oscillate at very nearly the same frequency. No separate output buffer is required for each generator as the output is derived from a resistor in the collector of one of the transistors, this point not being part of the feedback loop.

The ends of the keyboard resistors remote from the generators are connected to half the supply voltage. It is not sufficient to provide this supply merely with a potential divider of two resistors, as current drawn by one generator would alter the voltage of the main supply rail, thereby affecting the other generators. A conventional series stabilizing circuit provides a supply at half the main supply voltage and one that remains at half this voltage when current is drawn. The 470-ohm load resistor (R_{54} in Fig. 5) is required as, during a half of each cycle, current is fed onto the half voltage supply rail. Occasionally all the generators will be in this same half cycle so that the 470-ohm bleed resistor has to be adequate to carry the current from all the generators.

In the tone filters in Fig. 5, the inductors L_1 and L_2, which are both 650 mH, are provided by Eagle transformers, type LT-700. The secondary (black and white leads) is left open circuit and the centre-tap of the primary (white lead) is left unconnected. The inductor connections are made to the ends of the primary winding (red and green leads).

When building this organ it is advisable to keep the units as small and as close together as possible and to leave as much space spare as possible, as multiphonic organs are particularly amenable to the adding of extra facilities at later dates.

Components list

Variable resistors (RV)
1 to 13 — 3k wire wound
14 to 25 — 1k wire wound
26 to 37 — 3k wire wound
38 to 49 — 1k wire wound

Fixed resistors (R)
1 — 22k
2 and 26 — 21k
3 and 27 — 20k
4 and 28 — 19k
5 and 29 — 18k
6 and 30 — 17k
7 and 31 — 16k
8 and 32 — 15k
9 and 33 — 14k
10 and 34 — 13k
11 and 35 — 12.5k
12 and 36 — 12k
13 and 37 — 11k
14 and 38 — 10.5k
15 and 39 — 10k
16 and 40 — 9.5k
17 and 41 — 9.1k
18 and 42 — 8.6k
19 and 43 — 8.2k
20 and 44 — 7.8k
21 and 45 — 7.5k
22 and 46 — 6.8k
23 and 47 — 6.5k
24 and 48 — 6.2k
25 and 49 — 5.9k
All above fixed resistors, metal film 2%.
50 — 7.2k }
51 — 7.2k } metal film 1%
52 — 7.2k }
53 — 10k carbon 20%
54 — 470 carbon 20%
55 — 2.2k carbon 5%
56 — 2.2k carbon 20%
57 — 7.2k metal film 2%
58 — 15k }
59 — 4.3k }
60 — 2.0k } metal film 1%
61 — 1.0k }
62 — 2.0k }
63 to 66 — 100k carbon 20%
67 — 22k }
68 — 15k }
69 — 22k } carbon 20%
70 — 22k }
71 — 2.2k }
72 — 47k }

Capacitors
1 — 8μ 8V
2 — generators 1 to 3, 400n
generators 4 to 6, 100n
2% but matched in sets to 0.5%, polycarbonate or polyester
3 — as required to match generators
4 — 1n }
5 — 5n }
6 — 20n } any type 20%
7 — 100n }
8 — 20n }

Inductors
L_1 and L_2 — both 650mH, see text.

All parts and components can be obtained from: J. H. Asbery, 87 Oakington Manor Drive, Wembley, Middlesex.

Books Received

Telecommunication by Speech: the transmission performance of telephone networks by D. L. Richards presents a co-ordinated account of the principles and practice of telephone communication system design from the viewpoint of transmission performance. It presents a classification of knowledge in each branch of the subject and provides a method for translating the basic requirements for speech communication into performance standards and rules for system design that not only takes account of the variety of transmission and switching systems, but also the important economic factors involved. Price £12.00 Pp. 589. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

World Radio and TV Handbook 1973; 27th edition edited by J. M. Frost contains in the first section instructive articles relating to broadcasting, and information on broadcasting and television organizations. The main section of the book contains detailed information, country by country, of the radio stations and broadcasting organizations of every country in the world. Included are names and addresses of broadcasting companies, names and titles of leading officials, lists of broadcasting stations in each country including frequencies, wavelengths, transmitter power, call signs and station names. Programme schedule information is also listed, including times, frequencies, and beam areas of the broadcasts. Price £3.00 Pp. 400. Billboard Publications Inc., 7 Carnaby Street, London W1V 1PG.

Electronic Display and Data Systems: Constructional Practice by C. J. Richards. Both main elements of display and data systems — generation (and refinement) and display — must be mounted, housed and connected, and the operators' working conditions must be such that they will be able to concentrate on making the best use of the display. There must be mechanical engineering in support of the electronic engineering, and in value it can amount to 40% of the total cost of a system; there must therefore be co-operation between the engineers. To improve co-operation is the purpose of this book. It gives the electronic engineer an understanding of the mechanical aspects of an installation, and the non-electronic engineer an appreciation of the problems of the circuit designer. Price £9.00. Pp. 459. McGraw-Hill Book Company (U.K.) Ltd, Maidenhead, Berkshire.

Electronics: A Course Book for Students by G. H. Olson is a shortened and revised version of "Electronics: A General Introduction for the Non-Specialist". It is written specifically as a qualitative introduction with a minimum of mathematics and circuit analysis. The opening chapters introduce resistors, capacitors, inductors, transistors, diodes and their response to voltage and current changes. Subsequent chapters discuss indicating instruments, power supplies, amplifiers and oscillators. The book will be of value to all non-specialists and in addition should provide a useful text for the undergraduate in electrical or electronic engineering or to supplement more analytical books. Price £2.60. Pp. 351. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

M.O.S. Integrated Circuit Design edited by E. Wolfendale describes the metal oxide silicon transistor with the basic design equations derived, physical effects explained and typical values given. The basic logic elements used by the m.o.s. designer are taken in turn and translated into the dimensions necessary to create the mask for their fabrication. The layout of a fully integrated chip and the achievement of maximum density of devices are described. Checking and correction using logic simulation and an interactive graphics console form the final stage. The last chapter is an example of the design of a small chip, showing how all the techniques described are brought together to solve a practical design problem. Electronic equipment designers who are increasingly involved in the use of custom designed m.o.s. circuits will find this book a useful practical guide. It will also enable students to familiarize themselves with the techniques involved. Price £4.00 Pp. 120. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

Pattern Recognition Techniques by J. R. Ullmann provides a broad introduction to a subject which is becoming increasingly important in the processing of data where the use of human effort may be precluded by the number of patterns to be recognized, the speed of recognition required or simply by economic considerations. Examples range from recognition of fingerprints to faces and from cars to cardiograms, but it is the recognition of written and printed characters which has been most widely investigated and applied. Many different disciplines have to be considered: optics, statistics, switching theory, graph theory and Fourier analysis — these are introduced in simple terms so that specialist knowledge is not required. The book has been written for engineers, computer scientists and biologists and all those whose work is presenting them with the problems of automation of pattern recognition. Price £10.00 Pp. 412. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

Elements of Linear Microcircuits by T. D. Towers is based on a series of articles written by the author for *Wireless World* and gives practical guidance on the selection of commercially available devices. It shows how to use the wealth of circuit functions available and gives considerable attention to the practical aspects of handling these sensitive circuits in practical assemblies. The emphasis throughout is on applications and the every-day problems of designing electronic equipment rather than production technology. Chapter subjects include packaging, selection, handling, op-amps, audio, i.f. and wideband amplifiers, voltage regulators, radio and TV receivers. The book should be of great value to engineers in research and development laboratories and students at ONC/HNC level upwards. Price £2.80 Pp. 108. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

Satellite Broadcasting by Chayes, Fawcett, Ito and Kiss sets out the questions and answers to a questionnaire initiated by the International Broadcast Institute concerned with the social, economic and legal problems that satellite broadcasting brings. Price £5.00 Pp. 159. Oxford University Press, 37 Dover Street, London W1X 4AH.

Making and using Electronic Oscillators by W. Oliver is a practical guide to the use of oscillators in radio, TV, telecommunications and other electronic applications. Price £2.00. Pp. 120. W. Foulsham & Co. Ltd., Yeovil Road, Slough, Bucks SL1 4JH.

World of Amateur Radio

Power plus?

American journals from time to time take a cold look at the state of amateur radio in their country — and do not always like what they see. A recent outspoken editorial by Richard Ross, K2MGA, editor of *CQ*, comments severely on the apparent decline in the ethical standards of a small but growing number of amateurs; he claims that not a single day passes without examples on the amateur bands of "broadcasting, music transmissions, obscenity, false signals, unidentified communications and malicious interference" but considers that the most flagrant abuse of the regulations is in the area of excessive power.

Richard Ross recalls that only a few years ago a full 1kW (the legal limit for amateurs in the United States) was the dream of amateurs, and for most an unattainable dream. "Technological advances and greater affluence have made a joke of that dream . . . the kilowatt amplifier is as much a part of the amateur scene as the transceiver . . . the kilowatt linear serves all too often as an exciter . . . several firms make no secret of the availability of 4, 6 or even 10kW amplifiers . . . but the galling thing is the growing number of 'amateurs' on the air with 50 or more kilowatts at their finger tips for use when the going gets tough."

"How do you begin to return to sane attitudes towards transmitter power?" he asks, adding "The strongest weapon against known violators of the legal limit is the contempt of his peers . . . treat him as an outlaw and watch him react . . . that's what our self-policing tradition is all about".

Even allowing for an element of journalistic licence, the idea of 50kW transmitters being used with high-gain aerials on the amateur bands is something to make amateurs stop and think. The expression "Californian kilowatt" to cover the use of power a little above a kilowatt is almost traditional — but now it seems we could really be approaching the days of amateur operation with a *megawatt* of effective radiated power!

Satellites and special tests

Oscar 6 is now usually active for five instead of four days each week, being switched off for battery re-charging only on Tuesdays and Wednesdays. The first British amateur to gain the new A.R.R.L. Oscar 6 "1000" Award (*WoAR*, March) is P. J. A. Gowen, G3IOR of Hellesdon near Norwich; his 144MHz has 12 watts output to a "six-over-six" stacked slot-fed Yagi 33ft high. Among his best long-distance contacts through Oscar 6 have been K7BBO (4780 miles) and W5ORH (4556 miles). The French amateur Marc Tonna, F9FT at Reims has already made over 2500 contacts in more than 40 countries through Oscar 6.

The next Oscar satellite is being planned to carry three transposers: one for 432 to 144MHz and two for 144 to 29MHz which are being designed for an active life of the order of three years.

French amateurs are planning further balloon-carried transposer launchings this year, including the "Mirabel" which is scheduled for May 20; the transposer accepts 432.1 to 432.4 MHz and retransmits on 145.6 to 145.9MHz. Launchings of the "Anjou" series are planned for May 31, July 4 (or June 24), July 29, August 26 and September 23 (or October 21), although it is not certain that all these launchings will prove possible.

During the total eclipse of the sun on June 30, an h.f. propagation experiment will be conducted by A. Duffau, 5T5AD who will be in Akjoujt operating the special station 5T5SOL between 1000 and 1100 UT with KWM-2 transceiver and omnidirectional aerial (it is possible the station may function as an automatically keyed beacon).

The IARU Region 1 has asked the R.S.G.B. to re-plan frequencies of the entire European network of v.h.f./u.h.f. beacon stations.

Narrow-band f.m. on 144MHz

Karl Kanalz, G5AGX (6 Wood End, Hayes, Middx) of the U.K. FM Group (London) feels the item last month "a question of deviation" described the compatibility question of f.m. operation from the viewpoint of a.m. operators and notes that some a.m. and s.s.b. signals are equally wideband. He believes that most a.m. operators on 144MHz in the London region are misinformed about what constitutes a specified bandwidth for a signal — be it a.m., f.m. or s.s.b. — and do not have equipment capable of measuring transmitted or received bandwidths.

He says that the U.K. FM Group has set itself the task of showing newcomers to f.m. how to ensure that equipment is set up for true n.b.f.m. with deviation not greater than ± 3kHz by making available suitable test equipment for the alignment of equipment. They are also hoping to establish similar groups in other parts of the country. He believes that it is possible to clean up any "wideband" problems since almost all transmitters can be adjusted for narrow-band operation. He admits that some present receivers will not provide optimum signal-to-noise ratio on narrow signals although the FM Group is supplying narrowband filters for receivers. He agrees that problems can arise (on all modes) from the use of wide tolerance crystals.

Certainly our earlier comments were not intended to discourage the use of true n.b.f.m. but rather to draw attention to the problems that can arise when f.m. equipment is used without understanding the implications of deviation adjustment.

In brief

The British Amateur Radio Teleprinter Group is holding its second annual convention on Saturday, June 30 at Meopham Village Hall, Meopham, near Gravesend, Kent (11 a.m. to 6 p.m.). During the afternoon lectures will be given on r.t.t.y. operation, G4ATG will operate r.t.t.y. on 14090kHz and there will be a "teleprinter art competition" (tapes to D. Goacher G3LLZ). Further information from G. Shirville, G3VZV, 2 Orchard Close, Toddington, Dunstable (Toddington 2470) . . . . A recent World Radio Club interview with the former Irene Marcuse, widow of Gerald Marcuse, G2NM, described how "Empire" broadcasting was launched informally from G2NM at Caterham in the autumn of 1927. A special licence was granted by the Post Office and the broadcasts covered a period of about two years. Apart from many musical and other "live" broadcasts there were also re-broadcasts of B.B.C. medium-wave programmes; the transmissions were the first to broadcast the chimes of Big Ben to a world audience. The station operated on 32 metres with 1½kW from an excellent site with a 100ft mast and was heard all over the world . . . . DKoIEC is a special station being set up at Munich during the meetings of the International Electrotechnical Committee from June 15 to 29 . . . . Mobile rallies during June include: May 30 to June 2, Bath & West Show (Shepton Mallet, Somerset); June 10 Elvaston Castle Countryside Park, near Derby; June 17 Amateur Radio Mobile Society (RAF Cosford, 8 miles north-west of Wolverhampton); June 24 Bristol R.S.G.B. Group, Longleat, Wiltshire . . . . Hull & District Amateur Radio Society have a mobile rally on May 27 at the East Riding College of Agriculture, Bishop Burton, near Beverley (A1079 road) . . . . the R.S.G.B. is raising its Corporate membership subscriptions from July 1 . . . . American amateurs WA2LTM and W9WCD have raised the 23cm distance record from 551 to 770 miles . . . . Irish amateurs can now use an extended 70MHz band (70125 to 70450kHz) and consideration is being given to a telephony-only licence for v.h.f. operation . . . . The Irish Radio Transmitters Society celebrates its Diamond Jubilee in June — it was formed as the Dublin Wireless Group in June 1913.

PAT HAWKER, G3VA

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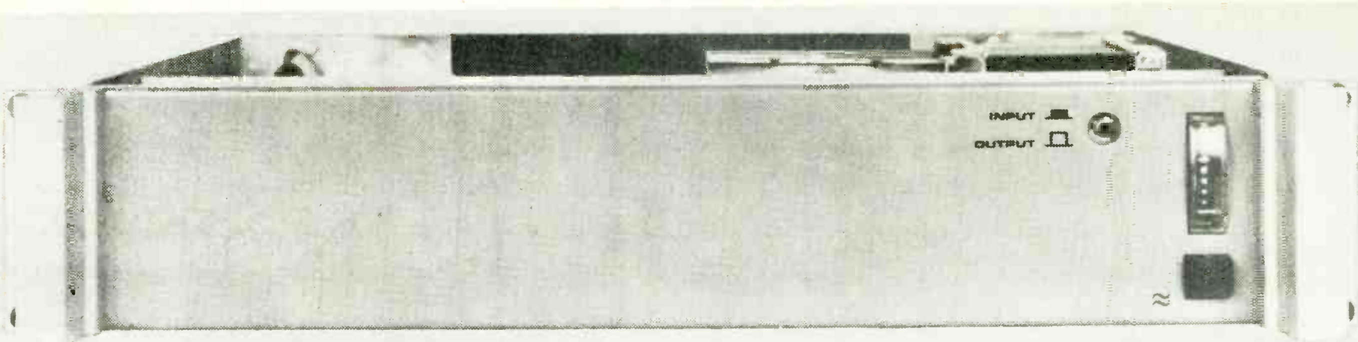
WW—095 FOR FURTHER DETAILS



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WW—096 FOR FURTHER DETAILS

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WW—097 FOR FURTHER DETAILS

New Products

Modular display system

The Series 1400 is a mounting and driving system for the Sperry SP750 information displays and is made by Spectra-Tek U.K. The displays are mounted in an extruded aluminium bezel, complete with decoders, panel fixing arrangement and a red or orange polarizing filter which carries a title strip area below the characters. Arrays of any length from two digits upwards may be ordered and they are delivered fully asembled and tested.

The life expectancy is 100,000 hours and at full brightness the 14mm high characters are said to be easily readable in direct sunlight at a distance of 40ft over a viewing angle of 130 degrees.

Connections to the t.t.l. decoders are via gold-plated edge-connectors and, in addition to full numerical display, the decoders are also capable of providing six alphabetical characters. Decimal points are fitted and a ± 1 unit is available.

With a bezel height of 35mm, character spacing of 13.5mm and a depth of only 32mm, the 1400 Series offers an alternative solution to display problems at £6 per decade complete.

Spectra-Tek U.K. Ltd, Kirkby Moorside, York Y06 6DW.

WW315 for further details

Instruments knobs

West Hyde Developments are now entering the knob market. The ranges to be sold by them will all be under their existing trade name Contil. Insulation is by means of a bush between the body of the knob and the shift, to comply with German V.D.E. standards

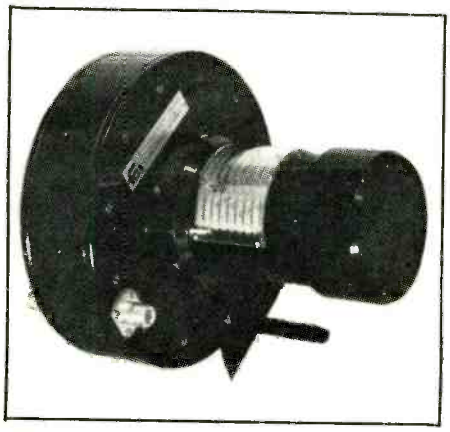
These knobs also have interchangeable dials of various colours and a dial lock. This provides a positive lock so that the knob cannot move by vibration but allows the setting to be easily changed. It also provides a scale line if required. Fixing is by grub screw and the shaft size is 4mm or 6mm.

The knobs cost from 22p for 100 off for the small knob to 43p for the largest knob with a coloured skirt and a line. The dial locks cost between 15p and 23p, depending upon quantity and line. West Hyde Developments Ltd, Ryefield Crescent, Northwood Hills, Northwood, Middlesex HA6 1NN.

WW305 for further details

Coaxial frequency meter

The model FMC 1 coaxial hybrid frequency meter, operating from 0.3 to 1GHz, is the low frequency version of a family of three such instruments designed for the 0.3 to 12GHz band of frequencies by Flann Microwave Instruments. Each instrument is of the absorption type and utilizes a mode change from coaxial to circular operation, thus providing extra



wide frequency coverage without spurious resonance. The multi-turn helical dial/drive mechanism is directly calibrated in GHz and gives high resolution throughout. The FMC 1 calibration accuracy is ±1MHz, and Type N connectors are fitted as standard. Flann Microwave Instruments Ltd, Dunmere Road, Bodmin, Cornwall.

WW304 for further details

Pocket pulser

Semra-Benney announce the introduction of the pocket pulser type 2113. This device is a miniature, self-powered source of pulses intended for quick checks on instruments and systems. Designed in the European Organization for Nuclear Research (CERN), Geneva, the pocket pulser is primarily intended for checking systems which monitor signals from photomultipliers, although it has many other obvious applications. The output is very similar to that obtained from a photomultiplier, having a 2.5ns rise and 5ns fall time.

Powered by a small mercury cell, it will deliver pulses continuously for over 300 hours into 50Ω before a battery change is necessary, and this, together with the long shelf-life of the battery, means infrequent battery changes. No power is used until the pulser is terminated by a load and there are no switches or moving parts.

Specification:

Output amplitude	— 1V ± 10% neg. going into 50Ω via a miniature coaxial socket (Lemo type 00250)
Risetime	— 2.5ns
Pulse width	— 5ns
Repetition rate	— 12kHz ± 30% (fixed)
Load	— 50Ω direct-coupled (Note: load must always be direct–coupled)
Output impedance	— Low impedance in series with 47pF capacitor
Power source	— Mallory Duracell TR152R (mercury)
Dimensions	— 60.325 × 44.45 × 19.05mm
Weight	— 56.7g
Case material	— A.B.S.
Price	— 1-9. £29.50 including battery and miniature mating coaxial output connector, plus v.a.t.

Semra–Benney (Electronics) Ltd, Chandler's Ford, Hampshire SO5 3ZU.

WW 309 for further details

Square wave inverter

A square wave inverter marketed by Gardners Transformers is of high power rating and will operate a wide range of 240, 50Hz equipment. Two versions are available — Type 107A for use from 12V batteries and Type 107B for 24V d.c. systems.

The 300W rating is claimed to be conservative and obtainable even when used with a single 12V car battery. This continuous rating is coupled with an adequate short-term overload capability, permitting the use of the inverter not only for resistive loads but now also for small electric motor-driven tools such as drills, polishers, and sanders which take substantially more current for starting than when running.

The frequency is almost independent of input voltage and load, and thus the unit can be used to drive tape-recorders and similar instruments employing synchronous motors. The inverters are supplied at a price of £61 ex works. Gardners Transformers Ltd, Christchurch, Hants.

WW322 for further details

Double-balanced mixer

Watkins-Johnson has introduced Model M1K double-balanced mixer, a high-intercept, wideband unit in a hermetically sealed package. It is said to provide superior two-tone performance over the frequency range from d.c. to 4GHz. With only +23dBm local oscillator drive level, this mixer has a +28dBm (typical) input third-order intercept point. With two input tones at 0dBm, the third order products will be typically suppressed 56dB relative to the desired output.

The M1K is also designed for a low noise figure — typically 6dB. In addition, +10dBm of output power can be obtained. This is important in up-converting applications where low-frequency amplification can be substituted for expensive microwave amplification.

Best isolation (typically greater than 30dB) is achieved by feeding the high-level l.o. signal to the L-port. Both L- and R-ports are a.c.-coupled and have a 1 to 4GHz frequency response. The I-port is d.c.-coupled and has d.c. to 1GHz frequency response.

Minimum conversion loss is achieved by providing an l.o. level of +20dBm. At this level, conversion loss is typically 6dB. For minimum intermodulation products, the input signal level is recommended to be as low as possible. Watkins-Johnson International, Shirley Avenue, Windsor, Berks.

WW324 for further details

L.S.I. socket with retaining cover

Jermyn Manufacturing have announced an addition to their range of specialized i.c. sockets. The main features of this socket, which is for 36-lead l.s.i. devices, are said to be very low insertion force and extremely low contact resistance. Normally, low contact resistance means high insertion force, and vice versa, but these two conflicting requirements have been optimized by employing a hinged cover which clamps over the i.c. after it has been placed in position. The cover when fitted, applies side pressure to the contacts, forcing them against the legs of the i.c., thus achieving a contact resistance on only 10mΩ.

A secondary benefit which is claimed to result from this arrangement is that i.cs. can be inserted in, and withdrawn from, the socket at high speed without fear of damage to the fragile i.c. legs. The socket, which is moulded in glass-filled polycarbonate, is fitted with gold-plated phosphor bronze contacts, to give long term reliability and resistance to environmental extremes. Jermyn Manufacturing, Vestry Estate, Sevenoaks, Kent.

WW318 for further details

L.F. charge amplifier

B & K Laboratories have announced a low frequency charge amplifier for use with piezoelectric force and vibration transducers. Known as the Type 2628, it is said to be particularly suitable for handling very low frequency and quasi-static signals, and, depending on its gain setting, it has time constants of up to 100,000 seconds. This corresponds to a low frequency limit of 2μHz, the upper frequency limit being 100kHz. These frequency limits are adjustable by step controls of high pass and low pass filters, the active low pass filter being incorporated so that unwanted higher frequency signals can be suppressed. A 3 digit variable "sensitivity conditioner" is provided in dial form and can be used to adjust the charge amplifier to the exact sensitivity of the transducer being used. The adjustment range is between 1 and 110pC/unit, and the position of the decimal point is automatically indicated by signal lights. The input of the 2628 itself automatically eliminates errors due to long connecting cables. Stage gain is step controlled and allows the signal output to be varied from 0.0001V/unit to 10V/unit. Two signal level indicators are provided. The first indicates overload at the input or output stage and the second lights when the signal is within 20dB of the full output, thus indicating the best output signal level for minimum noise. B & K Laboratories Ltd, Cross Lances Road, Houslow, Middx.

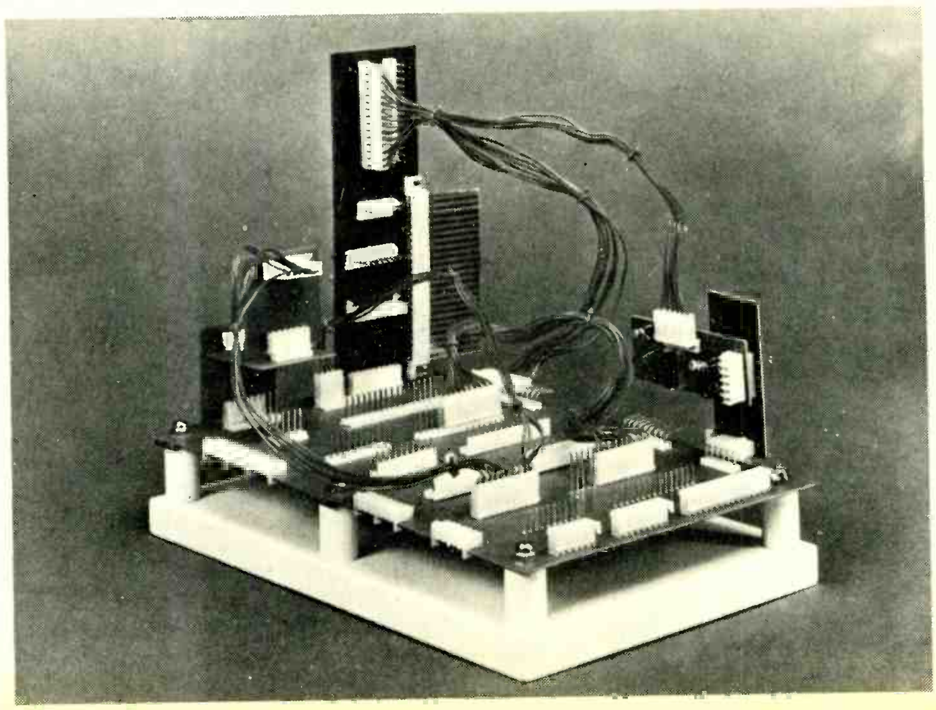
WW306 for further details

P.C.B. connection system

A new technique in printed-circuit board interconnections is now available from Molex International. Called Konektcon, the system utilizes rigid wire terminal points and claims to solve design, electrical and mechanical problems commonly associated with use of copper pads as contacts on p.c. boards. The connectors in the Konektcon series are injection moulded and can be supplied in a variety of materials centre spaced on 3.962mm and 5.08mm with a straightforward design. Internally, each connector terminal has the same basic spring configuration, a double cantilever. By restricting the opening in the connector and by allowing no pin larger than 2.032mm diameter to enter, the terminal cannot be overstressed.

In addition, by restricting the connector's end wall thickness, several connectors can be placed next to each other without sacrificing a circuit. With various conbinations of 3—, 4—, 5— or 6 — circuit connector housings, for example, any number of circuits from 3 to 24 can be terminated with no more than four connectors. Maximum wire size the terminal will accept is 20 gauge. Rigid, square or round wire 1.143mm diameter is recommended as the male terminal, but other wire sections can be used. Molex International, 14 Yeading Lane, Hayes, Middlesex.

WW308 for further details



Digital panel meters

Varian's Velonex Division introduces a range of digital panel meters of small size. These are named Impac (Instrument Meters Packaged as Components). The meters are available in models displaying 3, 3½, 4 or 4½ digits. Dimensions of all models are identical: front panel area is less than 1.7 sq.in. and the volume is less than 3 cubic inches. Other major features of the meters are:

- Low power consumption; less than 0.3W on standby and less than 1W with all characters illuminated.
- Automatic zeroing. Before each internal measurement cycle an automatic zeroing circuit calibrates the meter against any offset or drift errors that may have occurred. There is no need for manual zeroing. In fact, the meter needs only one kind of manual adjustment, a normal, full-scale calibration, and this can be done as infrequently as twice a year.
- L.e.d. display with a ± sign and decimal point give long life and easy, unambiguous readings.
- Inputs and outputs necessary for the system user are standard with the Impac meters, including b.c.d., strobe, end-of-conversion, sign and overload outputs. Inputs include convert and hold, display and sign blanking. All signals are compatible with d.t.l./t.t.l. logic. Decimal point can be placed before any digit or omitted altogether.

Some salient specifications of this range of digital panel meters are:

Warmup time less than 10 seconds to stated accuracy.

Accuracy 0.1% of reading for 3 and 3½-digit units; 0.05% of reading for 4 and 4½-digit units.

Temperature coefficient, 0.01%/°C, 10°C to 40°C.

Operating temperature range, 0°C to 50°C.

Sample rate: 10 per second for 3 and 4-digit meters; 7 per second for 3½ and 4½-digit models.

Weight, less than 3.5 oz.

F.O.B. prices — single quantity: series 30, 3-digit, $112; series 35, 3½-digit, $125; series 40, 4-digit, $169; and series 45, 4½-digit, $225.

Varian Benelux B.V., Postbus 9158, Maassluisstraat, 100, Amsterdam.

WW 313 for further details.

TV masthead amplifier

The new Star u.h.f. masthead amplifier from Belling-Lee increases signal levels by approximately 4 times, helping to give good quality television picture reception in fringe and secondary service areas. Three versions of the amplifier cater for reception on channels 21-34, 39-51 and 49-68. The power supply unit, moulded in flame retarding plastic, provides 15V d.c. for the masthead amplifier via the coaxial down lead. Belling and Lee Ltd, Great Cambridge Road, Enfield, Middx. EN1 3RY.

WW303 for further details

Educational logic kit

A set of educational equipment announced by Opto Electronic Displays Ltd consists of a power supply unit, a logic tutor and an analogue/control kit.

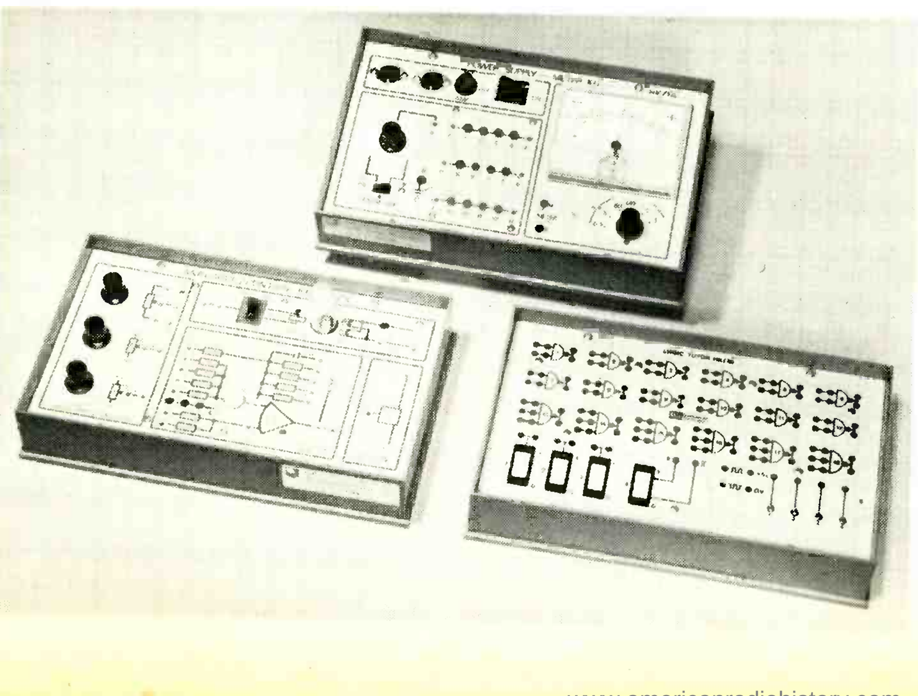
These three pieces of equipment were developed for the Open University Technology courses and the set is now to be made available to educationalists, electronics and computer-science-based industries. The power supply gives +5 volts, and has a meter and switched ranges, also variable outputs and current limiting circuits.

The logic tutor has 18 NAND gates, 4 switches and 4 output lamps which can be wired together with plug-in leads to investigate simple or complex circuits.

The analogue/control kit was designed specifically to teach simple analogue computing and control systems. It is based on the universally accepted 741C operational amplifier.

These units are marketed by the Open University and are available with text and course material in the form of books. Opto Electronic Displays Ltd, 269a Haydons Road, Wimbledon, London S.W.19.

WW312 for further details



Multipurpose test instrument

The Versatester 1 from Systron-Donner provides, in a single instrument, signal sources, power sources, a digital multimeter and a counter. Improved serviceability is claimed as the basic instrument can, in large part, be used for self–test and calibration. The major features are:

Supplies d.c. power, +5V, +15V, −15V, ±30V

Generates 20Hz to 20MHz: pulses; sine waves; and square waves

Digitally measures and displays to four digits: frequency, auto ranging 20Hz to 20MHz; d.c. volts, 0-500V in 4 ranges; a.c. volts. 0-500V in 4 ranges. and d.c. ohms, 0–5M in 5 ranges.

Systron-Donner Corporation. Datapulse Division, 10150 West Jefferson Blvd., Culver City, California 90230.

WW302 for further details

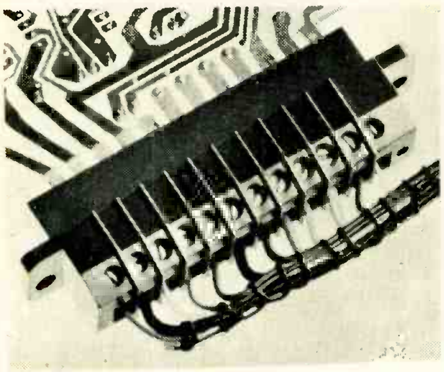
Digital multiplex clock

Designed for use in recording studios and by those engaged in the production of audio visual presentations, the Electrosonic ES1857 digital multiplex clock records on to tape the time elapsed in minutes, seconds, and half-seconds. Each time signal is recorded as a complete piece of information so that on replay it becomes possible to see the exact time information wherever you are on the tape. It is not a counting system, so there is no need to start from a specific point on the tape and any tape recorder with reasonable bandwidth can be used. The U.K. price of the ES1857 is £330.00. Electrosonic Ltd, 815 Woolwich Road, London SE7 8LT.

WW325 for further details

Edgeblock connector

Pye Connectors announce the availability of a component they believe to be unique. Called the Edgeblock, it combines in one moulding a printed circuit board edge



connector and a screw terminal block. The Edgeblock has a single row of 12 contact positions on 5.08mm pitch and is designed to accept p.c.b. thicknesses from 1.37mm to 1.88mm. The gold-plated phosphor bronze screw terminal contacts are rated at 5A and can accommodate wire sizes ranging from 7/0.22mm to 19/0.3mm. The dielectric moulding is grey self-extinguishing a.b.s. having a working temperature range of minus 20°C to plus 80°C. Pye Connectors Ltd, Hitchin Street, Biggleswade, Beds.

WW301 for further details

Counter timer

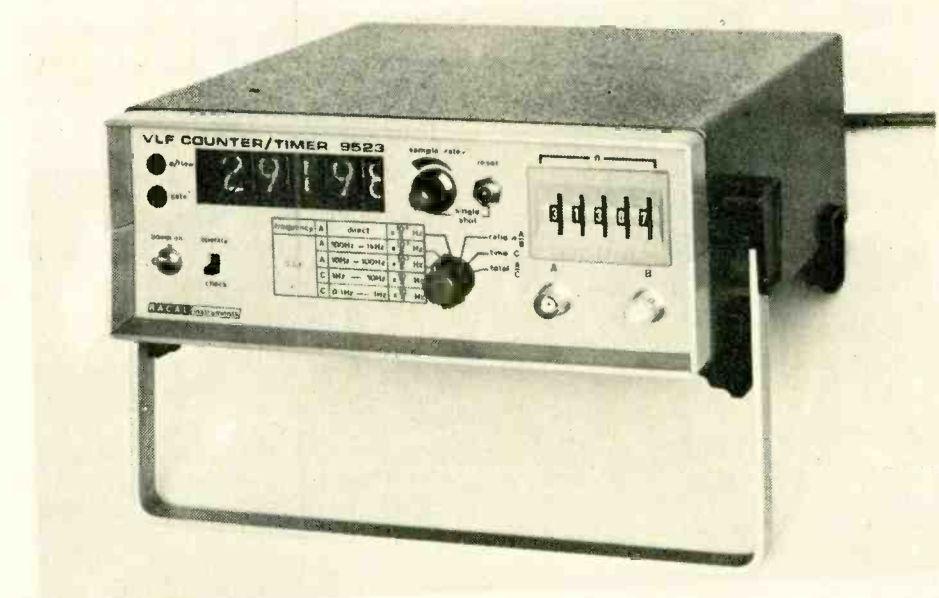
Racal Instruments have introduced the Model 9523 VLF Counter Timer. A reciprocal computing capability is utilized at low frequencies to improve frequency measurement resolution up to 1000 times, in four ranges covering 0.1Hz to 1kHz. An example of the claimed improvement in resolution is that a 50Hz signal would be displayed as 50.00Hz in little more than a second, or as 50.000Hz in about ten seconds.

The instrument measures frequency, frequency ratio, time interval and totalized counts in the 0.1Hz to 10MHz range. The variable digital timebase enables the instrument to be used in a variety of industrial applications where the presentation of measurements in "engineering units" is often essential, and direct readings in terms of r.p.m., litres per minute, miles per hour etc. can be obtained by selection of the correct gate time.

Three input channels are provided, two for direct frequency and frequency ratio readings and the third for v.l.f. measurement and as a gating channel for time interval measurements. In timer applications the start/stop signals may be electrical or contact closures with incorporated circuitry, to avoid false operation due to contact bounce.

The counter timer is of half-rack dimensions, 100mm in height, and weighs 2.7kg. Optional additions include b.c.d. data outputs and rear mounting inputs sockets. Racal Instruments Ltd., Duke Street, Windsor, Berks. SL4 1SB.

WW323 for further details



Studio Recorder

Scully Recording Instruments, a division of Dictaphone Corporation, have announced a new professional recorder/reproducer called the 280B. The new unit combines completely redesigned electronics and a new tape motion sensing system.

Specifications for the 280B include signal to noise ratio of 72dB at mastering speeds. Bandwidth is essentially flat, displaying ±2dB 30Hz to 18kHz. Mother-daughter board architecture results in a "clean" electronic cabinet and all test and adjustment points are readily accessible from a comfortable working position. The electronics slide out on roller arms and the individual channel modules are easily removed.

A new motion sensing system, called OPTAC, and internal logic enable the engineer to select a new mode and activate it without touching the stop button first. It also allows the engineer to enter and leave the record mode while the transport is in play.

Selective synchronization is standard on all multi-channel machines, thus there is the inherent ability to sequentially record programming material synchronous with previously recorded tracks.

The 280B series is available in either rack or console configurations, with 1, 2 and 4 channel models using most of the popular head configurations. Dictaphone Company Ltd., 14 Broadway, London S.W.1.

WW 326 for further information.

Solid State Devices

S.D.S. Components, the distributors for a number of semiconductor manufacturers, have announced the availability of the Signetics 82S90 Schottky decade counter which features typical clock rates of up to 100MHz. The device can be made to function as a decade counter with a b.c.d. output, as a decade counter in the bi-quinary code or as separate divide-by-two or divide-by-five counters.

A second Signetics device also from S.D.S. is the 2533V, a 1024-bit static shift register. This utilizes silicon gate p-channel m.o.s. construction, is t.t.l. compatible and is available in an 8 pin d.i.l. package that is exactly one half the length of a standard 16 pin d.i.l. A guaranteed 1.5MHz operating rate is offered for a power consumption of only 250W per bit.

Included in this month's announcements are details of the Plessey SL440, a power control circuit consisting of a triac firing circuit, a zero crossing detector, a servo amplifier and a timing circuit in a single package. The servo amplifier can be connected as an integrator to provide for a wide range in the rate of change of power in the load. The SL440 produces a 50μs, 60mA pulse to fire the triac and provides a stabilized 11.3V power supply for external circuitry. SDS Components Ltd, Hilsea Trading Estate, Portsmouth, Hants PO3 5JW.

WW330 decade counter
WW331 static shift register
WW332 power control circuit

New from R.C.A. is a range of devices for consumer applications. The CA2111A integrated circuits contain f.m.-i.f. amplifier limiters driving a quadrature f.m. detector. They feature low a.f.c. voltage drift over the full operating-temperature range, an input limiting voltage (knee) of typically 400μV at 10.7MHz and 2.5μV at 4.5MHz and 5.5MHz. The a.m. rejection is typically 45dB at 10.7MHz and finally the device represents a direct replacement for the Sprague ULN2111A and the Motorola MC1357. Suitable for use in colour or monochrome receivers is the RCA CA3120E, a signal processor incorporating a sync separator, noise inverter, a.g.c. comparator and an r.f.-a.g.c. delay amplifier.

The CA3096E and CA3096AE are n-p-n/p-n-p transistor arrays for general purpose use. They consist of five independent transistors, two p-n-p and three n-p-n types on a common monolithic substrate with separate connections for each transistor. The CA3096AE differs in that it has a matched n-p-n transistor pair. The devices are packaged in a d.i.l. 16-pin case.

Designed for u.h.f. power applications, the RCA 40970 is a silicon n-p-n epitaxial planar r.f. power transistor with internally mounted capacitors which provide an individual T matching network for each base cell. This design is said to provide a high input reistance and a low input *Q* to increase its broadband performance.

Three new liquid crystal display drivers that provide level shifting functions are also available on a limited sampling basis only, in 16 lead d.i.l. ceramic packages. They have preliminary designations CD 4054A, CD 4055A and CD 4056A.

The last device announced from RCA this month is a programmable power switch/amplifier integrated circuit family, types CA3094T, CA3094AT and CA3094BT. These differ only in supply voltage ratings, – up to 24V, 36V and 44V respectively. They have a power switching capability of over 10W peak or 3W average and can be programmed to idle at microwatt power levels. R.C.A. Ltd., Solid State Europe, Sunbury-on-Thames, Middlesex.

WW333 f.m.-i.f. amplifier-limiter
WW334 signal processor i.c.
WW335 transistor arrays
WW336 u.h.f. power transistor
WW337 liquid crystal drivers
WW338 programmable power switch/ amplifier

Celdis, distributors for General Electric, General Instruments, Transitron and Mullard, announce new devices from these manufacturers.

First, from Transitron comes the 745 series high speed Schottky t.t.l. These devices offer fast switching at low power levels, the range featuring typical propagation delays of 3ns with a power dissipation of 20mW per gate and 100MHz typical flip-flop clock input frequencies. Typical 100 up prices are 75p each for gates and £1.74 for flip-flops.

General Instruments have produced a new range of diodes given the generic name of Glass-amp II among which Celdis feature the 1N5059-1N5062 series. These have voltage ratings from 200 to 800V, and an average forward current rating of 1A at 75°C or 750mA at 100°C. Prices for the 200V version, IN5059, are 7.5p each and for the 800V version 1N5062 are 10.3p each (both prices at 100 up rate).

A new range of 15W zeners from Mullard are also stocked by Celdis, these being designated the BZV15 family. The devices will withstand a 600W surge rating and provide reference voltages from 10 to 75V with 5% tolerance on individual device ratings. Typical price is £0.284+2% each at 100 up rate.

Designed for the suppression of surge voltages and the protection of instrumentation and circuits, the metal oxide varistor (m.o.v.) is a new product from General Electric. These components are similar in size to a T05 transistor and are characterized by a response speed of 50ns. Variations are available for use on 130, 150 and 250V a.c. applications, capable of absorbing energy surges of 1, 2 or 4 joules, and, depending on type, of withstanding peak currents of 75A or 150A (7μs pulse width). Also from G.E. is a complete new family of photon coupled isolators capable of withstanding a surge voltage (input to output isolation) of 4000V. Known as the H15 series the devices are enclosed in a new 4-pin plastic package with pin spacing compatible with the normal d.i.l. centres. A range of variations is available from a simple photo-transistor and solid state lamp, to types which have their output in the form of a photo-Darlington array. General Electric have also announced the introduction of the H13 series of photon coupled interruptor modules designed to accept the edge of a computer card, tape or shaft encoder between the two components of the device to interrupt the signal. Celdis Ltd., 37/39 Loverock Rd., Reading, Berks RG3 1ED.

WW339 Schottky t.t.l.
WW340 rectifier diodes
WW341 zener diodes
WW342 metal oxide varistor
WW343 photo coupled isolators
WW344 photon coupled interruptors

New products added to the catalogue of G.D.S. (Sales) include an operational amplifier from Teledyne, several devices by Harris and some new digital devices from Motorola. The Teledyne 2740 is a hybrid operational amplifier with output short circuit protection, input overvoltage and latch-up immunity, internal 6dB/octave frequency compensation and an external offset voltage null capability. Limit parameters are quoted for a temperature range of 0°C to + 100°C and are as follows. Open loop gain 86dB, offset current 5nA, bias curretn 10nA, and offset voltage drift 10mV. Two new dual transistors with a 3μV/°C maximum base-emitter differential voltage drift have now been produced by Harris. Designated types 2N5117 (p-n-p) and 2N4044 (n-p-n) these are available in the standard 6-pin TO-78 package. Where the high performance of these devices are not required, the 2N4100 (n-p-n) and 2N5118 (p-n-p) with a 5μV/°C drift, or the 2N4045 and 2N5119, with a 10μV/°C drift are offered as alternatives. Also from Harris are the so-called fourth generation operational amplifiers which employ dielectric isolation and vertical p-n-p transistors which provide closed loop bandwidths up to a claimed 100 times better than conventional 741 devices operated at the same gain. These new amplifiers, the HA2605 and HA2625, have typical d.c. characteristics of 5nA offset current, 300MΩ input resistance and 80,000 minimum large signal open loop again. The HA2605 is internally compensated and has a 12MHz gain-bandwidth product, full power bandwidth of 75KHz, and a 7V/μs slew rate. The HA2625 is the uncompensated version of the HA2605 with 100MHz gain bandwidth product, 600kHz full power bandwidth and a 35V/μs slew rate. A bandwidth control pin is available on both amplifiers so that bandwidth can be specified where necessary.

A further two Harris operational amplifiers are characterized by fast slew rates. The HA2525 has a 120V/μs slew rate, 1.6MHz full power bandwidth and a 0.1μs settling time to 0.1%. An internally compensated version, the HA2515 has a 60V/μs slew rate, 1MHz full power bandwidth and 0.25μs settling time.

Finally three Motorola digital devices are introduced by G.D.S. The MC14527 is a b.c.d. rate multiplier (m.o.s. type) that provides an output pulse rate based upon the b.c.d. input number. A seven-segment latch/decoder/driver, type MC14511, represents a new addition to the Motorola c.m.o.s. family and provides the functions of a 4-bit storage latch, an 8421 b.c.d.-to-seven-segment decoder and an output drive capability. Also from the c.m.o.s. range of devices is the MC14528CL, a dual monostable multivibrator which may be triggered from either edge of the input pulse and will produce an output pulse with a width from 0.3 to 100μs. The device is packaged in a 16-pin d.i.l. case and costs £1.302 in 100 plus quantities.

G.D.S. (Sales) Ltd., Michaelmas House, Salt Hill, Bath Rd., Slough, Bucks.

WW 345 hybrid op-amp
WW 346 dual transistors
WW 347 fourth generation op-amps
WW 348 fast slew op-amps
WW 349 c.m.o.s. devices

S.G.S. Ates have introduced a new range of complementary m.o.s. devices some of which are to be made available later this year. Initially, it is intended to second source the CD4000A range manufactured by R.C.A. and from whom S.G.S. Ates have purchased the technology licence. The new range is to be identically numbered with the originals.

Four new complementary pairs of silicon power transistors designated BD433/34; BD281/82; BD283/84 and BD285/86 have also been introduced. Principally intended for audio applications, they can be used for audio output stages delivering, in the case of the last two pairs of devices, up to 20 watts of power into the load.

Finally a new protected audio power amplifier, type TBA810SΩ which will deliver 6W into a 4Ω load. Complete thermal protection is provided for by automatic limiting of output power. The device is available in a 12-lead quad-in-line plastic package with either flat, pierced tabs for the attachment of an external heat sink (TBA810AS) or bent metal tabs to solder direct to a printed circuit board. S.G.S. Ates Componenti Elebronici SpA, Via C. Olivetti, 1, 20041 – Agrate Br., Milan, Italy.

WW 350 m.o.s. range
WW 351 complementary power transistors
WW 352 audio power amplifier

Real and Imaginary

by "Vector"

Whatever Happened to the Likely Lads?

For what follows you can blame the recent Letters to the Editor on the subject of Marconi's 1907 patent for producing c.w. from a spark source. It seemed such an odd-ball invention that I wanted to know more about it, so I did what I always do on such occasions; I called on a friend of mine who is an ardent collector of old books on radio and kindred matters.

I didn't call in vain. He dug out a volume "Telephony Without Wires" (P. R. Coursey, Wireless Press Ltd, 1919) which is a mine of information on the subject. It seems that right from the start of wireless telegraphy lots of people had had a go at telephoning via spark-generated waves, the general approach being to connect a microphone in place of the morse key. Seeing that the original spark gaps produced heavily damped wave-trains with large chunks of nothing in between them (relatively speaking) the lack of success was predictable.

A little later some experimenters transferred allegiance to the arc system or the h.f. alternator, but others concentrated on trying to produce undamped wave-trains at faster sparking rates. The book traces the development of quenched spark, as it was termed, and devotes two chapters to methods of producing continuous waves from spark. I mustn't encroach upon the sacred ground of the correspondence columns, but there is no doubt that spark-begotten c.w. was no myth. Incidentally, you might be interested to know of two familiar names who made important contributions to the state of the art; one was W. Dubilier and the other — wait for it! — was H. Yagi.

Why, I wondered, seeing that input/output efficiencies of up to 75% were claimed, did such methods of producing c.w. die the death? Coursey gives part of the answer in connection with the smooth-disc approach; it was apparently only suitable for low powers (and output power was particularly important then because there were no amplifiers at the receiving end). Furthermore, the disc had to run at very high speeds even to achieve radiations of the order of 30kHz, while frequent gap-cleaning operations were necessary. Nevertheless, Marconi developed the 1907 device extensively and a highly sophisticated version (the timed disc c.w. generator) emerged which continued as the standard Marconi transmission system until the early 1920s when thermionic valves took over. P. R. Coursey's book has pictures of a 300kW installation and it's quite a piece of ironmongery.

Marconi, of course, was primarily concerned with telegraphy for trans-world communication and so introduced an audible note by means of studs on the discs to break up the pure c.w. (if pure is the right word, which it probably wasn't!). It certainly wouldn't have approached the regularity of valve-generated waves.

So that's what happened to one likely lad. I sometimes wonder, though, whether we aren't mistaken in assuming that nothing of value remains in the field of spark research. Consider, for a moment, a few unrelated facts. Spark techniques had developed into a highly efficient means of producing electromagnetic waves of all frequencies from centimetric to v.h.f. Even by 1907, rudimentary means had been found whereby c.w. could be obtained from it. And what of the oscillating crystal of 1911 in which a microscopic spark seems to have been a key feature? Remember, too, that Tesla suggested that spark-generated waves might be used for what we now call radar and, indeed, a primitive form of it was patented in 1904. Given the accumulated know-how of the past seventy years, isn't it just possible that somewhere lies the germ of, let's say, a simple, cheap sub-miniature radar transmitter for use on road vehicles in fog? Or something?

I've just mentioned Tesla. Now, there's a colourful character, if ever there was one. What was he? Charlatan? Showman? Mystic? Eccentric? Genius? Certainly he was continually bursting into the headlines with extraordinary inventions, a large proportion of which never got beyond print: automatons, communication from Mars, death-rays — you name it, Tesla had had a go at it. Yet over and beyond this, Tesla was a visionary-genius with a great number of solid patents to his credit, a pioneer of polyphase a.c. (he designed the alternators for the first Niagara Falls hydro-electric station) and a man who was years ahead of his time in matters concerning high potential, high frequency currents. A man whose worth is recognized by the bestowal of his name upon the unit of magnetic flux density. A complex character indeed.

In 1899 Tesla set up an impressive laboratory at Colorado Springs and before long announced that he had found it practicable to send and receive telegraphy and telephony around the world: many thousands of messages could be sent simultaneously. A cheap and simple device which could be carried in one's pocket would record the message.

But this was only the beginning; in addition, Tesla claimed that he could also distribute power in unlimited amounts without the aid of wire conductors. His "magnifying transmitter", as far as he described it, was essentially a circuit of very high induction and small resistance; the mode of operation (he said) was the diametrical opposite of conventional wireless telegraphy, the electromagnetic radiations being insignificant. With proper conditions of resonance obtained, the circuit "acts like an immense pendulum, storing indefinitely the energy of the primary exciting impulses upon the earth and its conducting atmosphere".

Eventually his transmitter was to emit a wave complex of a total maximum activity of 10 million horse power (this, added Tesla, rather unnecessarily, "is obtainable only by the use of certain artifices"). As a start he proposed to distribute 10,000 h.p. under a tension of 100 million volts "which I am now able to produce and handle with safety".

One of the chief benefits of the scheme, as Tesla saw it, would be the illumination of isolated homes, each one of which would have a power collector on its roof and with the lighting derived from vacuum tubes operated by h.f. currents. Tesla added that the driving of clocks and other such apparatus would be a feature, commenting that "the idea of impressing upon the earth American time is fascinating and very likely to become popular".

As far as one can gather, then, his idea was to set the entire earth into electrical oscillation at a frequency of 150kHz and to pump in power to be in resonance with the waves that he was sure would travel from the transmitting centre to a point diametrically opposite it on the earth's surface and then return. This travelling power could be tapped off anywhere by means of a tuned circuit, an earth connection and an elevated collecting rod. (How he proposed to stop pirating is not clear.)

Tesla built a central power plant and transmitting tower for his "World Telegraphy" at Long Island, New York. The tower was 187 ft high and topped by a hemispherical head 68 ft in diameter. The externals were completed by 1902 and some equipment installed, but by now the backers were crying off and Tesla was desperately short of money.

Tesla was forever dreaming up projects and then abandoning them, often because of lack of money. Many were undoubtedly crackpot but, on the credit side, he produced a great number of viable inventions. Isn't it possible that a careful search might reveal a few likely lads among those abandoned?

Sinclair Project 60

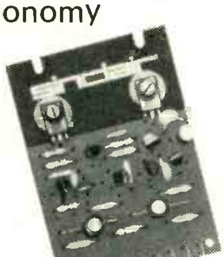
Now—the Z.50 Mk.2

with built-in automatic transient overload protection

When originally introduced, the Sinclair Z.50 proved how it was possible to design and produce a popularly priced modular power amplifier having characteristics to challenge the world's costliest amplifiers. Many thousands of Z.50's are now giving excellent service day in, day out. But we have also learned that constructors do not always use their Z.50's ideally. That is why we have introduced modifications whereby risk of damage through mis-use is greatly reduced and performance further enhanced. The Z.50 Mk.2 has improved thermal stability, more accurately regulated D.C. limiting to ensure more symetrical output voltage swing and clipping and still less distortion at lower power. Z.50 Mk.2 is compatible with all other Project 60 modules, and may be incorporated to advantage in existing systems. Eleven silicon epitaxial planar transistors are now used, two more than in the original Z.50; circuitry has been re-designed, making this versatile high performance amplifier better than ever.

with free manual
£5.48

Z.30 the power amplifier for quality and economy

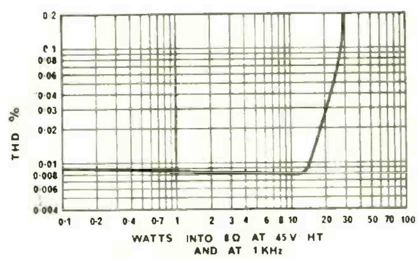


with free manual
£4.48

The Z.30 provides excellent facilities for the constructor requiring a high fidelity audio system of less power than that available from Z.50's. Using a power supply of 35 volts, Z.30 will deliver 15 watts RMS into 8 ohms, or 20 watts RMS into 3 ohms using 30 volts. Total harmonic distortion is a fantastically low 0.02% at 15 watts into 8 ohms with signal to noise ratio better than 70 dB unweighted. Input sensitivity 250mV into 100K ohms. Size 80 x 57 x 13 mm (3⅛ x 2¼ x ½) Z.30, Z.50 and Z.50 MK.2 modules are compatible and interchangeable.

Brilliant new technical specifications

Input impedance 100 KΩ
Input (for 30w into 8Ω) 400mV
Signal to noise ratio, referred to full o/p at 30v HT 80dB or better
Distortion 0.02% up to 20W at 8Ω. See curve
Frequency response 10Hz to more than 200 KHz ±1dB
Max. supply voltage 45v (4Ω to 8Ω speakers) (50v 15Ω speakers only)
Min. supply voltage 9v
Load impedance – minimum: 4Ω at 45v HT
Load impedance – maximum: safe on open circuit



Guarantee

If, within 3 months of purchasing any product direct from Sinclair Radionics Ltd., you are dissatisfied with it, your money will be refunded at once. Many Sinclair appointed Stockists also offer this same guarantee in co-operation with Sinclair Radionics Ltd.

Each Project 60 module is tested before leaving our factory and is guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you, if it is returned within two years from the date of purchase. Outside this period of guarantee a small charge (typically £1.00) will be made. No charge is made for postage by surface mail. Air Mail is charged at cost.

sinclair

Typical Project 60 applications

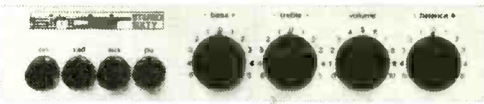
System	The Units to use	together with	Units cost
Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control, etc.	**£4.48**
Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control, etc.	**£9.45**
12W. RMS continuous sine wave stereo amp. for average needs	**2 x Z.30s, Stereo 60; PZ.5**	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	**£23.90**
25W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers	**2 x Z.30s, Stereo 60; PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
80W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60W. RMS into 8 ohms)	**2 x Z.50s, Stereo 60; PZ.8, mains transformer**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

F.M. Stereo Tuner **(£25)** & A.F.U. **(£5.98)** may be added as required.

WW—099 FOR FURTHER DETAILS

the world's most advanced high fidelity modules

Stereo 60 Pre-amp/control unit



Designed specifically for use on Project 60 systems, the Stereo 60 is equally suitable for use with any high quality power amplifier. Since silicon epitaxial planar transistors are used throughout, a really high signal-to-noise ratio and excellent tracking between channels is achieved. Input selection is by means of press buttons, with accurate equalisation on all input channels. The Stereo 60 is particularly easy to mount.

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ±1dB :20 to 25,000 Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE +12 to —12dB at 10KHz: BASS +12 to —12dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.

Built, tested and guaranteed. **£9.98**

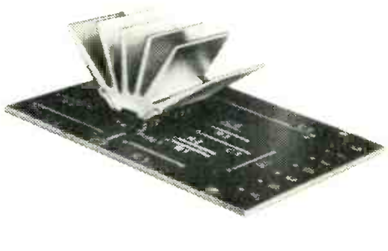
Project 60 Stereo F.M. Tuner

The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other advanced features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stero decoder and switchable squelch circuit for silent tuning between stations. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with most other high fidelity systems.

SPECIFICATIONS—Number of transistors: 16 plus 20 in I.C. **Tuning range:** 87.5 to 108MHz. **Sensitivity:** 7µV for lock-in over full deviation. **Squelch level:** Typically 20µV. **Signal to noise ratio:** >65dB. **Audio frequency response:** 10Hz – 15KHz (±1dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** 2µV. **Cross talk:** 40dB. **Output voltage:** 2 x 150mV R.M.S. maximum **Operating voltage:** 25–30VDC. **Indicators:** Stereo on; tuning. **Size:** 93 x 40 x 207mm.

Built and tested. Post free. **£25**

Super IC.12 Integrated circuit high fidelity amplifier



Having introduced Integrated Circuits to hi-fi constructors with the IC.10, the first time an IC had ever been made available for such purposes, we have followed it with an even more efficient version, the Super IC.12, a most exciting advance over our original unit. This needs very few external resistors and capacitors to make an astonishingly good high fidelity amplifier for use with pick-up, F.M. radio or small P.A. set up, etc. The free 40 page manual supplied, details many other applications which this remarkable IC. make possible. It is the equivalent of a 22 transistor circuit contained within a 16 lead DIL package, and the finned heat sink is sufficient for all requirements. The Super IC.12 is compatible with Project 60 modules which would be used with the Z.50 and Z.30 amplifiers. Complete with free manual and printed circuit board.

SPECIFICATIONS

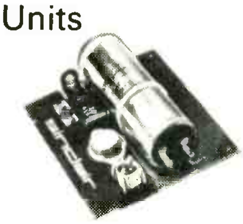
Output power: 6 watts RMS continuous (12 watts peak), 6–8Ω. **Frequency Response:** 5Hz to 100KHz ±1dB. **Total Harmonic Distortion:** Less than 1%. (Typical 0·1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feedback. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22 × 45 × 28mm including pins and heat sink..

Manual available separately 15p post free.

With FREE printed circuit board and 40 page manual.

£2.98 Post free

Power Supply Units The new PZ.8 Mk.3



The most reliable power supply unit ever made available to constructors. Brilliant circuitry makes failure from over load and even direct shorting of the output impossible. This is due to an ingenious re-entrant current limiting principle which, as far as we know has never before been available in any comparable unit outside the most expensive laboratory equipment. Ripple and residual noise have been reduced to the point of almost total elimination. This is, of course, the perfect unit for Project 60 assemblies, particularly where the new Z.50 MK.2 amplifiers are used. Nominal working voltage – 45.

PZ.8 Mk.3—£7.98
(Mains transformer, if required) £5.98
PZ.5 30v. unstabilised
(not suitable for Project 60 tuner) £4.98
PZ.6 35v. stabilised
(not suitable for IC. 12) £7.98

Project 605

the easy way to buy and build Project 60 without soldering

Project 605 in one pack contains: one PZ.5, two Z.30's, one Stereo 60 and one Masterlink, which has input sockets and output components grouped on a single module and all necessary leads cut to length and fitted with clips to plug straight on to the modules thus eliminating all soldering.

Complete with comprehensive manual, post free **£29.95**
All you need for a superb 30 watt high fidelity stereo amplifier

Order form

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I enclose cash/cheque/money order.

Name ____________________

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WW 6

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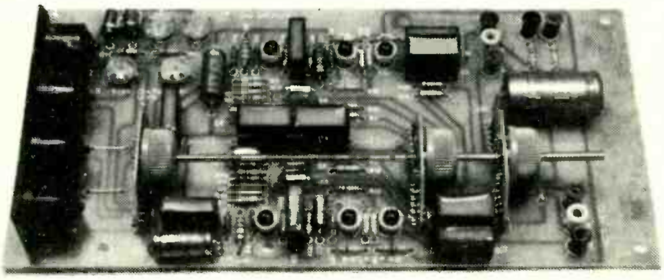
HART ELECTRONICS

Audio Kits



This is our Bailey/Burrows Stereo pre-amp front end. We think it is the best engineered kit of the best pre-amp circuit available, and there is a back end/tone control unit of similar advanced design to go with it which is only 1½" deep so it fits almost anywhere, but of course it's at its best in a Hart universal amplifier metalwork with a couple of Hart Bailey 30 watt power amps to keep it company. That's a recipe for real Hi-Fi with electronics you'll be too proud to cover up.

Also a delight to the connoisseur are our printed circuits and components for the Stuart tape circuits.

This is a most useful high quality circuit with the record, replay and bias functions on separate boards thus giving considerable versatility of use. For instance a stereo replay channel can be built for £6 for single speed use without external components or a switch may be added for multispeed operation.

WE ARE SUPPLYING

Printed Circuit Boards, Components and Kits for the

D. O'N. WADDINGTON DIGITAL MULTIMETER

This most interesting project fulfils the long-felt want for a Digital Multimeter with the added bonus of counter/timer functions, all at a price which makes it extremely attractive to the amateur, educational or commercial user.

Please send 9" x 4" SAE for full details:

Penylan Mill, Oswestry, Salop.

Personal callers are always welcome, but please note we are closed all day Saturday

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Newnes Radio Engineer's Pocket Book 14th Edition

H. W. Moorshead

A ready reference source for formulae, tables and definitions of electrical and electronic terms, including many mathematical tables. The book is very carefully indexed for quick and accurate selection of material.

1972 192 pp illustrated 0 408 00074 0 £1.20

Sound with Vision

Sound Techniques for Television and Film

E. G. M. Alkin

For the first time the methods developed by the BBC are here made available in book form for the benefit of television sound operators and production staff. The book discusses the problems of simultaneous production of sound and picture, giving practical instruction in methods of overcoming them. There are detailed discussions of operation equipment and trends which will be useful to designers and manufacturers of sound equipment.

1972 288 pp illustrated 0 408 70236 2 £6.00

Video Recording

Record and Replay Systems

Gordon White

This book describes the principles of video recording and discusses the various systems which are on the market or will soon make an appearance. Inevitably the book is technical, but it is designed so that people who have an interest in the subject should find no difficulty in understanding the principles, advantages and disadvantages of the various systems.

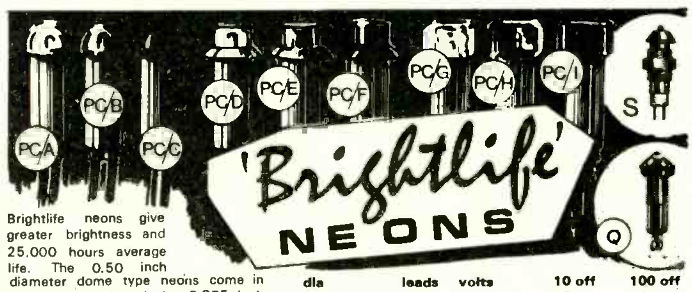
1972 216 pp illustrated 0 408 00085 6 £3.25

Obtainable through any bookseller or from

The Butterworth Group

88 Kingsway, London WC2B 6AB.
Trade counter: 4-5 Bell Yard, WC2.

WW—114 FOR FURTHER DETAILS



Brightlife neons give greater brightness and 25,000 hours average life. The 0.50 inch diameter dome type neons come in red or neutral and the 0.375 inch diameter types in red, amber or neutral. The latter are available in three cap shapes and all may be supplied for 115 V, 240 V and 440 V operation with 6" or 30" leads. The miniature Q type neon has Nato numbers and is available for 230 V as standard as is the sub-miniature S type which we believe to be the smallest available.

dia	leads	volts	10 off	100 off
⅜" PC/A to I	6"	240	15p.	14p.
⅜" PC/A to I	30"	240	17p.	16p.
Q		110/240	17p.	16p.
S		240	19p.	18p.
Not illustrated:				
½" PPA or B	6"	240	15p.	14p.

Minimum quantity each type, 10 off.
Add 15p., any quantity, P. & P., then add 10% V.A.T.

WEST HYDE

WEST HYDE DEVELOPMENTS LIMITED, RYEFIELD CRESCENT, NORTHWOOD HILLS, NORTHWOOD, MIDDX., HA6 1NN.
Telephone: Northwood 24941/26732. Telex: 923231

Contil Mod 3 cases come in six sizes and offer the manufacturer of small instruments an attractive low cost case available ex stock. Made in blue PVC coated steel, these cases offer strength and rigidity and come complete with front and rear panels. PCB and PSU mounting systems are also available.

	Dim. in ins.	One off (less for quantities)
Mod-301	7 x 3 x 5¼	3.25
Mod-302	7 x 4½ x 5¼	3.41
Mod-303	7 x 6 x 5¼	3.85
Mod-304	11 x 3 x 5¼	3.85
Mod-306	11 x 6 x 5¼	5.28

Prices include case, chassis, feet, stainless screws, P. & P., and V.A.T.

WEST HYDE

WEST HYDE DEVELOPMENTS LTD. RYEFIELD CRESCENT, NORTHWOOD HILLS, MIDDX. HA6 1NN
Telephone: Northwood 24941/26732 Telex: 923231 Code: West Hyde Nthwd.

WW—102 FOR FURTHER DETAILS

MAGNETIC HEADS P.O.A.

210028 RCA .... 9 TRACK
259019 RCA .... 7 TRACK
257124 RCA .... 8 TRACK
282812 RCA .... 8 TRACK
303489 RCA .... 7 TRACK
73927 RCA .... 7 TRACK
303464 RCA .... 7 TRACK
303462 RCA .... 7 TRACK
1215872 TYPE 1301 ...... 7 TRACK
5007821 POTTER .... 7 TRACK
19467 EPSYLON .... 8 TRACK
76815/948 BURROUGHES 9 TRACK
652623DRI 12/101 ...... 12 TRACK
L651922 DRI FR3000 ... 16 TRACK

TRANSISTORS & DIODES

2N457 .... 75p
2N1545 .... 50p
2N1542 .... 50p
2N1557 .... 50p
2N3055 .... 45p
2N3322 .... £1·00
2N3553 .... £1·00
2N5322 .... 50p
AC126 .... 20p
AC127 .... 25p
AC128 .... 20p
AF115 .... 25p
AF116 .... 25p
AF117 .... 25p
BC107 .... 8p
BC108 .... 8p
BC109 .... 8p
OC35 .... 40p
OC42 .... 40p
OC71 .... 12p
CV7006/OC72 .... 20p
OC75 .... 25p
OC77 .... 45p
OC83 .... 25p
2N356/OC139 .... 25p
Get110 .... 20p
2G106/2N711B ... 43p
OA5 .... 20p
OA10 .... 25p
RAS508AF 800PIV 50p
RAS310AF 1000v Av. 1.5a 2 for 50p
STC Wire ended 400PIV 1a 4 for 50p

RCA PHOTOMULTIPLIER C31005B

Checked and tested ...... £37·50

BRIDGE RECTIFIERS

1B40KO5 50v 4a 95p

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GEX541B1P2 ..... £6·88
GEX541B1P1 ..... £3·50
GEX541D2P1 ..... £3·50
GEX541NB1P1F ... £6·00
GEX541HP3F ..... £6·00
SX751N1B1P1F ... £6·00

DIGITAL COUNTERS

Veeder Root Zero Reset 6 dig. 110v. dc .... £4·75
Veeder Root Mech. Reset 4 dig. 50p
Hengstler Reset 6 dig. 210 Ω 24v. .... £3·50
Hengstler Reset 6 dig. 110v. Type 400 with suppressor .... £5·50

INTEGRATED CIRCUITS

MC3544 .... £1·10
MC353G .... £2·00
MC358AG .... £5·00
MC365G .... £5·00
CA3020 .... 93p
CA3021 .... £1·15
CA3055 .... £1·24
CD4035AE .... £1·91

THYRISTORS

GE2N1774 200v. 5a. £1·20
CR1-021C 20v. 1a. .. 25p
CR10-101B 100v. 10a. .... £1·00
CR10-021 10a. .... £1·00
CR10-40B 10a. .... £1·00
CR10-051 10a. .... £1·00
CR10-017 10a. .... £1·00
BTX-82-300R 300v. 26a. .... £2·00
STC 3/40 400v. 3a. ... 50p

SWITCHES

Edwards High Vacuum "Speedivac" model VSK1B range 25·760 torr contact ratings 250v. 5a. volume 4·2 cu. cm. max. working pressure 15lb/sq. in. gauge net weight 17 ozs. .... £6·20
Belling Delay hand reset L415 .... £1·10
Stackpole min. rocker 125v. 10a. 250v. 5a. 20p
Tippalite Rocket 12v 60p
Securex 5000 press button 250v. ac. .. £1·20

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Creed model 75 Receiver — 5w Mk 4 unused with connectors handbook & computer wiring diagram **£35.00** carr. £1.00.

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Siemens Min. 12/15v. 50p
Magnetic Dev. Type 596E .... £2·00
BR Type M51 240v. 65p

VARIACS

Zenith Duratrak Type V6M Inp. 135v. & 115v. Outp. 135v. at 6a .... £6·00
Philips Series E401 Inp. 240v. Outp. 0-270v. at 8 amps .... £15·00 carr. 67p

KEYBOARDS — special sale of Limited Quantity

ICT Alpha Verifier .... **£6.00** carr. 50p
ICT Numerical **£3.50** carr. 35p
ICL Alpha Verifier (PN7035 130) ...... **£27.50** carr. £1.00

"DIMMIT" Module PMSD-1000

1KW Dimmer used by Industry Theatre Disco 240v Full Radio & TV Interference Suppression Fibreglass PCB 60mm slider pot. permits linear control from min. to max. power using Triac Phase Control fused for O/L protection Dimen. 12 x 5 x 4 cm knob faceplate screws supplied **£6.50** pp 20p

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McMurdo Red Range, Plug RP24 .... 56p
McMurdo Red Range, SKT RS32 .... 90p
Eng. Elect. Edge. 36 way 0·2mm .... £1·00
Sylvania Edge. 48 way 0·1mm .... pair £1·40
Ultra Gold-plated Contacts. 0·1mm Type 10M 54631263C 38 way .... pair £2·00; 20 way .... pair £1·60

CAPACITORS

Daly Electrolytic 9000 uf 40v. **50p**; TCC Electrolytic 10,000 uf 70v. **50p**; Dubilier Metallised Paper Type 426 100 uf 150v. DC **50p**; R.I.C. type 1297 1.8uf 440v. AC **35p**.

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Crompton Parkinson 240v. 1ph 50c 0·125hp 1400rpm .... £5·00 carr. 67p
GEC fractional 1/12 hp 230/250v 1ph 50c 2850rpm .... £3·50 carr. 67p
E.E. ½hp 230v. 50c 1ph 50c. 1440rpm complete with cap 80/100uf 275v .... £13·00 carr. £1·00
76813-393 Potter Instr. 110v. DC 4amp 0·2hp. Cont. flange mounting precision tape transport motor (£80 value) .... £25·00 incl. carr.

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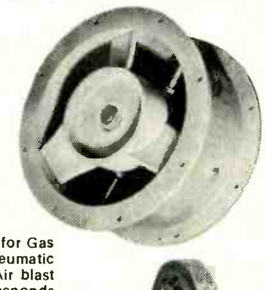

Airmax Type M1/Y3954 (3 blades) Cast Aluminium alloy impeller & casing (corresponds to current type 3965 7½") 230v. 1ph 50c 2900rpm Class "A" insulation 425cfm free air weight 9½lbs. incl. p.p. **£21·00.**

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William Allday Alcosa Two Stage Vacuum Pump Model HSPOB 8hg up to 29 in. mercury rpm 1420. E.E. 3 phase induction, motor ⅓hp cont. 220/250v. 380/440v. **£21·00** incl. carr.

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WW—112 FOR FURTHER DETAILS

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GERALD 900B Sweep Generator with SD8A sweep driver unit. V.H.F. and U.H.F. 0-1200MHz. centre frequency. 1, 10 and 100MHz markers. Built-in detector, attenuators etc. This instrument is probably the most comprehensive sweeper ever made. **P.U.R.**

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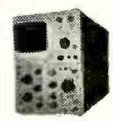

Type 547 with 1A2 plug-in. DC—50MHz. With display switching.
Type 545A with 'CA' plug-in. (Or 'L'). DC—30MHz.
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Also available:
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Solartron CD1400. With two CX1442 and a CX1443 units. Extremely sensitive instrument. Twin differential inputs.

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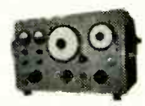

Marconi type TF801D. 10-485MHz. Excellent. **P.U.R.**
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Rohde & Schwarz SMAF. A.M. & F.M. 4-300MHz. FM Dev. 0-100KHz in 2 ranges. Fundamental-frequency generator ideal for radio-telephone test equipment. **P.U.R.**

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Airmec 210 Deviation meter. 3-300MHz. AM Mod and FM Deviation to 125 KHz.
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POWER TUBE BASES for 4X250 T/X Valves etc. BASES ARE BRAND NEW AND BOXED COMPLETE WITH THE CERAMIC CHIMNEY. Only **£3.25** each p.p. 10p.

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*Voltage Range 16-24V.
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*Full over-voltage and Current protection.
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LEICESTER 32 High St. (Closed Thurs.)
LIVERPOOL 73 Dale St. (Closed Wed.)
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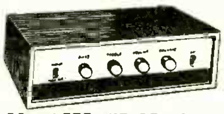

R.S.C. G66 MkII 6+6 WATT STEREO AMPLIFIER

High Quality Output. Rating I.H.F.M. Ind. Ganged Controls Bass Treble, Vol. and Balance. Solid state constr. employing 10 Trans. plus diodes. Range 20-20,000Hz. Bass control ± 12 dB Treble ± 13 dB. Selector switch P.U. or Tape/Radio. Output for 3-15 ohm speakers. Standard 200-250v. 50 Hz mains operation. Attractive Black/Silver metal face plate and matching knobs.

COMPLETE KIT OF PARTS INC. FULLY WIRED PRINTED CIRCUIT **£12·65** OR FACTORY BUILT IN TEAK VENEERED CABINET **£16·50**

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BUILD AN AMPLIFIER WORTH APPROXIMATELY DOUBLE THE KIT PRICE INCLUDING CABINET
Only high grade components by leading manufacturers

- Push Button Selector Switching
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- Solid State Circuitry
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For Magnetic or Ceramic Pick-Ups regardless of Price
Output (per channel) 15 watts RMS into 8 Ω
Frequency Response 7 Hz to 70 KHz ± 1½ dB

COMPLETE KIT (less cabinet). Carr. 70p Cabinet if req. £5 extra **£27·50**

FACTORY BUILT UNIT INC. CABINET with 12 months' guarantee. Or Dep. £7 and 9 monthly payments £4·54 (Total £47·86) **£42·50**

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R.S.C. STEREO FM III TUNER. Visually matches Super 30 Mk. III in cabinet **£37·50**

FANE ULTRA HIGH POWER LOUDSPEAKERS

Power Rating R.M.S. continuous. 2 years guarantee. Carr. free

12" 'POP' 50 50 Watts 15 Ω 13,000 Gauss **£11·99**
Or Dep. £2 and 9 monthly payments £1·33 (Total £13·97)
Pair suitable for all purposes.

15" 'POP' 60 60 Watts 8/15 Ω 14,000 Gauss **£14·75**
Or Dep. £3·30 and 9 monthly payments £1·50 (Total £16·80)

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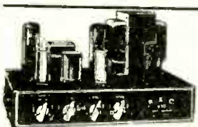
Or Dep. £6·00 and 9 monthly payments £2·49 (Total £28·41)

SUITABLE FOR BASS GUITAR, ELECTRONIC ORGAN, etc.



R.S.C. A10 30 WATT HI-FI AMPLIFIER

Including 2 ind. controlled inputs

Separate Bass and Treble Controls. Valves EF86, EF86, ECC83, GZ34, EL34, EL34. Sensitivity 36mV. For High Imp. mic. or pick-ups. Designed to high fidelity standards for CLUBS, SCHOOLS, THEATRES, DANCE HALLS, DISCOTHEQUES, etc. For use with Electronic Organ, Bass or Lead Guitar. For Gram, Radio or Tape. For 3 or 15 ohm speakers. Twin-handled metal cover £2·10 **FACTORY BUILT** with 12 months' guarantee. Or Dep. £4 and 9 monthly payments £2·27 (Total £24·43) S.A.E. for leaflet **£21·75**

FANE SPEAKERS 'POP' 25/2

12" 25 WATT **£7·95** Dual Cone 15 ohms NOT for Bass Guitar. Or Dep. £1·25 and 9 monthly payments 89p (Total £9·26)

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Teak veneer finish. Pleasing design. Acoustically lined. All sizes approx.
JE8 16 × 11 × 9 in. Pressurised. Excellent results with 8 in. Hi-Fi Speaker. **£5·50**
SE8 for optimum results with any 8 in. Hi-Fi Speaker. 19 × 10½ × 9 in. **£6·50**
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300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 130mA, 6.3v. 4a., c.t., 6.3v 1a. For Mullard 510 Amplifier	£2·95
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
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300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
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FILAMENT or **TRANSISTOR POWER PACK** Types 6.3v. 1.5a. 55p; 6.3v. 2a. 60p; 6.3v. 3a. 85p; 6.3v. 6a. £1·45; 12v. 1a 61p; 0-9-18v. 1½a. £1·25; 0-12-25-42v. 2a. £1·95; 12v. 3a. or 24v. 1.5a £1·50;

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Standard Pentode 5,000 Ω to 7,000 Ω to 3 Ω	55p
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R.S.C. BM1 battery eliminator completely replaces 1·5v. and 90v. Radio batteries where normal 200-250v. AC mains is available. Ready for use **£4·15**

FANE 807T HIGH FIDELITY SPEAKER 8" 10 WATT

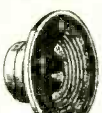
A full range unit to provide excellent sound quality in suitable enclosure. Roll P.V.C. cone surround and long throw voice coil to achieve very low fundamental resonance of 30 Hz. Tweeter cone extends high note response. Frequency range 25-15,000 Hz Imp. 3 or 8/15 Ω. (state requirement.) REMARKABLE VALUE **£3·70**

MODEL 803T 8" 15w. with parasitic Tweeter. Response 25 Hz to 15 KHz. Gauss 13,000 Imp 3 or 8-15 ohms. ONLY **£4·95**

FANE MODE ONE HI-FI SPEAKER KIT

inc. 803 8" unit, 303 Pressure Tweeter, Printed circuit, inductive capacitive cross-over, acoustic filling panels, screws, etc. Post free Response 30-20,000 Hz ONLY **£9·96**

HIGH FIDELITY SPEAKERS AUDIOTRINE RANGE



Heavy construction. Highly efficient ceramic magnets. Plastiflex cone surrounds. "D" indicates Tweeter cone providing frequency range up to 15 KHz. Exceptional performance at low cost.

HF 808T	8"	10W	£2·98
HF 102D	10"	10W	£3·30
HF 120	12"	15W	£4·95
HF 120D	12"	15W	£5·50
HF 126	12"	15W	£6 35
HF 126D	12"	15W	£6 85

Please state impedance required. 3 or 8-15 ohm.

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Audiotrine 121K. 12 in. 15 watt. 11,000 Gauss bass unit. Cross-over unit and Tweeter. Smooth response and wide frequency range ensure realistic sound reproduction. Carr. 33p **£6·50**

Audiotrine 125K with extra sensitive 15,000 Gauss 12 in. speaker. **£7·65**

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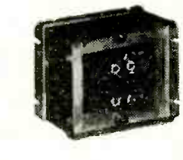

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Primary 200-250 Volts Secondary 240 Volts Centre Tapped (120V) and Earth Shielded
ALSO AVAILABLE WITH 115/120V SECONDARY WINDING

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	P & P £	p
07	20	1	11	7·0 × 6·0 × 6·5	1·77	30
100	60	3	8	8·9 × 8·0 × 7·7	2·62	36
61	100	5	12	10·2 × 8·9 × 8·3	2·88	52
30	200	9	8	12·0 × 10·3 × 10·0	4·83	52
62	250	12	4	9·5 × 12·7 × 11·4	6·38	67
55	350	15	0	14·0 × 10·8 × 12·4	8·55	82
63	500	27	0	17·1 × 11·4 × 15·9	12·32	*
92	1000	40	0	17·8 × 17·1 × 21·6	22·70	*
128	2000	63	0	24·1 × 21·6 × 15·2	37·50	*
129	3000	84	0	21·6 × 21·6 × 20·3	58·67	*
190	6000	178	0	31·1 × 35·6 × 17·1	96·27	*

440V 300VA ISOLATOR, Primary 440V Secondary 240V, Centre Tapped Screened and Shrouded, £10·37. P & P 67p.

AUTO SERIES (NOT ISOLATED)

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	P & P £	p
113	20		11	7·3 × 4·3 × 4·4	0-115-210-240	0·93	22
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	1·82	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	2·20	36
66	300	6	0	10·2 × 10·2 × 9·5	,, ,,	4·28	52
67	500	12	8	14·0 × 10·2 × 11·4	,, ,,	6·35	67
84	1000	16	0	11·4 × 14·0 × 14·0	,, ,,	11·54	82
93	1500	28	9	13·5 × 14·9 × 16·5	,, ,,	16·72	*
95	2000	40	0	17·8 × 16·5 × 21·6	,, ,,	21·82	*
73	3000	45	8	17·4 × 18·1 × 21·3	,, ,,	29·70	*

TOTALLY ENCLOSED 115V AUTO TRANSFORMERS

115V 500 Watt totally enclosed auto transformer, complete with mains lead and two 115V outlet sockets. £8·63. P & P 67p
Also available a 20 Watt version. £1·84. P & P 22p.

LOW VOLTAGE SERIES (ISOLATED)
PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps. 12V	24V	Weight lb	oz	Size cm.	Secondary Windings	P & P £	p
111	0·5	0·25		12	7·6 × 5·7 × 4·4	0-12V at 0·25A × 2	0·93	22
213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	1·11	22
71	2	1	1	9	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·46	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	2·04	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	2·46	42
108	8	4	5	4	10·0 × 8·3 × 8·2	0-12V at 4A × 2	2·73	52
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	3·23	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	4·99	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	6·35	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	11·73	82
226	60	30	34	0	17·0 × 14·5 × 12·5	0-12V at 30A × 2	21·57	*

30 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	P & P £	p
112	0·5	1	4	8·3 × 3·7 × 4·9	0-12-15-20-24-30V	1·11	22
79	1·0	2	0	7·0 × 6·4 × 6·0	,, ,,	1·48	36
3	2·0	3	2	8·9 × 7·0 × 7·6	,, ,,	2·21	36
20	3·0	4	6	10·2 × 8·9 × 8·6	,, ,,	2·72	42
21	4·0	6	0	10·2 × 10·0 × 8·6	,, ,,	3·23	52
51	5·0	6	8	12·1 × 10·0 × 8·6	,, ,,	4·02	52
117	6·0	7	8	12·1 × 10·0 × 10·2	,, ,,	4·80	52
88	8·0	10	0	14·0 × 11·7 × 10·0	,, ,,	6·20	67
89	10·0	12	2	14·0 × 10·2 × 11·4	,, ,,	7·85	67

50 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	P & P £	p
102	0·5	1	11	7·0 × 7·0 × 5·7	0-19-25-33-40-50V	1·46	30
103	1·0	2	10	8·3 × 7·3 × 7·0	,, ,,	2·13	36
104	2·0	5	0	10·2 × 8·9 × 8·6	,, ,,	2·96	42
105	3·0	6	0	10·2 × 10·2 × 8·3	,, ,,	4·01	52
106	4·0	9	4	12·1 × 11·4 × 10·2	,, ,,	5·31	52
107	6·0	12	4	12·1 × 11·1 × 13·3	,, ,,	7·85	67
118	8·0	18	9	13·3 × 13·3 × 12·1	,, ,,	10·25	97
119	10·0	19	12	16·5 × 11·4 × 15·9	,, ,,	12·83	97

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	P & P £	p
124	0·5	2	4	8·3 × 9·5 × 6·7	0-24-30-40-48-60V	1·48	36
126	1·0	3	0	8·9 × 7·6 × 7·6	,, ,,	2·06	36
127	2·0	5	6	10·2 × 8·9 × 8·6	,, ,,	3·23	42
125	3·0	8	8	11·9 × 9·5 × 10·0	,, ,,	4·92	52
123	4·0	10	6	11·4 × 9·5 × 11·4	,, ,,	6·35	67
120	6·0	16	12	13·3 × 12·1 × 12·1	,, ,,	9·20	82
122	10·0	23	2	16·5 × 12·7 × 16·5	,, ,,	15·23	*

EQUIPMENT TRANSFORMER

REF 238 PRI 0240 SCREEN SEC 3·0 3V RMS at 200mA SIZE CM 2·8 x 2·6 x 2·0 WEIGHT 2oz £1·08 P & P 10p.

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PRIMARY 200-250 VOLT FOR CHARGING 6 OR 12 VOLT BATTERIES

Ref. No.	Amps.	Weight lb	oz	Size cm.		P & P £	p
45	1·5	1	9	7·0 × 6·0 × 6·0	Please note, these units do not include rectifier.	1·47	30
5	4·0	3	11	10·2 × 7·0 × 8·3		2·23	42
86	6·0	5	12	10·2 × 8·9 × 8·3		3·37	52
146	8·0	6	4	8·9 × 10·2 × 10·2		3·84	52
50	12·5	11	14	13·3 × 10·8 × 12·1		5·72	67

All ratings are continuous. Standard construction: open with solder tags and wax impregnation. Enclosed styles to order.

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AD 161/162 60p pair with mica and bushes
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AC128	0·19
AC132	0·16
AC134	0·16
AC137	0·16
AC141	0·16
AC141K	0·19
AC142	0·16
AC142K	0·19
AC151	0·17
AC154	0·22
AC155	0·22
AC156	0·22
AC157	0·27
AC165	0·22
AC166	0·22
AC167	0·22
AC168	0·27
AC169	0·16
AC176	0·22
AC177	0·27
AC178	0·31
AC179	0·31
AC180	0·19
AC180K	0·22
AC181	0·19
AC181K	0·22
AC187	0·24
AC187K	0·22
AC188	0·24
AC188K	0·22
ACY17	0·28
ACY18	0·22
ACY19	0·22
ACY20	0·22
ACY21	0·22
ACY22	0·18
ACY27	0·20
ACY28	0·21
ACY29	0·39
ACY30	0·31
ACY31	0·31
ACY34	0·23
ACY35	0·23
ACY36	0·31
ACY40	0·19
ACY41	0·20
ACY44	0·39
AD130	0·42
AD140	0·53
AD142	0·53
AD143	0·43
AD149	0·55
AD161	0·37

AD162	0·37
AD161 & AD162 (MP)	0·61
ADT140	0·55
AF114	0·27
AF115	0·27
AF116	0·27
AF117	0·27
AF118	0·39
AF124	0·33
AF125	0·28
AF126	0·31
AF127	0·31
AF139	0·33
AF178	0·33
AF179	0·55
AF180	0·55
AF181	0·50
AF186	0·50
AF239	0·41
AL102	0·72
AL103	0·72
ASY26	0·28
ASY27	0·33
ASY28	0·28
ASY29	0·28
ASY50	0·28
ASY51	0·28
ASY52	0·28
ASY54	0·28
ASY55	0·28
ASY56	0·28
ASY57	0·28
ASY58	0·28
ASZ21	0·44
BC107	0·10
BC108	0·10
BC109	0·11
BC113	0·11
BC114	0·17
BC115	0·17
BC116	0·17
BC117	0·17
BC118	0·11
BC119	0·33
BC120	0·88
BC125	0·13
BC126	0·20
BC132	0·13
BC134	0·20
BC135	0·13
BC136	0·17
BC137	0·17
BC139	0·44
BC140	0·33
BC141	0·33
BC142	0·33
BC143	0·33
BC145	0·50
BC147	0·11

BC148	0·11
BC149	0·13
BC150	0·20
BC151	0·22
BC152	0·19
BC153	0·31
BC154	0·33
BC157	0·20
BC158	0·13
BC159	0·13
BC160	0·50
BC161	0·55
BC167	0·13
BC168	0·13
BC169	0·13
BC170	0·13
BC171	0·16
BC172	0·16
BC173	0·16
BC174	0·16
BC175	0·24
BC177	0·21
BC178	0·21
BC179	0·21
BC180	0·27
BC181	0·27
BC182	0·11
BC182L	0·11
BC183	0·11
BC183L	0·11
BC184	0·13
BC184L	0·13
BC186	0·31
BC187	0·31
BC207	0·12
BC208	0·12
BC209	0·13
BC212L	0·12
BC213L	0·12
BC214L	0·16
BC225	0·28
BC226	0·39
BCY30	0·27
BCY30	0·27
BCY31	0·29
BCY32	0·33
BCY33	0·24
BCY34	0·28
BCY70	0·16
BCY71	0·20
BCY72	0·16
BCZ10	0·22
BCZ11	0·28
BCX12	0·28
BD121	0·66
BD123	0·72
BD124	0·66
BD131	0·55
BD132	0·66
BD133	0·72
BD135	0·44

BD136	0·44
BD137	0·50
BD138	0·55
BD139	0·61
BD140	0·66
BD155	0·88
BD175	0·66
BD176	0·66
BD177	0·72
BD178	0·72
BD179	0·77
BD180	0·77
BD185	0·83
BD186	0·72
BD187	0·77
BD188	0·77
BD189	0·99
BD190	0·83
BD195	0·94
BD196	0·94
BD197	0·99
BD198	0·99
BD199	1·05
BD200	1·05
BD205	0·88
BD206	0·88
BD207	1·05
BD208	1·05
BDY20	1·10
BF115	0·27
BF117	0·50
BF118	0·77
BF119	0·77
BF121	0·50
BF123	0·55
BF125	0·50
BF127	0·55
BF152	0·61
BF153	0·50
BF154	0·50
BF155	0·77
BF156	0·53
BF157	0·61
BF158	0·61
BF159	0·66
BF160	0·44
BF162	0·44
BF163	0·44
BF164	0·44
BF165	0·44
BF167	0·24
BF173	0·24
BF176	0·34
BF177	0·39
BF178	0·33
BF179	0·33
BF180	0·33
BF181	0·33
BF182	0·44
BF183	0·44
BF184	0·28

BF185	0·33
BF188	0·44
BF194	0·13
BF195	0·13
BF196	0·16
BF197	0·16
BF200	0·50
BF222	1·05
BF257	0·50
BF258	0·66
BF259	0·94
BF292	0·61
BF263	0·61
BF270	0·39
BF271	0·33
BF272	0·38
BF273	0·39
BF274	0·39
BFW10	0·66
BFX29	0·30
BFX84	0·24
BFX85	0·33
BFX86	0·24
BFX87	0·27
BFX88	0·24
BFY50	0·22
BFY51	0·22
BFY52	0·22
BFY53	0·19
BPX25	0·94
BSX19	0·17
BSX20	0·17
BSY25	0·17
BSY26	0·17
BSY27	0·17
BSY28	0·17
BSY29	0·17
BSY38	0·20
BSY39	0·20
BSY40	0·31
BSY41	0·31
BSY95	0·14
BSY95A	0·14
Bu105	2·20
C111E	0·55
C400	0·33
C407	0·28
C424	0·22
C425	0·55
C426	0·39
C428	0·22
C441	0·33
C442	0·33
C444	0·39
C450	0·24
MAT00	10·21
MAT101	0·22
MAT120	0·21
MAT121	0·20
MPF102	0·46
MPF104	0·41

MPF105	0·41
OC19	0·39
OC20	0·70
OC22	0·42
OC23	0·46
OC24	0·62
OC25	0·42
OC26	0·28
OC28	0·55
OC29	0·55
OC35	0·46
OC36	0·55
OC41	0·22
OC42	0·27
OC44	0·17
OC45	0·14
OC70	0·11
OC71	0·11
OC72	0·16
OC74	0·16
OC75	0·17
OC76	0·17
OC77	0·28
OC81	0·17
OC81D	0·17
OC82	0·17
OC82D	0·17
OC83	0·22
OC84	0·22
OC139	0·22
OC140	0·22
OC169	0·28
OC170	0·28
OC171	0·28
OC200	0·28
OC201	0·31
OC202	0·31
OC203	0·28
OC204	0·28
OC205	0·39
OC309	0·44
OCP71	0·48
ORP12	0·48
ORP60	0·44
ORP61	0·44
P346A	0·22
P397	0·46
ST140	0·46
ST140	0·14
ST141	0·19
TIS43	0·33
UT46	0·30
2G301	0·21
2G302	0·21
2G303	0·21
2G304	0·27
2G306	0·44
2G308	0·39
2G309	0·39
2G339	0·22
2G339A	0·18

2G344	0·20
2G345	0·18
2G371	0·18
2G371B	0·13
2G373	0·19
2G374	0·19
2G377	0·33
2G378	0·18
2G381	0·18
2G382	0·18
2G401	0·33
2G414	0·33
2G417	0·28
2N388	0·39
2N388A	0·61
2N404	0·22
2N404A	0·31
2N524	0·46
2N527	0·54
2N598	0·46
2N599	0·50
2N696	0·14
2N697	0·15
2N698	0·27
2N699	0·39
2N706	0·09
2N706A	0·10
2N708	0·13
2N711	0·33
2N717	0·39
2N718	0·27
2N718A	0·55
2N726	0·31
2N727	0·31
2N743	0·22
2N744	0·22
2N914	0·16
2N918	0·33
2N929	0·23
2N930	0·23
2N1131	0·22
2N1132	0·24
2N1302	0·16
2N1303	0·16
2N1304	0·19
2N1305	0·19
2N1306	0·23
2N1307	0·23
2N1308	0·26
2N1309	0·26
2N1613	0·22
2N1711	0·22
2N1889	0·35
2N1890	0·50
2N1893	0·41
2N2147	0·79
2N2148	0·63
2N2160	0·66
2N2192	0·39
2N2193	0·39
2N2194	0·39

2N2217	0·24
2N2218	0·22
2N2219	0·22
2N2220	0·24
2N2221	0·22
2N2222	0·22
2N2368	0·19
2N2369	0·16
2N2369A	0·16
2N2411	0·27
2N2412	0·27
2N2646	0·52
2N2711	0·23
2N2712	0·23
2N2714	0·23
2N2904	0·19
2N2904A	0·23
2N2905	0·23
2N2905A	0·23
2N2906	0·17
2N2906A	0·20
2N2907	0·22
2N2907A	0·24
2N2923	0·16
2N2924	0·16
2N2925	0·16
2N2926(G)	0·14
2N2926(Y)	0·12
2N2926(O)	0·11
2N2926(R)	0·11
2N2926(B)	0·11
2N3010	0·77
2N3011	0·16

2N3053	0·19
2N3054	0·51
2N3055	0·55
2N3391	0·16
2N3391A	0·18
2N3392	0·16
2N3393	0·16
2N3394	0·16
2N3395	0·19
2N3402	0·23
2N3403	0·23
2N3404	0·31
2N3405	0·46
2N3414	0·17
2N3415	0·17
2N3416	0·31
2N3417	0·31
2N3525	0·83
2N3646	0·10
2N3702	0·11
2N3703	0·11
2N3704	0·12
2N3705	0·11
2N3706	0·10
2N3707	0·12
2N3708	0·08
2N3709	0·10
2N3710	0·10
2N3711	0·10
2N3819	0·31
2N3820	0·55
2N3821	0·39
2N3823	0·31
2N3903	0·31
2N3904	0·33
2N3905	0·31
2N3906	0·30
2N4058	0·13

2N4059	0·11
2N4060	0·13
2N4061	0·13
2N4062	0·13
2N4284	0·19
2N4285	0·19
2N4286	0·19
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2N4292	0·19
2N4293	0·19
2N5172	0·13
2N5457	0·35
2N5458	0·35
2N5459	0·44
28301	0·55
28302A	0·46
28302	0·46
28303	0·61
28304	0·77
28305	0·93
28306	0·93
28307	0·93
28321	0·62
28322	0·46
28322A	0·46
28323	0·62
28324	0·77
28325	0·77
28326	0·77
28327	0·77
28701	0·46
40361	0·44
40362	0·50

DIODES AND RECTIFIERS

AA119	0·09
AA120	0·09
AA129	0·09
AAY30	0·10
AAZ13	0·11
BA100	0·11
BA116	0·23
BA126	0·24
BA148	0·16
BA154	0·13
BA155	0·16
BA156	0·15
BY100	0·17
BY101	0·13
BY105	0·19
BY114	0·13
BY126	0·16
BY127	0·17
BY128	0·17
BY130	0·18

BY133	0·23
BY164	0·55
BYX38/30	0·46
BYZ10	0·39
BYZ11	0·33
BYZ12	0·33
BYZ13	0·28
BYZ16	0·44
BYZ17	0·39
BYZ18	0·39
BYZ19	0·31
CG62 (OA91 Eq.)	0o06
CG651 (OA70-OA79 Eq.)	0·07
OA5	0·39
OA5SL	0·23

OA10	0·39
OA47	0·08
OA70	0·08
OA79	0·08
OA81	0·08
OA85	0·10
OA90	0·07
OA91	0·07
OA95	0·08
OA200	0·07
OA202	0·08
SD10	0·06
SD19	0·06
1N34	0·8
1N34A	0·08
1N914	0·07
1N916	0·07
1N414B	0·07
1S021	0·11
1S951	0·07

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U 7	16 Sil. Rectifiers TOP-HAT 750mA VLTG. RANGE up to 1000	0·55
U 8	50 Sil. Planar Diodes DO-7 Glass 250mA like OA200/202	0·55
U 9	20 Mixed Voltages, 1 Watt Zener Diodes	0·55
U10	20 BAY50 charge storage Diodes DO-7 Glass	0·55
U11	25 PNP Sil. Planar Trans. TO-5 like 2N1132. 2N2904	0·55
U12	12 Silicon Rectifiers Epoxy 500mA up to 800 PIV	0·55
U13	30 PNP-NPN Sil. Transistors OC200 & 28 104	0·55
U14	150 Mixed Silicon and Germanium Diodes	0·55
U15	25 NPN Sil. Planar Trans. TO-5 like BFY51, 2N697	0·55
U16	10 3 Amp Silicon Rectifiers Stud Type up to 1000PIV	0·55
U17	30 Germanium PNP AF Transistors TO-5 like ACY 17-22	0·55
U18	8 6 Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	0·55
U19	25 Silicon NPN Transistors like BC108	0·55
U20	12 1·5 Amp Silicon Rectifiers Top Hat up to 1000 PIV	0·55
U21	30 AF. Germanium Alloy Transistors 2G300 Series & OC71	0·55
U23	30 MADT's like MHz Series PNP Transistors	0·55
U24	20 Germanium 1 Amp Rectifiers GJM Series up to 300 PIV	0·55
U25	25 300 MHz NPN Silicon Transistors 2N708, BSY27	0·55
U26	30 Fast Switching Silicon Diodes like 1N914 Micro-Min.	0·55
U27	12 NPN Germanium AF Transistors TO-1 like AC127	0·55
U29	10 1 Amp SCR's TO-5 can, up to 600 PIV CRS1/25-600	1.10
U30	15 Plastic Silicon Planar Trans. NPN 2N2926	0·55
U31	20 Silicon Planar Plastic NPN Trans. Low Noise Amp 2N3707	0·55
U32	25 Zener Diodes 400mW DO-7 case 3-18 volts mixed	0·55
U33	15 Plastic Case 1 Amp Silicon Rectifiers 1N4000 Series	0·55
U34	30 Silicon PNP Alloy Trans. TO-5 BCY26 28302/4	0·55
U35	25 Silicon Planar Transistors PNP TO-18 2N2906	0·55
U36	25 Silicon Planar NPN Transistors TO-5 BFY50/51/52	0·55
U37	30 Silicon Alloy Transistors SO-2 PNP OC200, 28322	0·55
U38	20 Fast Switching Silicon Trans. NPN MHz 2N3011	0·55
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100	0·28	0·37	0·52	0·52	0·55	0·64	0·70	1·54
200	0·39	0·41	0·54	0·54	0·63	0·67	0·83	1·76
400	0·48	0·52	0·62	0·62	0·74	0·83	1·03	1·93
600	0·59	0·63	0·75	0·75	0·85	1·07	1·38	—
800	0·70	0·77	0·88	0·88	0·99	1·32	1·65	4·40

SIL. SECTS. TESTED

50	0·04	0·06	0·06	0·08	0·16	0·23	0·66
100	0·04	0·07	0·06	0·15	0·18	0·26	0·83
200	0·06	0·10	0·07	0·16	0·22	0·27	1·10
400	0·07	0·15	0·08	0·22	0·30	0·41	1·38
600	0·08	0·18	0·11	0·26	0·38	0·50	2·05
800	0·11	0·19	0·12	0·28	0·41	0·61	2·20
1000	0·12	0·28	0·16	0·33	0·51	0·70	2·75
1200	—	0·37	—	0·42	0·63	0·83	—

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2N720	0·50
2N721	0·55
2N914	0·15
2N916	0·17
2N918	0·30
2N919	0·20
2N929	0·14
2N930	0·14
2N1090	0·23
2N1091	0·24
2N1131	0·20
2N1132	0·20
2N1302	0·16
2N1303	0·16
2N1304	0·20
2N1305	0·20
2N1306	0·22
2N1307	0·22
2N1308	0·25
2N1309	0·37
2N1483	0·90
2N1507	0·24
2N1613	0·20
2N1631	0·35
2N1637	0·30
2N1638	0·27
2N1701	1·10
2N1702	2·15
2N1711	0·17
2N1893	0·34
2N2102	0·30
2N2147	0·70
2N2148	0·60
2N2192	0·40
2N2192A	0·40
2N2193	0·40
2N2193A	0·42
2N2194	0·27
2N2194A	0·30
2N2195	0·37
2N2195A	0·18
2N2218A	0·30
2N2219	0·37
2N2219A	0·51
2N2220	0·20
2N2221	0·20
2N2221A	0·33
2N2222	0·31
2N2222A	0·41
2N2368	0·11
2N2369	0·39
2N2369A	0·17
2N2646	0·50
2N2647	1·20
2N2711	0·12
2N2712	0·12
2N2713	0·17
2N2714	0·17
2N2904	0·18
2N2904A	0·25
2N2905	0·26
2N2905A	0·23
2N2906	0·18
2N2906A	0·23
2N2907	0·18
2N2907A	0·25
2N2923	0·12
2N2924	0·12
2N2925	0·12
2N2926	
Green	0·10
Yellow	0·10
Orange	0·10
2N3053	0·31
2N3054	0·46
2N3055	0·60
2N3390	0·20
2N3391	0·20
2N3391A	0·22
2N3392	0·13
2N3393	0·12
2N3394	0·17

2N3402	0·12
2N3403	0·19
2N3404	0·24
2N3405	0·27
2N3414	0·10
2N3415	0·10
2N3416	0·15
2N3417	0·21
2N3570	1·25
2N3571	1·12
2N3572	0·97
2N3702	0·10
2N3703	0·10
2N3704	0·14
2N3705	0·10
2N3706	0·09
2N3707	0·10
2N3708	0·70
2N3709	0·09
2N3710	0·12
2N3711	0·90
2N3712	0·95
2N3713	1·08
2N3714	1·15
2N3715	1·23
2N3716	1·30
2N3773	2·35
2N3774	3·33
2N3775	4·19
2N3776	5·95
2N3777	4·84
2N3778	2·25
2N3779	3·15
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2N3781	3·67
2N3782	3·37
2N3789	1·76
2N3790	2·20
2N3791	2·06
2N3792	2·20
2N3794	0·10
2N3819	0·37
2N3820	0·47
2N3823	0·62
2N3824	0·75
2N3826	0·23
2N3854	0·16
2N3854A	0·16
2N3855	0·16
2N3855A	0·16
2N3856	0·16
2N3856A	0·16
2N3858	0·16
2N3858A	0·16
2N3859	0·16
2N3859A	0·16
2N3860	0·16
2N3866	0·70
2N3877	0·25
2N3877A	0·26
2N3878	1·22
2N3879	1·91
2N3900	0·20
2N3900A	0·21
2N3901	0·32
2N3903	0·20
2N3904	0·17
2N3905	0·21
2N3906	0·20
2N4036	0·63
2N4037	0·42
2N4058	0·16
2N4059	0·09
2N4060	0·11
2N4061	0·11
2N4062	0·11
2N4302	0·25
2N4303	0·32
2N4913	0·80
2N4914	0·87
2N4915	0·95
2N4916	0·20
2N4917	0·17
2N4918	0·50
2N4919	0·53
2N4920	0·60
2N4921	0·50
2N4922	0·55
2N4923	0·60
2N4926	0·90
2N4927	1·00
2N4928	1·80
2N4929	2·23
2N4930	2·25
2N4931	2·70
2N5172	0·08
2N5174	0·22
2N5175	0·26
2N5176	0·32
2N5190	0·92
2N5191	0·96
2N5192	1·24
2N5193	1·01
2N5194	1·10
2N5195	1·46
2N5245	0·43
2N5457	0·35
2N5458	0·33

2N5459	0·33
3N128	0·63
3N138	1·65
3N140	0·92
3N141	0·81
3N142	0·58
3N143	0·75
3N152	0·92
3N153	0·81
3N154	0·84
3N159	1·17
3N187	1·30
3N199	1·30
3N200	2·49
3N201	1·05
40050	0·78
40251	0·81
40309	0·33
40310	0·50
40313	0·92
40316	0·50
40318	0·92
40322	0·92
40360	0·46
40361	0·48
40362	0·50
40363	0·88
40389	0·46
40394	0·56
40395	0·50
40406	0·44
40407	0·33
40408	0·50
40409	0·52
40410	0·53
40411	2·25
40414	3·55
40438	1·44
40467	0·69
40468A	0·44
40600	0·69
40601	0·67
40602	0·46
40603	0·58
40604	0·56
40636	1·10
40673	0·70
AC107	0·35
AC113	0·16
AC115	0·16
AC117	0·20
AC121	0·13
AC126	0·25
AC127	0·25
AC128	0·25
AC141K	0·30
AC142K	0·25
AC151V	0·14
AC152V	0·17
AC153	0·22
AC153K	0·25
AC154	0·20
AC176	0·18
AC176K	0·20
AC187K	0·20
AC188K	0·26
ACY17	0·25
ACY18	0·15
ACY19	0·20
ACY20	0·20
ACY21	0·18
ACY22	0·13
ACY28	0·18
ACY30	0·42
ACY39	0·55
ACY40	0·17
ACY41	0·17
ACY44	0·31
AD136V	0·96
AD140	0·50
AD142	0·54
AD143	0·45
AD149V	0·66
AD150	0·63
AD161	0·37
AD162	0·37
AD161 }	Pr.
AD162 }	0·69
ADZ11	1·50
ADZ12	1·75
AF106	0·27
AF109R	0·40
AF114	0·25
AF115	0·24
AF116	0·25
AF117	0·20
AF118	0·50
AF121	0·22
AF124	0·24
AF125	0·20
AF126	0·19
AF127	0·20
AF139	0·38
AF170	0·25
AF172	0·25
AF178	0·55
AF179	0·65
AF180	0·50
AF186	0·40
AF200	0·35

AF211	0·55
AF239	0·41
AF240	0·72
AF279	0·54
AF280	0·54
AFY42	0·74
AL102	0·75
AL103	0·70
ASY26	0·30
ASY27	0·36
ASY28	0·28
ASY29	0·30
ASY50	0·20
ASY55	0·35
ASZ21	0·55
AU103	1·25
BC107	0·14
BC108	0·13
BC109	0·14
BC113	0·13
BC114	0·12
BC115	0·15
BC116	0·15
BC116A	0·18
BC117	0·21
BC118	0·11
BC119	0·27
BC121	0·23
BC123	0·29
BC125	0·15
BC126	0·20
BC132	0·50
BC134	0·11
BC135	0·11
BC136	0·15
BC137	0·15
BC138	0·20
BC140	0·34
BC141	0·39
BC142	0·24
BC143	0·21
BC144	0·24
BC145	0·21
BC147	0·11
BC148	0·10
BC149	0·13
BC153	0·18
BC154	0·18
BC157	0·14
BC158	0·13
BC159	0·14
BC160	0·37
BC167B	0·11
BC168B	0·13
BC168C	0·13
BC169B	0·13
BC169C	0·13
BC170	0·11
BC171	0·13
BC172	0·11
BC182	0·10
BC182L	0·12
BC183	0·09
BC183L	0·09
BC184	0·11
BC184L	0·11
BC186	0·25
BC187	0·25
BC204	0·11
BC205	0·11
BC206	0·11
BC207	0·10
BC208	0·09
BC209	0·10
BC211	0·30
BC212K	0·10
BC212L	0·16
BC214L	0·23
BC236	0·16
BC237	0·09
BC238	0·09
BC239	0·09
BC251	0·20
BC252	0·18
BC253	0·23
BC257	0·09
BC258	0·09
BC259	0·13
BC261	0·20
BC262	0·18
BC263	0·23
BC300	0·42
BC301	0·34
BC302	0·27
BC303	0·54
BC304	0·43
BC307	0·10
BC307A	0·10
BC307VI	0·10
BC308	0·09
BC308A	0·09
BC308B	0·09
BC309	0·10
BC309A	0·10
BC309B	0·10
BC313	0·30
BC327	0·24
BC328	0·22
BC337	0·19
BC338	0·19

BCY30	0·35
BCY31	0·40
BCY32	0·60
BCY33	0·34
BCY34	0·35
BCY38	0·40
BCY39	1·05
BCY40	0·50
BCY42	0·15
BCY43	0·15
BCY58	0·21
BCY59	0·22
BCY66	0·66
BCY67	0·94
BCY70	0·17
BCY71	0·22
BCY72	0·13
BCY87	3·47
BCY88	2·40
BCY89	0·80
BCZ10	0·35
BCZ11	0·50
BD115	0·75
BD116	0·75
BD121	0·75
BD123	0·82
BD124	0·67
BD130	0·57
BD131	0·40
BD132	0·50
BD135	0·43
BD136	0·49
BD137	0·55
BD138	0·63
BD139	0·71
BD140	0·83
BDY10	1·25
BDY11	1·50
BDY17	1·50
BDY18	1·75
BDY19	1·97
BDY20	0·92
BDY38	0·65
BDY60	0·90
BDY61	0·85
BDY62	0·75
BF115	0·23
BF117	0·43
BF119	0·58
BF121	0·25
BF123	0·27
BF125	0·25
BF127	0·27
BF152	0·20
BF153	0·29
BF154	0·16
BF158	0·15
BF159	0·27
BF160	0·23
BF161	0·35
BF163	0·20
BF166	0·35
BF167	0·18
BF173	0·19
BF177	0·25
BF178	0·25
BF179	0·30
BF180	0·35
BF181	0·32
BF182	0·30
BF183	0·40
BF184	0·17
BF185	0·17
BF194	0·14
BF195	0·15
BF196	0·15
BF197	0·15
BF198	0·15
BF199	0·18
BF200	0·35
BF224J	0·14
BF225J	0·19
BF237	0·22
BF238	0·22
BF244	0·16
BF245	0·33
BF246	0·43
BF247	0·49
BF254	0·14
BF255	0·15
BF257	0·41
BF258	0·46
BF259	0·48
BF261	0·23
BF264	1·45
BF270	0·25
BF271	0·21
BF272	0·53
BF273	0·25
BF274	0·28
BF457	0·53
BF458	0·65
BF459	0·57
BFS21	2·10
BFS21A	2·30
BFS28	0·92
BFS61	0·27
BFS98	0·28
BFW10	0·61
BFW11	0·61

BFW15	0·35
BFX13	0·23
BFX29	0·25
BFX30	0·25
BFX37	0·30
BFX44	0·33
BFX63	2·48
BFX68	0·30
BFX84	0·24
BFX85	0·29
BFX86	0·24
BFX87	0·25
BFX88	0·20
BFX89	0·45
BFY10	0·35
BFY11	0·45
BFY17	0·90
BFY18	0·25
BFY19	0·25
BFY20	0·50
BFY29	0·40
BFY37	0·20
BFY41	0·43
BFY43	0·62
BFY50	0·16
BFY51	0·18
BFY52	0·16
BFY53	0·15
BFY56	0·34
BFY64	0·41
BFY75	0·40
BFY76	0·22
BFY77	0·24
BFY78	0·36
BFY90	0·60
BRY39	0·30
BSX19	0·13
BSX20	0·14
BSX21	0·20
BSX26	0·34
BSX27	0·34
BSX28	0·25
BSX29	0·47
BSX30	0·68
BSX59	0·78
BSX60	0·54
BSX61	0·42
BSX76	0·15
BSX77	0·20
BSX78	0·25
BSW70	0·28
BSY24	0·20
BSY25	0·15
BSY26	0·20
BSY27	0·15
BSY28	0·15
BSY38	0·15
BSY39	0·15
BSY51	0·25
BSY52	0·25
BSY53	0·25
BSY54	0·30
BSY56	0·79
BSY65	0·15
BSY78	0·40
BSY79	0·40
BSY790	0·45
BSY95A	0·09
BU104	1·42
BU105	2·25
CIII	0·53
D40N3	0·62
GET111	0·45
GET113	0·20
GET114	0·20
GET115	0·50
GET119	0·35
GET120	0·25
GET535	0·20
GET536	0·20
GET538	0·20
GET873	0·12
GET880	0·30
GET883	0·20
GET887	0·20
GET890	0·22
GET895	0·25
TIP29A	0·49
TIP30A	0·53
TIP31A	0·62
TIP32A	0·74
TIP33A	1·01
TIP34A	1·51
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SN 74122	£1·35	SN 74161	£2·60	SN 74192	£1·90
SN 74123	£1·35	SN 74164	£2·26	SN 74193	£1·90
SN 74141	£0·90	SN 74165	£4·00	SN 74196	£1·60
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SN 74151	£1·10	SN 74175	£1·35		

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PIV	50	100	200	400	600	800	1000	1200
1A	8p	9p	10p	11p	12p	15p	20p	—
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10A	30p	35p	40p	47p	58p	66p	75p	—
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IN916	7p	AAZ13	12p	BAY31	7p	OA10	20p
IN4007	20p	AAZ15	12p	BAY38	25p	OA9	10p
IS44	7p	AAZ17	10p	BY100	15p	OA47	8p
IS113	15p	BA100	15p	BY103	22p	OA70	7p
IS120	12p	BA102	25p	BY122	47½p	OA73	10p
IS121	14p	BA110	25p	BY124	15p	OA79	7p
IS130	8p	BA114	15p	BY126	15p	OA81	8p
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IS132	12p	BA141	17p	BY164	57p	OA90	7p
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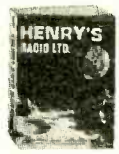

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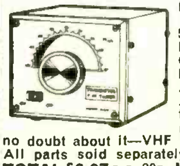

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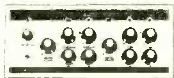

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SN7405	20p	18p	16p	SN7472	30p	27p	25p	SN74155	£1·55	£1·47	£1·35
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SC35B	200	79p
SC35D	400	85p
6 AMP RANGE (TO48)		
SC40A	100	85p
SC40B	200	90p
SC40D	400	£1·00
SC40E	500	£1·20
10 AMP RANGE (TO48)		
SC45A	100	95p
SC45B	200	£1·00
SC45D	400	£1·25
SC45E	500	£1·45
15 AMP RANGE (TO48)		
SC50A	100	£1·25
SC50B	200	£1·35
SC50D	400	£1·65
SC50E	500	£1·85
DIAC D32		25p
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40430	(TO66)	85p
40669	(Plastic)	£1·00
40486	(TO5)	80p

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BO5/05	50	20p
BO5/10	100	25p
ONE AMP ½×½H TUBULAR		
B1/05	50	25p
B1/10	100	25p
B1/20	200	30p
B1/60	600	35p
ONE AMP (G.I.) TUBULAR		
W005	50	30p
W01	100	35p
W02	200	40p
W06	600	45p
TWO AMPS ⅜H×⅜L×⅛		
B2/05	50	35p
B2/100	100	40p
B2/200	200	45p
B2/600	600	50p
B2/1000	1000	60p
FOUR AMPS ⅜H×⅜L×⅛		
B4/100	100	60p
B4/200	200	65p
B4/400	400	70p
B4/600	600	75p
B4/800	800	£1·00
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B6/100	100	70p
B6/200	200	75p
B6/400	400	90p
B6/600	600	£1·00

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CRS 1/05	50	25p
CRS 1/10	100	30p
CRS 1/20	200	30p
CRS 1/40	400	35p
CRS 1/60	600	45p
THREE AMP (TO48)		
CRS 3/05	50	30p
CRS 3/10	100	30p
CRS 3/20	200	35p
CRS 3/40	400	45p
CRS 3/60	600	55p
FIVE AMP (TO66)		
CRS 5/400	400	60p
SEVEN AMP (TO48)		
CRS 7/100	100	60p
CRS 7/200	200	65p
CRS 7/400	400	70p
CRS 7/600	600	95p
SIXTEEN AMP		
SCR 16/100	100	65p
SCR 16/200	200	70p
SCR 16/400	400	80p
SCR 16/600	600	£1·00

SILICON RECTIFIERS

WIRE ENDED PLASTIC

Type	P.I.V.	1-11
1 amp miniature		
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IN4002	100	7p
IN4003	200	8p
IN4004	400	8p
IN4005	600	10p
IN4006	800	12p
IN4007	1000	15p
1.5 amp miniature		
PL4001	50	8p
PL4002	100	9p
PL4003	200	10p
PL4004	400	10p
PL4005	600	12p
PL4006	800	15p
PL4007	1000	16p

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0·01mfd	10kV	50p ea.
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H8/2	2·2µf	25v	4p	H7/6	100µf	25v	5p
H8/2A	3·3µf	25v	4p	H7/6A	100µf	15v	4p
H8/3	3µf	50v	4p	H7/7	100µf	25v	4p
H8/3A	4µf	50v	4p	H7/8	125µf	16v	5p
H8/4	4·7µf	25v	4p	H7/8A	100µf	35v	6p
H8/4A	5µf	64v	4p	H7/9	100µf	63v	6p
H8/5	5µf	10v	4p	H7/9A	125µf	4v	4p
H8/5A	5µf	150v	4p	H7/10	125µf	25v	6p
H8/6A	10µf	10v	4p	H7/10A	160µf	2·5v	3p
H8/7	10µf	70v	4p	H7/11	160µf	25v	6p
H8/8	16µf	35v	4p	H7/11A	150µf	16v	5p
H8/8A	16µf	16v	4p	H7/13A	200µf	25v	8p
H8/9	20µf	6v	2p	H7/14	220µf	50v	10p
H8/9A	20µf	70v	4p	H7/14A	220µf	16v	6p
H8/10	22µf	50v	4p	H7/15	220µf	25v	5p
H8/10A	22µf	100v	4p	H7/15A	220µf	35v	10p
H8/11	25µf	12v	4p	H6/1A	250µf	4v	3p
H8/11A	24µf	275v	4p	H6/2	250µf	25v	3p
H8/12	32µf	15v	4p	H6/3A	320µf	2·5v	3p
H8/12A	30µf	10v	4p	H6/4	320µf	10v	4p
H8/13A	32µf	50v	4p	H6/4A	330µf	16v	5p
H8/14	40µf	25v	5p	H6/5	330µf	25v	10p
H8/14A	40µf	16v	4p	H6/5A	330µf	35v	15p
H8/15	47µf	50v	4p	H6/7	400µf	15v	5p
H8/15A	40µf	35v	4p	H6/8	470µf	25v	10p
H7/1	50µf	6v	3p	H6/8A	470µf	35v	20p
H7/1A	50µf	10v	4p	H6/9	500µf	15v	4p
H7/2	50µf	50v	4p	H6/9A	400µf	40v	20p
H7/2A	64µf	2·5v	2p	H6/10	750µf	12v	5p
H7/3A	64µf	25v	4p	H6/13A	1000µf	25v	16p
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Type No.	Working Voltage Vdc.	Capacitance µF	Max. Ripple Current at 50°C	Weight	Price
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071 15103	16	10000	7·9 amps	2½oz	27p
071 18222	63	2200	5·8 amps	3oz	30p
072 15752	16	7500 + 7500	10·5 amps	3oz	37p
072 15113	16	11000 + 11000	13·8 amps	4½oz	49p
071 16222	25	2200	2·2 amps	1oz	15p
071 16472	25	4700	5·4 amps	1½oz	22p
072 16502	25	5000 + 5000	9·6 amps	3½oz	37p
072 16752	25	7500 + 7500	12·6 amps	4½oz	49p
072 17342	40	3400 + 3400	9·1 amps	3½oz	37p
072 17502	40	5000 + 5000	12·0 amps	4½oz	49p
071 18681	63	680	2·1 amps	1oz	15p
072 18172	63	1650 + 1650	7·8 amps	3oz	37p

106 and 107 Series

106 15103	16	10000	7 amps	2½oz	65p
106 16223	25	22000	17 amps	10oz	£1·12
106 17103	40	10000	12 amps	7½oz	94p
106 18153	63	15000	28 amps	18oz	£1·79
107 10222	100	2200	10 amps	5½oz	74p

Type No.	Voltage	Capacitance	Weight	Price
102 15163	16	16000	8oz	20p
104 90003	20	39000	16oz	30p
102 16802	25	8000	7oz	25p
104 17562	40	5600	5oz	25p
104 90001	45	20000	16oz	50p
104 18332	63	3300	5oz	25p

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- 7495 .. 68p
- 5400 .. 10p
- 6404 .. 10p

RECORDING TAPE BARGAIN! The very best British Made low-noise high-quality Tape! 5in Standard **38p.** Long-play **45p.** 5¾in Standard **45p.** Long-play **60p.** 7in Standard **60p.** Long-play **82p.** We are getting a fantastic number of repeat orders for this tape. Might we suggest that you order now whilst we still have a good stock at these low prices?

TRANSISTORISED FLUORESCENT LIGHTS, 12 volt. All with reversed polarity protection. 8 watt type with reflector suitable for tents, etc. **£3.** Postage/Packing 25p. 15 watt type, batten fitting for caravans **£4.** Postage/Packing 25p. 13 watt type, batten with switch. 22in × 2in × 1in **£5.** Postage/Packing 25p. THESE CAN BE SENT ON APPROVAL AGAINST FULL PAYMENT.

NEW! NEW! NEW! NEW!

An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.

Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

- Light sensitive aerosol spray .. **£1·00** plus
- Developer and Etchant .. **50p** postage

NEWER THAN NEW!!!

Fibre Glass Board pre-treated with light-sensitive lacquer enabling you to produce prototype printed circuits within five minutes.
- 75mm × 100mm .. 33p
- 150mm × 100mm .. 66p
- 150mm × 200mm .. £1·32
- 250mm × 200mm .. £2·20

Epoxy-Resin
- 75mm × 100mm .. 22p
- 100mm × 150mm .. 44p
- 150mm × 200mm .. 88p

VEROBOARD

- 2½in × 1in × 0·15in .. 6p
- 3¾in × 2½in × 0·15in .. 16p
- 3¾in × 3¾in × 0·15in .. 25p
- 5in × 2½in × 0·15in .. 25p
- 5in × 3¾in × 0·15in .. 30p
- 17in × 2½in × 0·15in .. 55p
- 17in × 3¾in × 0·15in .. 79p
- 3¾in × 2½in × 0·1in .. 21p
- 3¾in × 3¾in × 0·1in .. 25p
- 5in × 2½in × 0·1in .. 25p
- 5in × 3¾in × 0·1in .. 29p

Spot Face Cutter **38p.** Pin Insert Tool **57p.** Terminal Pins (0·1 or 0·15) 36 for **22p.**

MULLARD POLYESTER CAPACITORS

500,000 in STOCK!!!

·001µf	·0018µf	·0056µf	·015µf
·0012µf	·0022µf	·01µf	·033µf
·0015µf	·0027µf	·012µf	·082µf

20p dozen; 75p-100; £5-1,000; £40-10,000

·15µf ·18µf ·22µf ·39µf ·68µf

20p dozen; £1-100; £6·50-1,000; £50-10,000

ERIE MONOLITHIC CERAMIC CAPACITORS

3p each; **24p** dozen; **£1·75** per 100

10pf	68pf	560pf
15pf	100pf	620pf
22pf	150pf	680pf
33pf	220pf	1,000pf
39pf	330pf	
47pf	470pf	

RECTIFIERS 1N4007 1200 peak volts, 30 amps peak current, 1 amp mean current. 100 for £7·50, 1,000 £50.

£1 100 ¼-½ WATT RESISTORS, 100 CERAMIC CAPACITORS, 100 DIODES — PACK No. 1

£1 1 VERO-BOARD CUTTER, 5 2½ in. x 1 in. x ·15 BOARDS, 50 SQ. INS. "ODD PIECES" VERO — PACK No. 3

£1 20 ASSORTED UNUSED MARKED, TESTED TRANSISTORS BC108 ETC. — PACK No. 5

£1 6 COMPUTER PANELS CONTAINING MASSES OF DIODES, TRANSISTORS, INDUCTORS, RESISTORS & CAPACITORS — PACK No. 7

£1 100 RESISTORS, 100 CERAMIC CAPACITORS, 100 POLYSTYRENE CAPACITORS — PACK No. 2

£1 100 RESISTORS, 100 CERAMIC CAPACITORS, 50 MULLARD POLYESTER CAPACITORS — PACK No. 4

£1 1 TRANSISTORISED SIGNAL TRACER KIT, 1 TRANSISTORISED SIGNAL INJECTOR KIT — PACK No. 6

£1 100 RESISTORS, 100 CAPACITORS (ASSORTED TYPES) — PACK No. 8

REMEMBER! ALL GOODS PLUS 10% V.A.T.

G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 15p.

COMPONENTS FOR W.W. AMPLIFIER DESIGNS

100W AMPLIFIER (FEB. 1972)
Designer approved kit.
Semiconductor set .. .. 15·60
Resistors capacitors, pots .. .. 2·50
F/Glass PCB .. .. 1·30

POWER SUPPLY (For 100W Amp.)
Designer approved kit.
Semiconductors, Resistors, capacitors, pots, transformers, F/Glass PCB .. .. 14·70

30W BLOMLEY (New approach to class B)
Semiconductor set .. .. 5·60
Resistors, capacitors, pots .. .. 1·85
F/Glass PCB .. .. 0·70

30W BAILEY (Single power rail)
Transistor set .. .. 4·60
Resistors, capacitors, pots .. .. 1·45
F/Glass PCB .. .. 0·65

LINSLEY-HOOD CLASS A (Dec., 1970, circuit)
Designer approved kit.
2N3055 pair, BC212L, 2N1711 .. .. 1·20
Resistors, capacitors, pot .. .. 1·80
F/Glass PCB .. .. 0·60

LINSLEY-HOOD 20W CLASS AB
Designer approved kit.
MJ481/491, MJE521, BC182L, BC212L, zener .. .. 3·35
Resistors, capacitors, pots .. .. 2·20
F/Glass PCB .. .. 0·70
Please state 8Ω or 15Ω

REGULATED 60V POWER SUPPLY
A 5 transistor series stabiliser, suitable for a pair of Bailey or Blomley amplifiers, featuring very effective S/C protection. All Semi/C's, R's, C's, F/Glass PCB .. 4·85
Power supplies for other amplifiers also available

BAILEY/BURROWS PRE-AMP (Aug., 1971)
Component Set: Mono .. .. 2·75
Component set: Stereo .. .. 6·35
Each component set comprises of all specified resistors, capacitors, transistors pots, including special balance control for stereo sets.
Stereo F/Glass PCB .. .. 1·60

STUART TAPE RECORDER
Set of stereo f/glass PCBs .. .. 2·70
Components sets on price list.

'TEXAN' TEXAS INSTRUMENTS DESIGNED & APPROVED FULL KIT

£28·50 INCLUDES TEAK CASE

20 Watt per channel stereo amplifier designed by Richard Mann of Texas Instruments and published in Practical Wireless May-July 1972.
This low distortion (0.09% at 20W into 8 ohm), wide bandwidth (—3dB 5Hz-35KHz) design is offered as a Texas Instruments approved full kit (including all metalwork and Teak case for a total of £28.50 post paid. Full details in price list.

METALWORK SYSTEM
Designed to house Bailey, Blomley or Linsley Hood Class AB amplifiers with simple or regulated power supplies and Bailey Burrows pre-amp. Options of standard or hum reducing toroidal mains transformer.

TOROIDAL TRANSFORMER 60 volt 2 amp.
Max. height 2in. Suitable for our regulated power supply £7.40
Simple clamp £0.20
Magnetically screening clamp.......................... £0.75

SEMICONDUCTORS

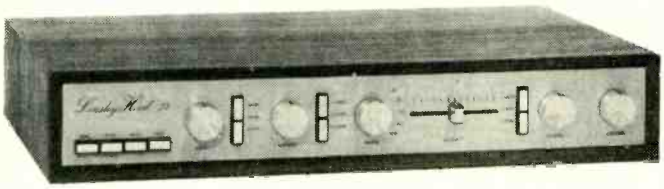
2N699	0·25	BC184L	0·11
2N1613	0·20	BC212L	0·12
2N1711	0·25	BC214L	0·14
2N2926G	0·10	BCY72	0.13
2N3053	0·15	BF257	0·40
2N3055	0·45	BF259	0·47
2N3442	1·20	BFR39	0.25
2N3702	0.11	BFR79	0.25
2N3703	0.10	BFY50	0·20
2N3704	0.10	BFY51	0.20
2N3705	0.10	BFY52	0.20
2N3706	0.09	MJ481	1·20
2N3707	0.10	MJ491	1·30
2N3708	0.07	MJE521	0·60
2N3709	0.09	MPSA05	0·30
2N3710	0.09	MPSA12	0·55
2N3711	0.09	MPSA14	0·35
2N3819	0·23	MPSA55	0·35
2N3904	0·17	MPSA65	0·35
2N3906	0·20	MPSA66	0·40
2N4058	0·12	MPSU05	0·60
2N4062	0·11	MPSU55	0·70
2N4302	0·60	SN72741P	0·58
2N5087	0.42	SN72748P	0·58
2N5210	0.54	THB11	1·10
2N5457	0·30	TIP29A	0·50
2N5830	0·30	TIP30A	0·60
40361	0·40	TIP31A	0·60
40362	0·45	TIP32A	0·70
BC107	0·08	TIP33A	1·00
BC108	0·08	TIP34A	1·50
BC109	0·08	TIP41A	0·74
BC125	0·15	TIP42A	0·90
BC126	0·15	TIP3055	0·60
BC182K	0·10	1B08T20	0·50
BC212K	0·12	1B40K20	1·40
BC182L	0·10	1N914	0·07
		1N916	0·07
		1S44	0·05
		1S920	0·10
		1S3062	0·25
		5B05	1·20

HI-FI NEWS 75 WATT AMPLIFIER

BY J. L. LINSLEY-HOOD

Published Nov. 1972 to Feb. 1973

DESIGNER APPROVED KIT



SLIMLINE STYLE CHASSIS DIMENSIONS: 17.0in. x 2.0in. x 12.0in.
This slimline unit has been made practical by the use of a specially designed TOROIDAL TRANSFORMER and highly compact printed circuit boards which have been fully tested and approved by Mr. Linsley-Hood.

- ★ **75 WATTS PER CHANNEL**
- ★ **BANDWIDTH (3dB) 3HZ-40KHZ**
- ★ **DISTORTION LESS THAN 0.01%**
- ★ **UNCONDITIONAL STABILITY**

COMPONENT PACKS

Pack		
1	Fibre glass printed circuit board for power amp.	£0.75
2	Set of resistors, capacitors, pre-sets for power amp. ..	£1.50
3	Set of semi-conductors for power amp. (highest voltage version)	£5.50
4	Pair of 2 drilled, finned heat sinks	£0.80
5	Fibre glass printed circuit board for pre-amp...........	£1.10
6	Set of low noise resistors, capacitors, pre-sets for pre-amp	£2.70
7	Set of low noise, high gain semi-conductors for pre-amp	£2.10
8	Set of potentiometers (including mains switch)	£1.55
9	Set of 4 push button switches, rotary mode switch	£3.10
10	Toroidal transformer complete with magnetic screen/housing primary: 0-117-234 V. secondaries: 33-0-33 V. 24-0-24 V., electrostatic screen	£9.15
11	Fibre glass printed circuit board for power supply	£0.55
12	Set of resistors, capacitors, secondary fuses, semi-conductors for power supply	£3.50
13	Set of miscellaneous parts including DIN skts., mains input skt. fuse holder, interconnecting cable, control knobs	£3.25
14	Set of metal workparts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£6.30
15	Handbook, based on Hi-Fi News articles	£0.30
16	Teak cabinet	£7.35

2 each of packs 1-7 inclusive are required for complete stereo system.

FREE
TEAK CASE
WITH 75 WATT PER CHANNEL COMPLETE AMPLIFIER KITS

Total cost of individually purchased packs:
£63.95

Cost of complete kit:
£56.60

TRADE ENQUIRIES WELCOME

P.S. Full circuit description in handbook **30p**

FOR FURTHER DETAILS PLEASE WRITE TO:

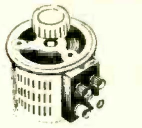
POWERTRAN ELECTRONICS
PORTWAY INDUSTRIAL ESTATE, ANDOVER : HANTS

MAIL ORDER ONLY POST FREE TO U.K. OVERSEAS AT COST
U.K. Orders Subject to 10% V.A.T. Surcharge

Basic Component Set
Set of semi-conductors, resistors, capacitors, printed circuit boards for stereo power amp, pre-amp. and power supply.
£31.35
Handbook Included

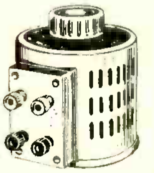
"YAMABISHI" VARIABLE VOLTAGE TRANSFORMERS

Excellent quality at low cost. All models—Input 230v. 50/60 c/s. Variable output 0-260v.



MODEL S-260 GENERAL PURPOSE BENCH MOUNTING

1 Amp	£7·00
2·5 Amp	£8·05
5 Amp	£11·75
8 Amp	£15·90
10 Amp	£22·50
12 Amp	£23·60
20 Amp	£49·00
25 Amp	£58·00
40 Amp	£82·50



MODEL S-260B

Panel Mounting.

1 Amp	£7·00
2·5 Amp	£8·05

Carriage and Packing Extra

AUTO TRANSFORMERS

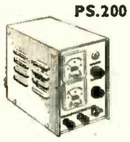
0/115/230V. Step up or step down. Fully shrouded.

80 W	£2·10	P. & P. 18p
150 W	£2·70	P. & P. 18p
300 W	£3·60	P. & P. 23p
500 W	£5·25	P. & P. 33p
1000 W	£7·50	P. & P. 38p
1500 W	£10·20	P. & P. 43p
2250 W	£17·25	P. & P. 50p
5000 W	£35·00	P. & P. £1

MCA. 220 AUTOMATIC VOLTAGE STABILISER

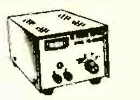
Input 88-125 VAC or 176-250VAC. Output 120VAC or 240VAC. 200VA rating. **£11.97.** Carr. 50p.

PS.200 REGULATED P.S.U.



Solid state. Variable output 5-20 volt D.C. up to 2 amp. Independent meters to monitor voltage and current. Output 220/240 V. A.C. Size 7¼" × 5¾" × 3¼". **£19·95.** Post 25p.

PS.1000B REGULATED P.S.U.

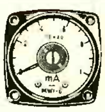


Solid state. Output 6-9 or 12 V. D.C. up to 3 amps. Meter to monitor current. Input 220/240 V. A.C. Size 4" × 3¼" × 6¼". **£11·97.** Post 25p.

230 VOLT A.C. 50 c/s RELAYS

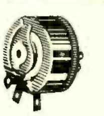
Brand new. 3 sets of changeover contacts at 5 amp rating. 50p each. Post 10p (100 lots £40). Quantities available.

240° WIDE ANGLE 1mA METERS



MW1·6 60mm. square £3·97
MW1·8 80mm. square £4·97
Post extra.

POWER RHEOSTATS



High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ⅜in. dia. shafts. Bulk quantities available.

25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. **90p.** P. & P. 10p.
50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. **£1·15.** P. & P. 10p.
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. **£1·65.** P. & P. 15p.

SEW CLEAR PLASTIC PANEL METERS

USED EXTENSIVELY BY INDUSTRY, GOVT. DEPTS., EDUCATIONAL AUTHORITIES, etc.

Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

TYPE SW.100 100 × 80mm

50µA	£3·80	100µA	£3·80
50–0–50µA	£3·80	100–0–100µA	£3·70
		500µA	£3·50
		1mA	£3·40
		20V. D.C.	£3·40
		50V. D.C.	£3·40
		300V. D.C.	£3·40
		1 amp. D.C.	£3·40
		5 amp. D.C.	£3·40
		300V. A.C.	£3·40
		VU Meter	£4·15

TYPE SD.830 82·5mm × 110mm Fronts

50µA	£2·75	10mA	£2·50
50–0–50µA	£2·70	50mA	£2·50
100µA	£2·70	100mA	£2·50
100–0–100µA	£2·70	500mA	£2·50
200µA	£2·70	1 amp	£2·50
500µA	£2·55	5 amp	£2·50
1mA	£2·50	10 amp.	£2·50
5mA	£2·50	5V. D.C.	£2·50
		10V. D.C.	£2·50
		20V. D.C.	£2·50
		50V. D.C.	£2·50
		300V. D.C.	£2·50
		15V. A.C.	£2·75
		300V. A.C.	£2·75
		VU Meter	£3·00

TYPE SD.640 63·5mm × 85mm Fronts

50µA	£2·60	500mA	£2·35
50–0–50µA	£2·55	1 amp.	£2·35
100µA	£2·55	5 amp.	£2·35
100–0–100µA	£2·55	10 amp.	£2·35
200uA	£2·55	5V. D.C.	£2·35
500µA	£2·35	20V. D.C.	£2·35
1mA	£2·35	50V. D.C.	£2·35
5mA	£2·35	300V. D.C.	£2·35
10mA	£2·35	15V. A.C.	£2·40
50mA	£2·35	300V. A.C.	£2·40
100mA	£2·35	VU Meter	£2·70

TYPE SD.460 46mm × 59.5mm Fronts

50µA	£2·40	500mA	£2·15
50–0–50µA	£2·35	1 amp.	£2·15
100µA	£2·35	5 amp.	£2·15
100–0–100µA	£2·35	10 amp.	£2·15
200µA	£2·35	5V. D.C.	£2·15
500µA	£2·20	10V. D.C.	£2·15
1mA	£2·15	20V. D.C.	£2·15
5mA	£2·15	50V. D.C.	£2·15
10mA	£2·15	300V. D.C.	£2·15
50mA	£2·15	15V. A.C.	[illegible] 30
100mA	£2·15	300V. A.C.	£2·30
		VU Meter	£2·55

"SEW" EDGWISE METERS
TYPE P.E.70

3 17/32in. × 1 15/32in. × 2⅞ in. deep.

50µA	£3·40	500µA	£3·05
50-0-50µA	£3·30	1mA	£2·70
100µA	£3·30	300V. A.C.	£2·70
100-0-100µA	£3·20	VU Meter	£3·75
200µA	£3·20		

✻ MOVING IRON—
ALL OTHERS MOVING COIL

Please add postage

TYPE MR.85P 4¼in. × 4¾in. fronts.

50µA	£3·95	10mA	£3·10
50-0-50µA	£3·40	50mA	£3·10
100µA	£3·40	100mA	£3·10
100-0-100µA	£3·30	500mA	£3·10
200µA	£3·30	1 amp.	£3·10
500µA	£3·20	5 amp.	£3·10
5000-500µA	£3·10	15 amp.	£3·10
1mA	£3·10	30 amp.	£3·20
1-0-1mA	£3·10	20V. D.C.	£3·10
5mA	£3·10	50V. D.C.	£3·10
		150V. D.C.	£3·10
		300V. D.C.	£3·10
		15V. A.C.	£3·10
		300V. A.C.	£3·10
		S Meter 1mA	£3·15
		VU Meter	£3·95
		1 amp. A.C.*	£3·10
		5 amp. A.C.*	£3·10
		10 amp. A.C.*	£3·10
		20 amp. A.C.*	£3·10
		30 amp. A.C.*	£3·10

TYPE MR.52P 2⅜in. square fronts.

50µA	£3·40	10V. D.C.	£2·20
50-0-50µA	£2·85	20V. D.C.	£2·20
100µA	£2·85	50V. D.C.	£2·20
100-0-100µA	£2·75	300V. D.C.	£2·20
500µA	£2·55	15V. A.C.	£2·30
1mA	£2·20	300V. A.C.	£2·30
5mA	£2·20	S Meter 1mA	£2·30
10mA	£2·20	VU Meter	£3·50
50mA	£2·20	1 amp. A.C.*	£2·20
100mA	£2·20	5 amp. A.C.*	£2·20
500mA	£2·20	10 amp. A.C.*	£2·20
1 amp.	£2·20	20 amp. A.C.*	£2·20
5 amp.	£2·20	30 amp. A.C.*	£2·20

TYPE MR.65P 3½in. × 3¼in. fronts

50µA	£3·70	10V. D.C.	£2·40
50-0-50µA	£3·00	20V. D.C.	£2·40
100µA	£3·00	50V. D.C.	£2·40
100-0-100µA	£2·90	150V. D.C.	£2·40
200µA	£2·90	300V. D.C.	£2·40
500µA	£2·65	15V. A.C.	£2·55
500-0-500µA	£2·40	50V. A.C.	£2·55
1mA	£2·40	150V. A.C.	£2·55
5mA	£2·40	300V. A.C.	£2·55
10mA	£2·40	500V. A.C.	£2·55
50mA	£2·40	S Meter 1mA	£2·60
100mA	£2·40	VU Meter	£3·70
500mA	£2·40	50mA A.C.*	£2·40
1 amp.	£2·40	100mA A.C.*	£2·40
5 amp.	£2·40	200mA A.C.*	£2·40
10 amp	£2·40	500mA A.C.*	£2·40
15 amp.	£2·40	1 amp. A.C.*	£2·40
20 amp.	£2·40	5 amp. A.C.*	£2·40
30 amp.	£2·55	10 amp. A.C.*	£2·40
50 amp.	£2·75	20 amp. A.C.*	£2·40
5V. D.C.	£2·40	30 amp. A.C.*	£2·40

"SEW" EDUCATIONAL METERS
TYPE ED.107

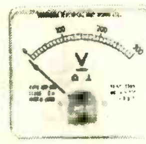
Size overall 100mm × 90mm × 108mm.

A new range of high quality moving coil instruments ideal for school experiments and other bench applications. 3in. mirror scale. The meter movement is easily accessible to demonstrate internal working.

Available in the following ranges:—

50µA	£5·50	10V D.C.	£4·85
100µA	£5·10	20V D.C.	£4·85
1mA	£4·85	50V D.C.	£4·85
50-0-50µA	£5·10	300V D.C.	£4·85
1-0-1mA	£4·85	Dual range	
1A D.C.	£4·85	500mA/5AD.C.	£5·10
5A D.C.	£4·85	5V/50 VD.C.	£5·10

TYPE MR. 38P 1 21/32in. square fronts.



50µA	£2·30	150mA	£1·75
50-0-50µA	£2·10	200mA	£1·75
100µA	£2·10	300mA	£1·75
100-0-100µA	£1·95	500mA	£1·75
200µA	£1·95	750mA	£1·75
500µA	£1·80	1 amp.	£1·75
500-0-500µA	£1·75	2 amp.	£1·75
1mA	£1·75	5 amp.	£1·75
1-0-1mA	£1·75	10 amp.	£1·75
mA	£1·75	3V. D.C.	£1·75
5mA	£1·75	10V. D.C.	£1·75
10mA	£1·75	15V. D.C.	£1·75
20mA	£1·75	20V. D.C.	£1·75
50mA	£1·75	50V. D.C.	£1·75
100mA	£1·75	100V. D.C.	£1·75
		150V. D.C.	£1·75
		300V. D.C.	£1·75
		500V. D.C.	£1·75
		750V. D.C.	£1·75
		15V. A.C.	£1·85
		50V. D.C.	£1·85
		150V. A.C.	£1·85
		300V. A.C.	£1·85
		500V. A.C.	£1·85
		S Meter 1mA	£1·85
		VU Meter	£2·30

TYPE MR.45P 2in. square fronts.

50µA	£2·50	5 amp.	£1·85
50-0-50µA	£2·30	10V. D.C.	£1·85
100µA	£2·30	20V. D.C.	£1·85
100-0-100µA	£2·05	50V. D.C.	£1·85
200µA	£2·05	300V. D.C.	£1·85
500µA	£1·95	15V. D.C.	£2·00
500-0-500µA	£1·85	300V. D.C.	£2·00
1mA	£1·85	S Meter 1mA	£2·05
5mA	£1·85	VU Meter	£2·50
10mA	£1·85	1 amp. A.C.*	£1·85
50mA	£1·85	5 amp. A.C.*	£1·85
100mA	£1·85	10 amp. A.C.*	£1·85
500mA	£1·85	20 amp. A.C.*	£1·85
1 amp.	£1·85	30 amp. A.C.*	£1·85

"SEW" BAKELITE PANEL METERS
TYPE MR.65 3½in. square fronts.

25µA	£3·85	1 amp.	£2·15
50µA	£3·00	5 amp.	£2·15
50-0-50µA	£2·60	15 amp.	£2·15
100µA	£2·60	30 amp.	£2·15
100-0-100µA	£2·50	50 amp.	£2·15
500µA	£2·45	5V. D.C.	£2·15
500-0-500µA	£2·15	10V. D.C.	£2·15
1mA	£2·15	20V. D.C.	£2·15
1-0-1mA	£2·15	50V. D.C.	£2·15
5mA	£2·15	150V. D.C.	£2·15
10mA	£2·15	300V. D.C.	£2·15
50mA	£2·15	30V. A.C.*	£2·20
100mA	£2·15	50V. A.C.*	£2·20
500mA	£2·15	150V. A.C.*	£2·20
		300V. A.C.*	£2·20
		500mA A.C.*	£2·15
		1 amp. A.C.*	£2·15
		5 amp. A.C.*	£2·15
		10 amp. A.C.*	£2·15
		20 amp. A.C.*	£2·15
		30 amp. A.C.*	£2·15
		50 amp. A.C.*	£2·15
		VU Meter	£3·40
		50 mV D.C.	£2·40
		100mV D.C.	£2·40

TYPE S.80 80mm Square Fronts

50µA	£3·50	100–0–100µA	£3·30
50–0–50µA	£3·40	500µA	£3·05
100µA	£3·40	1mA	£2·85
		20V. D.C.	£2·85
		50V. D.C.	£2·85
		300V. D.C.	£2·85
		1 amp. D.C.	£2·85
		5 amp. D.C.	£2·85
		300V. A.C.	£2·85
		VU Meter	£3·70

Send SAE for list of Semi Conductors and Valves

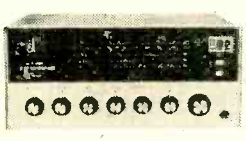
HAND HELD 2-WAY WALKIE TALKIES

Industrial quality in robust metal cases. Battery operation. Volume and squelch controls. Call button and press to talk button. Telescopic aerial. Complete with carrying cases.

2 channel 300 mW. **£52·50** Pair. Post 50p.
3 channel 2 watt. **£79·50** Pair. Post 50p.

Note: Licence required in U.K.

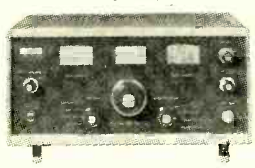
SKYWOOD CX203 RECEIVER



Solid state. 5 bands covering 200-420 KHz and ·55 to 30 MHz. Illuminated slide rule dial. Bandspread. Aerial tuning. BFO, AVC, ANL, "S" meter. AM/CW/SS B. Integrated speaker and phone socket. 220/240 v. A.C. or 12 v. D.C. Size 325 × 266 × 150 mm. Complete with instructions and circuit.

OUR PRICE £32·50 Carr. 50p

TRIO 9R59DS RECEIVER



4 bands covering 550 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 frequency 455 kc/s. audio output 1.5w. Variable RF and AF gain controls 115/250 v. A.C. Size: 7in. × 13in. × 10in. with instruction manual.

OUR PRICE £49·50 Carr. Paid.

FULL TRIO RANGE STOCKED.

ALL PRICES ARE EXCLUSIVE OF 10% VAT

UNR 30 RECEIVER

4 Bands covering 550 kc/s-30 mc/s. B.F.O. Built-in Speaker 220/240 v. A.C. Brand new with instructions.

OUR PRICE £15·75 Carr. 37p

UR-1A RECEIVER

4 Bands covering 550 kc/s-30 mc/s. FET, S Meter. Variable BFO for SSB. Built-in Speaker; Bandspread, Sensitivity Control. 220/240 v. A.C. or 12 v. D.C. 12½in. × 4½in. × 7in. Brand new with instructions.

OUR PRICE £25·00 Carr. 37p

LAFAYETTE HA-600 RECEIVER

General coverage 150-400 kc/s. 550 kc/s-30 mc/s. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, S Meter Bandspread. RF Gain. 15in. × 9½in. × 8½in. 18 lb. 220/240 v. A.C. or 12 v. D.C. Brand new with instructions.

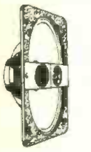
OUR PRICE £50·00 Carr. 50p

GWS

ALSO SEE FOLLOWING PAGES

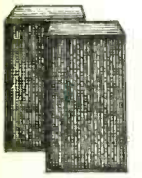
GWS G.W.SMITH & CO (RADIO) LTD

EMI LOUDSPEAKERS



Model 350. 13in. × 8in. with single tweeter/crossover. 20-20,000 Hz. 15 watt RMS. Available 8 or 15 ohms. £7·25 each. P. & P. 37p.
Model 450. 13in. × 8in. with twin tweeters/crossover. 55-13,000 Hz. 8 watts RMS. Available 8 or 15 ohms. £3·62 each. P. & P. 25p.

SPECIAL OFFER! STEREO SPEAKERS



Matched pair of bookshelf speakers. De luxe teak veneered finish. Size 14½in. × 9in. × 7½in. 8 ohms. 8 watts RMS. 16 watts peak. Complete with DIN lead.

OUR PRICE £12·95 Carr. 50p

HA-1D STEREO HEADPHONE AMPLIFIER

All silicon transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9 v. battery. Inputs 5MU/100MU. Output 50MW.

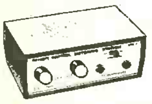
OUR PRICE £5·97 P. & P. 20p

MP7 MIXER PREAMPLIFIER

5 microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. 9½" x 5" x 3". Inputs Mics: 3 x 3mV 50K; 2 x 3mV 600 ohm. Phono mag. 4 mV 50K. Phono ceramic 100mV 1 meg. Output 250mV 100K.

OUR PRICE £8·97 P. & P. 20p

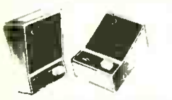
1021 STEREO LISTENING STATION



For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. 2 gain controls, speaker on-off slide switch, stereo headphone sockets. 6in. × 4in. × 2½in.

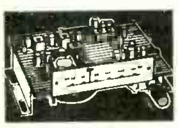
OUR PRICE £2·25 P. & P. 20p

HOMER INTERCOMS



Ideal for home, office, stores, factories, etc. Supplied complete with batteries, cable and free instructions.
2 Station £2·97. P. & P. 15p.
3 Station £5·25. P. & P. 15p.
4 Station £6·62. P. & P. 17p.

FM TUNER CHASSIS



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.

OUR PRICE £5·95 P. & P. 20p

Stereo Multiplex Adaptor £4·97.

GWS ALSO SEE PREVIOUS PAGES

SH628 STEREO HEADPHONES

Outstanding value. Soft earpads, adjustable headband. 8-16 ohms. 20-20,000 Hz. Complete with lead and stereo plug.

OUR PRICE £1·87 P. & P. 30p

TE1018 DE-LUXE MONO HIGH IMPEDANCE HEADSET

Sensitive magnetic headset with soft earpads. Impedance 2,600 ohms (d.c. 600 ohms). Frequency response 200-4000 Hz.

OUR PRICE £1·97 P. & P. 30p

LIGER LHO2S STEREO HEADPHONES

Lightweight headphones with padded earpieces. 4-16 ohms. 20-20,000 Hz. Complete with 6ft cord and plug.

OUR PRICE £1·95 P. & P. 30p

SDH8V MONO/STEREO HEADPHONES

Two way stereo/mono with volume controls. Padded headband. 4-16 ohms. 20-18,000 Hz. Complete with lead and stereo plug.

OUR PRICE £3·97 P. & P. 30p

BH001 HEADSET AND BOOM MICROPHONE

Moving coil. Headphone imp. 16 ohms. Mike imp. 200 ohms. Ideal for language teaching, communications etc. Complete with leads and plugs.

OUR PRICE £4·62 P. & P. 30p

DH.08S Stereo Headphones

De luxe model with unique 2 way mechanical units and volume controls. 8 ohms. 20-20,000 Hz. Complete with coil lead and stereo jack plug.

OUR PRICE £7·97 P. & P. 30p

ROTEL BARGAIN! RH700 STEREO PHONES

Soft leather ear cushions. Impedance 8-16 ohms. 20-20,000 Hz. 15ft. coiled lead. Brand New and boxed. (List £9.95).

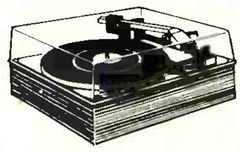
OUR PRICE £6·75 P. & P. 30p

4-CHANNEL STEREO HEADPHONES

TTC G3600—Soft vinyl covered head cushion and earphones. Each earpiece incorporates two 2" speaker units. Fitted 2/4 channel changeover switch. Impedance 4-16 ohm. Frequency response 20-20,000 Hz. Complete with 15ft. coiled lead fitted two stereo plugs.

OUR PRICE £9·95 P. & P. 30p

RECORD DECK PACKAGES



Carriage and Packing 75p
Complete units with Stereo cartridge ready wired in plinth cover.

GARRARD
2025 TC/9TAHCD .... £10·65
SP25 111/G800 .... £15·00
SP25 111/M44E .... £16·45
SP25 111/M44–7 .... £16·10
SP25 111/M55E .... £16·90
SP25 111 Module/M75–6 .... £18·99
AP76/G800 .... £23·50
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AP76/M44E .... £24·95
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AP76/M75ED .... £31·70
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AP76 Module M75–6 .... £26·95
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ZERO 1008 Module/M93E .... £41·85

B.S.R. McDONALD
210/SC7M .... £6·85
MP60/G800 .... £15·00
MP60/TPD1/G800 .... £15·20
MP60/M44–7 .... £16·75
HT70/TPD1/G800 .... £18·60

GOLDRING
GL72/G800 .... £30·90
GL75/G800 .... £34·10
GL75/G800E .... £36·75

GOODMANS
TD100/G800 Teak .... £46·85
TD100/G800 White .... £48·60

LEAK
Delta M75–6 .... £43·95

PHILIPS
GA105/GP200 .... £13·80
GA160/GP200 Teak .... £20·00
GA308/GP400 .... £32·75
GA308 (less cartridge) .... £23·95
GA212/GP400 .... £45·25

PIONEER
PL12D (Less cartridge) .... £31·75
PL15C (Less cartridge) .... £44·25
PL41D (Less cartridge) .... £104·75
PL50 (Less cartridge) .... £98·90
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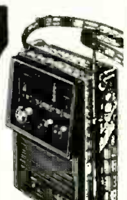
THORENS
TD160C/Ortofon M15E Super .... £62·50
TD125 AB/11/Ortofon M15E Super .... £96·95

WHARFEDALE
Linton/M44–7 .... £23·70

AUDIOTRONIC MULTIBAND RADIO



5 wavebands covering MW 535-1605KHz and FM 88-175MHz. All transistor. Battery or mains operation. Built in aerial and 8 section telescopic aerial. Complete with batteries, shoulder strap and earpiece.

ONLY £7·50 P & P 35p

AUDIOTRONIC SQ. QUADRAPHONIC DECODER

Fully transistorised containing all input, output and control facilities to reproduce 4 channel sound from SQ records and 4 channel discrete sources. Also provides conventional stereo reproduction, 2-channel and 4-channel tape recording and playback and enhancement of conventional 2-channel material. AC 220-240v. Frequency response ± 1dBm. 5Hz to 100KHz. Size: 180mm × 55mm × 220mm deep.

OUR PRICE £22·50 P. & P. 25p

ALL PRICES ARE EXCLUSIVE OF 10% V.A.T.

RECORD DECKS

Carriage & Packing 50p

B.S.R. McDONALD
C114 Mini .... £3·95
C129 Mono .... £5·50
C137 .... £7·00
510/TPD1 .... £13·95
610 .... £9·90
610/TPD1 .... £14·85
710 .... £19·20
810 .... £24·50
710/810 Plinth and Cover .... £8·35
MP60 .... £7·65
MP60/G800 .... £10·25
MP60/TPD1 .... £12·60
MP60/TPD2 .... £11·25
HT70 .... £10·97
HT70/G800 .... £13·60
HT70/TPD1 .... £15·95

CONNOISSEUR
BD1 Kit .... £9·10
BD1 Chassis .... £11·35
BD1/SAU2/Plinth/Cover .... £27·60
BD2/SAU2/Chassis .... £23·35
BD2/SAU2/Plinth/Cover .... £28·50

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SP25 III .... £8·50
SP25 III/Acos GP104 Ceramic .... £8·50
SP25/M75–6 .... £13·90
AP76 .... £15·55
SL65B .... £11·15
SL72B .... £17·75
SL95B .... £25·25
401 .... £23·50
ZERO 100A .... £30·30
ZERO 100S .... £27·95

GOLDRING
G99 .... £18·99
G101P/C .... £18·99
GL69/2 .... £15·75
GL72 .... £20·97
GL72/P .... £27·80
Plinth 69/72 .... £6·80
LID 72 .... £2·80
GL75 .... £26·60
GL75P .... £34·40
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TX25 .... £5·60
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Budget 401 Arm .... £11·95
Budget AP76/Zero 100S .... £3·95
Budget B.S.R. .... £2·95
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Garrard WB4 .... £3·25
Garrard SPC4 .... £2·55
SME2000 System .... £26·40

SPECIAL GARRARD OFFERS!

STEREO 1025T

1025T. 4 speed autochanger unit fitted with stereo ceramic cartridge.

OUR PRICE £4·95 Carr & Ins. 50p

SP25 III WITH ACOS GP104

SP25 MKII. 4 speed single record player fitted with Acos GP104 stereo ceramic cartridge.

OUR PRICE £8·50 Carr & Ins. 50p

SPECIAL OFFER OF NEAT EQUIPMENT (Buy now while stocks last)

Neat G30B Arm .. .. £8·40 P. & P. 25p
Neat V70 Cartridge (Original pack) .. .. £2·15
Neat V70 Cartridge (Bulk Pack) .. .. £1·50
Neat V70E Cartridge .. .. £3·35
Neat V60 MH Cartridge .. .. £3·15
P. & P. 12p extra.

SAVE OVER 50% NANIMEX NRC 3061 CASSETTE RADIO

Record/Playback facilities plus slide rule tuning of AM 535-1620 KHz and FM 88-108 MHz. Slider volume controls. Built in condenser microphone plus separate hand/desk microphone. Telescopic aerial. Complete with earpiece, batteries and instructions. (Tape not supplied.) (Rec. List price £55·56).

OUR PRICE £22·75 P. & P. 50p

LOW NOISE TAPE CASSETTES

Top quality in library cases.

	5	10	25
C60	£1·29	£2·53	£5·99
C90	£1·85	£3·62	£8·59
C120	£2·29	£4·48	£10·63
	P. & P. 15p	Post Free	Post Free

Tape Head Cleaner 30p each.

OUTSTANDING VALUE! AUDIOTRONIC DOLBY 'B' NOISE REDUCTION UNITS

Reduce tape hiss by 3dB at 600Hz, 6dB at 1200Hz and 10dB for all frequencies above 3000Hz. Size 16¾" × 8" × 3½". AC 200/250v.

PROCESS TWO

For use with cassette and tape recorders. Freq. res. 30Hz—20KHz ± 2dB. Off tape monitoring. Switchable multiplex filter. Two Dolby calibration meters. S/N better than 70dB. Supplied with test cassette or tape as required.

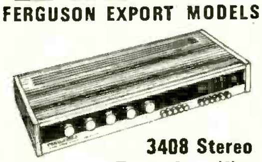
OUR PRICE £32·50 P. & P. 50p

PROCESS FOUR

For use with semi professional tape recorders. Freq. res. 30Hz—20KHz ± 2dB. S/N better than 70dB. Full source tape monitoring. Record/Replay metering. Switchable multiplex filter. Supplied with test tape.

OUR PRICE £48·00 P. & P. 50p

SPECIAL PURCHASE! FERGUSON EXPORT MODELS



3408 Stereo Tuner Amplifier

Covers FM 88-108 MHz. Five push button tuning scales. 8+8 watts rms. Inputs for stereo ceramic cartridge and tape, etc. Separate bass, treble, balance and volume controls.

OUR PRICE £31·50 Carr. 50p

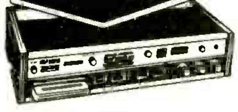
3416 Stereo Tape Deck

4 track. 7½, 3¾, 1⅞ i.p.s. Stereo/mono record/play. 7" reels. Inputs for dynamic mikes, radio, gram. Complete with cover.

OUR PRICE £41·95 Carr. 75p

SAVE UP TO 33⅓% OR MORE! GWS

AKAI BARGAINS



CASSETTE P. & P. 50p)

CS35D Deck	£44·95
CS35 Recorder	£57·75
CS35/CS88 Speakers	£67·95
GXC40D Deck	£57·75
GXC40 Recorder	£67·95
GXC40T Deck/Receiver	£101·25
GXC45 Deck	£78·25
GXC46D Dolby Deck	£84·30
GXC46 Recorder	£90·75
GXC60D Deck	£87·65
GXC65D Dolby Deck	£93·40
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CR81D Deck	£54·10
CR81T Recorder/Receiver	£93·70
CR80SS 4 channel Recorder	£114·25
CR80DSS 4 channel Recorder	£94·95
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4000DS Deck	£59·95
4000DS Dust Cover	£3·95
1721L Recorder	£60·35
X5000 Recorder	£82·50
X201D Deck	£108·20
GX220D Deck	£123·95
GX221D	£138·40
GX280D Deck	£196·50
GX370 Deck	£211·50
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GX1900D Deck	£144·50
TAPE/CARTRIDGE (P. & P. 75p)	
X1810D Deck	£138·40
TAPE/CASSETTE/CARTRIDGE (P. & P. 75p)	
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ADM.11 Dynamic (pair)	£7·50
STEREO RECEIVERS (P. & P. 75p)	
AA6300 20+20 watt	£61·95
AA8030 25+25 watt	£92·50
AA8080 40+40 watt	£117·50
AA8100S 2×36 or 4×18 watt	£175·00
AA8500 65+65 watt	£150·50
STEREO AMPLIFIERS (P. & P. 50p)	
AA5200 20+20 watt	£61·75
AA5500 30+30 watt	£78·50
AA5800 45+45 watt	£117·50
STEREO TUNERS (P. & P. 50p)	
AT550 AM/FM	£60·50
AT580 AM/FM	£94·50
4-CHANNEL UNIT (P. & P. 50p)	
SS1 Synthesiser	£39·95
SPEAKERS (P. & P. 50p)	
CS88 (Pair)	£10·20
SW155 (each)	£51·00
STEREO HEADPHONES (P. & P. 30p)	
ASE 11	£4·75
ASE 20	£7·30
ASE 22	£8·25

BSR 8 TRACK BARGAINS!

TD8S STEREO TAPE CARTRIDGE DECK
Connects to most stereo amplifiers (output 125 mV). Automatic/Manual programme selector.

OUR PRICE **£12·75** P. & P. 50p

TD83V £15·25 (P. & P. 50p)

SINCLAIR PROJECT 60 PACKAGE DEALS

2×Z30 Stereo 60/P/Z5 £15·95. P. & P. 37p.
2×Z30/Stereo 60/PZ6 £18·00. P. & P. 37p.
2×Z50/Stereo 60 PZ8 £20·25. P. & P. 37p.
Transformer for PZ8 £3·65
Active Filter Unit £4·45
Pair of Q16 Speakers £10·70 P. & P. 50p.
Project 60 FM Tuner £14·95 P. & P. 50p.
Sinclair Project 605 £20·97. P. & P. 37p.
All other Sinclair Products in stock.
2000 Amplifier £22·95. P. & P. 50p.
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Q830 Speaker £14·99. P. & P. 50p.

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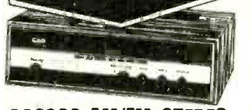

AA6300 AM/FM STEREO TUNER AMPLIFIER

20+20 watts rms. Magnetic, ceramic and tape inputs. FM 88-108 MHz. AM 535-1605 kHz. Dual stereo speaker outputs. Headphone socket. (Rec. List Price £117.46).

OUR PRICE **£61·95** P. & P. 75p

FANTASTIC OFFER!

AKAI CS35D STEREO CASSETTE DECK

High quality 4 track record/playback deck. Accepts chrome/regular tape cassettes. Two VU meters and slider controls for recording level. Photo/Din output/input sockets. Headphone socket for monitoring.

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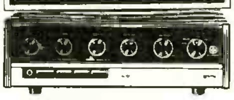

NIKKO TRM50 STEREO AMPLIFIER

17+17 watts rms. Inputs for magnetic and crystal phono, tuner, tape etc. Dual stereo speaker outputs. Headphone socket. Full range of controls. (Rec. List Price £59·50.)

OUR PRICE **£39·95** P. & P. 50p

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RA610 32+32 watt	£51·95
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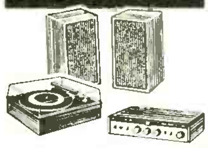
MONATONE 6750 SYSTEM

AM/FM 4+4 watt stereo tuner amplifier, Garrard 2025 T/C, plinth and cover, stereo cartridge, pair of matching speakers and all leads.

OUR PRICE **£30·50** Carr. £1·00

ALBANY HOUSE AM.108 SYSTEM



8 + 8 watt amplifier. Garrard SP25, plinth and cover, G800 cartridge, pair of Medway T138 speakers.

OUR PRICE **£52·75** Carr. £1·25

ROTEL RX150 SYSTEM

AM/FM 7½+7½ watt stereo tuner amplifier. BSR MP60, plinth and cover, G800, pair of Denton 2 speakers and all leads.

OUR PRICE **£75·95** Carr. & Ins. £1·25

TRIO KA 2000A SYSTEM

16+16 watt amplifier. BSR MP60, plinth and cover, G800 cartridge, pair of Denton 2 speakers and all leads.

OUR PRICE **£70·95** Carr. £1·25

Matching KT 1000A AM/FM Stereo Tuner £43·75.

TELETON SAQ206B SYSTEM

8+8 watt amplifier. BSR MP60, plinth and cover. G800 cartridge, pair of Apollo speakers and all leads.

OUR PRICE **£50·95** Carr. £1·50

NIKKO TRM50 SYSTEM

17+17 watt amplifier, Garrard AP76, plinth and cover. G800E cartridge, pair of Linton 2 speakers and all leads.

OUR PRICE **£93·95** Carr. £1·25

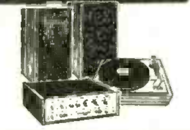
AUDIOTRONIC LA.1700 SYSTEM

17+17 watt amplifier. Garrard AP76, plinth and cover. G800 cartridge, pair of Wharfdale Linton 2 speakers and all leads.

OUR PRICE **£86·95** £1·50 Carr. & Ins.

Matching LT1700 AM/FM Stereo Tuner £37·50.

AUDIOTRONIC LA.4000 SYSTEM



40+40 watt amplifier. Goldring GL75, plinth and cover. G800E cartridge, pair of Wharfdale Dovedale 3 speakers and all leads.

OUR PRICE **£152·95** Carr & Ins. £2·00

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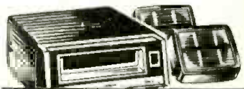

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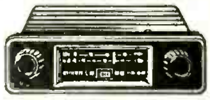
Attractive black and silver finish. 12v neg. earth. Slider controls for Volume, Tone and Balance. Channel selector button with red pilot lamp. Complete with speakers, mounting brackets and instructions.

ONLY **£12·50** P & P 40p



ACR 3500 CAR RADIO

Manual tuning of Medium and Long waves. 12v pos. or neg. earth. Complete with speaker, mounting brackets and instructions.

OUR PRICE **£6·50** P & P 50 p

ACR1 PUSH BUTTON CAR RADIO

Push button tuning of one LW and five MW stations of your choice. 12v pos. or neg. earth. Complete with speaker, mounting brackets and instructions.

OUR PRICE **£8·95** P & P 50p

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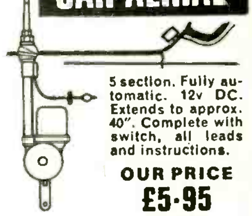

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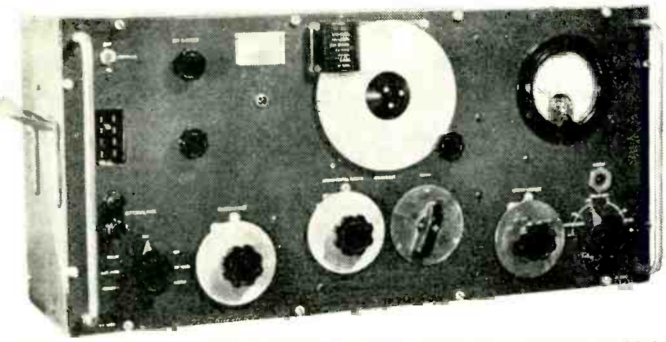

MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25 Mc/s in 8 ranges. Incremental: ±1% at 1 Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52·5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements 29 × 12¼ × 10 in. Secondhand condition. **£27·50** each, Carr. £1·50.

T.1509 TRANSMITTERS (FOR EXPORT ONLY): General-purpose HF communications transmitter for use in fixed or mobile ground stations. Hand or high-speed keying. Crystal or MO control, with temperature compensated MO circuit.CW, MCW and R/T. Frequency: 1.5 to 20 Mc/s. Modulation: 100% O/put impedance: 50 ohms. Audio input: 600 ohms. Valves: Power Amplifier 2 × 813 and Modulator 2 × 813. Power requirements 200-250 volts a.c., 50 cycles. Power out put 300 watts. Dimensions 2ft. 6in. W. × 2ft. D. × 5ft. H. Weight: 800 lbs. Excellent condition, price **£225.00** each.

AN/ARC-27 TRANSMITTER/RECEIVER (FOR EXPORT ONLY): Frequency 225-400 mc. 1750 channels 100 Kc apart with 18 preset channels. Modulation: am. Power output 9 watts. Receiver is superheterodyne. Max. output 2 watts. Antenna: 50 ohm impedance. Power requirements 24v d.c. Complete transmitter with operating cables, control box, headphones, microphone. Price **£250.00** each secondhand, excellent condition.

POWER SUPPLY suitable for AN/ARC-27: 100 volts to 250 volts a.c. input. 24v d.c. output @ 41 amps fully smoothed. **£45.00** each.

TEST SET TS-147C: Combined signal generator, frequency meter and power meter for 8500-9600 Mc/s. CW or FM signals of known freq. and power or measurement of same. *Signal Generator:* O/put −7 to −85 dbm. Transmission—FM, PM, CW. Sweep Rate—0-6 Mc/s per microsec. Deviation—0-40 Mc/s per sec. Phase Range—3-50 microsec. Pulse Repetition Rate—to 4000 pulses per sec. RF Trigger for Sawtooth Sweep—5-500 watts peak. 0.2-6 microsec. duration, 0.5 microsec pulse rise time. Video Trigger for Sawtooth Sweep—Positive polarity, 10-50V peak. 0.5-20 microsec duration at 10% max. amplitude, less than 0.5 microsec rise time between 90% and 10% max. amplitude points. *Frequency Meter:* Freq. 8470-9360 Mc/s. Accuracy—+2.5 Mc/s per sec. absolute, +1.0 Mc/s per sec. for freq. increments of less than 60 Mc/s relative, ±1.0 Mc/s per sec. a 9310 Mc/s per sec. calibration point. Accuracy measured at 25° C and 60 humidity. *Power Meter:* Input: +7 to +30 dbm. Output −7 to −85 dbm. Price: **£75** each + £1 carr.

SIGNAL GENERATOR TS-403B/U (or URM-61A): (Hewlett Packard). A portable, self-contained, general-purpose test equipment designed for use with radio and radar receivers and for other applications requiring small amounts of RF power such as measuring standing-wave ratios, antenna and transmission line characteristics, conversion gain, etc. Both the output freq. and power are indicated on direct-reading dials. 115V, AC, 50 c/s. Freq.—1800-4000 Mc/s. CW, FM, Modulated Pulse—40-4000 pulses per sec. Pulse Width—0.5-10 microsecs. Timing —Undelayed or delayed from 3-300 microsecs from external or internal pulse. O/put—1 milliwatt max., 0 to −127 db variable. O/put Impedance—50Ω. Price **£120** used, excellent condition. Unused as new condition **£150** + carr. £2.

TS-382/U AUDIO OSCILLATOR: 20 to 200,000 c/s. in four ranges. Freq. meter check 60 c/s. and 400 c/s. Emission CW. O/put voltage: 1 uv to 10V ±3% in seven ranges. Power req. 115V AC single phase. Price **£20** each, used good condition. Unused condition **£30** + carr. £1.50.

FREQUENCY METER BC-221: 125-20,000 Kc/s, complete with original calibration charts. Checked out, working order. **£18·50** + £1·00 carr. BC-221 Unused as new condition complete with headset, spare valves, charts. **£35·00** + £2·00 carr.

TS-452 F.M. SWEEP GENERATOR: Power supply 115V, 50c/s, 5-100MHz in 6 bands (rf o/put); 5-102MHz in 4 bands (freq. meter). Emission: F.M. R.F. Voltage o/put ·25V. Input impedance 470 ohms. O/put impedance 73 ohms. Displays band pass characteristics on 3in. C.R.T. S/hand good condition **£95·00** + £2·00 carr.

TS-419/URM 64 SIGNAL GENERATOR: Freq. 900-2100MHz. CW or pulse emission. Power o/put Zero dbm-120dbm continuously adjustable to ·2uv into 50. O/put impedance 50 ohms with VSWR of 2:1. 115V a.c. 50 c/s. As new condition **£150·00** + £2·00 carr.

TS-622/URM 44 SIGNAL GENERATOR: Freq. range —7 to 11 GHz Power o/put —10 to 127 dbm; Emission CW, FM, Pulse. Direct reading dials for both frequency and power. Operates on 115 volts, 50-1000Hz. As new condition **£175·00** + £2·00 carr.

CT.52 MINIATURE OSCILLOSCOPE: Portable. Operates from 115V or 250V 50-60c/s; or 180V 500c/s. A small compact tropicalised instrument designed to meet requirements of radar and communication engineers and general electronic service. Measures 9 in. × 8 in. × 6½in. Time base 10c/s-40Kc/s. Y plate sensitivity 40V per cm. Tube 2¾in. Frequency compensated amplifier up to 38dB gain. Bandwidth up to 1 Mc/s. Single sweep facilities. Complete with test leads, metal transit case. As new **£27·50 each. Carr. £1.**

TRANSFORMER HV: 228V input 19,500–0–19,500 4.5KVA, Wt. 220 lbs. £30 each. Carr. £4.

TS-683 CRYSTAL IMPEDANCE METER: 10-140MHz secondhand good condition. £75·00 each + £1·00 carr.

TUNING UNIT: 24V geared motor driving double 25pf double spaced variable capacitor. One m/c relay and 2 other relays. **£2·50** each 30p post, good condition.

UHF ASSEMBLY: (suitable for 1,000MHz conversion) including UHF valves: 2C42, 2C46, 1B40 (complete with associated capacitors and screening), 3 manual counters 0-999. Valves 6AL5 and 8 × 6AK5. **£10·00** plus 60p post, good condition.

MODULATOR UNIT: complete with transformer and 2 × 807 valves mounted in 19 in. chassis × 8 in. high × 8 in. deep. **£4·50** secondhand cond., or **£6·50** new cond. Carriage £1.

RF UNIT: suitable for use with the above unit. Complete with 2 × 3E29 valves. Ideal for conversion to 4 metres. **£5** secondhand cond., or **£7·50** new cond. Carriage £1.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 × 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19″W×11″H×14″D. (All connections at the rear.) Excellent condition **£6·50** each, carr. £1.

AUTO TRANSFORMER: 230-115V, 50-60c/s, 1000 watts, mounted in a strong steel case 5″ × 6½″ × 7″. Bitumen impregnated. **£7** each, Carr. 75p. 230-115V, 50-60c/s, 500 watts. 7″ × 5″ × 5″. Mounted in steel ventilated case. **£4·00** each, Carr. 75p.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7·50** each, 75p carr.

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DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each, 0·9 ohms. Tolerance ± 1% **£3** each, 25p post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ± 1% **£3·50** each, post 30p.

TF-1041B VALVE VOLTMETER: Measures 25mV to 300V, 20 c/s to 1500 Mc/s a.c. Also 10mV to 1000V d.c. Resistance 0.02 ohms to 500 Meg. ohms. Power requirements 200-250 volts a.c. Secondhand, excellent con. **£35·00**. Carr. £1.

VARIAC TRANSFORMERS: Input 115V, output 0-135V at 2 Amps. **£3** each 75p post. Input 115V, output 135V at 5 Amps. **£5** each, 75p post.

RACK CABINETS: (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high × 21 in. wide × 16 in. deep, with rear door. **£12** each, £2·50 Carr. OR 4 ft. high × 23 in. wide × 19 in. deep, with rear door.**£8·50**, each, £2 Carr.

INSTRUMENT CABINETS: 19″W. × 16″H. × 16″D. **£5·00** + £1·25 carr. 19″W. × 10″D. × 5″H. **£2·50** + £1·00 carr.

FUEL INDICATOR Type 113R: 24V complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in 3in. diameter case. Price **£2** each, 30p post.

TS-418/URM49 SIGNAL GENERATOR: Covers 400-1000MHz range. CW Pulse or AM emission. Power Range 0-120 dbm. **£125** each. Carr. £1·50.

TN/130/APR.9 UHF TUNING UNIT: Freq. 4300-7350MHz. IF Output 160MHz with bandwidth of 20MHz and is electrically tuned by a d.c. reversible motor. **£27·50** each. Carr. £1.

APR-4 AM RADIO RECEIVER: 90-1000MHz. This receiver is suitable for monitoring and measuring frequencies as well as relative signal strength. Power Supply 115V 50c/s. **£100** each. Carr. £2.

SIGNAL GENERATOR TS-497B/URR: (Boonton). Freq. 2-400 Mc/s in 6 bands. Internal Mod. 400 or 1000 c/s per sec. External Mod. 50 to 10,000 c/s per sec. External PM. Percent Mod. 0-30 for sine wave. Am or Pulse Carrier. O/put Voltage 0·1-100,000 microvolts cont. variable. Impedance 50Ω. Price: **£85** each + £1·50 carr.

CLASS "D" WAVEMETER NO. 2: Crystal controlled heterodyne frequency meter covering 2-8MHz. Power supply 6V d.c. Good secondhand cond. **£7·50** each. Post 60p.

RCA TE-149 HETERODYNE WAVEMETER: V-cut, 1MHz crystal (0·005%). Accuracy better than 0·02%. Dial directly calibrated every 1KHz from 2·5-5MHz. Useful harmonics up to 20MHz. Provision for fitting internal dry batteries. "As new" complete with Manual and Spares. **£14** each. Carr. 75p.

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POWER UNIT TYPE 24: (for R.216 Receiver) A.C. operated 100-125V or 200-250V, 50c/s. "As new" **£10** each. Carr. 75p.

ROTARY INVERTERS: TYPE PE.218E—input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1 Ph. P.F.9. **£17·50** each. Carr. £1·50.

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(as in Wireless World, July 1972)

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(1) Connect decorder to your tuner, possibly disconnecting one or two de-emphasis components.
(2) Provide 10 to 16 volts D.C. either from your tuner or a separate power supply.
(3) Tune to a stereo broadcast.
(4) Turn a "preset" resistor until the stereo beacon lights up. You then have stereo radio.

Comprehensive instructions provided, but if you are in doubt, just ask us!

£3.40 post free + 34p V.A.T. (Beacon 34p + 4p V.A.T.)

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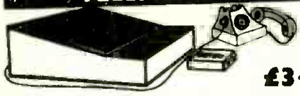

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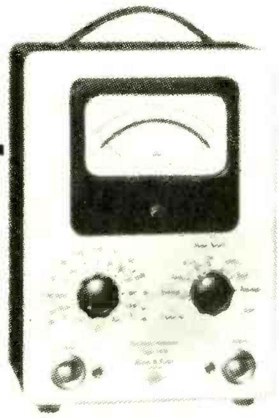

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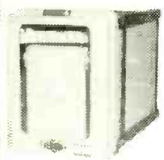

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500		Colvern	1.25
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100/100		Beckman	2.00
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10K	0.5	Beckman	1.25
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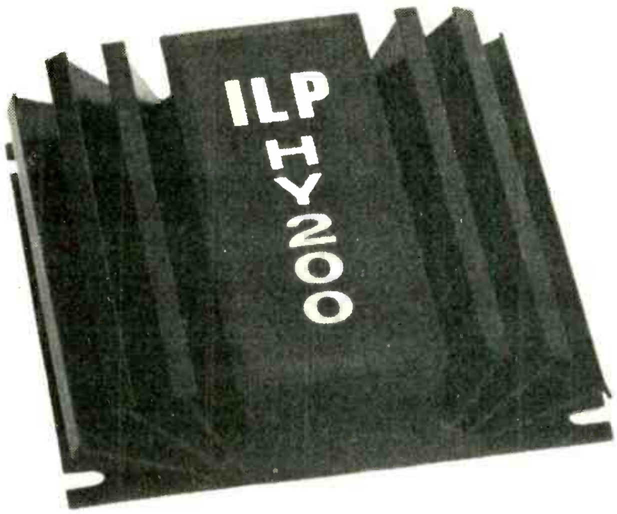

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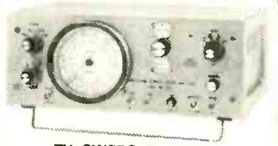

TV SWEEP MARKER GENERATOR Type VU 167

Suitable for alignment of tuned circuits in television sets. Incorporates a sweep generator, a market generator and a crystal-controlled oscillator operating at 5.5 MHz. Sweep frequency range 1-30 MHz. 170-260 MHz Fund. 470-780 MHz Harmonic. Marker frequency range 2-266 MHz, 480-800 MHz.

£195.00

PORTABLE WHEATSTONE BRIDGE

Designed for measurements of DC resistances in the range of 10^{-5} to 10^{6} Megohms. Basic accuracy 0.01 ohms to 10^{5} ohms is 0.2%. Dimensions 300x230x 150 mm. Weight approx. 13 lbs.

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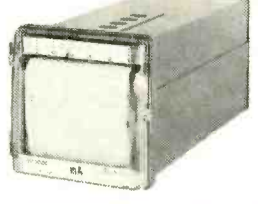

MINIATURE PEN RECORDER

Provides permanent record of DC currents up to 1mA. Eminently suitable for use where space is limited. Separate time marker pen provided. Chart width 80mm. Chart length 40ft. Chart speeds: Slow 20-60-180 mm/hour. Fast 600-1800-5400 mm/hour. Dimensions 120x 120x285mm. Weight 7.7 lbs. (3.5 Kg). Price complete with accessories

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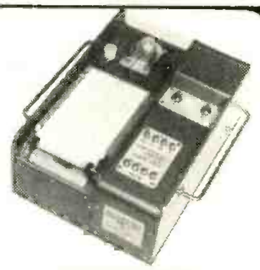

SINGLE CHANNEL HIGH SPEED RECORDER

Chart length 175ft. Footage indicator. Width of recording channel 80mm. Chart speeds (selected by push buttons) 1.2-6-12-30-60-120-300-600-3000 mm per minute. Full deflection current 8mA. Internal impedance 210 ohms. External impedance 800 ohms. Dimensions 320x340x175mm. Weight 35 lbs. Price complete with accessories

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The Supertester 680R is a completely new concept in measuring Instruments. In itself a high quality test meter with eighty ranges on a 128mm mirror backed scale. It is also the basis of a complete measurement system. With the addition of the appropriate accessories it can measure a wide range of values including light, temperature, gauss and phase sequence. And there are other accessories to greatly extend the 680R's range. The 680R System offers many advantages over conventional test meters including tremendous versatility and economy.

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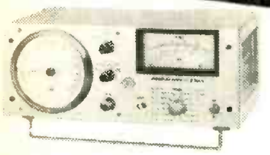

DISTORTION METER Type D 566 B

Fully transistorised for measurement of overall distortion of signals with frequencies between 10 Hz and 1 MHz. Built-in electronic voltmeter can also be used separately for measuring AC voltage, basic noise, gain or attenuation over a wide frequency range.
Distortion meter:—
Frequency range (in 5 ranges): from 10 Hz to 1 MHz. Distortion factor (in 7 ranges): from 0.03% to 100. Minimum testing voltage: 300 mV approx. Input impedance: 100 KOhm: 40 pF approx.
Millivoltmeter:
Voltage range (in 12 ranges): from 1 mV to 300 V f.s.d. Level range (rel. to 0.776 V): from + 52 dB to − 75 dB. Frequency range: from 10 Hz to 2 MHz. Bandwidth (within 3 dB): up to 8 MHz. Accuracy: better than 5%. Input impedance: 2 MOhm: 50 pF approx.

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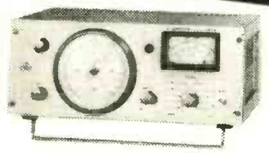

LF SIGNAL GENERATOR Type G 1165 B

Transistorised generator providing wide range of squarewave and sinewave signals. Suitable for measuring distortion, gain or attenuation when testing the frequency response of low-frequency equipment.
Sinusoidal output:—
Frequency range (in 4 ranges): from 10 Hz to 100 KHz. Output voltage: from 1 mV to 10 V. Output impedance: 600 Ohm constant. Frequency accuracy: better than 2%. Harmonic distortion: less than 0.3% (50 Hz . . . 30 KHz).
Squarewave output:—
Frequency range (in 4 ranges): from 10 Hz to 100 KHz. Output voltage: from 100 mV to 10 Vp. Output impedance: 75 Ohm constant. Risetime: less than 10nS.

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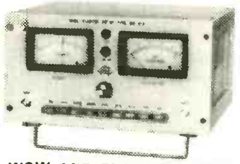
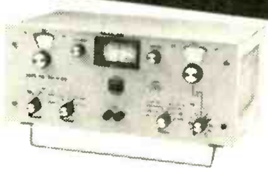


WOW AND FLUTTER METER Type WF 971

Solid state, high stability unit. Can be preset for either the European standard at 3150 Hz or the American standard at 3000 Hz. Provided with built-in oscillator.
Specifications: DIN and CCIR. Input Signal: 20 mV rms to 20 V rms approx. Frequencies (switchable): 3150 Hz and 3000 Hz. Ranges (flutter): +/− 0.1% +/− 0.3% +/− 1% f.s.d. Drift indication: +/− 2% max. Input impedance: 10mOhm max. Built-in oscillator: 3000 Hz or 3150 Hz switchable. Stability: better than 0.1%. Shifts for calibration: +/− 0.1% dynamic, 50 Hz + 2% static.

£225.00



RCL BRIDGE Type P 966

For measurement of RCL and capacitor dissipation factor and inductors figure of merit Q. Consists of a system of switchable bridges, a 1 KHz generator, and a sensitive tuned detector. Particularly suitable for testing of small production batches and selection of component parameters.
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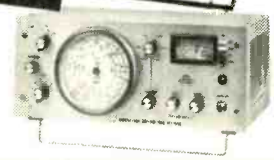

AM-FM GENERATOR Type AF 1065

Permits fast and accurate calibration of modern radio receivers. Suitable for calibration and testing in the laboratory.
AM frequency range: from 140 KHz to 46 MHz in 6 ranges expanded range 430-530 KHz. FM frequency range: 9.5-12 MHz; 85-110 MHz. Frequency accuracy: better than 1%. RF output voltage: adjustable from 0.1 μV to 0.1V. Output impedance: 75 Ohm constant. Modulation: AM; FM; AM + FM. Amplitude modulation: 400 Hz; from 0-50% adjust. Frequency modulation: 1000 Hz adjust. Deviation from 0 − +/− 50 KHz. External modulation: AM; FM: from 30 Hz to 15 KHz.

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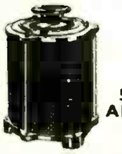

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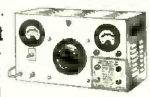
36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit



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Will handle liquids or gases up to 7 p.s.i. Forged brass body, stainless steel core and spring. ½ in. b.s.p. inlet/outlet. Precision made. British mfg. PRICE: £2·15 incl. P. & P. Special quotation for quantity. NEW in original packing.

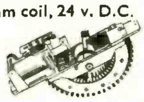
FOOT SWITCH

Suitable for Motors, Drills. Sewing Machines, etc., etc. 5 amp. 250 Volt. Price £1·00.

POWER RHEOSTATS

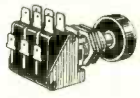
New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10/25/50/100/250/500/1k/1·5k ohm £1·13.
50 WATT 1/5/10/25/50/100/250/500/1k/1·5k/2·5k/5k ohm £1·57.
100 WATT 1/5/10/25/50/100/250/500/1k/1·5k/2·5k/3·5k ohm £2·23.
Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia brass bush. Ideal for above Rheostats, 20p ea.

UNISELECTOR SWITCHES—NEW



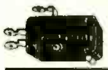
4 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. operation. £6·74 inc. P. & P.
6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. £7·43, inc. P. & P.
8 BANK 25 WAY FULL WIPER 24 v. D.C. operation. £8·67, inc. P. & P.

'HONEYWELL' PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY



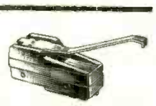
Each bank comprises of a change-over rated at 10 amps 240 volt A.C. Black knob 1 in. dia. Fixing hole ½ in. Prices: 1-bank 33p, 2-bank 44p, 3-bank 61p. (Illustrated) Inc. P. & P. Special quotes for quantities.

VERY SPECIAL OFFER
MICRO SWITCH



5 amp. c/o contacts. Fitted with removable metal plate Ex P.O. 20 for £1·10 (min. order 20).

'HONEYWELL' LEVER OPERATED MICRO SWITCH



15 amps 250 volt A.C. c/o contacts. TYPES: N39, N95, N100, N101. NEW in maker's carton. Price 10 for £2·09

STROBE! STROBE! STROBE!

FOUR EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES, SOLID STATE TIMING + TRIGGERING CIRCUITS, PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION.

EXPERIMENTERS "ECONOMY" KIT
Adjustable 1 to 30 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + Instructions £7·20 incl. P. & P.

NEW INDUSTRIAL KIT
Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor. Adjustable 1-80 f.p.s., approx. ½ output of Hy-Lyght. Price £12·10. Incl. P. & P.

HY-LIGHT STROBE
Designed for use in large rooms, halls and the photographic field and utilizes a silica tube, printed circuit and a special trigger coil, Speed adjustable 1-20 f.p.s. Light output greater than many (so called 4 Joule) strobes. Price £13·75. Incl. P. & P.

'SUPER' HY-LIGHT KIT
Approx. 4 times the light output of our well proven Hy-Lyght strobe.
Incorporating, Heavy duty power supply.
Variable speed from 1-13 flash per sec.
Reactor control circuit producing an intense white light.

Never before a Strobe Kit with so HIGH an output at so LOW a price. ONLY £22·83, incl. P. & P.

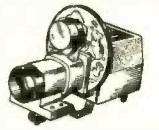
ATTRACTIVE, ROBUST, FULLY VENTILATED METAL CASE specially designed for the Super Hy-Lyght Kit including reflector, £8·20 incl. P. & P.

FOR HY-LYGHT STROBE incl. reflector, £4·90 incl. P. & P.

7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price 73p incl. P. & P.

RAINBOW STROBE FOUR LIGHT CONTROL MODULE
Will operate four of our Hy-Lyght or Super Hy-Lyght Strobes in either 1, 2, 3, 4 sequence; 2 + ; or all together. Thoroughly tested and reliable. Complete with full connection instructions. Price: £20·63 incl. P. & P. Send S.A.E. for details.

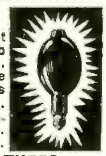
COLOUR WHEEL PROJECTOR



Complete with oil filled colour wheel. 100 watt lamp. 200/240V AC. Features extremely efficient optical system. £20·74, incl. P. & P.

6 INCH COLOURWHEEL
As used for Disco lighting effects, etc. Price £5·72 inc. p. & p.

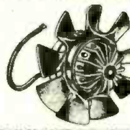
BIG BLACK LIGHT



400 Watt. Mercury vapour ultra violet lamp. Outer bulb designed to absorb visible light and transmit u.v. rays. Extremely compact and powerful source of u.v. Inumerable industrial applications also ideal for stage, display, discos etc. P.F. ballast is essential with these bulbs. Price of matched ballast & bulb £18·15. Incl. P.&P. Spare bulb £8·03, incl. P.&P.

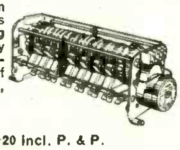
BLACK LIGHT FLUORESCENT U.V. TUBES
4ft. 40 watt. Price £6·38 incl. P. & P. (For use in standard bi-pin fluorescent fittings). MINI 9 inch 6 watt black light U.V. tube. £1·60 incl. P. & P. Complete ballast unit and holder for 9 in. tube £2·04 incl. P. & P.

BLOWER UNIT



200-240 Volt A.C. **BLOWER UNIT** Precision German built. Dynamically balanced, quiet, continuously rated, reversible motor. Consumption 60mA. Size 60mm. dia. x 60mm. high. Price £3·50.

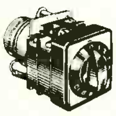
HONEYWELL PROGRAMME TIMERS



240V. A.C. 5 r.p.m. motor. Each cam operating a c/o micro switch. Cams are individually variable, allowing inumerable combinations. Ideally suited for machinery control, automation etc. Also in the field of entertainment, for chaser lights, animated displays, etc.
15 cam model £6·60 incl. P. & P.
10 cam model £5·50 incl. P. & P.
2 cam model with 15 r.p.m. motor £2·20 incl. P. & P.

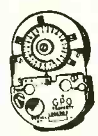
SIMPLE 12 CAM PROGRAMMER with 4 adjustable cams and 8 that may be profiled to individual requirements. Available with 15 or 13 r.p.m. motor £4·13 incl. P. & P.

24 HOUR TIMER



Can be adjusted to give a switching delay of between ½ hr. to 24 hrs. Driven by 200/250v. A.C. synchronous motor. 15 amp. c/o contacts. Mfg. Crater Controls Ltd. Supplied with scale calibrated 0-10 (2 hours per division) Brand new. £2·20 incl. P. & P.

VENNER ELECTRIC TIME SWITCH

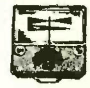


200/250 volt. Ex-GPO. Tested, perfect condition. Two ON. two OFF, every 24 hrs. at any manually pre-set time. Price: 15 amp, £3·80. 20 amp, £4·35. Incl. P. & P. Also available with Solar Dial ON at dusk, OFF at dawn. Prices as above.

INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 11p each. Incl. P. & P. Minimum order 6.

METER BARGAIN
BALANCE/LEVEL METERS



100-0-100 Micro Amp. Size 1½in. × 1½in. × ⅞in. Price only 83p including P. & P.

AMMETERS NEW! 2½in. FLUSH ROUND

available as D.C. Amps 1, 5, 15, 20 or A.C. Amps 1, 5, 10, 15, 20. Both types £1·93 incl. P. & P. 0-300V. A.C. £2·09 incl. P. & P.

RELAYS
SIEMENS PLESSEY, etc. MINIATURE RELAYS

1	2	3	4	1	2	3	4
				700	12-24	2 c/o	69p*
52	4-6	6M	69p*	700	15-35	2c/oHD	80p*
52	4-6	4 c/o	86p*	700	6-12	1c/oHD	55p*
150	6-12	4 c/o	86p*	700	16-24	6 M	69p*
185	8-12	6 M	69p*	700	20-30	6 c/o	83p*
280	9-12	2 c/o	80p*	1250	24-36	4 c/o	69p*
410	10-18	4 c/o	80p*	2500	36-45	6 M	69p*
600	9-18	2 c/o	69p*	2400	30-48	4 c/o	55p
700	16-24	4M2B	69p*	9000	40-70	2 c/o	55p*
700	16-24	4 c/o	86p*	15k	85-110	6 M	55p*

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD=Heavy Duty. All Post Paid. (*including Base)

12 VOLT D.C. RELAY
Type 1: Three sets c/o contacts 5 amp. 86p incl. P. & P. (Similar to illustration below).
Type 2: One set c/o contacts 66p incl. P. & P.
Type 3: 4-8 volt 3 c/o HD, 67 ohm coil. 86p incl. P. & P.

SPECIAL OFFER.
700 ohm. 4 c/o Ex. new equipment. £55·00 per 100 incl. bases (minimum 100).

'DIAMOND H' 230 VOLT A.C. RELAYS (Unused)

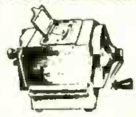
Three sets c/o contacts rated at 5 amps. Price 66p. incl. P. & P. (100 lots £44·00 incl. P. & P.)

230 VOLT A.C. RELAYS
One set c/o contacts rated at 7·5 amps. Boxed. Price 50p. Incl. P. & P. (100 lots £35·20 incl. P. & P.)

MINIATURE RELAYS
9-12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1 in. x ⅞ x ½ in. Price 64p incl. P. & P.
30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3,200 ohm coil. Size only 1 x 11/16 x ⅞ in. 47p incl. P. & P.

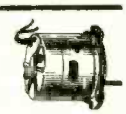
MINIATURE LATCHING RELAY
Mfg. by Clare-Elliott Ltd. (Type F) 2 c/o permanent latching in either direction. Coil 1150 ohm. 15-30 v. D.C. New 80p, incl. P. & P.

INSULATION TESTERS (NEW)



Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8 in., W. 4 in., H. 6 in. weight 6 lb., **500 VOLTS**, 500 megohms £30·80 carriage paid
1,000 VOLTS, 1,000 megohms £37·40 carriage paid

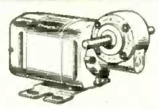
230V/240V COMPACT SYNCHRONOUS GEARED MOTORS



Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox.
5 RPM A/cw 3 RPH A/cw 20 RPH cw
2 RPH cw 6 RPH cw 12 RPH cw All at 83p
cw=Clockwise. A/cw=Anti-clockwise

REVERSIBLE SPLIT PHASE MOTOR
250 r.p.m. 100-115/210-240V AC. 2 in. × 1 in. Ideal for rim-drive models, display etc. Extremely powerful for size 83p. incl. P. & P. (including small capacitor.)

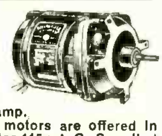
PARVALUX
Type: SD1.S/86896/0J



230/250v. A.C. 50 r.p.m. 7 lb/ins. Continuously rated. Less base £6·30

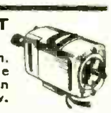
TYPE: SD1.S/89400/OM
230/250v. A.C. 50 r.p.m. 22 lb/ins. Continuously rated. Incl., base £8·03
The above motors are new and unused.

BODINE TYPE N.C.I. GEARED MOTOR



(Type J) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle ·38 amp. (Type 2) 28 r.p.m. torque 20 lb. in **Reversible** 1/80th h.p. 50 cycle ·28 amp.
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for 230/240v A.C. input.
Price, either type £4·81 incl. P. & P. or less transformer £2·77 incl. P. & P.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines, etc, etc.

PARVALUX TYPE SD2. 200/250 VOLT A.C. D.C. HIGH SPEED MOTOR



Speed 9,000 r.p.m. approx. or 3,200 r.p.m. if used with built-in governor, or variable speed over a wide range if used in conjunction with our Dimmer Switch, illustrated below. PRICE: £2·20 incl. P. & P.

600 WATT DIMMER SWITCH

Easily fitted. Fully guaranteed by makers. Will control up to 600 watts of all lights except fluorescent at mains voltage. Complete with simple instructions. £3·30 including P. & P.

ALL MAIL ORDERS, ALSO CALLERS AT:
57 BRIDGMAN ROAD, CHISWICK, LONDON, W4 5BB. Phone: 01-995 1560
Closed Saturdays.

SERVICE TRADING CO.
SHOWROOMS NOW OPEN
AMPLE PARKING

PERSONAL CALLERS ONLY
9 LITTLE NEWPORT STREET, LONDON, WC2H 7JJ.
Tel.: 01-437 0576

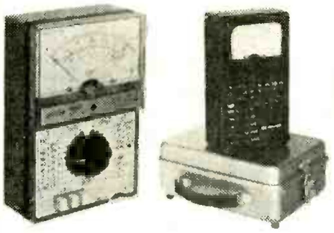
Z AND I AERO SERVICES LTD

ZAERIX BRAND

AC/DC TAUT SUSPENSIONS

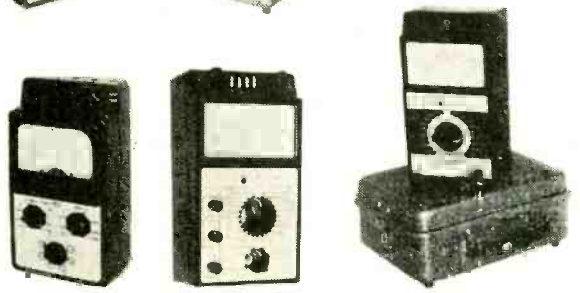
MULTIMETERS

(Made in U.S.S.R.)



Large selection of multimeters with prices ranging from £4·95 to £10·50.

Please write for full Catalogue.



ALL PRICES ARE EXCLUSIVE OF VALUE ADDED TAX. WHEN ORDERING BY POST PLEASE ADD £0.12½ IN £ FOR HANDLING AND POSTAGE (SUBJECT TO A MINIMUM CHARGE £0.15) AND 10% OF THE TOTAL VALUE FOR VAT.

FULL WAVE SILICON BRIDGE RECTIFIERS 1B100M10

100 p.i.v., 10 AMPS EPOXY ENCAPSULATED CHARGING RECTIFIERS.

AT A SPECIAL PRICE OF £3·50.

PHOTO EMISSIVE DEVICES

Photo-Transistors

OCP71	£0·90	BPX25	£1·00

Photo-Conductive Cells

ORP12	£0·50	ORP90	£1·10
ORP60	£0·50	ORP93	£1·00
ORP61	£0·32		

Photocells

90AG	£2·40	90AV	£2·50
90CG	£2·40	90CV	£2·40

SOLID STATE LIGHT EMITTING DIODES MV10B

TO18 outline. Brightness 500 FT-L at 50 mA. Forward voltage. 1.65 to 2V. Diode gives bright red pinpoint of light when supplied from a 2V source. Lens diameter 0.170 in. PRICE £0·85.

AVALANCHE RECTIFIERS

1AS029 1000 p.i.v., 1.5A, 1 surge 125A.	£0·30
RAS310AF 1000 p.i.v., 1.5A, 1 surge 40A.	£0·35
RAS508AF 960 p.i.v., 6A, 1 surge 100A.	£0·40

HIGH CURRENT THYRISTORS

BTX47-1000R; 1000V 11.5A.	£2·00
BTX47-1200R; 1200V 11.5A.	£2·50
BTX48-1000R; 1000V 16A.	£2·50

SILICON POWER RECTIFIERS

Wire Ended

BY101 450 p.i.v. 1.1A.	£0·15
BY105 800 p.i.v. 1.1A.	£0·20
BY126 650 p.i.v. 1A.	£0·10
BY127 1250 p.i.v. 1A.	£0·12

Stud Mounted

KD202B 50 p.i.v. 1A.	£0·15
KD202A 50 p.i.v. 3A.	£0·25
KD202G 100 p.i.v. 1A.	£0·15
KD202V 100 p.i.v. 3A.	£0·25
KD202E 200 p.i.v. 1A.	£0·20
KD202D 200 p.i.v. 3A.	£0·30

ZENER DIODES

1 watt 5%, series BZX61: 7.5 to 68V.	£0·20
2 watts 5%, series BZX70: 10 tp 27V.	£0·25
5 watts 10%, series D816: 22 to 47V.	£0·35
5 watts 10%, series D817: 56 to 100V.	£0·35
8 watts 10%, series D815: 4.7 to 18V.	£0·35

FULLY GUARANTEED ZAERIX BRAND FIRST QUALITY VALVES

Valve	£	Valve	£	Valve	£
OA2	0·40	5V4G	0·50	6BX6	0·25
OA3	0·48	5W4GT	0·55	6BX7GT	0·90
OA4G	1·00	5X8	0·70	6BZ6	0·45
OB2	0·40	5Y3GT	0·45	6C4	0·35
OB3	0·70	5Z3	0·75	6CB5A	1·50
OC2	1·00	5Z4G	0·45	6CB6	0·40
OC3	0·40	6/30L2	0·90	6CD6GA	1·30
1A3	0·45	6AS6	0·45	6CG7	0·60
1A5GT	0·45	6AB4	0·45	6CH6	0·60
1AB5	0·50	6AC7	0·50	6CL6	0·60
1B3GT	0·45	6AF4A	0·80	6CL8	0·80
1C5GT	0·45	6AG5	0·25	6CU6	0·80
1G4GT	0·60	6AG7	0·45	6CW4	0·70
1G6GT	0·60	6AH6	0·60	6CY5	0·50
1H5GT	0·55	6AJ8	0·30	6CY7	0·75
1L4	0·25	6AK5	0·40	6D3	0·55
1N5GT	0·55	6AK6	0·60	6DC6	0·80
1Q5GT	0·60	6AL3	0·43	6DE7	0·70
1R4	0·50	6AL5	0·22	6DK6	0·60
1R5	0·45	6AM6	0·37	6DQ6B	0·75
1S4	0·30	6AN8	0·60	6DS4	1·25
1S5	0·30	6AQ5	0·42	6E5	0·70
1T4	0·30	6AQ6	0·70	6EA8	0·65
1T5GT	0·50	6AR5	0·55	6EH7	0·30
1U4	0·40	6AR6	0·65	6EJ7	0·35
1U5	0·75	6AR11	1·25	6EW6	0·70
1V2	0·55	6AS5	0·50	6F5	0·75
1X2B	0·55	6AS6	0·45	6F6G	0·45
2A3	0·50	6AS7G	0·85	6F11	0·50
2AP1	3·00	6AT6	0·38	6F13	0·50
2C26A	0·60	6AU5GTA	1·25	6F14	0·70
2C40	5·00	6AU6	0·30	6F15	0·65
2C51	0·50	6AV5GTA	0·90	6F17	0·75
2CW4	0·75	6AV6	0·40	6F18	0·50
2D21	0·40	6AW8A	0·65	6F22	0·30
2E22	5·00	6AX4GTB	0·70	6F23	0·90
2E24	3·20	6AX5GT	0·75	6F24	0·80
2X2	0·60	6B4G	1·00	6F25	1·00
3A4	0·45	6B7	0·60	6F28	0·70
3A5	0·75	6B8G	0·30	6GK5	0·60
3B28	3·00	6BA6	0·28	6GK6	0·60
3D6	0·35	6BE6	0·32	6J4	0·60
3D21A	3·50	6BF6	0·55	6J5GT	0·40
3Q4	0·60	6BH6	0·75	6J6	0·30
3Q5GT	0·55	6BJ6	0·55	6J7	0·45
3S4	0·40	6BK4B	1·25	6K6GT	0·75
3V4	0·70	6BK7A	0·75	6K7	0·43
4-125	9·00	6BL7GTA	1·00	6K8G	0·45
4-250A	14·50	6BN6	0·60	6K8GT	0·50
4-400A	16·50	6BQ5	0·25	6K23	0·75
4THA	0·60	6BQ6GTB	0·80	6K25	0·75
5AR4	0·60	6BQ7A	0·55	6L7	0·45
5B/254M	2·80	6BR7	0·90	6L18	0·50
5B255M	3·20	6BR8	0·75	6LD20	0·50
5CP1	5·00	6BS7	1·35	6M11	1·50
5D21	6·00	6BW6	0·90	6N7GT	0·55
5R4GY	0·75	6BW7	0·90	6P28	0·65
U4G	0·40			6Q7	0·50
				6R7G	0·55
				6S2	0·40
				6S4A	0·70

Valve	£	Valve	£	Valve	£	Valve	£
6SA7	0·45	12AV6	0·45	30FL12	1·10	725A	25·00
6SC7	0·80	12AV7	0·70	30FL14	0·90	805	11·00
6SG7	0·45	12AX4GTB	0·70	30L1	0·40	807	0·50
6SH7	0·45	12AX7	0·33	30L15	0·95	812A	3·50
6SJ7	0·50	12AY7	0·75	30L17	0·95	813	4·00
6SK7	0·50	12B4A	0·65	30P13	0·80	829B	4·00
6SL7GT	0·45	12BA6	0·45	30P19	0·95	833A	17·00
6SN7GT	0·45	12BA7	0·50	30PL1	0·95	837	1·00
6SQ7	0·50	12BE6	0·50	30PL13	1·10	866A	1·00
6SR7	0·50	12BH7	0·50	30PL14	1·25	884	0·75
6SS7	0·40	12BY7	0·65	30PL15	1·25	927	4·00
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6U4GT	0·70	12E1	3·00	35C5	0·60	955	0·40
6U5	0·75	12E14	4·30	35D5	0·75	991	0·50
6U8A	0·48	12H6	0·35	35W4	0·40	4378	2·00
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6X8	0·65	12K7GT	0·50	42	0·60	5670	0·60
6Y6G	0·80	12Q7GT	0·45	50A5	0·80	5761	0·70
6Z4	0·50	12SC7	0·45	50B5	0·70	5763	0·80
7B5	0·75	12SG7	0·45	50C5	0·60	5796	12·00
7B6	0·75	12SH7	0·45	50CD6G	1·20	5814A	0·70
7B7	0·70	12SJ7	0·50	50EH5	0·65	5842	3·00
7F8W	1·00	12SL7GT	0·55	50L6GT	0·60	6072	0·90
7F7	1·00	12SN7GT	0·55	52KU	0·45	6080	1·75
7Z4	0·75	12SQ7	0·50	53KU	0·75	6146	1·60
10C2	0·60	12SR7	0·50	75B1	0·50	6146A	2·00
10D1	0·65	12X4	0·50	75C1	0·50	6146B	2·50
10D2	0·55	20D1	0·60	80	0·60	6360	1·25
10F1	0·75	20F2	0·70	83	1·35	6883	3·00
10F9	0·65	20L1	1·10	85A2	0·55	6922	0·70
10F18	0·60	20P1	0·50	85A3	0·60	6939	2·25
10L1	0·60	20P3	0·60	90AG	2·40	7025	0·50
10LD11	0·70	20P4	1·10	90AV	2·50	7199	0·85
10P13	0·75	20P5	1·20	90C1	0·75	7360	3·00
11D3	0·60	25L6GT	0·50	90CG	2·40	7551	2·00
11D5	0·60	25Z4G	0·35	90CV	2·40	7591A	1·00
11E2	4·00	25Z6GT	0·70	108C1	0·40	7895	1·50
11E3	4·80	30A5	0·60	150B2	0·70	9002	0·45
12AB5	0·70	30AE3	0·40	150B3	1·50	9003	0·50
12AC6	0·60	30C1	0·30	150C1	1·50	A1834	0·85
12AD6	0·60	30C15	1·00	150C4	0·65	A2900	3·00
12AH7GT	0·40	30C17	1·10	305	0·75	A2293	2·50
12AL5	0·55	30C18	0·90	310A	1·75	AC/HL/DD	0·70
12AQ5	0·60	30F5	1·00	311A	2·00	AC/TH1	0·60
12AT6	0·40	30FL1	0·80	328A	2·00	AZ31	0·55
12AT7	0·40			329A	2·00	BT5	9·00
12AU6	0·45			715A	3·00	C1166	26·00
12AU7	0·33			715C	6·00	CBL1	0·90
				723A/B	7·00	CBL31	1·00

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CL33	1·50	EBC33	0·60	ECL83	0·70	ELL80	0·85	HK90	0·50
CY31	0·50	EBC41	0·65	ECL84	0·55	EM71	0·80	HL23	0·50
DAF91	0·30	EBC81	0·33	ECL85	0·55	EM80	0·45	HL23DD	0·55
DAF92	0·75	EBC90	0·38	ECL86	0·40	EM84	0·35	HL42DD	0·70
DAF96	0·50	EBC91	0·40	ECLL800	3·20	EM85	1·00	HL92	0·60
DC90	0·60	EBF80	0·40	EF9	0·90	EM87	0·70	HL94	0·60
DF91	0·30	EBF83	0·40	EF36	0·60	EN10	6·00	KT8	2·50
DF92	0·25	EBF89	0·32	EF37A	0·85	EN11	5·00	KT36	1·20
DF96	0·50	EBL21	0·60	EF40	0·50	EN32	1·50	KT44	0·70
DH76	0·50	EBL31	1·50	EF41	0·65	EN91	0·40	KT45	2·00
DH81	0·70	EC53	0·50	EF42	0·70	EY51	0·40	KT66	2·35
DH101	0·70	EC80	2·65	EF80	0·25	EY80	0·75	KT71	0·60
DK40	0·65	EC86	0·60	EF83	0·60	EY81	0·40	KT76	0·60
DK91	0·45	EC88	0·60	EF85	0·35	EY83	0·55	KT77	1·00
DK92	0·70	EC90	0·35	EF86	0·30	EY84	0·60	KT88	2·25
DK96	0·60	EC92	0·45	EF89	0·28	EY86	0·40	ME91	0·65
DL66	1·25	EC93	0·60	EF91	0·37	EY87	0·43	ME1400	1·30
DL68	0·70	EC8010	2·25	EF92	0·35	EY88	0·43	MH4	0·75
DL91	0·30	ECC34	0·50	EF93	0·28	EZ35	0·45	ML6	0·60
DL92	0·40	ECC40	0·70	EF94	0·30	EZ40	0·50	MSPEN/7	0·70
DL93	0·45	ECC70	1·25	EF95	0·40	EZ41	0·75	MT17	5·50
DL95	0·60	ECC81	0·40	EF96	0·25	EZ80	0·28	MU12/14	0·75
DL96	0·55	ECC82	0·33	EF97	0·65	EZ81	0·29	N78	1·60
DM70	0·60	ECC83	0·33	EF98	0·75	EZ90	0·40	NSP1	5·00
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DY51	0·55	ECC85	0·40	EF184	0·35	FW4/500	0·75	PABC80	0·40
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DY87	0·36	ECC88	0·40	EF811	1·00	GC10B	4·50	PC88	0·60
E80CC	1·10	ECC89	0·50	EF812	0·90	GN4	1·50	PC92	0·50
E80CF	1·75	ECC91	0·30	EF814	0·80	GR10M	1·50	PC96	0·45
E80F	1·35	ECC189	0·65	EH90	0·50	GS10C	5·50	PC97	0·50
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E182CC	1·20	ECH42	0·75	EL81	0·55	GZ32	0·50	PCF80	0·30
E186F	1·25	ECH81	0·30	EL83	0·50	GZ33	0·75	PCF82	0·35
E188CC	1·10	ECH83	0·45	EL84	0·25	GZ34	0·60	PCF84	0·60
E810F	2·90	ECH84	0·45	EL85	0·43	HABC80	0·55	PCF86	0·60
EA50	0·25	ECL80	0·50	EL86	0·40	HBC90	0·40	PCF87	1·10
EABC80	0·38	ECL81	0·50	EL90	0·42	HBC91	0·45		
EAF42	0·60			EL91	0·40	HF93	0·45		
EAF801	0·50			EL95	0·35				
EB34	0·25			EL360	1·15				
				EL821	0·60				

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PCF800	1·00	QQV02-6	2·25	UC92	0·45
PCF801	0·50	QQV03-10	1·25	UCC85	0·45
PCF802	0·50	QQV03-20A	8·00	UCF80	0·70
PCF805	0·90	QS83/3	0·55	UCH21	0·60
PCF806	0·75	QU37	6·50	UCH42	0·70
PCF808	0·90	QV03-12	0·80	UCH81	0·40
PCH200	0·70	QY3-125	9·00	UCL81	0·60
PCL81	0·50	QY4-250A	14·50	UCL82	0·35
PCL82	0·35	QY4-400A	16·50	UCL83	0·65
PCL83	0·65	R18	0·60	UF9	0·65
PCL84	0·45	RG3-250A	0·85	UF11	0·60
PCL85	0·50	RL18	0·50	UF41	0·65
PCL86	0·45	S130	1·75	UF42	0·65
PCL88	1·25	S130P	1·75	UF43	0·65
PCL200	0·75	SP2	0·85	UF80	0·35
PCL800	1·10	SP4	0·70	UF85	0·40
PCL801	0·95	SP61	0·75	UF89	0·40
PCL805	0·50	TP22	0·80	UL41	0·65
PD500	1·30	TP25	0·60	UL84	0·48
PEN4DD	0·70	TT21	3·80	UM4	0·60
PEN36C	0·75	TT22	4·00	UM84	0·30
PEN45	0·75	TY2-125	11·00	UU5	0·75
PEN45DD	0·75	U18/20	0·75	UY1N	0·50
PEN46	0·50	U19	4·50	UY11	1·00
PEN383	0·75	U20	0·75	UY41	0·48
PEN384	0·75	U25	0·85	UY82	0·50
PEN453DD	0·75	U26	0·85	UY85	0·40
PF86	0·70	U31	0·70	VLS631	2·30
PF818	1·00	U37	6·50	VP41	0·75
PFL200	0·65	U50	0·45	VP133	1·00
PL33	0·40	U52	0·40	VR75/30	0·48
PL36	0·55	U76	0·40	VR105/30	0·40
PL38	0·65	U78	0·40	VR150/30	0·40
PL81	0·50	U191	0·75	VU33	0·75
PL82	0·45	U201	0·50	VU39A	0·75
PL83	0·45	U281	0·55	VU111	0·75
PL84	0·40	U282	0·55	VU120	1·00
PL302	0·95	U301	0·55	VU133	0·75
PL504	0·75	U403	0·70	W729	0·75
PL508	0·90	U404	0·70	X65	0·60
PL509	1·10	U801	0·80	X66	0·60
PL802	0·95	UABC80	0·40	X76M	0·60
PLL80	0·70	UAF41	0·70	XC11	1·00
PM84	0·65	UAF42	0·60	XC12	0·60
PY31	0·35	UB41	0·65	XC15T	0·50
PY33	0·63	UBC41	0·55	XC23	0·90
PY80	0·40	UBC81	0·45	XC25	0·40
PY81	0·30	UBF80	0·40	XR1-1600	12·00
PY82	0·35	UBF89	0·40	Z329	1·00
PY83	0·38			Z700U	0·60
PY88	0·40			Z719	0·25
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Please apply in writing, enclosing brief details of qualifications, experience and present salary to: L. A. Jemmett, Personnel Manager, Racal Group Services Limited, The Elms, Broad Street, Wokingham, Berks.

RACAL
The Electronics Group

Middlesex Polytechnic at Hornsey

Technical Assistant

Required to work in educational film and television unit based in Alexandra Palace Badminton Suite. A knowledge of electronics and experience of lighting and sound work essential, film editing an advantage. The post involves working with staff and students on CCTV studio production and on filming.

Salary on Technical T3 scale—£1,416 to £1,635—entry point according to experience and qualifications.

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Application forms from The Bursar (Ref. WW/6), Middlesex Polytechnic at Hornsey, Crouch End Hill, London, N8 8DG, to whom they should be returned within fourteen days of this advertisement.

[2656

ELECTROSONIC LIMITED
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to be responsible for the repair and maintenance of our expanding range of audio and projection control equipment in the Hire and Presentation Departments.

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Please write stating qualifications, age, experience and salary expected to :-

The Personnel Officer,
ELECTROSONIC LIMITED,
815 Woolwich Road,
London, SE7 8LT

[2674

AUDIO PRODUCTS
PRODUCTION; TEST; INSPECTION

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Applications are invited for a wide range of positions from trainee technical and supervisory through to qualified senior management levels. The vacancies occur on any of three sites situated in Essex.

Experience and qualifications required will depend on the level of enquiry but senior appointments will be offered to applicants conversant with high volume flow line production, test and inspection methods in the radio/hi fi audio equipment field. Alternatively, applicants capable of team motivation and sound administration in the electronics industry should also apply.

Written applications, setting out career details to date and current salary level to:—

**The Personnel Manager,
Thorn Consumer Electronics Ltd.,
62/70 Fowler Road,
Hainault,
Ilford,
Essex.**

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2627

Granada Television

Electronic Engineers for Operational Television

Expansion has created further vacancies at the TV Centre in Manchester for electronic engineers to work in all aspects of Granada's broadcasting operations, covering studio vision, videotape, telecine, transmission switching and maintenance of sound and vision equipment.

Vacancies exist at all levels from 1st year Engineer to Substantive Grade (6th year) Engineer at salaries between £1992 and £2944 per annum. Entry point will depend on experience. Candidates who lack experience in broadcast engineering will need a minimum of two years experience in communications engineering and preferably an ONC or equivalent. Shift work, including weekends. Generous Granada Group pension and life assurance benefits. Four weeks holiday.

Applications, stating full details of education and experience to:

Robert Connell Granada Television MANCHESTER M60 9EA

GRANADA

TECHNICIAN VACANCIES

Senior Laboratory Technicians at Research Department, Kingswood Warren, Surrey. (Ref: 73.E.4039)/WW

The work will involve field strength measurement and planning work associated with the development of the sound and television transmitter networks. Candidates should have a good knowledge of basic electronic circuits and of radio propagation theory, and preferably be qualified to O.N.C. or an equivalent level. Following a brief period of training, they will be expected to work with a minimum of supervision. Applicants must be prepared to travel and work for periods anywhere in the United Kingdom, including working some weekends. Starting salary in the range £1908 to £2118 rising by annual increments of £105 to £2433 p.a. Inexperienced candidates may initially be appointed at a lower grade and salary.

Laboratory Technicians at Equipment Department, Chiswick, London W.4. (Ref: 73.E.2098)/WW

Work will involve the checking and alignment of new electronic systems which are being made for the colour television and radio services. Applicants should have some knowledge of basic electronic circuits and be able readily to familiarise themselves with the test techniques employed on audio and video equipment. After gaining experience, Laboratory Technicians are encouraged to apply for vacancies which occur from time to time for Senior Laboratory Technicians. Starting salary £1674 to £1860 p.a., rising by annual increments of £93 to £2139 p.a. for Laboratory Technicians. Senior Laboratory Technicians rise to a maximum salary of £2433.

Receiver Technician at Equipment Department, Balham, London, S.W.12. (Ref: 73.E.4040)/WW

Duties include the overhaul, maintenance and installation of colour television and stereo sound receivers which are used for the critical appraisal of technical quality and programme content. Candidates should have a good general scientific education and have or be studying for an appropriate technical qualification. They must have had considerable experience in radio and television receiver servicing and be physically fit and be capable of undertaking roof work. Candidates must possess a current driving licence. Starting salary in the range £1674 to £1860 rising by annual increments of £93 to £2139. There are opportunities for progression to a higher grade with a roof salary of £2433.

All the above vacancies are pensionable and day release facilities for higher education will be considered in appropriate cases. Requests for application forms to the Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA, quoting the appropriate reference number and enclosing an addressed foolscap envelope. The closing date for completed application forms is the 11th June 1973. 2691

BBC

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If you would like to know more, please write to the Inspector of Wireless Telegraphy, Post Office, IMTR/WTS1.1.3, Union House, St. Martin's-le-Grand, London EC1A 1AR. L48

Post Office Telecommunications

91

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Fernando el Católico, 63
Madrid 15
SPAIN

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Mrs. Audrey Darkin, Pye Telecommunications Ltd., Cambridge Works, Elizabeth Ray, Cambridge CB4 1DW
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Mrs. Cath Dawe, Pye Telecommunications Ltd., Colne Valley Road, Haverhill, Suffolk. 2672

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Apply to:

crown agents

M. Division, 4, Millbank, London, SW1P 3JD for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/730367/WF

2606

Wandsworth Technical College **IBEA**

Wandsworth High Street, London, SW18 2PP

TELEVISION STUDIO

Senior Technician

up to £1,209

to be responsible for the general management of a large new well equipped Television Studio and Control Room.
He will be assisted by a Technician and will be responsible to the Vice-Principal.
The Senior Technician will be required to become fully conversant with all the equipment and to assist users to operate it. Post Ref. 1ST.

Technician

up to £1,788

Salary:
Senior Technician—on a scale within the range £1,629 - £2,019 with starting point and maximum dependant on qualifications and experience (plus £90 London Allowance).
Technician—on a scale within the range £1,248 - £1,698 with starting point and maximum dependant on age, qualifications and experience (plus £90 London Allowance).
Conditions include a basic 36½ hours per week with possibly some evening and overtime work.
Further details and application form from the Senior Administrative Officer; completed forms to be returned within 2 weeks of publication of this advertisement. Post Ref. 2T. [2659

TECHNICIAN TRAINEE

Intelligent young man 16-18 yrs old offered opportunity to train ultimately as a Public Address and Sound Recording Engineer. Must be of smart appearance and live with parents in Central London area. Write for interview to:

Managing Director,
GRIFFITHS HANSEN (RECORDINGS) LTD.
12, Balderton Street, London W1Y 1TF

2641

AUDIO ENGINEER

Required to maintain professional equipment. Experience in the field of studio and/or domestic sound essential.
Current driving licence an advantage.
Please write, giving full details to:
FELDON AUDIO LTD., 126 Great Portland Street, London, W1N 5PH. Attention W. Dyer. [2638

BROMLEY GROUP HOSPITAL MANAGEMENT COMMITTEE

ELECTRONICS MAINTENANCE TECHNCIAN

for the acceptance, testing and maintenance of a variety of electronic control and communication equipment and electro-medical apparatus.
Salary £1896 by increments to £2448.
Applicants must hold, as a minimum, O.N.C. or O.N.D. in Electronics or Light Current Electrical Engineering or the City & Guilds Final Certificate in Telecommunications Engineering. Practical experience in industry or the armed services is essential; hospital experience an advantage but training with manufacturers possible. Own transport, for which mileage is payable, essential.
Applications, with details of training, experience, age, etc., and naming two referees, to reach the Group Engineer "Bassetts", Starts Hill Road, Farnborough, Kent (Tel: Farnborough 53333), not later than 31st May, 1973.
No accommodation available for married applicants. [2655

ATV NETWORK LIMITED
has a vacancy in BIRMINGHAM for an

ENGINEER (Vac. 34)

APPLICANTS should have a good knowledge of television engineering, practical experience in the appropriate field being considered an advantage. Duties will include the operation and maintenance of VTR equipment and associated apparatus.

ENGINEER (Vac. 35)

A vacancy exists for an Engineer in the Outside Broadcast Vision Section.

APPLICANTS must have thorough theoretical knowledge and understanding of colour television broadcast engineering. They must also have experience of operating colour vision control equipment.

Previous O.B. experience would be an advantage. The job entails travelling and working away from base possibly for several days at a time.

SALARIES for both posts will be in the range £1,992 — £2,944 per annum according to qualifications and experience.

Application Forms may be obtained by writing to:
Head of Staff Relations,
ATV Network Limited,
ATV Centre,
Birmingham B1 2JP. 2673

Please quote the appropriate vacancy number.

ELECTRONICS TECHNICIANS, TEST, AND SERVICE ENGINEERS REQUIRED.

Interesting work on digital instruments and Radio Control Equipment.
Apply in writing to:—
J. A. BONIGENT,
Radio Control Specialists,
National Works, Bath Road, Hounslow. 2642

VTR ENGINEERS
up to
£6,000 p.a.
Home counties & Overseas
Box WW2666

SALESMEN AND SERVICE ENGINEERS

required by busy, expanding private company in one of Britain's pleasantest areas. These positions carry good salaries, life insurance and pension schemes and other benefits. We have a contented staff and good working conditions in comfortable modern premises. We require personable and knowledgeable staff and a number of vacancies are available in each category. The service engineers would need to be fully experienced with audio equipment and colour television.

Please apply in writing to:
MERROW SOUND LTD.
205-207 EPSOM ROAD,
GUILDFORD, SURREY. 2618

Production Engineer

We are well established with our Leak and Wharfedale range of equipment as quality brand leaders in the expanding hi-fi market. We shall be introducing shortly a new range of products into our Electronics factory and now wish to appoint an additional Production Engineer. He will liaise between the Development and Production departments, and his job will be to construct document and test electronic prototypes according to specifications and thus ensure that production standards are maintained throughout the pre-production phase.

This is a most interesting position and would be suitable for a man aged 25-40 with qualifications in Electronics and who has a sound knowledge of production methods and experience of similar work on radio and amplifier manufacture and testing.

Terms and conditions of employment are most attractive and prospects are good with this expanding company.

Please write to:
Mr. J. S. Bateman
Personnel Manager
Rank Radio International
Bradford Road
Idle
Bradford BD10 8SF

RANK RADIO INTERNATIONAL
[2605

A leading Radio Manufacturer in
JOHANNESBURG, SOUTH AFRICA
requires several experienced

FACTORY SUPERVISORS

AS WELL AS

RADIO TECHNICIANS

with good knowledge of Radio & Tape Recording circuits

For further information, please apply in writing, giving details of qualifications and résumé of career to:—

MR. G. MOSER,
Factory Manager,
TELTRON INDUSTRIES (PTY.) LTD.,
11, RICHARD STREET,
SELBY, JOHANNESBURG,
REPUBLIC OF SOUTH AFRICA.

[2614

WORK AS A

RADIO TECHNICIAN

ATTACHED TO SCOTLAND YARD

You'd be based at one of the Metropolitan Police Wireless Stations.

Your job would be to maintain the portable VHF 2-way radios, tape recorders, radio transmitters and other electronic equipment which the Metropolitan Police must use to do their work efficiently.

We require a technical qualification such as the City & Guilds Intermediate (telecommunications) or equivalent.

Salary scale:
£1,415 to £1,715 according to age from 21 to 25, to a maximum £2,025 p.a. (plus a London Allowance of £175 or £90 p.a.).

Promotion to Telecommunications Technical Officer will bring you more.

For details of this worthwhile and unusual job write to: Metropolitan Police, Room 733 (RT/WW), New Scotland Yard, Broadway, London SW1H 0BG or telephone 01-230 3122 (24 hour service).

[2613

ELECTRONIC ENGINEERS

CBS Records, part of the largest recorded music company in the world, are continuing their expansion into the pre-recorded tape market with their manufacture of cassettes and cartridges at Aylesbury, Bucks.

We now require Engineers with electro-mechanical or electronic experience for the maintenance of various types of machinery in the tape audio field.

There is an attractive salary, four weeks holiday, a good canteen, social club and pension scheme.

Interested? Please write or phone R. J. Black, Personnel Officer, for an interview.

CBS RECORDS

CHAMBERLAIN ROAD, AYLESBURY.
TELEPHONE: AYLESBURY 84331

ELECTRONICS ENGINEER

Required at the central research laboratories of the Wiggins Teape Group of Papermakers in Beaconsfield, Bucks. Applicants should be aged 21-27 and qualified to H.N.C. or equivalent. To work on the development of Electronic systems and instruments both digital and analogue.

A further post for a Technician is also available. Candidates should be aged 18-20 with O.N.C. (Engineering). Previous experience in an electronics laboratory desirable but applicants with an amateur interest considered.

Staff appointments with excellent salaries and conditions.

Please apply to: The Head of Personnel Service, Wiggins Teape Research and Development Ltd., Butler's Court, Beaconsfield, Bucks.

[2602

NORTH BIRMINGHAM & DISTRICT HOSPITAL MANAGEMENT COMMITTEE
GOOD HOPE DISTRICT GENERAL HOSPITAL

MEDICAL PHYSICS TECHNICIAN II

A post is being created at the above hospital within the Group Engineer's Department to initiate a unit dealing with maintenance of electro-medical, laboratory and other scientific equipment.

The successful candidate will possess an HNC. HND in electronics or equivalent, preferably with hospital experience.

Ability to organise servicing programmes for Electronic equipment, supervise activities of other technical personnel together with ability to liaise with medical staff is essential.

He will be concerned with enhancing reliability, capability and safety of all electro-medical equipment. With the expansion of the department there will be opportunities for promotion. Some travelling between centre and peripheral hospitals will be involved, travelling allowances will be paid at standard rates.

Basic salary commences at £1,911 increasing by eight increments to £2,508 p.a.

Application form, job specification and conditions of service may be obtained from:
The Group Engineer, Holly Lodge, St. Michael's Hospital, Lichfield. [2652

HEARING AID SERVICE MECHANIC

(experienced) required. Top rates.

Tel:- Mr. Allen 01-549 2611

[2654

DESIGN ENGINEER

20-30 year old General Electronic Design Engineer with some experience in Antenna design required for small expanding Company.

Must be capable of working by himself.

He should be willing to assist on test supervision and occasional visits to customers.

Please apply to:

Mr. D. A. R. Wallace — Managing Director,
Antenna Specialists UK Limited,
Thame Industrial Estate, Bandet Way,
Thame, Oxfordshire. Tel: Thame 3621/2

Wandsworth Technical College

IBEA

Wandsworth High Street, London, SW18 2PP

CLOSED CIRCUIT T.V. & AURAL-VISUAL AIDS

Senior Technician

up to £2,109

To be responsible to the Vive-Principle for the Closed Circuit T.V. system in the College (including operation, use and 1st line maintenance of equipment), and also for organising the use and maintenance of other Aural-Visual Equipment in the College. He will be assisted by a Technician.
This is a new job, full of interest and requires a person with sufficient technical background but also with clear thinking and organising ability. Post Ref. 3ST.

Technician

up to £1,788

to assist the Senior Technician and to have a prime interest in Aural-Visual Aids. Post Ref.
Salary:
Senior Technician—on a scale within the range £1,629 - £2,019 with starting point and maximum dependant on qualifications and experience (plus £90 London Allowance).
Technician—on a scale within the range £1,248 - £1,698 with starting point and maximum dependant on age, qualifications and experience (plus £90 London Allowance).
Conditions include a basic 36½ hours per week with possibly some evening and overtime work.
Further details and application form from the Senior Administrative Officer; completed forms to be returned within 2 weeks of publication of this advertisement. Please quote post Ref. 4T. [2660

SOUND ENGINEER

Experienced man with high standards required in the Public Address and Sound Recording Field, capable of organising and operating temporary P.A. Systems covering Conferences etc.—Knowledge of Electronics, tape editing and recording desirable.
Smart Appearance Essential—Salary negotiable—
Full written details to:
Managing Director.
GRIFFITHS HANSEN (Recordings) LTD., 12, Balderton Street, London W1Y 1TF
[2640

VIDEO ENGINEER

to take charge of operation and maintenance of B & W CCTV system Apply:
P. Sowerby. Tel: 01-240 5354
[2657

LONDON BOROUGH OF BRENT

Willesden College of Technology

Denzil Road, London, N.W.10 2XD

DEPARTMENT OF ELECTRICAL ENGINEERING

Required:
LECTURER GRADE I to teach on C & G Radio, Television and Electronic Technicians and Mechanics courses. Applicants should be well qualified and have appropriate practical experience.
SALARY: LI—£1,618 to £2,643. incl. London Allowance with increments for qualifications and experience.
Further particulars and application forms from the Registrar, to be returned within two weeks from the appearance of the advertisement.
2612

Test Engineers enjoy more variety at Redifon

. . . *and* one of the best-equipped electronics test departments in Britain.

You'll be working on a vast variety of solid-state devices, including — high-power transmitters, communications receivers, military pack-sets, MF beacons, mobile HF, marine VHF and teleprinter terminal equipment.

The job involves a wide area of testing operations—from GO/NO GO sub-assembly testing through to fault-diagnosis on complex systems.

Interesting work with one of the U.K. leaders in electronics expertise—located in London.

To qualify, you'll need to be thoroughly experienced in the field—with considerable knowledge of semi-conductor or logic circuitry.

We pay well—from £1,450 to over £2,200 p.a. (depending on experience) for a 37½ hour week with ample opportunities for overtime. Additional benefits include an excellent company pension scheme and generous sickness allowances.

Please write, including full details of your past experience, to:

Chief of Test
Redifon Telecommunications Ltd.,
Broomhill Road, Wandsworth, SW18 4JQ.

REDIFON

A Member Company of the Rediffusion Organisation 1970

ASSISTANT ENGINEERS Grade I/II

BOTSWANA

up to £3070 + Gratuity

- ★ Gratuity 25% of total basic salary
- ★ Subsidised accommodation
- ★ 24/36 month tour
- ★ Appointment Grant £100-£200 normally payable
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- ★ Holiday Visit Passages
- ★ Education Allowances
- ★ Free family passages

Required by the POSTS AND TELECOMMUNICATIONS Department to install open-wire carrier and VFT systems, VHF/UHF and microwave systems up to 300 channel capacity at 2 GHz.

Candidates for the GRADE I post must possess the City and Guilds Telecommunications Final Certificate and for the GRADE II post, the Intermediate Certificate, or equivalent qualifications. For either post candidates must be aged 25/45 years and have had five years' experience, excluding training, of the above mentioned equipment. Experience of single channel HF and VHF systems is also required.

Apply to: **M. Division, 4, Millbank, London, SW1P 3JD for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/720470/WF**
2619

SITUATIONS VACANT

A SENIOR DEVELOPMENT ENGINEER who has knowledge of HF SSB radio receivers and transmitters up to 10 KW is required to lead a small team engaged in new designs. Minimum qualifications HNC, salary negotiable up to £3,500 p.a. Assistance will be given with re-location expenses. Company is situated South West of London. Apply in writing to Box No. WW 2629.

AUDIO ELECTRONICS DESIGNER required to work on the development of sound recording equipment for the film and television industry. Previous experience in this field an advantage. For further details please contact Glyn Powell-Evans, P.A.G. Films Ltd., 492 Kingston Road, London, S.W.20. Tel. 01-542 1171. [2601

EXPERIENCED ENGINEER offers field service facilities London area covering Electronic and Electro-mechanical equipment.—Box No. WW2676.

HI-FI AUDIO ENGINEERS. We require experienced Junior and Seniors and will pay top rates to get them. Tell us about your abilities. 01-437 4607. [18

PART-TIME INSTRUMENT SALES. Expanding company seeks part-time Sales Engineers. High commission paid. Write with full particulars to Box No. WW 2637.

TELEVISION COLOUR SERVICE ENGINEER. Private Firm Glorious Devon. Some audio experience advantage. Pleasant Flat available suit young couple, no children.—Full particulars, Coles, 14, Wolborough Street, Newton Abbot. [2683

ARTICLES FOR SALE

AUTOMATIC audio frequency response plotter. "Radiometer" B.F.O. and chart recorder. Excellent condition, £450. Heath 10 18U oscilloscope, as new, £40. Roband 0-50V 2 Amp power supply transistorised, £20. Box No. WW 2621.

AARVAK ELECTRONICS. 3-channel sound-light converters, £18. Strobes, £16. Rainbow Strobes, £132.—12A Bruce Grove, N17 6RA. 01-808 9096. [23

BUILD IT in a DEWBOX quality plastic cabinet 2 in. x 2½ in. x any length. D.E.W. Ltd. (W.), Ringwood Rd., Fernwood, Dorset. S.A.E. for leaflet. Write now—Right now. [76

BRAND NEW FIBRE GLASS P.C. BOARD — NOT OFFCUTS. Custom cut to your own specified sizes, up to 12 x 11½in. per piece. High quality FLAME RETARDANT approved NEMA grade 1/16in. single sided one ounce copper at just 5½p per 6 sq. in. including all VAT charges. We offer a first-class service of a quality branded product. Minimum order value 50p. Add 10p p. and p. per sq. foot. (10p min.). Send CWO (not stamps) to S. & D. Systems Ltd., The Ridgeway, Trading Estate Iver, Bucks., SL0 9HW. [2663

COLOUR, UHF and TV SERVICE SPARES. Colour and UHF lists available on request. Varicap/Varactor UHF Tuners ELC1043 £4.50, VHF Varicap Tuners for Band 1 and Band 3 £2.85, Salvaged Varicap Tuners £1.50, incl. Connection Data, P/P 25p. Delay Lines DL20 £3.50, DL1 £1.50, P/P 25p. Luminance Delay Line 50p. P/P 15p. PHILIPS G6 Convergence Control Panel, Single Standard, 16 Controls Switches, etc. £5.00, P/P 25p. Philips G6 Decoder Panel incl. DL1E, Crystal, etc., £6.50, P/P 30p. G8 Decoder Panels, almost complete, incl. I/C, £2.50, P/P 25p. BUSH CTV25 surplus Time Base Units, Frame, Line & EHT, £3.95, P/P 80p. GEC 2040 surplus Panels suitable for parts, Decoder £3.50, Time Base £1.00, RGB £1.00, P/P 25p. Mullard type colour Scan Coils plus latest convergence coils for electronic control of static convergence £5.25, P/P 35p. PYE CT70 Colour LOPT assy. incl. EHT output and focus control £3.50, P/P 35p. Integrated transistd. decoder unit incl. circuits £1.25, P/P 10p. Colour Crt. Base 25p, P/P 25p. B9D valve bases for colour valves and PL500 series 10p, P/P 5p. UHF tuners transistd. £2.85, incl. slow motion drive, indicator £3.95. 6 Position transistd. push button £4.95. UHF/VHF basic integrated tuner £3.25. Cyldon UHF valve tuners £1.50; all tuners P/P 25p. Transistd. UHF/VHF IF panels £4.75 (or salvaged £2.50) P/P 25p. MURPHY 600/700 series complete UHF conversion kits incl. tuner, drive assy., 625 IF amplifier, 7 valves, accessories housed in cabinet plinth assembly £7.50 P/P 50p. SOBELL/GEC 405/625 Dual standard switchable IF amplifier and output chassis incl. cct. £1.50 P/P 30p. THORN 850 Dual standard time base panel £1.00 P/P 30p. PHILIPS 625 IF amplifier panel incl. cct. £1.00 P/P 25p. VHF turret tuners AT7650 incl. valves for KB featherlight, Philips 19TG170, GEC 2010 etc. £2.50, PYE miniature incremental for 110 to 830, Pam and Invicta £1.95, A.B. miniature with UHF injection suitable KB, Baird, Ferguson, 75p, Ekco, Ferranti, Plessey push button with UHF injection £1.00, all tuners P/P 25p. New fireball tuners Ferguson, HMV, Marconi £1.90 P/P 25p. Large selection LOPTs, Scan coils, FOPTs available for most popular makes. PYE/LABGEAR transistd. Masthead UHF Booster £5,25, Power unit £4.25 P/P 25p, or setback battery operated UHF booster £4.25 P/P 25p. MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6 (No. 28, 59, 159 Buses or W. Hampstead Bakerloo and Brit ;Rail). MAIL ORDER: 64 GOLDERS MANOR DRIVE, LONDON, N.W.11. Tel. 01-794 8751. [60

CLOSED CIRCUIT TV CAMERA Shiba HV-14 and Video Tape Recorder Shibaden SV.700E in nearly new condition for sale together £300. Contact Jersey Central 24809 or write Arkay Music, 16 York Street, St. Helier, Jersey. [2610

COSSOR 1035 Double Beam Scope, good condition, space needed hence bargain at £12.50.—'Phone 01-449 8409 after 6.30 p.m. [2679

CONTRACT WANTED with outlet for high quality components. Large quantities of bankrupt stock, surplus components, transistors, caps, resistors, tuners, audio from W. German sources, could be reciprocal arrangement. Write SIMAC, Thames House, Thames Street, Sunbury on Thames, Middx. [2583

ELECTRONICS TECHNICIAN

We require a specialist to join a small team engaged on the design and construction of transistorised and integrated-circuit equipment for electro-hydraulic control. In order to contribute to our product development effort the successful candidate will

either: have a minimum of 3 years experience covering the use of electronic instrumentation, and circuit checking, together with formal instruction, such as City & Guilds, or training with the Armed Forces.

or: be qualified to HNC level and have approximately 1 year's experience in this field.

We are a major international company offering secure employment and good working conditions. Benefits include 4 weeks annual vacation, subsidised canteen, life assurance and pension scheme.

SPERRY VICKERS

EUROPEAN GROUP
SPERRY RAND LTD
78 PORTSMOUTH ROAD
COBHAM KT11 1HY SURREY
TEL COBHAM 4161

[2645

TECHNICIANS
FOR
PRODUCTION ENGINEERING (ELECTRICAL) DEPARTMENT

Good Remuneration & Prospects. Preference will be given to those with experience in design, construction and maintenance of T.V. test gear.

Write with experience details to

Personnel Manager
Pye Ltd: Manufacturing Division
Oulton Works, School Lane
Lowestoft, Suffolk

2603

TV Studio Engineer

The Road Transport Industry Training Board has in operation at its Wembley Headquarters, a 3-camera broadcast-quality colour television studio with full telecine and video recording facilities, which includes R.C.A. TR 50 and 1" Helical Scan systems. We now wish to appoint an experienced studio engineer to join a small team working on the production of training and educational television programmes.

The applicant should not be less than 24 years of age and have a good working knowledge of the above equipment. Salary will be negotiable depending on qualifications and experience. Three weeks' holiday, contributory pension and life assurance scheme.

Please send all relevant personal history stating how the above requirements are met and quoting reference ZH.297 to:

Mrs. H. M. Brown, Personnel Manager,
Road Transport Industry Training Board,
Capitol House, Empire Way,
Wembley, Middlesex, HA9 0NC.

OFFICER COMMANDING

Force Electronic Workshop

Brunei

- ★ Salary up to £4500
- ★ 12½% gratuity
- ★ Tour of 24 months with prospect of renewal
- ★ Free family passages
- ★ NO INCOME TAX
- ★ Free accommodation
- ★ Education Allowances
- ★ School children's visit passages

Required by the ROYAL BRUNEI MALAY REGIMENT to run the air conditioned Workshop, which will include equipment repair and the implementation of a scheduled inspection and testing programme; administration of personnel under his command; part-time training of small numbers of local technicians.

Candidates, 38-45 years, must be ex-Services, Technical Branch (e.g. R. Signals, REME) and possess at least 15 years' experience in Service Communications with a good record of man-management and administrative ability. They need possess no formal qualifications although AMBIM or equivalent, AMIEE or AMIERE would be an advantage. Previous experience of the Far East is desirable.

For further particulars you should apply, giving brief details of experience to:
M. Division, 4, Millbank,
London, SW1P, quoting
reference number
M2K/730414/WF.

2643

TEST ENGINEERS

The leading U.K. manufacturer of high grade TV monitors require Test Engineers for their expanding Test Department.

Situated in the Berkshire town of Maidenhead, the Company offers pleasant working conditions, good salaries and friendly environment.

Duties will cover the testing and trouble-shooting of monochrome and colour TV monitors together with other ancillary sophisticated TV broadcast equipment manufactured by the company. Previous experience of TV equipment would be an advantage. Please apply to:

PROWEST ELECTRONICS
Boyn Valley Road, Maidenhead, Berks.
Maidenhead 29612

[2670

ABILITY

IS THAT YOUR MIDDLE NAME?

Then come and join us at TELENG, we need you.

JUNIOR AND SENIOR ELECTRONIC DEVELOPMENT ENGINEERS

are urgently required for our expanding UHF/VHF Television Distribution Laboratory.
Write or phone for an immediate interview (which can be arranged outside normal working hours if necessary) to:
Mrs. V. NELSON,
Personnel & Training Officer,
ARISDALE, AVENUE, SOUTH OCKENDON, ESSEX.
Tel. South Ockendon 3477.

[2599

Broadcast Video Tape Engineer

required for expanding company near London Airport. To have good knowledge of TV Broadcasting and use of Tele-Recording equipment would be useful. Excellent salary for man with right experience. The Company operate a length of service incremental scheme and pay London weighting allowance.

Phone: 01-759 5432

ask for Mr. R. Hallen or write:
THE VIDTRONICS CO. (U.K.) LIMITED,
Bath Road, Harmondsworth, West Drayton, Middlesex.

2644

DIODES SILICON RECT. GLASS lamp 100 to 800PIV. Offers for 2,600 complete stock. Box No. WW2597.

EARPHONES, ZA-Can 0842, with matching ear-cushions. About 125 pairs, as new, to be sold in one lot. Buyer collects. Phone: Littler, Woodbridge (Suffolk) 2647. [2624

ELECTRIC WIRE: 3 core rubber covered cable, 28/0076, £4.00 per roll, plus p.&p. 75p; 3 core pvc black cable, 14/0076, £3.50 per roll, plus p.&p. 50p; single core black pvc, 14/0076, 60p per roll, plus p.&p. 20p; 3 core black pvc flat, 28/0076, £3.50 per roll, plus p.&p. 50p; single core pvc black, 14/36, 60p per roll, plus p.&p. 20p. **Flat Instrument Case** Braid 5/16in. wide, 50p per roll, plus p.&p. 20p. (All the above in 100 yds. rolls.) **Plastic (Rigid) Sheet,** ABS brown 38in. x 40in. x .10 thick, 25p each, plus p.&p. 10p; 1/20 hp Fracmo motor, fitted with W51 gearbox, complete with capacitor £4.50 each, plus p.&p. 50p. **Plastic sheet** (grey), 54in. wide x 100 yds. rolls, £12.50 per roll, plus p.&p. £2 or £1.00 per 3 yds., plus p.&p. 30p. Broxbourne Eng. Co., Salisbury Road, Hoddesdon, Herts. [2554

ERIE CERAMICS—PRICES 1/3p. 10/25p, 100/£1. Values In PF:- 1. 1.5. 1.8. 2.2. 2.5, 2.7. 3.3. 3.9, 4, 4.2. 4.4. 4.7, 5, 6, 6.8, 9.1, 10. 12. 13. 15, 16. 18, 18.5, 22, 33, 43, 47, 50. 60, 68. 70. 82, 120, 175, 390, 470. 550, 656, 700, 820, 1000. 1200, 1500. 1800, 2200, 2500, 3300. 3900. 5600, 8200PF. Postage 10p. ELECTRONIC MAILORDER. Ramsbottom, Bury. Lancs. [2685

FRY'S 10in. Wave Flowsolder Machine complete with Stand and Motorised conveyor 230/250V, 50 cycle, filled with solder. Good working condition. Can be viewed by appointment. Contact: Mr. L. Clark, telephone Lodge Hill 3441, ext. 34. [2562

FOR SALE: 8 Pye Westminsters W15 and ex-commercial, recent, band-A 148-174 MHZ, in working order. £70 each. Evans, 104 Stonnall Road, Aldridge, Staffs. Tel: Aldridge 51551. [2622

GLASS FIBRE P.C. BOARD large supplies available. 1/16 in single sided one ounce copper 2p per 3 sq. inches (under 1 ft). 75p per sq. ft. (over 1 ft). 1/16 in double sided one ounce copper 1p per sq. inch (under 1 ft). £1 per sq. ft. (over 1 ft). Please add 10p per sq. foot postage and packing. We can cut to your size at 1p per cut. Solid State Lighting, The Firs, Smallworth Lane, Garboldisham, Diss, Norfolk. [16

LARGE Quantity test equipment. Receivers, transceivers, meters, variacs PSV's. Over 1,000 items for immediate disposal. S.A.E. plus 25p, refunded on purchase over £2.00. F. J. C. Colne Mill, Alvington, Gloucs. [2475

LABGEAR LSM 100p mobile transmitter receiver circuit, diagrams and workshop manual, will accept copies if complete urgent. Box No. 2543 WW.

OSCILLOSCOPES. Tektronix 515A. Frequency—DC to 15 MC, 2 cycles to 15 MC.A.C. Rise time .023 microselonds. 22 Calierated time bases .2H SEC/CM to 2 SEC/CM. Sweep manifer to .04u SEC/CM. Offers. Solartron double beam C.C. 1014-2 £50. Complete with manuals. Phone Coventry 414047 after 2.30 p.m. [2598

PRINTED Circuit Exposure Unit, 30 x 40, Fully Automatic, travelling source — almost new. £900 o.n.o. Cost £1,800 new. Ring 01-534 4123. [2671

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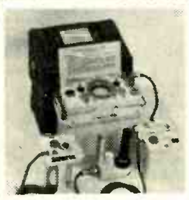

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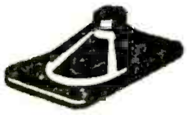

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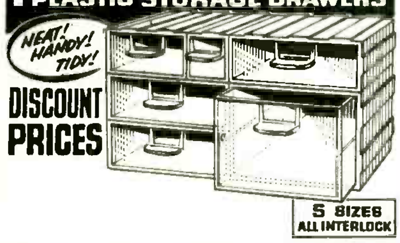

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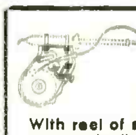

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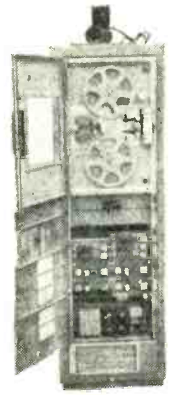

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