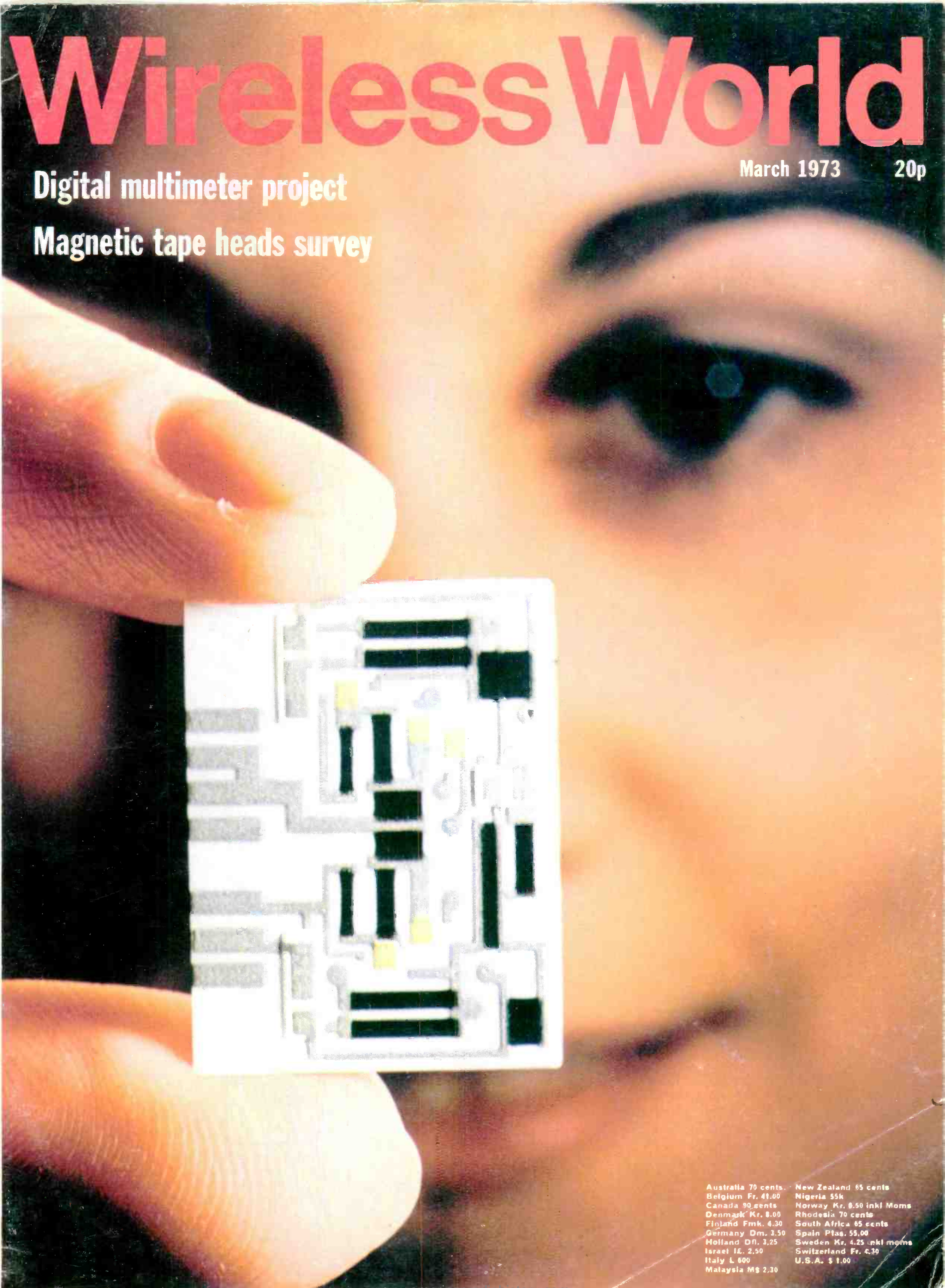
Wireless World

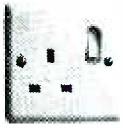
March 1973 20p

Digital multimeter project

Magnetic tape heads survey



Australia 70 cents.
Belgium Fr. 41.00
Canada 90 cents
Denmark Kr. 8.00
Finland Fmk. 4.30
Germany Dm. 3.50
Holland Dfl. 3,25
Israel I£. 2,50
Italy L 600
Malaysia M$ 2,30
New Zealand 65 cents
Nigeria 55k
Norway Kr. 6.50 inkl Moms
Rhodesia 70 cents
South Africa 65 cents
Spain Ptas. 55,00
Sweden Kr. 4.25 inkl moms
Switzerland Fr. 4.30
U.S.A. $ 1.00

Think of what you'd pay for a Digital Frequency Counter and a Modulation Meter capable of testing mobile radio both in the field and on  the bench

now halve it!

Our new TF2424 Frequency Counter is light, compact and portable – designed for field and workshop maintenance of mobile radio installations. Measures frequencies directly in the v.h.f. and u.h.f. bands with a 4-decade solid state numeric display.
The provision of x1 and x1000 ranges allows measurements up to seven digits to 512MHz. In addition a x10 facility increases the resolution to 10Hz. Crystal stability is ±1 x10^{-7}. Battery operated with a built-in charger. Weight: 6½ lb. Supplied with detachable mains lead and various optional extras. Price: £425 (inc. batt.).

The TF2303 narrow band Modulation Meter is also very compact and portable – designed for use on FM and AM mobile radios. Noise level is low: better than —40 dB relative to 5kHz deviation. Measures narrow band f.m. deviation up to 15kHz at carrier frequencies up to 520MHz, a.m. depths up to 95% at carrier frequencies up to 225MHz. Battery or mains operated – built-in charger. Weight 13 lb. Supplied with mains lead and various optional extras. Price: £305 (plus £25 for optional re-chargeable battery).

Which means you could buy the pair for just over £750 – or about half the price of two equivalent competitive models. Full details by return.

mi

MARCONI INSTRUMENTS LIMITED
Longacres, St. Albans, Herts, England.
Tel: St. Albans 59292 Telex: 23350
A GEC-Marconi Electronics Company

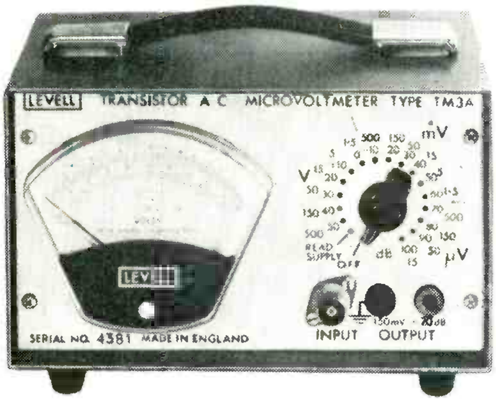
WW—001 FOR FURTHER DETAILS

LOW COST VOLTMETERS

LEVELL
PORTABLE INSTRUMENTS

NOTE: All prices subject to V.A.T.

These highly accurate instruments incorporate many useful features, including long battery life. All A type models have $3\frac{1}{4}$" scale meters, and case sizes 5" x 7" x 5". B types have 5" mirror scale meters and case sizes 7" x 10" x 6".



A.C. MICROVOLTMETERS

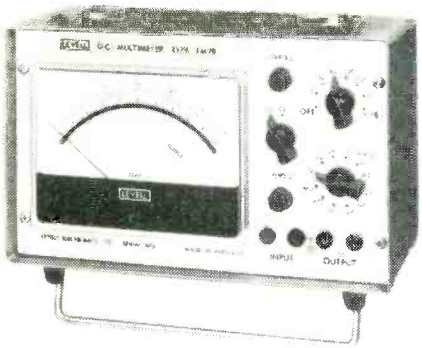
VOLTAGE & db RANGES: 15µV, 50µV, 150µV ... 500V f.s.d. Acc. ± 1% ± 1% f.s.d. ± 1 µV at 1 kHz. – 100, – 90 ... + 50dB, scale – 20dB/ + 6dB rel. to 1mW/600Ω.
RESPONSE: ± 3dB from 1 Hz to 3MHz, ± 0·3dB from 4Hz to 1 MHz above 500µV. Type TM3B can be set to a restricted B.W. of 10Hz to 10 kHz or 100 kHz.
INPUT IMPEDANCE: Above 50mV : > 4·3MΩ < 20pf. On 50µV to 50mV : > 5MΩ < 50pf.
AMPLIFIER OUTPUT: 150mV at f.s.d.

£49 type TM3A **£63** type TM3B

D.C. MICROVOLTMETERS

VOLTAGE RANGES: 30µV, 100µV, 300µV ... 300V. Acc. ± 1%, ± 2% f.s.d., ± 1µV. CZ scale.
CURRENT RANGES: 30 pA, 100 pA, 300 pA, 300 mA. Acc. ± 2%, ± 2% f.s.d., ± 2 pA. CZ scale.
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

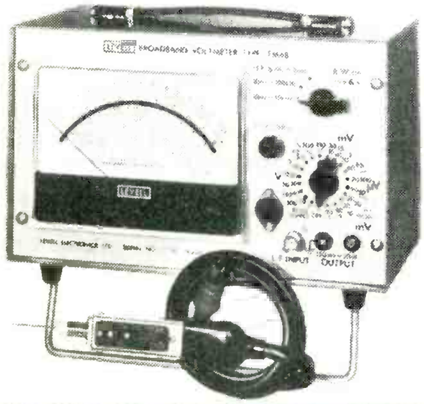
£55 type TM10 (appearance similar to type TM9B)



D.C. MULTIMETERS

VOLTAGE RANGES: 3µV, 10µV, 30µV ... 1kV. Acc. ± 1% ± 1% f.s.d. ± 0·1µV. LZ & CZ scales.
CURRENT RANGES: 3pA, 10pA, 30pA ... 1mA (1A for TM9BP) Acc. ± 2% ± 1% f.s.d. ± 0·3pA. LZ & CZ scales.
RESISTANCE RANGES: 3 Ω, 10 Ω, 30 Ω ... 1kM Ω linear. Acc. ± 1%, ± 1% f.s.d. up to 100M Ω.
RECORDER OUTPUT: 1V at f.s.d. into > 1k Ω on LZ ranges.

£75 type TM9A **£89** type TM9B **£93** type TM9BP



BROADBAND VOLTMETERS

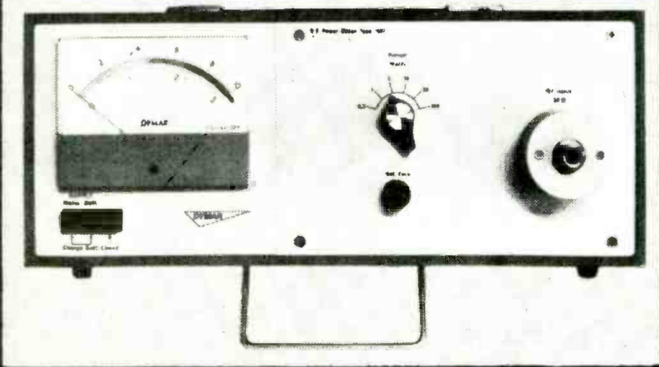
H.F. VOLTAGE & dB RANGES: 1mV, 3mV, 10mV ... 3V f.s.d. Acc. ± 4% ± 1% of f.s.d. at 30MHz. – 50dB, – 40dB, – 30dB to + 20dB. Scale – 10dB/ + 3dB rel. to 1mW/50 Ω ± 0·7dB from 1MHz to 50MHz. ± 3dB from 300kHz to 400MHz.
L.F. RANGES: As TM3 except for the omission of 15µV and 150µV.
AMPLIFIER OUTPUT: Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

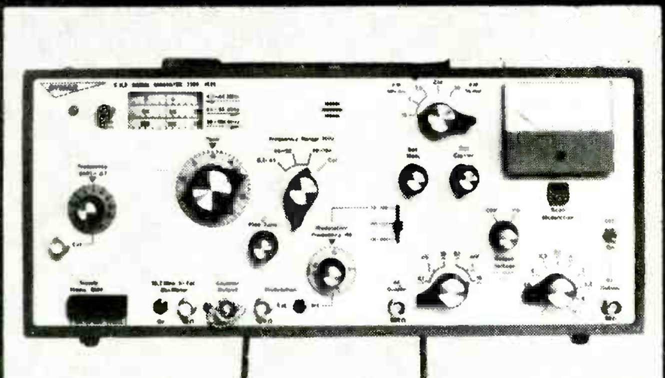
£85 type TM6A **£99** type TM6B

Send for literature covering our full range of portable instruments.

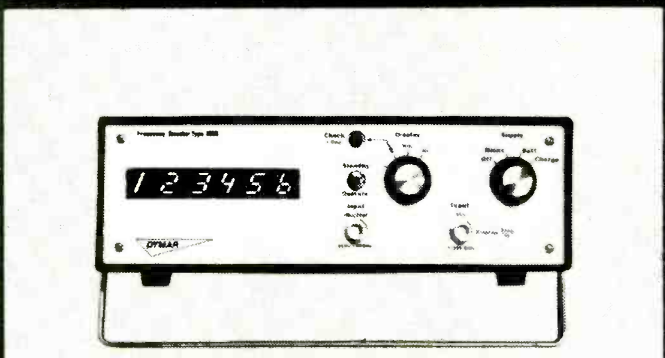
LEVELL ELECTRONICS LTD. Moxon Street, High Barnet, Herts. EN5 5SD Tel: 01-449 5028/440 8686

From the Dymar instrument range, take the 1581 RF power meter.

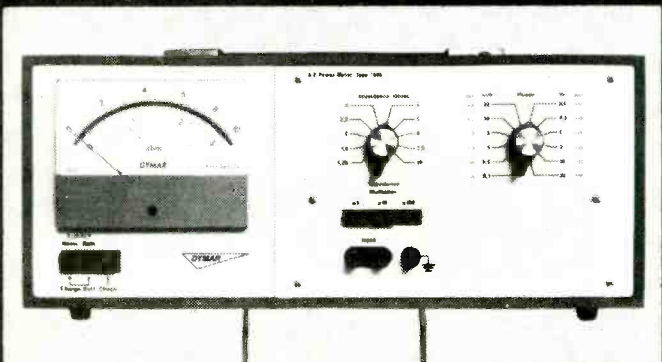




1525



1620



1585

1765

Anywhere.

Take it into the test bay – it's rack mountable. Take it into the field – it works as well from its rechargeable NiCd batteries as it does from AC mains.

The new Dymar 1581 is an RF power meter intended primarily for testing the transmitters of HF, VHF and UHF portable, mobile and base radiotelephones.

The technical specification includes a wide power measuring range from 30mW to 100W and a frequency range of from DC to 500MHz. 'True' power is measured, regardless of harmonic or sideband content, by a UHF thermocouple. Large linear scales in 1-3-10 sequence make for easy accurate reading, VSWR is 1:1.3 at 500MHZ and accuracy is 5% of fsd to 200MHz and 10% to 500MHz.

With performance like that, the 1581, like many other Dymar instruments, will turn up, too, in a good many laboratories. Not to mention on the premises of some of our rival RT manufacturers.

Dymar instruments are like that. A lot of people take them to a lot of places. They're good, versatile and available.

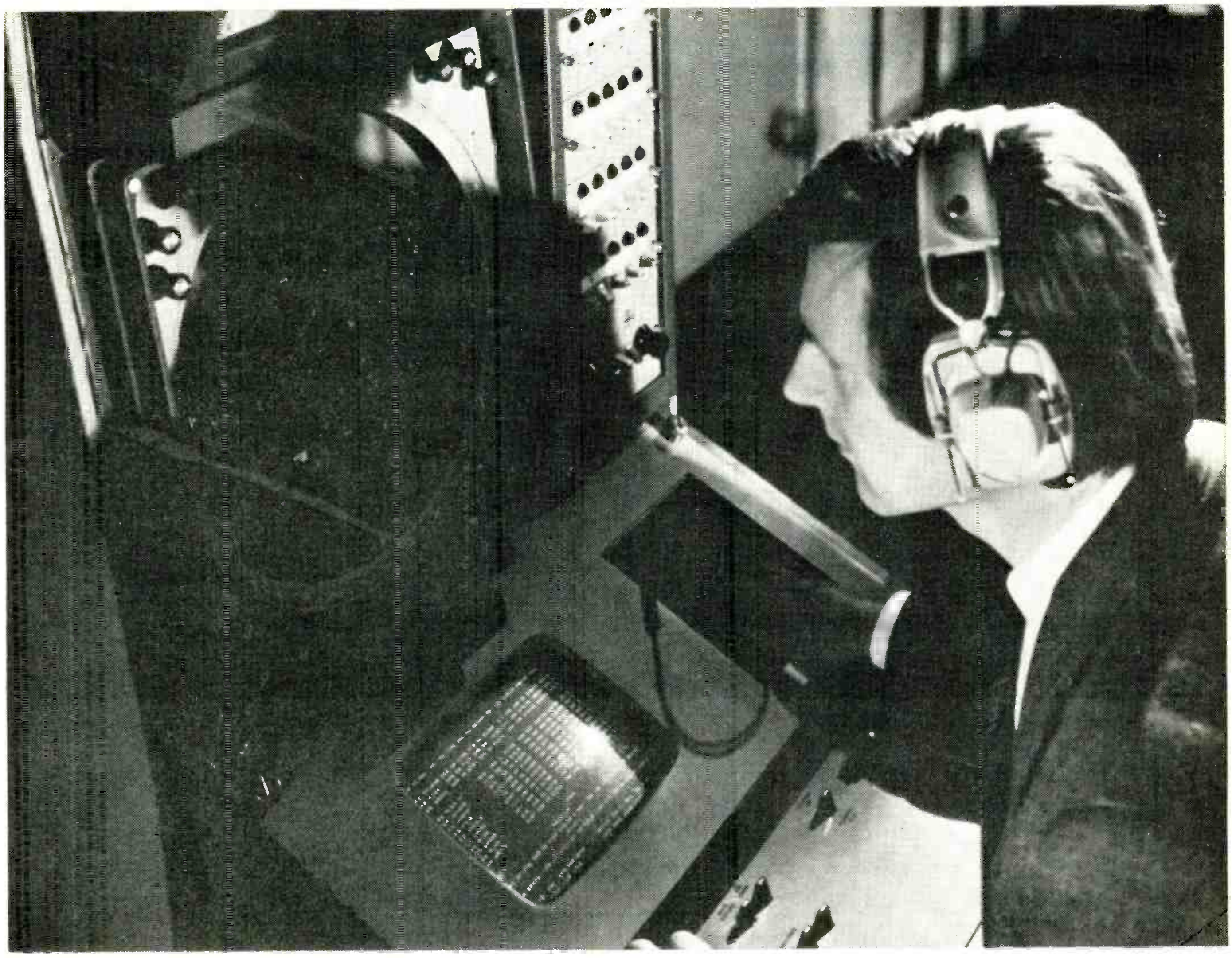
Use the Reader Enquiry Service for more details, or contact Dymar direct.

DYMAR **the name in radiotelephones**

Dymar Electronics Limited Colonial Way Radlett Road Watford Hertfordshire WD2 4LA. Tel: Watford 21297 Telex: 923035 Cables: Dymar Watford

WW—005 FOR FURTHER DETAILS

Presenting the facts



Wherever there's a clear need for the swift and accurate presentation of data, you'll find a cathode ray tube from M-OV.

In the air, for example, where the sturdy 700J Series tubes are used to project vital information to the pilots of fast-moving jets via head-up displays. Or the compact 700H Series projection units which enable large displays to be presented in situations unsuitable for conventional, large screen tubes.

Or on the ground, where M-OV's uniform density spot systems give better resolution and enhanced legibility than conventional tubes. You'll find them in many control installations, presenting both analogue and alpha-numeric information.

Or at sea in marine radar installations. Or in industry... or in any situation where a superior tube, quality engineered to the highest specs (BS 9000, CV and MIL) is essential.

Our comprehensive catalogue gives full details of all our tubes, including those for instrumentation, radar, data display and TV studio applications.

So if you'd like the facts about M-OV tubes, please write, phone or telex.

A BRIEF SELECTION FROM THE DATA DISPLAY & AVIONIC TUBE RANGE

TYPE	SCREEN SIZE AND SHAPE cm	FINAL ANODE VOLTAGE kV	DEFLECTION ANGLE degrees	SPOT SIZE mm	LENGTH mm
700H	7 (circular)	30	35	0.10	259
700J	7.5 (circular)	15	45	0.15	195
A17-20	17 (rectangular)	12	45	0.25	345.5
T9017	21 (rectangular)	14	60	0.25	290
2800B*	28.5 (rectangular)	8	50	0.30	506
A36-48	35 (rectangular)	14	70	1.0	455
T994*	42.5 (rectangular)	15	70	0.25	608

*Uniform density spot types

G.E.C. The M-O Valve Co. Ltd Hammersmith, London W6 7PE. Tel: 01-603 3431. Telex: 23435. Cables: Thermionic London

A member of The GEC Electronic Tube Co. Ltd., a management company which unites the activities of The M-O Valve Co. Ltd., and English Electric Valve Co. Ltd.

WW—005 FOR FURTHER DETAILS

Custom Tailoring...

. . . but at off-the-peg prices.

That's the GEC range of miniature magnetrons. Seven versatile versions of one proven, lightweight design. All built to conform to the most rugged and demanding military and civil specifications. Custom tailored for all potential applications, from low-cost marine radars to ultra-sophisticated airborne and military systems.

Little bigger than a latch key, a GEC magnetron weighs about 250 gms, operates at 800V anode voltage and 0.5 to 2A anode current and gives up to 300 watts peak power. Options include fast warm up—90% output power is available within two seconds of initial switch on of heater.

And you can choose models with nominated fixed frequencies over the range 9 to 17GHz or with limited tuning capabilities. Interline noise and r.f. leakage are exceptionally low and sophisticated construction eliminates missing pulses.

To find out more about these versatile GEC magnetrons, please contact the address below.

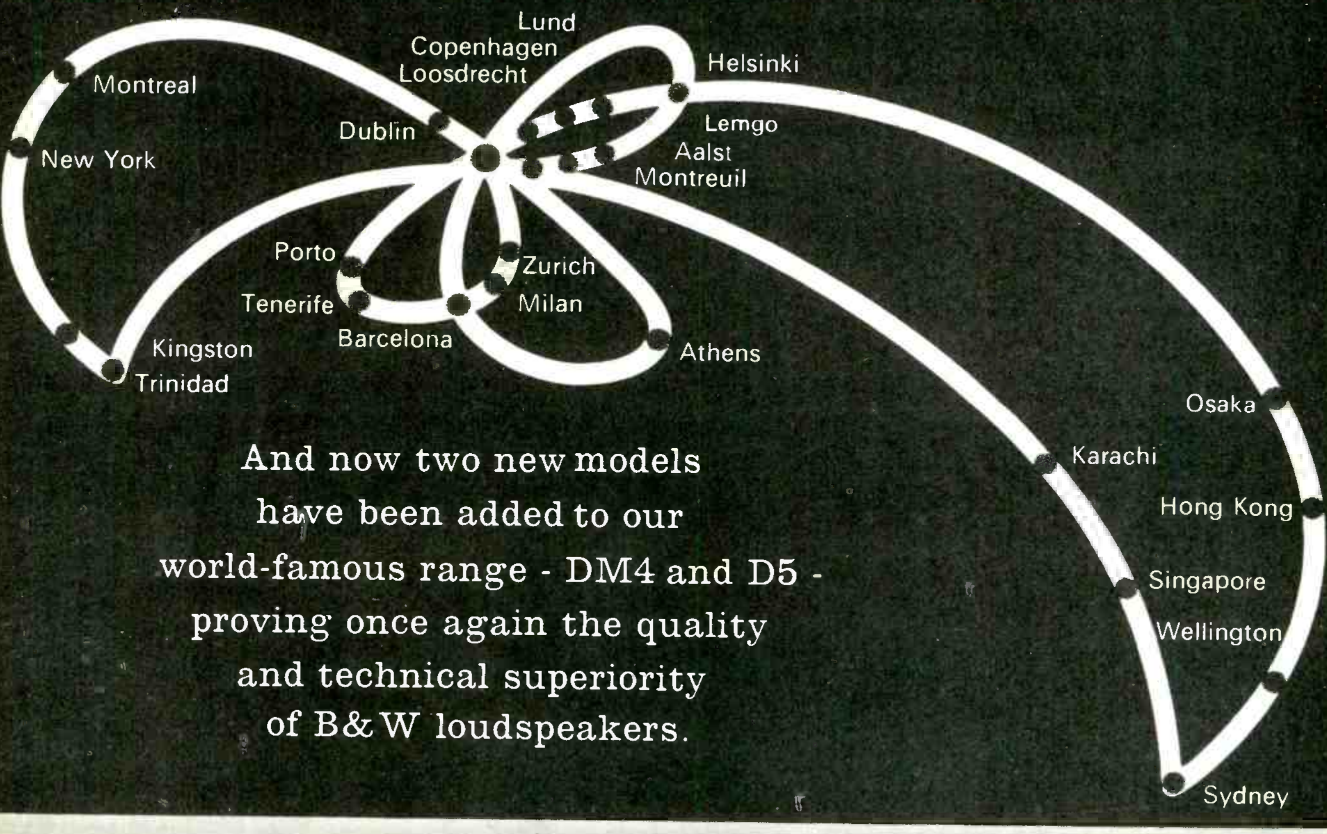
G.E.C. The M-O Valve Co. Ltd

Hammersmith, London W6 7PE Tel: 01-603 3431
Telex: 23435 Cables: Thermionic London

A member of The GEC Electronic Tube Co. Ltd., a management company which unites the activities of The M-O Valve Co. Ltd., and English Electric Valve Co. Ltd.

WW—008 FOR FURTHER DETAILS

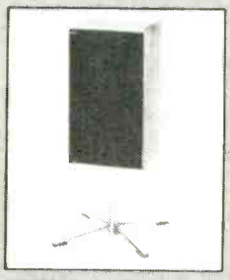
Throughout the world B&W Monitor Loudspeakers set the standard



And now two new models have been added to our world-famous range - DM4 and D5 - proving once again the quality and technical superiority of B&W loudspeakers.

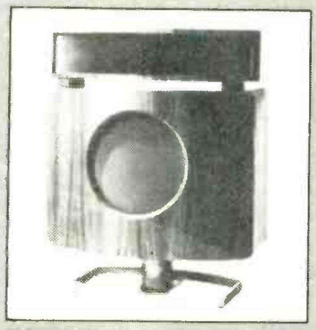
DM4 A small monitor using three units including a new, bass/mid range unit to provide a top quality sound rarely achieved by speakers at twice the price.

D5 A small, two-unit system offering the unique combination of B & W precision, quality performance and a remarkably low recommended retail price of under £30.



DM2 Already well-known, this three-unit system has achieved a truly world-wide reputation for excellence and been rated as one of the best top quality systems.

DM1 The original B & W three-unit miniature—not much larger than an LP sleeve—enjoying increasing popularity.



DM70 Now released on the UK market for the first time in its continental styling. One of the world's finest loudspeakers—and included in the Design Council's Index.

see you at Sonex

B&W electronics

Meadow Road, Worthing, Sussex Tel. 0903 205611

Teonex are better known abroad... because we don't sell in the U.K.

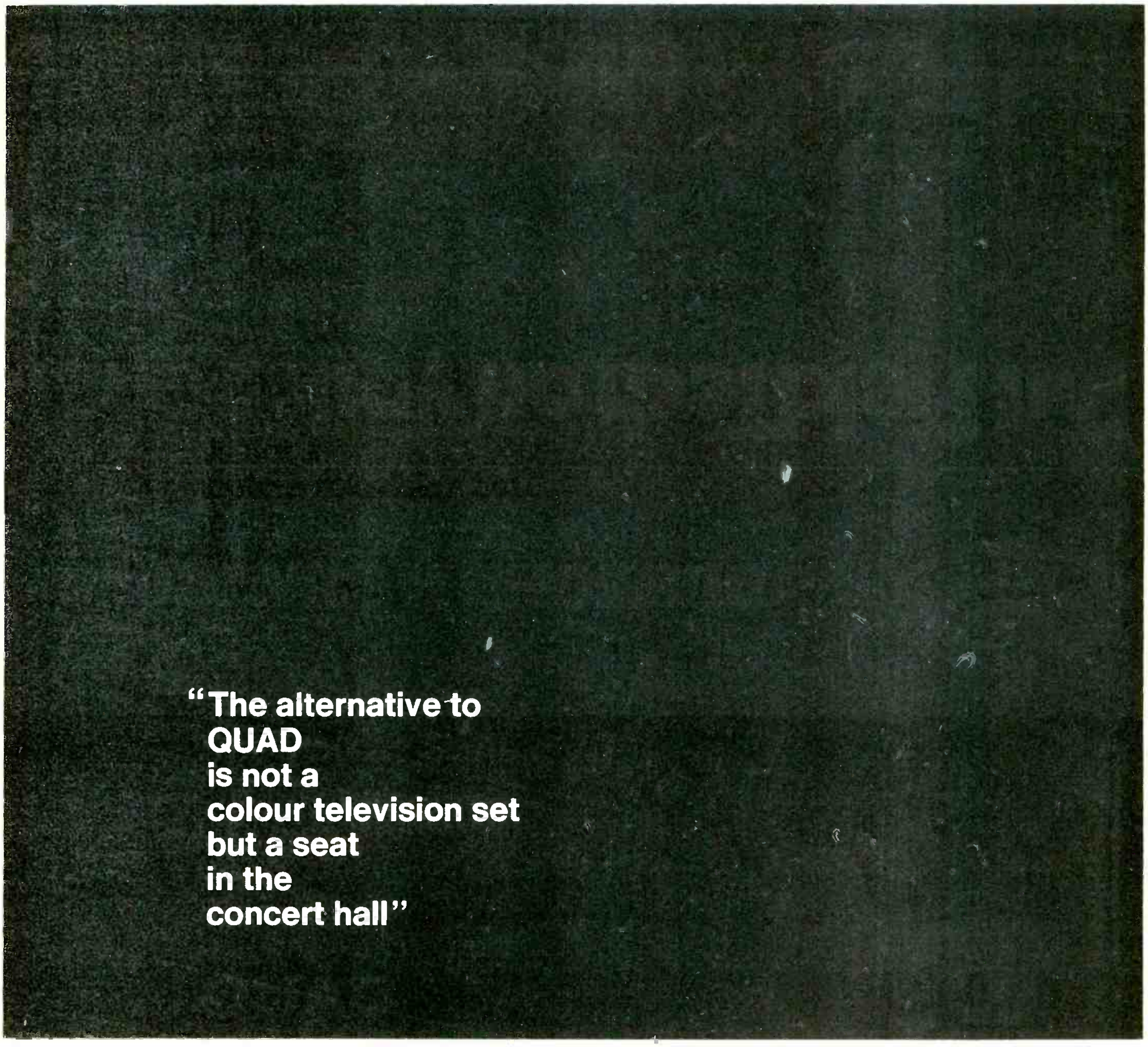
Electronic valves (a really comprehensive range), semi-conductors (a wide variety), integrated circuits.

Teonex offers more than 3,000 devices. They are competitively priced and they are superlative in performance, because the company imposes strict quality control. Teonex concentrates entirely on export and now operates in more than sixty countries, on Government or private contract. All popular types in the Teonex range are nearly always available for immediate delivery. Write now for technical specifications and prices to Teonex Limited, 2a Westbourne Grove Mews, London W11 2RY, England.
Cables: Tosuply London W11. Telex: 262256

REGD. TRADE MARK TEONEX

ELECTRONIC VALVES + SEMI CONDUCTORS **for Teonexport only**

WW—010 FOR FURTHER DETAILS



See you at Sonex '73

Excelsior Hotel,
London Heathrow.

March 28 – April 1

Room No. 452
Demonstration Room L3

QUAD

for the closest approach to
the original sound

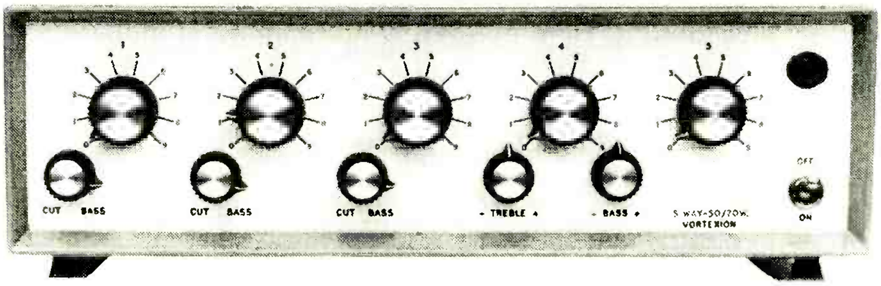
Send postcard for illustrated leaflet to Dept WW

Acoustical Manufacturing Co. Ltd., Huntingdon, Tel: (0480) 2561. QUAD is a Registered Trade Mark.

WW—012 FOR FURTHER DETAILS

Vortexion

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 5-WAY MIXER USING F.E.T.s.



This is a high fidelity amplifier with bass cut controls on each of the three low impedance balanced line microphone stages and a high impedance (1.5 meg.) gram stage with bass and treble controls, plus the usual line or tape input. All the input stages are protected against overload by back to back low self capacity diodes and all use F.E.Ts for low noise, low intermodulation distortion and freedom from radio breakthrough.

A voltage stabilised supply is used for the pre-amplifiers making it independent of mains supply fluctuations and another stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75% efficient and 100V balanced line or 8-16 ohms output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected. The mixer section has an additional emitter follower output for driving a slave amplifier, phones or tape recorder, output .3V out on 600 ohms upwards.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER

(0.3% intermodulation distortion) using the circuit of our 100% reliable 100 Watt Amplifier with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer Amplifier, again fully protected against overload and completely free from radio breakthrough. The mixer is arranged for 2-30/60Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output or 5/15Ω and100 volt line.

100 WATT ALL SILICON AMPLIFIER

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

THE 100 WATT MIXER AMPLIFIER

With specification as above is here combined with a 4 channel F.E.T. Mixer, 2-30/60Ω balanced microphone inputs, 1-HiZ gram input and 1-auxiliary input with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25% and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

CP50 AMPLIFIER

An all silcon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms-15 ohms and 100 volt line. Bass and treble controls fitted. Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

20/30 WATT MIXER AMPLIFIER

High fidelity all silicon model with F.E.T. input stages to reduce intermodulation distortion to a fraction of normal transistor input circuits. The response is level 20 to 20,000 cps within 2dB and over 30 times damping factor. At 20 watts output there is less than 0.2% intermodulation even over the microphone stage at full gain with the treble and bass controls set level. Standard model 1-low mic. balanced onput and HiZ gram. Outputs available 8/15 ohms OR 100 volt line.

200 WATT AMPLIFIER

Can deliver its full audio power at any frequency in the range of 30 c/s—20 Kc/s ± 1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 mW 600 ohms. Output 100-120 V or 200-240 V. Additional matching transformers for other impedances are available.

F.E.T. MIXERS and PPMs

Various types of mixers available. 3, 4, 6 and 8 channel with Peak Programme Meter. 4, 6, 8 and 10 Way Mixers. Twin 3, 4, and 5 channel Stereo, also twin 4 and 5 channel Stereo with 2 PPMs.

VORTEXION LIMITED, **257-263 The Broadway, Wimbledon, S.W.19 1SF**

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

WW—014 FOR FURTHER DETAILS

We'll tell you why. We're now able to offer our complete range of Magnetic Heads for tape decks at a price which could reduce the prime cost of your decks by something like 5–10%.

As a result of our new production line, your loading bay is reached much cheaper and quicker.

We believe that our quality remains unchallenged.

Delivery – we offer the most reliable delivery in the Business.

We'd like to hear from you. If the quantities you use are large enough, maybe we can upset your marketing plans even more!

Please write to Ronald Gorton and ask him to tell you how.

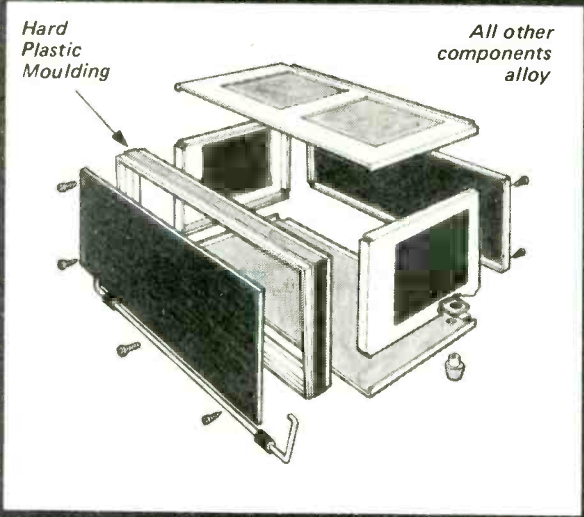
WW—015 FOR FURTHER DETAILS

MARRIOTT MAGNETICS LTD

Penryn, Cornwall. Telephone: 032–67 2267

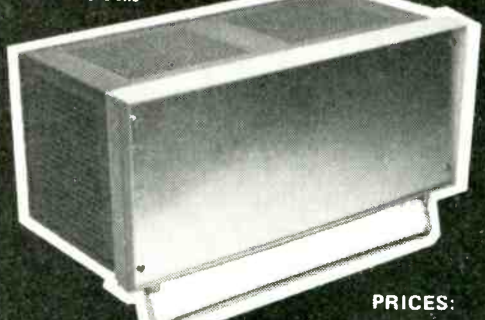
Metal cabinets

Supplied in kit form for power supply units voltage stabilizers and electronic apparatus



CODE NO: 300900 Height 120mm Length 284mm Depth 138mm
300910 Height 120mm Length 224mm Depth 138mm
300920 Height 120mm Length 284mm Depth 188mm

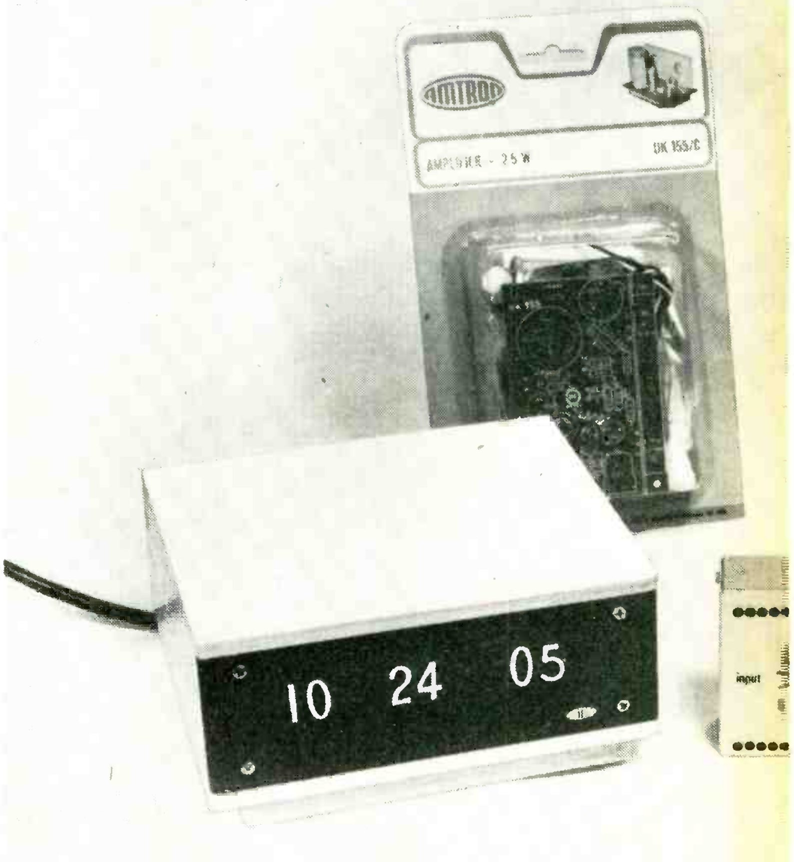
Internal dimensions



PRICES:
300900 £3.84
300910 £3.29
300920 £4.18

AMTRON UK

There are good reasons AMTRON



SYNTHESIZED DRIVE UNIT (MA. 1720)
1.6-30 MHz in 100 Hz steps SSB/ISB/MCW/CW/AM/FSK modes Local/Extended/Remote Control. Alternative crystal controlled and Transmitter/Receiver exciters available.

FEEDER MATCHING UNIT
Permits FULL power output to be delivered to feeder system with VSWR of up to 3:1. Fully automatic with manual override. An alternative switched filter unit may be fitted.

METER PANEL
Monitors voltage/current conditions of individual RF modules and RF input and output (forward and reverse) power.

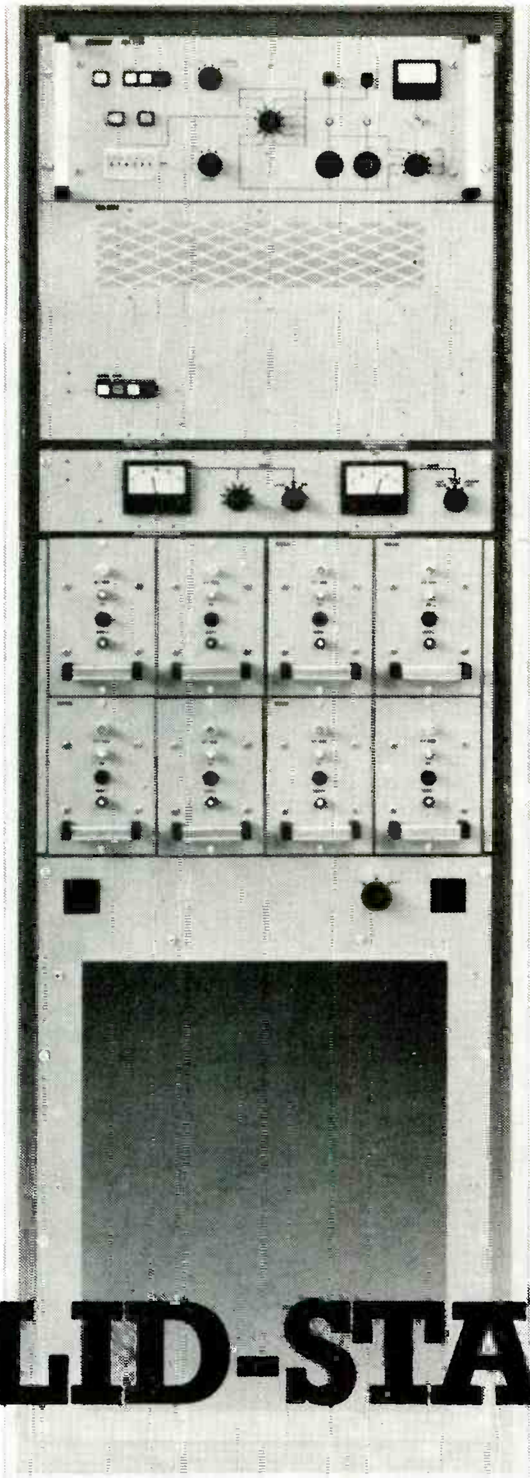
COMBINER UNIT
(behind meter panel)
Combines output of 8 power modules with negligible loss but complete isolation.

POWER AMPLIFIER MODULES
Eight identical plug-in wideband 125 watt modules which may be removed for servicing without traffic "break"

TWO 'DUAL' POWER UNIT MODULES
(Each 2 x 250 watt units.) May be withdrawn individually for "no-break" maintenance.

TWO INDEPENDENT BLOWER UNITS

AIR FILTER
Optional front or rear access.



the SOLID-STATE one

The RACAL TTA. 1860 series 1 kW solid-state low noise Transmitter provides unequalled reliability with maximum operational flexibility. Suitable for static, mobile and shipborne installations for military or civil applications. A wide range of alternative drive units and remote control systems are available together with suitable antenna matching units and antenna systems. Where lower output is required the TTA. 1863 500 watt version, using identical modules, is available. Now in full quantity production, the TTA. 1860 series is ready to meet all your HF transmitter requirements.

APPROVED NATO Nos. 5820-99-624-5393/4/5 5820-99-624-2248

Racal...the communications people

RACAL COMMUNICATIONS LIMITED,
Western Road, Bracknell, Berks, RG12 1RG, England.
Tel: Bracknell 3244. Telex: 848166. Grams: Racal Bracknell.

RACAL
The Electronics Group

WW—020 FOR FURTHER DETAILS

It's not like us to cover up.

Because we make the best equipment there is.

And it shows.

Only this time we aren't showing it.

Because our new range of amplifiers, mixers, speakers, and sound systems are so special, they deserve to be launched in style.

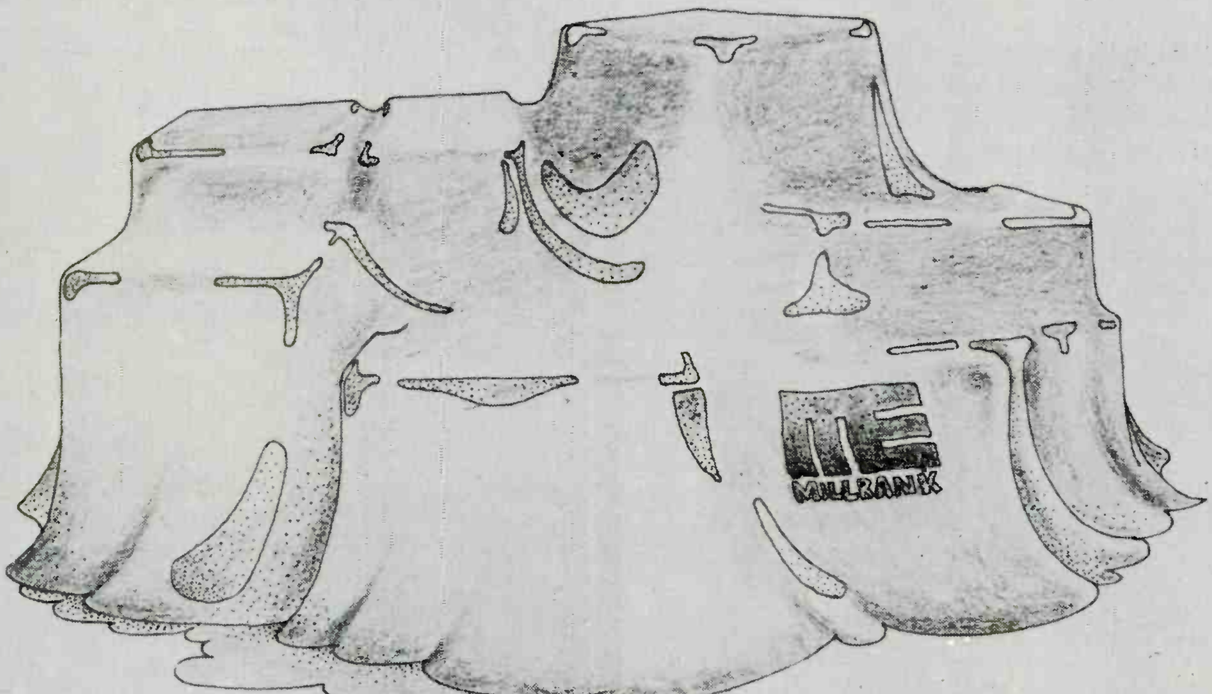
Which is exactly what will happen at Sound '73.

It's not that we have anything to hide.

We just thought we'd go under cover.

Until March. **Millbank**

It's got to be good.



Sound '73 International is at the Bloomsbury Centre Hotel, London, on March 13th-15th.
See us on Stands 19, 20, 33 and 34.

Millbank Electronics Group, Uckfield, Sussex, England. Tel: UCK (0825) 4166. From Europe: 892-96-4166
Manufacturers of specialist audio equipment for industrial and entertainment applications.
Sound mixers, tuners, sound systems, loudspeakers, tuner amplifiers, audio modules and amplifiers.

MILLBANK

WW—021 FOR FURTHER DETAILS

Magnetic shielding

TELCON offers these simple answers

Standard shields

Telcon Metals offer an extensive standard range of high efficiency Mumetal shields, which fit most cathode ray, photo multiplier and radar tubes, together with a selection of boxes and cans for microphones pick-ups, transistors and transformers. These are normally supplied stove enamelled in hammer grey externally and matt black internally. Other finishes can be supplied by arrangement.

Fabricated shields

Telcon Metals offer complete facilities for fabricating special shields in Mumetal and composite shields in Mumetal/Radiometal to customers' individual requirements. All Telcon shields are made to close tolerances and have excellent finish and appearance. For the highest efficiency and extra close fitting tolerances, the 'Telform' technique is recommended. These shields can be produced in complex shapes with a minimum of welded seams and very close uniformity throughout batches. A comprehensive design/advice service is available to assist all customers.

'Telshield' wrap around foil

'Telshield' is an easy to use, ferromagnetic shielding foil, which can be cut with scissors, wound into cylinders, cones, etc., and fixed with adhesive tape, clips or spot welds, to provide a permanent efficient shield. It is economical to use, especially for research, development and short-run applications which do not merit the tooling involved in the production of fully fabricated shields. 'Telshield' is supplied in a standard thickness of 0·05 mm. in widths of 150, 50 and 25 mm in convenient packs costing approximately £5. Other thicknesses and widths are available by arrangement.

T M **TELCON**

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

WW—028 FOR FURTHER DETAILS

PM **Pacific Measurements**

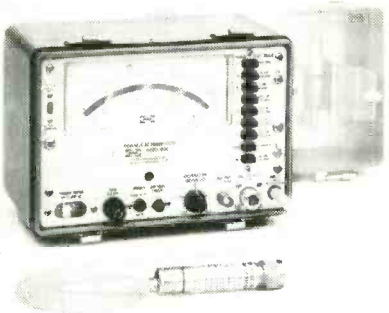
can be in the

RIGHT PLACE

at the

RIGHT TIME

with the Portable RF Power Meters 1034 and 1035



For	*with*
Communication Links	● Self-Checking
Microwave Data Links	● 1 MHz to 14 GHz
Laboratory	● 50 and 75 ohms
Factory	● Special 60 dB scale
	● High burn-out protection

and the Digital Power Meters 1036 and 1037

For		
Laboratory	● 1 MHz-18 GHz	● 50dB dynamic range
Factory	● Down to —40 Db	● High accuracy
Systems	● 0.01 dB resolution	● Excellent match

Full data and specifications for Models 1034 to 1037 will be sent upon enquiry to:

aveley electric LTD

Roebuck Road, Chessington, Surrey.
Telephone: 01-397 8771
Telex: Avel London 928479

WW—029 FOR FURTHER DETAILS

'Chorale' the greatest thing in ENTERTAINMENT SOUND SYSTEMS since music

Here comes the latest in Audio Consoles! Here comes commercial sound for the professional! Here comes Chorale, the ultimate in complete Entertainment Sound Systems. From SNS . . . who else.

Chorale brings a whole range of new dimensions to your sound scene. Chorale is versatile with applications ranging from cabarets to conventions. And because it comes from SNS, its performance is superb, its reliability total, its quality supreme, its features uncomparable – 50W. or 125W. RMS output. 6 Channels with facilities illustrated below. Low impedance or 100V. line output. Know what we mean? Ask our representative when he arranges your trial.

See us at
SOUND '73'
STAND 18
Bloomsbury Centre Hotel
13th-15th March

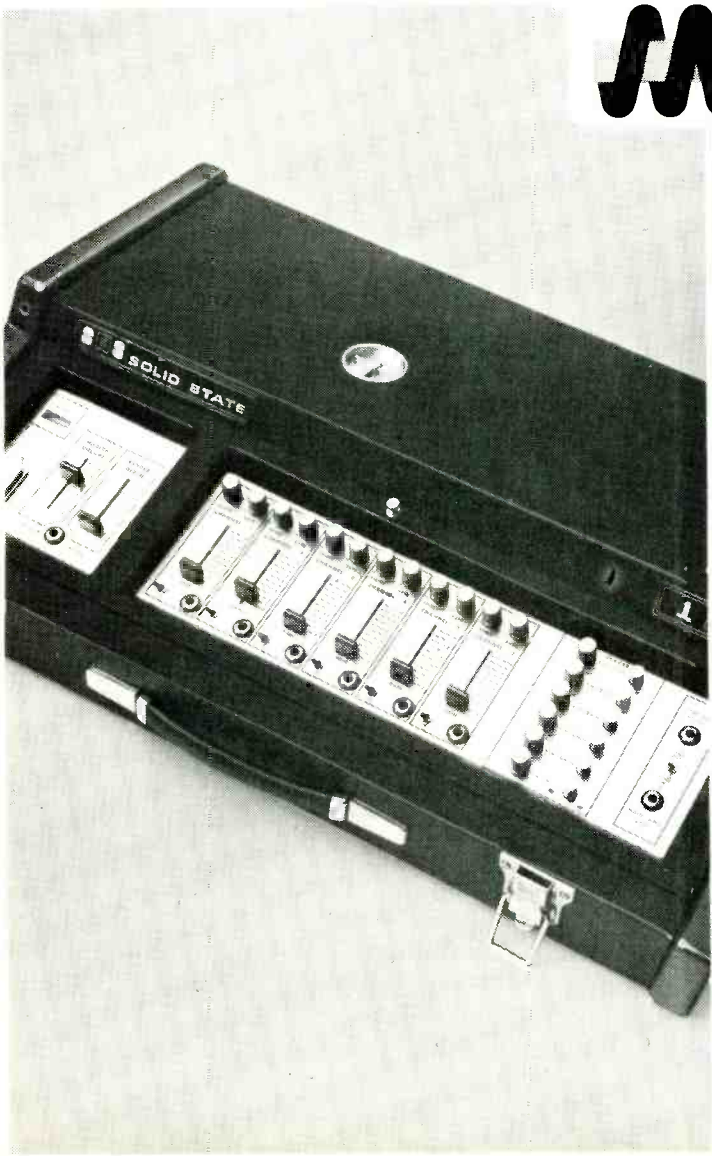
... and two big advances in quality COMMERCIAL SOUND SYSTEMS

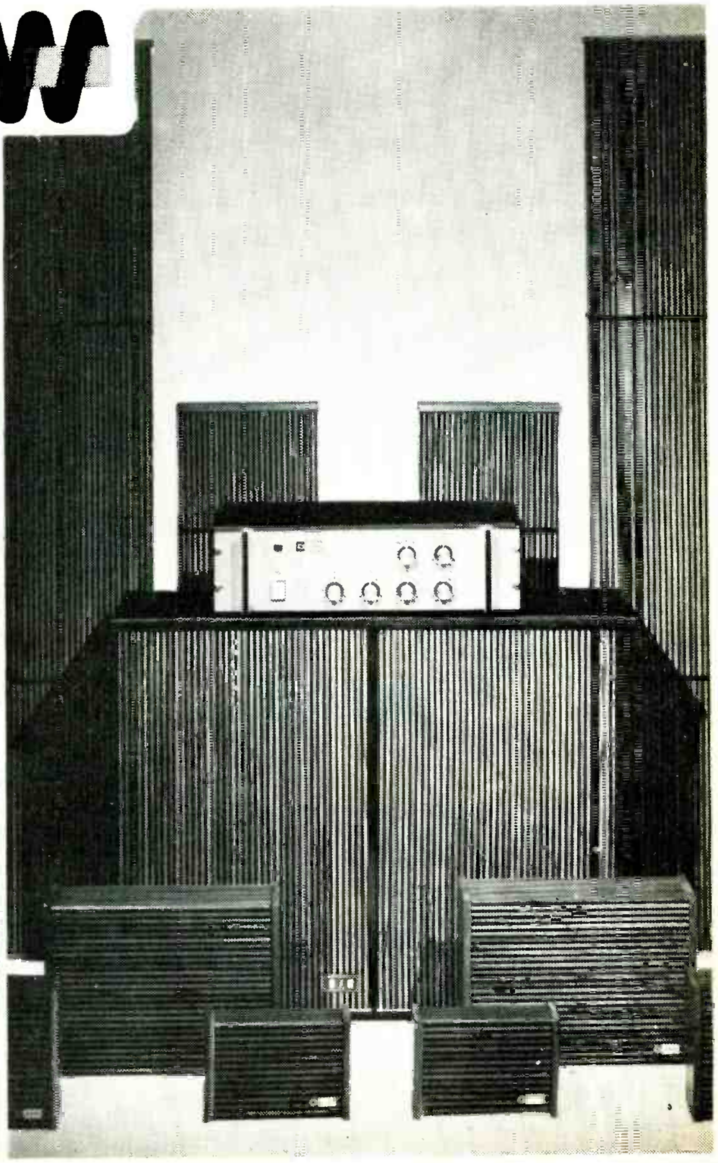
Welcome the new range of SNS P.A Mixer-Amplifiers. New? They're all of that. A new flexibility, new features which incorporate 12W. or 40W. RMS output and the latest integrated circuits used throughout the pre-amplifier stage – in fact a new kind of finesse in medium power Commercial Sound Systems.

Link them to another big new range – SNS column and cabinet speakers. That's a seven league step forward! Put each range together or use them apart. Quality marks them both. Performance singles them out. Where else could they come from but SNS?

Of course, you need a trial to feel as confident about them as we do. Call your SNS representative soon.

SNS Communications Ltd., 851 Ringwood Road, Bournemouth BH11 8LN. Tel: Northbourne (02016) 5331.





WW—030 FOR FURTHER DETAILS

The background music machine.

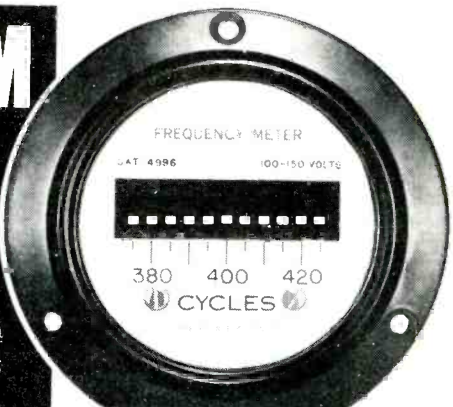
For people who want the right kind of music behind them, one name comes immediately to the fore. It is TOA – with their versatile PA-100 background music machine. This compact and easy-to-install machine plays standard 8 track cartridges, gives a programme lasting from 60-80 minutes, and can be played continuously if required. It also incorporates a solid state 15W P.A. Amplifier with 100V line output and provision for microphone and record player. It's ideal for use in hotels, bars, amusement and bingo halls and shops where it can also be used to sell as well as entertain. Get in touch with us. And we'll play over all the benefits to you.

Goldring

Goldring Ltd.
10 Bayford Street, Hackney, London E8 3SE.

WW—031 FOR FURTHER DETAILS

FRAHM resonant reed FREQUENCY METERS



used as standards in many industries

- Accurate to ±0.3% or ±0.1% as specified
- Not sensitive to voltage or temperature changes, within wide limits
- Unaffected by waveform errors, load, power factor or phase shift
- Operational on A.C., pulsating or interrupted D.C., and superimposed circuits
- Need only low input power
- Compact and self-contained
- Rugged and dependable

FRAHM Resonant Reed Frequency Meters are available in plastic and hermetically sealed cases to British and U.S. Government approved specification. Ranges 10–1700 Hz. Literature on these meters and Frahm Resonant Reed Tachometers available on request. Manufacture and Distribution of Electrical Measuring Instruments and Electronic Equipment. The largest stocks in the U.K. for off-the-shelf delivery.

ANDERS ELECTRONICS LIMITED

48/56 Bayham Place, Bayham Street, London NW1. Tel: 01-387 9092

Anders means meters

WW—032 FOR FURTHER DETAILS

The TT21. Cost per what?

Before you listen to us, listen to a few communication transmitters.

Because the chances are they'll have our TT21 already fitted.

Because it's the best beam tetrode you can buy. Best in its class. Best for the money.

So, if you require a communication transmitter tube at the lowest possible cost per what, sorry, watt, here's the address to find out more.

G.E.C. The M-O Valve Co. Ltd

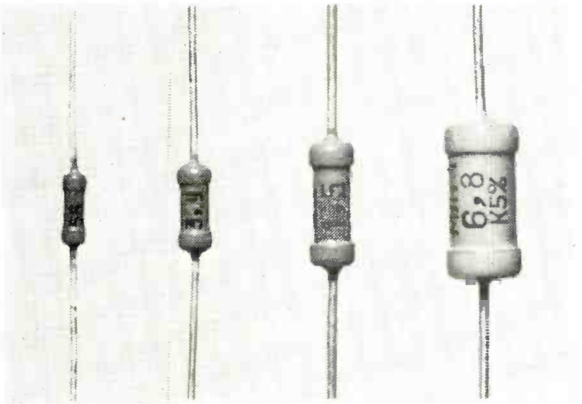
Hammersmith, London W6 7PE Tel: 01-603 3431
Telex: 23435 Cables: Thermionic London

A member of The GEC Electronic Tube Co. Ltd., a management company which unites the activities of The M-O Valve Co. Ltd., and English Electric Valve Co. Ltd.

WW—033 FOR FURTHER DETAILS

ELECTRONORGTECHNICA (USSR)

METAL FILM
RESISTORS



Reliable general purpose metal film resistors ±5% $\frac{1}{8}$ & $\frac{1}{4}$w £3.50, $\frac{1}{2}$w £3.60, 1w £3.80 per 1000 (one value) $\frac{1}{8}$, $\frac{1}{4}$ & $\frac{1}{2}$w carbon film resistors ±5% £2.30 per 1,000

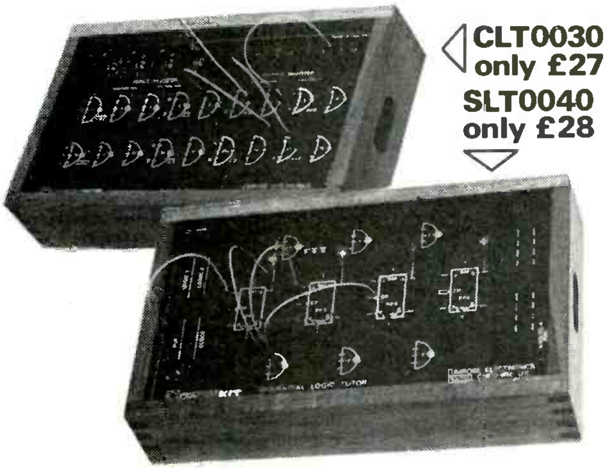
AVAILABLE FROM

Z & I AERO SERVICES LTD.
44A, WESTBOURNE GROVE,
Tel: 727/5641 LONDON, W2 58P Telex: 261306

Also Available: ELECTROLYTIC CAPACITORS
CERAMIC CAPACITORS
CARBON SKELETON PRE-SETS

WW—034 FOR FURTHER DETAILS

teaching logically made easy....



◁ CLT0030 only £27

SLT0040 only £28 ▽

These two new, compact and low-cost logic tutors are just what you need for courses on Computer Appreciation and Logic.

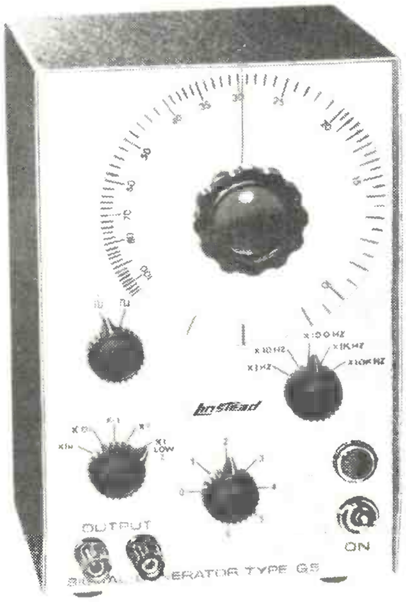
The Combinational Logic Tutor CLT0030 has a selection of AND, OR, NAND and NOR logic gates and the Sequential Logic Tutor SLT0040 has JK Flip-flops and NAND gates. Both units are supplied complete with instruction books, batteries and solderless patch leads.

For further information, please telephone 061-928 8063 or write to

LIMROSE ELECTRONICS LIMITED,
8-10 KINGSWAY,
ALTRINCHAM, CHESHIRE,
ENGLAND, WA14 1PJ.

WW—035 FOR FURTHER DETAILS

NEW Linstead G5
WIDE RANGE SIGNAL GENERATOR



NO OTHER QUALITY INSTRUMENT GIVES ALL THIS

10Hz to 1MHz
±2% ±1Hz
Sine and square waves
3 watts in 5 ohms

FOR

£32

FULLY TRANSISTORISED

Linstead means a good deal in electronics

Linstead Electronics, Roslyn Works, Roslyn Road, London N15 5JB Telephone: 01-802 5144

WW—036 FOR FURTHER DETAILS

With the Aerialite Mastatic System you wouldn't know you were in a difficult reception area

The **'Mastatic'** whip-type vertical rod aerial is made to be fixed high above electrical interference.

When it's used with the **'Antistatic'** system it returns superb performance in difficult reception areas.

The **'Antistatic'** (AM) has a frequency range covering all popular broadcast and short wave bands. It consists of a weatherproofed aerial transformer connected by 60 ft. of screened downlead to a compact receiver transformer.

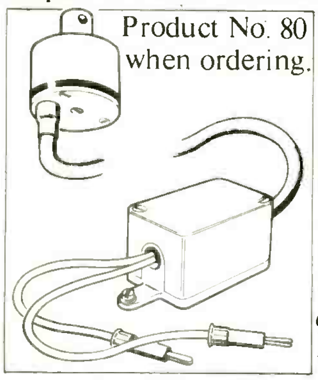
The **'Mastatic'** (AM) comes in three configurations:

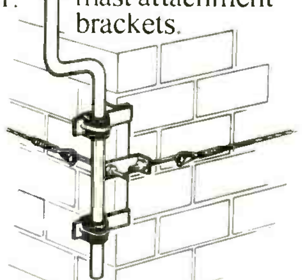
Product No. 79
3 sections. Total height 18 ft. Complete with chimney lashing kit.

Product No. 79a
3 sections. Total height 18 ft. Complete with wall mounting brackets.

Product No. 79b
2 sections. Total height 12 ft. Complete with 2 in. mast attachment brackets.

Product No. 80 when ordering.





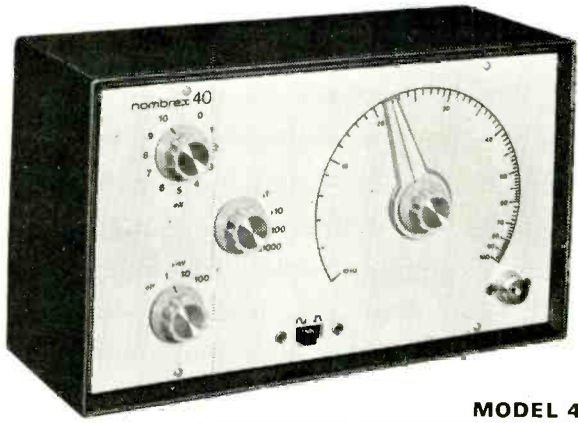
For full information please contact your local Aerialite Distribution Depot or write to:

Aerialite Aerials Ltd

Radnor Park Trading Estate, West Heath, Congleton, Cheshire CW12 4PX. Telephone: Congleton 3892/8
Telegrams: Aerialheat, Congleton. Telex: 669640.

WW—037 FOR FURTHER DETAILS

nombrex



MODEL 40
WIDE RANGE AUDIO GENERATOR
PRICE £24.75

- ★ 4 RANGES, 10 Hz–100 KHz.
- ★ SINE AND SQUARE WAVE OUTPUT.
- ★ DUAL CALIBRATED ATTENUATOR.
- ★ STABILIZED OUTPUT LEVEL 1 V.

Trade and Export enquiries welcome
Send for full technical leaflets
Post and Packing 35p per unit

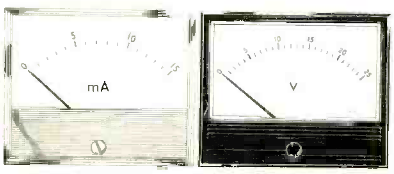
NOMBREX (1969) LTD., EXMOUTH, DEVON.
Tel: 03-952 3515

WW—038 FOR FURTHER DETAILS

put the President on your panel

'President' moving coil panel instruments. Two presentations — AZ and BZ. Three sizes — scale lengths 2.2 in., 2.8 in., 3.8 in. Also moving iron and rectifier movements.

Contact your Ferranti Field Sales Engineer or Instrument Sales, Ferranti Limited, Moston, Manchester, M10 0BE
Tel: 061-681 2071
Telex: 667857



FERRANTI

FI314a rb

WW—039 FOR FURTHER DETAILS

Your invitation to the latest electronic developments in the world.

23rd International

London Electronic Component Show

Olympia London 22-25 May 1973

Daily 09.30-17.30

Because the London Electronic Component Show is concerned primarily with equipment for the professional market, it is an essential occasion for all forward-looking management executives, engineering, research, development and design staff and specialist buyers.

New materials and improved design techniques are pushing the limits of electronic component technology to even greater heights.

Following closely the advances made in component design, the precision and quality of related electronic instrumentation and production equipment have undergone major improvements. Providing the ideal opportunity to examine new developments on all fronts of the industry – in passive and active devices, in thick and thin film technology, in printed circuitry, in opto-electronics and other significant techniques – LECS 73 is an invaluable guide to future trends.

Completely international, occupying Olympia's two largest halls, the 1973 show offers a complete picture of the international electronics industry.

Sponsored by the Radio and Electronic Component Manufacturers' Federation. Organised by Industrial Exhibitions Ltd.

For descriptive multi-lingual leaflets and season tickets for the show, complete and return the coupon below.

Please send me............leaflets and............season tickets.

Special package deal travel arrangements, fully inclusive of all charges for individuals or parties have been arranged by the show's official travel agent. In addition, a special hotel reservation service is available.

Please tick the appropriate box for further information.

Package deal ☐ **Travel** ☐ **Hotel** ☐

Complete this coupon and return to:
London Electronic Component Show, Industrial Exhibitions Ltd., Commonwealth House, New Oxford Street, London, WC1A 1PB,

Name

Company

Address

RECMF

...TER THERMOSTATIC SOLDERING UNIT 'INVADER' SOLDERING INSTRUMENTS BATTERY SOLDERING INSTRUMENTS HEAVY DUTY SOLDERING INSTRUMENTS DE-SOLDERING INSTRUMENT CABLE STRIPPERS SOLDER POTS PYROMETER

ADCOLA

take the risks out of soldering

ADCOLA PRODUCTS LIMITED
GAUDEN ROAD LONDON SW4 6LH
TELEPHONE 01-622-0291/3

WW—040 FOR FURTHER DETAILS

Getting valves is getting tricky.

Ever spent hours trying to get a valve, only to find that putting it in circuit makes no difference?

Everybody has.

With VCM 163 you can check exactly which valves are OK and which aren't. And spend time getting only the valves that really need replacing.

As valve testers go – and let's face it, most of them have – Avo VCM 163 is a very sophisticated instrument. It even has a NATO stock number.

And what's more there's a new Avo Valve Data Manual (19th edition) free with each VCM 163. It includes obsolete types and 84 pages of equivalents, and could save a fortune in wasted time. The manual is also available separately at just £5.25 (U.K. Trade).

So write or telephone for more details of VCM 163 now. Send us a cheque for £5.25, and we'll send you a 19th edition Valve Data Manual too.

Trust Avo to look after you.

Avo Ltd., Dover, Kent.
Telephone: Dover 2626.

Avo

So be sure you get the right valve. With an Avo VCM 163 valve tester.

Thorn Measurement Control and Automation Division. THORN

WW—041 FOR FURTHER DETAILS

I.M.O. PRECISION CONTROLS LTD

313 EDGWARE ROAD, LONDON W2 3BR.
telephone: 01 723 2231 Cable: Omrontrols London.

OMRON telephone: 01 723 2231 telex 28514

TIMERS SWITCHES TRANSFORMERS VOLTAGE CONTROLS FOR IMMEDIATE DELIVERY

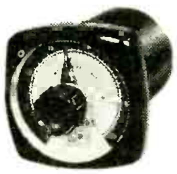
VARIABLE TRANSFORMERS

FAMOUS "SLIDUP" & "SLIDTRANS" MODELS

1 amp	£7.00	C. & P. 37p
2.5 amp	£8.05	,, 57p
5 amp	£11.75	,, 67p
10 amp	£22.50	,, 75p
12 amp	£23.60	,, 75p
20 amp	£49.00	,, 95p

"OFF THE SHELF" delivery of all types.
*Fully shrouded. *Bench Mounting.
*Panel Mounting. *Low Price.
*Input 240VAC. Output: 0-260VAC.

PANEL MOUNTING "SYS" SYNCHRONOUS TIMER



OMRON brand Synchronous Motor driven timer with single instantaneous and two timed change-over contacts. MINIMUM guaranteed electrical and mechanical 10,000,000 operations.

*Stocked in 110VAC 240VAC up to twenty eight hours time range; ½% repeat accuracy.
£14.90 "one off" £10 in quantity.

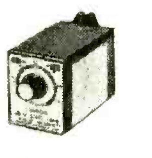
PNEUMATIC OMRON TIMER UP TO 200 SECS DELAY—"ATS"

Easily adjustable from delay on energise to delay on de-energise. The OMRON ATS works on an air damped principle and can be adjusted between 0.200 secs with screwdriver adjustment. A precision snap action switch provides a 6A contact and minimum 1,000,000 ops life.
"One off" £8.10. In quantity £5 for 110V/240VAC types.

LOW COST PANEL MOUNTING MINIATURE TIMER—"STPYMH"

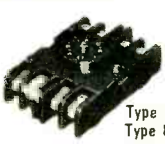
Plug-in timer for panel mounting. Synchronous Motor driven with auto-reset facility. Instantaneous and time limit contacts rated at 5A. This timer has fixed and moving pointers.
£8.40 "one off" £5 in quantity.

HIGH ACCURACY SOLID STATE PLUG-IN TIMER—"TDS"



Genuine 1% repeat accuracy with solid timing.
Life 50 million operations minimum. instantaneous & time limit contacts.
Full time scales 0–1sec; 0–2sec. 0–5sec. 0–10sec; 0–30sec; 0–60sec; 0–180sec.
Dual Voltage 110/240VAC £18.50 to £13 each.

EXCLUSIVE SOCKETS FOR OMRON TIMERS & FLOATLESS SWITCHES



Screw terminals, with clips to hold the timer or switch firmly in place where mounted.
Type 8PF for STPNH, TDS, DTS
Type 8PFI for 61FGP & TDA.
75p "one off" and 50p each in quantity.

ELECTRONIC PLUG-IN SWITCH FOR LIQUID LEVEL & ICE BANK CONTROLS "61FGP"

Electronic switch senses a change in resistance using Stainless Steel probe assemblies or other conductive probes.
Proven use in sewage. water beer. milk ice in vending. effluent, boilers and other industries.
£5.85 for "one off" £3.50 in quantity.

STAINLESS STEEL PROBE ASSEMBLY "PS31"

Length 1 metre, for use on differential and alarm control of conductive liquids with "61FGP" (illustrated above).
£1.60 "one off" £1 in quantity.

ELECTRONIC RECYCLING TIMER FOR CONTINUOUS ON/OFF OPERATION "TDA"

Electronic twin timer for continous recycling operations. On/Off time control, 0–6secs with 2% repeat accuracy setting 0–6sec with transfer switch X10.
Dual voltage 110/240VAC £28.60 but down to £18 each in quantity.

PANEL MOUNTING "NSY" SYNCHRONOUS TIMER

"New Square Dial"

The OMRON timer type NSY features the modern "DIN" type square fixed dial. This attractive package has two time limit changeover contacts.
Stock range 110/240 VAC up to 28 hrs £12.50 "one off" to £8 in quantity

OMRON MICROSWITCHES

*Interchangeable with all British & Continental Manufacturers
*Approvals from: CSA; MIL; UL; SEVC; SAA; DEMKO ETC

VIC WITH AMP TERMINALS
Single Pole Changeover 15amp switch O.F. 400gm R.F. 114gm M.D.O. 4mm. £19 per 100; £150 per 100; £700 per 5000.

VV-15-1A WITH SOLDER TERMS.
Single Pole Changeover 15amp Switch O.F. 230gm. R.F. 50gm. M.D. 1mm. £19 per 100; £150 per 1000; £650 per 5000.

SIA SUBMINIATURE SWITCH
Cheaper than all its competitors. Single pole changeover 5amp switch O.F. 200gm. R.F. 40gm. M.D. 0.1mm. £23 per 100; £180 per 1000; £850 per 5000.

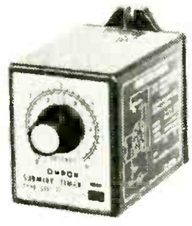
SIAL WITH LEAF SPRING
Subminiature 5amp microswitch of 56-180gm R.F. 14gm M.F. 0.8mm. £27 per 100; £220 per 1000; £1000 per 5000.

SIAL 2 WITH ROLLER ACTUATOR
Subminiature 5amp microswitch. O.F. 56-180gms R.F. 14gms. M.D. 0.8mm. £33 per 100; £270 per 1000; £1250 per 5000.

CCR-5 LOW TORQUE SWITCH
Low cost microswitch for coin operated or air vane applications. O.T. 10gm. R.T. 13gm. M.D. 15°. £31 per 100; £190 per 1000; £900 per 5000.

VAQ4 PUSHBUTTON MICRO-SWITCH.
15amp Microswitch with push-button actuator low operating force and buttons in various colours. £49 per 100; £360 per 1000; £1750 per 5000.

WORLD'S SMALLEST SYNCHRONOUS MOTOR PLUG-IN TIMER STPNH



AT LAST! ±½% REPEAT ACCURACY IN A MINIATURE PLUG-IN TIMER UP TO 28HRS.

Only OMRON could provide a timer of such unrivalled superiority over all its competitors, anywhere in the world.
The STPNH is a synchronous motor driven timer with automatic reset function. Both instantaneous and time limit contacts are fitted and the timer is mounted on an international 8 pin octal base.
Time ranges start 0.6 secs and finish 0-28hrs with operating voltage at 110VAC or 240VAC.

Up to 72 mins £7.90 "one off" and £4 in quantity. Long time ranges around £8.

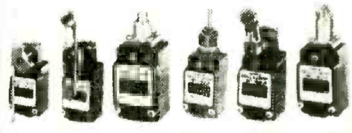
PFQ3 SUBMINIATURE PUSHBUTTON SWITCH.

"Push to make" switch with black button 3 amps @ 240VAC 15p each per 1000.

1SAT4 SUBMINIATURE TOGGLE MICROSWITCH.

CSA approved toggle switch rated 5A @ 240V 50p ea. in small quantities.

OMRON LIMIT SWITCHES

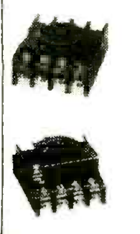


Full range available with 15amp switching capacity. Approved by CSA Authorities & guaranteed for twelve months.
Interchangeable with other British and Continental manufacturers typical price is around £3.50 for the coil spring type.

VOLTAGE STABILISER

Famous I.M.O. Constant Voltage Stabiliser still only £12.50 each.
FEATURES:
*200 watt rating
*Input 240VAC ±20%
±Output 240VAC±1%.

AT LAST OMRON FRONT CONNECTION SOCKETS—NOW SUPPLIED FROM STOCK



These new miniature sockets with screw terminal connections are only available through I.M.O. or authorised stockists. Moulding is UL approved and OMRON "know how" brings all the advanced features of a modern product.
PF083 (8 pin) 44p each 1000 lots.
PF113 (11 pin) 58p each 1000 lots.

SOLID STATE VOLTAGE CONTROLS 5AMP & 10AMP MODELS

Full solid state control over AC voltages.
Input of 230VAC variable on output to 25-230VAC.
Miniature and lightweight with finned aluminium housing these units can truly replace wirewound transformers.
VP05C (5AMP) £9.90 "one off" £6 in quantity.
VPI0C (10AMP) £16.90 "one off" £10 in quantity.

PHOTOELECTRIC SWITCHES

Reflective and "slot" type photoelectric switches. Will sense any material passing the light beam up to 3mm and provide an output signal of 02AMPS at 240VAC. Reflective distance up to 25mm on reflective surfaces, far longer with external light.
WORK DIRECT FROM 24VAC SUPPLY.
PRIOOR (Reflective) £7.50 "one off" £4 in quantity.
PRIOOC (slot) £7.50 "one off" £4 in quantity.

OMRON PROXIMITY SWITCHES SWITCHING OF 240VAC or 24VDC

Solid state Proximity Switch opening without a separate power supply unit. Works off 240VAC or 24VDC, senses ferrous and non ferrous metals up to 5mm from the head.
TL-2-GPA (DC) £9.50 each.
YL-2-GPA (AC) £25.70 "one off" £18 in quantity.

TECHNICAL LITERATURE

Full literature is available on all the products illustrated here. Please telephone our sales office on 01-723 2231.

ALL THE PRODUCTS ILLUSTRATED HERE ARE ALSO AVAILABLE FROM THE FOLLOWING I.M.O. FRANCHISED DISTRIBUTORS.

BIRMINGHAM	Aston Electrical Ltd	tel: 021 327 4064
BLACKBURN	Wilson Automation Ltd	tel: 0254 59921
BRISTOL	Techniservices Ltd	tel: 0272 30701
LEICESTER	B.P.X. Ltd	tel: 0533 64281
LEEDS	Scattergood & Johnson Ltd	tel: 0532 30203
LONDON (STH.)	D.T.V. Group Ltd	tel: 01 670 6166
NEWCASTLE	Gledson & Co Ltd	tel: 0632 860955
SHEFFIELD	John Riley & Son Ltd	tel: 0742 49851
SLOUGH	Blore Barton Ltd	tel: Burnham (Bucks) 5524

I.M.O. TERMS OF TRADING

CASH WITH ORDER UNLESS A NETT MONTHLY ACCOUNT HAS BEEN ESTABLISHED. TELEPHONE: 01-723 2231.

ENCAPSULATED POWER SUPPLIES

DUAL POWER SUPPLIES

DPS—25 ± 15V @ 25mA general purpose, low cost
DPS—100 ± 15V @ 100mA general purpose
DPS—150 ± 15V @ 150mA general purpose
APS—30 ± 15V @ 30mA precision p.s.u.

DC—DC CONVERTER

3W5—30 ± 15V @ 100mA + 5volt supply

SINGLE POWER SUPPLY

SPS—1.5 1.5V @ 10mA dry cell elimination

BRITISH MADE

The Ancom range of power supplies covers a wide range of requirements offering a choice of inputs, 115 volts ac, 240V ac, 40-60V ac, 25-40V dc, & plus 5 volts dc, with regulation between 0.01% and 1% depending upon the module selected.

Typical parameters are; inputs 240V ac, outputs ± 15 volts dc at 25mA to 150mA
5V dc — regulation 0.01%
25-40V dc — stability .003% 1°C

ancom Devonshire Street, Cheltenham, Glos. GL50 3LT England.

WW—046 FOR FURTHER DETAILS

VARIABLE AUTOTRANSFORMER LATR-2M*

Bench mounted fully shrouded.
Input: 120, 220 and 250V.
Output: 0–260V.
Max. load 2 Amps.
£6.55

SIX-DECADE 0.01 CLASS RESISTANCE BOX TYPE P327*

6 decades of 0.1-1-10-100-1000-10,000 steps. All decades and their respective wipers are brought out to separate terminals.
All-metal construction, fully screened.
Capacity: 0.3A for 0.1 and 1Ω decades; 0.1A for 10Ω decade, 0.03A for 100 decade; 0.01A for 1000 decade and 0.003A for 10,000 decade.
£65.00

SUB-STANDARD MULTI-RANGE * AC/DC VOLTMETER

Mirror scale 175mm long.
Knife edge pointer.
48 ranges from 75mV to 750V and from 300μA to 7.5A.
Accuracy 0.5% DC; 1% AC.
Transistorized relay protects movement and circuits.
Push button range selection.
£49

SIX DECADE 0.02 CLASS ACCURACY* RESISTANCE BOX TYPE P327

6 decades 0.1-1-10-100-1000–10,000Ω.
Four terminals enable the box to be used also as a potential divider.
Rated power 0.25W per step with full accuracy or 1.00W per step with reduced accuracy.

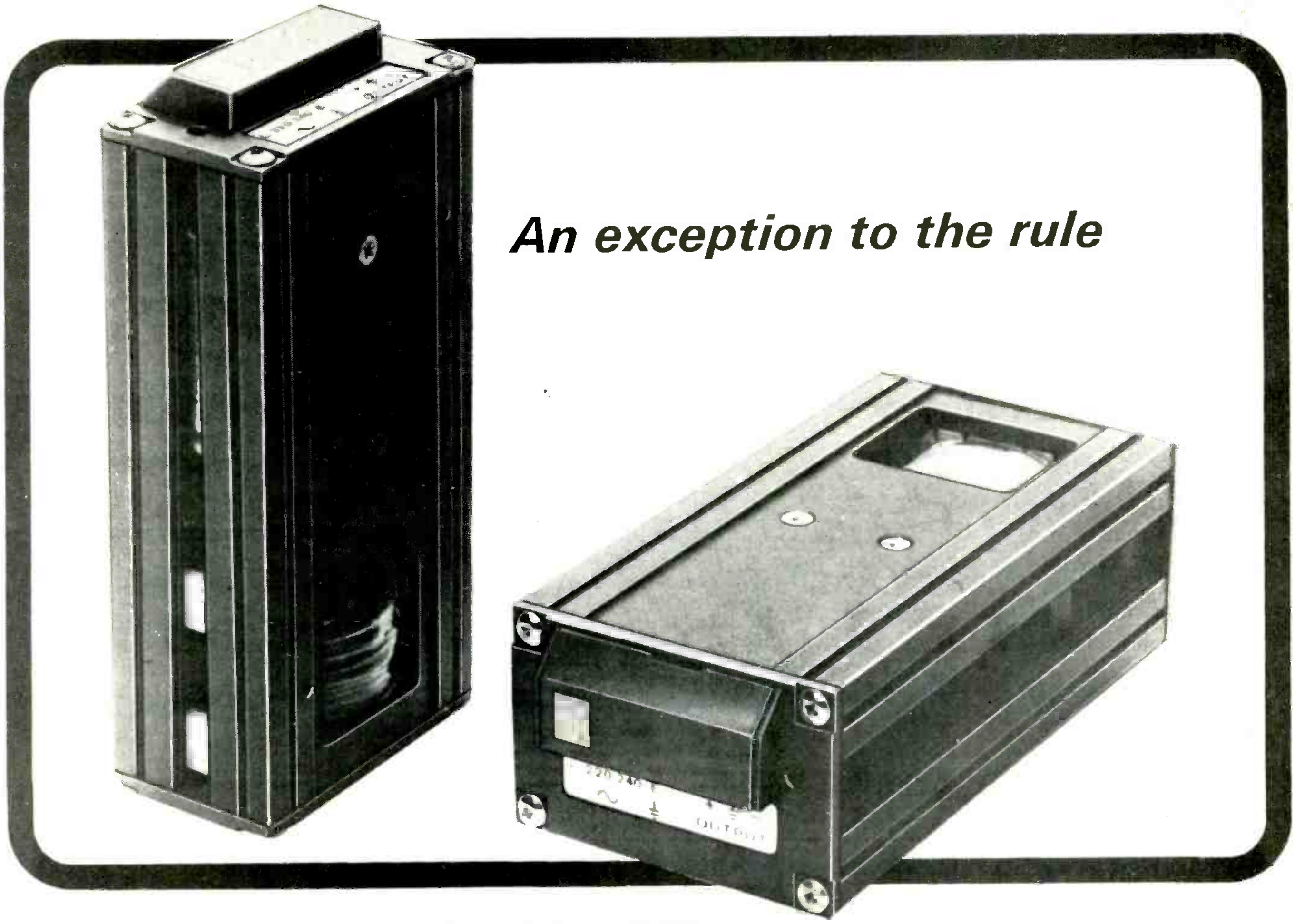
£45.00

PLEASE WRITE FOR FULL TEST EQUIPMENT CATALOGUE *Made in USSR

Z & I AERO SERVICES LTD.
44A WESTBOURNE GROVE, LONDON W.2
Tel: 727-5641 Telex 261306

WW—047 FOR FURTHER DETAILS

An exception to the rule



Cheap power supplies can be expensive — but there's always an exception to the rule. Here's ours.

These new miniature d.c. power supplies are well engineered and compact. They're suitable for either bench use or for incorporating into original equipment and they feature good regulation, low ripple and full protection.

Send for the leaflet (better still, try a unit) and we think you'll agree—they *are* excellent units and surprisingly inexpensive.

Instant miniature power from :—

Units available

GROUP 1 UNITS: Dimensions (mm) 35H x 64W x 128D. Wt. 0.51kg

Model	OUTPUT Adjust range (Vd.c.) min. max.	Current rating (mA) at T. amb. 30°C	40°C	60°C	PRICE 0-9 units
6/500P	4 — 6	500	500	250	£13
12/250P	6 —12	250	250	125	£12
24/125P	12 — 24	125	125	62.5	£12
15/15/100P	12–17 O 12–17	100	100	50	£13.50

GROUP 2 UNITS: Dimensions (mm) 40H x 64W x 131.5D Wt. 0.51kg.

Model	Adjust range (Vd.c.)	30°C	40°C	60°C	PRICE
6/1P	4 — 6	1000	750	250	£15
12/500P	6 — 12	500	500	250	£14
24/250P	12 — 24	250	250	125	£14
15/15/200P	12–17 O 12–17	200	200	100	£16

Farnell

POWER SUPPLIES DIVISION

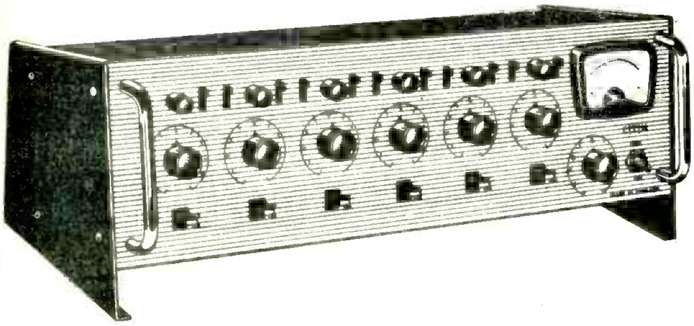
FARNELL INSTRUMENTS LTD · SANDBECK WAY · WETHERBY · YORKSHIRE LS22 4DH TELEPHONE 0937-3541 · TELEX 557294

LONDON OFFICE: TELEPHONE 01-802 5359

WW—048 FOR FURTHER DETAILS

CTH STUDIO QUALITY MIXER FOR FIELD USE . . .

— as used for professional broadcasting and recording



TYPE TM61 MIXER★

- ☐ All silicon six-way mixer.
- ☐ +12 dBm output on mains or 12V battery.
- ☐ Adjustable for 30Ω mic, 200Ω mic, or 600Ω lines.
- ☐ Sensitivity −85 dBm to +20 dBm.
- ☐ VU meter (PPM available).
- ☐ Muting switch on each channel.
- ☐ Bass and treble cut on each channel.
- ☐ Master gain control.
- ☐ XLR type input connectors.

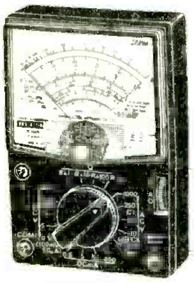
★ This studio quality mixer is also available fitted with an internal 12V battery and with a wooden carrying case, giving you an easily portable mixer of true studio quality for use in general field work.

CTH also manufacture a range of modular mixing units, consoles, distribution amplifiers, studio disc player units, speaker amplifiers, cable drums and many other items of studio equipment. Send for details and price list now.

CTH ELECTRONICS

Industrial Estate, Somersham Road, St. Ives, Huntingdonshire, PE17 4LE Telephone: St. Ives 64388 (0480 64388)

WW—049 FOR FURTHER DETAILS



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	£5.77	Model AT-45	£18.64
Model JP-5D	£6.93	Model 380-CE	£18.92
Model 360-YTR	£9.79	Model N-101	£22.00
Model U-50DX	£9.90	Model 460-ED	£25.74
Model A-303TRD	£13.03	Model EM-700	£50.56
Model K-30THD	£14.90	Model R 1000CB	£65.17
Model F-80TRD	£16.22		

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.

47-49 HIGH STREET, KINGSTON-UPON-THAMES, SURREY. KT1 1LP

Tel: 01-546 4585

WW—050 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** 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

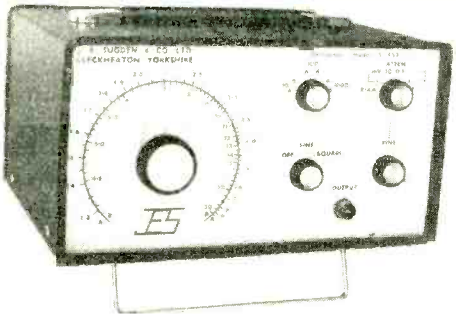
IN4001 50V 1A RECT DIODES. Full Specification Devices. ONLY 5p each.
709' DIL 14 PIN OP AMPS. Full Specification Devices ONLY 34p each.

FI-COMP ELECTRONICS

BURTON ROAD, EGGINTON, DERBY, DE6 6GY

WW—051 FOR FURTHER DETAILS

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

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

WW—052 FOR FURTHER DETAILS

The FX-107, FX-207, FX-307 are a powerful and flexible family of high performance monolithic signalling devices based on 3-Tone Sequential Code signalling techniques. Constructed using MOS/LS1 technology, the devices perform all frequency discrimination, tone generation and code timing functions on-chip, using simple external CR networks.

The family members are FX-107, a single code Transceiver with Transponder capability; FX-207, a multi-code Transmitter with logic controlled selection of any one-from eight codes; and FX-307, a multi-code Receiver which decodes 8 different input codes and provides an appropriate binary coded output.

Each code consists of three tones, each of different consecutive frequency and sent in a pre-determined sequence (Group Code).

Transmitter devices generate the programmed Group Code on receipt of a logic instruction; Receivers decode Group Codes applied to their signal input and operate integral output switches when the programmed code/s are received.

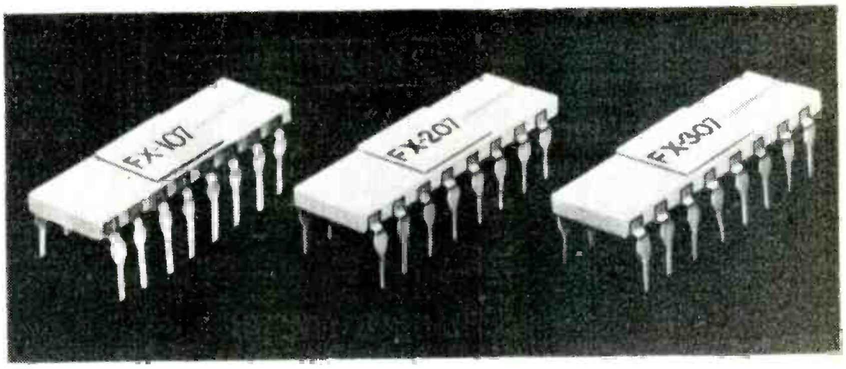
These exciting new devices may be used separately, or in any required combination, to yield high performance/low cost solutions in application areas involving selective signalling between one or more points, using a common transmission line. Virtually any number of outstations may be connected to the common line and a variety of instructions signalled to each one selectively.

P.C.B. Evaluation Boards for FX-107, FX-207 and FX-307 are available.

Completely new!

SELECTIVE SIGNALLING SYSTEMS

in Monolithic Form



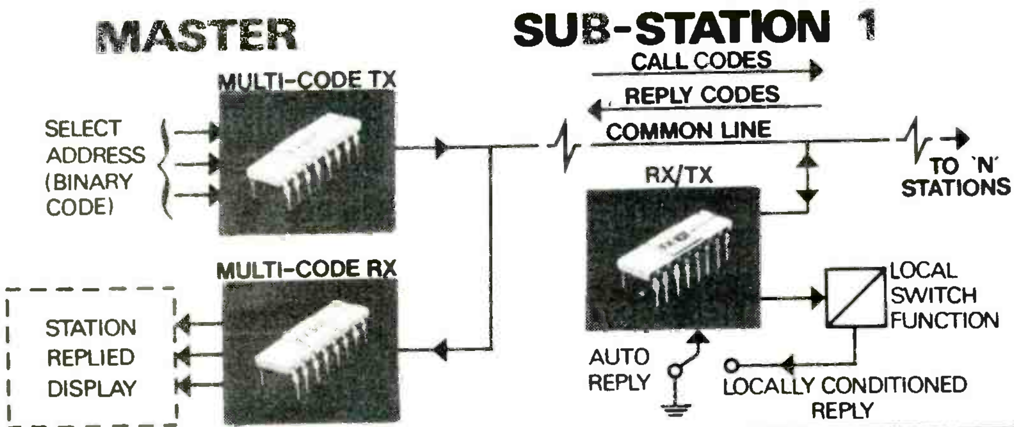
FX-107 3-TONE CODE TRANSCEIVER (RX/TX)

FX-207 3-TONE MULTI-CODE TRANSMITTER (TX)

FX-307 3-TONE MULTI-CODE RECEIVER (RX)

ex-stock

MULTI-STATION SELECTIVE CALL WITH ANSWER BACK



This example shows how simply the '07 family solves a typical complex signalling problem. The Master transmits switching instructions over a common line to selected outstations, which transpond on receipt of their address code. Transponded replies are decoded at the Master for display or verification purposes. Outstations may also signal the Master independently, or transpond giving coded status data.

OVERSEAS AGENTS:

FRANCE
D.I.M.E.S., 31 Rue George-Sand, 91-Palaiseau, Paris, France.
International Semiconductor Corporation, 20 Rue Gambetta, 92 – Boulogne, Paris, France.

GERMANY
Ginsbury Electronic GMBH, 8012 Ottobrunn, Ahornstr 10, Munich, Germany.

BENELUX
Heynen N.V., Postbus 10, Steendalerstraat 56, 6940 Gennep, Netherlands.

SWEDEN
Komponentbolaget Naxab, Bjornsonsgatan 243, S-161 56 Bromma, Sweden.

SWITZERLAND
Egli Fischer & Co. Ltd., Gotthardstr 6, Claridenhof, 8022 Zurich, Switzerland.

AUSTRIA
Datentechnik, Wr. Neustadter Strabe 7, A-2490 Ebebfurth, Austria.

ISRAEL
Bet K.D.M. Ltd., 21, Tchernihovsky St., P.O.B. 4770, Tel-Aviv, Israel.
Hamashbir Electronics, 76, Giborei, Israel St., Tel-Aviv, Israel.

JAPAN
Cornes & Co. Ltd., Marden House, CPO Box 329, Osaka, Japan.

AUSTRALIA
Ammon Pty. Ltd., 69, Peter Street, Box Hill North, Victoria 3129, Australia.

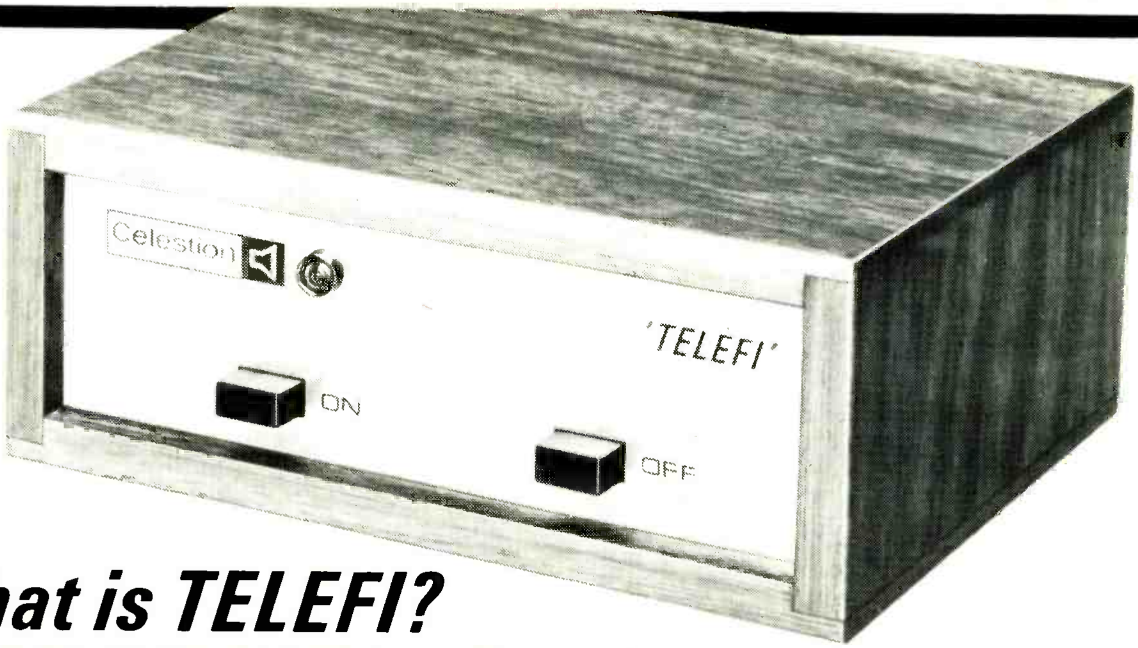
MEXICO
Industrias Electronicas Ese, S. de R. L., Amado Nervo 156, Mexico 4, D.F.

Frequency is our business

CONSUMER MICROCIRCUITS LTD.
Rickstones Road, Witham, Essex.
Telephone: Witham 3833/5
Telex: 99382 (Reaction)

Applications from Agents in other countries will be considered.

WW—053 FOR FURTHER DETAILS



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 recevier 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

WW—057 FOR FURTHER DETAILS

CLANSMAN
AUDIO EQUIPMENT BY S G BROWN COMMUNICATIONS

Introducing the range of CLANSMAN headsets, microphones and ancillary audio equipment.
Headset for radio manpacks·Respirator microphone·Single sided headset·Clansman Audio Equipment Test Set

Send for literature to: –

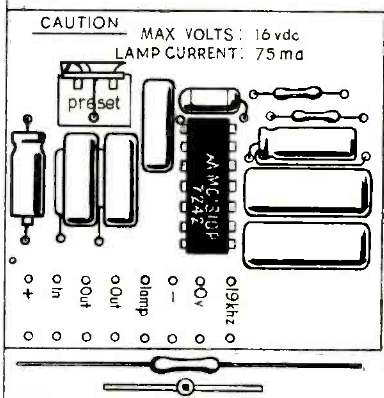
RACAL *The Electronics Group*

S G BROWN COMMUNICATIONS LTD.

King George's Avenue Watford Hertfordshire England
Telephone: Watford 23301 Telex: 23412 Telegrams: Radiolink Watford.

WW—058 FOR FURTHER DETAILS

Stereo radio from your existing tuner.



A complete set of parts from Jermyn to build a stereo decoder module that will convert your existing mono tuner for stereo reception whilst maintaining a high standard of reproduction.

The distortion is very low (typically 0.3% at 560 mV RMS composite input signal) with 40dB channel separation.

The stereo switching is automatic and there is a light emitting diode which acts as a stereo beacon.

The kit requires no coil and there are no alignment problems.

Fitting. The module requires a 10-16 volt power supply which can normally be tapped off the existing tuner. The signal input is taken off before the de-emphasis circuit which in practice means disconnecting one, or at the most, two capacitors. Any radio engineer will be able to spot these capacitors, but if you're really stuck send the circuit with a SAE to us and one of our engineers will indicate the output point. (This is the full extent of our involvement, no hardware please).

Of course, if you have a modern mono tuner with a multiplex output our module simply plugs in.

The outputs go via a screened twin cable to the tuner inputs of your stereo amplifier.

And the cost? £4.90 for the Kit with 100% tested integrated circuit. Also available assembled and aligned, checked and ready for use at £6.90 (includes 12 month guarantee). Beat that!

To Jermyn Industries
78 Vestry Estate
Sevenoaks
Kent

Please rush me ☐ Kit(s). ☐ made up Stereo decoders.
I enclose cheque/postal order for £
Name
Address

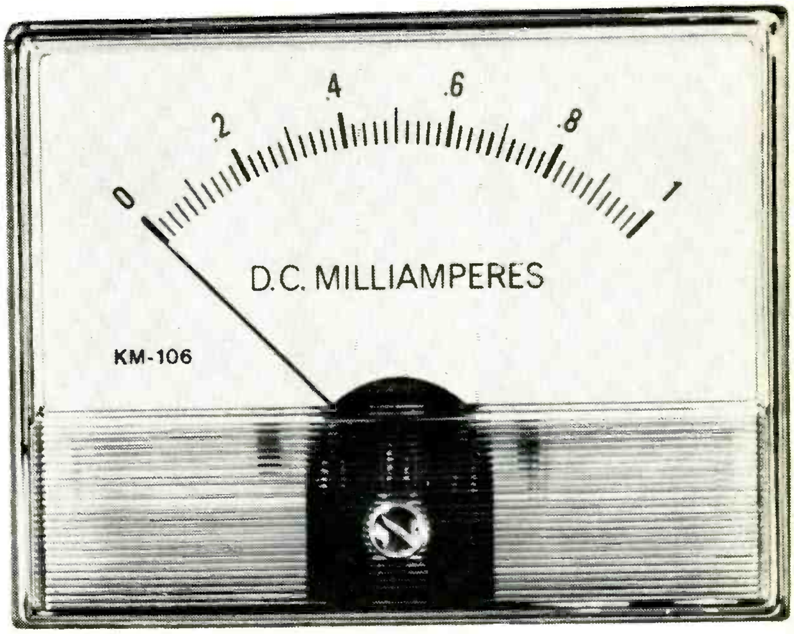
Block Capitals Please

WW—059 FOR FURTHER DETAILS

ANDERS MEANS METERS...

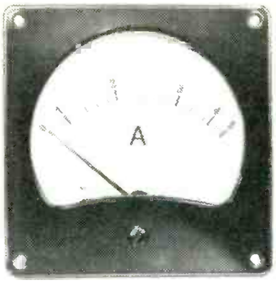
KESTREL RANGE

- Modern styling, with clearfront plastic case.
- Seven models, scale lengths from 1.3" to 5.25".
- Extensively used by many leading manufacturers of electronic and electrical equipment.
- Available in all ranges, moving coil and moving iron.
- Competitive prices.

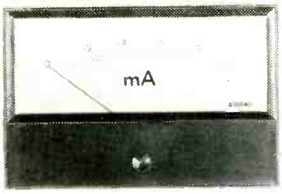


Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.

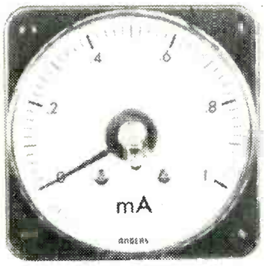


Vulcan Moving Iron. 4 models, 1·5", 1·8", 2·7", 3·7" scales. Voltmeters, ammeters and motor starting meters.

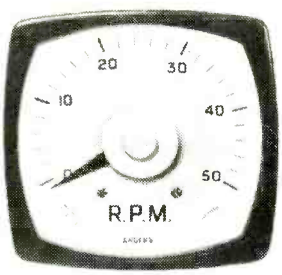


Regal Range 100° flattened arc. 2 models 2.5" and 3.2" scales. Taut band. DC moving coil and AC moving coil rectified.

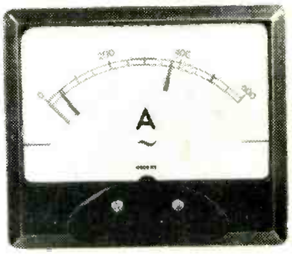
Profile 350 edgewise 4·3" scale. DC moving coil and AC moving coil rectified. Horizontal or vertical mounting.



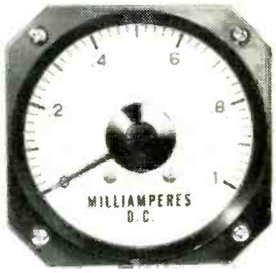
Oxford Long Scale 240°. 2 models, 5·5", 8" scales. DC moving coil and AC moving coil rectified.



Stafford Long Scale 240 6 models, 3·5"—11·5" scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.



Solicontroller Moving Coil Relay. DC moving coil and AC moving coil rectified. 1 or 2 adjustable alarm controls.



Lancaster Long Scale 240 . 2 models, 4", 5·5" scales. DC moving coil and AC moving coil rectified.

Send for fully illustrated catalogue.

ANDERS ELECTRONICS LIMITED 48/56 Bayham Place, Bayham Street, London, N.W.1. Telephone 01-387 9092.

Manufacturers and distributors of Electrical Measuring Instruments. Sole U.K. distributors of FRAHM Resonant Reed Frequency Meters and Tachometers. Manufacturers of purpose built electrical and electronic equipment to customers requirements.

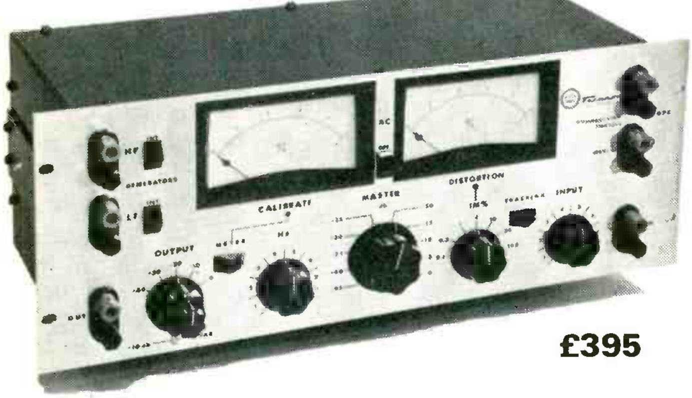
WW—060 FOR FURTHER DETAILS

amcron

(formerly Crown International)

INTERMODULATION DISTORTION ANALYSER

MODEL I.M.A



£395

Amcron Model IMA Intermodulation Distortion Analyser is a ruggedly engineered dual-meter instrument providing facilities for measuring to exceptional degrees of precision covering both L.F. and H.F. audio ranges (10-150 Hz and 2.5KHz to 20KHz). Tests over a wide range of varying amplitudes can be made quickly and accurately. FET circuitry assures measurements approaching a typical residual of 0.005% and within 5% of full scale. Many original features are incorporated in this instrument whereby generator interaction is eliminated, as are microphonics through the use of FET controlled AGC. Provision is made for connecting external oscillators over both LF and HF (audio) ranges. The use of dual meters allows one minute calibration and IM reading for highest efficiency in lab or on production line. Leaflet available on request.

ABRIDGED TECHNICAL DETAILS

I.M. Range — 0.1, 0.3, 1, 3, 10, 30, 100% full scale on separate I.M. meter.
Range of tracking — 45dB in 5dB (± 1%) increments
Input Impedance — 100K max. and 45K min depending on setting of input level control
Necessary HF input — 17mV min.
Outputs — 10K impedance for scope A and scope B showing HF envelope and demodulated IM signal
Controls — include switching to allow meter input and output controls to remain set when testing, using the master attenuator.
Size — 19" x 7" high x 7½" (standard rack mounting)

MACINNES LABORATORIES LTD. STONHAM, STOWMARKET. IP14 5LB
Telephone Stonham (044 971) 486.

WW—061 FOR FURTHER DETAILS

When a panel meter has to stand out in a crowd–specify Taylor Edgewise.

Introducing the model 330 with a 2¼ in. scale length and the slimmest body size in the Edgewise series to enable closer stacking. The latest in a range of three Edgewise panel meters that have been designed to combat the problem of increasingly crowded instrument panels. Housed in transparent acrylic mouldings, they provide shadowless readings and offer outstanding reliability. Find out more. Write for a data sheet now.

Taylor

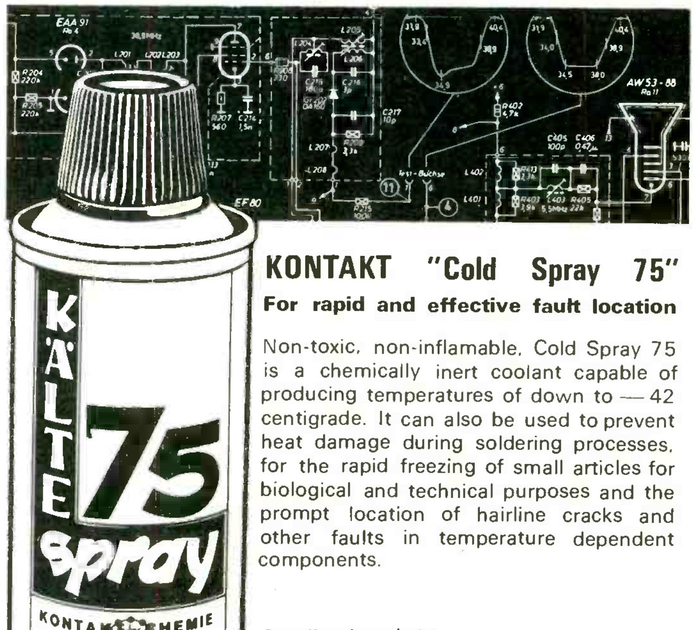
Taylor Electrical Instruments Ltd.,
Archcliffe Road, Dover, Kent.
Telephone: Dover 2634 Telex: 96283

Thorn Measurement Control and Automation Division.

THORN

WW—062 FOR FURTHER DETAILS

FAULT LOCATION



KONTAKT "Cold Spray 75"

For rapid and effective fault location

Non-toxic, non-inflamable, Cold Spray 75 is a chemically inert coolant capable of producing temperatures of down to — 42 centigrade. It can also be used to prevent heat damage during soldering processes, for the rapid freezing of small articles for biological and technical purposes and the prompt location of hairline cracks and other faults in temperature dependent components.

Other Kontakt products:
Kontakt 60 and Kontakt 61 for relay contact cleaning.
Plastic Spray 70. transparent protective lacquer.
Insulating Spray 72.
Kontakt WL. Spray Wash.
Antistatic Spray 100. Antistatic agent for plastics.
Politur 80. Polish and cleaner.
Fluid101. Dehydrating Fluid.

Details from UK distributors.

SPECIAL PRODUCTS DISTRIBUTORS LTD;
81 Piccadilly, London, W.1 Tel: 01-629 9556

WW—063 FOR FURTHER DETAILS

How to make the 'digitronic' solid-state digital clock using just 30 bits

Full instructions in this month's issue for versions with either four or six figures

And many other constructional features, including directions for making an electronic maze that will keep everyone amused for hours.

All in the March issue on sale Feb 2 · price 20p

PRACTICAL WIRELESS

PLUS a **free** 6"x 5" transfer sheet of labels for audio equipment

Easy to apply and ideal for an impressively professional finish

---

TRANNIES

(Formerly C. R. Hadley Electronics).
Telephone
Harlow (02796) 37739

24 WOODHILL, HARLOW, ESSEX
(No callers please)

AC126	11p	AL102	59p
AC127	11p	AL103	49p
AC128	11p	BC107	8p
AD161 } AD162 }	55p per pr.	BC108	8p
		BC109	8p
AF114	12p	BC182L	8p
AF115	12p	BC183L	8p
AF116	12p	BC184L	8p
AF117	12p	BC212L	8p
		BC214L	8p

TRANSISTORS LOWEST PRICES

Ring for bulk enquiries.

OC44	13p	TIP31A	58p
OC45	13p	TIP32A	69p
OC71	12p	40636	55p
OC25	28p	2N2926G	10p
OC28	30p	2N3053	20p
OC29	36p	2N3055	49p
OC35	28p	2N3702	11p
OC36	36p	2N3703	11p

BARGAIN PACKS

Plastic BC109 (fully tested) 5p each

1N4001-2-3: 1-9 5p; 10-99 4p; 100 plus 3p

Unmarked but fully tested. **2N2926G** 5p each

Minitron 7 segment indicator Type 3015F £1.50 each

Unmarked but fully tested. **2N3055** 1-9 25p each; 10 plus 22p each

Pack of 25 **1N4148** 50p

★ SUPER LOW PRICED LINEAR K's

709c TO99	28p	723c TO99	75p
709c DIL	32p	723c DIL	89p
741c TO99	38p	741c 8 pin DIL	38p
741c DIL	36p	748c TO99	42p

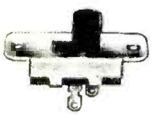
TTL BARGAINS

7400	12p
7401	12p
7410	12p
7475	45p
7490	60p
7492	62p

AND LOTS MORE. See our price list. Also Super New **Cosmos**.

SLIDE SWITCHES

SPST 10p
DPDT 12p

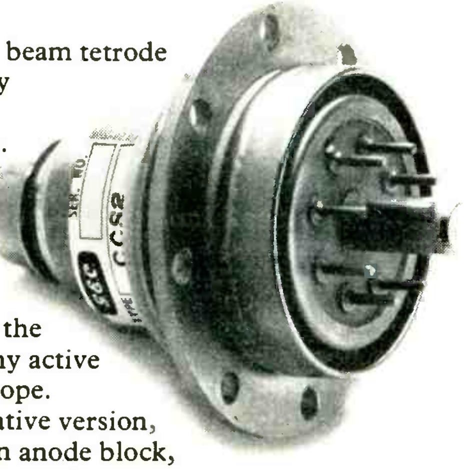


MINIATURE NEON LAMPS

109mA. 230v. or 110v. 5p each. 10 plus, 4p.

WW—067 FOR FURTHER DETAILS

The CCS2 gives you a cool 250 watts.



Our CCS2 beam tetrode is especially easy to design into co-axial circuits.

That's because we've designed a special beryllia ceramic flange which separates the heatsink from any active part of the envelope.

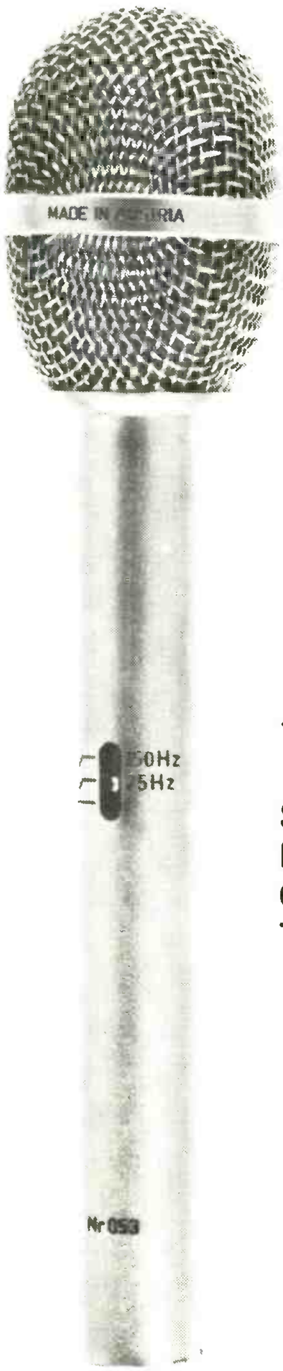
The alternative version, the CCS1, has an anode block, the face of which is bolted directly to the heatsink.

So, if you find air blowers an embarrassment to your design, get the facts on these conduction cooled beam tetrodes.

G.E.C. The M-O Valve Co.Ltd
Hammersmith, London W6 7PE Tel: 01-603 3431
Telex: 23435 Cables: Thermionic London
A member of The GEC Electronic Tube Co. Ltd., a management company which unites the activities of The M-O Valve Co. Ltd., and English Electric Valve Co. Ltd.

WW—068 FOR FURTHER DETAILS

C451EB MODULAR SYSTEM



Comprising pre amplifier with 3 position switch to give:

(1) Flat response
(2) Roll off at 75 Hz
(3) Roll off at 150 Hz

The C451EB is for use with the CK9 gun attachment or the CK8 miniature gun attachment and various other cardioid and omni directional capsules;

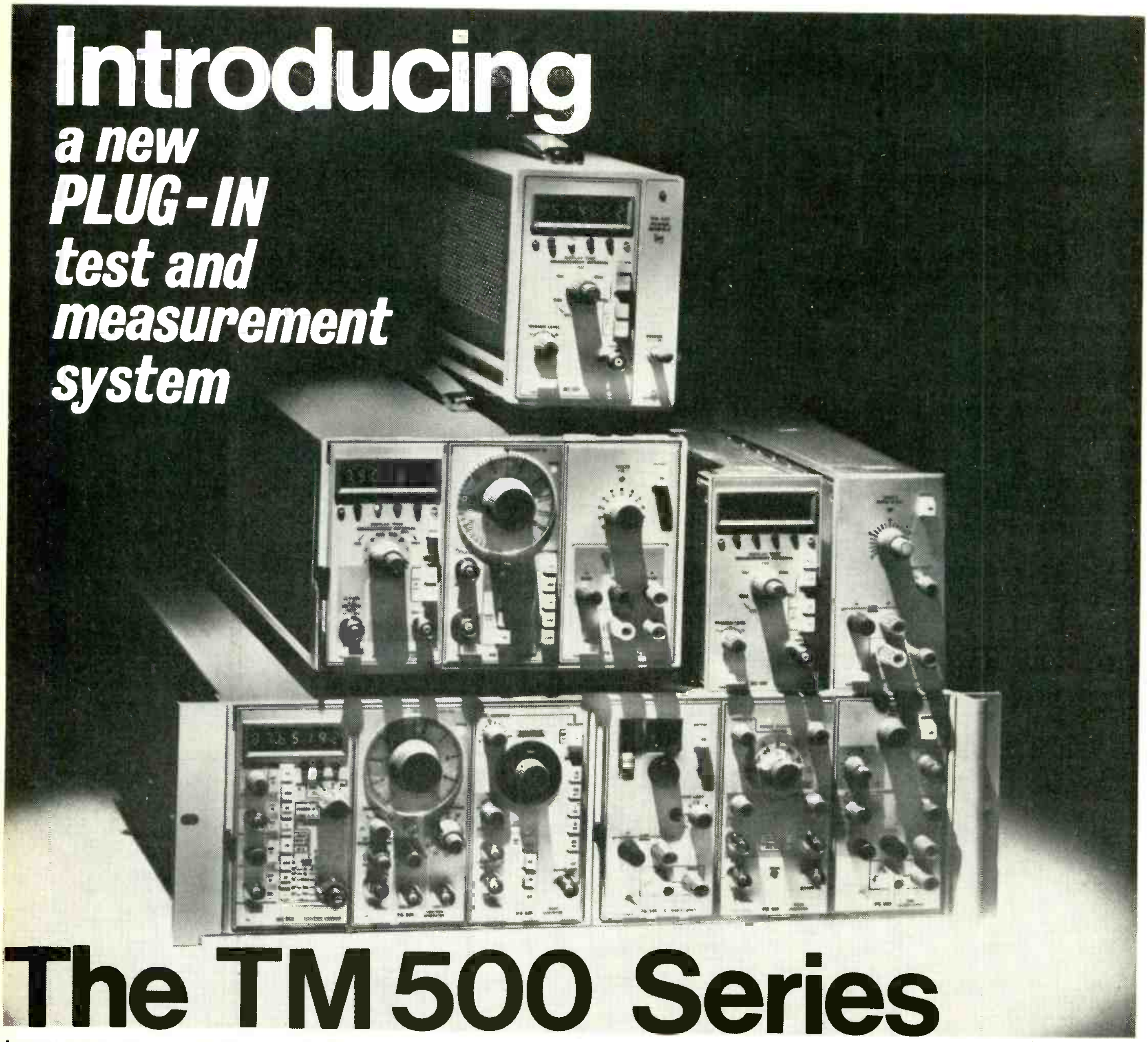
Can also be used with the special AKG cradle on Fisher & Mole booms; and as a hand mike with a pop shield.

THE VERSATILE AND INEXPENSIVE C451 SYSTEM IS ONE OF THE MOST WIDELY USED IN OUR BROADCASTING AND TELEVISION INDUSTRY.

FOR FULL INFORMATION CONTACT:

AKG

AKG EQUIPMENT LTD.
182/4 Campden Hill Road
Kensington London W8 7AS
Telephone 01·229 3695.



Low-cost, space-saving modules you can mix and interface for specific applications. Any single unit and its compact, single-hole mainframe offers good value. For only a few pounds more, the three-hole mainframe gives you extra room to grow, and extra flexibility. Here's an example of what you can do: Combine a ramp generator, function generator, and universal counter in in the 3-hole mainframe. Using the intracompartment interface you can use the ramp generator to sweep the function generator, and monitor the output with the counter. Complete cost of this system is only £722-20 (Duty Paid).

The TM 500 has these plug-in functions available:

- *550-MHz digital counter*
- *100-MHz digital counter*
- *100-MHz universal counter*
- *20-V single- or dual-tracking power supplies*
- *1-MHz function generator*
- *10-µs ramp generator*
- *50-MHz pulse generator*
- *1-MHz RC Oscillator*
- *Digital multimeter*

Need a compact 3-function system for your bench?
The TM 503 power module accepts any 3 plug-ins, i.e., digital multimeter, function generator, ramp generator, yet only occupies 6 by 8.7 by 15.3 inches on your bench.

Need a rack installation?
Mount one or two TM 503s in a rack, and get 3 or 6 functions in only $5\frac{1}{4}$ inches of rack height. Compatible large-screen monitors available.

Need mobility?
The TM 501 accepts any single plug-in module for maximum carrying ease. The 203-3 Scope-Mobile® powers any 3 plug-ins, stores up to 4 more, and supports a scope or other instrument on its tilting platform.

NEED MORE INFORMATION?
SEND TODAY FOR FULL DETAILS—

TEKTRONIX®

TEKTRONIX UK LTD.
BEAVERTON HOUSE, P.O. BOX 69.
HARPENDEN, HERTS.
TEL: HARPENDEN 61251 TELEX 25559

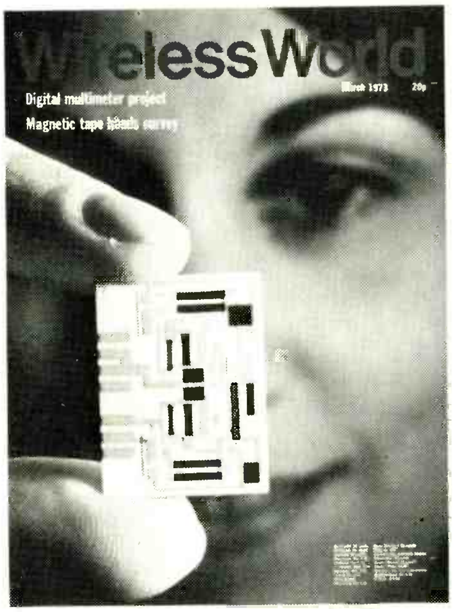
DDL 2926

WW—076 FOR FURTHER DETAILS

Wireless World

Electronics, Television, Radio, Audio

Sixty-third year of publication **March 1973** **Volume 79 Number 1449**



Thick-film circuits (see p.121) are symbolized on the **front cover** which shows a microcircuit based on a DuPont composition.

Contents

107 **The Transistor and the Future**

108 **Digital Multimeter — 1** *by D. E. O'N. Waddington*

112 **News of the Month**
Electronic telephone exchange
Bipolar i.c. process III
Image processing robot

114 **Surround-sound Circuits** *by G. B. Shorter*

117 **Conferences & Exhibitions**

118 **Letters to the Editor**

121 **Hybrid Thick-film Circuits** *by G. Brooke & W. E. B. Baldwin*

125 **Sixty Years Ago**

126 **Audio Magnetic Recorder Heads** *by B. Lane*

129 **Announcements**

130 **About People**

131 **The Realm of Microwaves — 2** *by M. W. Hosking*

134 **H.F. Predictions**

135 **Industrial Electronics — 1** *by R. Graham*

136 **Books Received**

137 **The Semiconductor Story — 3** *by K. J. Dean & G. White*

141 **Experiments with Operational Amplifiers — 8** *by G. B. Clayton*

142 **Circuit Ideas**

144 **Evolution of the A.C. Mains Valve** *by J. H. Ludlow*

149 **Sonex '73**

150 **World of Amateur Radio**

151 **New Products**

156 **March Meetings**

158 **Literature Received**

A90 APPOINTMENTS VACANT

A108 INDEX TO ADVERTISERS

Circards see p.129

In our next issue
(publication date March 19)

Digital multimeter project. The series continues with an article describing in detail the circuit operation of the instrument. All circuit diagrams are included.

Magnetic tape survey demonstrates compatibility between different makes of tape, enabling recorder users to change brands without loss of quality and without having to try the tapes in their machines.

We apologize for any indistinctness of printing in parts of this issue. This is due to lack of gas drying during the dispute in the gas industry.

ibpa
International Business Press Associates

I.P.C. Electrical-Electronic Press Ltd
Managing Director: George Fowkes
Administration Director: George H. Mansell
Publisher: Gordon Henderson

Price 20p. (Back numbers 40p.)
Editorial & Advertising offices: Dorset House, Stamford Street, London SE1 9LU.
Telephones: Editorial 01-261 8620; Advertising 01-261 8339.
Telegrams/Telex, Wiworld Bisnespres 25137 London. Cables, "Ethaworld, London S.E.1."

Subscription rates: *Home*, £4.35 a year. *Overseas*, 1 year £4.35; 3 years £11.10 (U.S.A. & Canada 1 year $11, 3 years $27.75). Student rates: Home and Overseas 1 year £2.18, 3 years £5.55 (U.S.A. & Canada 1 year $5.75, 3 years $14.50).
Distribution: 40 Bowling Green Lane, London EC1R 0NE. Telephone 01-837 3636.
Subscriptions: Oakfield House, Perrymount Rd, Haywards Heath, Sussex RH16 3DH. Telephone 0444 53281. Subscribers are requested to notify a change of address four weeks in advance and to return envelope bearing previous address.

PROMISES, PROMISES

When Akai make them, they keep them

Some guarantees are worth little more than the paper they're printed on.
An Akai guarantee is as good as its word. Always.

PROMISE 1

Every Akai product carries a 1 year guarantee on all parts and labour. If a part fails we'll replace it free of charge. That's a promise.

PROMISE 2

Akai Glass and Crystal Ferrite Heads are guaranteed wear-free for life. If a GX head shows any signs of wear after normal use we'll replace it free of charge. We'll also be very surprised.

PROMISE 3

(we haven't made this one before.)
Akai now offer a 5 year guarantee on all motors in all their products. And if you have any idea what a motor costs, you'll know that's a guarantee worth having. All you have to do is pay for any labour costs involved – but if the motor fails in normal use during the first five years of its life, the new one's on us, absolutely free.

PROMISE 4

If you send off the coupon, we promise we'll send you a copy of the Akai range leaflet. It will tell you all about all the Akai cassette, cartridge and reel-to-reel equipment available. We guarantee you'll be impressed.

Akai, Rank Audio Products, P.O. Box 70, Great West Road, Brentford, Middlesex TW8 9HR.
Please send me the Akai range leaflet.
Name ....
Address ....
.... WW1

Akai equipment is made in Japan by Akai Electric Co. Ltd., and is distributed and serviced in the UK exclusively by Rank Audio Products.

AKAI

WW—077 FOR FURTHER DETAILS

Wireless World

The transistor and the future

Editor:
H. W. BARNARD

Technical Editor:
T. E. IVALL, M.I.E.R.E.

Assistant Editors:
G. B. SHORTER, B.Sc.
W. E. ANDERTON, B.Sc.
B. LANE

Drawing Office:
L. DARRAH.

Production:
D. R. BRAY

Advertisements:
G. BENTON ROWELL *(Manager)*
Phone 01-261 8339
G. J. STICHBURY
Phone 01-261 8037
A. PETTERS *(Classified Advertisements)*
Phone 01-261 8508 or 01-928 4597

During the week of February 12-16 the I.E.E. (in collaboration with the I.E.R.E.) has marked the 25th anniversary of the discovery of the transistor by a series of lectures. It included one by Dr. Walter Shockley who, with his two colleagues Drs. Bardeen and Brattain, jointly invented the device which has had such a profound effect on electronics technology and indeed on the everyday life of us all. The lecture was noteworthy for various reasons; never before has a lecturer in the hallowed walls of the Institution's lecture theatre entertained his hearers with one or two conjuring tricks during his talk and rarely has such documented detail of the day-to-day experiments which led up to the production of a particular device been presented. It was a memorable occasion but one felt that had it not been for the personal anecdotes it had all been said many times before.

Dr. Shockley, who is now professor of engineering science at Stanford University and executive consultant to Bell Telephone Laboratories, Murray Hill, where he carried out his early research work on the transistor, rightly dealt with the early history and left the present and the future to be covered by other speakers in the series of lectures. However, during a pre-lecture interview he was asked if he would speculate on the likelihood of a further major reduction in the size of transistors. To which he replied that he foresaw an increase in compactness by a factor of 10^9. He stated, in answer to a question, that the transistor's most significant contribution to his own life was his portable tape-recorder (Japanese, incidentally), which certainly appeared to be his *vade-mecum*.

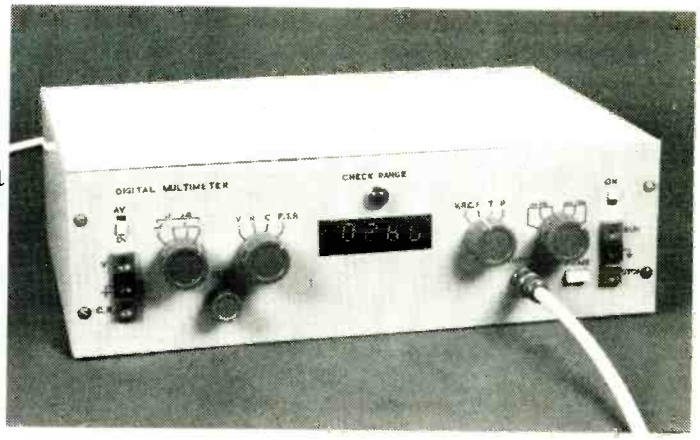
The impact of the transistor on current technology is well known and it was, therefore, those papers among the commemoration series which looked into the future which were of particular interest.

As Professor W. E. J. Farvis, of Edinburgh University, said in his lecture "The influence of the transistor in our society and economy" the transistor has enabled us to effect circuit functions and operations in computing or control too complex to have been contemplated even a decade ago. It has also brought an increasing use of digital methods for achieving system functions and perhaps of even greater significance the building in of redundancy in equipment.

Germanium and silicon were the semiconductors from which the first and second generation of transistors came, but who can foretell what lies ahead with use of other materials as yet untried. Dr. Farvis pointed to the newer areas of opto-electronics and acousto-electronics adding "the scope of ingenuity in exploiting the electronic and physical properties of materials for the service of man seems boundless".

At the discussion meeting on "What next in semiconductors?" emphasis was laid upon materials and the various methods of processing them. R. A. Hilbourne (Mullard, Southampton) posed the question "where is l.s.i. leading us?". In the course of his contribution, having pointed out that the majority of l.s.i. circuits which have replaced non-electronics equipment have been designed by the i.c. maker, he asked "will the conventional electronic equipment makers wish to retain, in house, their circuit system design?". This brings us back to the question asked so many times before as to the role of the circuit designer of the future. Will he be, in fact, a systems engineer using l.s.i. circuit blocks?

Digital Multimeter



1. Introduction and design criteria

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

The $3\frac{1}{2}$-digit electronic multimeter described in this and succeeding articles contains provisions for the measurement of voltage (alternating or direct, with polarity and a.c. indication), resistance, capacitance, frequency, period and time. The design has been kept as simple as possible and is so arranged that the constructor can build the complete instrument or include only the facilities he needs. Nevertheless, it must be pointed out that a large number of connections must be made and that the project is not suitable as a first exercise in construction.

A few years ago, a project such as building a digital multimeter would have been unthinkable for the home constructor, on the grounds of both cost and complexity. However, these objections have been reduced if not completely overcome by the availability of reasonably priced integrated circuits, which provide major building blocks and simplify the physical task of wiring the instrument.

The main problems to be resolved before this design could be started were what features to include and which of the many available techniques to use. In order to do this, it was necessary to examine desirable measuring capability, accuracy and display.

Desirable measuring capability

The difficulty here is not what to put in but what to leave out! The best plan is to list the measurements and then to delete those which are neither practical nor essential. Possible measurements are (a) voltage—alternating and direct, (b) current—alternating and direct, (c) resistance, (d) capacitance, (e) inductance, (f) frequency, (g) period, and (h) time.

For most users, voltage measurement is of prime importance and justifies its place at the top of the list. Given a sensitive high impedance voltmeter, it is relatively simple to measure current by the use of suitable shunt resistors. However, current measurements frequently require that both the input terminals should be isolated from ground. For d.c. measurement this does not impose insuperable difficulties but, unless battery operation or sophisticated design techniques are employed, the isolation as far as alternating currents are concerned is likely to be very poor. For this reason, regretfully, current measurement was not provided. Passive components are not "naturals" for digital methods of measurement but, as a high input impedance voltmeter is available, it is easy to measure resistance with the aid of a constant-current source. Capacitance can also be measured relatively easily by measuring the time required for the voltage across a capacitor, fed from a current source, to reach a predetermined value. Inductance is not so easy to measure and, as it is so seldom required, it was not considered essential.

Digital measuring instruments were originally developed for the measurement of frequency and time, so that it would be a pity to leave these out of a design of this sort, although their omission would not impair the performance of the voltmeter section. Having a particular interest in time measurement, I decided to include the counter/timer features in this instrument.

Accuracy, display

These are treated together as, for most people, "digital displays" is synonymous with "accurate displays". This is not necessarily true. Digital displays can give better resolution than their analogue counterparts but the accuracy of the measurement is limited by both the accuracy of the techniques used and the accuracy of the standards within the instrument. Furthermore, it is all too easy to specify an accuracy which is very much greater than is necessary simply because it can be obtained. A typical example of this is the operator who measures the gain of an audio amplifier at a frequency of $1000\text{Hz} \pm 0.1\text{Hz}$ simply because he has a frequency counter with a ten second gate!

Having these points in mind and adding to them the limitations of the home laboratory, I decided on a frequency, period and time measuring accuracy of the order of 1 part in 10^5, which can be obtained using a readily-available crystal, with no necessity for temperature control, as the frequency standard. Accurate voltage measurement is far more difficult so that it is likely that the accuracy achieved will lie between 5 parts in 10^3 and 1 part in 10^2. With this sort of accuracy, the question of the display can be settled fairly easily. The use of a display with three significant digits will give a resolution of 0.1% of full scale. While this is sufficient for most purposes, in practice it is uncomfortable because there will be no over lap between successive decade ranges. Thus I decided to include a fourth digit which is either one or zero, adding very little to the complexity. A display of this type is commonly known as a $3\frac{1}{2}$ digit display, and does not prevent the full accuracy of the frequency counter from being realized as the count period can be switched to display whatever significant figures are required. For example, with an input frequency of 1,256,345Hz, a count period of one second will give a display of 0345, while a count period of 1 millisecond will give a display of 1256. The ambiguity caused by the overlap i.e., the "zero" in 0345 and the "six" in the 1256 can be resolved by switching to an intermediate count period.

A further decision needed was on the type of presentation to use. Many digital counters use a display method which permits the figures to "roll" between successive readings. This is very tiring to use so I decided on a "non-blinking" display which uses a memory to store the answer between successive readings. This adds marginally to the cost but it gives a bonus in that it permits the use of the "dual ramp" technique for voltage measurement.

Having decided what features to include the next stage was to choose the configurations for the various measurements. In order to do this several building blocks are needed. These are:

1. Counter/display. This consists of the $3\frac{1}{2}$ decade counter, memory, decoder and the display devices. It has three inputs: count, transfer and reset. It also gives an output from the counter section to control the analogue measuring functions.

2. Control logic. This section includes the gating and pulse generating circuits necessary to route the inputs to the counter and to control the counter functions.

3. Master clock. This consists of a crystal oscillator and a frequency divider chain to provide the main timing for all the measurements.

4. Input wave shaper. This circuit is used, during frequency and period measurement, to convert the input signal into a form suitable for connecting to logic circuitry.

5. Timer control. This unit is used to start and stop the counter for time measurement.

6. Voltmeter. This unit consists of the high input impedance stage, the rectifier and the dual-ramp voltage-to-time converter used for voltage and resistance measurement.

7. Resistance and capacitance unit. This contains the current source used for resistance and capacitance measurement and the circuitry necessary to obtain a capacitance-to-time conversion.

This selection of sections is convenient as it is very easy to vary the function of the instrument by selecting the appropriate modules. For example, if only a frequency counter is wanted, Blocks 1, 2, 3 and 4 are the only ones which need be built. However, if a voltmeter only is required, it is a simple matter to choose the appropriate blocks.

Specification

The performance which can be achieved with this instrument will, of necessity, depend upon the accuracy of the components used rather than the techniques employed. The following specification should be regarded as a target for the performance.

Direct voltage:

Input resistance	11.1MΩ
Range	199.9mV to 199.9V in 4 ranges.
Accuracy	±0.1% f.s.d. ±0.2% of reading.

Automatic polarity indication.

Alternating voltage:

Input impedance	10MΩ in parallel with 25 pF.
Ranges	As d.v.
Measurement	Average, calibrated r.m.s.
Accuracy	±0.1% f.s.d. ±0.5% of reading.
Frequency range	50Hz—10kHz 10Hz—50kHz±5%

Automatic indication that the input is a.v.

Resistance:

Range	1.999kΩ to 1.999MΩ in 4 ranges.
Accuracy	±0.1% f.s.d. ±0.5% of reading.

Capacitance:

Range	1999 pF to 1.999 μF in 4 ranges.
Accuracy	±0.1% f.s.d. ±0.5% of reading.

Counter/Timer:

Frequency range	0 to 5MHz
Period/Time interval	20 μs minimum.
Accuracy	Frequency ±1 part in 10^5±1 count. Period ±1%±1 count. Time interval ±1 part in 10^5±1 count.
Input level	Frequency/period 10mV to 10V. Time interval d.t.l. input.
Impedance frequency/period.	100kΩ in parallel with 10 pF.
Gate times	10 μs to 1 second.

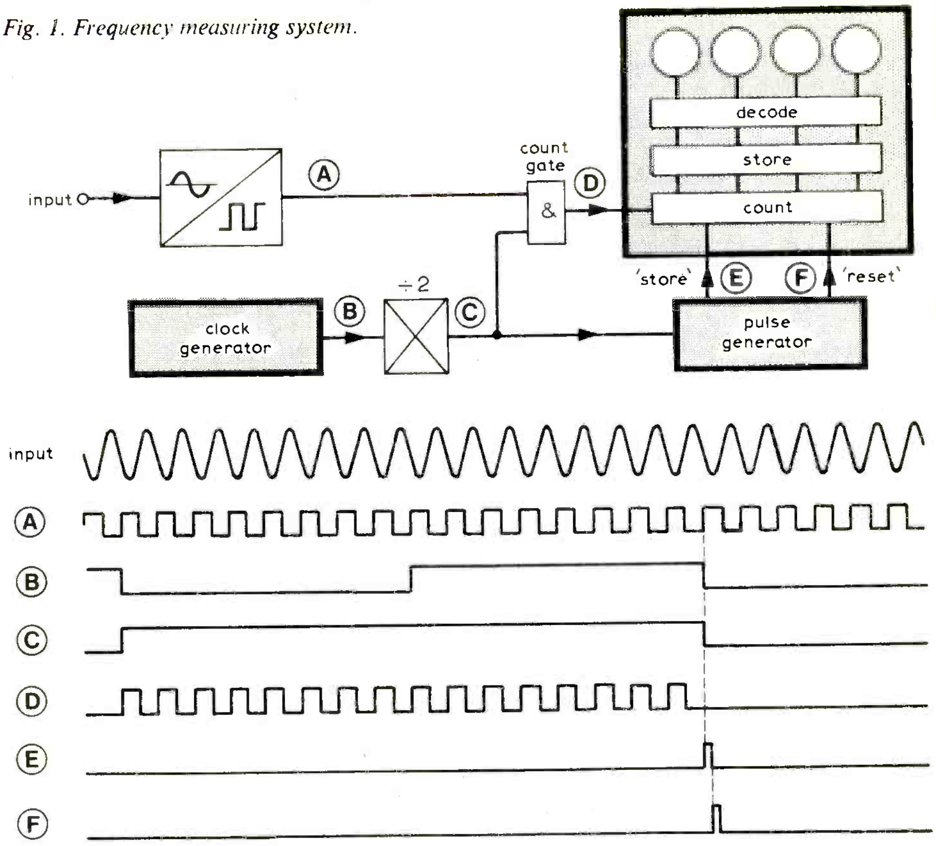


Fig. 1. Frequency measuring system.

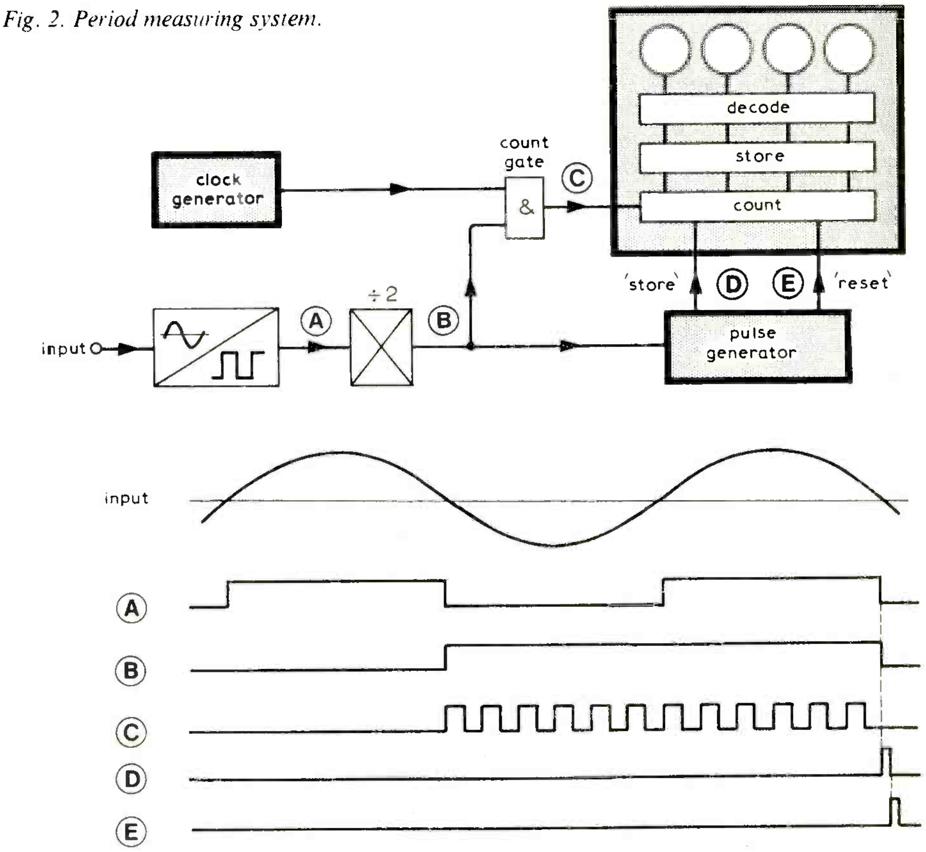


Fig. 2. Period measuring system.

Frequency measurement

The signal whose frequency is to be measured is applied to the input of the wave shaping module in Fig. 1. This either amplifies and/or limits the input signal, depending on its amplitude, and then converts it into a rectangular wave form (A) having a peak-to-peak amplitude of 5V.

The master clock frequency (B) has a period equal to the desired count duration. For example, if the count duration is to be 10 milliseconds, a frequency of 100Hz will be selected. In order to open the count gate for the correct time, this clock frequency is divided by two (C) before it is applied to the count gate and also to the control pulse circuit which generates the "store" (E) and "reset" (F) commands.

Assuming that the counter has been set to zero, the sequence of operation is as follows. The count gate is enabled for one clock period by the output of the divide-by-two. This connects the shaped input waveform to the input of the counter so that it counts the number of cycles during one clock period. At the end of this period, the negative going edge of the timing signal (C) causes the pulse generator to generate two successive pulses. The first of these (E) commands the counter unit to "store" and display the state of the count section. The second (F) "resets" the count section to zero ready for the next cycle of operation. This process will then restart when the timing signal (C) goes positive once more. Thus the unit counts and updates the display on alternate clock periods and, with a constant input frequency, produces a steady reading.

Period measurement

The major difference between period and frequency measurement is that the roles of the clock generator and input wave-shaper are reversed as in Fig. 2. Instead of counting the number of input cycles during one clock period, the number of clock pulses during one input cycle is counted. As with frequency measurement, the input waveform is "squared up" (A) by the input wave shaper. It is then divided by two (B) and fed to the count gate and to the control pulse generator. The output from the clock generator is also fed to this gate so that, when it is enabled by the input, clock pulses (C) are fed to the counter. The "store", "display" and "reset" functions are the same as for frequency measurement. This period measurement facility has its main application at low frequencies where the normal counter would be very inaccurate. For example a frequency of 5Hz measured using a one second count period could only be measured to an accuracy of ±1 cycle or ±20%. By measuring period (200 ms), however, the accuracy could be very much improved. In practice the accuracy could be better than 0.1% provided that there was no noise present on the waveform to be measured. The main disadvantage of period measurement is that the result is the reciprocal of the required answer.

Time interval measurement

The only difference between the period and time measuring functions is that, whereas period is measured continuously on a cyclic basis, time is measured as the interval between two separately applied impulses, as shown by Fig. 3. To prevent the time information from being upset by contact bounce or other spurious inputs, the timer control circuit is arranged to work on a "one shot" basis so that it needs priming before each measurement.

Fig. 3. Time interval measuring system.

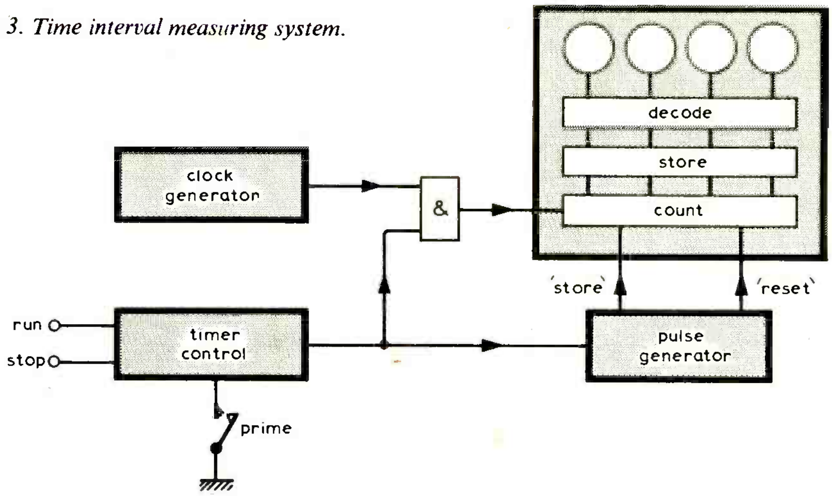
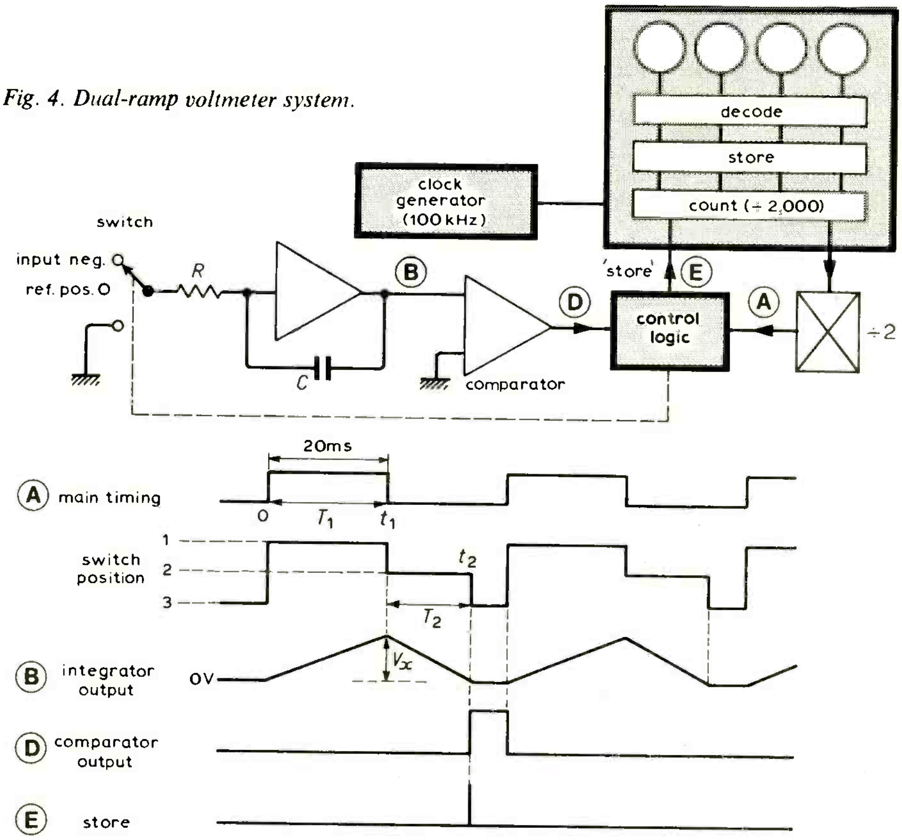


Fig. 4. Dual-ramp voltmeter system.



Voltage measurement

The method of voltage measurement to be adopted occasioned considerable thought. Potentiometric methods were examined and rejected on several counts. They are not really compatible with frequency counters, for in addition to a reference voltage they require an accurate resistor chain together with accurate switches. In addition, unless a suitable low pass filter is included in series with the input, potentiometric methods tend to be noisy and to give erratic readings in the presence of 50Hz interference. For these reasons, an integrating method was selected. Both voltage-to-frequency and voltage-to-time conversion methods were examined and finally I decided to adopt the well-known "dual ramp" voltmeter principle.[1] This method has the advantage that the accuracy of the basic range theoretically depends only on the accuracy of the reference voltage. Actually this is not strictly true in practice as several other design points affect the accuracy.[2] However, for a meter of this type, the reference accuracy is the major factor. The system works as follows:

At the beginning of the measurement cycle the capacitor C in Fig. 4 is fully discharged. The input to the integrator is connected to the unknown voltage so that the capacitor C begins to charge at a rate determined by this voltage and the resistor R. The charging is continued until the counter has counted 2000 (that is, for 20 milliseconds). At the end of this period, the voltage, V_x, across this capacitor will be

$$\frac{1}{RC}\int_0^{t_1} V_{in}\,dt \quad \text{or} \quad V_x = \frac{V_{in}T_1}{RC}.$$

The input to the integrator is then switched to the reference voltage V_{ref} so that the capacitor discharges at a rate determined by the reference voltage and the resistor R. As this voltage is larger than the voltage to be measured, the charge on the capacitor decreases more rapidly than it built up and at a time T_2 it will be zero.

$$\text{i.e.}\quad 0 = V_x - \frac{1}{RC}\int_{t_1}^{t_2} V_{ref}\,dt$$

$$= V_x - \frac{V_{ref}T_2}{RC} = \frac{V_{in}T_1}{RC} - \frac{V_{ref}T_2}{RC}$$

thus

$$V_{in}T_1 = V_{ref}T_2$$

$$V_{in} = \frac{T_2}{T_1}V_{ref}.$$

The zero voltage condition is sensed by the comparator which causes the control logic to switch the input of the integrator to zero volts thus preventing any further change in the charge on the capacitor. At the same time, the control logic commands the counter to store the count. As has been shown above, the time displayed gives a direct measure of the input voltage in terms of the reference voltage. Thus, the reference voltage can be chosen to give a suitable basic range for the voltmeter. For example, with a reference voltage of 2 volts, the basic range will be 2 volts although it will only be possible to display 1.999 volts. The counter continues counting until it reaches the all zero state, when the measurement cycle is repeated. An incidental advantage of this method of measurement is that the choice of a measuring period of 20 milliseconds gives good rejection of 50Hz interference (see Fig. 5).

Resistance measurement

The methods of measurement used in conventional moving coil multimeters are of no use here as the scale shape which results is non-linear and thus very inconvenient for digital display. Instead the method, shown in Fig. 6, is to pass a known current through the unknown resistor and to measure the voltage drop across it. In theory this method is ideal and I have no doubt that Georg Simon Ohm would approve. However, it does present some practical difficulties. Low resistances would need very high currents to develop sufficient voltage. It is difficult to establish the low currents necessary for high resistance measurement and high resistance measurements are necessarily made inaccurate by shunt resistance paths. Luckily, the majority of resistances to be measured in most electronics work lie in the range from 100 ohms to 100kΩ. This is the best range for this method of measurement and adequate accuracies can be obtained easily.

Capacitance measurement

Conventionally, capacitance is measured by bridge methods. While it is possible to arrange an auto-balance bridge system so that it can give an output suitable for applying to a digital readout, the circuits are likely to be complicated. An approach which, at first sight, appeared hopeful was the use of resonance techniques. Unfortunately they normally give an output frequency which is proportional to the reciprocal of the square root of the capacitance. This is a non-linear function and not easily applicable to a simple digital meter. In view of these difficulties I decided to exploit the relationship:

$$Q = CV = it$$

$$\text{or}\qquad C = \frac{it}{V}$$

$$C = t\ (i \text{ and } V \text{ constant}).$$

This suggests that it is possible to measure capacitance in terms of the time required for the voltage drop across the capacitor, charged from a constant current source, to reach a predetermined level. The method of implementing this technique is illustrated in Fig. 7.

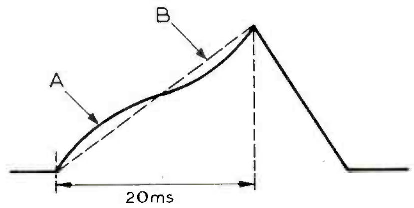


Fig. 5. Integrator output when measuring a direct voltage with a superimposed 50Hz signal. The area "A" cancels the area "B" so that the interfering signal is effectively rejected. This rejection also occurs at the other frequencies which have an integral number of cycles in 20 milliseconds.

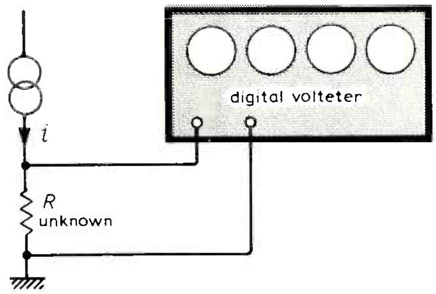


Fig. 6. Resistance measuring system.

At the beginning of the measurement cycle, the capacitor under test is completely discharged. The shorting switch across the capacitor is then opened allowing the current from the constant current source to flow into the capacitor. This, in turn, causes the voltage across the capacitor to rise linearly with time. The comparator detects when the voltage across the capacitor equals the reference voltage and causes the control logic to send a "store" command to the counter thus displaying the time taken and, hence, the capacitance value. At the halfway point during the cycle, the switch is closed once more so that the capacitor is discharged ready for the next measurement cycle.

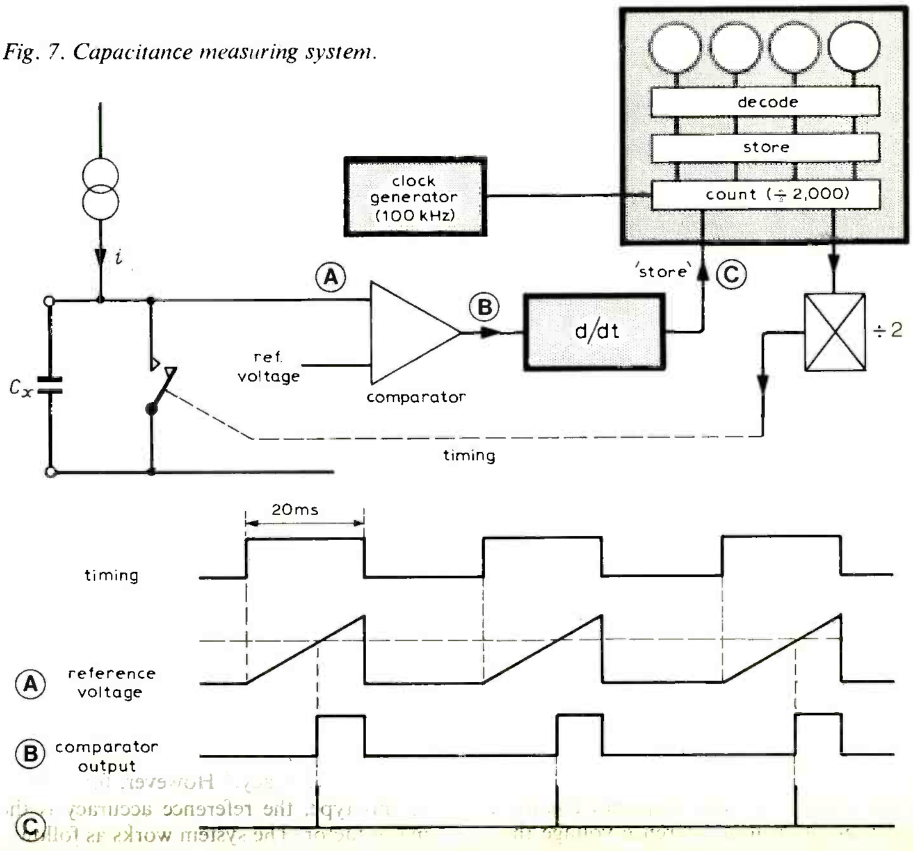
This method of measurement has two main shortcomings, both of which produce similar effects. Firstly, it cannot resolve the effects of leakage resistance. As leakage generally occurs in electrolytic capacitors, this method is not really suitable for measuring them. Accordingly the top range has been limited to 1.999 μF. Secondly, very low currents, or very short periods are needed when measuring low values of capacitance. As a result, the lowest range was chosen to be 1999 picofarads giving a possibility of resolving one picofarad.

In the next section of this article, I will describe the circuits used to perform the measurements which I have discussed above.

REFERENCES

1. Schmid, H., "Digital meters for under $100". *Electronics*, November 28, 1966, p. 88.
2. Wheable, D., "Optimization of the Dual Ramp Voltmeter". *The Radio and Electronic Engineer*, Vol. 40. No. 2, August 1970, p. 59.

Fig. 7. Capacitance measuring system.



News of the Month

Electronic telephone exchanges for U.K.

The first equipment of Britain's initial 18 large electronic telephone exchanges is now being installed at the Rectory Exchange, Sutton Coldfield, Warwickshire. This follows the Post Office's decision that, in the modernization of the telephone network now proceeding, large electronic exchanges should be used alongside modern crossbar (electromechanical) equipment already being supplied to replace the old Strowger step-by-step equipment. The electronic exchange chosen is the TXE4 — an electronically controlled reed relay switching system — which has been developed by Standard Telephones and Cables for the Post Office as the design authority. By means of this, exchanges with initial capacities of 2000 lines can be extended in stages to a maximum of 40,000 lines. S.T.C. is now working on a £15 million contract to develop and supply 18 TXE4 exchanges, but later it is expected that other companies will also be brought in as manufacturers. Altogether the Post Office will spend about £100 million over a seven-year period on the introduction of this type of exchange.

The TXE4 is not fully electronic, in that the essential connections between the speech wire pairs of subscribers are made by reed relays arranged in a matrix switching system. The operation of these relays, however, is automatically controlled by electronic, solid-state, computer-like equipment working under programme control. Consider the analogy of a human switchboard operator using eyes, brain and hands in a manual exchange. The hands of the operator making connections are equivalent to the reed relay switching apparatus; the eyes of the operator looking at indicators are equivalent to electronic scanning and storage equipment examining the state of the incoming lines to see whether calls are being made on them; while the brain of the operator is equivalent to electronic "control units" which identify calling subscribers, determine the connections required, select suitable routes through the network and finally operate the reed relays.

Programme control for the "brain" part — an ordered sequence of instructions which must be followed to set up each connection — is provided physically by a permanent wired programme. This consists of energizing wires running in various paths through an array of small ferrite cores carrying sensing windings. Each wire is energized in turn by having a current pulse passed through it, and this causes a particular combination of the cores to be magnetized — forming an instruction. Whichever pattern of cores is magnetized (the instruction) is read out by means of the sensing windings. In later electronic exchanges this wired programme will be replaced by an alterable stored programme as used in digital computers.

One electronics unit of the TXE4 telephone exchange removed from its rack for inspection. In the case of failure a unit may be removed and replaced with no interruption of subscriber service.

Bipolar i.c. "Process III" in production

Plessey bipolar "Process III" for silicon integrated circuits is now in large scale production at the main Plessey Semiconductors plant at Cheney Manor, Swindon. The line of development taken has been thickness reduction of the epitaxial layer and of the subsequent diffusions, to obtain the best possible performance and improved packing density, even though the complexity of the process increases. Using Process III, the epitaxial layer is only four microns thick, while the emitter-base and base-collector junctions are, respectively, about $\frac{1}{4}$ and $\frac{1}{2}$ micron deep. This has resulted in transistors with f_T greater than 2GHz, the sort of performance normally associated with discrete microwave transistors. In previous bipolar processes, the limits of both packing density and performance have been set by the depth of the diffusions. In the new Plessey process the limits are set by the process of photoengraving, i.e. by the wavelength of light used. Future improvements in packing density and performance will depend on developments such as the replacement of light in engraving by another agent, e.g. electrons, and by the replacement of diffusion for isolation by an improved technique. Reduction of the surface geometry will bring the necessity to reduce the junction depths and this may involve the application of ion implantation.

Initial application of the process has been for a range of counter and divider circuits which can operate at up to 1.2GHz input. The divider range includes programmable dividers and b.c.d. output devices. Linear circuits have been produced including a $300V/\mu s$ slew rate operational amplifier and a squaring circuit which has a 0-200MHz operating bandwidth.

Microcircuit telephone coin mechanism

Long-distance calls from public telephone boxes could be made with much greater ease using an electronic coin operated mechanism developed by Associated Automation in collaboration with General Instrument Microelectronics. Key to the mechanism is a single m.o.s. microcircuit chip onto which has been packed all the logic, computing and signalling functions for the instrument. The logic unit, which has been designed and manufactured by General Instrument Microelectronics, calculates the charge as the call progresses and automatically debits this sum from a pre-charged coin store. On completion of the call unused coins are automatically refunded. By this method of operation, frantic meter feeding which can occur on long-distance or high-tariff calls is thus eliminated. Instead, a user can empty his pocket of any small change and insert the money into a single coin slot before dialling.The mechanism accepts coins of three specified denominations. These are mechanically sorted into storage chutes and unsuitable coins are automatically ejected.

Once the coins have entered the storage chutes the progress of the call is controlled entirely by the 24-pin m.o.s. l.s.i. microcircuit. This chip marshals over 16 input signals and controls the call through eight output pins. It has over 600 logic gates in three major logic blocks, a three register memory, an arithmetic unit, and a control logic circuit block which also incorporates a tone generator together with its associated timing circuitry.

Each chute is controlled by solenoid operated pins so that money held in store can be taken coin by coin. On entering the storage chute, coins roll over a microswitch, producing a signal which is routed to the equivalent storage register on the chip. An arithmetic unit then translates the numbers held in the three storage registers into a total credit amount. To accommodate different currencies the ratio between the three specified denominations can be altered and the tariff rate adjusted. In the U.K., for example, the Series 7000 could be set to accept 1p, 5p and 10p coins and the coin ratio of 1:5:10 selected from the eight available.

Time control for recorded speech

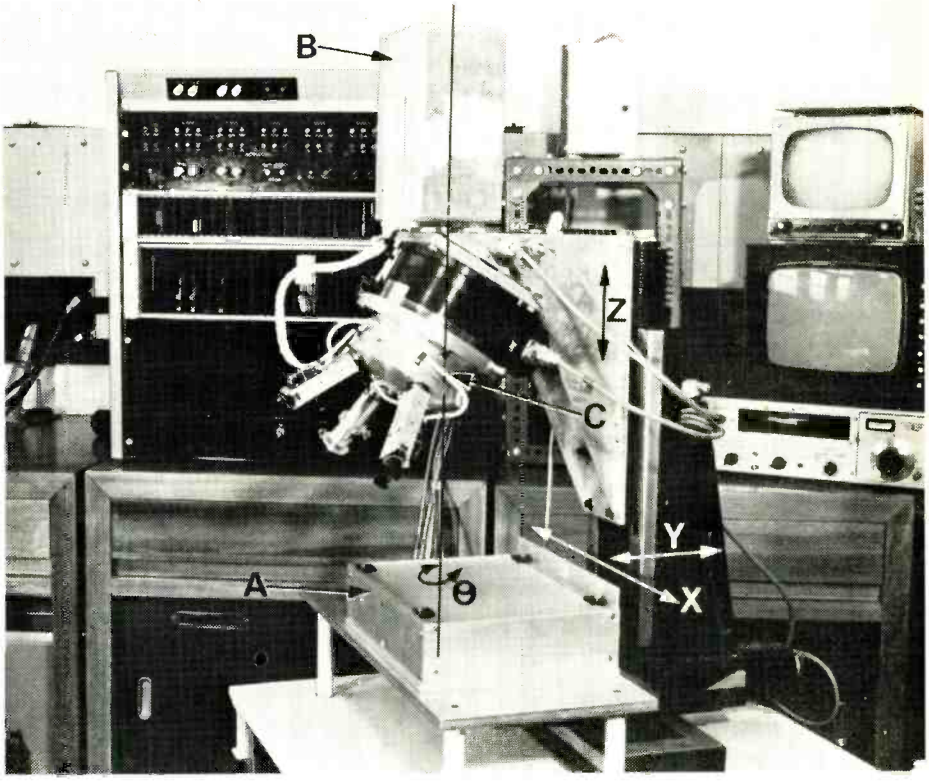
"Varispeech" is a machine, marketed by F.W.O. Bauch Ltd, which can produce time compression or expansion of recorded speech without the frequency distortion which occurs if the recording and play-back speeds of normal tape recorders are altered. The operating principle is to convert the voice signal, which is recorded in analogue form on a cassette, to a digital equivalent. This signal is then converted to a second digital format with or without time compression or expansion. Re-conversion to analogue form restores the original speech without loss of intelligibility or speaker identification. The recording medium is a standard audio tape cassette operating at $1\frac{7}{8}$ i.p.s. and playback speed is variable from $\frac{1}{2}$ to $2\frac{1}{2}$ times the original.

Visual image processing robot

A team of researchers at the University of Nottingham has developed a robot intended to carry out assembly functions in manufacturing industries. Following up the news item on a Hitachi image processing robot (December 1972), British development in this field is not lacking at all. Referring to the accompanying photograph, parts are presented on a back-illuminated platform (A) which is capable of being scanned by a vidicon system (B) through an aperture in the gripper turret (C). There are three linear axes X, Y and Z operated by stepping motors at speeds of up to 4000 steps per second. Two rotational axes are also operated by stepping motors, one of these being associated with the angular position of the image as presented to the TV camera. The actuator is mechanically coupled to three gripping mechanisms mounted on the turret which will assume the same angular mechanical displacement as the image, so that the device can sense the random orientation of any image placed on the viewing platform.

The image of the part to be handled is transmitted through the viewing station in the turret to the television camera tube. The video signal from the camera is then processed by a Honeywell DDP516 computer, which is programmed to the shape and angular disposition of the image in numerical form. The machine can be "taught" to recognize any basic shape by allowing it to view the part and then initiating a learning procedure. Thereafter, if a part is recognized, the machine is programmed to select the appropriate gripper and move towards the part which has been selected for manipulation to any pre-determined angular and linear position.

The Nottingham University development team will exhibit this machine at a conference on Industrial Robot Technology organized by the Universities of Nottingham and Birmingham and to be held at the University of Nottingham in the Department of Production Engineering and Production Management on 27th to 29th March.



Visual image processing robot which has been developed at Nottingham University. Refer to the text for explanation of symbols and operation.

Arabian telecommunications

A telecommunication complex, which will include a satellite earth station, is to be installed by Cable and Wireless Ltd in the United Arab Emirates in the Arabian Gulf. The earth station, which will be the tenth to be owned and operated by Cable and Wireless and its associates, will be built in Dubai, close to the border with Abu Dhabi. Cable and Wireless engineers will be responsible for the design, overall project control and acceptance testing of the installation. They will also operate and maintain it when it is in service. As well as the earth station, there will also be a modern international telephone switching centre and an automatic telex service is to be provided. The new earth station in Dubai, which is due to be completed by the end of next year, will provide all forms of international telecommunication, including telephony, telegraph, telex, and facsimile transmission. High-speed data transmission facilities will also be available for the international interconnection of computer systems.

"Molniya" satellite launched

Another Molniya communication satellite has been launched in the Soviet Union. It is to be used in a long-range telegraphic radio communications system and for broadcasting Soviet Central Television programmes to points of the "Orbita" network in the Far North, Siberia, the Far East and Central Asia. The satellite was put into an elliptical orbit with a perigee of 470km in the southern hemisphere and an apogee of 39,200km in the northern hemisphere. Its period of revolution is 11h 43 min, and the orbital inclination is 65 degrees. Apart from apparatus for transmitting television programmes and long-range multi-channel radio communications, the satellite is also carrying instruments of a control and measurement complex and systems of orientation and orbit correction.

Distance measuring equipment errors

A circular letter from the Civil Aviation Authority states that on infrequent occasions reports have been received from pilots that they have experienced faulty D.M.E. operation. These reports have been received only from aircraft flying at low altitudes, generally below 1,000ft, and at ranges of less than 20 miles from the D.M.E. beacon. The fault has taken the form of the indicated range being too high, or a failure to "lock-on" to the beacon. It seems possible that the reported errors may be caused by multi-path reflections due to surrounding terrain, but only in combination with certain aircraft attitudes and altitudes and, possibly, with some types of airborne equipment.

Physics Exhibition

The 57th annual Physics Exhibition will this year be held at Earls Court, which should make access easier for potential visitors who were discouraged by the trek out to Alexandra Palace in previous years. The exhibition will be open from 9-13th April, from 10.00 to 18.00 each day except on the 13th when it will close at 17.00. Tickets of admission to the Physics Exhibition will also secure admission to Labex International, which is being held simultaneously on the ground floor of Earls Court. Further information about the Physics Exhibition is available from The Exhibitions Officer, The Institute of Physics, 47 Belgrave Square, London SW1 8QX.

Philip Berkeley Award

The British Kinematograph Sound and Television Society is proposing to make an annual award to mark the memory of a late vice-president, Philip R. Berkeley (see obituary notice, February issue, p.90). This award will be known as the "Philip Berkeley Award" and will be given for the most outstanding technical contribution in the field of television production in the United Kingdom. Final details will be announced in the BKS&T *Journal* published in March.

Briefly

New 'speaker

Rumour has it that Quad are working on a new loudspeaker.

Last valves

The last of Eddystone Radio's valve receivers is being phased out of production in favour of a solid-state range of general purpose receivers.

Science fiction factory

This is an example of the state of the art in computer written science fiction epics, the author being a giant computer in Cleveland, Ohio. "The fury of the motors rocked the hill. The moon stared coldly down. Jackie Lukar spoke as the 'copter started. Matches; torches; all were needed. 'Switch on the disintegrator!' Vilma expostulated. Then screamed Oriath the immortal patriarch: 'Let there today be war within these planets' ". Brian Aldiss need not worry for a little while.

Surround-sound Circuits

Build your own matrix circuits using i.cs

by Geoffrey Shorter

Whichever proposal is adopted for all-round sound recording and reproduction, if indeed any one system is, it is a fact that in the U.K. the SQ system is the one for which most records are presently available. And there are many people who are anxious to try them out, some of whom, with limited resources, may not wish to buy commercial SQ decoders for fear that the SQ system may not be standardized and with the consequence that a different decoder would be required.

Two circuits are given to enable constructors to build SQ decoders, one using all discrete components and the other including integrated circuits. If you wish to try out a simple matrix circuit for getting a surround-sound effect from stereo records a simple set-up is possible using a Toshiba integrated circuit. No doubt further i.cs will become available for other systems. One, made by Texas Instruments for Electro-Voice, is compatible with SQ and claimed to be compatible with discs encoded to other systems, but is still not made available outside the U.S.A.

The basis of the SQ system has been covered before in these pages but a resumé is not out of place. Sounds from a pair-wise mixed four-channel master tape are coded into the left and right channels of a stereo disc according to

$$L = L_F - 0.707jL_B + 0.707R_B$$
$$R = R_F - 0.707L_B + 0.707jR_B$$

where j indicates a phase difference of 90° between channels. These two signals are basically the inputs to the front speakers in playback and the two rear signals are derived from $j0.707L - 0.707R$ for the left back speaker and $0.707L - j0.707R$ for the right back speaker.

These equations give rise to unique crosstalk properties (shown on page 56 February 1972 issue of *W.W.* for the four corners), with the feature of little or no crosstalk between the two front "channels" but with the particular penalty of infinite crosstalk for centre front and centre back positions with a "straight" SQ decoder. This makes localization of a centre front sound imprecise. (The simple diagrams of page 56 do not convey how accurately sounds are localized at the corners or other points around the compass.)

The essence of an SQ decoder is shown in the block diagram of Fig. 1. As the j operator shown in the above equations indicates a relative phase difference of 90°, on playback the coded left and right

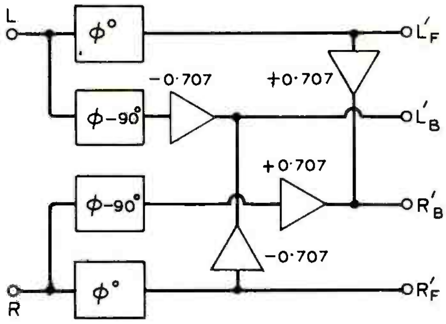


Fig.1. Basic decoder scheme for use with SQ records.

channels are first passed through networks in which phase is an approximately linear function of frequency over most of the audio band. These same signals also pass through similar networks which give a linear phase-frequency response, but shifted in phase by 90°.

With such a decoder a sound intended to appear at centre front produces equal outputs from all four speakers. And although the rear sounds are in anti-phase, they are going to interfere with centre front localization. To alleviate this situation, a certain amount of blending is arranged in some SQ decoders between the two front outputs and the two rear outputs. This has the effect of cancelling some of the antiphase components of the signals, thus reducing the outputs from the rear speakers in the case of a centre front sound. The most common amounts of blend are 10% between front outputs and 40% between rear outputs. In such a decoder the gain of the back channels is reduced by 1dB, giving a total front to back crosstalk of 7dB. Front "channel" crosstalk is increased to 20dB and back channel crosstalk increased to 8dB.

A circuit of a 10-40 blend decoder is shown in Fig. 2, which follows the scheme of Fig. 1. The 90° phase difference provided by these networks is accurate to within ±10° from 100Hz to 10kHz. The 68 and 47kΩ resistors provide the relative gain of 0.7 between front and back signal paths, and two transistors in the second stages of the phase difference networks provide inversion. (This circuit is used in many commercial SQ decoder units. Better phase difference networks are provided in some decoders, like the Lasky's Audiotronics decoder which gives a deviation of ±10% over 20Hz to 18kHz.)

In constructing the circuit of Fig. 2,

resistor values should be ¼-watt, 5%-tolerance types, and the eight capacitors in the phase-shift networks should be 10% tolerance. Recommended transistors are 2N3393, except for the output transistors which should be 2N3390. (Both types are made by G-E and Siemens. Motorola have similar devices: MPS 3393 and MPS 6521 respectively.) Input impedance is 20kΩ, output impedance 1.8kΩ and nominal input level 500mV r.m.s., the circuit having unity gain. To convert to a high input impedance the upper and lower bias resistors can be changed to 3 and 1.8MΩ respectively, using 2N5308 (G-E) input transistors.

Integrated circuits are now available from Motorola for this circuit at £1.65. Components need to be added, as indicated in Fig 3, and these should be within 5% tolerance to give a ±8.5% deviation from the 90° norm between 100Hz and 10kHz. With a 20V supply rail (maximum 30V) consumption is 16mA. For a nominal input of 500mV distortion is 0.1%, clipping occurring at 2V. Input impedance is 3MΩ. The blend resistors, shown in broken lines, should be 47kΩ between the two front outputs and 7.5kΩ between the two rear outputs for the 10-40 blend.

Another way of reducing unwanted outputs from speakers is the gain control circuit given on page 597 of the December 1972 issue of *W.W.* Here a discrete component circuit was shown that provides automatic blend and consequent cancellation of antiphase components in the rear signals when a source appears at front centre. When $L+R>L-R$ some cancellation will occur and this also applies in the front "channels" when $L+R<L-R$. Whether this additional complexity is justified depends largely on the programme material. It is very effective for single sources, but multiple sources will defeat the circuit, suppress secondary sources, or cause odd time-varying effects.

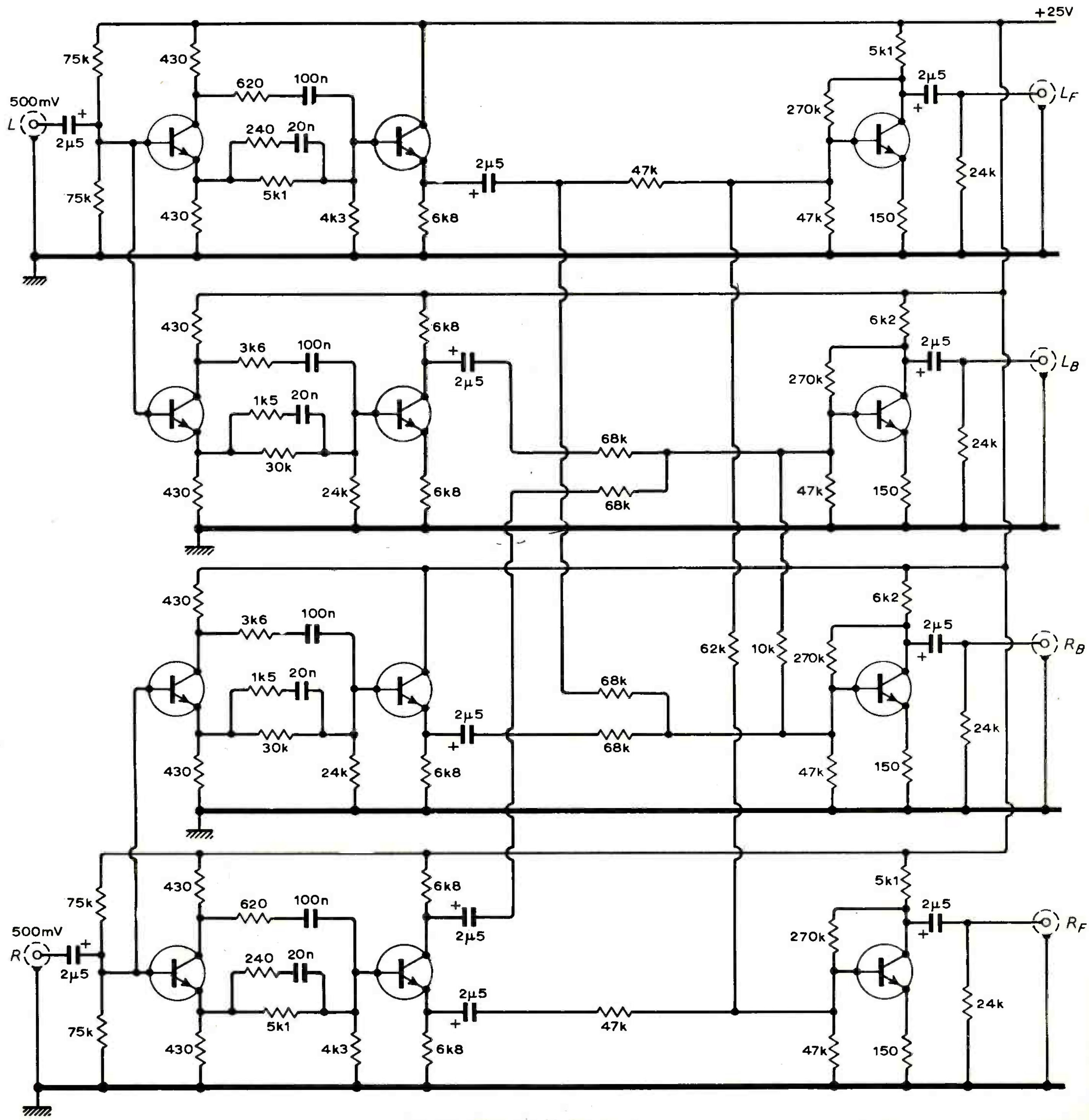


Fig.2. Circuit of SQ decoder used on some inexpensive decoders in which front outputs are blended by 10% and back by 40%.

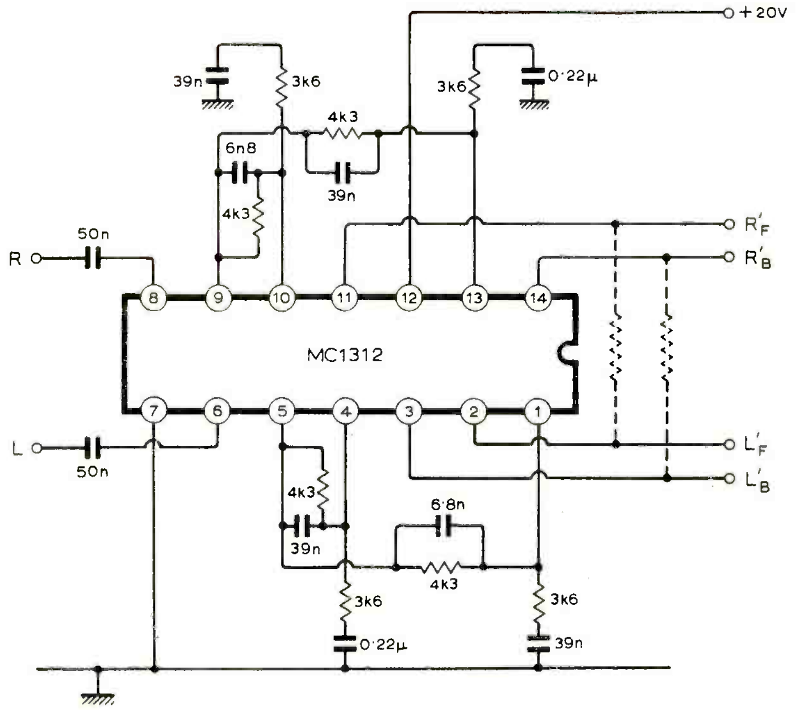


Fig.3. Integrated circuit for SQ decoder. Add resistors of 47kΩ for front pair and 7.5kΩ for rear pair of outputs for '10-40' blend.

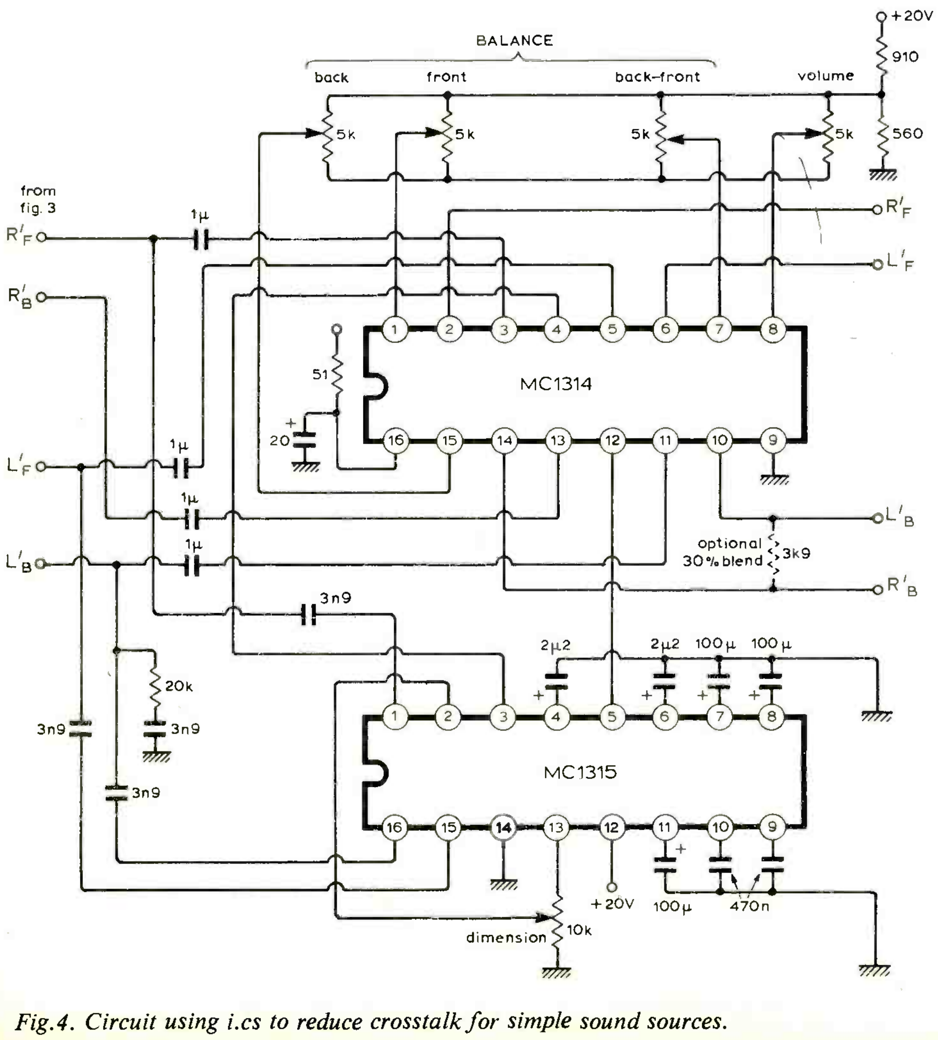


Fig.4. Circuit using i.cs to reduce crosstalk for simple sound sources.

If you wish to try it out chips will be shortly available from Motorola for this and a circuit is shown in Fig. 4, which feeds directly from Fig. 3 with the omission of the two blend resistors. The MC1314 includes the voltage-controlled amplifiers and the MC1315 provides the control voltages. As well as improving centre sounds at front the MC1315 includes circuitry to detect and attenuate unwanted outputs for corner signals.

Components in this circuit should be 5% tolerance in the phase shift networks (around pins 1, 4, 5, 9, 10, 13 on MC1312) and 10% otherwise, excepting electrolytic capacitors. The 5kΩ volume control should have a semi-log law, and the balance controls, which give a 12dB constant-power variation, should be linear. Front and rear balance controls can be "ganged" by connecting pins 1 and 15 on MC1314 and omitting one potentiometer.

If you want to omit volume and balance controls, connect pin 8 of MC1314 to a potential divider giving +6V, and leave pins 1, 7 and 15 open-circuit.

The automatic action can be varied with the linear 10k Ω "dimension" control, which CBS recommend setting at 50%, giving a front-to-back crosstalk of 15dB typically. Signal handling capability of the circuit is reduced at maximum setting unless V_{CC}=30V on the MC1314.

Surround-sound from stereo records

The other readily available i.c. is the Toshiba TA7117P. Phase difference circuits are not a part of this i.c., so the chip contains merely differential amplifiers, matrix circuit and output amplifiers, as indicated in Fig. 5. This chip is fine for getting surround-sound from ordinary stereo records. The two inputs are added and subtracted in varying proportions depending on choice of external resistors. The two added signals, $L+aR$ and $R+bL$, feed two front amplifiers and speakers and the two subtracted signals, $L-CR$ and $R-dL$, feed the two rear amplifiers

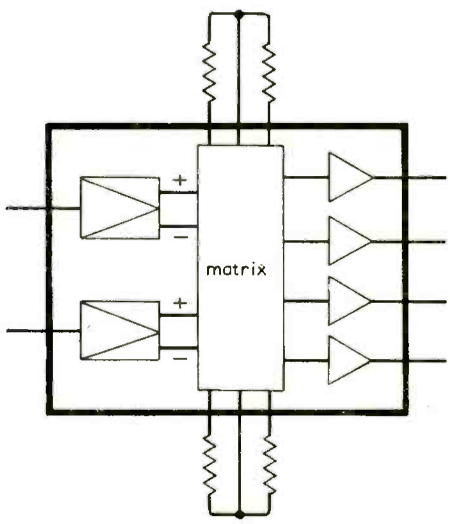


Fig.5. Scheme of Toshiba matrix i.c.

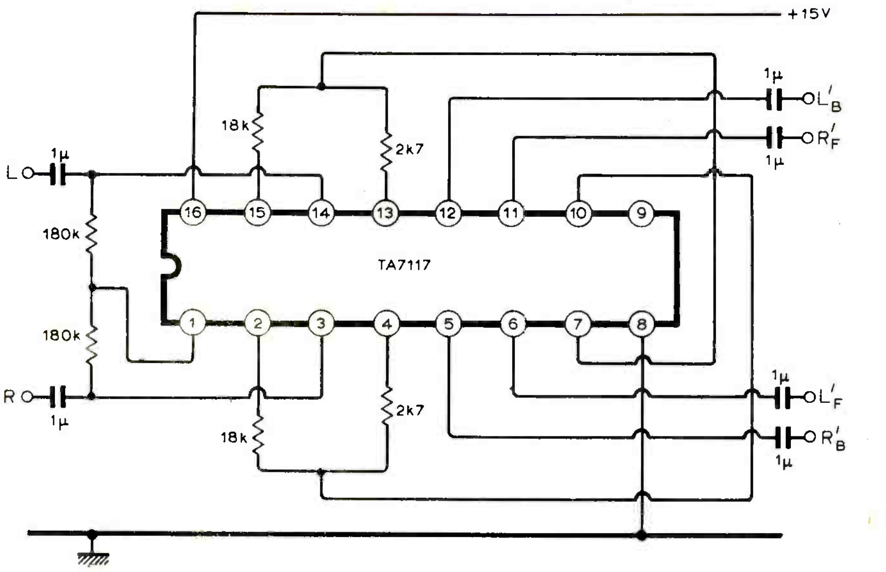


Fig.6. Circuit for getting surround-sound from ordinary records and certain coded records.

and speakers. With such an arrangement the amount of front and rear crosstalk can be experimentally varied, keeping $a=b$ and $c=d$. With $a=b=0$ and $c=d=1$, this gives the equivalent of the simple speaker matrix (obtained with only two power amplifiers by connecting the two rear speakers in antiphase and across the "live" terminals of the two amplifiers, used frequently to enhance the ambience of stereo programmes).

This is not entirely satisfactory, one effect being an increase in apparent width of the stereophonic field. Considering a left-only signal, for instance, sound will emerge from the left front, the left back and right back (in antiphase) speakers, tending to pull the image round anticlockwise from left front. This is counteracted by blending the two front outputs (and in the interests of symmetry the back two). A good starting point is by choosing $a=b=c=d=0.414$, experimenting by varying $a=b$ and $c=d$. The circuit of Fig. 6 has resistor values chosen according to this value. The 18k Ω resistors can be altered to a value of 7.3 divided by the crosstalk fraction required for the front speakers and 7.3 multiplied by the crosstalk fraction required for the rear speakers.

The circuit might give acceptable results for certain coded recordings like the early American Dynaco and Electro-Voice-encoded discs and some Japanese records. Coded QS/RM/Pye records should give acceptable results, but with all records there will be no precise back images and any sounds intended to come from the back speakers will be shifted round toward the nearest front speaker.

With the Toshiba i.c. current consumption is typically 16mA at 15V or 10mA at 8V. Input impedance is 3M Ω. With an input of 100mV r.m.s. harmonic distortion is 0.1% (rising to 0.3% for 300mV and 1% at 1V). Price is £1.67* from Eric Electronics Ltd, South Denes, Great Yarmouth, Norfolk.

The Toshiba i.c. should give better results for the Pye QS/RM records than an SQ decoder. An SQ record played through the Toshiba i.c. would not reproduce intended sound directions from the rear speakers.

Quadraphonic two-channel records available in the U.K. total about 100 with around 70 SQ discs from CBS, 15 from EMI and 12 QS/RM discs from Pye. (Total for U.S.A. and Japan is at least 500.)

*Prior to any revaluation of the Yen.

Communications of the future

The core of a system which, when fully implemented, will transmit 300,000 telephone conversations or 200 colour television signals simultaneously through a 50mm diameter waveguide "pipe", is now in operation at the Great Baddow Research Laboratories of GEC-Marconi Electronics.

The demand for U.K. communications capacity is rising at a rate of well over 10% each year, not only as a result of the increased use of telephone and telex services, but also because of the rapidly increasing traffic in computer-derived data. The new circular waveguide offers the basis of a practical solution to the problem of high capacity communications for the future. It is capable of transmitting signals throughout the frequency band from about 32 to 110GHz. For the field trials, transmitter and receiver equipment is being installed to provide several complete channels, each of 500Mbit/s capacity and operating below 50GHz, to carry either simulated or genuine pulse code modulation communication traffic.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Feb. 26-Mar. 2 — Bloomsbury Centre
Seminex
(Evan Steadman and Partners, 4 Lyewood Common, Withyham, Hartfield, Sussex)

Mar. 13-15 — Savoy Place
Satellite Systems for Mobile Communications and Surveillance
(I.E.E., Savoy Place, London WC2R 0BL)

Mar. 13-15 — Bloomsbury Centre Hotel
Sound 73
(Assoc. of Public Address Engineers, 6 Conduit St, London W1R 9TG)

Mar. 22 & 23 — Royal Garden Hotel
Man Made Memories
(Mrs. Rosemary Willson, Mercury House, Waterloo Road, London SE1)

Mar. 27-29 — Imperial College
Ultrasonics International
(*Ultrasonics*, 32 High Street, Guildford, Surrey)

Mar. 28-Apr. 1 — Excelsior Hotel
Sonex Audio Exhibition
(Federation of British Audio, 31 Soho Sq., London W1V 5DG)

CARDIFF

Mar. 26-30 — Sophia Gardens
Aimex 1973 (industrial measurement and control)
(Exhibitions Wales & West Ltd, Holly House, Rhiwderin, Nr. Newport, Mon.)

OVERSEAS

Mar. 6-10 — Basle
Medical Electronics and Bio-engineering
(Sekretariat MEDEX 73, CH-4021 Basel)

Mar. 6-10 — Basle
INEL 73 — Industrial Electronics
(Sekretariat INEL 73, CH-4021 Basel)

Mar. 19-23 — San Francisco
Avionics Maintenance Conference
(Aeronautical Radio Inc., 2551 Riva Road, Annapolis, Maryland 21401, U.S.A.)

Mar. 20-Apr. 5 — Peking
British Industrial Technology Exhibition
(Tek Translation & International Print, 11 Uxbridge Rd, London W12 8LH)

Mar. 27-29 — Chicago
International Coil-winding Convention and Exhibition
(Electromation Exhibitions Ltd, Cleveland House, 344a Holdenhurst Road, Bournemouth, England.)

Apr. 2-7 — Paris
Audiovisual and Communication Exhibition
Société pour la Diffusion des Sciences et des Arts, 14, rue de Presles, 75740 Paris)

Apr. 2-7 — Paris
Electronic Components Exhibition
(Société pour la Diffusion des Sciences et des Arts, 14 rue de Presles, Paris-15eme.)

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Quadraphonic controversy

So far, your excellent letters column appears to have avoided the great "discrete versus matrix quadraphonics" controversy. I would have thought that after the two highly informative articles by Geoffrey Shorter appearing last year on this subject (Jan. and Feb. 1972), everybody would appreciate the differences between the two systems, and nobody would be in any doubt as to which one produces genuine four-channel stereo. Furthermore, those who like myself were able to visit the London Audio Fair and compare demonstrations by all the four-channel equipment manufacturers could make their own subjective evaluation of the two systems. As an electronics engineer, it seems to me that the discrete 4-channel approach, as pioneered by JVC Nivico, is the truly elegant "engineering approach", whilst the matrix systems offered by other manufacturers are very second rate technical compromises. I am not alone in holding these opinions as well known quadraphonics experts, like Walter Carlos, have previously pointed out in depth the inadequacies of the matrix systems ("Moog Soundings", letter to *Billboard*, Aug. 1972).

Consequently, I was amazed to find, whilst reading the December 1972 "London Audio Fair Review", that under the section headed "Four-channel progress" not a mention was made of JVC's CD-4 equipment range. How can the reviewer justify a full seven paragraphs describing the products of no less than ten different manufacturers of matrix equipment only, and claim to represent a fair assessment of progress in the four-channel field?

This would appear to be a somewhat biased view and could mislead those entering the world of quadraphonics into thinking that the matrix is the best solution when informed and unbiased opinion most definitely says otherwise.

H. B. Kendler,
London, W.1.

Our reporter writes:
The CD-4 four-channel disc system developed by the Victor Company of Japan was first reported by *W.W.* on page 487 of the October 1971 issue. The 1971 Audio Fair review referred readers back to the October report, no additional information being available. Developments were reported in the 1972 Sonex review and in "Letter from America" (both in May 1972) and in more detail in the September issue, page 424.

To reiterate our own words then, "the technical achievement is remarkable" and the fact that we have devoted 1200 words to CD-4 and much more to matrix systems should not of course be taken to imply any comment as to the relative merits of the two! It is true that the 1972 Audio Fair report did not mention CD-4 but neither did it mention a host of other products that were not new. (The current CD-4 package was announced in the 1972 Sonex report.) The National demodulator in use was new, but there was no information available and to this day circuit diagrams have not been supplied (though we do now have half the circuit!)

Matrix systems for encoding pair-wise mixed four-channel master tapes onto two-channel discs have been dealt with in more detail for various reasons. Mixing four inputs into two and getting four outputs back leads to compromises in the commercial matrix systems, the particular compromises varying from system to system. And of course there is the great attraction of being able to use the existing stereo broadcasting system, record players and cheaper decoders. Hence more attention.

Then there is the question of whether four full-bandwidth audio channels are really needed for surround sound. Discs can be produced for three or four audio channels with the carrier channels having reduced bandwidth, with consequent improvement in noise and distortion and generally less stringent requirements in recording and playback. There is, for instance, a prototype carrier disc, called QMX, an augmentation of the two-channel BMX phasor matrix due to Duane Cooper and being developed by Nippon Columbia, that might make the future of CD-4 less certain.

Why praise horn loudspeakers?

Gilbert Telfer's letter in the February 1973 issue probably puzzles many readers — readers who consider themselves to possess equipment of monitoring quality (having impeccable technical credentials), or possibly those who scorn allusions to extremely vibrant resounding "reedy quality" and a "glitter and gloss" effect as being laughably irrelevant to the field of modern loudspeaker technology.

However, over the last three years my experience has been such that I can only endorse Telfer's enthusiasm for horn loading. It can give a series of unique benefits throughout the audio frequency range. I suggest that what he calls "motor slip" may well be responsible for the unreal bass and mid-range that can still be heard even from systems employing specially designed plastic cones; even though tone-burst tests show delays and storage in the cone to be at a very low level. The correction afforded by even modest horn loading over a range in which the driver cone operates as a single piston is such that the transient response judged subjectively is markedly enhanced.

I also agree that "electronic crossovers" — by which I presume Telfer means standard electrical crossover networks — are less than ideal. However they can be very carefully designed, and provided crossover regions do not lie in the mid-band region where the human ear is acutely sensitive to phase changes (so I believe) they may be a necessary expedient in producing a commercial system.

Finally I would like to say that I believe we may soon see the conventional steady-state interpretation of audio phenomena — which gives a very imperfect definition of perfection — gradually give way to a less arrogant treatment. Then perhaps our notions of musical realism will for the first time be properly accounted for in engineering terms.

John Greenbank,
Lecson Audio Ltd,
St Ives,
Hunts.

Seeing in the dark

In reply to Mr Whitehead's letter in the January issue in which he asks for comments, may I put forward some further considerations?

Mr Whitehead has correctly pointed out some of the changes in performance of the human eye and brain which occur at low light levels. As he says, the principal effects which occur without any conscious realization on our part are a reduction of acuity and a gradual change from normal colour vision to a monochrome or luminance-only appreciation of the scene. Both these effects occur subconsciously as the observer dark-adapts and he is therefore hardly aware that they are happening.

The situation in television is very different for two basic reasons. First, the average viewer watches television in a well-lit room and therefore never dark-adapts; thus he retains normal acuity and colour vision regardless of the pictures presented by the television set. Secondly, the viewer is not usually interested in the fact that the scene the television camera is viewing may be poorly lit. A common case in point is a football match which may start in full daylight and end after dark in artificial lighting which may not be adequate to permit good pictures to be provided. The viewer expects to see good pictures in full detail and colour at all times and should not be expected to appreciate or allow for any deterioration in lighting. If he was actually at the football ground then it would be quite a different matter.

Under low-light conditions, the broadcaster may be forced to strike a compromise in which he partially sacrifices resolution, colour accuracy and contrast range in order to maintain acceptable pictures with sufficient freedom from noise and camera-tube lag effects. He avoids doing this, however, as much as possible, as the pictures so produced are easily recognized by the viewer as being below the normal standard.

J. R. Sanders,
B.B.C. Research Dept.,
Kingswood Warren,
Surrey.

Modular i.c. audio mixer

In their article in the December 1972 issue (p.564) J. H. Evans and P. Williams have pointed out that the main objections to using 741 operational amplifiers in low level audio circuits are the high noise level of the 741 compared to that of discrete transistors, and the cross-over distortion of the class-B output stage.

In the same issue (Letters p.575) D. R. S. Hedgeland describes an elegant solution to the noise problem by adding a discrete transistor input stage to the 741.

The cross-over distortion can be eliminated by connecting a resistor, R, between the 741 output and one of the power supply rails. Then, for small signal voltages, the output current is always of the same sign, only half of the output stage is conducting, and so the 741 output stage behaves like a class-A emitter follower. The current through R should be considerably larger than the $60\mu A$ quiescent current of the output transistors.

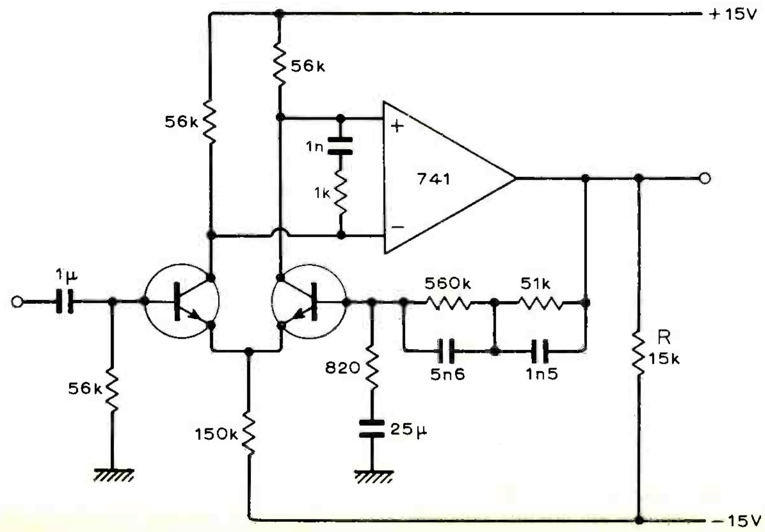
The diagram shows Mr Hedgeland's circuit with R added. The $15k\Omega$ resistor gives an offset current of $1\mu mA$ which ensures class-A operation for outputs up to 2V p-p into a load impedance (including the feedback network) of greater than 1 $k\Omega$. For larger signals than this the percentage cross-over distortion is probably no longer significant. The low closed-loop output impedance of the operational amplifier prevents any power supply ripple voltage being transferred to the output by the added resistor.

The diagram also includes two further modifications to Mr Hedgeland's circuit.

First, a $1k\Omega$ resistor in series with the 1nF frequency compensation capacitor improves the stability by increasing the phase margin at frequencies above 160 kHz.

Secondly, the feedback components have been changed to give frequency break points of 51, 480 and 2080 Hz which are closer to the recommended R.I.A.A. values of 50, 500 and 2120 Hz than the 34, 365 and 1870 Hz frequencies given by the original circuit.

M. L. G. Oldfield,
Department of Engineering Science,
University of Oxford.



Loudspeaker parameters

I found the article "Loudspeaker Survey" by Mr Stanley Kelly in the November 1972 issue very useful. The chart relating reverberation time, room volume and acoustic power, at a sound pressure level of 104 dB, is particularly useful as a design aid. However, there are several points that I think merit clarification.

First, the graph in question refers to a sound pressure level of 104 dB *in the reverberant field,* i.e. beyond the critical distance, given by

$$D_c = 0.14\sqrt{QS\bar{a}}$$

where D_c is the critical distance in feet, Q is the directivity factor of the speaker involved, and $S\bar{a}$ is the total absorption, in sabins, of the room surfaces. Between D_c and the speaker the sound level increases according to the inverse square law; + 6 dB per halving of distance.

In a domestic living room D_c is typically a couple of feet, and so the point is somewhat academic. However, in an auditorium D_c is usually significant and must be allowed for in estimating the distribution of sound.

Second, the graph relating radiation angle and ratio of wavelength to piston diameter is only useful for cone loudspeakers if one knows how the effective diameter of the cone changes with frequency. It would be most helpful if one knew this, not only for estimating polar distribution but for the design of crossover networks.

Third, I am surprised that, with all the development work and consumer interest in high fidelity speaker systems, there has been so little interest in the use of active crossover networks and separate power amplifiers for each speaker. (Altec Lansing in the United States — who refers to this as the Biamplifier approach — is the only manufacturer presently using this system, to my knowledge.)

Several authors, writing in the *Journal of the Audio Engineering Society,* have pointed out that active crossover networks improve transient response. One would also expect — and the subjective results I obtained on my own system bear this out — that intermodulation distortion would also be reduced.

Finally, may I make a plea for more complete data from speaker manufacturers, particularly with respect to transducer efficiency? That the power handling capability of a speaker in an enclosure is 20 watts is of no use if one has no idea how much of that energy is converted into sound.

Peter D. Hiscocks,
Ryerson Polytechnical Institute,
Toronto.

The well-heeled amateur

Pat Hawker's tirade against those radio amateurs who like to buy the best radio equipment they can afford, many after spending years building their own, in January's "World of Amateur Radio" smacks of sour-grapes, as he writes that "some of us continue to find much interest in what are virtually 'junk box' stations". Let them so continue but don't try to condemn those who think differently. Surely this idea of his springs from recent letters in the Radio Society of Great Britain's monthly membership magazine *Radio Communication* when new and younger (?) members were told how they should enter and continue this absorbing hobby, as if they were old-time schoolchildren. Grandparents, let alone parents, know only too well how differently the younger generation view present-day prices and financial commitments — generally with disdain — and go their own sweet way; that is what we amateurs who like to spend *our* money on *our* hobby will continue to do despite the preachers against it.

But what also troubles me is that this may now be the policy of the R.S.G.B., remembering that Pat Hawker is one of the three members of the Editorial Panel of *Radio Communication* and that one of our past presidents, Edward Ingram, GM6IZ, told "Peterborough" of the *Daily Telegraph* at our Diamond Jubilee Year Presidential Installation in London that "the most extravagant" of radio hams "have equipment costing as much as £6,000". Remember also that both Mr Hawker and Mr Ingram are or were professional radio engineers, and they must know only too well what their employers and their customers *have* to pay for commercial services and equipment, commencing prices that make the prices quoted against certain amateurs look like chicken feed.

I now await with dismay what to me will be the natural adverse reaction of the main advertisers in our magazine — surely a goodly source of income — of the imported and, very little, U.K. manufactured equipment now so strongly decried.

Maybe my reaction is at fault, but I also await the reaction of the Editorial of the rival magazines.

R. F. G. Thurlow,
Wimblington,
Cambs.

Pat Hawker replies:

Come off it Richard, you are tilting at windmills! Wherever you may have read a tirade against buying the best equipment you can afford it was not in World of Amateur Radio or anything else I have ever written. The item "Hobby for the well-heeled?" reported the present position with some examples of prices, stated this was a matter that aroused strong feelings (evidently!) and contrasted it with the position some decades ago. It did *not* attack amateurs who buy equipment — indeed this would be absurd since amateurs have been doing this to a greater or lesser extent since the hobby began.

So far as I am concerned if anyone wants to spend £6000 or £60,000 on a station — or hire a maintenance team to keep it in trim — that is his or her own affair. But it is my affair, in World of Amateur Radio, to report such trends.

I am puzzled (flattered?) to find myself somehow credited with representing or even forming "the policy of the R.S.G.B." My influence, if any, on the policy makers of Doughty Street hardly runs so high! As to advertisers, I feel they have more respect for the integrity of technical journals and journalists than Richard Thurlow suggests. Certainly over many years I have never consciously refrained from reporting matters of fact for fear of offending them — I hope I never will.

Personally I believe that an element of home-construction is an important part of the hobby and should be encouraged — after all it is one of the best forms of "self-training" which is included in the international definition of Amateur Radio. Similarly I do not want youngsters put off from joining our ranks because of any feeling that only high-cost equipment produces worth-while results — do you Richard?

Audio pre-amplifiers

May I join in the discussion between Messrs Walker and Linsley Hood on the subject of distortion in low-noise amplifiers?

Mr Linsley Hood claims that series feedback can give more distortion than shunt feedback. He gives results from some experiments with a 741 operational amplifier which prove his point — where 741s are concerned. The discussion is concerned with the behaviour of low-noise

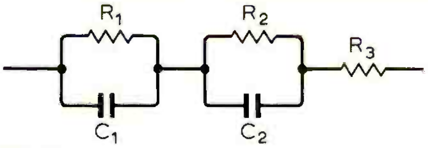


Fig. 1

pre-amplifiers, and in particular the case where series feedback is applied to the emitter of the input transistor. A 741 has four transistors in the signal path between the two inputs, so the situation with this is not comparable. One doesn't use a 741 if one wants minimum noise, so experiments with a 741 are hardly relevant. The subject, in fact, seems to have become diverted somewhat. However, Mr Linsley Hood's results are certainly a warning to anyone using 741s in audio circuits.

Now Mr Linsley Hood has recently published a design (*Hi-Fi News,* November 1972) for a very low distortion amplifier and a pre-amplifier to go along with it (January 1973). The input stage of the pre-amplifier uses his "Liniac" circuit with shunt feedback. However, in the power amplifier (for which he gives the distortion as < 0.01%) he uses series feedback. Surely this is good evidence that in the normal type of audio circuit with series feedback the effect he found with the 741 will be quite insignificant? My vote, I think, goes to Mr Walker's pre-amplifier circuit rather than Mr Linsley Hood's.

I would now like to change the subject to that of the pickup compensation which one should use. Mr Linsley Hood has observed (*W.W.,* July 1969, p.310) that the pickup inductance will produce a top cut which has to be compensated somewhere. Compensation may possibly be provided to a greater or lesser degree by the manufacturer, but just what the user should provide seems to be a bit hazy. However, the appropriate feedback network for compensating for the top cut is shown in Fig.1. I have a Shure V15-II, which is stated to have a resistance of 630Ω and an inductance of 720mH. When loaded with the recommended 47kΩ the inductance will produce a top cut with a break point of about 10kHz. The network values to compensate for this are given for two cases: (A) assuming R.I.A.A. characteristic and (B) giving extended bass down to 25Hz (as per Linsley Hood). I offer these as a suggestion: I haven't tried them. If there is any compensation already present, the result will be overcompensation. An advantage of this network will be reduction of high frequency loop gain, which will improve stability, and I observe that Mr Walker's circuit includes an extra resistor in the feedback network for just this purpose. The values I have given result in an impedance of 47kΩ at 1kHZ. They may be scaled to give any other impedance required and rounded off to convenient preferred values. Series and shunt arrangements using the network are shown in Fig.2. In the shunt arrangement, R_3 is R_4 plus the parallel combination of R_5 and R_6. In the series arrangement it is R_7 plus R_8. Stage gains are of course readily calculated.

J. E. A. Fison,
Harrogate,
Yorks.

Component values

	A (R.I.A.A.)	B (extended bass)
R_1	24.0kΩ	23.4kΩ
R_2	352kΩ	727kΩ
R_3	7.73kΩ	7.64kΩ
C_1	3.13nF	3.21nF
C_2	9.04nF	8.75nF

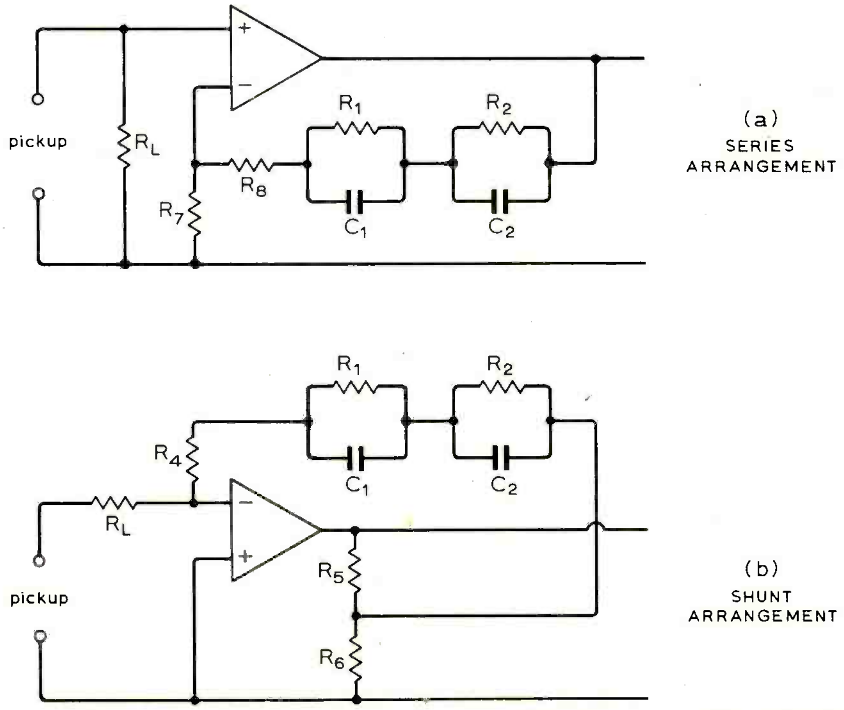


Fig. 2

Hybrid Thick-film Circuits

Their design, application and manufacture

by G. Brooke, Grad.I.E.R.E. and W. E. B. Baldwin,** M.I.E.E., M.I.E.R.E.*

Thick-film circuits were first produced commercially about eight years ago, at a time when the range of monolithic integrated circuits was not so extensive as it is today and their power handling capabilities were smaller. Although today, monolithic circuits have been greatly extended in range and capabilities, there are many potential applications where the thick-film technique is more economic, quicker to produce and technically better if the circuits are designed to be compatible with the technology.

Some helpful notes on the criteria for choosing a circuit fabrication technique are given in Morton Topfer's book,[1] but the actual technique adopted depends on the quantities involved. It can be said here that the thick-film technique incurs very low tooling costs relative to monolithic circuits and hence even sample quantities are not expensive; in quantity the price per unit is even lower and will generally level off at about the 2000 mark.

Other positive reasons for choosing thick-film circuits are:

(*a*) they can cater for a wide range of *C* and *R*, and higher voltages.

(*b*) they are able to dissipate high powers without damaging the performance of the lower-power parts of the circuit.

(*c*) they are particularly suitable for analogue circuits where the range of monolithic integrated circuits does not match up to the demands of the great diversity of applications.

(*d*) they can be designed to fit exactly the customer's circuit without the necessity of trying to adapt standard circuits to produce the desired performance.

Conversely, as more designs are made, some standard circuits will become available in thick-film form, for example amplifiers and resistor networks.

All this is not to say that only one technique should be used for any given circuit to get the best all-round results. It is essential to keep an open mind and, if necessary, combine techniques; hence hybrid thick-film microelectronics.

General construction

A hybrid thick-film module consists of a ceramic substrate on which is screen-printed conductor, resistor and dielectric inks which, when fired at a very high temperature, form an almost indestructible electronic circuit. Various sizes of ceramics are used up to about 10cm square, but the most common practical circuits are printed on standard sizes from 1cm to 5cm square. Resistors can easily be adjusted to give the required value and tolerance and hence the manufacturing yield can be very high. Even without trimming, a yield of better than 90% is achievable for a tolerance of less than ±15%; similar resistors will track within ±2%.

One of the big attractions of thick-film circuits is in their ease of handling: conformal coating or dipping, shown in Fig. 1, often gives sufficient protection for even a very stringent requirement, while the printed conductors accept soft solder very easily so that tinned leads or pins are attached without much difficulty. Figure 2 shows one such moulded assembly—one section of a radio paging device. In special cases more protection is necessary and then hermetically-sealed cans are used as in Fig. 3.

Attached to the thick-film circuits will be the discrete components, such as transistors, silicon integrated circuits, high or special performance capacitors and miniature coils. These will either be in "chip" form or microminiature protected packages, and the range of these is continually increasing. The use of silicon transistors is essential because of the subsequent processing temperatures.

Hybrid module design

The manufacturing designer of a hybrid thick-film module will have a wide knowledge of the many different technologies that are used in their construction, covering electronics, mechanics and chemical processes, but the potential customer may be unaware of the many practical details that have to be clearly defined before even a preliminary design can be outlined. Therefore each of the component parts and technologies will be described.

The component that forms the basis of the module is the thick-film circuit. This consists of a flat slice of high-alumina ceramic, either 0.6mm or 1mm thick, on which is screen-printed the patterns forming the conductors, resistors and capacitors. The actual pattern that is applied to the fine-mesh stainless steel screen has first been drawn many times full size and then

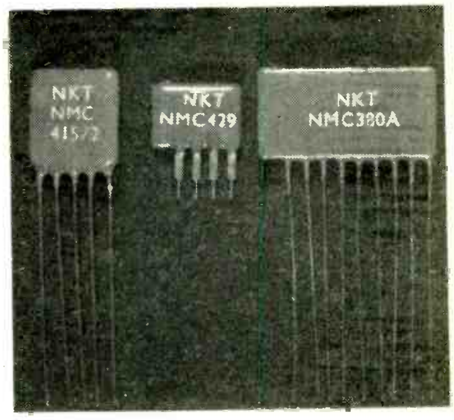


Fig. 1. Typical examples of conformal (dipped) coating applied to single-line edge-pin packages.

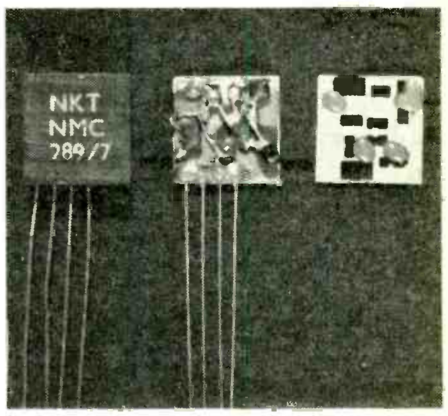


Fig. 2. A moulded package, in three stages of construction.

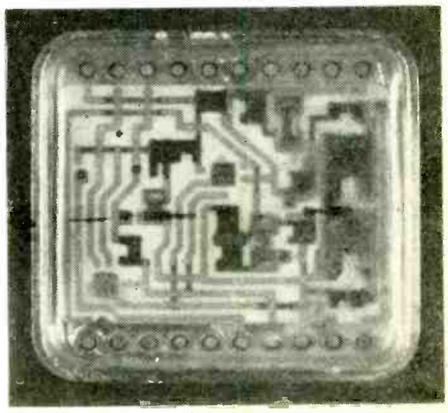


Fig. 3. A thick-film circuit before encapsulation in a hermetically-sealed can.

*Maidenhead Consultants, Maidenhead.
**E.M.I. Electronics Ltd., Hayes.

reduced photographically. Each layer of ink will have its own screen but all have to be reproduced carefully so that the final printed patterns will match and register with one another.

For each screen, a special ink will be specified: for conductors a palladium silver ink together with an organic binder can be used and will give a typical fired resistance of about 0.03 ohm per square. For a lower conductor resistance an ink consisting of gold or gold alloy is available and this gives a conductor resistance of about 0.005 ohm/square. There are many other metal combinations on the market and their use will depend on particular circuit requirements. Solder coating is often used to reduce conductor resistance.

After the conductor is printed and fired, the second screen may be a resistor pattern. Once again a specially-formulated ink is used that will produce a sheet resistance from about 10 ohms/sq to at least 10 megohms/sq, depending on the particular composition and firing temperature as in Table 1. It is from a knowledge of the precise sheet resistance for a given ink, printer and firing furnace that the length and width of the resistor elements can be determined.

Similarly, other inks can be used to produce dielectrics for capacitors, insulators for crossovers and protection glazes (Fig. 4). The range of inks available is now very extensive but each ink may have a special characteristic, such as temperature coefficient, noise factor, stability, etc., The potential user will be advised by the particular thick-film manufacturer that he approaches on the sort of characteristics that he can be offered. Generally speaking, each manufacturer adopts one or, at the most, two ranges of inks: this is because the cost of stocking say 200g of ink is about £300 and there may be at least 12 inks required in each range. Of course, this would be sufficient to produce at least 20,000 one-inch square circuits. Figure 5 shows a typical resistor test pattern and a customer can often obtain such a sample from the manufacturer on which he can carry out evaluation tests.

After all the layers of inks have been printed and fired, the next process is usually the trimming of the resistors. Normally the resistors will be within ±15% of their designed value despite the very many variables in the printing and firing processes. To bring each resistor to a closer tolerance, a trimming process is carried out which usually consists of cutting away the width of the resistor by an abrasive powder, thereby increasing its value. The process is now an automatic one and an adjustment to better than ±1% can easily be made at little extra cost.

Attached components

To make a complete functional circuit, other components will be required and these will have to be attached to the thick-film circuit. Transistors and, quite often, capacitors, particularly large values, are now produced specially for this type of module construction. Transistors may be in the micro-package form shown in Fig. 6, but more manufacturers are now attaching

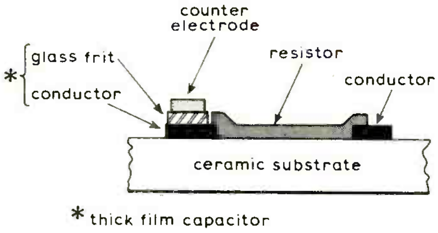


Fig. 4. The layout of a resistor, conductors and capacitor.

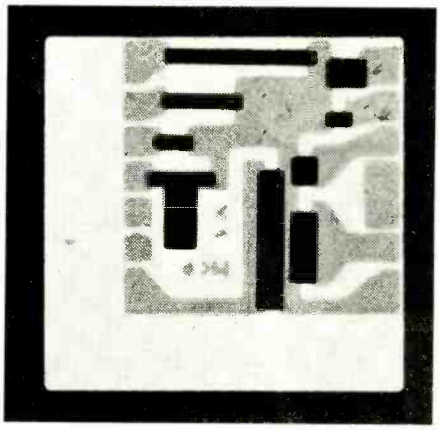


Fig. 5. Resistor test pattern.

TABLE 1
Characteristics of resistor inks.

Resistor element characteristics	
Parameter	Value
Standard range	0.5Ω to 50MΩ
Tolerance	Initially ±5%/±15% dependent on size and ±0.1% by individual adjustment
Temperature coefficient	Within the range −100 to +330 p.p.m./°C
Stability	0.4% to 2% at 150°C, 2,000 hours test
Substrate dissipation	4W per in² at 25°C (600mW per cm² at 25°C) in free air substrate temperature 165°C
Derating factor	30mW/°C per in² (5mW/°C per cm²)
Resistor dissipation (in free air)	60W/in² (9W/cm²)

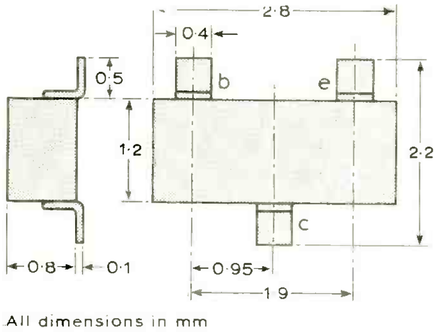


Fig. 6. Micro-package transistor.

TABLE 2
Typical microminiature devices for hybrid thick-film circuits, packaged as in Fig. 6.

Type no.	Construction	Technique	Maximum Ratings V_{CBO} (V)	V_{CEO} (V)	$I_{C(AV)}$ (mA)	T_j (°C)	P_{tot} at 25°C (mW)	h_{FE} at min.	max.	I_C (mA)	f_T min. (MHz)
BCW31R								110	220		
BCW32R	Y1	PE	30	20	50	125	150	200	450	2.0	300
BCW33R								420	800		
BCW71R	Y1	PE	50	45	50	125	150	110	220	2.0	300
BCW72R								200	450		
BFS17R	Y1	PE	30	15	25	125	150	25	150	2.0	1200
BFS20R	Y1	PE	30	20	25	125	150	40	—	7.0	250
BSV52R	Y1	PE	20	12	50	125	150	40	120	10	400

the basic silicon chip directly to the circuit. The advantage of the former is that a completely tested transistor can be put on to the circuit whereas the full test cannot be carried out on a chip transistor until after it has been bonded and sealed to the circuit. The range of micro-package transistors is relatively limited at the moment (Table 2) but more or less any silicon chip transistor, diode or s.c.r. can be bonded directly to the circuit.

The attachment of silicon integrated devices to a thick-film circuit is possible but a similar problem to that of transistors exists when it comes to testing. The use of a chip i.c. means that the complete function of the i.c. cannot be fully checked prior to attachment and bonding of the wires, and the resultant yield of good thick-film circuits will be lower. For many applications it is usually better to use a standard dual-in-line package i.c. and mount it alongside the associated thick-film circuit that contains the remainder of the components. For initial evaluation of a circuit, this is the most economic way and it would only be necessary to include the device within the thick-film substrate if space was a critical factor.

Chip capacitors can be obtained in either a general purpose characteristic from about 200pF to 100,000pF or as an NP0 type from 1pF to about 400pF. A typical set of characteristics from one manufacturer is shown in Table 3. If printed capacitors are used, general purpose and NP0 types are available and the area required can be calculated from a typical 20,000pF/sq. inch and 2,000pF/sq. inch respectively. The breakdown voltage is usually more than 200 volts but unlike chip capacitors this cannot be determined until the whole circuit is fired and sealed.

Very large values of capacitance can only be obtained by using tantalum components, but these are, at the moment, rather expensive compared with standard types, and it is advisable to mount these outside the module if possible.

For a quick production turn-round, a manufacturer would have to carry a very large stock of transistors and capacitors in order to accommodate all the different characteristics and tolerances that a customer may require. It is therefore very important that, where possible, standard types and values are specified with the widest possible tolerance. With close-tolerance resistors easily achievable, it is often possible to widen the associated capacitance tolerance.

TABLE 3 Characteristics of chip capacitors.

General capacitor specifications	
Capacitance range:	1.0 to 470,000pF
Temperature range:	−55°C to +125°C
Temperature characteristics:	A (NPO) 0±30 p.p.m./°C at 0 and rated voltage X (Gen. Purpose): ±15% at OV d.c. and +15% −25% at rated voltage
Voltage ratings:	50V d.c. at 125°C 100V d.c. at 85°C (other voltage ratings available on request)
Capacitance tolerances:	D = ±0.5pF (1.0–9.1pF only) K = ±10% M = ±20% J = ±5% (available in NPO and Gen. Purpose on special order only)
Dissipation factor:	at 25°C at 1V r.m.s. at 1kHz NPO: 0.1% (Typical Q value = 2000) Gen. Purpose: 2.5%
Insulation resistance	at 25°C and rated voltage: 1000MΩμF or 100,000MΩ, whichever is less

Note: Other capacitance values can be obtained.

Ceramic substrate

The actual material used for the ceramic substrate is 96% alumina and is suitable for most general applications. It may be necessary to use a special grade where applications in the u.h.f. and microwave regions are considered. There are many standard sizes of ceramics available and usually each thick-film circuit manufacturer has had special tooling made to give him a further standard size. It is once again important for economic reasons to design a circuit around one of the standards which in turn usually determines the method of the pin or lead-frame attachment.

For specially-shaped substrates a tooling cost of £300–£400 is usual with a delay of 12 to 16 weeks. A special shape may require new assembly jigs which will add to the total cost. For very small sample quantities, it is possible to diamond cut standard substrates to the special size but this is not easy and should be avoided if possible.

The power dissipation depends primarily on the thermal conductivity of the ceramic and to a lesser extent on the overall package configuration. A typical figure for this is 3 watts/sq. inch, although the dissipation of the resistive elements may be as much as 60 watts/sq. inch. For most applications, if care is taken with the encapsulation and package design, 3 watts/sq. inch is adequate. The use of a higher thermal conductivity ceramic such as beryllia is possible but the advantages are small compared with the extra cost and the very severe health hazard that ensues if abrasive trimming of resistors is adopted.

Package design

The packaging and encapsulation of hybrid circuits usually presents the most difficult problems of all which, unfortunately, are often only considered when the electronic circuit has been designed. The method of lead termination, the materials for the encapsulation and the general construction of the package requires a considerable development time. Each manufacturer will have carried out these tests and will be able to offer a fully proven package. Two basic forms have evolved: the multi-pin, dual-in-line arrangement (Fig. 7) and the single-line edge pin arrangement (Fig. 1).

In either case, the pins may be round or rectangular in section, soldered to the conductor pads in the form of a lead frame (Fig. 8) or round pins inserted through holes in the ceramic and bonded to the pads (Fig. 9). Whichever method is adopted it is important that the final encapsulation should provide a further mechanical support to the pin.

The cheaper form of encapsulation is where the completely assembled and tested circuit is dip coated in an epoxy resin, giving it a conformal coat, and is perfectly adequate for most commercial applications. For the most exacting environmental requirements, the welded metal can incorporating glass-to-metal seals may have to be used, but the cost of this can be many times the actual value of the complete hybrid thick-film circuit that will be inside.

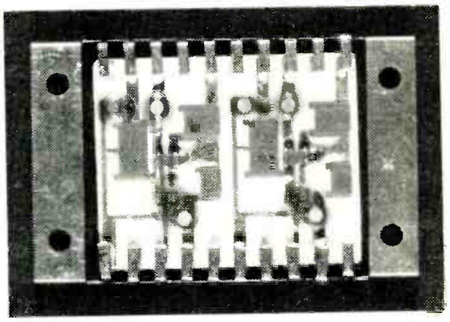


Fig. 7. A typical dual-in-line package before encapsulation.

Design guide

Most manufacturers now produce their own brief design guides giving the characteristics of the inks, transistors and capacitors that they can supply. But in order to get the best possible design and cost the potential user must be familiar with all the parameters that need to be given to the manufacturer and should have designed the circuit with these in mind. To translate many conventional circuits to thick-film on a 1 to 1 basis is not easy and often creates severe problems such as crossovers and the subsequent stray capacitances. One particular factor that is often overlooked is the thick-film conductor resistance which in conventional wiring or copper p.c.b. wiring can be ignored. The length and width of the conductor becomes just as important as the actual resistors and exact information on the peak currents must be specified. The thick-film conductors are capable of carrying about 0.7A per millimetre width of track.

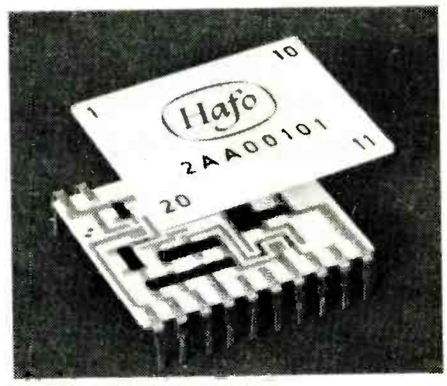


Fig. 8. Dual-in-line flat pins soldered to the thick-film conductors.

The manufacturer will require all the circuit parameters in exact values from which he can make necessary calculations and then add safety factors. Such parameters are: value, tolerance, temperature coefficient, noise factor, power (peak and mean), current (peak and mean), voltage, tracking tolerances, temperature range and, most important, the driving and load circuits. The mechanical parameters such as package size, pin arrangements and connections have to be specified before the design can start. Obviously the customer should give as much freedom in layout arrangement as possible so that the simplest construction can be achieved. Fig. 10 shows typical dimensions for the thick-film circuit that one must comply with to ensure satisfactory registration, insulation and power dissipation.

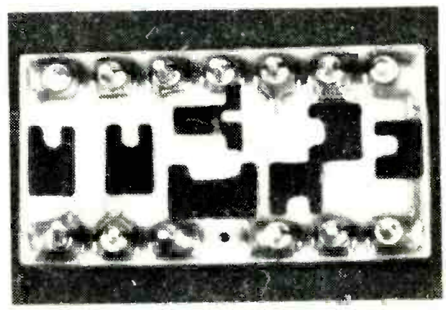
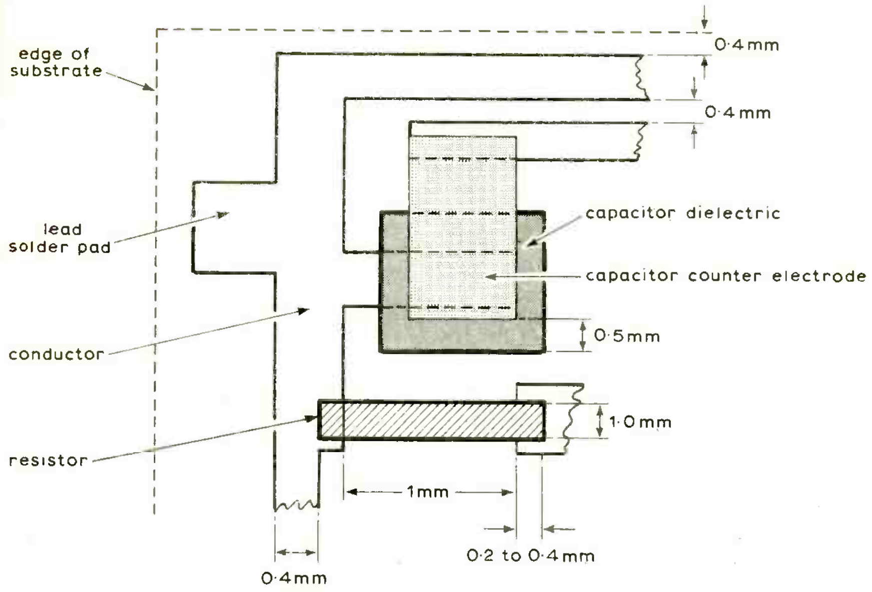


Fig. 9. Round-section pins inserted through holes in the substrate and conductor pattern.

An important factor that is unique to any particular circuit is the testing requirements. This information is broken down to give the specification for the intermediate stage testing, which means that the manufacturing designer must know in detail how the



minimum dimensions

Fig. 10. Typical pattern dimensions.

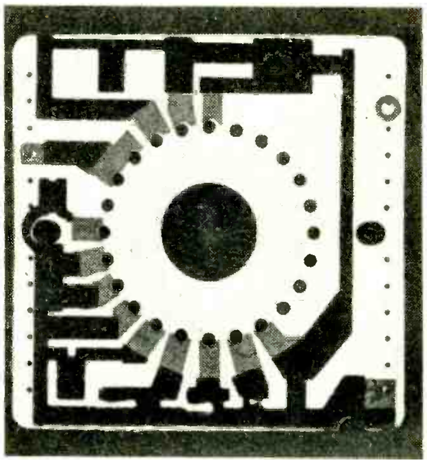


Fig. 11. A switch wafer with thick-film circuit.

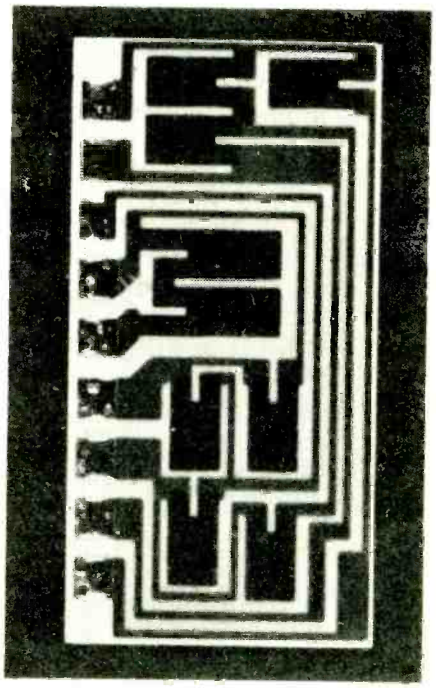


Fig. 12. A typical industrial circuit. The small slots in the resistors are the result of trimming.

TABLE 4 Comparison between the main types of integrated circuit.

	Type of Integrated Circuit		
	Silicon	**Thin Film**	**Thick Film**
Range of single resistances	<5kΩ	60Ω–100kΩ	5Ω–10MΩ
Tolerance	20%	±5% (0.1% by adjustment)	±10% (1% by adjustment)
Possible tracking tolerance		±5p.p.m./°C	±15p.p.m./°C
Temp. coeff.	Depends on the basic materials and manufacture	+25p.p.m.	50–200p.p.m.
Stability		1% at 100°C for 10,000h test	0.4% at 125° for 2,000h test
Conductor resistance	Low	Low	Very low
Package	d.i.l. flat pack, T.O.5	Can or Epoxy	Plain or Epoxy
Substrate loading	Limited by package	50 mW/cm²	500mW/cm²
Robustness	High	Fragile when unencapsulated	Very High
Types of attached components		Micro plastic transistors. Chip i.c's and transistors, chip capacitors	Micro plastic transistors. Chip i.c's and transistors, chip transistors
Single capacitor range (printed) approx. voltage rating	few hundred pF 20 volts	Up to 0.02μF/cm² 50 volts	Up to 0.02μF/cm² 200 to 500 volts
Substrate temp. limit	+200°C	+250°C	+500°C
Frequency limit	500MHz	10 GHz+	10 GHz+
Relative cost: samples (of a unique circuit) Large quantities	Very High Low	High Medium	Medium Low
Typical application	Digital circuits Pulse circuits Analogue (op. amps)	Filter networks Precision attenuators Tuned attenuators Microwave filters Low noise amps.	Medium power circuits High voltage networks Microwave power circuits
Possible component densities	Mounted Flat-pack 1200/in³	Packaged 200/in³	Packaged 200/in³

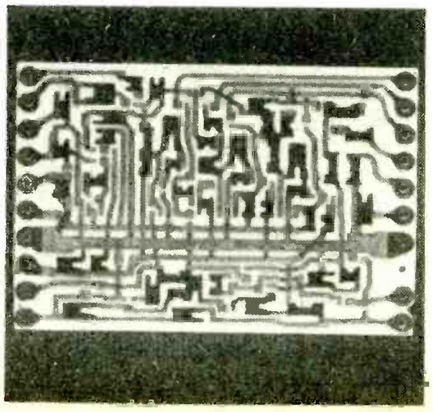


Fig. 13. Circuit incorporating cross-overs.

customer's circuit really works. This often means that a lot of confidential information has to be handed over by the customer.

A further factor that affects the manufacturing cost is the test gear that is required for the final as well as the stage by stage testing. Some sort of plug-in programme-card system is often adopted which means that the circuit layout will have to conform with certain standards. It is only when the more critical aspects of circuits are considered, such as high frequency and low signal level, that special test gear will have to be made and hence add to the cost of the final circuit.

It will be apparent that, because of the many details that have to be specified by the customer to the manufacturer, a very good working relationship must be established between them, for the latter can often give immediate solutions to some of the customer's problems and so make a great saving in cost. There are now more than a dozen hybrid thick-film module manufacturers in Britain who are well established and can offer a well-designed and reliable product. Generally they also tend to specialize in a particular type of application or quantity and hence have special tooling available. But by the very nature of the hybrid technology, most manufacturers can make and supply sample quantities or many thousands of a given circuit at a very competitive price.

There are currently three forms of hybrid circuit manufacturing technique available for incorporation in equipment, and their relative performance is summarized in Table 4.

Applications

In a short article, it is only possible to mention a few of the many applications that this technology is most suited to. They range from television line-scan circuits and high power audio stages to large computers such as the IBM 360. In the automobile industry this technique is most suited to applications such as alternator regulators, and there will in the future be a need for fuel and ignition systems, road warning sensors, collision avoidance, pollution control, speed and braking control.

Some designers become over-concerned with the need for smallness: the continuing need for controls which can be operated by human beings means that rotary switches are still common and it is sometimes possible to use the substrate as the wafer switch and print the other components around the edge, as in Fig. 11.

There are many diverse applications in industrial control and communications equipment and Fig. 12 shows an industrial circuit with a good resistor layout permitting easy trimming. A more complicated circuit incorporating insulated cross-overs, is shown in Fig. 13. Note the good registration of the conductors printed adjacent to the lead-pin holes. The hard-wearing and low noise properties of some of the modern fired-resistor inks make them suitable for potentiometer tracks: Fig. 14 shows the variable element used as part of a resistive network in a focus control module for colour television. Because of the high dissipation properties of fired-resistor inks, use can be made of them to produce a heating element for bimetal switch control used in domestic cookers, street lighting control and "White" electricity meter time-switches (Fig. 15). Fig. 16 shows a capacitor matrix code substrate.

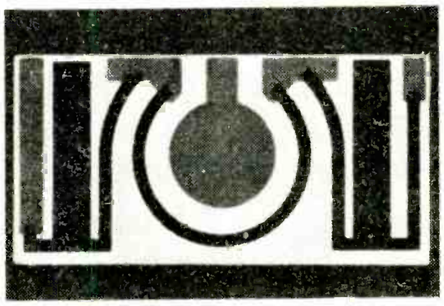


Fig. 14. The thick-film track of a potentiometer.

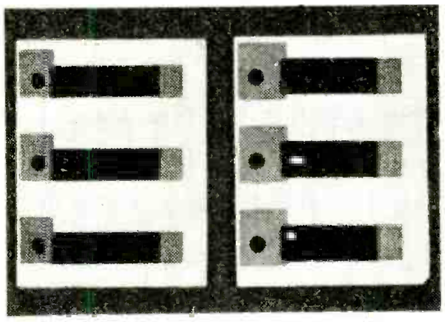


Fig. 15. Thick-film bi-metal heating elements.

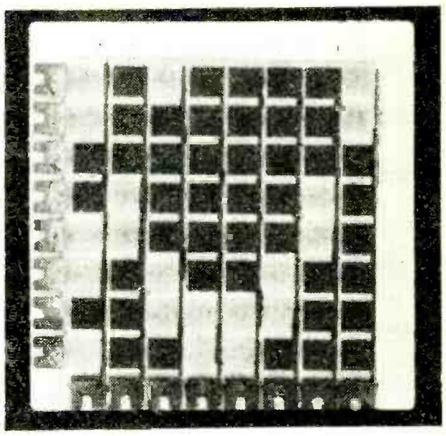


Fig. 16. Matrix of capacitors, using the substrate as dielectric. Counter-electrodes are on the reverse side.

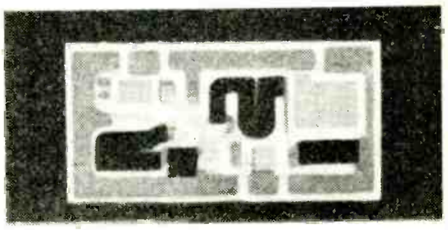


Fig. 17. A thick-film v.h.f. amplifier.

Today it is quite practical to consider the use of this technology for high-frequency applications and some manufacturers will gladly accept designs for frequencies up to about 150MHz, as illustrated by the v.h.f. amplifier in Fig. 17. U.h.f. and microwave applications are possible but these are, at the moment, still in the development stage and can be rather too expensive for all but military projects. This is not the area of application that the new customer for the thick-film technology should contemplate.

Conclusion

The brief description of the hybrid thick-film technology that we have given is intended to give encouragement and help to the equipment builders who have yet to adopt this form of component and circuit construction. There have been many years of experience gained in its use, and the resultant reliability and exciting new applications of it that are only now being investigated mean that the future is assured for this technology. We are convinced that this will be still essential and popular well after the turn of the century.

The change-over by an equipment builder from the use of conventional circuit component construction to an integrated form such as the thick-film technique is a very serious and critical move and could mean ultimately considerable changes in space, staff and technical control, but the overall advantages will certainly give an economic advantage over his more reluctant competitor.

Thanks are gratefully given to the following manufacturers for permission to publish information and photographs of their products:
Beckman Instruments Ltd.
Du Pont Ltd.
E.M.I. Electronics Ltd.
Erie Electronics Ltd.
Hafo Ltd., Vällingby, Sweden.
M.C.P. Electronics Ltd.
Mullard Ltd.
Newmarket Ltd.
Vitramon Ltd.

References

1. "Thick Film Microelectronics" by M. L. Topfer, Van Nostrand, 1971.
2. "Hybrid Thick-film Microelectronic Design and Manufacture": NEPCON 1970.

Sixty Years Ago

While discussing the intended use of wireless telegraphy on Captain Roald Amundsen's Polar Expedition in 1913, *The Marconigraph* mused in its March "Monthly Miscellany" column that such equipment would, perhaps, have saved the members of Captain Scott's ill-fated Antarctic Expedition. It went on to say: "In Polar exploration, of course, the minimum of weight is essential. One of the lightest types of wireless equipment made is of the "Knapsack" type for conveyance by hand. The total gross weight of the complete "station" is only 86lbs. It can be erected in six minutes by four men, and has an approximate maximum range of twelve miles. It will be highly interesting to note from Captain Amundsen's experience with his wireless equipped sledges what future radiotelegraphy has in Polar exploration."

Audio Magnetic Recorder Heads

Modern design and production technologies

*by Basil Lane**

Magnetic recording has now become an important part of broadcasting and the communications industry, as well as forming a component of increasing popularity in the home high-fidelity system. The electroacoustic performance of the tape recorder is governed by a complex relationship between the record/playback heads on the one hand and the tape on the other. This article explores those design parameters in tape heads which govern this final performance, and gives some details of the interesting new production techniques employed, leaving the subject of tape to a survey to be published next month.

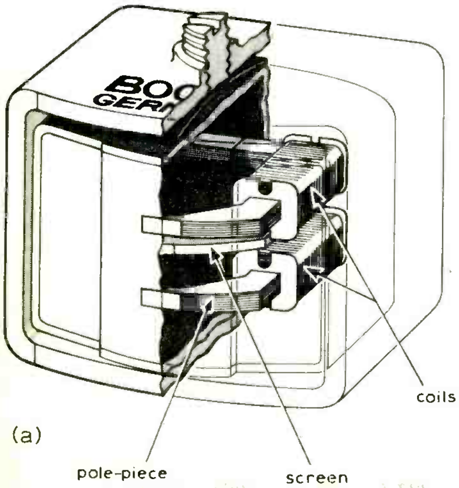
The essential features of magnetic heads for tape recorders have not changed from the early days of recording, and consist in elemental form of a circuit of high permeability "soft" magnetic material with one or two gaps and wound with one or more coils. Typical of the various commercial realizations of this basic form are the heads illustrated in Fig. 1, which could be either recording or replay heads. In general a magnetic head for audio applications requires an operational bandwidth on record from about 15Hz to 300kHz and on replay from the same low frequency point to at least 20kHz. The design and construction of heads for the two functions are similar, any small differences being incorporated to improve the efficiency of either the record or playback functions. Naturally, where the head combines both record and replay functions, there is some conflict which requires a compromise solution and the nature of these will vary from manufacturer to manufacturer.

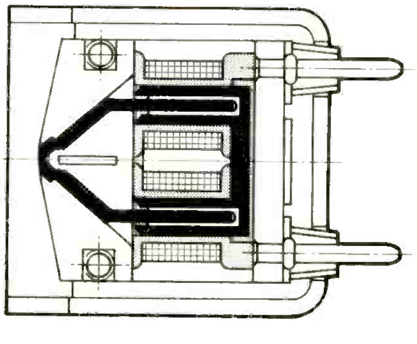
To appreciate some of the diversification in manufacturing technique a brief examination of the fundamental principles is necessary. The prime function in the recording process is to produce a remanent magnetization in the tape which is a linear representation of the signal current flowing in the coil. Since remanent flux is an inherently non-linear representation of the magnetizing flux, h.f. bias is used to minimize the distortion and improve the sensitivity of the tape. Obviously the conversion of the signal currents into a magnetizing field must also be a linear process and in any recording head design this factor needs to be taken into account.

Design fundamentals

Taking the basic structure of the record head (Fig.2), the magnetic circuit consists of a core and pole pieces sometimes made in one, the permeability of which needs to be high over the whole bandwidth mentioned. It also includes a front gap of high reluctance designed to produce not only the maximum magnetic field gradient, but also a flux distribution normal to the tape surface that ensures adequate penetration of the coating thickness. Linearity within the head itself is ensured by two factors, first the selection of a core and pole piece material with a high saturation intensity of magnetization, and second by the introduction of a second, rear, gap in the magnetic circuit. Using such a feature is less desirable, since it obviously reduces the magnetizing field at the front gap and, in fact, the rear gap rarely appears as a feature of modern recording heads. The design of the front gap and pole pieces is of fundamental importance and Daniel[1] outlines the laws governing these physical parameters. The length of the gap, l, has to be chosen as something of a compromise between the rule of thumb that requires it to be

*Assistant Editor, *Wireless World*





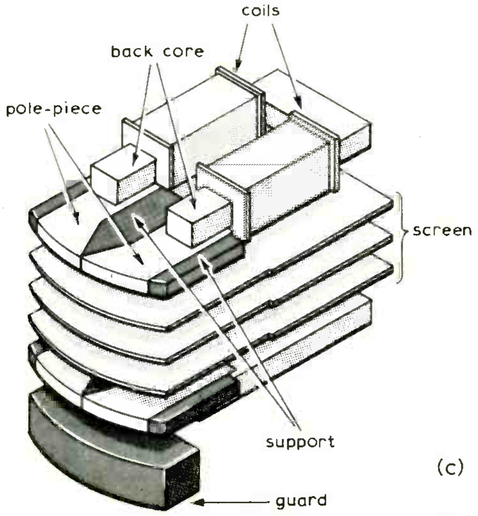


Fig. 1. (a) Bogen metal laminated head. (b) Transverse laminations used in a head by Woelke Magnetobandtechnik. (c) Ferrite head as made by Sony.

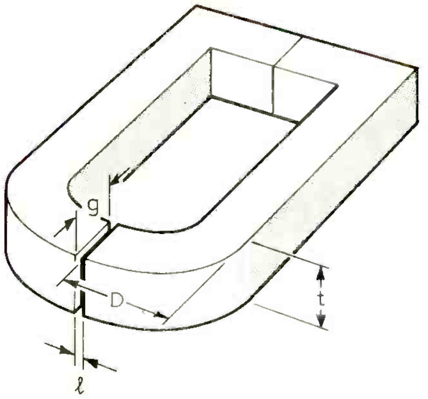


Fig. 2. Typical magnetic circuit for a tape head.

at least equal to the depth of oxide coating on the tape, and the need to keep the total reluctance of the magnetic circuit within reasonable bounds thus avoiding high magnetizing currents in the head coils. Figs.3 and 4 show the differences in electroacoustic performance for two record gap lengths, first 10μm and in Fig. 4, 20μm.

Since one of the objectives in the design of a record head is to ensure that the largest part of the reluctance of the magnetic circuit appears at the record gap, the gap depth, *g*, can also be of great importance. In general, the smaller the gap depth, the greater is the sensitivity of the head. However, too small a gap depth can give rise to a secondary difficulty, that of pole tip saturation.

During the record process, any one element of the tape is subjected to a finite number of cycles of magnetization and the final remanent flux is determined largely by the field strength distribution at a critical point beyond the trailing edge of the gap. The exact location of this point is determined as being where the intensity of the magnetizing field has fallen below the coercivity of the tape. Since, as has been pointed out by Westmijze[2], the individual particles forming the tape coating have a distribution of coercivities, then the critical point where the final remanent field is established in the tape is spread over a finite length. Ideally, if the recording field can be made to drop to below the critical strength over a very short distance, then the demagnetizing effect of the decremental field would be reduced to zero. This means therefore that the shape of the recording field needs to be carefully determined, this largely being effected by gap edge definition. Part of the problem is the selection of bias current, since increasing the bias current extends the radius of the field distribution so that the tape takes longer to pass through the critical gradient (Fig. 5). Pole tip shape can influence the field distribution to a degree, this being one of the reasons for the frequent selection of an almost hyperbolic curve for the pole piece faces.

In some respects the design problems with replay heads are rather smaller than for record heads. To reproduce the small magnetic signals on the tape, the permeability of the core needs to be high, the core reluctance low and the gap reluctance high. Since the core reluctance needs to be minimal the inclusion of a rear gap is highly undesirable and this does present some problem in the case of certain types of constructional method. The impedance of playback head coils is also often higher than for record, due to the increased number of coil turns used to maximize the output voltage. Finally the gap length of the head needs to be as small as possible to resolve the short recorded wavelengths found at high frequencies and low tape speeds.

Construction — materials

The selection of magnetic materials for use in the manufacture of tape heads is dictated by the following parameters. First the highest permeability is required, commensurate with low coercivity and ease of mechanical working. Second, the permeability must be optimal over the operating bandwidth of the head. Third, losses due to hysteresis or eddy currents must be kept low to optimize the sensitivity over the bandwidth and to keep noise levels low. Finally the hardness value should be as high as possible to reduce wear to a minimum. Several materials have emerged as being suitable for tape recorder heads, though none of them is ideal. Early heads were made from Mu-metal*, an iron-nickel alloy with a maximum initial permeability of the order of 15 $\times$ 10^3 at 0.4A/m for frequencies up to about 1kHz. At higher frequencies the permeability drops fairly sharply as shown in Fig. 6. There are a number of other problems associated with Mu-metal, the most important of which is the need to laminate the material to reduce eddy current losses, thus also reducing the initial permeability and making some compromise necessary. The normal thickness selected for many heads is of the order of 100 microns. A secondary problem is that mechanical working of the material destroys its permeability and thus during the manufacture of heads using Mu-metal there is sometimes the need to anneal three times to restore either the malleability or in the final case to restore the magnetic properties. A modern technique which considerably reduces the need for annealing is to etch the laminations through a photo resist, the remaining resist acting as a bond and insulant when the lamination pack is pressed together. Considerable accuracy and improved magnetic performance can be attained by this production technique, this being a principal reason for the continuing popularity of this type of head. Hardness is about 118 on the Vickers HV 5 scale. Where higher values of hardness are required Permalloy or Vacudor† may be selected. Vacudor is similar to Alfenol, both being an iron-aluminium alloy with a very low initial permeability at about 50 Hz and 0.4A/m of 25 to 27 $\times$ 10^3. Permalloy is some-

*Proprietary name registered by Telcon Ltd.
† Vacuumschmelze AG, Hanau a.M., Germany.

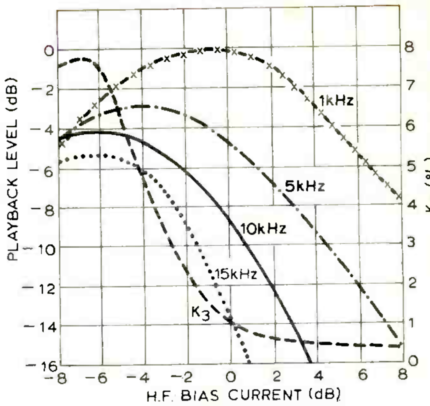


Fig. 3. Tape/head characteristics, 10 m gap (Bogen).

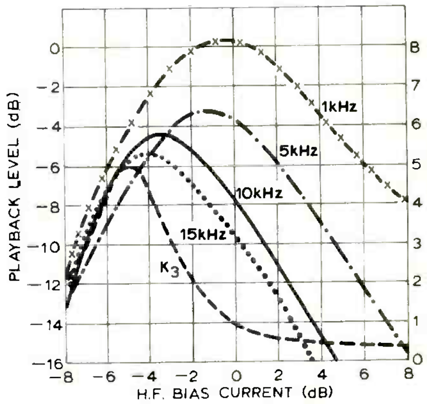


Fig. 4. Tape/head characteristics 20μm gap (Bogen).

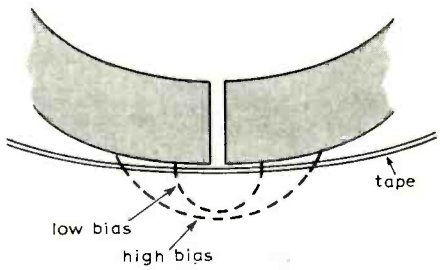


Fig. 5. Location of critical bias field with current.

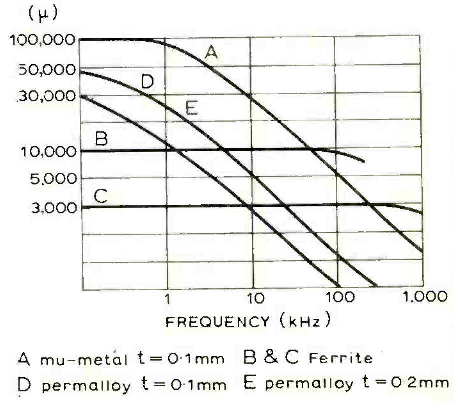


Fig. 6. Initial permeability of various magnetic materials.

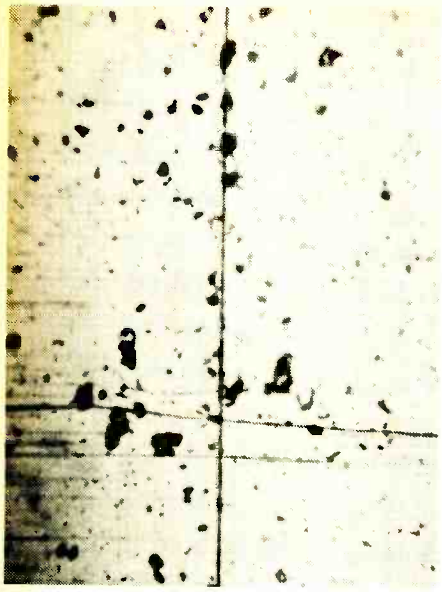


Fig. 7. Poorly machined ferrite head.

Fig. 8. Damaged gap edges on ferrite head.

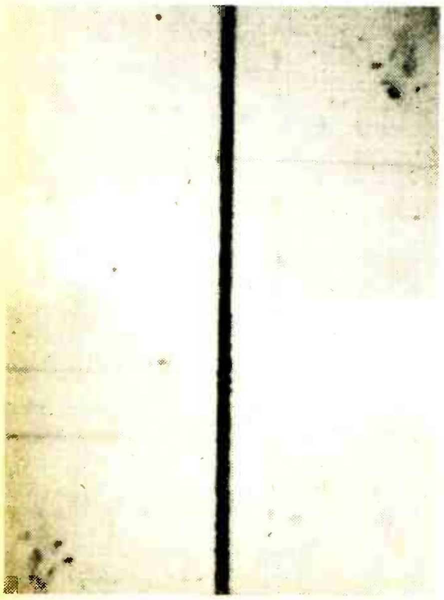


Fig. 9. Gap definition of Sony F&F head (×1000).

what better with an initial permeability of 50 × 10^3 under similar conditions. Both these materials are metal alloys and the constructional techniques used for Mu-metal are equally applicable. Hardness values are 132 for Permalloy and 220-350 for Vacudor.

Finally there is a range of ferrites which in recent years has become popular for tape heads. The composition can vary, but recent types seem to be mostly based on a mixture of ferric oxide (Fe_2O_3), manganese oxide (MnO), and zinc oxide (ZnO). This particular composition is specified by Sony, but a variant can be found in the Philips heads[3] where niobium oxide (NiO) is also included in the mix and MnO has been left out. The permeability of ferrites at low frequencies is considerably poorer than the metal alloys; however, it is maintained over a far greater range of frequencies, the resulting high *Q* improving the high-frequency noise performance of the head. The real advantages of high dimensional accuracy have only recently been realized, since ferrites are brittle and gap edges tended to chip and crumble under the mechanical pressure applied when assembling. However, the use of a glass gapping material which can be melted into place not only bonds the head components together but improves the mechanical strength of the gap.

Ferrite components can be produced in a variety of ways, the most popular being hot pressing. Here the raw ferrite powders are mixed and sintered under pressure. The sintering reduces the powders to a semi-plastic state and ensures that due to pressure the porosity is kept low. A second method, popular for video heads, is to grow a single ferrite crystal using the Verneuil technique to be seen operated by the semiconductor industry. This is a difficult and expensive process often resulting in a ferrite with high thermal noise and coefficient of friction (an important factor in tape heads). Only one manufacturer, Akai, appears to make use of this type of head for audio machines, and they seem to have overcome these disadvantages with specialized techniques.

Gap edge definition can, as has been mentioned, vary with manufacturing method and Fig. 7 shows how porosity spoils the smooth finish and in Fig. 8 leads to gap edge chipping. Selection of glass with an identical coefficient of expansion eliminates any final difficulties (Fig. 9) and the lapping process used to contour the head considerably reduces the porosity — partly as a result of plastic flow of the debris from the lapping. Duinker[3] has shown that accuracy of forming the gap length (*l* in Fig. 2) is simplified using glass spacers since, with a knowledge of the original shim thickness and taking into account bonding pressure, shim area and viscosity at the bonding temperature, final dimension can be precisely predicted.

Recently, an all ferrite construction[4] has become popular where screens and mounting block are also made of ferrite. The advantage to be gained is that a uniform wear characteristic is preserved

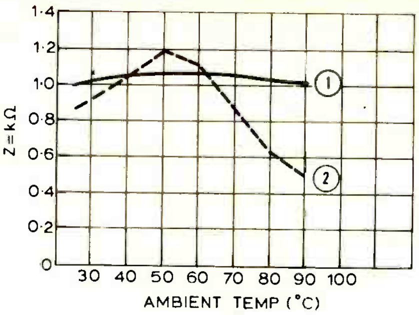


Fig. 10. Temperature characteristics of two ferrite heads: (1) Sony F&F, (2) poor ferrite formulation.

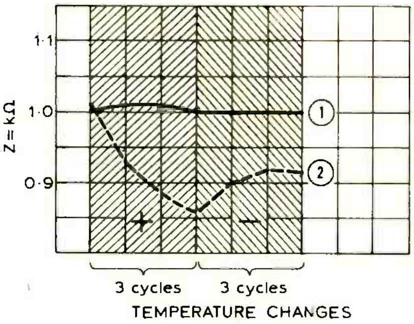


Fig. 11. Temperature cycling of ferrite heads; key as above.

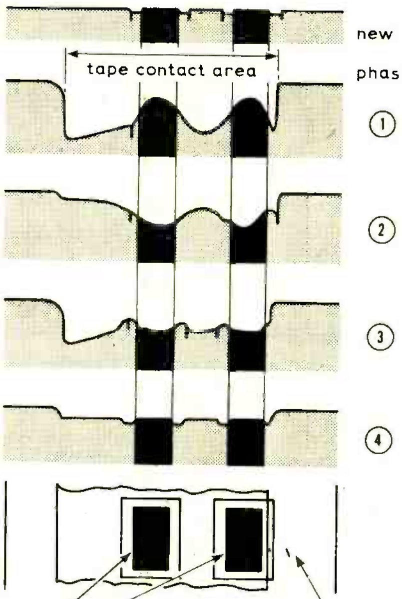


Fig. 12. Surface wear characteristics of several types of head.

over the area of tape contact. The importance of this is emphasized in a series of surface contours shown in Fig. 12. Temperature stability of permeability with ferries can be controlled (Figs. 10 and 11) this often being achieved with the addition of small amounts of cobalt[3].

There are few U.K. head manufacturers but Marriott Magnetics Ltd have refined a technique, for producing metal cassette and cartridge recorder heads to the extent that they claim to beat the Japanese and Americans on their own ground for price and quality. Their success is not so much in new design, but rather in the rapid adoption of automated manufacture which reduces production time to a minimum. A much smaller company, Phi Magnetronics has developed an elegantly simple method of constructing tape heads that enables small quantities of special designs in almost any track configuration to be produced at low cost. These heads are of the metal type and consist of etched laminations fitted into two slotted metal shells which are then clamped together after inserting a metal gap foil. Transverse laminations are used in heads made by several companies, but Woelke Magnetobandtechnik, of Germany, have evolved this technique to bond pole piece shanks into the body and slot the core around the shanks. The result is a more linear gap uninterrupted by laminar interfaces.

As for ferrite heads, the form used by Sony is shown in Fig. 1(c) and is typical of modern trends. The manufacturing advantages to be accrued are that the pole pieces can be made as a large block which can then be sliced to the appropriate track widths. Similar methods are used by most manufacturers.

Unfortunately this article can only skim the surface and there is still the complex aspect of the tape to head interrelationship to be studied and aspects of this will be presented in the audio tape survey to appear next month.

Acknowledgements

My thanks to Sony (U.K.) Ltd, Rank Audio Visual and Akai, Marriott Magnetics Ltd, Phi Magnetronics Ltd, Woelke Magnetobandtechnik, Bogen, and many individual engineers who have contributed information on modern design and production technology to make this article possible.

References

1. "The influence of some head and tape constants on the signal recorded on magnetic tape", E. D. Daniel. *Proc. I.E.E.* 1953, 100, Pt III, pp.168-175. "The reproduction of signals recorded on magnetic tape", E. D. Daniel and P. E. Axon. *Proc. I.E.E.* 1953, 100, Pt.III, pp.157-167.

2. "The principle of the magnetic recording and reproduction of sound." W. K. Westmijze. *Philips Technical Review,* 1953, vol.15, p.84.

3. "Durable high resolution ferrite transducer heads employing bonding glass spacers." S. Duinker. *Philips Research Reports* 1960, vol.15, pp.342-367.

4. "Sony's ferrite head for tape recorders." H. Ishii, translation from *Radio Technology* (Japanese) May 1972

Bibliography

Book: "Magnetic Tape Recording" by H. G. M. Spratt 1958 (now out of print) *Articles:* "A survey of factors limiting the performance of magnetic recording systems." E. D. Daniel et al. *Proc. I.E.E.* March 1957, Paper 2296R.

"Recording gap fields by Lorentz shadowgraph and characteristics of single crystal MuZo ferrites." R. D. Fisher and J. D. Blades, *I.E.E.E. Trans. Mag.* vol. Mag-8, No. 2, June 1972, pp.232-238.

Announcements

Two new correspondence courses — **"Modern control theory"** and **"Colour television"** — have been added to the "Individual Study Service" of the Institution of Electrical Engineers, Savoy Place, London WC2R OBL. Information available from the Education Officer.

Minicomputers in Industrial Process Control is a three-day course at the Polytechnic of Central London, 115 New Cavendish Street, London W1M 8JS from 21st to 23rd March.

British Radio Corporation Ltd, a member of Thorn Group, Thorn House, Upper Saint Martin's Lane, London W.C.2, has announced that on 1st April it will change the name of the company to **Thorn Consumer Electronics Ltd.** It will continue to manufacture and market TV and audio products under the Ferguson, Ultra, HMV and Marconiphone brand names.

Jermyn Distribution, Vestry Estate, Sevenoaks, Kent, have signed a franchise agreement with the Swedish company Aktiebolaget Rifa under which Jermyn are Rifa's exclusive U.K. distributors. Initial stocks purchased from Rifa are capacitors, transient voltage protectors, potted *RC* networks and radio interference suppressors.

As an accessory to its lower priced oscilloscopes, S.E. Laboratories (Engineering) Ltd, North Feltham Trading Estate, Feltham, Middlesex, are marketing a **dual-channel oscilloscope adaptor** to convert single beam instruments to dual-channel operation. The unit, designated HZ36, can be attached by simple cable connections to any S.E. or other single beam oscilloscope.

Vero Electronics Ltd, Industrial Estate, Chandlers Ford, Hants, SO5 3ZR, has been appointed U.K. agent and distributor for the American **E. F. Johnson Company** range of components (hardware and devices).

A London base of **Mackarl Electronics**, who have three factories in Taiwan and one under construction in the Philippines, has been established at Albany House, Petty France, London SW1H 9EA. Mackarl Electronics (London) offers a range of audio equipment in chassis form or completely assembled for manufacturers or under private label for retail organizations.

British Aircraft Corporation Electronic and Space Systems Group, Brooklands Road, Weybridge, Surrey, have been awarded a contract by the Ministry of Defence for the design and development of a low gain L-band aerial system, suitable for aircraft-to-satellite communication. The contract is part of an Aerosat experimentation programme on behalf of the Civil Aviation Authority.

A contract worth £½M, to improve the performance and reliability of the 50cm radars which form the major part of the **U.K. Airways en-route radar** coverage, has been awarded by the Civil Aviation Authority to Marconi Radar Systems Ltd, Marconi House, Chelmsford, Essex, CM1 1PL.

GEC Telecommunications Ltd., P.O. Box No. 53, Coventry CV3 1HJ, has received contracts from the Government of the Republic of Zambia for equipment to expand the telecommunications system which the company installed and commissioned six years ago in conjunction with the Zambian General Post Office. Carrier-multiplex equipment will expand the number of telephone circuits on a 400km microwave-radio link.

APT Electronic Industries, Byfleet, Surrey, the radar division of Bonochord Ltd, has received from the Ministry of Defence a contract worth more than £100,000 involving three of the company's precision automatic tracking radars.

Martron Associates, 81 Station Road, Marlow, Bucks, has been appointed U.K. distributor for Dynapar Corporation, Gurnee, Illinois, U.S.A., manufacturers of digital industrial **process control equipment.**

Thomson-CSF United Kingdom Ltd have appointed **Transonics Ltd,** 303 Edgware Road, London W.2, to handle their range of semiconductor and passive components.

Circards — future series

We regret the delay in the distribution of Circards series 4 and 5. This has been largely due to production difficulties. It is expected that orders for series 5 will be dispatched during the week March 5-9. In general readers should allow a delivery time of at least two weeks from the date of ordering.

After the trial period the hopes for Circards expressed in the editorial and introductory article in the October 1972 issue are fully justified. The scheme will be continued and extended. The authors and editors are concerned that user reaction should be taken into account as fully as possible. To allow time for this, and the resulting preparation of further series, the next set of cards (series 6) will not be announced until the next issue of *Wireless World.*

Also in the next issue we shall outline the plans for forthcoming sets of Circards. Readers' comments on series presented so far, and suggestions for future Circard topics, are welcomed.

About People

Peter Mothersole, F.I.E.E., F.I.E.R.E., has rejoined Mullard Ltd as chief commercial engineer. Mr Mothersole originally joined Mullard in 1953 and became section leader of the television group at Mullard's research laboratories. He later moved to the central application laboratory as head of the consumer application division and in 1969 became engineering manager and a member of the executive management team of Pye TVT (both Mullard & Pye are members of the Philips group). He is a member of the I.E.E. Electronics Divisional Board and chairman of the Professional Group (E14) Television and Sound. Mr. Mothersole succeeds **T. Aspin,** who was recently appointed a member of Mullard's executive board.

David R. Hall, Solartron's U.K. sales manager since 1963, has been appointed to head a U.K. sales and service division of Schlumberger Instruments & Systems. Mr Hall will further develop a field sales team backed by technically and commercially trained sales office staff, and after-sales service units for the marketing of Schlumberger instrumentation in the U.K.

John S. Halliday, B.Sc., Ph.D., F.Inst.P., has been appointed to the board of AEI Scientific Apparatus Ltd as technical director. Dr Halliday went to the University of Reading from Sir William Borlase's School, Marlow, in 1944 with a state bursary in radio. In 1946, at just over nineteen years of age, he had passed the B.Sc. General Honours with first class honours and a year later also graduated with a B.Sc. Special Honours in Physics. After research in the University's physics department he obtained a Ph.D. in 1951. He was elected a Fellow of the Institute of Physics in 1961. He joined the staff of the Research Laboratory, AEI Aldermaston, on leaving university and from 1957 onwards was responsible for advanced research concerned with electron microscopes. After transferring to the mass spectrometry team at AEI Scientific Apparatus, Barton Works, in 1963, Dr Halliday became responsible for all the engineering and development work on these products in 1964.

The Electrocomponents Associated Group has appointed **Arthur Crouch** as director and general manager of the newly acquired Radio Resistor Company. Recently Mr Crouch started Pact International, the marketing company formed to introduce specialized instrumentation from European manufacturers. Before that he was marketing director of Spectrol Reliance, part of the U.S.A.-based Carrier Corporation. Earlier management posts were held with A.B. Electronic Components and the E.M.I. Group. He has travelled extensively during his career, visiting all the major European countries, the U.S.A. and Middle East. Of special interest among several appointments are his past chairmanship of the R.E.C.M.F. "Resistor Group" and membership of the R.E.C.M.F. Council.

Welwyn Electric announce the promotion of their managing director, **J. E. Herrin,** M.I.E.E., to the board of the parent company Royal Worcester Ltd. John Herrin joined Welwyn last November from the Federal Pacific Electric Company, New Jersey, U.S.A., where he had been general manager of the switchgear division.

The award of the Faraday Medal to **Sir Nevill Mott,** F.R.S., emeritus professor of physics in the University of Cambridge, has been announced by the Institution of Electrical Engineers. This was the 51st award of the medal and was made to Sir Nevill for his distinguished contributions to quantum mechanics and solid-state physics which have provided a theoretical foundation for the development of solid-state electronic devices.

Gerard White, B.Sc., Ph.D., has been asked by the Post Office to head the newly created Advanced Technology Studies division of its research department. He is to "explore possibilities for the creation and utilization of advanced technology and its application in new telecommunication systems". Dr White gained his degrees at the University of Wales, Bangor, where he obtained first-class honours in electronics, control engineering and materials technology, and a doctorate in electronics; later he undertook part-time post-graduate studies in communication theory at the Polytechnic Institute of Brooklyn, New York. He has held short-term appointments with the United Kingdom Atomic Energy Research Establishment, Harwell, and the Royal Aircraft Establishment, Farnborough and, on telecommunication assignments, with the National Telephone Company of Spain and the Ohio Bell Telephone Company.

T. A. L. Paton, C.M.G., F.R.S., has succeeded **Sir Arnold Lindley,** D.Sc., as chairman of the Council of Engineering Institutions. Mr Paton is a former president of the Institution of Civil Engineers. The new vice-chairman of the C.E.I. is **Major-General Sir Leonard Atkinson,** K.B.E., B.Sc., F.I.E.E., F.I.E.R.E., who was educated at Wellington College and University College, London. After first being commissioned into the R.A.O.C., he transferred to the R.E.M.E. in 1942, and saw service in Europe, India and the Far East. After a varied career in R.E.M.E., he became Colonel Commandant in 1967. On retirement, he was appointed a director of Harland Engineering, of Alloa, and of Simon Electronics, Bletchley, later becoming managing director of Harland Simon, and a director of Weir Engineering Industries, Glasgow. He is a past president of the I.E.R.E.

Tempatron Ltd have announced the appointment of **W. Gaiger** as their production manager. Mr Gaiger joined Tempatron Ltd from Data Recording Ltd, where he has been production supervisor for $2\frac{1}{2}$ years. Previously, he was with Ampex Electronics Ltd.

A. Martin Shaw, Ph.D., has joined Irvin Great Britain Ltd as chief engineer of their Electronics Division at Letchworth, Hertfordshire. He will be responsible for all engineering activities in the division. Dr Shaw, aged 28, took a first class honours degree in physics at Cambridge and did research for his Ph.D. at the Cavendish Laboratory, Cambridge, and the Department of Metallurgy in Oxford. From 1969–72 he worked for International Computers Ltd as a project leader in the design of computer memories and peripherals.

W. D. Akister, Ph.D., F.I.E.E., has recently joined Cambridge Consultants Ltd, the technical consultancy operation based at Bar Hill, near Cambridge. He has special responsibility for the production engineering and production control aspects of all electronics projects and will also be involved in the handling and management of large inter-disciplinary projects. Before joining the company, Dr Akister spent six years as engineering consultant to the chief executives of Redifon Flight Simulation Ltd, where he was responsible for the standardization and rationalization of equipment, systems and methods between separate units producing similar equipment. Dr Akister was previously chief electronics engineer and project manager of large flight simulator and trainer projects for Air Trainers Ltd.

Wing Commander J. A. F. Morgan (R.A.F. Ret'd) has joined Wayne Kerr as Services liaison representative. He will handle the company's growing range of automatic test equipment as well as their established series of laboratory instruments. John Morgan studied at Glasgow University and was commissioned as Signal Officer in 1942. For some years prior to his retirement he was responsible for air traffic control and aircraft radio/radar facilities at Mintech (now Ministry of Defence) research and development establishments.

The Society of Electronic and Radio Technicians has recently appointed as its first vice-president **Sir Cyril English,** B.Sc.(Eng.), director general of the City & Guilds of London Institute. Sir Cyril is a member of many important national committees concerned with education and training, including the James Committee of Enquiry into the training of teachers, and for the last two years he has been chairman of the British Association for Commercial and Industrial Education (BACIE).

At a dinner given at the beginning of February in the House of Lords, the Society of Electronic and Radio Technicians presented certificates of honorary fellowship to three of the Society's leading figures. **Lord Orr-Ewing,** O.B.E., M.A., F.I.E.E., the first S.E.R.T. president, is chairman of Ultra Electronics and has had many years' experience with E.M.I., the B.B.C., the R.A.F. and Cossor. He was a Conservative M.P. and was appointed a life peer in 1970. **E. A. W. Spreadbury,** F.I.E.R.E., formerly editor of our associated publication *Electrical and Electronic Trader* was involved in the formation of the Radio Trades Examination Board, and during his chairmanship of this organization helped to found S.E.R.T. He has been described as the "Father of S.E.R.T." **Kenneth Tempest** is closely associated with the teaching of technicians. During his term as chairman of S.E.R.T., membership reached 5000.

The Realm of Microwaves

2. Microwave transmission lines

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

Over the last five years in particular, the microwave industry has devoted time to reducing the size of its circuits. Although the basic concepts involved have been known for over 20 years, recent improvements to the theory and the technical advances made in the semiconductor, thick-film and thin-film fields have enabled extremely compact circuits to be built. Attention has concentrated on the microstrip form of transmission line, with the inclusion of suitably-packaged semiconductor devices to form hybrid devices, and also on lumped-element circuit design. This article gives a general practical review of the standard forms of microwave transmission line, leading up to a review in a following article of microwave i.c.s and lumped-element design.

Microwave transmission lines

Those readers for whom microwave engineering is not the source of their daily bread I must ask to temporarily forget the parameters of voltage and current. These do not have practical significance and for example, in a hollow waveguide there is no unique value for either term. Instead, energy is carried by sinusoidally-varying electric and magnetic fields which propagate along the transmission line and have instantaneous values which are functions of both position and time. The practically-measured quantities are always power, variations in power and impedance, either absolute or normalized.

The waveguide

Although all transmission lines are waveguides, the term has come to apply specifically to the dielectric-filled conducting tube; the dielectric usually being air. When an electromagnetic field is confined in this way, its propagation characteristics are changed from their free-space value. The conducting boundaries force the enclosed field to conform to specific patterns for it to exist and the properties of the overall arrangement are directly related to the shape and size of the waveguide. In addition, the presence of any discontinuity within the guide influences its properties as a transmission line. This is most important and enables reactive effects, either inductive or capacitive, to be realised; hence the design of microwave components.

A particular combination of electric and magnetic field patterns which can propagate within the guide is called a mode and there is an infinity of such modes. However, the waveguide behaves as a high-pass filter: attenuating energy at frequencies below a cut-off frequency. Also, it is standard practice to operate within a limited frequency range near cut-off where only one mode can exist. This is termed the dominant mode for the guide and is the one with the lowest cut-off frequency. If operation at higher or lower frequencies is required, then a different-sized waveguide must be used. Rectangular, Fig. 1(a), and circular, Fig. 1(b), guides thus come in assorted sizes, roughly spanning the range 400 MHz to 400 GHz. With few exceptions, the rectangular aspect

*British Aircraft Corporation.

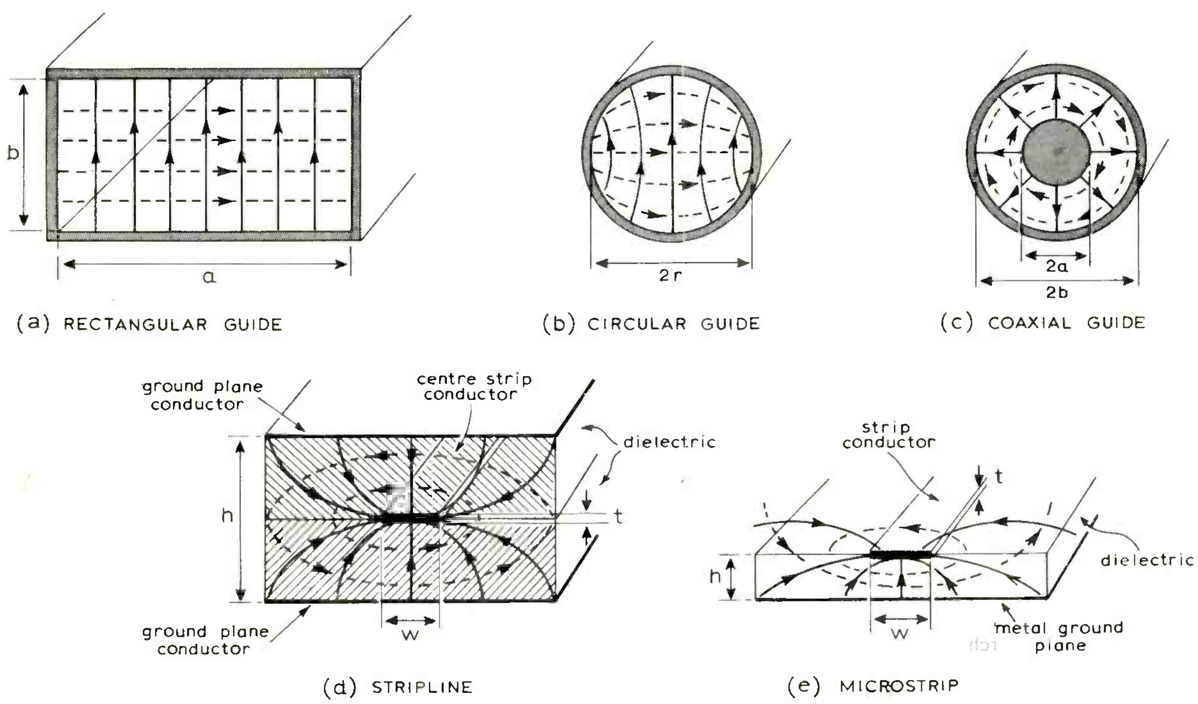


Fig. 1. Common forms of microwave transmission line with field pattern of the dominant mode. Solid lines are electric field, broken lines are magnetic field.

ratio is fixed at 2:1; this being a compromise between power handling, loss and overmoding.

The longest wavelength which can propagate down the guide, i.e. that of the dominant mode, is equal to twice the width of the guide: $2a$. In practice, the centre frequency of rectangular guide is made about 1.5 times the cut-off frequency and operation is restricted to within about $\pm 20\%$ of this. For a circular guide the derivation of the cut-off wavelength is a little more complicated and is given by the ratio of circumference to one of the Bessel function roots. Which root it is depends on the particular mode in question but, for the dominant mode, the cut-off wavelength is equal to $3.42\,r$.

The reason why waveguides are restricted to the higher frequencies is now obvious: that of size. For example, to cover the f.m. broadcast band from 88 MHz, the necessary size of rectangular guide could serve as a garage for two Minis side by side.

Enclosing an e.m. field within conducting boundaries alters the wavelength of propagation from that in free space; it is made longer and becomes a function of the guide dimensions. The general expression for any shape of guide is

$$\frac{1}{\lambda_g^{\,2}} = \frac{\varepsilon_r}{\lambda_o^{\,2}} - \frac{1}{\lambda_c^{\,2}}$$

where the wavelengths are λ_g in the guide, λ_o in free space and λ_c at cut-off, and ε_r is the relative dielectric constant of the medium filling the guide, usually air for which $\varepsilon_r \approx 1$.

As with any other transmission line, the waveguide has an impedance, but unlike other types it is not possible to say exactly what this is. Due to the field patterns within the guide, there is no unique value of impedance because there is no single value of voltage or current. In practice, the situation is not too bad as one very rarely needs an absolute impedance and most design work can use relative values, i.e. the comparison with an effect at one point with a similar effect at another. The basic impedance does, though, depend on the waveguide mode and for a given mode is also a function of frequency.

An instance of when a value of impedance is needed is in the estimation of the power handling capacity of a guide. Metal waveguides can handle large amounts of power, the exact quantity depending on surface roughness, humidity, pressure, allowable temperature rise and frequency. The maximum power density can be defined as the ratio of maximum electric field squared to impedance. Under normal sea-level conditions the breakdown field for air is taken as 30kV/cm, and over the most commonly used portion of the microwave spectrum, say 4 to 40GHz, waveguides at the lower end will handle 10MW of power and at the higher end 100kW. These are maximum peak powers and are usually reduced by a safety factor of four and still further if there are discontinuities within the guide.

Waveguides are mainly used for high power carrying and/or long transmission line runs and thus attenuation is important. This attenuation is caused by losses in the metal conductor and is a function of frequency, conductor material, surface finish and the particular mode within the guide. For the range of waveguides previously quoted, typical losses with copper walls are 0.01dB/ft at 4GHz to 0.24dB/ft at 40GHz.

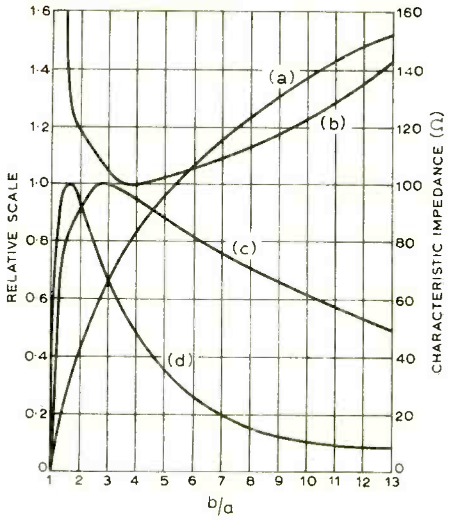


Fig. 2. Some properties of air-filled coaxial line showing the dependence on the diameter ratio: (a) characteristic impedance, (b) attenuation, (c) breakdown voltage, (d) power handling capacity.

Coaxial line

Unlike waveguides, coaxial lines have no cut-off frequency and propagate energy at frequencies from d.c. to infinity. There is, however, still a dominant mode of propagation and higher order modes can be generated under certain conditions. The dominant mode is termed a transverse electromagnetic one (TEM) as both the electric and magnetic field components are always at right angles (transverse) to the direction of propagation. This mode requires at least two separate conductors and therefore cannot exist in waveguides. Higher-order modes, having different field patterns can exist and for these the coaxial line behaves as a high-pass filter.

Using the nomenclature of Fig. 1(c), the first of the higher modes appears when the frequency is high enough such that the mean circumference approaches one wavelength. The wavelength itself in coaxial line is simply that which would exist in a free-space medium of the same dielectric constant as that filling the line, i.e. $\lambda_g = \lambda_o/\sqrt{\varepsilon_r}$.

Unlike the waveguide, it is possible to define an exact impedance for the TEM mode in coaxial line. Basically, the characteristic impedance Z_o of a transmission line can be defined as:

$$Z_o = \left(\frac{R + j\omega L}{G + j\omega C}\right)^{\frac{1}{2}}$$

where R, G, L and C are the per unit length resistance, conductance, inductance and capacitance of the line, ω being the radial frequency. Neglecting losses, $Z_o = (L/C)^{\frac{1}{2}}$ from which it is relatively simple to calculate L and C for a coaxial line. On evaluation, Z_o is found to be a function of the ratio b/a and ε_r.

Sidetracking slightly, this definition also enables a free-space wave impedance to be calculated. The inductance per unit length of free space is the absolute permeability μ_o and the capacitance per unit length is the absolute permittivity ε_0. Thus with $L = \mu_0 = 4\pi \times 10^{-7}$ H/m and $C = \varepsilon_0 = 1/36\pi \times 10^{-9}$ F/m, the free-space impedance results as 120π or 377Ω.

Coaxial lines of the same material have higher conductor losses than waveguides and usually have dielectric losses as well. The latter stem from the fact that, apart from short lengths of line for special applications or components, the centre conductor needs supporting concentrically. Again, apart from short lengths when carefully spaced beads can be inserted, this support is provided by completely filling the line with a solid dielectric. Attenuation due to conductor loss is proportional to the square root of frequency while that due to dielectric loss is directly proportional. This means that at frequencies within the microwave band, dielectric losses are the most significant and are prohibitively large for long lengths of line.

The maximum peak power handling of coaxial line is limited by the breakdown voltage of the dielectric (30kV/cm for air) and by the ratio of inner and outer diameters. In general, for commonly used coaxial cable sizes, the peak and mean power handling capacity is two to three orders of magnitude less than that for corresponding waveguide sizes.

The above parameters are a function of the coaxial diameter ratio b/a and there is an optimum but different ratio for each parameter. It is interesting to compare this dependence on b/a, (Fig. 2). Attenuation is a minimum for b/a of 3.6 corresponding to the characteristic impedance $Z_o = 77\Omega$. Maximum breakdown voltage occurs when b/a is 2.718, giving $Z_o = 60\Omega$ and maximum power handling when b/a has the value 1.65, giving $Z_o = 30\Omega$. These figures apply to air-spaced line for which $\varepsilon_r = 1$.

For a different dielectric, the ratio of b/a remains the same, but the corresponding impedance will be the above values divided by $\sqrt{\varepsilon_r}$. Freedom of design thus exists to optimize the dimensions for a particular application. Widely varying impedances are found within coaxial components. Commonly available cable comes with two standard impedances: 50 and 75Ω. The former is a reasonable compromise of the factors in Fig. 2, b/a being 2.3 for $\varepsilon_r = 1$; while the latter, as well as being low loss, is close to the impedance of some aerials: the half-wave dipole, for example, has an impedance of 73.1Ω.

Stripline

This form of transmission line is shown in Fig. 1(d). It can be considered as rectangular-section coaxial line with the side walls removed and, provided the open edges are not too close to the centre strip, its properties are similar to those of coaxial line. The dielectric can be air, but is more commonly a solid material and in this form is marketed in a large range of materials and sizes as copper-clad sheet. In this respect it is like printed-circuit board and the same processing techniques can be used to produce circuits. Three of the most common dielectric materials available are irradiated polyolefin, cross-linked polystyrene and p.t.f.e.-impregnated glass fibre. Between them, these probably cover the full range of materials properties and enable trade-offs to be made between such things as loss, temperature and chemical resistance, solderability and toughness.

Circuits are produced by etching the required conductor geometry on one side of a double-clad sheet, the other copper layer being left as a ground plane. On top of this is then placed a second sheet, copper clad on only one side, to give the sandwich of Fig. 1(d). The two pieces are then clamped together. Although any required thickness can be used, there are standard sheet sizes ranging from 1/32 to 1/4-in, the overall strip-line thickness being twice these values.

The principal advantage of the stripline form of circuit is that the normal range of components and sub-systems can be constructed without any change in thickness. All designs are realized by variations in the shape and size of the centre strip. Thus the circuit is essentially a two-dimensional one, unlike coaxial line and waveguide, which results in a considerable saving in volume especially at the lower end of the microwave spectrum. Transmission properties of stripline are very similar to coaxial line, the main difference being that not having a closed boundary nor an infinite ground plane an exact determination of the characteristic impedance has not been possible. However, the years have witnessed the emergence of increasingly more accurate formulae and it is now possible to relate theory and practice to within experimental error. The main cause of this uncertainty has been in establishing the value of the strip fringing fields.

It is interesting to make use of some very fundamental relationships to arrive at the characteristic impedance. Remembering from before that the impedance of a medium can be defined in terms of its inductance and capacitance per unit length, one can say $Z_o = (L/C)^{\frac{1}{2}}$. The velocity of propagation v can also be expressed in terms of L and C as: $v = (LC)^{-\frac{1}{2}}$. This velocity is equal to the speed of light c in the medium and the fundamental definition of the speed of light is $(\mu_c\mu_r\varepsilon_o\varepsilon_r)^{-\frac{1}{2}}$. For instance, in vacuo, μ_r and ε_r are unity and, with $\mu_o = 4\pi \times 10^{-7}$H/m and $\varepsilon_o = 1/36\pi \times 10^{-9}$F/m then $v_c = 3 \times 10^8$m/s. Making use of these relationships $Z_o = L/C = 1/vc = \mu_r\varepsilon_r/3 \times 10^8 c$ ohm.

Thus if the capacitance per unit length can be determined the characteristic impedance is known. For wide strips of negligible thickness, C is simply the parallel-plate capacitance indicated in Fig. 1(d) and the impedance can be obtained quite accurately. However, as the strip thickness increases and the width decreases, then the fringing fields become important and the calculation of C becomes more difficult. This is especially true in the case of a variant of stripline, sometimes called slabline, where to obtain low losses, the dielectric is air and the centre conductor is made very thick ($\frac{1}{2}$in or more). The dependence of Z_o on the variables ε_r, ω, t and h is shown graphically in Fig. 3. The centre strip thickness has a significant effect and the impedance increases as the strip width decreases.

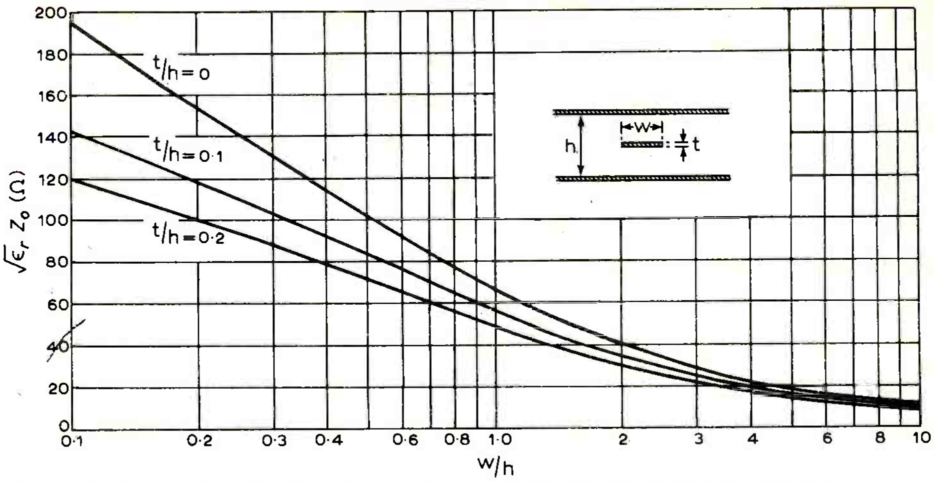


Fig. 3. Variation of stripline impedance with strip width, showing strong dependence on strip thickness. Commercially available laminate usually has t = 0.0014in and $t/h < 0.02$.

Like coaxial line, the mode of propagation can be assumed to be TEM, though not exactly because of the open sides, and thus stripline will pass all frequencies. Again, if the frequency is high enough, higher order modes can also propagate. This situation is reached when the ground plane spacing h is approximately half the dielectric wavelength. For instance, if operation at 15GHz was required using irradiated polyolefin with $\varepsilon_r = 2.32$, the dielectric wavelength $\lambda_o/\sqrt{\varepsilon_r} = 1.31$cm and so h must not be greater than 0.65cm (0.256in).

Quarter-inch stripline could thus be used, made from two $\frac{1}{8}$-in sheets. If this were coated with standard 1-oz copper, which is 0.0014-in thick, then $t/h = 0.0056$ and consultation of Fig. 3 would reveal that for a 50-ohm system a line width of about 0.2-in is required. Attenuation and power handling is similar to that of coaxial line filled with the same material. But unlike coaxial line there is no well-defined optimum for these and other parameters. Continuing the example from before, the material has a low loss factor of 5×10^{-4} and the resulting attenuation due to dielectric loss is 0.01dB/m and to conductor loss is 0.64dB/m.

Microstrip

There is a fair amount of inconvenience with stripline when it comes to incorporating solid-state devices into the circuit and it is impractical to use with semiconductors in chip form. Also, as indicated by Fig. 3, for a given impedance the higher the dielectric constant, the smaller the linewidth and suitable high-dielectric constant materials tend to be hard, brittle and unsuitable for sandwich-type construction. For these reasons, the microstrip circuit form of Fig. 1(e) is used for hybrid systems, usually as a high-dielectric constant substrate.

To take full advantage of this type of circuit, two conditions must exist: accurate enough design equations and a high definition technology for producing the conductor patterns. It is really only within the last five years that sufficient advance has been made in these two areas to ensure that high-dielectric constant microstrip is a very attractive commercial competitor for most microwave sub-systems.

Of the many materials available for use as substrates, the three most popular are alumina, sapphire and ferrite, with alumina topping the bill. This material is a very hard and brittle ceramic of aluminium oxide usually supplied with a purity of between 96% and 99.9%. The latter has a loss tangent of 0.0002 and dielectric constant of 9.7 at 10GHz. Conductor material is usually gold and is invariably produced by vacuum deposition, the desired pattern being either photo-etched from a completely coated substrate or directly deposited through a mask.

A popular thickness for the alumina is 0.025in with about a ±1% tolerance and a surface finish might typically be less than 10μin. The latter is important with respect to line definition and conductor loss. For example, the loss (in dB/unit length) for a 2-μin finish has been shown to be about 35% less than that for a 24-μin finish and the smallest obtainable line width to vary from 0.001 to 0.006in between the two finishes.

With regard to the main transmission parameters, an exact computation of the velocity of propagation, hence impedance, has not yet been made. The difficulty lies in defining the boundary conditions and the exact mode of transmission. However, within the range of impedances and frequencies generally used, the existing mathematics is sufficiently accurate in predicting the performance of microwave circuits.

Because not all of the electromagnetic field is confined within the dielectric, resulting in parts of the wave travelling through the air, there exists an effective dielectric constant, ε_{eff}, instead of the substrate value of ε_r. This new constant is less than ε_r and is a function of both ε_r and w/h, as plotted in Fig. 4. ε_{eff} gradually approaches ε_r as the dielectric constant of the material approaches the free space value of unity and also as w becomes large thereby enclosing the material, or as h becomes small, causing most of the field to travel in air. Thus, using pure alumina with a typical w/h value of 1, the effective dielectric con-

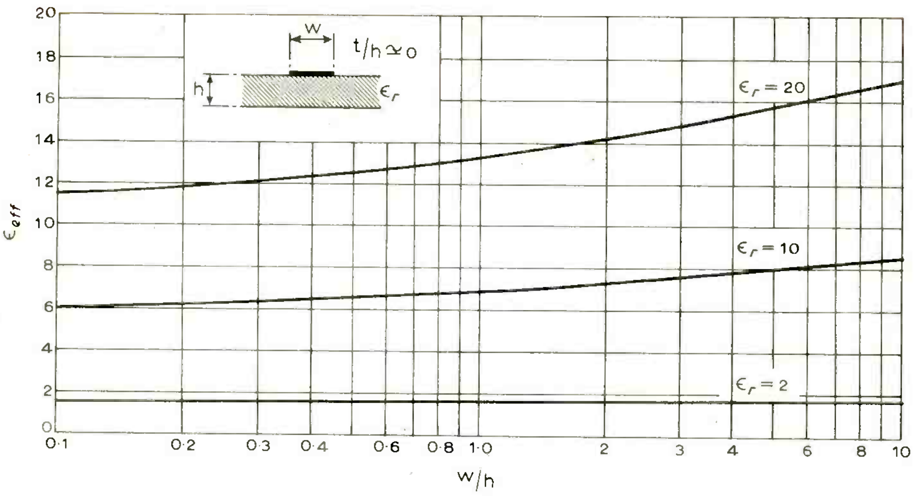


Fig. 4. Showing the effective dielectric constant for microstrip and how it varies with strip width. Difference between ε_{eff} and ε_r is because the field is not completely confined within the dielectric.

stant is only 69% of the value of the material.

Once ε_{eff} for a particular w/h value has been obtained, the characteristic impedance is well on the way to being determined. While no exact design equations have yet been formulated, several versions exist with acceptable accuracy. The most widely accepted impedance equations are due to Wheeler* and are shown graphically in Fig. 5. Taking the previous example of the commonly used 99.5% pure alumina with $\varepsilon_r = 9.7$ and 0.025-in thick, then Fig. 5 indicates that a w/h ratio of 1 is required for a 50-ohm impedance. That is, the line itself will be 0.025-in wide. Doubling this impedance to a not-unreasonable 100 ohms, decreases the linewidth to just under 0.004in. Thus, it can be appreciated why a high-definition technology is required if full advantage is to be taken of the microstrip form of transmission line. Even so, impedances much above 100 ohms are not really practical on alumina and in these cases it is best to go to a lower dielectric constant material such as fused quartz for which $\varepsilon_r = 3.78$. If this is still not sufficient, Fig. 5 indicating about a 50% impedance increase for the same width, then other microstrip structures can be used.

Increasing the substrate thickness could be another way of achieving attainable linewidths at high impedance levels, but this can be done to a certain extent before higher order modes start to propagate. The first of these modes exists as a surface wave: highly undesirable in a carefully tuned circuit and can propagate when the substrate is approximately $\lambda_o/4\varepsilon_r$ thick. Thus, a circuit operating at 10GHz must not be more than 0.095-in thick. Loss in microstrip is composed of dielectric and conductor loss and is a function of frequency and impedance. For 50-ohm at 10GHz on alumina, both types of loss on a per unit length basis are about 10 times those given in the stripline example. However, comparison is really only fair on a loss per wavelength basis and in this case the difference is not so great. Conductor loss in microstrip is generally higher than in stripline because the conductor dimensions are usually smaller.

* Wheeler, H. A. "Transmissionline properties of parallel wide strips separated by a dielectric sheet". *I.E.E.E. Trans.* vol. MTT-13, 1965, pp. 172-85.

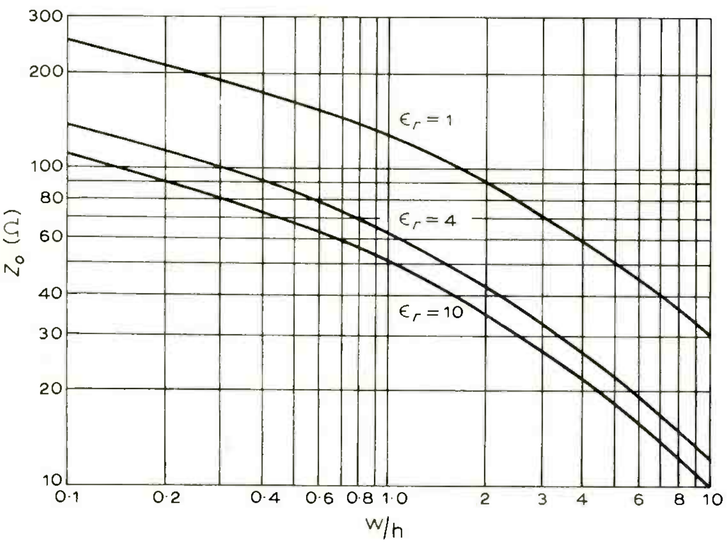
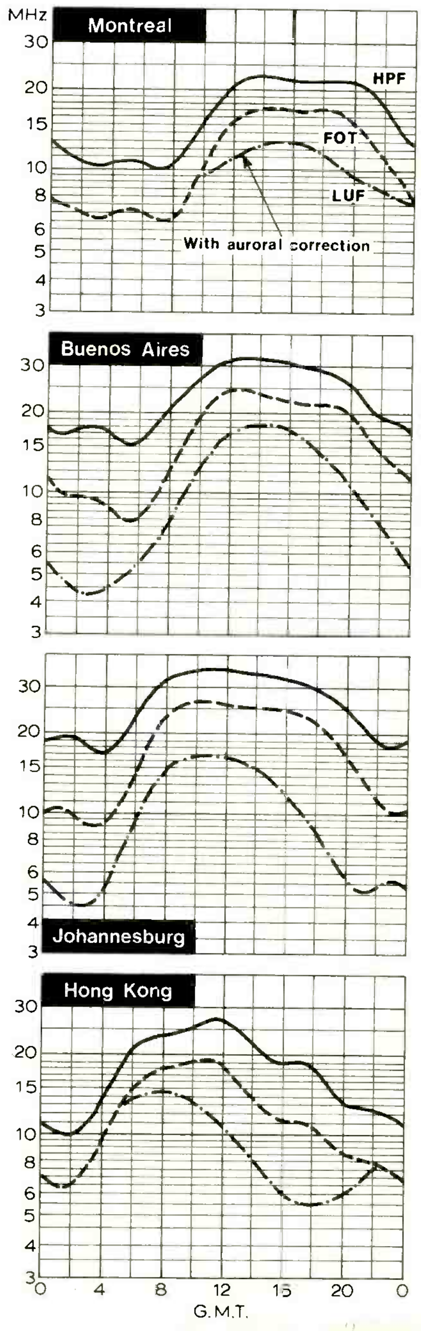


Fig. 5. Impedance of microstrip with ε_r as a parameter; $\varepsilon_r = 1$ for air, 3.78 for quartz and 9.7 for alumina.

H.F. Predictions March

The monthly mean sunspot number has dropped to the low thirties for the first time since 1966. This month's charts were drawn for a sunspot value of 40 so the curves will probably prove to be around 1MHz too high particularly at the end of the month.

The pattern of frequency usage established over sunspot maximum is just beginning to change. Daytime frequencies above 20MHz continue in use but are fading out earlier in the afternoon. Some commercial circuits are finding a need for frequencies down to 3MHz for the pre-dawn period. Apart from the unavoidable increase in absorption loss, high-gain aerials are not common at these lower frequencies due to size and cost, so circuit reliability decreases and poor aerial directivity and reduced channel space give rise to serious interference problems.



Industrial Electronics

1. The new industrial revolution

by Richard Graham

In this series, the author examines in each article a particular electronic technique used in industry. Transducers and circuitry will be discussed, and applications of the equipment are described. The second part, in the April issue, will be devoted to the measurement of displacement and will be followed by articles on electronic weighing, object counting, flow, pressure and the like.

The art of electronics has almost completely taken over the mantle of alchemy, at least as far as the average, non-scientific person is concerned. The only difference is concerned with the somewhat differing aims of the two arts; in place of elemental transmutation, the avowed intention of applied electronics may appear to be the complete elimination of all human intervention in any tedious, unpleasant, difficult or otherwise undesirable activity.

While such an object is laudable indeed, it is, perhaps, a touch impracticable. The efforts of most engineers working in industrial electronics are directed into two main channels; to perform tasks which were previously entirely impossible and to assist people to work at an efficiency far higher than by their unaided efforts.

The elimination of the human element is hardly ever as complete as initially envisaged. We have all heard stories of how a computer was installed in an organization "to reduce staff", and before sufficient time has elapsed to allow the chief programmer to say "Cobol", the staff has increased two-fold. This apparently fundamental failure in planning is concerned with the phrase in quotes above. It is very rare that a computer is used for that purpose alone, and the installation is justified by the fact that, with a two-fold staff increase, perhaps eight times as much work is done. Whether the extra work is always worth doing is another matter.

Most work in industrial electronics is aimed at improving the results obtained by earlier mechanical equipment. Relatively infrequently, the electronic development is able to do something not possible with earlier devices. For example, it is possible to detect, measure and record the stresses inflicted on the blades of a gas turbine, while it is rotating at speed. Or to relay to the ground masses of information about rocket behaviour. Still more infrequently, it is found that electronic methods have trouble beating, or even matching, the traditional mechanical ways of working. It is only fairly recently that electronic weighing equipment has been able to put up much of a fight against ordinary knife-edge weigh-bridges, and even now, the electronic variety has to rely largely on a headstart from its read-out and data-processing advantages.

If it is possible to make a general statement in such a situation, it can be said that modern, solid-state electronics has improved on processes in use a few years ago by virtue of its incredible speed, reliability, low power consumption, small size and, in most cases, improved accuracy.

Reliability

On the subject of reliability, many early users of electronics in an industrial environment would quite probably emit a concerted, hollow laugh, the hollowness depending to some extent on the amount it cost them to be in the fashion. It must be admitted, with a brave smile and a stiff upper lip, that some of the early gear was a shade ethereal for the clobbering that your average shop-floor salt of the earth can mete out.

It is not the slightest bit of good building equipment which works in the lab., as long as the zero pot. can be tweaked before anyone wants to use it, or which, when the meter hammers the end stop, only needs a new BC108. But it was some time before engineers came to realize that the industrial scene is a hostile one, and that the "belt and braces" approach is essential, and by then, the early users had had their fingers burnt and weren't going to be the first next time. All that said, however, it has to be pointed out that electronic equipment has now become respectable and can often be a good deal tougher than the older devices it replaces.

The life expectancy of electronic equipment, disregarding replacement for reasons of improvement, is usually much longer than its mechanical equivalent, simply because there is nothing to "wear out". In the case of equipment using thermionic devices, periodic replacement keeps the equipment up to scratch, and of course, solid-state instrumentation requires no maintenance whatever, Ambient atmosphere conditions is one area where badly designed electronics can, on occasion, let the side down.

Equipment which employs analogue circuitry is particularly prone to drifts caused by temperature variations unless great care is taken to overcome them. At extremes of temperature, both analogue and digital circuitry begins to flag, but at these extremes (−50°C, +70°C) even mechanical equipment can be difficult.

Humidity is probably a greater enemy to delicate mechanics than to electronics, although most electronic devices contain a degree of mechanical construction in the form of switches, plugs, and sockets and the like, which are also vulnerable to humidity.

Vibration is not the threat it once was; the use of electronics in missile and aviation applications taught engineers how to avoid its effects, and the relative vulnerabilities are now about even, depending on the application. In addition, the emergence of integrated circuitry has improved matters beyond recognition in this respect, as in all aspects of reliability.

Applications

An example of one of the categories of equipment, namely the performing of work not possible before the adoption of electronic techniques, is radio telemetry. The same could be said of most of the "action at a distance" systems employing radio, but the methods of transducing and modulation are especially worthy of note.

Telemetry was introduced largely to aid the designers of guided weaponry, and is capable of the transmission to a ground station of data on virtually any aspect of missile performance and structural behaviour. Mechanical-to-electrical transducers of many types modulate a f.m. subcarrier which amplitude modulates a v.h.f. carrier. Time-division multiplexing allows a large number of information channels to be used, the individual channel sampling rate being at least 120Hz. This was one typical system in brief outline, and we will return to the subject in a later article.

In the area of improvement on traditional machinery, the numerically controlled machine tool, used properly, is an industrial engine of awesome capabilities. These machines come in all varieties from the simplest drilling machine to a contour milling machine capable of machining an aircraft wing entirely without human intervention, apart from the little job of programming the machine to start with! If one considers the cost of a mistake by the equivalent human being towards the end of machining a wing from a lump of titanium, one begins to see the point. Not all numerically controlled machines are on this scale, of course, but the sophistication of these processes is finding its way into lower and lower levels of industry and is returning very well worthwhile results in lowering costs and improving outputs.

Instances of electronics lending assistance to human operators are legion, and one can think of inspection equipment, non-destructive testing gear, process controllers, recorders, weighing equipment, and others. Even farms are well used to the occasional black box lurking in anonymous obscurity, and battery chicken-houses would be difficult indeed to run properly without their automatic electronic ventilation systems. Then again, the difficulty of assessing the amount of fat on a pig's back, without assaulting the luckless beast with a sharp instrument, is alleviated by a device which does this without even causing the pig to breathe heavily.

Most of the industrial applications need, at some stage, a mechanical-to-electrical transducer, or vice versa, or both. Indeed, in some equipment, it is the transducer which is the clever bit, the rest of the device consisting prosaically of amplifiers, displays, power units, and the like. For example, numerically controlled machine tools use an extremely precise mechanical-to-electrical transducer to determine the position of the tool or work piece. Some of them use diffraction gratings which produce interference fringes as the moving parts of the machine-tool move, these being detected photo-electrically and passed to the electronics. The manufacture of these gratings and the detection and processing of the fringes is a story in itself, while the electronic part of the machine is more-or-less standard digital computer practice.

Another example of the importance of the transducer is the electronic weighing machine. The transducer here is the strain-gauge load cell, which relies basically on the fact that the resistance of a piece of metal depends on its length and thickness (and on its resistivity, but that is relatively constant). If the piece of metal is fixed to a metal billet, which bears the weight of the object being weighed, it will deform when the billet deforms, so changing its resistance. The minute change is measured and processed and is displayed as weight by a selection of amplifiers, displays, comparators, etc., in themselves not particularly noteworthy.

In each article of this series, it is the intention to take each time a particular type of industrial electronic equipment, to discuss the transducers and circuitry peculiar to the device, and to illustrate the discussion with examples. It is not intended to go deeply into design, but to exemplify the possibilities of electronics in industry to engineers or students who are forced to specialize in other types of work, and who may be surprised to learn that electronics is becoming respectable in industry.

Books Received

Engineering Electromagnetics by David T. Thomas has been prepared for undergraduate electrical engineering students. In contrast to the traditional presentation of physical laws in the chronological order of their discovery, Maxwell's equations are adopted in the beginning as the fundamental laws. The use of Maxwell's equation provides a basis of general applicability. Real life problems are presented and then reduced to an appropriate model or facsimile which is solved by the laws of electromagnetics. Emphasis is placed on understanding fundamental physical laws and boundary conditions. Topics of interest include: computer solutions in electromagnetics, transmission lines including wave transients, boundary value problems and properties of materials. Other areas covered are radiation and aerials, a brief history of electromagnetics and a reference chapter on vectors and co-ordinates. Pp.453. Price £8.50. Pergamon Press Ltd, Headington Hill Hall, Oxford OX3 0BW.

Broadcasting technology — past, present and future is a publication from the Institution of Electrical Engineers and is a record of the lectures delivered to the IEE commemorating the recent fiftieth anniversary of the commencement of broadcasting. The lecture topics range from the B.B.C. in the 1980s and the future of broadcasting from an engineer's point of view to a survey of the British domestic receiver starting in 1922. Other topics cover the development of the television camera tube, transmitter output-valve developments above and below 30MHz, television and sound signal orientation, studio-transmitter links and terrestrial, satellite and cable broadcasting systems. This valuable record is well illustrated with photographs and relevant diagrams and circuits. Pp.104. Price £5. The Institution of Electrical Engineers, P.O. Box 8, Southgate House, Stevenage, Herts. SG1 1HQ.

Making and using Electronic Oscillators, by W. Oliver, provides typical examples of the most popular and useful oscillator circuits for a wide variety of applications. The theoretical working principles are discussed as briefly as possible so that maximum space can be devoted to the practical aspects of the subject. Ready-made as well as home-built equipment is covered and sources of supply are suggested. Some valve circuits are included but the accent is on transistors and allied semiconductor devices. The circuit diagrams are intended mainly to illustrate the typical basic features of the various circuits discussed and are not necessarily meant to be used as designs for practical interpretation. Chapter headings include classification, crystal, variable and audio oscillators, oscillators in receivers, test equipment and electronic musical instruments, components for oscillators, troubleshooting and finally sources of supply and information. Pp.120. Price £2.00. W. Foulsham & Co. Ltd., Yeovil Road, Slough, SL1 4JH.

Colour TV Servicing Manual Vol. 1, by Gordon J. King, provides a study of the circuits of nine basic colour television chassis and covers the normal operation of the sets with a view to enabling the engineer and the student to understand the working of the complex circuitry. while a certain amount of theory is present, the emphasis is on normal operation, so that it will be readily apparent when a circuit is not functioning correctly. Each chapter concludes with detailed servicing notes, the accent being on the colour sections of receivers in terms of alignment, adjustments, fault symptoms and corrections. The book is illustrated with circuit diagrams, chassis layouts and normal oscilloscope traces. The sets covered include a selection of models marketed under the Bang & Olufsen, Bush, Decca, Dynatron, Ekco, Ferguson, GEC, HMV, Invicta, ITT/KB, Marconiphone, Masteradio, Murphy, Pye, Sobell and Ultra brand names. Also studied is the decoder principle used in the Sony KV-1320UB. Pp.232. Price £4.90. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

Electrical Who's Who 1972/1973, compiled by *Electrical Review*, contains many new names in this revised edition. The directory contains an index to the personnel of companies, boards and associations compiled from lists supplied by the organizations themselves. Firms, electrical contractors and technical colleges are grouped under separate headings. Pp. 440. Price £3.75 (by post £4). IPC Electrical-Electronic Year Books Ltd, Dorset House, Stamford Street, London SE1 9LU.

1973 RCA Solid State Data Books is a series of six volumes providing data on all RCA's solid-state components with application notes in many cases. Data on new devices introduced in 1972 has been added to this current series with many data sheets revised and updated. Eighteen new application notes have also been added. The subjects covered by the six volumes are: linear i.cs and m.o.s. devices (2 volumes), power transistors and power hybrid circuits, c.o.s./m.o.s. digital i.cs, r.f. power devices and finally thyristors, rectifiers and diacs. Price £5.40 (6 vols.). RCA Ltd. Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex TW16 7HW.

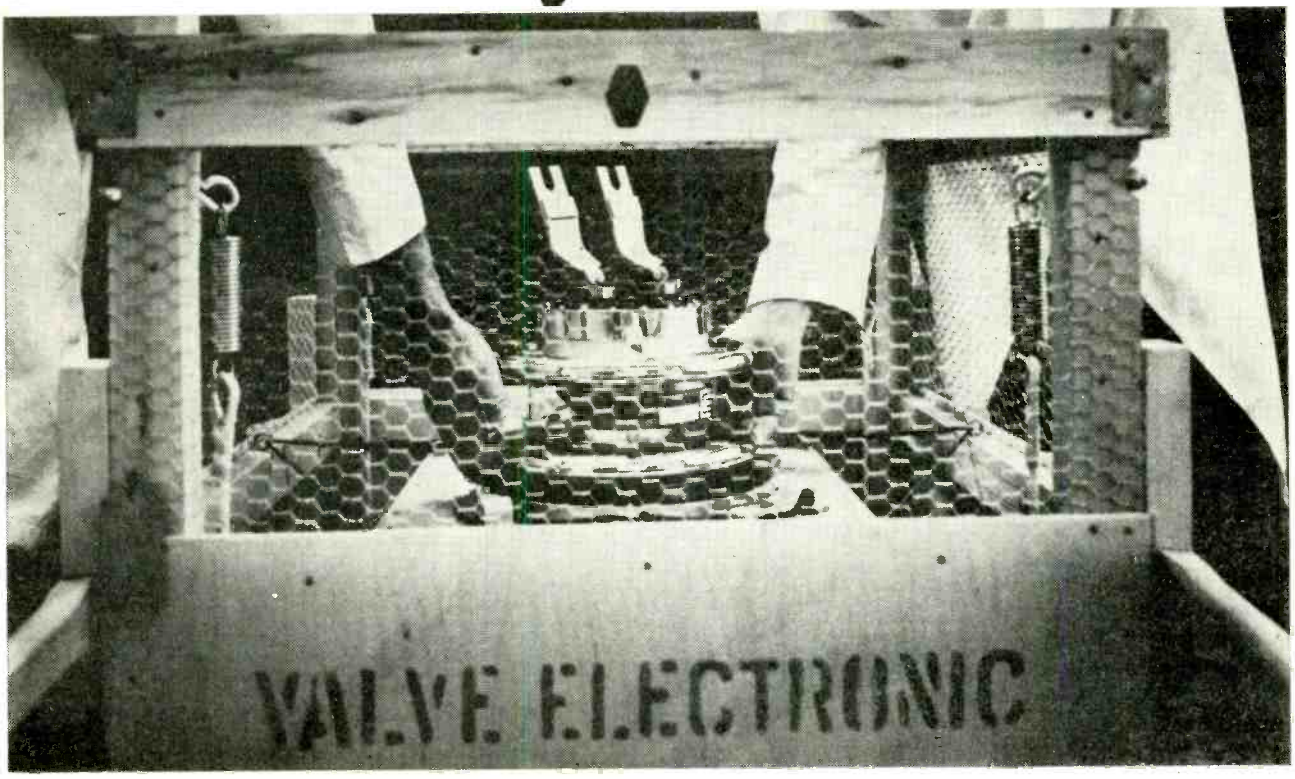
Educational film-strips

Mullard's latest additions to their educational 35mm film-strips are six colour tutorials, all available in either single- or double-frame film-strip or double-frame slides. Briefly, they are: The transistor (ref: E144) which deals with the operational aspects of these devices and includes illustrations of alloy-junction, diffused and planar constructions. Magnetism, part 1 (ref: E145) which discusses the physical effects of magnetic fields, including the Hall effect, and part 2 (ref: E146) describing interaction effects such as moving-coil instrumentation, B and H relationships, and consideration is given to differentiating between diamagnetism, paramagnetism and ferromagnetism. Semiconductor photocells (ref: E147) classifies optoelectronic devices and explains the action of light quanta on atomic structure. Photo sensitive diode and transistor theory and applications are considered and a brief mention of photo f.e.ts and thyristors is included. Conduction in solids (ref: E148) is the fifth topic which demonstrates the dependence of electrical conductivity on material lattice structures. Some of the factors governing electron mobility, work function and material contact potentials are also covered. Conduction in gases (ref: E149) in which the mechanism of gas conduction is explained, deals with molecular motion, ionization, work function, electron and ion collision and finally illustrates glow and arc discharges at high and low pressure.

Prices are between £2.00 and £2.50 for single-frame film-strip, £2.25 and £2.75 for double frame film-strip and £2.75 and £3.25 for double-frame slides. The price includes a teacher's booklet. Further information can be obtained from The Slide Centre Ltd, Portman House, 17 Brodrick Road, London SW17 7DZ.

EEV POWER TUBES: TETRODES & TRIODES

Why you should replace one of theirs by one of ours!



There are at least three reasons for this.

First, this is an EEV tube and EEV is one of the biggest tube makers in the world. When you replace with EEV, you know you are getting a tube that you can depend on.

Second, EEV tubes are very competitively priced.

Third, you'll find you get more than a good tube from EEV. Our service is quick, efficient, informed. We go to endless trouble to keep our customers out of trouble.

Ask any EEV customer, or try us for yourself. Write for details, or if you have a specific problem 'phone us at Chelmsford and ask for extension 428.

Ours	Theirs	Anode dissipation max. (kW)	Output power (kW)	Anode voltage max. (kW)	Frequency (MHz)	Filament ratings (V)	(A)
4CX1000A 4CX1000K	4CX1000A 4CX1000K	1.0	3.2	3.0	110	6.0	9.0
4CX1500B	4CX1500B	1.5	2.7	3.0	30	6.0	9.0
4CX5000A	4CX5000A CV8295	5.0	16	7.5	30/110	7.5	75
4CX10, 000D	4CX10, 000D CV6184	10	16	7.5	30/110	7.5	75
4CX15, 000A	4CX15, 000A	15	36.5	10	110	6.3	160
4CX35, 000C	4CX35, 000C CV11107	35	82	20	30	10	300
BR1161	CV9343 RS726	35	100	14	10/30	11	155

Ours	Theirs	Anode dissipation max. (kW)	Output power (kW)	Anode voltage max. (kW)	Frequency (MHz)	Filament ratings (V)	(A)
CY1172	RS2002V	150	220	15	30	21	350
BW1184	YD1202	80	120	14.4	30	12.2	255
BW1185	YD1212	120	240	16.8	30	12.6	380
BY1161	RS826	60	120	14	10/30	11	155

EEV know how.

LAP 44

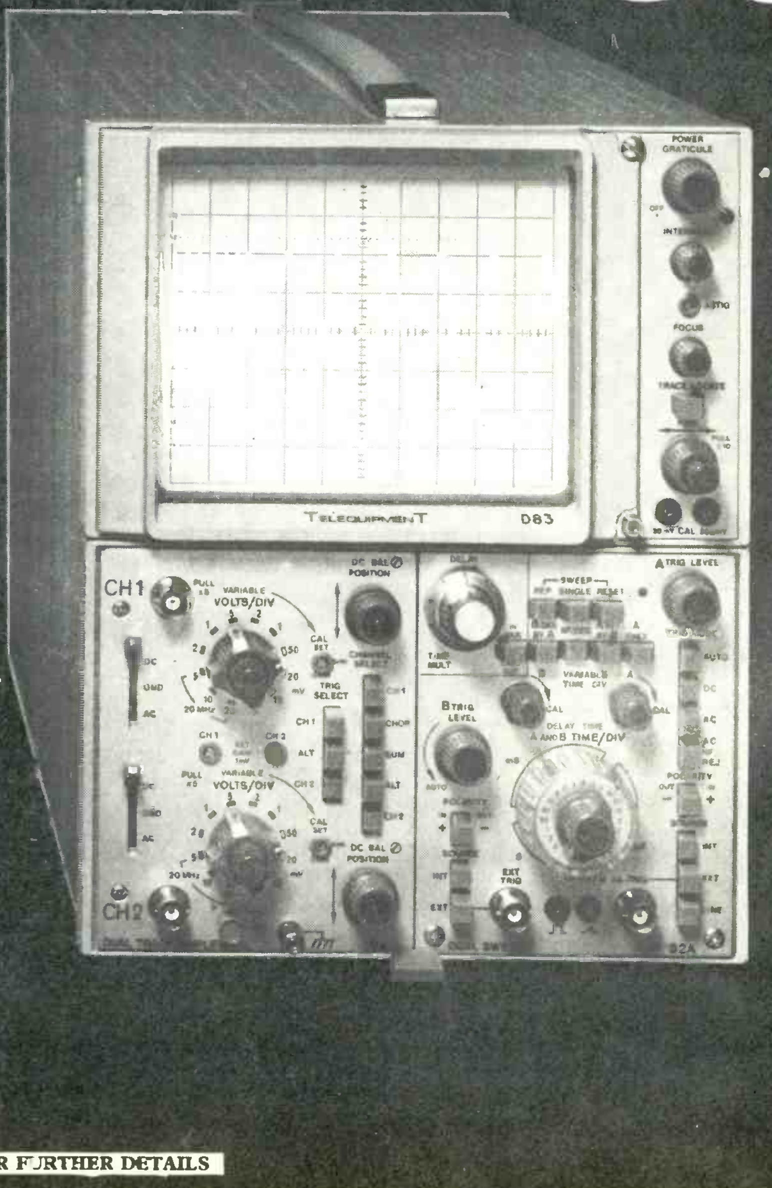
ENGLISH ELECTRIC VALVE CO LTD, Chelmsford, Essex, England, CM1 2QU Tel: 0245 61777 Telex: 99103 Grams: Enelectico Chelmsford
A member of THE GEC ELECTRONIC TUBE CO LTD, a management company which unites the activities of English Electric Valve Co Ltd and The M-O Valve Co Ltd

WW—078 FOR FURTHER DETAILS

a new 50MHz oscilloscope

Telequipment's D83
is not just another 50MHz scope.
It's a brilliant combination
of performance and plug-in versatility

at the incomparable price of £450



Look what you get –

A 6½ in CRT operating at 15kV which provides brighter traces and 50% more viewing area than 8 x 10cm CRT's.

Dual trace operation in alternate and chopped modes with 5mV/div sensitivity all the way up to 50MHz.

Choice of a High Gain Differential Amplifier operating down to 50μV/div sensitivity.

Easier and faster measurements of complex waveforms with the MIXED SWEEP feature built into the DELAYED SWEEP TIME BASE. Think of the advantages of two selectable sweep speeds on a single trace.

Stability of a high order due to the adoption of the latest solid-state circuit technology, ensuring trouble-free operation over long periods.

These are only some of the advantages offered by the D83 – find out the rest by sending for full details now.

TELEQUIPMENT

TEKTRONIX UK LTD.,
Beaverton House, P.O. Box 69, Harpenden, Herts.
Telephone: 61251 Telex: 25559.

WW—079 FOR FURTHER DETAILS

The Semiconductor Story

3: Solid circuits — a new concept

by K. J. Dean, M.Sc., Ph.D. and G. White†, M.Phil., B.Sc.*

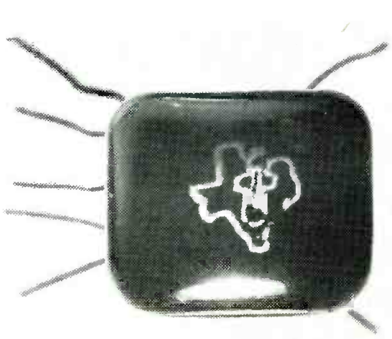
The development of the transistor, described last month in part 2 of this series, had been a strange mixture of chance and directed scientific research, of skill with difficult processes and of commercial brinksmanship in which some went too near the abyss and never recovered or withdrew from competing. However, there were occasions when someone intimately involved in the struggle was able to look beyond the immediate technical difficulties and point to an idea not then matched by technological skill, but for which the technology would one day be available. Remarkably enough there are two instances of this happening in the same year, 1952, only four years after the discovery of the transistor effect by Bardeen and Brattain. In both cases the prophesies, for that is what they were, came true in the years to come. W. Shockley, writing in the *Proceedings* of the American Institute of Radio Engineers (now the I.E.E.E.) laid down the theory of the field effect transistor, fourteen years before it was to become a commercial proposition. G. W. A. Dummer of the Royal Radar Establishment (now at Malvern) speaking at a transistor conference in Washington pointed out that semiconductors could be used to make resistors, capacitors, diodes and transistors so that the possibility of putting a number of all these elements on a single piece of semiconductor existed — in fact that it was possible to make an integrated circuit. It was however to be seven years or so before this idea reached any sort of fruition and about sixteen years before these two, the integrated circuit and the field effect device, came together as a complex commercial product.

Of course the germanium technology of 1952 was quite inadequate to put Dummer's idea into practice and it was five years before the Plessey Company, who were by then more interested in precise photo-chemical processes, were given a contract in association with the R.R.E. to investigate the possibility of a solid circuit. In 1957 an international symposium on electronic components was held in Malvern at which, reported *Wireless World* in November, the solid circuit was little more than an idea to be discussed in the same breath as ferrite blocks and resin-potted circuits. But there was one point which was significant — the solid circuits being proposed in 1957 were silicon, not germanium.

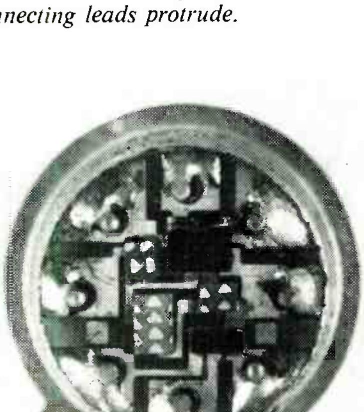
*South East London Technical College
†Twickenham College of Technology

Technology available

By this time a number of other companies both in the U.S.A. and in Europe were interested in solid circuits, amongst them Texas Instruments (in Bedford as well as in the U.S.A.) and Fairchild. Not only were silicon transistors available but the mesa process had also been recently developed, largely by Texas Instruments. Now this process has the important advantage of requiring diffusion from only one face of the silicon slice. Hence it was thought possible to place various active and passive components side by side on a single slice and then inter-connect them. In 1958 this is what Texas were able to show they could do. As was the case with transistors where increasing skill with technology and governmental patronage produced a variety of transistor types, changes in solid state techniques had a vital impact on the development of integrated circuits. The key technology was the development by Fairchild of the planar process, so that even by 1960 it was clear that planar devices would most easily lend themselves to interconnection as solid circuits. In fact it can be argued that two of the major efforts since that time have been to minimize the profile contours of silicon chips and reduce the size of transistors within the chip. These have been brought about using modifications of the planar process.



Early Texas mesa integrated circuit showing the vitreous enamel package, from the underside of which the connecting leads protrude.



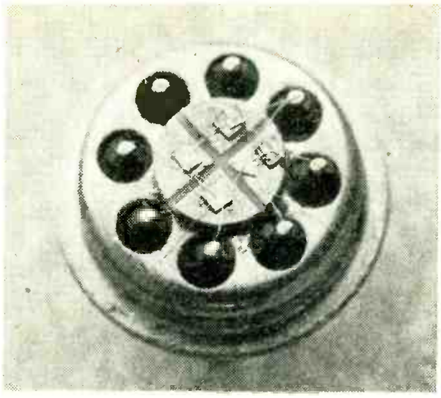
Multi-chip integrated circuit by S.T.C. mounted in a TO5 header on a printed circuit board on which the interconnection pattern has been etched. The circuit, sold in 1964, is that of a d.t.l. gate.

The patronage which proved decisive and turned, alas once more, a British idea into a foreign product, came from the U.S. Government. The Minuteman project was at the end of the '50s the American contribution to the U.S./U.S.S.R. arms race and represented the ultimate then possible in electronic sophistication. It was funds from this project, principally to Fairchild but also to Texas which provided the immediate incentive to devise high component-density circuits of great reliability for use in the limited space and very difficult environment of a missile. Thus the early integrated circuits were born. Although by this time a technology to make a form of integrated circuit was available on a laboratory basis, it had a number of limitations, both of cost and as a production method. Failure to produce a reliable isolation technique meant that multi-chip circuits were the best that many companies could do. One chip might carry a single transistor, another might have a resistive network and a third might consist of diodes. The chips were at first mounted on a suitable sub-divided printed circuit board or a ceramic button which was in turn mounted on a TO5 header. Another area of difficulty lay in the interconnections. Contact pads were provided on the silicon chips by depositing an aluminium pattern. This metal had low resistance and was found to give good adhesion to the surface of both p-type and n-type silicon. The interconnection leads were gold wire. A reaction may take place between these two metals at the fairly high temperatures used in bonding. This results in high resistance purple or black coloured compounds known as purple plague and black death respectively. These are intermetallic compounds which arise in the presence of silicon. Whilst purple plague for example could and did exist with discrete devices, it was with early integrated circuits, particularly multi-chip circuits, that it became widely known. For instance some of the i.cs used in Minuteman missiles had a gold/aluminium interconnection system and so suffered from purple plague.

The development of integrated circuit technology was almost rocket-like with the U.S. Government support it attracted. The 1962 Minuteman II project might be regarded as the second stage of the rocket. In this project Texas had a contract to supply 300,000 i.cs thus setting the scene for later large scale production. At this time the U.K. Government was abandoning its independent nuclear deterrent; for example, the Black Knight programme was cancelled. There was therefore relatively little incentive in Britain to develop British i.cs for the world-wide defence market which undoubtedly existed. The state of the art here can be seen in a report from S.T.C., "Report on commercial valve developments — solid state circuit techniques" which showed separate resistors, capacitors, transistors and diodes on a single chip wire bonded to give an r.c.t.l. gate and stated that the first circuits were made in March 1962. Similar gates had been available in limited quantities in the U.S.A. for at least 12 months before that and in 1962 the first commercial planar circuits were already being advertised in British journals by Fairchild. These were r.t.l. (resistor-transistor logic) gates and were capable of operation at 1MHz. The chips were typically 1mm square — one hundredth of the surface area of the $\frac{3}{8}$in square chips proposed by Dummer ten years earlier.

Why logic gates as i.cs?

The first integrated circuits were almost exclusively logic circuits. This was because the electronic control of missiles was very largely of a digital nature and because it was much easier to design switching circuits which had only two states of operation than it was to produce linear amplifiers. Silicon technology made it possible to design circuits in which the tolerance was relatively tight between components in a circuit but it was unable at that time to yield circuits in which the absolute tolerance of any one component could be kept small. This suited the design of switching circuits.



Multi-chip low noise cascode amplifier for use at frequencies up to 100MHz produced by Marconi Microelectronics in 1965. The chips are mounted on a ceramic button fixed to the header, and are wire bonded; the button has been divided into four "lands".

One of the transistors from a low noise 100MHz cascode amplifier. The transistor was made by an early form of planar process and the chip size is 0.46mm square.

Perhaps stage 3 of the "i.c. rocket" was fired when it was realized that the limited market of defence requirements could be replaced by the much larger market of the growing computer industry which also used logic circuits and already had very definite views about their modular nature. Thus from the start the need for switching circuits rather than linear amplifiers was paramount. Integrated circuits were therefore gold doped and this method of obtaining a speed advantage was almost always followed until the advent of Shottky diodes in about 1970. By the end of 1963 work in the U.K. was catching up and a report on a C.V.D. project by C. P. Sandbank describes the manufacture of circuits which include isolation lands, just as are used in the epitaxial circuits we have to-day, with buried layers to eliminate parasitic p-n-p transistors, and of course with gold doping. These circuits were a form of transistor-capacitor logic with 35ns propagation delay through each gate. This at least was an improvement.

Industrial pressures

The effect of all this was a scramble for a place in the market, and a highly competitive market it turned out to be. Fairchild linked up in Europe with the Italian company, S.G.S., later to separate again. Elliott set up a production line at Boreham Wood and Marconi at Witham near Chelmsford and at Glenrothes in Scotland. These companies later merged with G.E.C. who had been in semiconductors from the start, and with A.E.I. who had already withdrawn from making small junction transistors. Eventually the manufacturing plants at Glenrothes and Witham were closed although not until near the end of the sixties. Meanwhile Plessey's semiconductor plant was turned over almost exclusively to i.c. manufacture at the expense of transistors. What brought about these traumatic changes?

In 1960 integrated circuits cost £20 per package and were available for military purposes only. Ten years later they had fallen to one per cent of their original cost and were incorporated in a wide range of industrial equipment and were even making a substantial impression on the traditionally cost-conscious domestic market. To understand how this came about one must know something of the factors which influenced industrial growth and falling price. Circuit development costs are substantial when only a small number of devices is required. It was commonly stated in the middle sixties that the price of the design work for a set of masks to diffuse an integrated circuit was £10,000, but frequently all this cost had been covered by defence contracts and it did not recur so long as the same device was manufactured for the industrial market. Labour costs are high when production lines have to be staffed with costly graduates, but as the technology becomes better understood less skilled labour is employed, so that eventually plants were set up in low labour cost areas such as Taiwan, Hong Kong, New Guinea and Portugal — often referred to as "off-shore" plants. Due to the small size of i.cs air transport charges are very small and slices could be diffused centrally under excellent supervision and good environmental conditions and then flown to an off-shore plant for encapsulation and testing.

The cost of the material used in making an i.c. is directly related to the yield of good devices which can be obtained.

The resistivity of slice material affects the tolerance of components from one chip to another. It is now possible to hold this to less than 15% instead of 25% formerly from the centre to the edge of the slice. The number of dislocations in the material was typically 30,000 per sq. cm. It is now only 500 per sq. cm.

Circuit designers soon realized that active elements took up less space than the passive elements which they could replace. The space occupied by a 1kΩ resistor was at least equal to that taken up by four transistors and in some cases more. If a large value resistor could be eliminated or its resistance drastically reduced by using a few transistors this could well result in a smaller surface area for the circuit. Hence a new circuit design philosophy developed in which active elements were to be preferred to passive ones and resistors were restricted to values between about 30Ω and 1kΩ.

The first commercial integrated circuits which were monolithic, i.e. on a single chip, were produced using one inch silicon slices. To-day 2in slices are typical. So not only did percentage yields rise, but device sizes became less and four times the number of devices were provided on each processed slice. The high percentage yields and the greater throughput per slice meant that the manufacturing plants which had been set up with U.S. Government money were in an extremely strong position to compete not only with the U.S. manufacturers but with manufacturers in Europe, in Japan and even in the U.S.S.R. In the Soviet Union the effect of the large American output was to concentrate effort on thick film and hybrid circuits, for silicon circuits could always be imported, for example, through Austria and Hungary. Thus, by 1970 there was only the barest token U.S.S.R. export market for integrated circuits and then only in specialized circuits with only a very small market potential.

High speed circuits

As the computer industry became more and more the main customer for integrated circuits, so "he who pays the piper" began to call the tune. Computer manufacturers wanted two things: reliable high speed circuits and the availability of the same package from a number of sources. The i.c. suppliers felt bound to comply and so with "second sourcing" available a new twist was given to competition and price cutting.

In late 1963 the American Motorola company started to make emitter-coupled logic gates. A typical dual two-input NOR gate in an eight-lead TO5 can consisted of a single 1mm square chip. These Motorola e.c.l. gates had propagation times which were less than 5ns, but they were potentially even faster and by 1971 types called MECL3 with less than 1ns delays were amongst the fastest circuits on the market. One of the problems of the Motorola e.c.l. which delayed acceptance of these gates was that the switching potentials were less than 1V apart and neither of them was at the potential of either supply line. This necessitated the use of special reference voltage i.cs in addition to the gates of which a system might be composed.

In 1965 both S.T.C. and Marconi made agreements to second source Fairchild diode-transistor logic and Plessey started to make i.cs at Swindon on a production line basis — a year later they were producing 300,000 circuits per annum. Though Plessey had started in r.t.l. they were now second sourcing the Motorola MECL series. Well separated logic levels and under 20ns propagation time were provided by d.t.l. gates. Their competition in 1965 was from r.t.l., the natural successor of modular circuits such as Norbit and Minilog. They had been developed early and their design costs amortized, hence they were cheaper then than other i.cs. But r.t.l. gates were not fast enough for the computer manufacturers, so production quantities fell and prices no longer fell. Principally developed by Texas, t.t.l. soon took over with under 10ns propagation time and in due course were second sourced also, by Mullard, Siemens, and (in 1968) by I.T.T. (formerly S.T.C.).

Dual-in-line packages

The first Texas mesa solid circuits were encapsulated in vitreous enamel and subsequent circuits used standard transistor packages, principally TO5, whilst military buyers insisted on more expensive flat-packs. However, these became less acceptable as more complex circuits were devised which required more connecting leads. Hence dual-in-line plastic and other hermetic packages were progressively introduced from 1966 until eventually this type of package became exclusively accepted for industrial and commercial applications and for many military purposes also. In fact, once adopted, it has been used for a number of other non-semiconductor electronic components.

Linear circuits

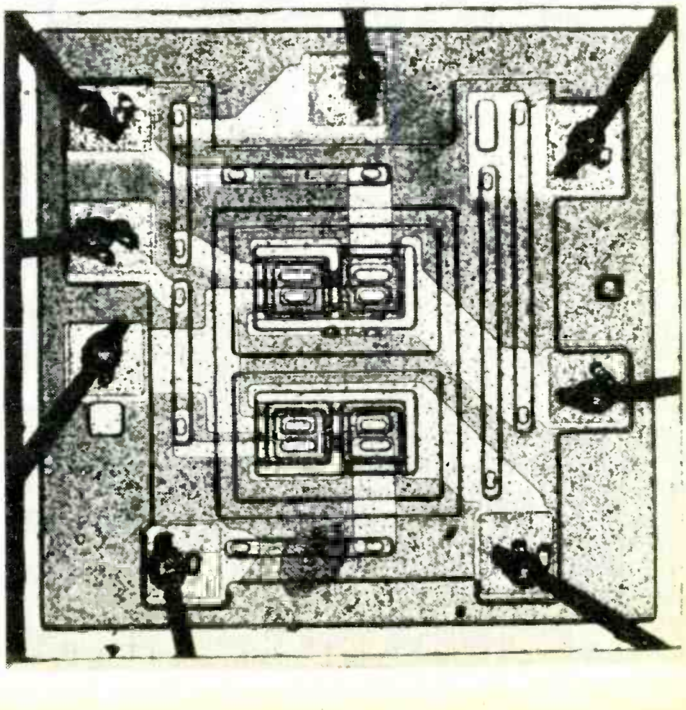
As familiarity with the technology grew it was certain that at some stage linear circuits would be tackled by leading manufacturers. In the U.S.A. Fairchild introduced the 700 series of operational amplifiers and in the U.K. Plessey was working along similar lines. One of their SL500 series, for example, designed in 1967, had a current gain of 26dB at 30MHz with a response from 5MHz to 100MHz. The amplifier circuit elements consisted of three transistors, a diode, seven resistors and three capacitors on a single chip 1.5mm square. The advantages of excluding capacitors, which were wasteful of surface area, were quickly realized. Gain and frequency response were then controlled by external reactive shunts and by internal feedback. Thus one amplifier circuit could be used for a wide range of applications with consequent sales benefit to the manufacturer. For example, the Fairchild μA730 was a differential amplifier which consisted of seven resistors and five transistors whilst the μA709 high gain amplifier which used external feedback to control gain consisted of 15 resistors and 15 transistors. Neither of these circuits included areas specifically devoted to capacitance. Of course, capacitance is always present, limiting frequency response.

By 1968 a number of manufacturers were experimenting with special purpose i.cs hoping to break into new markets, such as radio, television, automobile electronics and the "white goods" trade (fridges, washing machines, etc.). One company produced a car radio chip — basically a superhet with reflex i.f. and a.f. amplifiers though they found a market for it very difficult to obtain, and in 1969 Plessey had a single chip colour demodulator for Rank-Bush-Murphy colour television receivers.

A goal is reached

It was in 1968 when those two great ideas, mentioned earlier, of the solid circuit and the field effect transistor came together, and none too happy a union it was at first. Field effect transistors had been in production since about 1963, first with junction gates and later with metal oxide insulating gates. However their reputation for reliability was very poor.

Small silicon area, fewer diffusions than for bipolar transistors, high input resistance and a high fan-in when used as switches are all properties of m.o.s. devices. They depend however on surface effects and so are liable to surface con-

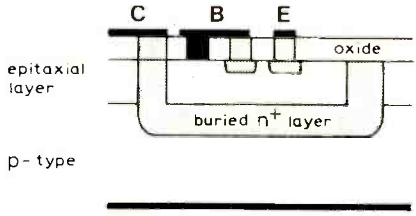


Motorola MC910. A 1mm square chip containing four transistors and six resistors. Designed in late 1963, this is an r.t.l. dual two-input NOR gate which has a 40ns turn-off time. The four input resistors are 1.5kΩ each.

tamination, and in some cases suffer from poor surface stability. Catastrophic failures were not at all uncommon due not only to contamination but to electrostatic pick-up. Also silicon dioxide decomposes in the presence of aluminium resulting in pin-holes in the insulation layer which are fatal to the device. Contamination is particularly likely when an m.o.s. circuit is encapsulated in plastic, such as the dual-in-line packages then becoming popular. The solution to this problem was found to be to use not only an oxide layer but also a nitride layer to give passivation of the surface since silicon nitride is not affected in the same way by aluminium as is silicon dioxide. These m.n.o.s. gates were introduced by a number of companies, among them Ferranti. A few months later Plessey set up a production line for m.o.s. circuits at Swindon and by 1972 30% of their output of 1.2 million chips per annum consisted of m.o.s. circuits.

Finding their feet

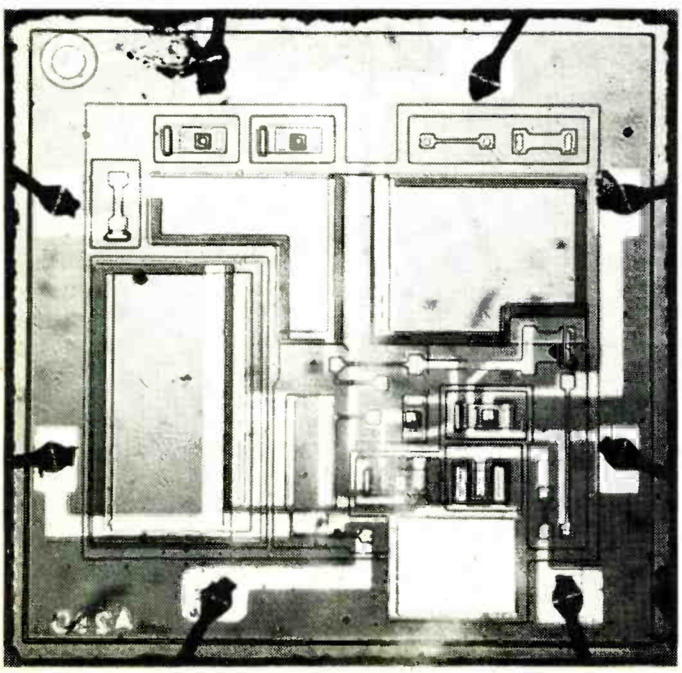
Soaring yields, even with integrated circuits, due to familiarity with processing technology, and the lure of even larger bipolar and m.o.s. circuits all enticed manufacturers to do better and build bigger, while growing competition and the dramatic failure of some and ever falling prices were never far from their thoughts. Of course chips have got bigger. A typical maximum chip size in production now is 4mm square with the occasional 6mm square "special" but m.o.s. has been something of a disappointment with the larger chip sizes. There has been steady progress towards m.s.i. (medium scale integration) and l.s.i. (large scale integration) except for agreement on exactly where a function on a chip becomes large enough to warrant the term m.s.i. or even l.s.i. (more about this in part 4). However, there have been some interesting ideas floated by engineers



Collector diffusion isolation (c.d.i.) process involves diffusion of an n^+ layer into a p-type silicon slice. Subsequent growth of a p-type epitaxial over the now buried n^+ layer is used to hold emitter diffusion and collector diffusions which link up with the buried layer. This results in the isolation of each transistor so formed.

about methods for making larger circuits without yields becoming vanishingly small and it may be that among them are those who have had a glimpse of what the future really holds.

As long ago as 1966 the theory was being proposed that circuit yield depended on the density of the interconnection pattern of the aluminium on the surface of the chip. It was claimed that devices on the chip could be made smaller and the separation between devices less so that the limiting factor in the technology was the resolution of the aluminium pattern. Hence ways were sought to reduce the number of conductors on the chip. Some diffused layers were conveniently available as underpasses, but generally an underpass takes up more space than the corresponding conductor on the surface. It was suggested that a number of interconnection layers would reduce the density of conductors in any one layer so much that yields would rise. But more layers mean more masks and yield is proportional to the power of the number of masks, so yields fell when this was attempted. Some, like Fairchild, had a special slant on this problem: the chip consisted of say, 32 gates, and the first layer of metallization connected the circuit elements on the chip into gates. The customer was then asked to design the pattern which interconnected the gates to form the functions he wanted. The idea foundered, both due to the low yields which meant that prices were high, and because customers did not see why they should do part of the i.c. manufacturer's work for him. It is interesting that those manufacturers who either do not use two-layer metallization or who have tried and failed point to the contour of the silicon surface as the core of the problem. Although one might imagine the planar surface to be flat its profile is far from this with windows in the oxide layer making contact with the various diffusions and aluminium contacts as well.



British-designed linear amplifier chip which shows the area of surface taken up by capacitors, compared with the much smaller areas taken up by transistors and resistors. The circuit is that of a capacitor-coupled r.f. amplifier.

Beam leads and flip chips

High on the list of advantages of solid state devices is reliability. It has long been recognized that the weakest link in transistor technology is the bonding of the chips to the posts on the header, or directly to a printed circuit board or other components. Two alternatives to wire bonding are available. Flip chips have thickened bonding pads so that the device can be bonded face to face by contact between these pads and another surface. Although some work has been done with flip chip i.cs, automatic assembly of chips is seldom used so that it is chiefly with discrete transistors that they have been used. The main exception is the I.B.M. solid logic modules where flip chips have been used in assembling random access memories.

Beam leads are produced by multiple deposition, usually of platinum and gold to extend the conductors beyond the edge of the chip, so that when the silicon is etched away from the edges of the chip, the beam leads protude. Beam leads have been found more appropriate for i.cs, the circuits being separated either by a lap and etch technique or by air abrasion. Beam lead technology is of some significance in the U.S. but once again there have been no significant contracts in the U.K.

What next?

An early Texas project had been called "A computer on a chip". At the time it seemed this was just American "talk" but l.s.i. has now turned this into a potential reality. Part 4 of this series will look at the development of l.s.i. and make some sober guesses about the future. Some cynics might wonder whether there is a future, for the last five years have certainly brought over-production and shown the perils of being tied to a pace-making industry like computing. But the faint-hearted don't work in semiconductors. If the cost of a small domestic car like the Vauxhall Viva had fallen as dramatically as that of integrated circuits over the last ten years, its cost today would be comparable to that of a secondhand bicycle.

to be concluded

Experiments with Operational Amplifiers

8. Comparators — simple types and regenerative comparators with hysteresis

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

When an operational amplifier is used without feedback a small input signal causes the amplifier output to switch between its saturation limits. There is a range of applications for this switching characteristic, one of which is the comparator.

A comparator is basically a device which compares two signals and indicates which of the two is the larger. There is a variety of ways in which a differential input operational amplifier can be used to perform the comparator function.

A simple experimental circuit for demonstrating comparator action is shown in Fig. 8.1. Input and reference signals can be interchanged in order to obtain an output transition of reverse polarity.

A second comparator circuit in which the output transition occurs when the sum of two voltages reaches a defined level is given in Fig. 8.2. The action of the circuits can be investigated by applying measured d.c. input signals, with a d.c. voltmeter connected to the amplifier output to indicate the state of the comparator. Alternatively, a low frequency sinusoid can be used as an input signal and the comparator transfer curve can be displayed by an oscilloscope.

Regenerative comparators

When the input signal to a simple comparator varies very slowly the comparator switching time becomes dependent upon the rate of change of the input signal. In such circumstances comparator switching time can be reduced to a limiting value set by amplifier slewing rate by applying positive feedback. Comparators which employ positive feedback are called regenerative comparators. A regenerative comparator has a transfer curve which exhibits hysteresis. An experimental circuit for investigating the action of such a comparator is shown in Fig. 8.3.

Typical transfer curves which illustrate the action of the circuit are shown by the oscillograms in Fig. 8.4. In the lower trace a value for R_2 of 47kΩ was used, resulting in a greater amount of hysteresis. The upper and lower transition level values for the input signal are determined by the relationships

$$e_{i\,upper} = V_{+ve\ limit} \cdot \frac{R_1}{R_1+R_2}$$

$$e_{i\,lower} = V_{-ve\ limit} \cdot \frac{R_1}{R_1+R_2}$$

The effect of applying a reference voltage (other than zero) to point B should be observed, also the effect of interchanging input and reference signals.

Note that the 1741CG op-amp used in the experiments is quite suitable for demonstrating comparator action but an amplifier type with a faster slewing rate should be used for practical comparator applications which require a rapid transition.

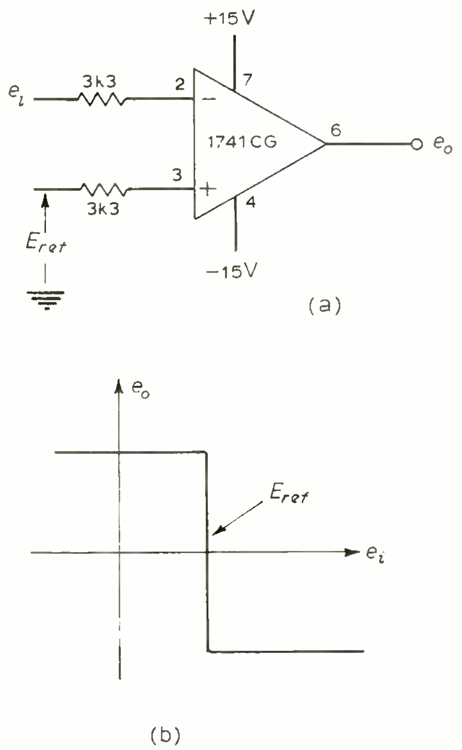


Fig. 8.1. (a) Simple comparator; (b) comparator transfer curve.

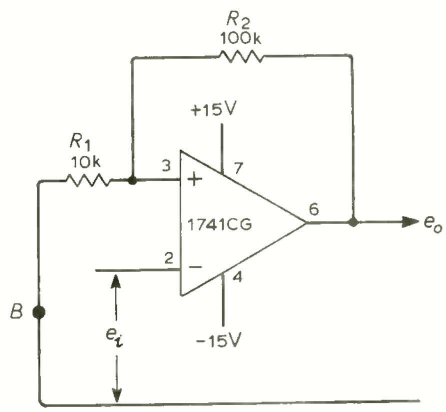


Fig. 8.3. Regenerative comparator.

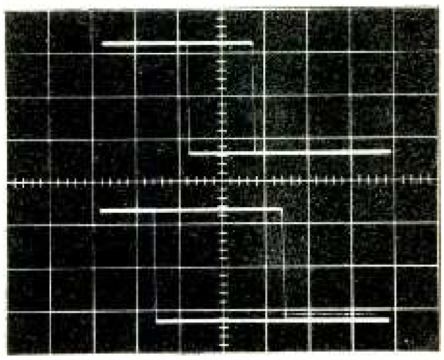
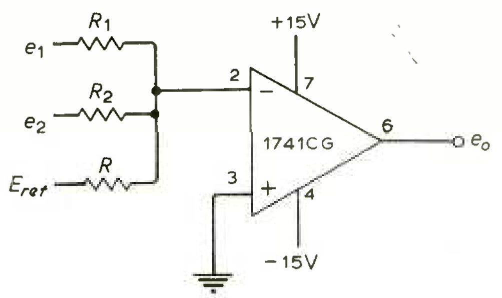


Fig. 8.4. Two transfer curves, showing hysteresis, obtained with the regenerative comparator in Fig. 8.3. Horizontal scale (2V/div.) is input voltage, and vertical scale (10V/div.) is output voltage. For the lower trace a value of 47kΩ was used for R_2.



Output transition when

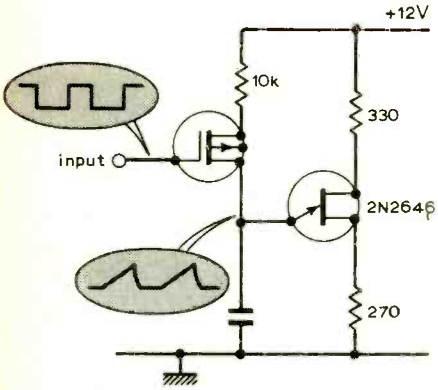
$$\frac{e_1}{R_1} + \frac{e_2}{R_2} + \frac{E_{ref}}{R} = 0$$

Fig. 8.2. Circuit comparing the sum of two input voltages with a defined level.

Circuit Ideas

Triggered ramp generator

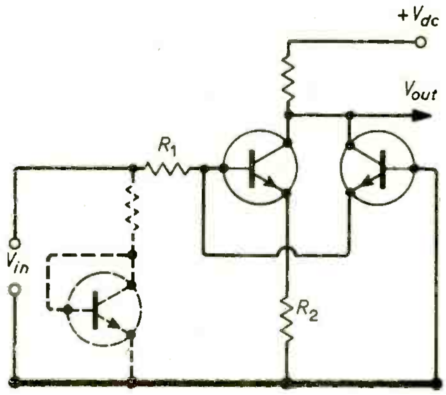
A simple triggered linear ramp generator can be made with a p-channel enhancement m.o.s.f.e.t. and a unijunction transistor. When the m.o.s.f.e.t. is turned off by a positive pulse to the gate the capacitor is unable to charge and is kept discharged by the unijunction leakage. A negative pulse to the f.e.t. gate turns it on and the capacitor charges linearly through the f.e.t. acting as a constant-current source. A triggered sweep for an



oscilloscope can be made easily with the addition of a bistable circuit which is switched into one state by the triggering signal and switched back again by a pulse from base 1 or 2 of the unijunction transistor. For a linear sweep the bistable switch must give a sharp pulse to switch on the f.e.t. quickly. I used a surplus unmarked m.o.s.f.e.t. but I imagine any type would be suitable.
S. P. Jarman,
University of Sussex.

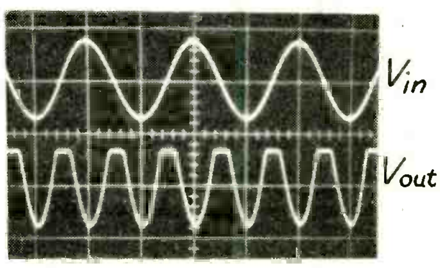
Simple frequency doubler with unbalanced input

Known aperiodic frequency-doubler circuits require a push-pull balanced input, or have internal push-pull circuit arrangements. The circuit shown in the next column is a simpler solution to the problem, and gives excellent doubling action, as shown in the photograph, provided $R_1 = R_2$. Input voltage was 2.5V



pk-pk. If the source of V_{in} has appreciable internal resistance, R_1 should be reduced accordingly.

The input impedance of the circuit is higher when V_{in} goes positive than when it goes negative, and this leads to unsymmetrical operation if V_{in} is supplied via a coupling capacitor. This trouble may be cured by adding a "transdiode" and resistor as shown in broken-line, the resistor value being the same as that of R_1 and R_2. (An ordinary silicon diode may be used, but gives a less perfectly symmetrical input impedance.) With this modification, the internal resistance of the V_{in} source is no longer critical.

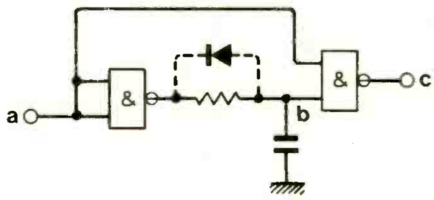


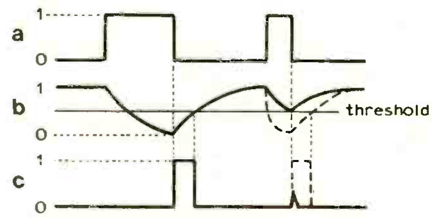
Resistors R_1 or R_2 may, of course, be made adjustable, and set for total elimination of fundamental-frequency output, though this will not usually be necessary. The gains of the circuit to positive and negative inputs are well controlled by negative-feedback action.

If the collector load resistor is replaced by a tuned circuit of only moderate Q-value, say 10, a clean double-frequency sinewave output may be obtained.
Peter J. Baxandall
Malvern
Worcs.

T.T.L. monostable maintains pulse width

Addition of a single diode allows a monostable circuit to be used with much shorter input pulses. Introduction of an *RC* delay is a useful means of producing short pulses at the leading and trailing edges of an input pulse (e.g. H.A. Cole, *WW* January 1972 pp. 31-2.) The delay introduced by *RC* limits the minimum usable input pulse width; for an input pulse of duration around *RC* the width of the output pulse is reduced. Addition of the diode restores the pulse width, as shown dashed.

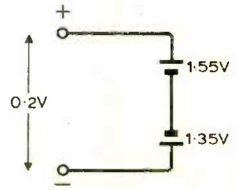




The general principle of using an *RC* delay in this way is acceptable only if adequate rise and fall times are maintained. For ordinary t.t.l. a rate of change of voltage at the logic threshold equivalent to a rise or fall time of more than about a microsecond may give rise to spurious oscillation.
J. V. Yelland,
Didcot,
Berks.

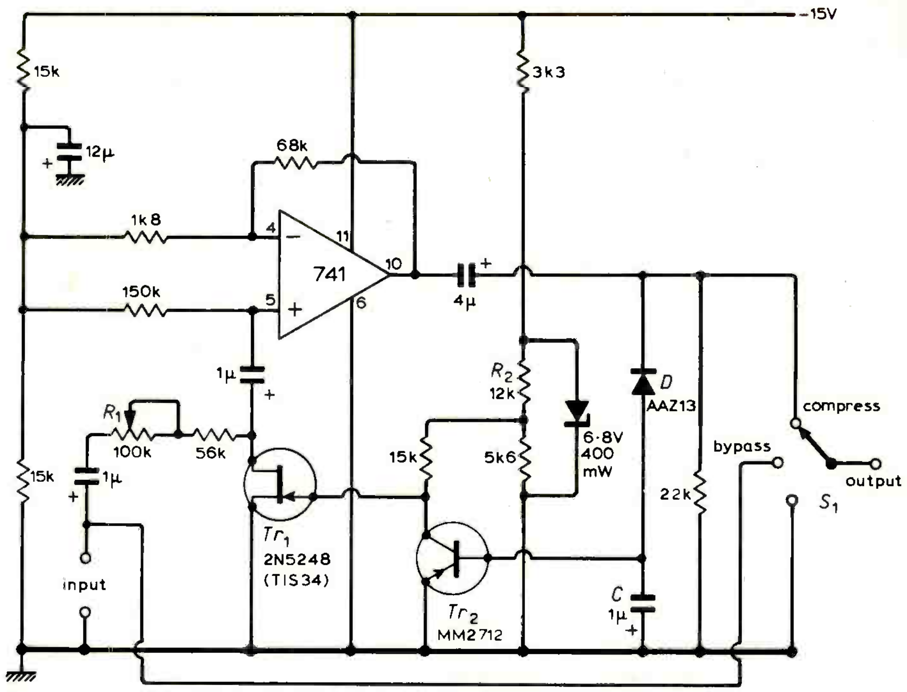
Low-voltage source

To provide a portable source of multiples of approximately 0.2V, for example for tunnel diode circuits, without use of a power-wasting voltage divider, this circuit



is offered, using a Lechlanché cell and a mercury cell. The 1.35V mercury cell should offer shelf life or better, as the circuit current demand value is a *charging* current for the mercury cell.
David R. Schaller,
Milwaukee,
Wisconsin.

Audio dynamic range compressor



This circuit was designed for use with tape recorders to reduce distortion occurring during transients and unforeseen crescendos, and to allow a higher average recording level, hence improving signal-to-noise ratios. It also gives interesting effects if fed excess signals, especially with pop music, as the recovery time of the a.g.c. mechanism appears as a modulation of the signal. It uses a readily available operational amplifier to provide a high input impedance and a well-defined gain. The low output impedance is used to drive the envelope detector *D* and its associated reservoir capacitor, *C*, thus giving fast reaction to spikes. The recovery time depends on *C*, (I have found 40-50ms reasonable) and its minimum value must be comparable with the period of the lowest frequency encountered. The voltage at Tr_2 collector should be between −2V and −2.3V, and is fairly critical as it defines the working point of the f.e.t. The sensitivity control R_1 adjusts the point at which limiting commences. If a stereo version is attempted, it is wise to equalize the operation of the two channels by adjustment of the collector voltage via R_2, as R_1 is a fine control.

Gain of the circuit is around unity at low levels, reducing as the input signal approaches 350mV. The output voltage remains a fairly constant 400mV for input signals in the range 450mV to 4V. There may be some room for adjustment in the circuit values, but I have found that a higher value of gain in the op-amp stage slightly improves limiting, but reduces the upper limit at which the limiting action ceases. Reducing the gain just causes the amplitude to "hunt" in response to large input signals. Consumption of a stereo version is around 6mA.

P. Hanson,
University of Kent.

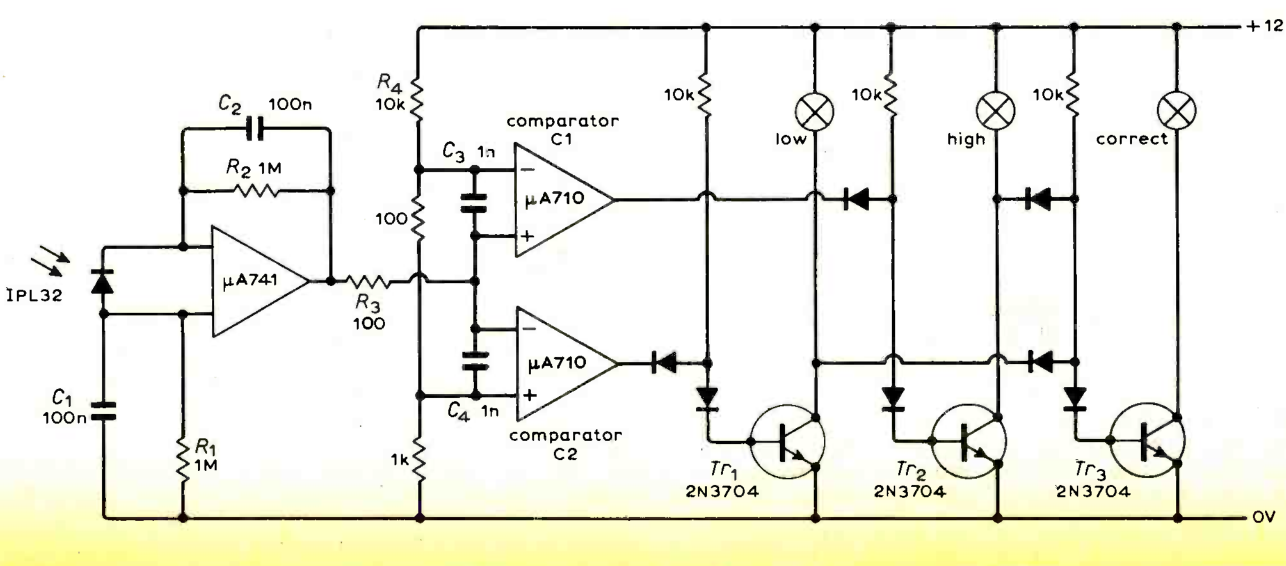
Light level indicator

When making optical experiments, testing or calibrating photocells, it may be necessary to set a known light level each time before the experiment is performed. The following circuit provides a simple way of setting a light level to a particular value. A silicon planar photodiode, generates a photo-current proportional to the incident illumination, which is fed to the input of an op-amp connected as a current amplifier. The output is thus the equivalent photo-current developed across a 2-M resistor. Two comparators are used to compare the output voltage with a fixed reference set by a potential divider chain. Comparator 2 is set at nominally 1V and comparator 1 at 1.1V. The amplifier output is fed via R_3 to the non-inverting input of comparator 1 and the inverting input of comparator 2. When the output is below 1V, the output of comparator 2 is positive, which enables the current in R_5 to turn on Tr_2, lighting the "low" lamp. When the output of the amplifier is above 1.1V the output of comparator 1 will be positive, enabling Tr_2 to turn on and lighting the "high" lamp. If the amplifier output is between the two thresholds, both comparator outputs will be low and both lamps off, and the green "correct" lamp lights.

Changing the values of R_1 and R_2 alters the basic sensitivity of the system. Capacitors C_1 and C_2 provide decoupling of noise pick-up for remote detection or small content of a.c. lighting. Components R_3, C_3 and C_4 minimize instability in the comparators as they pass through their linear region.

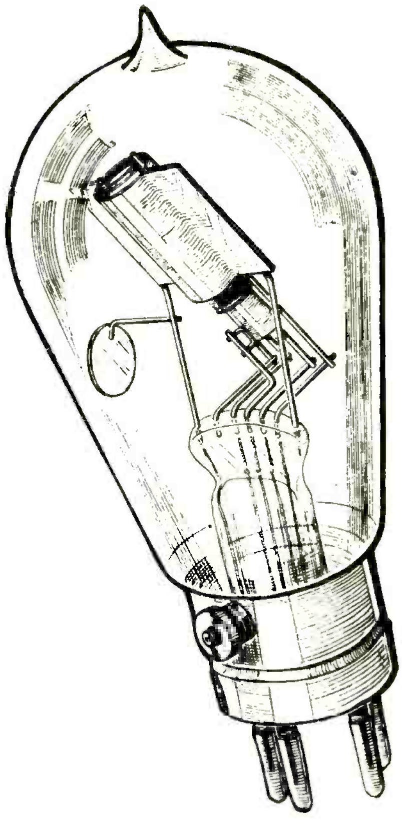
Values in the diagram shown give an acceptance band of 10%. Reducing the value of R_4 to 50 Ω reduces the pass band to 5%. For closer bands, higher gain comparators may be used (e.g. μ A734).

David C. Porter,
Poole,
Dorset.



The Evolution of the A.C. Mains Radio Valve

by J. H. Ludlow, A.C.G.I., M.I.E.E.



The advent in the late 1920s of the first receiving valves which could be satisfactorily fed from an a.c. supply is rightly regarded as an important phase of thermionic history. Nevertheless in these days of compact and easily carried radio receivers of good performance for which a mains lead would be an unwelcome restriction, the advantages of such a facility may not be at all clear. Through this brief account of the mains valve's evolution and development, it may be possible to see which, if any, of the more important inventions may be said to have contributed the essential element which brought success to the design eventually adopted by all the main valve manufacturers, and which is still in use in the fast dwindling production of today.

Bright emitters

It is generally accepted that the radio valve first established itself as an important element in communications during the first world war: the extreme pressures of military urgency created an extensive technology which could never have grown up in the restrictive circle of pre-war "wireless". When peace came, not only were there many thousands of Allied ex-servicemen who had personal experience of what radio could do, but additionally there were tens of thousands of "war-surplus" valves, mainly of the Army "R" type, available for experimentation. Out of the resulting body of amateur radio enthusiasts there grew up the beginnings of broadcasting, first in America and then in Europe, and this was destined to become the next force to promote and direct valve development. However, whereas war had left a legacy of valves and equipment suited to its aims of reliable message-sending with portable apparatus in the field of battle, broadcasting required radiotelephony to be adapted to the social and commercial functions of providing a maximum of entertainment and edification for its public with a minimum of expense and inconvenience to them.

The plentiful supply of valves which had helped to launch broadcasting could not satisfy the demand for very long—the life expectancy of the "R" valve was 100 hours only—and it was replenished promptly enough by the wartime makers, who were happy to promote this new market. Even so, a typical receiver of the time was a modest matter of one or two valves feeding a pair of headphones, and requiring an outside aerial of considerable size. Each "R"-type filament needed a supply of 0.7A from a 4V accumulator, so that a pair took a continuous power of nearly six watts from this and the bulky high-tension battery, in order to give a signal of a few milliwatts. The fact that the valves were bright enough to illuminate a signal-pad was poor compensation—even in an era of gas-light and candles—for the constant drudgery and expense of taking the battery to be charged, often at the local cycle-shop, and for the periodic replacement of the high-tension unit.

Dull emission

As long as "listening-in" involved wearing headphones, most of those within a few miles of a broadcasting transmitter understandably preferred the cheaper and simpler, though sometimes tantalizing, crystal receiver. The poor performance of the "bright" tungsten filament was highlighted by demands for multivalve sets to give greater range, and for power valves to drive the new loudspeakers which made family listening so much more comfortable. The first response to this pressure for improved efficiency was the thoriated-tungsten filament, which was developed from an effect which had been observed in certain "R" type valves some years before. These "dull-emitters" became generally available in 1922–23, and reduced the capacity of the necessary accumulator to about one quarter of that previously needed. A year or so later the oxide-coated filament, derived from Wehnelt's discovery of 1902, still further reduced demands on the low-tension battery, and domestic receivers using four or more valves and a loudspeaker became practicable.

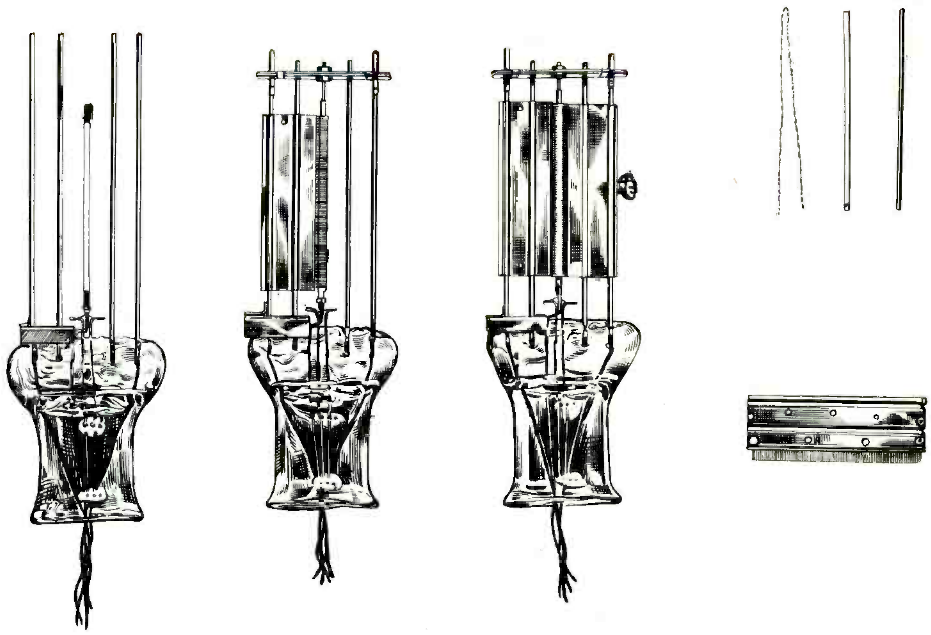
Filaments on a.c.

In the meantime a disquieting fact had become apparent to manufacturers and users alike. Centrally generated electric supplies were bringing the convenience of lighting by incandescent filament lamps to more and more homes, and yet the occupants had to put up with wireless sets which had all the inconveniences of a battery-fed reading lamp. Clearly, means had to be devised whereby the power needed by the receiver was derived from the supply mains. Designers found little difficulty in replacing the h.t. battery with a rectifier unit and smoothing filter, and it is perhaps significant that when they were marketed they were universally called "battery-eliminators", indicating the freedom from toil they would confer on the purchaser. But the elimination of the even more irksome l.t. accumulator was much less simple. Heating the filament of any of the available valves with raw a.c. from a suitable transformer resulted in an entirely unacceptable modulation of the output signal, mainly because a part of the heating voltage appeared at the input, and because the temperature and hence the emission of the fine wire varied at twice the supply frequency.

One of the earliest attempts to overcome this problem was made in 1922 by the French Mazda Company, who marketed a special form of "R" valve for this application. This was their Type "RS", Radio-Secteur (mains-radio) valve, and its filament was designed to minimize the effects of the a.c. heating voltage by making it low, and those of temperature variation by using a thick wire. This consumed 2.0A at 2.3V, and with the aid of a rectifier with a similar filament made an early type of mains receiver practicable. It should be remembered that the output of such a set would have been fed into headphones with a poor low-frequency response, and that in those days the signal would be judged by its intelligibility rather than its realistic quality. The production of these valves presumably ceased with that of the "R" type on which they were based.

Using d.c. mains

The incentive to find a satisfactory solution increased with the growth of broadcasting and the contemporaneous spread of domestic electric lighting. But it was to be some years before the first acceptable examples of mains-fed valves appeared, and in the meantime equipment was marketed which would heat the filaments of available types of battery valves from the electric supply. In some districts in England this was direct current, and battery-eliminators took the form of well-ventilated boxes of wire resistors which provided both high and low tension current for the new low-consumption (0.060A) filament valves. This basically simple arrangement presented the designer with a number of difficulties resulting from the direct connection of the radio circuits to the supply, the characteristics of which varied from place to place. One trouble was the ingress of mains-borne "noise" which was very difficult to eliminate on some systems. Another was hazard from electric shock, which was increased by the general use of separate direct-connected loudspeakers. Again, in addition to the radio noise already mentioned, d.c. mains frequently carried pronounced ripples at frequencies in the mid-audio range: these were well reproduced by the moving-iron speakers of the period, and were difficult to remove from the filament supply as high-value capacitors for low voltages were not yet on the market.



Details of the electrode assembly of a "Micromesh" a.c. valve: left to right, the cathode, the grid and its cooling fin, the complete assembly: the heater, cathode and magnesia insulator (above), and finally the construction of the grid. (Reproduced from Wireless World *5th Aug. 1932.)*

Need for a separate heater

Manufacturers were more interested in the a.c. mains, since they were scheduled to supplant the d.c. systems in due course. Many of the above difficulties could be avoided by the use of a transformer in an h.t. eliminator. Moreover, it was found that the heavier filament of an output valve could be heated with raw a.c. by using a centre-tapped transformer winding, but heating the filaments of the earlier-stage valves remained an intractable problem. One of the earliest a.c. receivers, marketed in 1926, fed battery-type filaments in series from the smoothed output of an h.t. unit; but the scheme did not survive the introduction of satisfactory a.c. valves, for reasons which will become apparent later.

It had been realized several years before that the short, thick filament of the type pioneered by the French Mazda Company could only lessen the effects of a.c. heating: it could never eliminate them altogether. The heating voltage could only be reduced usefully to the point at which the magnetic field due to the necessarily increased current contributed equally to the noise in the output from the valve. What was required was a cathode which carried none of the heating current, but which was maintained at temperature by an electrically independent heater.

Ceramic insulators for heaters

One of the first designs for an indirectly-heated receiving valve cathode to be developed commercially was patented in 1923 by Freeman and Wade of the Westinghouse Company of America. They describe how the anode current of a valve with a.c. heating its filament is subject to alternating variations due to the electric and magnetic fields so set up, and to the fluctuating filament temperature, and propose to avoid these effects by providing a tubular equipotential cathode, within which is mounted a slim cylinder of refractory ceramic with two longitudinal perforations through which is threaded a hairpin-shaped heating filament. The magnetic field of this filament is preferably made small by arranging the perforations close together. The inventors claimed that valves made with cathodes of this type are free from the faults mentioned, and they also found that they gave a better performance than previous valves.

One of the valuable features of this development was that it showed for the first time that the presence of ceramic insulation held at high temperature did not affect the thermionic performance of small receiving valves made in quantity. During the next few years several designs of cathode were evolved which used such ceramic parts in one way or another, including the function of supporting coiled heaters for high voltages. Although the new technology led to the production of several types of a.c. valve in both the U.S.A. and Germany, a number of troubles prevented the realization of unqualified success. One of these was an undesirably long warm-up time of over a minute; more important was a high incidence of early failure, caused in some cases by the development of emission from the control-grid, by heater failure due to thermochemical action with the ceramic, or by the deterioration of insulation between other electrodes.

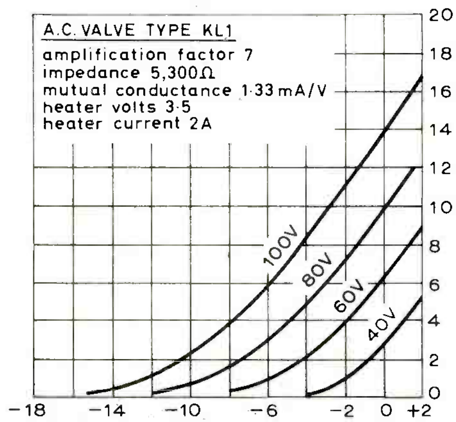
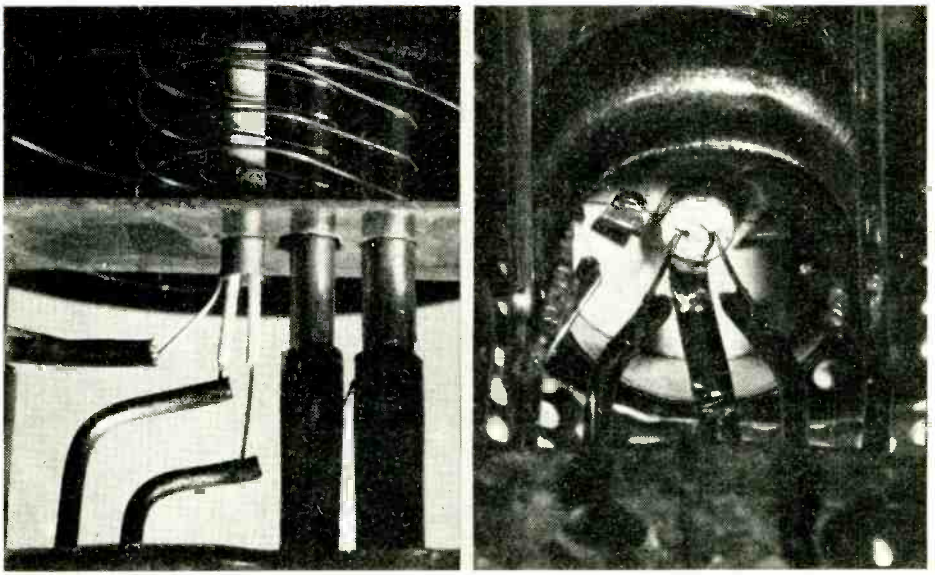


*Fig. 1. "The grid volts anode current characteristics show the K.L.1 to be a good general purpose valve or with 100 volts on the plate it is suitable as a moderate power amplifier." (*Wireless World *26th Jan. 1927.)*

The slow heating may well have been accepted as a small price to pay for the convenience of mains operation, and indeed was quoted as evidence that the bugbear of temperature variation had been thoroughly eradicated. Short life, however, was unacceptable, and a great deal of effort was made to identify and eliminate the causes. Grid emission was caused by the evaporation of oxide from the unprecedentedly large cathode surface on to the surrounding control grid, the temperature of which was raised to emitting level by the considerable radiation from it. Means were sought to inhibit this unwanted activation, which rendered the valve useless in service, but a Western Electric method indicates some of the difficulties. They had demonstrated that a thin layer of oxidation on the nickel of the grid would prevent the development of this unwanted emission at any temperature. But their patent does not claim primarily the use of such a layer, but covers a triode in which the anode is made of decarbonised metal. They had found that if carbon was not removed from the anode metal, it combined during exhaust with water vapour and oxygen remaining in the bulb, to form carbon monoxide, and this later reduced the pre-oxidized grid surface to a clean condition which activated readily under a deposit of cathode coating, and so ended the useful life of the valve.

Problems connected with the ceramic tubes proved to be more intractable. The first ones to be used by American valve-makers were of porcelaineous material, and these proved to be insufficiently refractory to stand the temperature of the heater, which failed through chemical attack. A change was made to magnesia, a material also used in Germany, but this led to insulation troubles in other parts of the valve: the magnesia was reduced by the hot tungsten and the resulting magnesium metal vaporized and condensed on cooler parts of the assembly, producing conducting films between parts normally insulated from each other. There was evidence that alumina would provide the required stability, but fine tubes of that material could not be made commercially at that time.

By the middle of 1926 the position was sufficiently unresolved for two British firms to initiate their own proposals for indirectly-heated cathodes, and in both cases ceramic components were eliminated. On 25th June, C. W. Stopford of the M-O.V. Company patented a novel design which stemmed from H. J. Round's idea of 1914, in that it used no insulation between the heater and the cathode tube. The specification describes a helically coiled hairpin heater which is supported by its centre-point on an axial silica-insulated rod, within an enclosing thimble-shaped cathode tube. This assembly is mounted with suitable grid and anode on the usual "pinch" seal, but with the electrode axis at about 45°, so as to reduce the heat which would otherwise radiate on the supporting glass. A heater voltage as high as 100V is mentioned.



These two photographs show clearly the difference between the slip-coated filament (left) of a Mazda type AC/Pen and the ceramic insulated filament (right) of the DeForest Audion type 451. The valves are examples from the Fowler Collection recently acquired by the North-Western Museum of Science and Industry. (Photographs by courtesy of British Science Museum.)

Marconi K.L.1

Seven months later, in January 1927, a valve of this type, the "K.L.1" (Fig. 1), was described in *Wireless World* as having been newly added to the Osram and Marconi ranges. Figures quoted from the journal's own tests show that the 3.5V heater brought the cathode to emitting temperature in about 15 seconds, that the amplification factor was 7, and that the average anode impedance was 5300Ω. The article refers to the American version of the indirectly-heated cathode as not having "attained a wide popularity", and concludes that: "In the hands of the amateur the utility of this valve will probably develop, and it is a great advance towards the production of receiving sets working entirely off the mains". Whilst the verdict was only cautiously favourable, it must be remembered that the valve was developed and brought to production at a time when several designs employing ceramic tube insulation were being tried out commercially. The new design might well have pointed the way to a successful solution, in spite of its high heater power (7W) and its somewhat unstable characteristics.

Slip-coated heaters

The second British design for an a.c. cathode was disclosed in a patent which was lodged on 7th July 1926, twelve days after the Stopford-M-O.V. application, by E. Y. Robinson of Metrovick. He based his invention for the improvement of ceramic insulated heaters, not on the use of insulation of better quality which could withstand the high temperature of the heater, but on a simplified construction which reduced it, and so avoided the snags which beset previous arrangements. The patent was an important one in the series with which he introduced his novel and efficient "Cosmos" short-path valves into a somewhat conservative market, beginning in 1925. He had already shown that close-spaced electrodes could be made and held with precision, and that compact grids and anodes could be kept cool. These techniques opened the way to an a.c. valve with exceptionally good characteristics without resorting to a unipotential cathode of large area, and hence high wattage.

To suit his design of electrodes, a cathode tube of a millimetre or less in outside diameter and about 40mm long was needed. Also, if means could be provided whereby a heater of suitable wattage could be insulated and inserted in such a tube, the temperature of the former would be beneficially lowered, since it depended on the ratio of the heater surface to that of the cathode: the higher the ratio, the cooler the heater.

The manufacture of such ceramic tubes of small cross-section was at that time commercially impracticable, and the essence of Robinson's invention was to omit such components altogether. Instead, the heater was first coated, by any convenient method, with a paint or sludge made up from an insulating substance mixed with a vehicle. This layer was then baked on the heater, and the process repeated until the insulation was sufficiently thick, after which the insulated assembly was inserted in the cathode tube. This process is for convenience referred to throughout as "slip-coating" and includes any process in which a heater is covered with a suitable paint or paste subsequently baked in situ, as distinct from enclosure in preformed insulating components. With this process the diameter of the tube could be made very small, and the specification states that a tungsten heater of 0.1mm diameter wire in the form of a hairpin could be so insulated and mounted in a tube 40mm in length and 2.0mm in periphery (0.64mm in diameter). The cathode structure so formed had been found to give a long life at an input of 1.0A at 4.0V. These values were adopted as the standard rating for Cosmos a.c. valves, and it is pertinent to record that one of these completed a life of over 200,000 hours between the years 1935 and 1961.

Cosmos a.c. valves

Metrovick introduced the first valves with cathodes of this pattern, as types AC/R and AC/G, in the autumn of 1927, at about the same time as the M-O.V. Company added their high-frequency amplifier type K.H.1 to the low-frequency type K.L.1 already mentioned. Thus appeared the first two British designs for a.c. valves, each of which differed in concept from the other and from those being tried out abroad. Of the two, the initial advantage seemed to lie with the Cosmos types. Their heater consumption was 4W against the 7W of the "K" type, and they gave an amplification of about twice that of the latter. The good performance of both valves, which was many times better than most current battery types, must have been welcome to British set designers, dedicated as they were to a maximum gain from every stage, to offset the effect of the Marconi royalty, which was calculated on the number of valves in a receiver. The Cosmos valves in particular were commended by several writers for their high efficiency.

Apart from the electrode differences between the Marconi-Osram and the Cosmos a.c. valves, the styles of their base connections were dissimilar. The "K" type base was a standard 4-pin, in which the heater connections were taken to the normal filament pins, and the extra lead required for the cathode was taken to a terminal on the side of the base. On the other hand the Cosmos valves were given a special base in which one of the standard filament pins served for the cathode, and the other was replaced by a pair of short pins for the heater supply. These, of course, required special sockets (which Cosmos marketed) in new sets. But there were in Britain a very large number of battery receivers, and plenty of enthusiasts, both amateur and professional, ready to convert to mains operation sets in houses enjoying electric light. With an eye on this market, Cosmos produced a cheap adaptor in the form of a thin disc, through which a valve could be plugged into an existing standard valve-holder, and this connected the heater pins with a flex lead which emerged from its side. With this provision they could also interest the many British zealots whose pride, sometimes doubtless born of necessity, was in their ability to "get America on one valve", as distinct from their opposite numbers in the U.S. who were more likely to rate an amateur listener's prestige by the number of "tubes" his receiver used.

1928: Trials in Europe and the U.S.

Throughout the world of broadcasting, public demand for reliable mains-fed receivers had become acute, and manufacturers were forced to take urgent steps to provide suitable valves before a satisfactory design for an a.c. cathode had been proved. Not surprisingly, the methods they adopted showed very little unanimity.

We have noted that German designers had been following the American technique of insulating heaters with ceramic tubes. But in 1928 they had decided to explore an alternative approach: this was a revival of the short, thick filament such as had been used in the French "Radio-secteur" valve of 1922, except, of course, that the new one had an oxide coating. A report on the Berlin Radio Show of 1928 finds ". . . well represented both the older indirectly-heated type and the new low-voltage type in which the emitting surface is heated directly". Screen-grid valves, which in battery form had brought about a transformation in high-frequency amplification in receivers the previous year, were available with either sort of cathode.

Valve makers in England also appreciated the importance of developing an a.c. type screen-grid valve. It had been remarked in the autumn of 1927 that whereas high-frequency amplification had previously been the prerogative of the few who could handle the neutralized triode, the screen-grid valve had made it available to all. Even highly efficient triodes like the K.H.1 and the AC/G would be immediately supplanted by an a.c. version for this service.

Accordingly the M-O.V. Company, whilst continuing the "K" type valves for their 1928-29 season, also introduced a series of valves with thick, low-voltage filaments for direct a.c. heating, as had been done in Germany, and this included a screen-grid type. They consumed 0.8A at 0.8V, and were accordingly called the "Point 8" range. A tetrode version of the "K" type was probably too complex to be commercially successful, and did not appear. The K.L.1, however, had an important part to play: as in Germany, customers were warned against using a "Point 8" triode as a detector, as it was almost impossible to avoid an unacceptable hum in its output in this position. An indirectly-heated type was recommended for this duty. As a result, receivers such as the G.E.C. "All-Electric Three" used a mixture of valve-types: a K.L.1 as detector, an HL Point 8 as l.f. amplifier, and a P625A as a directly-heated super-power output valve. Later on, an effort to regularize matters was made by the introduction of a special "D Point 8" for detection. This had an even heavier filament, taking 1.6A at 0.8V.

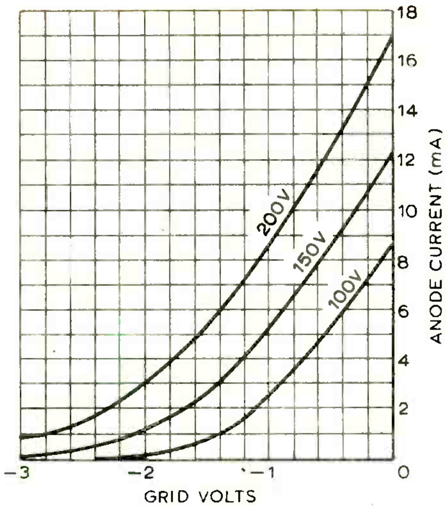


Fig. 2. "Curves connecting anode current and grid volts for "Micromesh" HLA1 valve." (Wireless World *5th Aug. 1932.)*

The marketing of these valves with thick, low-voltage filaments both here and in Germany indicates that the indirectly-heated types they superseded had not enjoyed unqualified commercial success. Indeed, some considered them to be preferable to the more complicated heater-cathode assemblies.

Yet another method of heater insulation was adopted by the Ediswan Company, who marketed a pair of a.c. triodes, types M141LF and M141RC, in 1928. These were based on a design developed the year before by T. W. Price, who used fine silica tubing to cover the heater wire. To encourage their use in the conversion of battery sets, and as an alternative to the Cosmos adaptor disc, these valves were fitted with a standard 4-pin base, and in addition, with a 2-way connector on the top of the bulb for the heater supply. This made it simpler to keep the alternating current leads away from the existing set wiring, and so to minimize induced hum. A similar double-ended construction was adopted by the Cossor Company for their range of five type M.41 valves. Neither company produced a screen-grid version at this time, and it is to be noted that they both followed the Cosmos lead by using a heater rating of 1.0A at 4.0V.

Philips All-mains 3-1 Receiver

In 1927 the N. V. Philips Company had acquired full control of the Mullard Company, and the latter offered no a.c. valves in their 1928 programme. But during the year the parent company marketed a 3-valve mains receiver of particularly progressive design, and many were sold in England. Unlike contemporary but more traditional models, such as the Metrovick 5-valve set, with its base-plate construction and separate eliminators, this new receiver was compactly enclosed in a functional metal case which also housed the power-unit, with its full-wave rectifier. The circuit employed a screen-grid h.f. amplifier, a triode detector and a pentode output valve, all of which were indirectly-heated, as was the rectifier. The cathodes of these valves were rather larger in diameter than the Cosmos design, and were connected to side terminals on the 4-pin bases. They are of special interest because their appearance indicates that they had been insulated by a slip-coating technique, so that their makers were among the first to follow Cosmos practice.

Another novel feature of the set was the output valve, which was the first indirectly-heated pentode to be marketed in England, and probably in Europe. This presumably followed from the fact that the output pentode, as such, had originated in the Philips Company shortly before. However, we have already noted that hum-free operation had been obtained from filamented output triodes for some time, and the new battery-type pentodes were being used in the same way. Indeed, the 1929 successor to this set, the Type 2514, used a Mullard PM24A directly-heated pentode as output valve. Nevertheless, the use of a cathode with a slip-coated heater ultimately resulted in the development of a pentode of great sensitivity, the Mazda AC/2Pen of 1934.

Ediswan—Cosmos—Mazda

This reference to the brand name of "Mazda" makes it desirable to explain briefly the effect of the formation of Associated Electrical Industries, which embraced the three valve-making firms of Metrovick, B.T.H. and Edison Swan, in 1928. In the following year the brand names Cosmos and Ediswan were dropped, and valve-making was taken over by the Edison Swan Electric Company, who concentrated it at the Cosmos Works (Brimsdown), using and expanding the facility which had previously made the Cosmos valve for Metrovick, and marketing the product under the Mazda brand name. Thus, from the technological point of view, the AC/2Pen mentioned above was a lineal descendent of the Olympia award-winning Mazda AC/Pen of 1930, the similarly honoured Mazda AC/SG of 1929, and the Cosmos AC/S of 1928.

Slip-coating accepted by British valve-makers

An event which marked the year 1929 as a turning-point in our story was the official adoption by British valve manufacturers of the 5-pin valve base, with its extra central pin for the cathode. This signalled acceptance of the fact that the a.c. valve of the future would be an indirectly-heated type, and paved the way for its general manufacture. So plentiful were a.c. valves and receivers at the Radio Show in September, that 1929 was called "All-Mains Year", even though a contemporary survey counted only 39 a.c. sets out of a total of 300 different models. All the four main British valve-makers announced a.c. types, including screen-grid amplifiers, in their programmes, and in each case they were using indirectly-heated cathodes, with heaters rated at 4V, 1A, and the new 5-pin base. The Ediswan silica-insulated heater had been discarded in favour of the original Cosmos (now Mazda) design, and the M-O.V. Company had dropped the "K" type triodes. On the other hand the valves of the "Point 8" series were continued through 1930, although it was said of them, during the previous year, that ". . . there appears to be no directly-heated model which has not got an indirectly-heated counterpart with substantially better characteristics, and there is no advantage in price". It was the slip-insulated cathode, which had given Cosmos a.c. valves their exceptionally high performance in 1927, that was being adopted universally in Britain two years later.

In making this point, a *Wireless World* article of October 1929 outlined the process of making such a cathode, and ascribed its development to the Metrovick Research Department, where a cure for grid-emission—the bane of other types—had also been devised. This was true in so far that the Cosmos electrode design kept the grid cool enough to allow low-temperature inhibitors, such as copper or silver, to remain effective during life. Cosmos grids were given a thin flash of silver.

Progress abroad

During this period the position on the Continent was changing in a somewhat similar pattern. After their brief resort to heavy directly-heated filaments, German manufacturers returned to heater-type cathodes of the new style in 1929 for all except power valves which, as in England, were directly heated. For their new designs they had the advantage of the lead given by the Philips Company.

Circumstances in France, however, were exceptional: the radio industry there had been isolated from the effects of foreign competition by high tariffs, and receiver development had followed a notably different course from that in the outside world. Thus in 1928 the Paris Radio Show offered practically no "battery-eliminators", let alone any a.c. valves. The French choice was, and had been for some years, the battery-operated superheterodyne, ostensibly to provide reliable reception of foreign stations on a small aerial, the outdoor type being considered unsightly. With the benefit of hindsight we may read with some interest that a British reporter at this show regarded the French preference as almost pitifully obsolescent, as the superhet system had been tried out, and discarded, years before by radio men in England.

During the following year, however, the first indirectly-heated valves appeared. Amongst others, the Métal brand cathodes followed American practice, using short twin-bored ceramic tubes for the 2V, 1.75A heaters. The range included a screen-grid type, and development continued through 1930 with an h.f. pentode and various multiple valves.

This importing of American technology followed the successful culmination of the Freeman and Wade cathode development, which had given the U.S. commercially acceptable a.c. valves by 1928. These, with the corresponding screen-grid model, were of considerable help to the set designer in meeting his aims of mains-operation, simple tuning, and maximum sensitivity with selectivity to cope with the congested broadcast waveband. A typical receiver at the New York Radio Show of 1929 exploited high-frequency amplification to the full: three screen-grid stages were used, with the variable capacitors for all the circuits "ganged" on a single shaft. This provided the required single-knob control, but inaccuracies in tuning, due to unavoidable tracking errors resulted in a poor stage-gain. As two correctly tuned stages would have given all the amplification that could be used, the losses due to the simplified tuning were made up by adding an extra amplifier. Such a solution would have been quite unacceptable to a royalty-conscious British designer.

In spite of the success of these a.c. valves, the difficulties which beset the ceramic-tube cathode seem to have persisted, for within a few years U.S. valve-makers had relinquished it in favour of the slip-coating technique which was proving so successful in Britain. One element in this transition was dated in this country when the American-owned firm of Standard Telephones & Cables introduced their "Micromesh" range of a.c. valves in 1932. On the 5th August the construction and performance of some advance specimens were described in *Wireless World* as having heaters insulated with twin-bored magnesia tubes, and a heating-time of about 50 seconds. Six weeks later a letter from the company was published, pointing out that several improvements had been made in the interim, and these included a refractory-coated heater which reduced the warm-up time to 25 seconds. (Fig. 2.)

Finally, the technique which had originated in England in 1927 was passed in 1933 from the U.S. to France, where the first popular receiving valves had originated, and where the first attempt at a commercial a.c. valve had been made some eleven years before.

Thus by the early 1930s most of the valve-makers in the broadcasting world had adopted the type a.c. cathode construction which, with sundry variations and improvements, is still used throughout the industry today, and the development may be said to have been complete by then. Over the previous decade, attempts had been made by many workers to devise a satisfactory solution to the problem, and the more important results have been described.

Much useful information has been derived from patent specifications, which epitomize the efforts of the inventors so conveniently. But these give no indication of the importance of the inventions they record, nor of the benefit they brought to the public. Indeed, the ownership of patents has from time to time been used to inhibit technical progress.

The early days of the thermionic valve can provide an outstanding example of such obstruction to free development. The Marconi Company brought a patent suit, claiming that the "Audion" infringed their own Fleming diode, against De Forest, who immediately filed a countersuit. Eventually the U.S. Court decided that both patents were valid, and that each company had infringed the other's. As a result, neither company could legally manufacture the triode. It took a world war to break the deadlock, and to demonstrate the great potential of the invention the litigation had sought to stifle.

Bibliography

Briggs, A., "The birth of broadcasting". Vol. 1, pp. 28, 38.
Dejussieu-Pontcarral, P., "L'épopée du tube electronique", 1961.
Gossling, B. S., J.I.E.E., Vol. 58 (1920), p. 682.
"Hum proof d.c. eliminator", *Wireless World*, 28th Oct. 1929.
Scott-Taggart, J., "Thermionic tubes", *Wireless Press*, London 1921, p. 22.
"The Gambrell Baby Grand", *Wireless World*, 21st Apr. 1926, p. 593.
British patent nos. 6476 (of 1915); 209, 415; 243, 868; 277, 754; 278, 787.
Herrman, G. and Wagener, S., "The oxide-coated cathode", London, 1951, p. 43.
"Filamentless valves for a.c. supply", *Wireless World*, 26th Jan. 1927.
"Guide to the show", *Wireless World*, 21st Sept. 1927, pp. 372, 375.
Met-Vick A.C. Valve Catalogue, Nov. 1927, p. 2.
"Impressions of the Berlin Show", *Wireless World*, 12th Sept. 1928.
"The trend of progress", *Wireless World*, 3rd Oct. 1928.
"Show number", *Wireless World*, 26th Sept. 1928, pp. 416, 422, 436.
Oatley, C. W., "The use of a.c. for heating valve filaments", *Experimental Wireless*, Vol. 5, No. 58, pp. 380–384.
Mazda Valve Manual, 1935, p. 48.
"A.c. screen-grid valves", *Wireless World*, 10th July 1929.
"The trend of design", *Wireless World*, 2nd Oct. 1929.
"Receiving sets of today", *Wireless World*, 20th Nov 1929.
"The Berlin Show", *Wireless World*, 11th Sept. 1929.
"Review of the Paris Show", *Wireless World*, 7th Nov. 1928.
"The Paris Show", *Wireless World*, 6th Nov. 1929.
Maclaurin, "Invention and innovation in the radio industry", Macmillan, 1949. p. 174.
"The New York Show", *Wireless World*, 30th Oct. 1929.

Sonex 73

Exhibitors and a preview of their new equipment

The fourth Sonex audio show is to be held in the Excelsior Hotel, Bath Road, West Drayton, from Friday 30th March to Sunday 1st April. Times of opening are 11.00–21.00 (Friday and Saturday) and 11.00–18.00 (Sunday). Free tickets are available from Sonex 73, 20th Century House, 31 Soho Square, London W1V 5DG and from individual exhibitors.

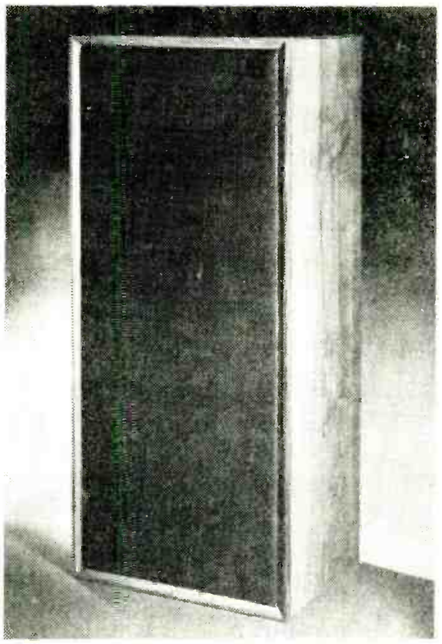
Exhibition briefs

New from Acoustic Research will be the AR4xa, an improved version of the AR4x which uses the same woofer and cabinet but has a new tweeter and crossover network with the aim of improving high frequency response and dispersion.

Sennheiser will display two versions of their Elektret microphones — the MKE201 (omnidirectional) and MKE401 (supercardioid). Each microphone incorporates a miniature battery and i.c. in the microphone housing, providing components for amplification, equalization and impedance transformation of the sound signal.

Among the magnetic cartridges new to Sonex, the 820 series by Goldring will be demonstrated on the current range of Goldring/Lenco turntables.

Two new Sonab products will be on display. First, two headphones, the HS10 and HS20. Second, a Mark II version of the R4000 tuner-amplifier which outwardly looks like the Mark I but incorporates some new circuit design.



One of two new loudspeaker systems from Jordan-Watts, the Jupiter TLS, a transmission line speaker. Panel resonances are said to be minimized by lining the enclosure with sheet lead.

Successor to the Tandberg 3000X is the stereo tape deck 3300X shown left. Features include easy to read peak-equalized recording meters, separate record and replay heads and the cross-field recording technique.

Brand names at the show

Acoustic Research
Acoustico
Agfa-Gevaert
Amstrad
Antiference
Armstrong
B.A.S.F.
J. Beam
Bib
Britex
B & W
Condor
Connoisseur
Cosmocord
Fisher Radio
Gabraphone
Gale Electronics
Goldring
Harman-Kardon
Hisound
IMF
Jordan-Watts
KEF
JVC Nivico
Klinger
J.B.L.
Lecson
Lowther
Lustraphone
Memorex
Metrosound
Keith Monks
Mordaunt-Short
Musitapes
Nagra
Onkyo
Philips
Precision Tapes
Quad
Richard Allan
Rogers
Rola Celestion
SABA
Sennheiser
Sinclair
Siemens
Sonab
Spendor
Tandberg
Tape Recorder Spares
Teac
Vernitron
Cecil E. Watts

World of Amateur Radio

Transistor transmitters

The "all solid-state" transmitter has been heard on the amateur bands almost since the first practical transistors capable of oscillating at h.f. appeared — providing contacts with a few milliwatts of power. For a long time now devices have been available capable of providing watts and even tens of watts output but, for the amateur, these have often proved terribly easy to destroy accidentally by parasitic oscillation, mismatches and the like. As a result, apart from the dedicated experimenters, most amateur solid-state stations have been confined to 1.8MHz mobile or portable units where a few watts can prove very effective. Recently however, there has been growing interest in extending the use of transistors in low-power exciters and also in the final amplifiers — a trend encouraged by the appearance of h.f. transceivers in which the receiver section uses direct-conversion techniques. Very effective miniature "stations" have been developed by Ten Tec and more recently by Heathkit. The "Mini-Ring" HW7 transceiver provides about 3W output on 7MHz, 2.5W on 14MHz and 2W on 21MHz. Edgar Janes, G2FWA, who has been using an HW7 for several weeks, says that "several of us in the Cheltenham Group have been fascinated by this little 9 by 8 by 4 inch box — average reports seem to be RST 569 whether from Europe or North America. The limiting factor is often interference at the distant end since 2-3W doesn't punch much of a hole . . . but how nice it is to get back on the morse key with a purpose . . . this type of low-power operation is attracting quite a following . . . it's a pity the transceiver does not also cover 3.5MHz since 21 and 14MHz are not so good in the evenings at this time of the year . . . direct conversion "breakthrough" can be considerably reduced by an attenuator in the receiver input . . . a wonderful little unit".

Ten Tec with its range of similar low-power transceivers recently introduced a 50W solid-state linear amplifier, while another well-known amateur supplier, Swan, is introducing an all solid-state transceiver capable of 200W p.e.p. So at least it looks as though the all transistor approach (often combined with sufficient broad-band response to allow tuning of the power amplifier to be eliminated) may at last spread fairly rapidly in many categories of amateur transmitters, even though as a power amplifier the valve retains many useful features.

Phasing out a.m. on 1.8 and 3.5MHz?

In what may well prove a controversial move, the R.S.G.B. Council has stated that it will "encourage its members to use s.s.b. rather than amplitude modulation (A3) on the 1.8 and 3.5MHz (shared) bands" to conform with the International Telecommunication Union requirements for maritime mobile stations in these bands from 1975. *Short-wave Magazine* states that it is "in entire agreement that sideband telephony is the only acceptable mode for the future". In the American journal *CQ* Paul Abbott, WA2RJV says "s.s.b. is the superior method just as jet engines outperform piston types . . . the need to conserve spectrum space is sufficient justification to phase out 'broadcasting' in the amateur bands". But by no means all amateurs agree that there is no place left for a.m. operation (particularly on 1.8MHz where at present it is the dominant telephony mode) or that s.s.b. will prove the ultimate mode — double-sideband suppressed carrier transmission has many advantages especially where there is no fixed channelling arrangements, as J. P. Costas pointed out many years ago. In his classic article "Poisson, Shannon and the Radio Amateur" (*Proc I.R.E.*, December 1959) he showed that in a congested band, broader bandwidths and the ability to move frequency can be expected to provide better communications reliability. But in the face of so many advocates of s.s.b. it may seem heresy to quote Costas!

From all quarters

A.R.R.L. have introduced a special Oscar 6 satellite DX Achievement Award "1000". To claim the new award, amateurs must accumulate 1000 points on "via-satellite" contacts: each contact with a new station scores 10 points; each new country 50 points; each new continent 250 points. QSL cards must confirm Oscar 6 contacts after December 15, 1972. A French amateur, F8VN, should have little difficulty in claiming the new award — he has already made more than 200 contacts with amateurs in 26 countries via Oscar 6. The limiting factor with Oscar 6 contacts is usually 29.5MHz reception rather than gaining access on 145.95MHz.

In 1973, the golden jubilee year of the City of Belfast Y.M.C.A. Radio Club (GI6YM), a number of special activities are being planned for this and also for the 75th anniversary of the tests carried out by Marconi and Kemp, between Ballycastle and Rathlin Island, which led to the establishment of public service maritime radio in 1898. The Belfast club is to issue a special award between July 1, 1973 and June 30, 1974, and activity from GI6YM will be at high level throughout the period. The Ballymena Amateur Radio Club will operate a special station on all h.f. bands during the first week in July.

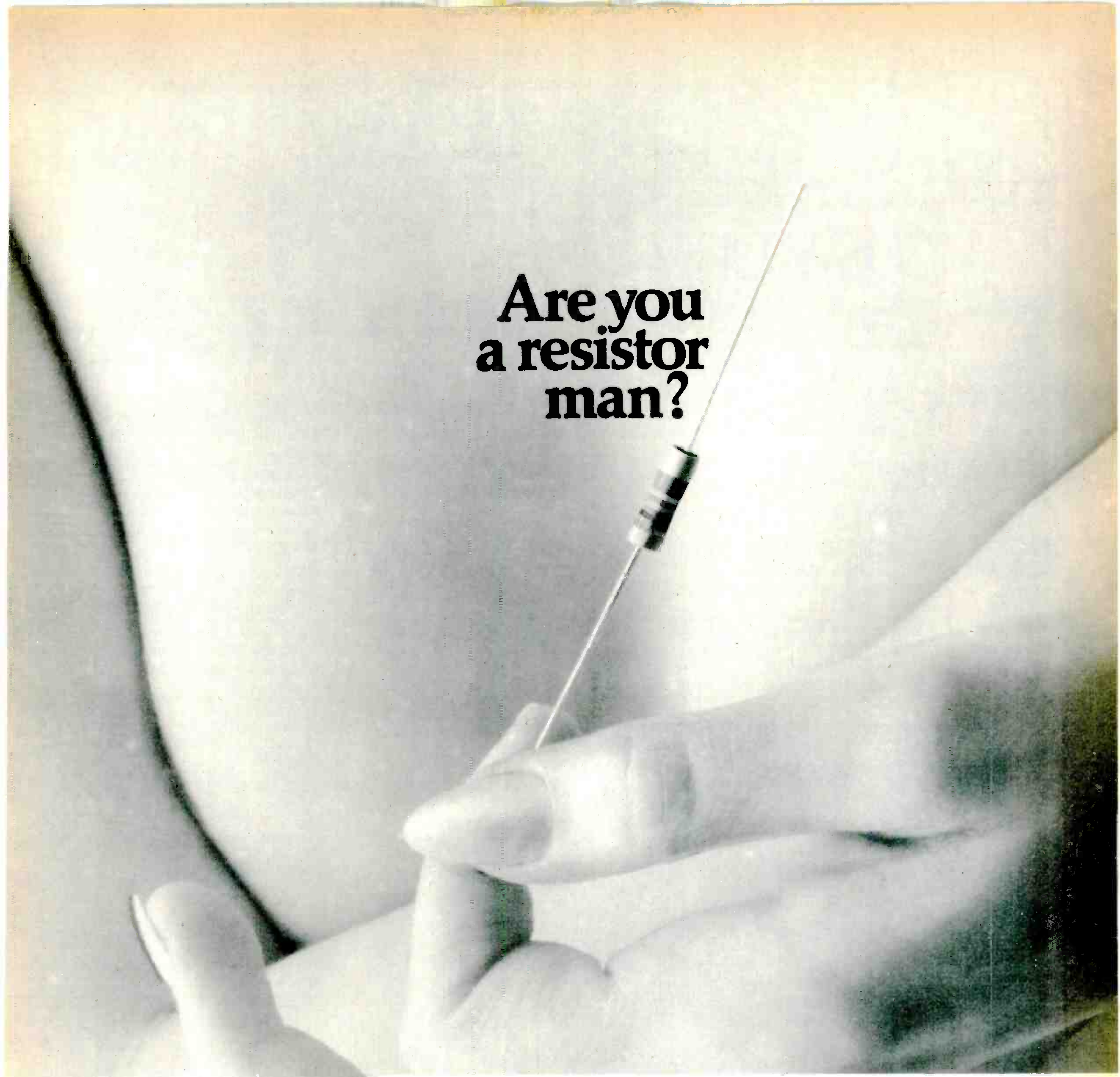
An unusual "wanted" notice was published recently in the A.R.R.L's journal *QST* — the official photographs of one Benjamin Hoskins Paddock who the F.B.I. are seeking for band robbery and escape and who is listed as one of the ten most wanted American fugitives. Reason for publication? He was licensed as K7JIH in Tuscan, Arizona from 1959 to 1964.

Quote from Syd Griffith, VK2ZYD, in "Tuned Lines": "I would say to those who would be a little intolerant to the modified commercial rig user the old adage 'to each his own' is just as applicable in this modern, solid-state integrated-circuit state-of-the-art age, as it ever was. The amateur who experiments with modifications to commercial gear is doing as much to further his knowledge as that amateur who has a complete laboratory set-up to perform more complicated and expensive experiments".

In Brief

The International Amateur Radio Club is conducting a special study of the unusual solar events of August 1972 and would welcome details of long-distance h.f. contacts between July 26 and August 14, 1972 (I.A.R.C., P.O. Box 6, 1211 Geneva 20, Switzerland) . . . Edward P. Tilton, W1HDQ, recently retired after many years as v.h.f. Editor of *QST* — one of his many contributions was being the United States end of the first transatlantic v.h.f. (50MHz) contact on November 24, 1946 with Denis Heightman, G6DH . . . The death has occurred of Leslie Knight, G5LK, for many years a well-known blind amateur of Mitcham, Surrey, and more recently Waterlooville, Hants . . . B.O.A.C. is donating special prizes for the R.S.G.B. Diamond Jubilee h.f. contests including (for winners of the c.w. and phone sections) return tickets to a choice of Bermuda, Hong Kong, Seychelles, St Lucia, Antigua or Nassau . . . French stations F5MI, F1VL and F9ON are now equipped for 1296MHz operation.

Pat Hawker, G3VA



Then the area of greatest attraction for you will be our reputation for reliability of product, reliability of supply, reliability of expertise, and wide, wide range. Electrosil resistors are almost universally first choice where dependability is paramount under conditions of environmental stress. This is due to their unique fused glass-tin-oxide method of manufacture. The range includes the most comprehensive series yet approved to BS 9000, and also embraces the C3, smallest available in the UK, the FP range (flameproof), the TR range (triple rated) and the NC range for supreme precision. And we produce millions every week!

Electrosil LIMITED

have the experience

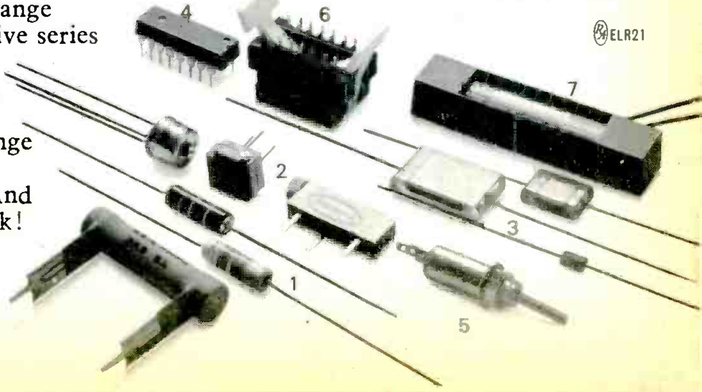
Wherever your interests lie...

(1) Resistors (2) Potentiometers
(3) Capacitors (4) Cordip (5) Switches
(6) Pick-a-back (7) ETM.

Use the Reader Reply Service in this publication for full details, indicating the product range(s) in your field.

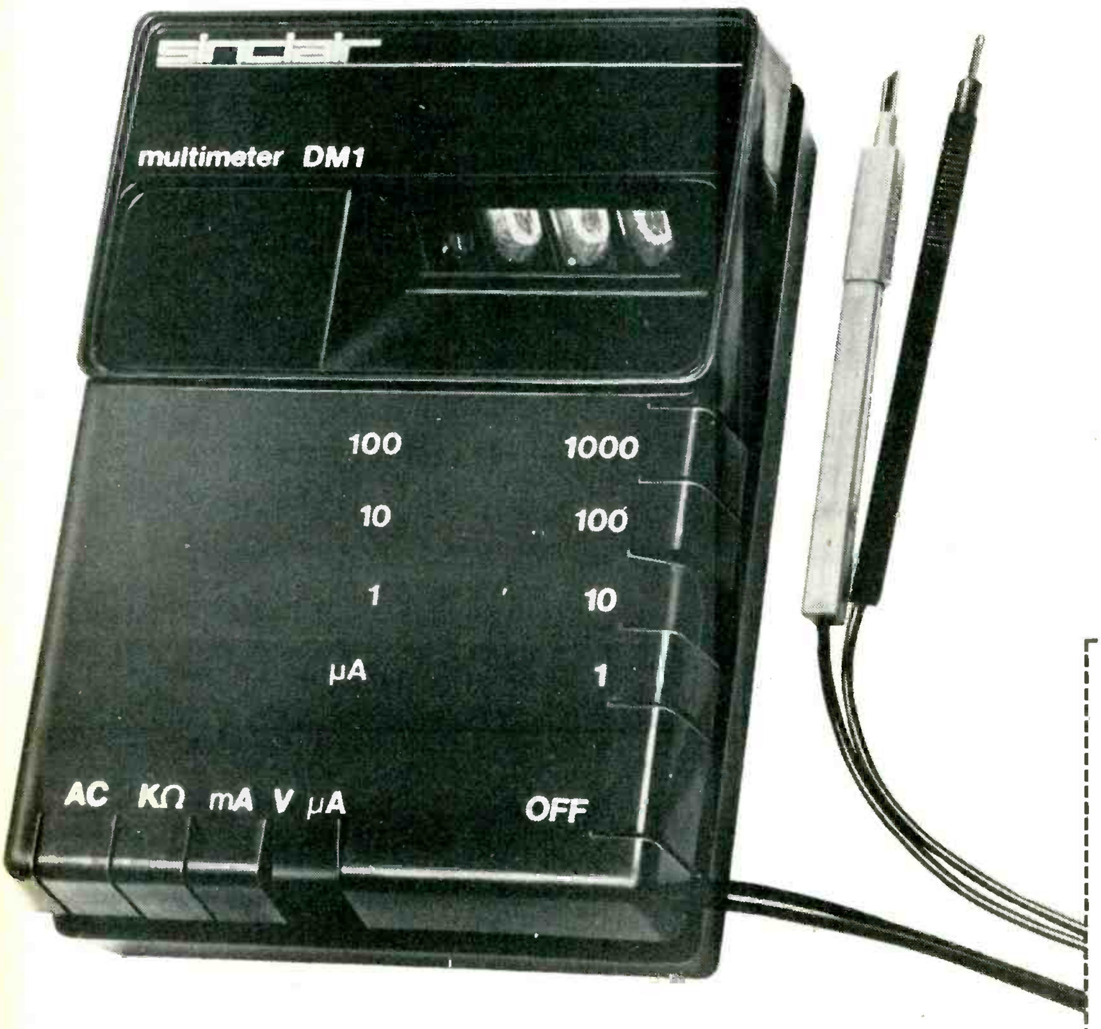
Electrosil Limited, P.O. Box 37, Pallion, Sunderland, Co. Durham, SR4 6SU.

ELR21



This new digital multimeter from Sinclair costs only £49

Wide range	The new 3½ digit Sinclair DM1 Multimeter provides a total of 23 ranges to give you a really versatile instrument. An added bonus is the convenience of push-button range selection.	On all but the 1000V range, automatic overranging to 1900 is provided.
Lightweight and compact	With a weight of only 0.6kg and dimensions of 190x130x58mm the Sinclair DM1 brings true portability to the world of digital multimeters.	
Good accuracy	Typical accuracies of the Sinclair DM1 are ±0.5% of reading (±2 digits) on the DC and resistance ranges, and ±1.0% of reading (±2 digits) on the AC ranges (measured at 50Hz).	Better accuracies than this are are not available at anywhere near £49.
High Input resistance	1000MΩ is a very conservative specification for the input resistance of the Sinclair DM1 on its most sensitive range, thanks to the clever design of the input circuits, which draw only 50pA.	The loading problems which beset measurements with normal analog instruments are now a thing of the past.
Robust construction	The high strength polypropylene casing has been designed to take the knocks that will inevitably occur during use. The flush fitting push-button range selection switches are moulded integrally with the case to provide an even greater degree of robustness.	This push-button design, with a lifetime in excess of 1 million operations, is yet another first for the Sinclair DM1.
Complete freedom from the mains	A total current drain of between 10mA and 12mA provides over 80 hours of useful life from the throwaway dry battery, giving total freedom of movement over weeks of use. Only Sinclair expertise can give you this. Accuracy is maintained at all battery voltages during discharging.	The Nixie tube display automatically extinguishes before accuracies deteriorate.



	Range of full scale	Maximum resolution
AC & DC Voltage	1V to 1000V	1mV
DC Current	1μA to 1A	1nA
AC Current	1mA to 1A	1μA
Resistance	1kΩ to 1MΩ	1Ω

Fill in the coupon below to order your new Sinclair DM1 multimeter. Your money will be refunded in full if you are not satisfied with the instrument's performance, and return it in its original packing

Send the coupon to Multimeter Sales, Sinclair Radionics Ltd., London Road, St Ives, Hunts. Tel (0480) 64311.

Tick whichever is applicable ww2

☐ I enclose a cheque for £49 for a Sinclair DM1 digital multimeter. I understand that unless I am completely satisfied with the performance of this instrument if I return it in its original packing within 14 days of receipt, I shall receive a full refund.

☐ Please send me a descriptive leaflet on the Sinclair DM1

Name

Position

Company

Address

Tel no

sinclair

New Products

tion (typically 0.02%) from 0.01W to 150W. Hum, and noise is 110dB below 150W.

When converted for mono operation, which is now effected by means of a simple internal plug-in, the DC300A will deliver 650W r.m.s. into 4Ω or 8Ω loads.

The number of output transistors has been doubled and the safety margin greatly increased. The input circuitry now employs i.cs, and the DC300A has undergone a complete chassis redesign with a new front panel to match the IC150/D150 models. Price £380. Macinnes Laboratories Ltd., Stonham, Stowmarket, IP14 5LB.
WW303 for further details

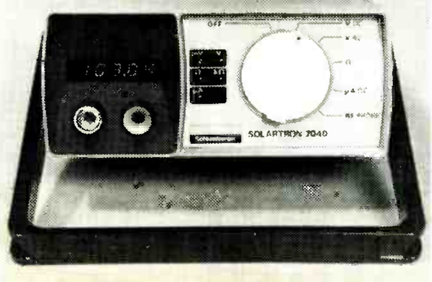
Digital multimeter

Solartron-Schlumberger have developed a new technique of analogue-to-digital conversion for their 7040 miniature digital multimeter, which is about the same size as a portable cassette recorder. As in the dual-slope technique, developed by the same company, mains-frequency interference is greatly reduced (less than −60dB) without the use of filters. Triple-slope integration has the additional advantage of a much greater conversion rate, while retaining a six-digit resolution, although only four "full" digits are displayed.

During the second negative-going ramp of the normal dual-slope process, the 7040 counts in units which are 100 times coarser than those displayed, while the ramp slope is made 100 times faster than normal. As it crosses the base-line it is allowed to continue for a short time, when a ×100 attenuator is switched in and the count rate increased by a factor of 100. The counter reverses and counts back until the base line is again reached, thereby interpolating the coarser counting units.

The instrument is notable in that no range switching is needed, the full six digits always being used; the relevant four displayed digits are automatically selected. Light-emitting diodes indicate the units of measurement and quantity being determined, which may be alternating or direct voltage up to 1000V with a maximum resolution of 10μV on the 100mV range, direct current up to 1mA or resistance up to 10MΩ.

The 7040 is claimed to be suitable for very rough usage by unskilled operators and prototypes have undergone "tests" such as being dropped from several feet on to concrete floors without damage, apart from dents in the polycarbonate case. Weight is 1.14kg., price £195. Electroplan Ltd., P.O. Box 19, Orchard Road, Royston, Herts., SG8 5HH.
WW306 for further details



Low profile keyboard switch

Designed for low profile applications in calculator, data entry, communications and instrumentation equipment, this unit has an overall height of 0.415in and is available in 0.625in and 0.75in sizes as single or double widths. An option of five standard colours with hot stamped characters is offered. Unit cost, depending on specification and quantity, is approximately 7p. Diamond H Controls Ltd, Vulcan Road North, Norwich, Norfolk NOR 85N.
WW 313 for further details

Audio power amplifier

Crown International/Amcron have announced a new version of their DC300 power amplifier. The DC300A, as the new model is known, will now operate into 1Ω loads and, it is claimed, will drive any load including totally reactive loads without fuss, and without the previously incorporated "hysteresis/normal" switch. The d.c. protection fuses have also been eliminated as a new sophisticated protection circuit has been developed which, it is claimed, exhibits no flyback pulses, thumps, or shutdown.

The DC300A will now deliver 425W r.m.s. into 2Ω, 500W r.m.s. into 2.5Ω, 350W r.m.s. into 4Ω, 200W r.m.s. into 8Ω, and 110W r.m.s. into 16Ω from each of its two channels. It will also provide 100W r.m.s. into a 1Ω load, which will be welcomed by vibration engineers.

Harmonic distortion is now specified as being below 0.05% from d.c. to 20,000Hz, and below 0.05% i.m. distor-

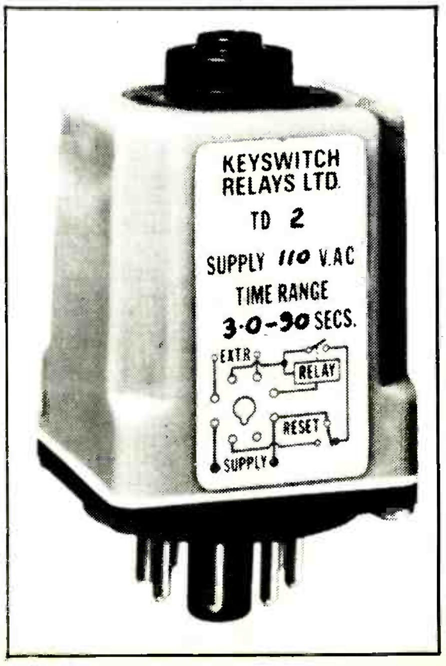
Plug-in time delay units

The range of low cost, solid state, plug-in TM and TD time delay modules by Keyswitch Relays is designed for use in either a.c. or d.c. circuits and provides for accurately timed delay periods of between 2.5 seconds and 300 seconds.

The TM timer incorporates a Keyswitch MS relay with changeover contacts rated at 2A. The delay period, between 2.5 seconds to 300 seconds, is set by adjustment of a potentiometer which may be mounted on the timer unit or wired to it from a remote control position. At the end of the timed interval, which is initiated by the supply connection, the timer will deliver an output.

The TD version is designed for use with an external relay and operates in a similar manner to the TM timer and also provides a time delay period of between 2.5 seconds to 300 seconds. At the end of the timed interval the TD timer output is supplied via an integral s.c.r. circuit. The solid state switch output is rated at 300V, 10-800mA.

Both timers have a reset time of 120ms and are housed in small moulded polypropylene casings, 1.3 × 1.3 × 2.025in (above



socket) and can be supplied with or without adjustment potentiometers. Keyswitch Relays Ltd, Bendon Valley, Garratt Lane, Wandsworth, London SW18 4LZ.
WW301 for further details

Selective level and voltage meter

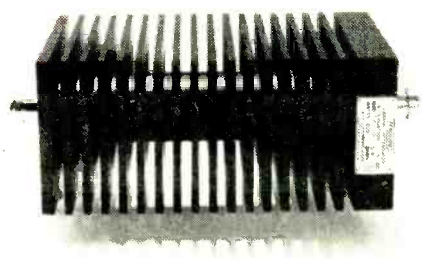
A selective level and voltage measuring set, capable of investigating acoustic phenomena below the normal audible range has been developed by Siemens. Normally the lowest frequency at which measurements are made in electrical instrumentation engineering is 16.67 Hz — the frequency of the fundamental component of a traction current. Now, with the Siemens D2040, a frequency range starting at 10Hz is offered to provide adequate measurement capability at 16.67Hz, and frequencies extending to 60kHz, can also be analysed. The D2040 is tunable throughout this frequency range to 60kHz without band switching, and all functions of the instrument can be remotely controlled. It is a superheterodyne receiver, the frequency resolution of which is 1Hz throughout the measuring range, the frequency being read with this resolution and accuracy by a built-in digital frequency meter. The attenuation of signals which lie only 25Hz above or below the centre frequency of the filter is 60dB, so that, for instance, a 15.05kHz signal can be distinguished from a 15kHz signal of similar level. The high selectivity of this narrow-band filter permits the analyser to be used for Fourier analysis as well as for level and voltage measurement. The dB bandwidth of the receiver can then be switched from 8 to 80Hz, which also applies to the analyser when it is used as an active, continuously tunable filter. Of special interest is the wide dynamic range offered, −120dB to +20dB or 1V to −10V, with a measuring error of less than 0.1dB. The instrument is also designed for determining the spectral density of complex waveforms and for measuring distortion and modulation products. If the input frequency here has to be measured with greater accuracy than the filter width permits, the analyser can be switched to automatic frequency control. When this is done, the local oscillator is automatically synchronized to the incoming signal. All the switch functions, such as level, input impedance and filter bandwidth, can be remotely controlled, and it is also possible to control externally the frequency setting.

The range of application of the analyser D2040 can be extended by using a standard microphone, for space and sound analysis or a vibration pick-up, which converts mechanical vibrations into electrical value. As the measuring range extends down to 10Hz it permits investigation of physical vibrations for stability test and similar applications. Siemens Ltd, Great West House, Great West Road, Brentford, Middx.
WW312 for further details

Wideband coaxial attenuator

Bird Electronics have introduced a 50Ω coaxial attenuator — the Model 8343-060 — which has a continuous rating of 100 watts in free air without the need for an additional heat sink.

Nominal attenuation of the standard model is 6dB from d.c. to 1000MHz and maximum deviation is $\pm\frac{1}{2}$dB from d.c. to 500MHz and ±0.75dB from 500 to 1000MHz. Input v.s.w.r. for these ranges is 1.10 and 1.15 respectively and since the unit is symmetrical, output v.s.w.r. is similarly low. This is also obtained by the use of Bird QC quick-change connectors which permit mating with most standard male or female connectors without the need for performance degrading adaptors. In addition to the standard 6dB attenuator



versions nominal attenuation values of 10 and 20dB can also be supplied. Price of the Model 8343-060 is £90 duty paid. Bird Electronics Ltd., 18a High Street, Northwood, Middlesex, HA6 1BN.
WW338 for further details

Oscilloscopes with built-in multiplication

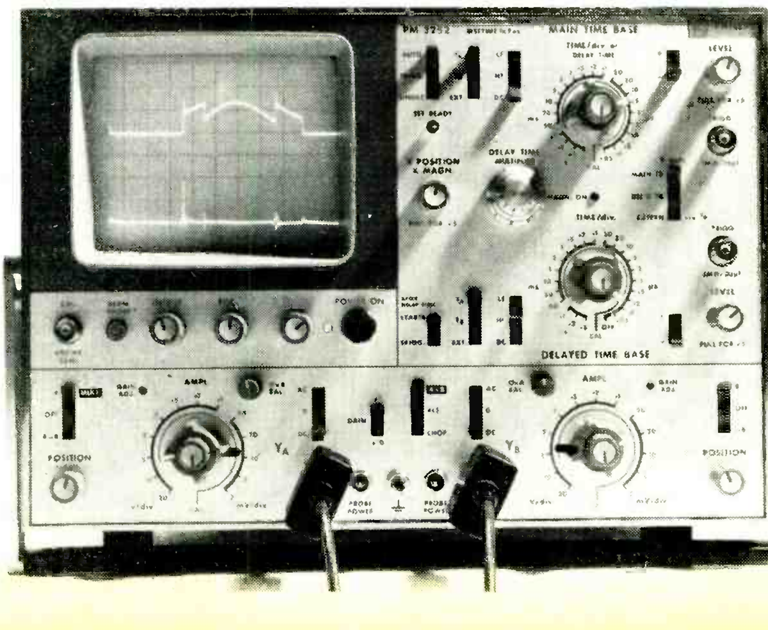
The first oscilloscopes in the world to provide a built-in, high-frequency multiplication facility is Philips claim for the latest additions to the company's oscilloscope range. This feature permits the product of the two input signals to be displayed simultaneously with one of the original signals.

Known as the PM 3252 and 3253, these new instruments not only offer a simple-to-operate multiplication facility but one that extends over a much broader bandwidth than is at present possible with conventional building-block type multiplier units.

While the PM 3252 is a standard 50 MHz portable or laboratory instrument, its sister instrument, the PM 3253, employs a storage c.r.t. Another feature of these oscilloscopes is the special output provided on the instruments' rear panels which can be switched so that either the instantaneous or average value of the displayed product can be shown on an indicating device or used for processing. For example, any d.c. voltmeter connected to this output can be used as a wattmeter. The output, which is derived from the multiplier, is calibrated in terms of the oscilloscope screen display (100mV/div), and for power measurements (product of $i \times v$) the voltmeter will clearly indicate average power while the instantaneous power is displayed on the oscilloscope's screen.

It is possible, by adjustment of front panel controls, to change both oscilloscope-display and meter sensitivity from the low microwatt to the kilowatt range.

Apart from their multiplier applications, the PM 3252 and 3253 can also be employed as standard 50MHz dual-trace oscilloscopes with delayed timebase facility. As such they have a 2mV input sensitivity over their entire 50MHz bandwidth, and 200V over a reduced bandwidth of 5MHz. They also feature a drift-compensation circuit on both *Y* amplifiers. Pye Unicam Ltd., York Street, Cambridge.
WW333 for further details



R.F. power meter

The Sanders Division of Marconi Instruments has announced a low cost power meter, the f.o.b. U.K. price of which is £140. The meter, designated Type 6555, is for use with "tft" (thin film thermoelectric) power heads such as the present Sanders range of Series 6420 power heads.

Power measurement by this method is claimed to be extremely stable and the 6555 meter provides repeatable r.f. power measurement over wide frequency and power ranges. Four power ranges cover 30nW (−15dBm) to 3W (+35dBm) and the range of Sanders t.f.t. heads accommodates frequencies from 10kHz to 40GHz. Noise is less than 0.03% of full scale per deg. C on the least sensitive range. Meter indication with power and dBm scales is provided, as well as a calibrated analogue output (0 to −1V f.s.d.) so that an external recorder or digital voltmeter can be used. Meter accuracy is ±2% f.s.d. or ±1% f.s.d. analogue. The heads cost from £111 f.o.b. U.K. to £284 f.o.b. U.K. according to frequency and power specification.

Note: The abbreviation "tft" for thin film thermoelectric is a registered term, the property of General Microwave Corporation (USA) from whom the power heads are manufactured under licence. Marconi Instruments Ltd — Sanders Division, P.O. Box 10, Gunnels Wood Road, Stevenage, Herts SG1 2AU.

WW305 for further details

Video tape

A new video tape now available from Memorex U.K., called Vidichrome is claimed to have a drop-out rate of less than ten per minute on Ampex VR 5000 and 7000 series machines, as well as a high signal-to-noise ratio of over 42dB. The possibility of static charge build-up which attracts foreign particles and causes drop-out is reduced with a back coating.

The tape is also claimed to have an extremely high resistance to the detrimental effects of heat and humidity due to a new and unique binder formulation: this reduces head-wear and cinching, and extends tape life to more than 500 passes.

Capable of recording both colour and monochrome values, Vidichrome is available in lengths of either 1500 feet or 3000 feet giving ½ hour and 1 hour running time respectively. It is packed in a functional plastics shelf box with carrying handle. Price of the new tape depends on quantity ordered and will be quoted on request. Memorex U.K. Ltd., Memorex House, St. Ives Road, Maidenhead, Berks.

WW327 for further details

Digital multimeter

Features of the Model 171 a.c./d.c. digital multimeter by Keithley Instruments include 4½ digit display, guaranteed 90-day accuracies on all functions, and floating capability to 500V off ground.

The Model 171 gives a broad selection of full scale ranges from ±10mV to ±1000V d.c., 100mV to 1000V a.c. r.m.s., 1μA to 1A a.c. or d.c. and 1kΩ to 1000MΩ. In addition pushbutton function selection, automatic decimal position, automatic polarity, and a front-panel link for selection of either grounded or floating operation are provided.

A full 100% overranging to 19999 is provided on all ranges except the 1000V range. When overloaded, the 171 shows only the polarity of the overload and the digit "1". The remaining four digits are blanked so that no misleading information is displayed. An analogue recorder output located on the read panel furnishes a 1V output for continuous monitoring on a real-time basis.

Range scales: 1μV to 1000V d.c., 10μV to 1000V a.c. r.m.s., 0.1nA to 2A a.c. or d.c., 0.1Ω to 2000MΩ. Keithley Instruments Ltd., 1 Boulton Road, Reading RG2 0NL.

WW310 for further details

High grade capacitors

A new range of professional computer grade capacitors has been introduced by Advance Filmcap Ltd. The Prosec 85E devices offer extended ranges over the Prosec 85 without any reduction of essential safety margins on forming voltages for long life and high reliability. This is achieved through the selection of high gain etched foils.

Capacitance values range from 2,200μF to 220,000μF with e.s.r. values as low as 0.01Ω (at 100Hz).

Prosec 85E range offers greatly increased *CV*/volume over the standard range. In many cases, the *CV* rating is at least 50% greater for the same can size compared to a "standard" component of equivalent electrical characteristics.

Units currently available cover the most popular voltage ranges from 10V d.c. to 63V d.c. Present development work is aimed at extending the Prosec 85E capability to cover from 6.3V d.c. to 500V d.c. Advance Filmcap Ltd, Rhosymedre, Near Wrexham, Denbighshire.

WW331 for further details

Ten-turn potentiometer

Pyror Electric S.A. have introduced a basic 10-turn wire-wound (3- or 5-turn optional) potentiometer, the model PH10, having a power rating of 2 watts at 40°C. The resistance range offered is 100Ω-10kΩ, with resolutions of 0.056%-0.010% respectively. Standard linearity tolerance is ±5% and the overall temperature range for the devices is −40°C to +125°C.

Particular attention has been paid to the contacts to ensure reliability. All sur-

faces are of precious metal (with the exception of the wire element) and the case is thermoplastic material, which has been specially selected for both strength and compatibility with the wire element. The dimensions of the device are 20mm diameter × 29mm length, and it has a weight of only 20 grams. Price £1.78 each at the 100-piece level. Electrautom Ltd., Etom House, Queens Road, Maidstone, Kent.

WW340 for further details

100MHz oscilloscope

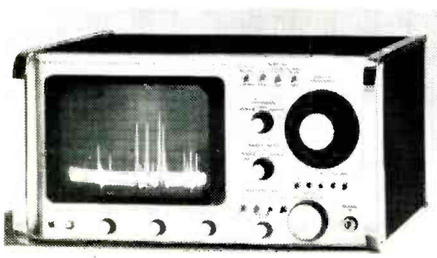
The model 200, wideband, low-cost oscilloscope is the latest equipment product from G. & E. Bradley Ltd. It is claimed that the new design philosophy adopted, allowing every feature to be designed to a price without sacrificing electrical specification, has achieved a no-compromise performance at the cost of medium priced instruments. It comprises a mainframe and plug-in module technique allowing maximum flexibility and economy of instrumentation. The mainframe features an 8 × 10cm cathode-ray tube with provision for standard camera fittings, a trace finder, internal calibration with 0.5% amplitude accuracy, a mode selector providing Y1 and Y2 only, alternative, chopped and added displays, also switches to select internal trigger source from Y1 or Y2 separately or true alternative triggering when operating in dual display modes. Additional facilities such as variable trigger hold-off, Z modulation, ramp and gate signals, are available as standard. The first two plug-in modules available are: Model 211, twin timebase unit providing intensified and delayed modes of operation

additional to which A and B mixed is available, allowing the B timebase to be run immediately after the A timebase delay period; Model 210, dual channel Y amplifier featuring a 3dB bandwidth of d.c. to 100MHz on all input sensitivities down to 5mV/cm, a pre-set d.c. balance (not affected by sensitivity settings) and a Y2 pre-amplifier output enabling Y1 and Y2 channels to be cascaded for an ultimate sensitivity of 500 μ V/cm (d.c. to 50MHz bandwidth) or fully controlled XY plotting by linking the Y2 output to the X deflection input. G. & E. Bradley Ltd., Electral House, Neasden Lane, London N.W.10.

WW327 for further details

1-300MHz spectrum analyser

Texscan announce the addition of a low-cost, sensitive spectrum analyser to their range. This analyser, the Model AL-40, covers the frequency range with dispersion continuously variable from 10kHz to 300MHz and i.f. resolution of 500Hz or 200kHz, selectable by a front panel switch. Amplitude measurements from −113dBm

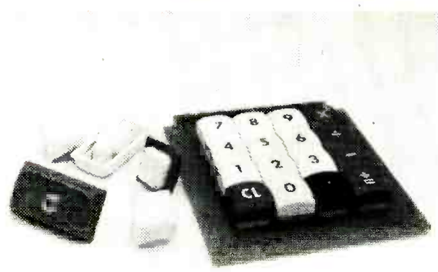


to +30dBm can be made with a maximum dynamic range of 80dB displayed on the 9in screen. A feature of the instrument is the incorporation of crystal controlled harmonic frequency markers, enabling accurate frequency measurements to be made with signal levels down to −113dBm. Texscan Instruments Ltd., 1 North Bridge Road, Berkhamsted, Herts.

WW309 for further details

Alpha-numeric displays

A range of incandescent alpha-numeric displays from Chicago Miniature Lamp Works is announced by Magnus Electronics Ltd. Incorporating the advantages of solid state digital readouts, they are compatible with standard i.cs, featuring wide viewing angle, shock and vibration resistance and carrying all numbers plus 9 distinct letters. These displays have a field proven life history (in excess of 100,000 hours) and have been incorporated in military programmes for which full test data is available. They exceed the requirements of MIL–STD 202C on shock and vibration and have the advantage of stable operation at thermal extremes of −55°C and +125°C and 27,800 cd/m² brightness. They withstand high transient



voltages and are readable in direct sunlight. Available in a wide range of colours. Magnus Electronics Ltd., 23-31 King Street, London W.3.

WW304 for further details

Electrolytic capacitors

A professional grade electrolytic capacitor, the LMT 018, has been introduced by ITT Components Group Europe. With rated voltages available from 6.3 to 500V, the LMT 018 offers capacitances in the range 10,000μ F to 150,000μ F at 6.3V to 68μ F to 1,000 μ F at 500V. Capacitance tolerance is −10% + 50%. These devices are intended for use where applications demand large capacitance and long life. ITT Components Group Europe, Capacitor Product Division, Brixham Road, Paignton, Devon.

WW311 for further details

Vertical heatsink resistors

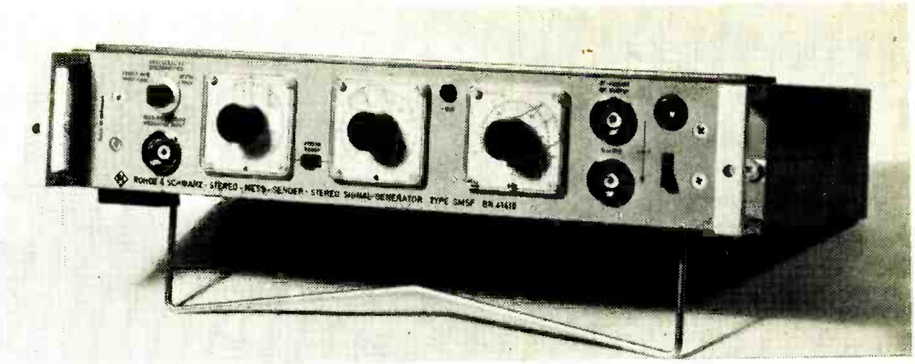
The Ashburton Resistance Company has recently introduced its HSV range of heatsink resistors designed for vertical mounting direct to chassis. These ARCOL HSV resistors are available in 10W, 15W, 25W and 50W sizes within a resistance range of 0.01Ω to 86kΩ. Ashburton Resistance Co. Ltd., 40 Bavaria Road, London N19 4ET.

WW302 for further details

Stereo signal generator

The Rohde & Schwarz Stereo Signal Generator Type SMSF is designed to check the performance of f.m. receivers and demodulators in the v.h.f. broadcast range 87 to 108MHz and at their i.f. of 10.7MHz. Type SMSF continuously covers the entire v.h.f. range and the frequency of the i.f. range can also be continuously varied within ±500kHz, facilitating either selectivity measurements or determination of discriminator characteristics as required. In conjunction with the Rohde & Schwarz Stereocoder Type MSC, the generator affords all facilities for measurements on stereo receiving systems. With the aid of one or more tunable amplifiers, e.g.

R & S Type ASV, the output signal of Type SMSF can be amplified or made available at several work benches without circuit loading. The use of Type ASV offers, moreover, the advantage of high-precision amplitude modulation of the output signal of Type SMSF. The Types MSC SMSF and ASV can be combined to form a central signal generator system in a plant.
Aveley Electric Ltd., Roebuck Road, Chessington, Surrey.
WW307 for further details



Solid State Devices

Bourns (Trimpot) act as U.K. representatives for Precision Monolithics, who announce a series of low input current operational amplifiers called SSS 108A. These amplifiers are directly interchangeable with the existing 108/108A types but offer an improved input noise voltage. Bourns also announce the availability of a series of d.c.-d.c. converters by Ohmic S.A. (a Bourns affiliate). Designated the HCC25/2 × 15 the basic unit has an output voltage rating of 2 × 15V at 250mA for a 25V ±3V input. Also from Ohmic is a pair of voltage regulators, models HAC 50 and HAC 51. These are complementary devices in as much as the HAC 50 provides a regulated voltage range from +10 to +30V and the HAC 51 from −10 to −30V.

Finally Semmech, also represented by Bourns, have produced a series of radiation resistant silicon rectifiers designated R1-4 featuring a p.i.v. of 100-400V d.c. and a forward current of 1.0A, together with a series of low current fast recovery rectifiers, series F1-5. Bourns (Trimpot) Ltd., Hodford House, 17/27 High Street, Hounslow, Middx.
WW 318 operational amplifiers
WW 319 d.c.-d.c. converters
WW 320 voltage regulators
WW 321 R1-4 rectifiers
WW 322 F1-5 rectifiers

Diodes feature strongly in the list of new semiconductors from Mullard and include three new Gunn effect families. These are Types CXY16, CXY17 and CXY18 developed to cover bands from 4 to 18GHz when mounted in suitable cavities.

A zener diode family with a dissipation of 15W is available, designated type BZV15. The diodes have been produced in a logarithmic series of preferred values from 10 to 75V ±5% and are encapsulated in a new rectangular form with a metal plate on one side to aid dissipation.

A diode array for thick or thin film circuits consists of two series-connected devices with a third pin connection to a common anode (BAW56), a common cathode (BAV70) or, in the BAV99, at the anode/cathode point of the series circuit.

Four Darlington transistors with a maximum current rating of 1A are announced by Mullard. Types BSS50, BSS51 and BSS52 have high gains and short turn-off times. Minimum *hFE* is 1500 at 500mA. The fourth, type BCX21 has a minimum *hFE* of 2000 at 150mA. All these devices are encapsulated in a metal TO-39 (short lead TO-5) can. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.
WW 323 Gunn effect diodes
WW 324 Zener diodes
WW 325 Film diode array
WW 326 Darlington transistors

Among the Teledyne Philbrick new products is a low cost, fast settling operational amplifier, Model 1324, with a bandwidth of 10MHz and packaged in a TO-100 case. An expansion of the 1400 series of f.e.t. operational amplifiers is also announced, based on the existing 1421 general purpose device. Nineteen devices in all have been added.

Complementing the 1400 series are two f.e.t. instrumentation amplifiers, models 4253 and 4253/01. The former has single resistor gain selection and an inbuilt output offset capability of ±10V. Also from Teledyne is the 4702 F-to-V which is a modular frequency to voltage converter complementing the function of the 4701 V-to-F, a voltage to frequency converter. Teledyne Philbrick, Chandler House, Knaphill, Woking, Surrey GU21 2NP.
WW 314 1324 op-amp
WW 315 1400 f.e.t. op-amp series
WW 316 instrumentation amplifiers
WW 317 frequency/voltage converter

Among this month's crop of devices from Motorola Semiconductors are four additions to the high threshold logic family (MHTL). These are the MC686, a four-bit shift register; MC684, a decade counter; MC685, a binary counter and the MC688, a dual J-K flip-flop. Also among the digital products are the MC10165 high speed 8-input, priority encoder which is an addition to the MECL 10000 family.

A fast response PIN diode, the MRD500 has been made available. Sensitive throughout the visible and near infra-red spectral range it has a minimum radiation sensitivity of 1.2A/mW/cm^2.

Three high-current triac ranges with current capacity from 235 to 470A and voltage ratings from 100 to 1500V are now available. These are the MCR235 series with a current rating of 235A r.m.s. over the quoted voltage rating, the MCR380, accepting 380A, and the MR470 which will carry 470A over a voltage range from 200 to 1300V. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx.
WW 328 shift register
WW329 decade counter
WW 330 dual J-K flip-flop
WW 332 priority encoder
WW 333 pin diode
WW 334 triacs

Burr-Brown have introduced three devices. The first is an i.c. multiplier/divider giving a guaranteed accuracy of 1% without external components being required. This device is designated the 4203K and is one of a family offering slightly differing facilities. The second is a 16-bit d.a.c., the DAC45. This converter is designed primarily for use in high resolution servo mechanism controllers, programmable instruments and automatic measurement equipment and has low drift characteristics. The final device is a low cost f.e.t. operational amplifier series designated 3522 packaged in a TO-99 case. Principal features include internal frequency compensation, output short circuit protection and input protection up to the supply voltage. Burr-Brown International Ltd, 25A King Street, Watford WD1 8BY.
WW 335 multiplier/divider
WW336 d.a.c.
WW 337 f.e.t. operational amplifier

March Meetings

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

LONDON

1st. RTS — "Philips LDK5 colour camera" by M. Cosgrove at 19.00 at I.B.A., 70 Brompton Rd., SW3.

5th. IEE — Colloquium on "Digital and distributed filters" at 10.30 at Savoy Pl., WC2.

7th. IERE — Colloquium on "Optical communications" at 14.30 at 9 Bedford Sq., WC1.

7th. BKSTS — "A survey of TV reproducing systems" by W. Kemp at 20.30 at the National Film Theatre, South Bank, Waterloo, SE1.

8th IEE — "Electronic aids in archaeology" by Dr. E. T. Hall at 17.30 at Savoy Pl., WC2.

8th. RTS — "More digits for television communications" by Peter Michael at 19.00 at I.B.A., 70 Brompton Rd., SW3.

8th. IEE Grads — "Some novel semiconductor photo-detectors and their application to the measurement of temperature" by M. J. Hampshire at 18.00 at Thames Polytechnic, School of Electrical & Electronic Engineering, Riverside House Annexe, Beresford St., SE18.

8th. IERE — "The feedback classroom" by K. Holling at 18.00 at 9 Bedford Sq., WC1.

9th. IEE — Colloquium on "Thin-film optical waveguides" at 10.30 at Savoy Pl., WC2.

12th. IEETE — "Air navigation, radar and radio approach aids: aerodrome ground lighting and control systems" by R. G. Barnard and A. M. S. Hurrell at 18.00 at the IEE, Savoy Pl., WC2.

13th. AES — "Microphones and sound control equipment in television" by John Tasker at 19.15 at the IEE. Savoy Pl., WC2.

14th. IEE/IERE — Colloquium on "Image techniques in medicine and biology" at 10.00 at 9 Bedford Sq., WC1.

14th. SEE — Symposium on "Packaging test instrumentation and measurement" at 15.00 at Imperial College, SW7.

16th. IEE/I.Phys. — Colloquium on "Solid state microwave amplifiers" at 10.30 at Savoy Pl., WC2.

19th. IEE — "The 60MHz FDM system" by L. J. Bolton, J. M. Weller and H. L. Bakker at 17.30 at Savoy Pl., WC2.

21st. R.I.Navigation — "Developments in aircraft equipment which affect accuracy, reliability and integrity" by S. S. D. Jones at 17.00 at Royal Inst. of Naval Architects, 10 Upper Belgrave St, SW1.

21st. IEE — "Opto-electronics" by Prof. E. A. Ash at 17.30 at Savoy Pl., WC2.

21st. IEE/I.Phys. — "Electron beam/semiconductor devices" at 17.30 at Imperial College.

22nd. IEE — "Uncertainties and confidence in measurement" by F. L. N. Samuels at 17.30 at Savoy Pl., WC2.

22nd. SERT — "Magnetic recording" by Dr. B. Speedy at 19.00 at 9 Bedford Sq., WC1.

23rd. IEE — "Microwave landing guidance system using the Doppler technique" by J. M. Jones and F. G. Overbury at 17.30 at Savoy Pl., WC2.

26th. IEE — Discussion on "The stability of microwave oscillators" at Savoy Pl., WC2.

27th. IEE/IERE — Colloquium on "Arrhythmia recognition and detection" at 14.30 at 9 Bedford Sq., WC1.

28th. IERE — Colloquium on "Secondary radar in maritime applications" at 14.30 at 9 Bedford Sq., WC1.

29th. IEE — "Up to, and onwards from, TXE1 (Leighton Buzzard): the evolution of a telephone system" by J. B. Warman at 17.30 at Savoy Pl., WC2.

ABERDEEN

6th. IEE/IERE — "Seismological measurements" by Dr. P. L. Willmore at 19.30 at Robert Gordon's Institute of Technology, St. Andrews St.

BATH

7th IEE/ IERE — "Sound in syncs" by Dr. C. J. Dalton at 19.00 at the University, Room 2E.3.1.

14th IERE — "Modern dynamic measurement techniques" by Dr. J. D. Lamb and Dr. P. A. Payne at 19.00 at the University, Room 2E.3.1.

BEDFORD

21st. IEE — "Artificial organs — an introduction to bio-medical engineering" by J. A. S. Crawford at 19.45 at County Hotel.

BIRMINGHAM

26th. IEE/IERE — "Sonar and underwater acoustic communications" by V. G. Welsby at 18.00 at MEB Offices, Summer Lane.

BRIGHTON

6th. IEE — "Data collection systems" by V. Cornelius at 18.30 at the Polytechnic.

6th. IERE — "Advances in MOS technology" by Dr. D. R. Lamb at 18.30 at the Technical College.

CAMBRIDGE

8th. IEE — "Photocathodes" by Prof. A. H. W. Beck at 18.30 at University Engineering Dept., Trumpington St.

22nd. IEE — "Millimetric waveguides for tomorrow's telecommunications" by R. H. White at 18.30 at the University Engineering Dept., Trumpington St.

CARDIFF

7th. SERT — "Television studio techniques" by R. Stinton at 19.15 at Llandaff College of Technology, Western Avenue.

19th. IEE/IERE — "Modern measurement techniques in control engineering" by Dr. J. D. Lamb and Dr. P. A. Payne at 18.00 at UWIST.

CHATHAM

1st. IERE — "Opto-electronics" by D. A. Bonham at 19.00 at the Medway College of Technology.

CHELTENHAM

21st. IEE/RAeS — "Navigation systems" by C. Fowler at 19.30 at St. Mary's Lecture Hall, The Park.

CLEETHORPES

21st. IEE/G.Inst.SE — "Radio astronomy" by R. S. Booth at 19.30 at the Floral Hall.

COLCHESTER

14th. IERE — "Acoustic surface waves — the prospects for device applications" by Prof. E. A. Ash at 18.30 at Dept. of Electrical Engineering, University of Essex, Wivenhoe Park.

28th. IEE — "A trip in telecommunications" by H. B. Law at 18.30 at the University of Essex, Wivenhoe Park.

EDINBURGH

7th. IEE/IERE — "Seismological measurements" by Dr. P. L. Willmore at 19.00 at Napier College of Science and Technology, Colinton Road.

EXETER

22nd. IEE — Faraday lecture on "Navigation — land, sea, air and space" by Dr. A. Stratton at 19.00 at the University.

FAREHAM

12th. IERE — "Modern dynamic measurement techniques" by Dr. J. D. Lamb and Dr. P. A. Payne at 18.30 at HMS Collingwood.

FARNBOROUGH, Hants.

29th. IERE — "Aspects of stereo broadcasting" by J. H. Brookes at 19.00 at the Technical College.

GLASGOW

8th. IEE/IERE — "Seismological measurements" by Dr. P. L. Willmore at 19.00 at the College of Technology, North Hanover Street.

21st. IEE — "50 years of broadcasting" by J. Redmond at 19.00 at the Boyd Orr Building, the University.

28th. IEE — "The induction and development training of engineer graduates in the Post Office" by M. Mitchell at 18.00 at Rankine House, 183 Bath St.

HEMEL HEMPSTEAD

1st. IEE — "Integrated circuits for leisure and pleasure" by I. J. A. Brown at 19.30 at Dacorum College.

HULL

21st. SERT — "Rediffusion colour television" by M. C. Mahony at 19.30 at E. H. Bullock Lecture Theatre, College of Technology, Queens Gardens.

IPSWICH

21st. IEE/IERE — "The transistor: its history and consequences" by E. Wadham at 18.30 at Lecture Theatre 2, The Civic College.

LEEDS

6th. IEE — "Electronics in crime detection" by A. T. Torlesse at 18.30 at the University.

13th. IEE Grads — "Hi-fi today" by G. T. Hathaway at 19.00 at the University.

29th. IERE — "Radio communication within the North Eastern Gas Board" by R. Grant at 19.30 at N.E. Gas Board, New York Road.

LEE-ON-SOLENT

19th. IEE — "Training avionics technicians" at 18.30 at HMS Daedalus.

LEICESTER

20th. IERE — "Application of digital logic" by I. D. Brown and S. L. Norman at 18.45 at Lecture Theatre A, Physics Block, the University.

LINCOLN

15th. SERT — "Stereophonic sound" by P. Harvey at 19.30 at Forge Restaurant, 1 West Parade.

LIVERPOOL

7th. IERE — "Systems control in the electricity supply industry" by Dr. J. T. Boardman at 19.00 at Dept. of Electrical Engineering and Electronics, the University.

19th. IEE — "New concepts in computer process control" by A. L. Stott at 18.30 at Electrical Engineering Dept., the University, Brownlow Hill.

LOWESTOFT

27th. BAS/SUT — "Sonar in fisheries" at Fisheries Research Lab.

MALVERN

13th. IERE — "Telecommunications in the year 2000" by A. G. Hare at 19.30 at Abbey Hotel.

15th. I.Phys. — "Photon correlation methods" at 13.45 at the Royal Radar Establishment, St. Andrews Rd.

MANCHESTER

13th. IEE — "Nickel cadmium alkaline battery" by D. Fraser at 18.15 at Lancs County Cricket Club, Talbot Rd., Old Trafford.

28th. IEE/IERE — "Satellite communication systems" by Lt. Cdr. B. E. Collins, at 18.15 at Lecture Theatre RG7, Renold Building, UMIST.

29th. SERT — "Integrated circuits for motor vehicles" by B. Shepherd at 19.30 at Room D7, Renold Building, UMIST.

MIDDLESBROUGH

27th. SERT — "Electronic ignition" by W. Norrie at 19.30 at the Cleveland Scientific Institution, Corporation Rd.

NEWCASTLE UPON TYNE
5th. IEE — "Conversations with computers" by C. R. Evans at 18.30 at the University of Newcastle-upon-Tyne, Room M421.
14th. IERE — "A communication and control system for motorways" by E. H. Walker at 18.00 at Main Lecture Theatre, Ellison Building, the Polytechnic.
19th. IEE Grads. — "Making electronic music" by G. Rodgers at 18.30 at the University of Newcastle-upon-Tyne.

NORWICH
7th. IEE/IERE — "Video recording" by D. M. Bowd at 19.30 at The Audio Visual Centre, University of East Anglia.

NOTTINGHAM
13th. IEE Grads. — "How to see in the dark" by R. Hodgson at 19.30 at Tower Block Lecture Theatre, the University.

PLYMOUTH
13th. IEETE — "Satellite communications" by V. C. Meller at 19.30 at the Post Office.

READING
13th. IERE — "Modern dynamic measurement techniques" by Dr. J. D. Lamb and Dr. P. A. Payne at 19.30 at The J. J. Thomson Physical Laboratory, University of Reading, Whiteknights Park.

ROTHERHAM
6th. SERT — "Thyristors and their application in adjustable speed drives and power controllers" by P. A. Bennett at 19.15 at the College of Technology, Howard St.

RUGBY
20th. IEE Grads. — "Artificial organs" (biomedical) by R. N. Mornsey at 18.15 at Lanchester Polytechnic.
28th. IEE — "Instrumentation in vehicle research and development" by T. R. Aston at 18.15 at Lanchester Polytechnic.

SHEFFIELD
27th. IEE — Faraday lecture on "Navigation — land, sea, air and space" by A. Stratton at 19.00 at the City Hall.

SOUTHAMPTON
14th. IEE/IERE — "Communication UHF modules" by P. Tunbridge at 18.30 at Lanchester Theatre, the University.
21st. IEE/IERE/IEETE — "Application of control to artificial limbs" by Prof. J. M. Nightingale at 18.30 at Lanchester Theatre, the University.

WEYMOUTH
22nd. IEE — "Numerical control of machine tools" by T. E. Zombory-Moldovan at S. Dorset Technical College.

Portable Oscilloscopes

Additions to last month's review

The following information became available too late for inclusion in the main review, published in our February issue. We have selected five instruments from the large Telequipment range, referring, where possible, to the missing types. "*Y* extension", which was referred to in the February article, is a measure of the horizontal distance over which the *y* amplifier rise-time is extended at maximum sweep speed.

TELEQUIPMENT

Serviscope Minor (single-trace): **bandwidth** 0-30kHz; **sensitivity** 100mV/div; **timebase** 10ms/div-100μs/div; ***y* ext.** 0.5mm; **trigger** automatic; **e.h.t.** 600V; **display** 10 × 10 divs (each 4.2mm); **power** a.c.; **dimensions** 14.5cm.W, 16.2cm.H, 24.8cm.D; **weight** 2.25kg; **price** £30.

A very small, light instrument primarily intended for teaching. It has simplified controls, triggering being completely automatic. The display is fairly small and the timebase is slow. It is capable, however, of displaying most phenomena encountered in the initial teaching of electrical theory. It is the cheapest instrument we have found.

S54U (single-trace): **bandwidth** 10MHz; **sensitivity** 10mV/cm; **timebase** 5s/cm-200ns/cm; **mag** ×5; ***y* ext.** 8.75mm; **trigger** source, slope, level, auto, t.v.; **e.h.t.** 4kV; **display** 10 × 6cm; **power** a.c. or d.c. (11.5-30V) or int. batteries (3 hours); **dimensions** 17cm.W, 24cm.H, 45cm.D; **weight** 11.3kg; **price** £190 with batteries.

An instrument for general use, possessing a fast, expanded, sweep. F.e.t. input circuitry is used for rapid availability from cold. Mains-powered and rack-mounted versions are available at £125 and £140, and the D54 is a dual-trace version at £160.

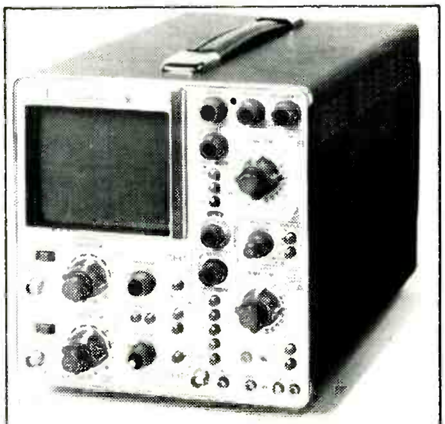
DM64 (dual-trace storage): **bandwidth** 10MHz; **sensitivity** 10mV/cm; **mag.** ×10; **modes** single, alt. chopped, summed, ch.2 inverted, *x-y;* **timebase** 5s/cm to 100ns/cm; **mag** × 5; ***y* ext.** 1.75cm; **trigger** source, slope, coupling, level, single-shot, t.v.; **e.h.t.** 3.5kV; **display** 10 × 8cm; bistable storage tube; **power** a.c.; **dimensions** 21cm.W, 24cm.H, 37cm.D; **weight** 12.5kg; **price** £320.

One of the two storage oscilloscopes in the survey, with a choice of storage modes. A very fast expanded sweep is provided, and the *x-y* facility, selected by the timebase switch, operates with less than 1° phase error at 100kHz.

D66 (dual-trace): **bandwidth** 25MHz; **sensitivity** 10mV/cm (1mV/cm at 15MHz); **sig.delay** 200ns; **modes** single, alt. chopped, summed, ch.2 inverted, *x-y*; **timebase** 5s/cm to 100ns/cm; **mag** ×5; ***y* ext.** 7mm; **trigger** source, coupling, slope, level, single-shot, t.v.; **e.h.t.** 10kV; **display** 10 × 8cm; **power** a.c.; **dimensions** 21cm.W, 24cm.H, 37cm.D; **weight** 11.5kg, **price** £225.

A high-performance oscilloscope for wide general use on most types of equipment. The signal delay makes possible the investigation of fast pulses. A similar instrument is the D65, which has a bandwidth of 15MHz at 10mV/cm and a c.r.t. accelerating voltage of 4kV. The price is £195.

D67 (dual-trace): **bandwidth** 25MHz; **sensitivity** 10mV/cm; **sig.delay** 200ns; **modes** single, alt, chopped, summed, ch.2 inverted; **timebase A** (main delaying) 5s/cm to 200ns/cm; **trigger** auto, single-shot plus usual facilities; **timebase B** (delayed) 5s/cm to 200ns/cm.; **mag (both)** ×5; **trigger** B trig.by A, B trig.gated by A; **modes** A, A intensified by B, B del. by A; ***y* ext** 3.5mm; **e.h.t.** 10kV mesh; **display** 10 × 8cm; **power** a.c.; **dimensions** 21cm.W, 24cm.H, 44cm.D; **weight** 11.5kg; **price** £295.



Telequipment D67.

A similar instrument to the D66, but with the added facility of a delaying sweep. The timebase is slower, but still adequate, and the instrument is suitable for work on all types of digital and analogue circuitry. The use of push-buttons for timebase and *y* amplifier mode selection in this and other instruments has reduced the front-panel clutter considerably.

Errata. One or two small errors crept into the review, for which we apologize.
The **Tektronix 485** has a bandwidth of 350MHz, not 300MHz.
The **Hewlett-Packard 1206** should be included with the single-trace models, and the range of prices of the 1200 series is £392-565.

Literature Received

For further information on any item include the WW number on the reader reply card

ACTIVE DEVICES

The 534-page "Integrated Circuits Manual 1973" containing details and specifications of the range of t.t.l., e.c.l. and m.o.s. digital i.cs, also commercial and industrial analogue i.cs currently available from Siemens (U.K.) Ltd. Great West House, Great West Road, Brentford, Middlesex WW401

Two data sheets describing a range of "Uni-tunnel" tunnel diodes with characteristics claimed to be ideal for low-power industrial and military application such as computer logic, modulators, detectors, tunnel diode amplifiers and oscillators. clamping and limiting circuits are:

700-4, device type 1N3539-3543 inc (TO-18) WW402
700-6, device type U1001-1010 inc (DU-17) WW402

Joseph Lucas (Electrical) Ltd, Electronics Product Group, Mere Green, Sutton Coldfield, Warwickshire.

A short-form catalogue listing the range and prices of transistors, diodes, power supply modules, a.f. amplifier modules and digital i.c. test equipment received from Semiconductor Supplies (Croydon) Ltd, 55 Whitehorse Road, Croydon, Surrey CR0 2JG WW404

A condensed catalogue of silicon rectifiers manufactured by Semtech giving brief details of the range of "Metoxilite" rectifiers and voltage regulators, high voltage, high current and power diodes, bridges and multipliers is available from Bourns (Trimpot) Ltd. Hodford House. 17-27 High Street, Hounslow, Middlesex WW405

Details of semiconductor products manufactured by Solid State Scientific Inc. of America are available in three data brochures:

"Quick reference r.f. power-frequency chart" describing transistor power amplifier performance for devices designed to operate over the range 100MHz to 1000MHz with output power from 1W to 50W. Device physical characteristics are also shown WW406
"Data book of c.m.o.s. integrated circuits" gives electrical characteristics for digital i.cs in the SCL4000A, SCL4400A and SCL5000 series of elements WW407
"C.M.O.S.", a quick reference brochure to the above in terms of the most common types, shows basic logic functions generated by devices of different type number WW408

Impectron Ltd, Impectron House, 23-31 King Street, London W.3.

A comprehensive short-form catalogue details the range of products available from both English Electric Valve Co. and the M-O Valve Co. covering, in one publication, the range of transmitting, receiving, microwave and cathode ray tubes, power control and electro-optical devices, microwave components and other special products. The G.E.C. Electronic Tube Co. Ltd, Waterhouse Lane, Chelmsford, Essex CM1 2QU WW409

PASSIVE DEVICES

Radio frequency filters covering tubular and lumped element low pass (5MHz-5GHz), tubular, lumped element, cavity and waveguide bandpass (5MHz-18GHz), mechanically and electrically tunable bandpass (50MHz-4GHz) filter characteristics, is the subject of a brochure from Texscan Instruments Ltd, 1 Northbridge Road, Berkhamsted, Hertfordshire WW410

A 20-page catalogue describing the complete range of electromagnetic delay lines includes dual-in-line, continuously variable, low profile and standard p.c. mounting, subminiature nanosecond, tapped, lumped constant and extended delay/rise time types and a discussion on custom-designed delay lines. G.E. Electronics (London) Ltd, Eardley House, 182-184 Campden Hill Road, Kensington, London W8 7AS WW411

Subminiature and miniature coaxial connectors is the subject of a catalogue giving mechanical dimensions and some r.f. characteristics of Microclic, Subvis, Subclic, SMA, BNC, TNC, u.h.f., N, C, HN and LC types of connector. Some detail of coaxial cables is also included. Radiall, 101 rue Philibert Hoffman, Zone Ind, 93-Rosny s/bois, France WW412

The "Venture" range of high speed electromagnetic impulse counters covers resettable and non-resettable types with three, four, five or six figures, counting rates of up to 3000 per minute, a.c. or d.c. working, multigroup assemblies and plug-in module types. Smiths Industries Ltd, Industrial Instruments Division, Waterloo Road, Cricklewood, London NW2 7UR WW413

"Connections and Connection Systems" is the title of the 1973 catalogue giving mechanical and electrical specification of the range of multiway edge, wire wrapping, low force and a claimed "unique" flat cable connecting system utilizing a standard one-inch wide flat cable. Ferranti Ltd, Dunsinane Avenue, Dundee, Scotland WW414

"Hybrex" silicon dioxide chip capacitors for microcircuit use, providing low temperature coefficient and dissipation factor, single or five electrode geometries and configurations which are compatible with silicon diodes, transistors and integrated circuits are the subject of a brochure from Burr-Brown International, 25A King Street, Watford, Herts WD1 8BY WW415

Bulletin 1058 gives technical details for the use of "Radiax TM" slotted coaxial cable in communications systems employing the controlled leakage of r.f. from concealed transmission line. Consideration is given to the system design problem and specifications are given for six different types of cable covering a wide range of possible installations. Andrew Antenna Systems, Lochgelly, Fife, Scotland WW416

The Maury MT7119A, liquid nitrogen cooled, cryogenic termination which may be used for carrying out noise temperature measurements in a variety of applications including radio receiver and aerial system calibration, maser and parametric amplifier noise evaluation over the frequency range d.c. to 8.5GHz, is the subject of a data sheet from Tony Chapman Electronics Ltd, 3 Cecil Court, London Road, Enfield, Middlesex WW417

EQUIPMENT

A data sheet is concerned with broadband isotropic radiation detection equipment for the monitoring of near and far field power densities over the frequency range of 300MHz to 18GHz with a maximum full scale deflection of 20W/cm^2 and a dynamic range of 23dB. Aveley Electronic Ltd. Roebuck Road, Chessington, Surrey KT9 1LP WW418

Two short-form catalogues dealing with data processing equipment and instrumentation are from:

Ithaco, manufacturers of hydrophones, lock-in amplifiers, instrumentation amplifiers and pre-amplifiers, filters and automatic data acquisition systems WW419
M.F.E. Corporation, who deal with display and data translating equipment such as strip chart recorders, digital printers, X/Y recorders, torque motors, angular transducers, galvanometers, Teletype projectors, graphic translators and linear actuators WW420

Techmation Ltd, 58 Edgware Way, Edgware, Middx.

A brochure describing plug-in disc, fixed head mass memory systems having an average access time of 16.7 milliseconds and a capacity range of 32,000 to 1,000,000 words, was received from Data Disc Inc, 686 West Maude Avenue, Sunnyvale, California 94086 ....WW421

A descriptive leaflet about a special series of five sound selector units which select or direct connections for a number of stereo headphones, speakers or amplifiers in suitable combinations, is available from Tape Recorder Spares Ltd, 206-210 Ilderton Road, London SE15 1NS WW422

A 28-page catalogue describing the manufactured range of power supplies, covering hybrid thick film regulators, preset, variable, programmable and high current units, also carriers for multiple assemblies in standard 19-inch rack mounting. Lambda Electronics, Marshlands Road, Farlington, Portsmouth PO6 1ST WW423

The TK28 telecine camera in which three tubes are used (vidicon or lead-oxide) and containing automatic colour balance, one of several camera devices for improving the quality of reproduced cine film, is the subject of a brochure from R.C.A., Communications System Division, Camden, New Jersey, 08102, U.S.A. WW424

A leaflet has been received describing the PM1 phasemeter, an instrument with a meter readout registering differential phase of between 0 and 180° (lead or lag shown on front panel lamps) for input voltages of between 20mV and 250V r.m.s. over a frequency range of 10Hz to 100kHz. Farnell Instruments, Sandbeck Way, Wetherby, Yorkshire LS22 4DH WW425

APPLICATION NOTES

An application note showing that if the significant differences between photometric and radiometric terms, as related to light sources and photodetectors, are understood, meaningful measurement of major optical parameters can be obtained by a relatively simple approach using a calibrated transfer standard and other readily available electronic test equipment. Joseph Lucas (Electrical) Ltd, Electronics Product Group, Mere Green Road, Sutton Coldfield, Warwickshire WW426

A model control application of integrated circuit type ZN403E providing a high performance proportional control servo amplifier which is adaptable to almost any digital decoding system is described in brochure ESA440172 from Ferranti Ltd, Gem Hill, Chadderton, Oldham WW427

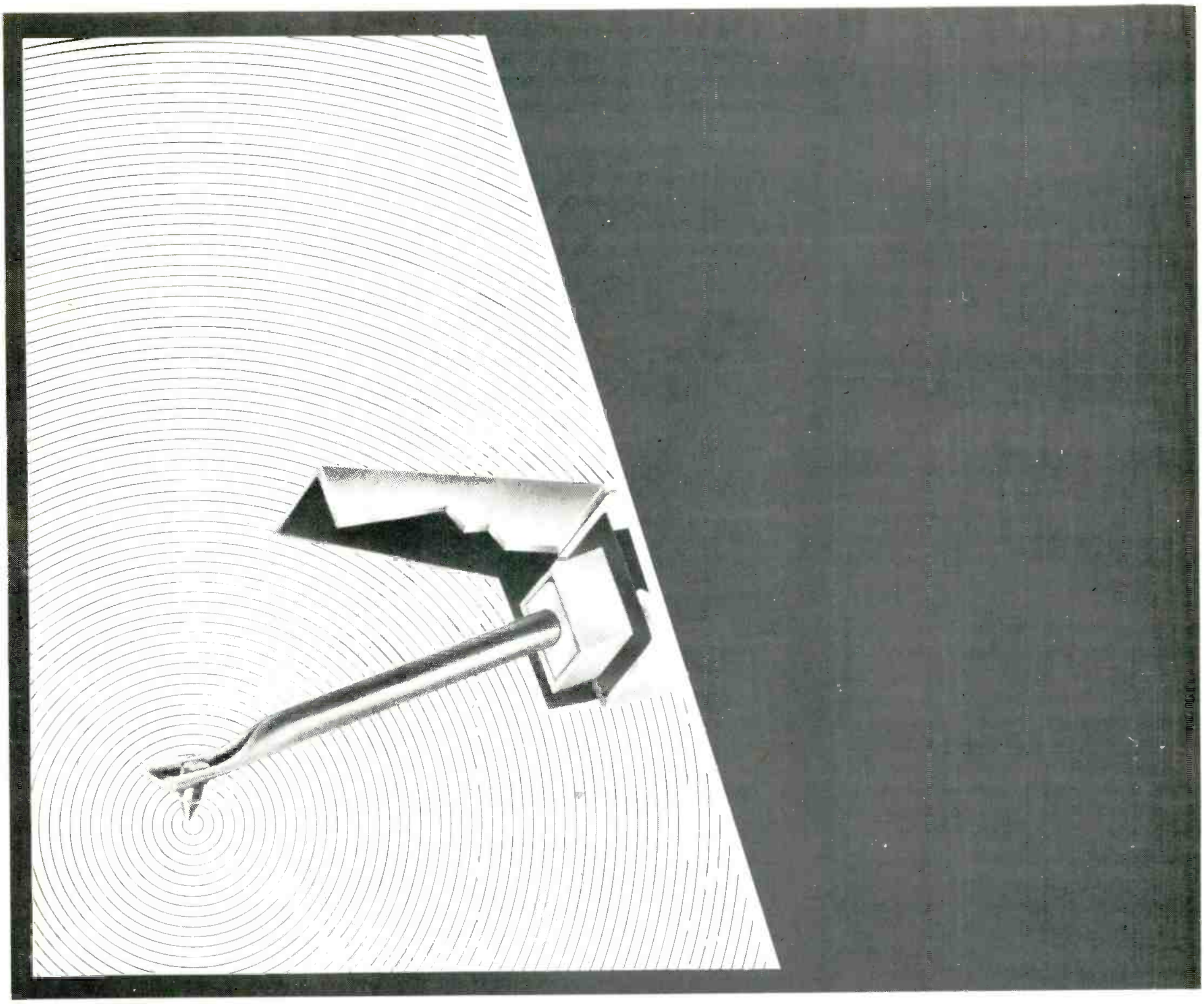
GENERAL INFORMATION

A leaflet detailing a printed circuit manufacturing service covering printed circuit artwork, the latest technique for producing stencils in screen printing, profile cutting, drilling, inspection and assembly was received from K. J. Bentley and Partners Ltd, 18 Greenacres Road, Oldham, Lancs. WW428

The 1973 catalogue of electronic components including additions such as high power voltage regulators, light emitting diodes, contact fluid pens, audible warning devices, dual-in-line switches and crossover networks can be obtained from R. S. Components Ltd, P.O. Box 427, 13-17 Epworth Street, London EC2P 2HA WW429

Single copies of the "Bulletin of Special Courses 1973" Part 2 contain information about full and part time courses held in the spring and summer educational terms at colleges and other institutions in the London and Home Counties region, and can be obtained for 60p (post free U.K. only) from The Secretary, Regional Advisory Council, Tavistock House South, London WC1 9LR.

A wide range of gas torches for soldering, brazing, welding and cutting, manufactured by Allanter Instruments Ltd, is illustrated in a brochure showing the five basic torch units and numerous other attachments from Microflame (U.K.) Ltd, Abbots Hall, Ricking Hall, Diss, Norfolk WW430



Straight talk about a stylus

Listen carefully and you will hear someone call a stylus . . . "the needle." We would like to go on record, so to speak, as observing that the Shure stylus of today bears no more resemblance to a needle than it does to a six-inch nail. In fact, it is probably the most vitally important, skillfully assembled, and critically tested component in any high fidelity system. It must maintain flawless contact with the undulating walls of the record groove—at the whisper-light tracking forces required to preserve the fidelity of your recordings with repeated playings. Our new High Fidelity Products catalogue abounds with helpful stylus information, and of course, describes the superb line of Shure pickups for your consideration. For your copy, post the coupon. Write:

Shure Electronics Limited, 84 Blackfriars Road, Dept. E/3
London SE1 8HA Telephone (01) 928 3424

Please send me a copy of the free Shure High Fidelity Products catalogue.

NAME

ADDRESS

SHURE

WW—082 FOR FURTHER DETAILS

Sinclair Project 60

Now–the Z.50 Mk.2

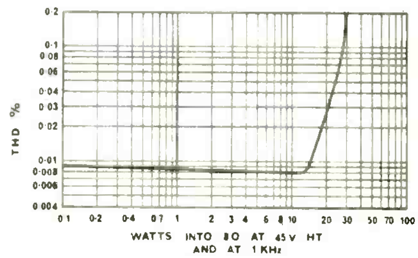
with built-in automatic transient overload protection

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.

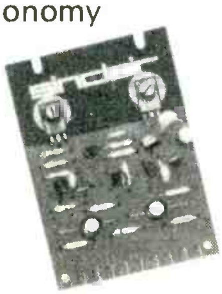
with free manual
£5.48

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



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

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.

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.

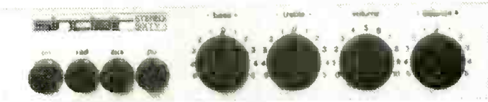
Each Project 60 module is tested before leaving our factory and is guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you. If it is returned within two years from the date of purchase. Outside this period of guarantee a small charge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

sinclair

WW—083 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**

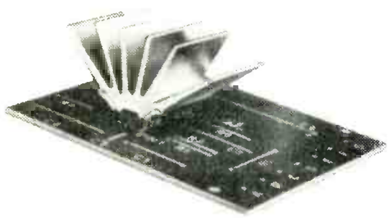
Project 60 Stereo F.M. Tuner

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

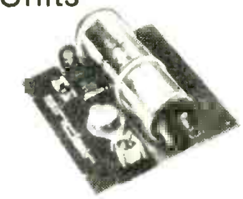
Output power: 6 watts RMS continuous (12 watts peak). 6–8Ω. **Frequency Response:** 5Hz to 100KHz ± 1dB. **Total Harmonic Distortion:** Less than 1%. (Typical 0·1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal.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

Please send ________
I enclose cash/cheque/money order.
Name ________
Address ________

SINCLAIR RADIONICS LTD., LONDON ROAD, ST. IVES, HUNTINGDONSHIRE, PE17 4HJ

sinclair

WW—084 FOR FURTHER DETAILS

ESI Nuclear

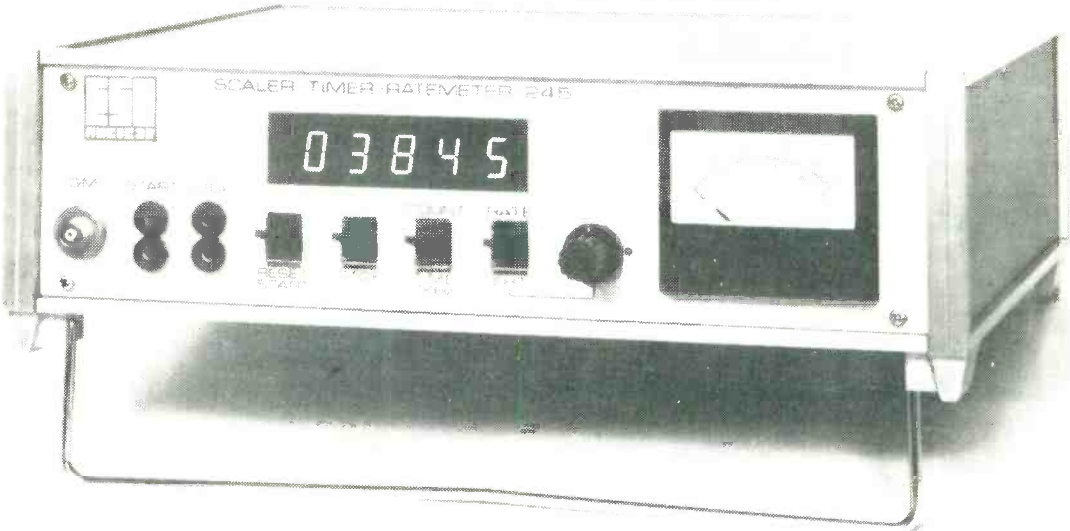
For use in schools in Nuffield 'O' and 'A' Level experiments

Scaler-Timer & Ratemeter 245

OFFERS

- Large, clear seven-segment display of all five digits.
- Built-in ratemeter and loudspeaker with volume control.
- Built-in gating circuits for timing experiments using phototransistors or contacts.
- Meter indication of EHT voltage.
- Automatic reset on start initiation.
- Separate key for stop.
- Built-in timing pulse generator.
- Integrated circuits used throughout.
- Complete range of accessories available.

PRICE £79.00



For full details and specifications contact:

ESI Nuclear
2 Church Road
Redhill
Surrey
Tel: Redhill 64993
(STD Code 0737)
An associate company of
Edwards Scientific International Ltd.
Mirfield, Yorkshire.

WW—088 FOR FURTHER DETAILS

PORTABLE VHF TRANSCEIVER

MODEL: TTR-21

Easy-handling, superb performance!!

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.

(150MHz, 1W)

TOYOCOM

TOYOCOM
TOYO COMMUNICATION EQUIPMENT CO., LTD.

EXPORT DEPARTMENT
TOYO BUILDING NO 6-12-20 JINGUU MAE SHIBUYA-KU TOKYO JAPAN
CABLE EXPORTOYOCOM-TOKYO
TEL (03) 406-3355
TELEX 02423001

WW—086 FOR FURTHER DETAILS

Valradio

The Marine Valradio range of Transvertor are designed for operating low voltage DC battery equipment. Models are also available for AC equipment. Dual 110v and 220v DC available as standard as well as single voltage units.

Type	Input	Output	Price
CR110/220/60RT	110/220	12v 5A smoothed or 24v 2.5A DC	£66.00
CR110/220/12T	110/220	12v 10A Smoothed DC	£88.00
C110/220/60S	110/220	115 & 230v sine wave 60 watts	£70.40
C220/200S	220	115 & 230v sine wave 200 watts	£101.20

Other similar units available to operate from 12, 24, 32 & 50V DC and outputs of from 30W to 750W in square, sine wave or DC.

Send for information leaflet WC13.

VALRADIO LIMITED
BROWELLS LANE, FELTHAM, MIDDX. TW13 7EN
TEL: 01 890 4242/4837

WW—107 FOR FURTHER DETAILS

Would you spend an hour a day to earn more money in Electronics-Television-Radio?

If you're willing to give up one hour or more a day we can help you get into the lucrative growth industries of electronics, television, radio.

And if you're already *in*, we can help you get on!

With our know-how and our wide experience in teaching, plus your determination to study, we can turn your interest into the technical knowledge you need for success. Once you've got the qualifications you need, you'll be in a good position to take full advantage of the opportunities which exist today in all fields of electronics – in television (colour and black/white) and in radio. (We teach you the theory and practice of valve and transistor portable circuits while you build your own 5 valve receiver, transistor portable and high grade test instruments).

With ICS you study at home – at your own pace, when *you* choose, in the time you've got available. Your ICS tutors will give you all the help and encouragement you need to pass any exams you want to take.

Don't waste another day. Take your first step *now* towards a better paid, more assured future. Send for your FREE Careers Guide today.

ICS your key to the door of opportunity

Tick or state subject of interest and post to:
International Correspondence Schools, Dept. 234 D,
Intertext House, Stewarts Road, London SW8 4UJ.

Subject of interest ______

- ☐ Society of Engineers Graduateship (Electrical Engineering)
- ☐ C & G Telecommunications Technicians Certificates
- ☐ C & G Electrical Installation Work
- ☐ C & G Certificate in Technical Communication Techniques
- ☐ MPT General Certificate in Radio Telegraphy
- ☐ Audio, Radio & TV Engineering & Servicing
- ☐ Electronic Engineering, Maintenance, Engineering systems, Instrumentation & Control systems
- ☐ Computer Engineering and Technology
- ☐ Electrical Engineering, Installations, Contracting, Appliances
- ☐ Self-build radio courses

Name ______

Address ______

______

Occupation ______ Age ______

■Accredited by the Council for the Accreditation of Correspondence Colleges■

INSIST ON VERSATOWER

Acclaimed as the World's leading telescopic tiltover tower in the field of radio communication
Models from 25' to 120'

Look for the name
STRUMECH
Strumech Engineering Co Ltd
Coppice Side, Brownhills, Walsall, Staffs.

OVERSEAS AGENCIES

Italy	I.E.G. International Eng. Group, Viale XX1 Aprile 21, Rome
W. Germany	Kurt Fritzel K.G., 6702, Bad Durkheim, Hammelstralstrasse 72.
Switzerland	Megex Electronic AG, Badenerstrasse 582, 8048 Zurich.
Sweden	Pergus AB, Box 755, S - 181 07 Lidingo 7.
Denmark	Hans Holtman, Ordrup Jagtvej 183, 2920 Charlottenlund.
South Africa	Vanrow Eng. (PTY) Ltd., P.O. Box 25601, Denver TVL, Bessemer & Wriggle Road, Johannesburg.

WW—087 FOR FURTHER DETAILS

The largest selection

BRAND NEW FULLY GUARANTEED DEVICES

AC107	0·20	AD162	0·33	BC148	0·10	BD137	0·45	BF188	0·40	OC19	0·35	2G371	0·16	2N2219	0·20	2N3054	0·46	2N4059	0·10
AC113	0·20	AD161 &		BC149	0·12	BD138	0·50	BF194	0·12	OC20	0·63	2G371B	0·12	2N2220	0·22	2N3055	0·50	2N4060	0·12
AC115	0·23	AD162 (MP)		BC150	0·18	BD139	0·55	BF195	0·12	OC22	0·38	2G373	0·17	2N2221	0·20	2N3391	0·14	2N4061	0·12
AC117K	0·20		0·55	BC151	0·20	BD140	0·60	BF196	0·14	OC23	0·42	2G374	0·17	2N2222	0·20	2N3391A	0·16	2N4062	0·12
AC122	0·12	ADT140	0·50	BC152	0·17	BD155	0·80	BF197	0·14	OC24	0·56	2G377	0·30	2N2368	0·17	2N3392	0·14	2N4284	0·17
AC125	0·17	AF114	0·24	BC153	0·28	BD175	0·60	BF200	0·45	OC25	0·38	2G378	0·16	2N2369	0·14	2N3393	0·14	2N4285	0·17
AC126	0·17	AF115	0·24	BC154	0·30	BD176	0·80	BF222	0·95	OC26	0·25	2G381	0·16	2N2369A	0·14	2N3394	0·14	2N4286	0·17
AC127	0·17	AF116	0·24	BC157	0·18	BD177	0·65	BF257	0·45	OC28	0·50	2G382	0·16	2N2411	0·24	2N3395	0·17	2N4287	0·17
AC128	0·17	AF117	0·24	BC158	0·12	BD178	0·65	BF258	0·60	OC29	0·50	2G401	0·30	2N2412	0·24	2N3402	0·21	2N4288	0·17
AC132	0·14	AF118	0·35	BC159	0·12	BD179	0·70	BF259	0·85	OC35	0·42	2G414	0·30	2N2646	0·47	2N3403	0·21	2N4289	0·17
AC134	0·14	AF124	0·30	BC160	0·45	BD180	0·70	BF262	0·55	OC36	0·50	2G417	0·25	2N2711	0·21	2N3404	0·28	2N4290	0·17
AC137	0·14	AF125	0·25	BC161	0·50	BD185	0·65	BF263	0·55	OC41	0·20	2N388	0·35	2N2712	0·21	2N3405	0·42	2N4291	0·17
AC141	0·14	AF126	0·28	BC167	0·12	BD186	0·65	BF270	0·35	OC42	0·24	2N388A	0·55	2N2714	0·21	2N3414	0·15	2N4292	0·17
AC141K	0·17	AF127	0·28	BC168	0·12	BD187	0·70	BF271	0·30	OC44	0·15	2N404	0·20	2N2904	0·17	2N3415	0·15	2N4293	0·17
AC142	0·14	AF139	0·30	BC169	0·12	BD188	0·70	BF272	0·80	OC45	0·12	2N404A	0·28	2N2904A	0·21	2N3416	0·28	2N5172	0·12
AC142K	0·17	AF178	0·50	BC170	0·12	BD189	0·75	BF273	0·35	OC70	0·10	2N524	0·42	2N2905	0·21	2N3417	0·28	2N5457	0·32
AC151	0·15	AF179	0·50	BC171	0·14	BD190	0·75	BF274	0·35	OC71	0·10	2N527	0·49	2N2905A	0·21	2N3525	0·75	2N5458	0·32
AC154	0·20	AF180	0·50	BC172	0·14	BD195	0·85	BFW10	0·60	OC72	0·14	2N598	0·42	2N2906	0·15	2N3646	0·09	2N5459	0·40
AC155	0·20	AF181	0·45	BC173	0·14	BD196	0·85	BFX29	0·27	OC74	0·25	2N599	0·45	2N2906A	0·18	2N3702	0·10	28301	0·50
AC156	0·20	AF186	0·45	BC174	0·14	BD197	0·90	BFX84	0·22	OC75	0·15	2N696	0·12	2N2907	0·20	2N3703	0·10	28302A	0·42
AC157	0·24	AF239	0·37	BC175	0·22	BD198	0·90	BFX85	0·30	OC76	0·15	2N697	0·13	2N2907A	0·22	2N3704	0·11	28302	0·42
AC165	0·20	AL102	0·65	BC177	0·19	BD199	0·95	BFX86	0·22	OC77	0·25	2N698	0·24	2N2923	0·14	2N3705	0·10	28303	0·55
AC166	0·20	AL103	0·65	BC178	0·19	BD200	0·95	BFX87	0·24	OC81	0·15	2N699	0·35	2N2924	0·14	2N3706	0·09	28304	0·70
AC167	0·20	ASY26	0·25	BC179	0·19	BD205	0·80	BFX88	0·22	OC81D	0·15	2N706	0·08	2N2925	0·14	2N3707	0·11	28305	0·84
AC168	0·24	ASY27	0·30	BC180	0·24	BD206	0·80	BFY50	0·20	OC82	0·15	2N706A	0·09	2N2926 (G)		2N3708	0·07	28306	0·84
AC169	0·14	ASY28	0·25	BC181	0·24	BD207	0·95	BFY51	0·20	OC82D	0·15	2N708	0·12		0·12	2N3709	0·09	28307	0·84
AC176	0·20	ASY29	0·25	BC182	0·10	BD208	0·95	BFY52	0·20	OC83	0·20	2N711	0·30	2N2926 (Y)		2N3710	0·09	28321	0·56
AC177	0·24	ASY50	0·25	BC182L	0·10	BDY20	1·00	BFY53	0·17	OC84	0·20	2N717	0·35		0·11	2N3711	0·09	28322	0·42
AC178	0·28	ASY51	0·25	BC183	0·10	BF115	0·24	BPX25	0·85	OC139	0·20	2N718	0·24	2N2926 (O)		2N3819	0·28	28322A	0·42
AC179	0·28	ASY52	0·25	BC183L	0·10	BF117	0·45	BSX19	0·15	OC140	0·20	2N718A	0·50		0·10	2N3820	0·50	28323	0·56
AC180	0·17	ASY54	0·25	BC184	0·12	BF118	0·70	BSX20	0·15	OC169	0·25	2N726	0·28	2N2926 (R)		2N3821	0·35	28324	0·70
AC180K	0·20	ASY55	0·25	BC184L	0·12	BF119	0·70	BSY25	0·15	OC170	0·25	2N727	0·28		0·10	2N3823	0·28	28325	0·70
AC181	0·17	ASY56	0·25	BC186	0·28	BF121	0·45	BSY26	0·15	OC171	0·25	2N743	0·20	2N2926 (B)		2N3903	0·28	28326	0·70
AC181K	0·20	ASY57	0·25	BC187	0·28	BF123	0·50	BSY27	0·15	OC200	0·25	2N744	0·20		0·10	2N3904	0·30	28327	0·70
AC187	0·28	ASY58	0·25	BC207	0·11	BF125	0·45	BSY28	0·15	OC201	0·28	2N914	0·14	2N3010	0·70	2N3905	0·28	28701	0·42
AC187K	0·20	ASZ21	0·40	BC208	0·11	BF127	0·50	BSY29	0·15	OC202	0·28	2N918	0·30	2N3011	0·14	2N3906	0·27	40361	0·40
AC188	0·22	BC107	0·09	BC209	0·12	BF152	0·55	BSY38	0·18	OC203	0·25	2N929	0·21	2N3053	0·17	2N4058	0·12	40362	0·45
AC188K	0·20	BC108	0·09	BC212L	0·11	BF153	0·45	BSY39	0·18	OC204	0·25	2N930	0·21						
ACY17	0·25	BC109	0·10	BC213L	0·11	BF154	0·45	BSY40	0·28	OC205	0·35	2N1131	0·20						
ACY18	0·20	BC113	0·10	BC214L	0·14	BF155	0·70	BSY41	0·28	OC309	0·40	2N1132	0·22						
ACY19	0·20	BC114	0·15	BC225	0·25	BF156	0·48	BSY95	0·12	P346A	0·20	2N1302	0·14						
ACY20	0·20	BC115	0·15	BC226	0·35	BF157	0·55	BSY95A	0·12	P397	0·42	2N1303	0·14						
ACY21	0·20	BC116	0·15	BCY30	0·24	BF158	0·55	Bu105	2·00	OCP71	0·43	2N1304	0·17						
ACY22	0·16	BC117	0·15	BCY31	0·26	BF159	0·60	C111E	0·50	ORP12	0·43	2N1305	0·17						
ACY27	0·18	BC118	0·10	BCY32	0·30	BF160	0·40	C400	0·30	ORP60	0·40	2N1306	0·21						
ACY28	0·19	BC119	0·30	BCY33	0·22	BF162	0·40	C407	0·25	ORP61	0·40	2N1307	0·21						
ACY29	0·35	BC120	0·80	BCY34	0·25	BF163	0·40	C424	0·20	ST140	0·12	2N1308	0·23						
ACY30	0·28	BC125	0·12	BCY70	0·14	BF164	0·40	C425	0·50	ST141	0·17	2N1309	0·23						
ACY31	0·28	BC126	0·18	BCY71	0·18	BF165	0·40	C426	0·35	TIS43	0·30	2N1613	0·20						
ACY34	0·21	BC132	0·12	BCY72	0·14	BF167	0·22	C428	0·20	UT46	0·27	2N1711	0·20						
ACY35	0·21	BC134	0·18	BCZ10	0·20	BF173	0·22	C441	0·30	2G301	0·09	2N1889	0·32						
ACY36	0·28	BC135	0·12	BCZ11	0·25	BF176	0·35	C442	0·30	2G302	0·19	2N1890	0·45						
ACY40	0·17	BC136	0·15	BCZ12	0·25	BF177	0·35	C444	0·35	2G303	0·19	2N1893	0·37						
ACY41	0·18	BC137	0·15	BD121	0·60	BF178	0·30	C450	0·22	2G304	0·24	2N2147	0·72						
ACY44	0·35	BC139	0·40	BDI23	0·65	BF179	0·30	MAT100	0·19	2G306	0·40	2N2148	0·57						
AD130	0·38	BC140	0·30	BD124	0·60	BF180	0·30	MAT101	0·20	2G308	0·35	2N2160	0·60						
AD140	0·48	BC141	0·30	BD131	0·50	BF181	0·30	MAT120	0·19	2G309	0·35	2N2192	0·35						
AD142	0·48	BC142	0·30	BD132	0·60	BF182	0·40	MAT121	0·20	2G339	0·20	2N2193	0·35						
AD143	0·83	BC143	0·30	BD133	0·65	BF183	0·40	MPF102	0·42	2G339A	0·16	2N2194	0·35						
AD149	0·50	BC145	0·45	BD135	0·40	BF184	0·25	MPF104	0·37	2G344	0·18	2N2217	0·22						
AD161	0·33	BC147	0·10	BD136	0·40	BF185	0·30	MPF105	0·37	2G345	0·16	2N2218	0·20						

DIODES AND RECTIFIERS

AA119	0·08	BY133	0·21	OA10	0·35
AA120	0·08	BY164	0·50	OA47	0·07
AA129	0·08	BYX38/30		OA70	0·07
AAY30	0·09		0·42	OA79	0·07
AAZ13	0·10	BYZ10	0·35	OA81	0·07
BA100	0·10	BYZ11	0·30	OA85	0·09
BA116	0·21	BYZ12	0·30	OA90	0·06
BA126	0·22	BYZ13	0·25	OA91	0·06
BA148	0·14	BYZ16	0·40	OA95	0·07
BA154	0·12	BYZ17	0·35	OA200	0·06
BA155	0·14	BYZ18	0·35	OA202	0·07
BA156	0·13	BYZ19	0·28	SD10	0·05
BY100	0·15	CG62		SD19	0·05
BY101	0·12	(Eg) OA91		IN34	0·07
BY105	0·17		0·5	IN34A	0·07
BY114	0·12	CG651		IN914	0·06
BY126	0·14	(Eq) OA70-		1N916	0·06
BY127	0·15	OA79	0·06	IN414B	0·06
BY128	0·15	OA5	0·35	18021	0·10
BY130	0·16	OA58L	0·21	18951	0·06

FULL RANGE OF ZENER DIODES VOLTAGE RANGE
2-23V. 400mV (DO-7 Case) 13p ea. 1¼W (Top-Hat) 18p ea. 10W (SO-10 Stud) 25p ea. All fully tested 5% tol. and marked. State voltage required.

10 amp POTTED BRIDGE RECTIFIER on heat sink. 100PIV. 90p each

NEW LINE
Plastic Encapsulated
2 Amp. BRIDGE RECTS.
50v RMS 32p each
100v RMS 37p ,,
400v RMS 46p ,,
Size 15 mm × 6 mm.

UNIJUNCTION
UT46. Eqvt. 2N2646. Eqvt. TIS43. BEN3000 27p each, 25-99 25p 100 UP 20p.

CADMIUM CELLS
ORP12 43p
ORP60, ORP61 40p each

GENERAL PURPOSE NPN SILICON SWITCHING TRANS. TO-18 SIM. TO 2N706/8. BSY-27/28/95A. A.I.I usable devices no open or short circuits. ALSO AVAILABLE in PNP Sim. to 2N2906, BCY70. When ordering please state preference NPN or PNP.

		£p
20	For	0·50
50	For	1·00
100	For	1·75
500	For	7·50
1000	For	13·00

SIL. G.P. DIODES £p
300mW 30..0·50
40PIV(Min.) 100..1·50
Sub-Min. 500..5·00
Full Tested 1,000..9·00
Ideal for Organ Builders.

TRIACS

VBOM	2A TO-1 £p	6A TO-66 £p	10A TO-88 £p
100	30	50	76
200	50	60	90
400	70	75	1·10

DIACS
FOR USE WITH TRIACS
BR100 (D32) 37p each

FREE
One 50p Pak of your own choice free with orders valued £4 or over.

BRAND NEW TEXAS GERM. TRANSISTORS
Coded and guaranteed

Pak No.			EQVT
T1	8	2G3713	OC71
T2	8	D1374	OC75
T3	8	D1216	OC81D
T4	8	2G381T	OC81
T5	8	2G382T	OC82
T6	8	2G344B	OC44
T7	8	2G345B	OC45
T8	8	2G378	OC78
T9	8	2G399A	2N1302
T10	8	2G417	AF117

All 50p each pak.

2N2060 NPN SIL. DUAL TRANS. CODE D1699 TEXAS. Our price 25p each.

120 VCR MIXIE DRIVER TRANSISTOR. Sim. BSX21 & C407, 2N1893 FULLY TESTED AND CODED ND 120, 1-24 17p each. TO.5 NPN 25 up 15p each.

Sil. trans. suitable for P.E. Organ. Metal TO-18 Eqvt. ZTX300 5p each. Any Qty.

NEW EDITION 1971

TRANSISTOR EQUIVALENTS BOOK. A complete cross reference and equivalents book for European, American and Japanese Transistors. Exclusive to BI-PAK 90p each.

KING OF THE PAKS Unequalled Value and Quality

SUPER PAKS NEW BI-PAK UNTESTED SEMICONDUCTORS

Satisfaction GUARANTEED in Every Pak, or money back.

Pak No.		Description	Price
U 1	120	Glass Sub-Min. General Purpose Germanium Diodes	0·50
U 2	60	Mixed Germanium Transistors AF/RF	0·50
U 3	75	Germanium Gold Bonded Sub-Min. like OA5, OA47	0·50
U 4	40	Germanium Transistors like OC81, AC128	0·50
U 5	60	200mA Sub-Min. Silicon Diodes	0·50
U 6	30	Sil. Planar Trans. NPN like BSY95A. 2N706	0·50
U 7	16	Sil. Rectifiers TOP-HAT 750mA VLTG. RANGE up to 1000	0·50
U 8	50	Sil. Planar Diodes DO-7 Glass 250mA like OA200/202	0·50
U 9	20	Mixed Voltages, 1 Watt Zener Diodes	0·50
U10	20	BAY50 charge storage Diodes DO-7 Glass	0·50
U11	25	PNP Sil. Planar Trans. TO-5 like 2N1132, 2N2904	0·50
U12	12	Silicon Rectifiers Epoxy 500mA up to 800 PIV	0·50
U13	30	PNP-NPN Sil. Transistors OC200 & 28 104	0·50
U14	150	Mixed Silicon and Germanium Diodes	0·50
U15	25	NPN Sil. Planar Trans. TO-5 like BFY51, 2N697	0·50
U16	10	3 Amp Silicon Rectifiers Stud Type up to 1000PIV	0·50
U17	30	Germanium PNP AF Transistors TO-5 like ACY 17-22	0·50
U18	8	6 Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	0·50
U19	25	Silicon NPN Transistors like BC108	0·50
U20	12	1·5 Amp Silicon Rectifiers Top Hat up to 1000 PIV	0·50
U21	30	AF. Germanium Alloy Transistors 2G300 Series & OC71.	0·50
U23	30	MADT's like MHz Series PNP Transistors	0·50
U24	20	Germanium 1 Amp Rectifiers GJM Series up to 300 PIV	0·50
U25	25	300 MHz NPN Silicon Transistors 2N708. BSY27	0·50
U26	30	Fast Switching Silicon Diodes like IN914 Micro-Min.	0·50
U27	12	NPN Germanium AF Transistors TO-1 like AC127	0·50
U29	10	1 Amp SCR's TO-5 can. up to 600 PIV CR81/25-600	1.00
U30	15	Plastic Silicon Planar Trans. NPN 2N2926	0·50
U31	20	Silicon Planar Plastic NPN Trans. Low Noise Amp 2N3707	0·50
U32	25	Zener Diodes 400mW DO-7 case 3-18 volts mixed	0·50
U33	15	Plastic Case 1 Amp Silicon Rectifiers 1N4000 Series	0·50
U34	30	Silicon PNP Alloy Trans. TO-5 BCY26 28302/4	0·50
U35	25	Silicon Planar Transistors PNP TO-18 2N2906	0·50
U36	25	Silicon Planar NPN Transistors TO-5 BFY50/51/52	0·50
U37	30	Silicon Alloy Transistors SO-2 PNP OC200, 28322	0·50
U38	20	Fast Switching Silicon Trans. NPN MHz 2N3011	0·50
U39	30	RF. Germ. PNP Transistors 2N1303/5 TO-5	0·50
U40	10	Dual Transistors 6 lead TO-5 2N2060	0·50
U41	25	RF Germanium Transistors TO-5, OC45, NKT72	0·50
U42	10	VHF Germanium PNP Transistor TO-1 NKT667, AF117	0·50
U43	25	Sil. Trans. Plastic TO-18 A.F. BC113/114	0·50
U44	20	Sil. Trans. Plastic TO-5 BC115/NPN	0·50
U45	7	3A SCR. TO66 up to 600PIV	1·00

Code No's. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

QUALITY TESTED SEMICONDUCTORS

Pak No.			Price £p
Q1	20	Red spot transistors PNP	0·50
Q2	16	White spot R.F. transistors PNP	0·50
Q3	4	OC 77 type transistors	0·50
Q4	6	Matched transistors OC44/45/81/81D	0·50
Q5	4	OC 75 transistors	0·50
Q6	5	OC 72 transistors	0·50
Q7	4	AC 128 transistors PNP high gain	0·50
Q8	4	AC 126 transistors PNP	0·50
Q9	7	OC 81 type transistors	0·50
Q10	7	OC 71 type transistors	0·50
Q11	2	AC 127/128 Complementary pairs PNP/NPN	0·50
Q12	3	AF 116 type transistors	0·50
Q13	3	AF 117 type transistors	0·50
Q14	3	OC 171 H.F. type transistors	0·50
Q15	7	2N2926 Sil. Epoxy transistors mixed colours	0·50
Q16	2	GET880 low noise Germanium transistors	0·50
Q17	5	NPN 2 × ST.141 & 3 × ST.140	0·50
Q18	4	MADT'S 2 × MAT 100 & 2 × MAT 120	0·50
Q19	3	MADT'S 2 × MAT 101 & 1 × MAT 121	0·50
Q20	4	OC 44 Germanium transistors A.F.	0·50
Q21	4	AC 127 NPN Germanium transistors	0·50
Q22	20	NKT transistors A.F. R.F. coded	0·50
Q23	10	OA 202 Silicon diodes sub-min.	0·50
Q24	8	OA 81 diodes	0·50
Q25	15	1N914 Silicon diodes 75 PIV 75mA	0·50
Q26	8	OA95 Germanium diodes sub-min. 1N69	0·50
Q27	2	10A PIV Silicon rectifiers IS425R	0·50
Q28	2	Silicon power rectifiers BYZ 13	0·50
Q29	4	Silicon transistors 2 × 2N696, 1 × 2N697, 1 × 2N698	0·50
Q30	7	Silicon switch transistors 2N706 NPN	0·50
Q31	6	Silicon switch transistors 2N708 NPN	0·50
Q32	3	PNP Silicon transistors 2 × 2N1131, 1 × 2N 1132	0·50
Q33	3	Silicon NPN transistors 2N1711	0·50
Q34	7	Silicon NPN transistors 2N2369, 500MHz (code P397)	0·50
Q35	3	Silicon PNP TO-5, 2 × 2N2904 & 1 × 2N2905	0·50
Q36	7	2N3646 TO-18 plastic 300 MHz NPN	0·50
Q37	3	2N3053 NPN Silicon transistors	0·50
Q38	7	NPN transistors 4 × 2N3703, 3 × 2N3702	0·50

ELECTRONIC SLIDE-RULE

The MK Slide Rule, designed to simplify Electronic calculations features the following scales:— Conversion of Frequency and Wavelength. Calculation of L, C and fo of Tuned Circuits. Reactance and Self-Inductance. Area of Circles. Volume of Cylinders. Resistance of Conductors. Weight of Conductors. Decibel Calculations. Angle Functions. Natural Logs and 'e' Functions. Multiplication and Division. Squaring, Cubing and Square Roots. Conversion of kW and Hp. A must for every electronic engineer and enthusiast. Size: 2 cm. × 4 cm. Complete with case and instructions. Price each: £3·35

NEW LOW PRICE TESTED S.C.R.'s

PIV	1A TO5	3A TO66	5A TO66	5A TO64	7A TO48	10A TO48	16A TO48	30A TO48
50	0·23	0·25	0·35	0·35	0·47	0·50	0·53	1·15
100	0·25	0·33	0·47	0·47	0·50	0·58	0·63	1·40
200	0·35	0·37	0·49	0·49	0·57	0·61	0·75	1·60
400	0·43	0·47	0·56	0·56	0·67	0·75	0·93	1·75
600	0·53	0·57	0·68	0·68	0·77	0·97	1·25	—
800	0·63	0·70	0·80	0·80	0·90	1·20	1·50	4·00

SIL. SECTS. TESTED

PIV	300mA	750mA	1A	1·5A	3A	10A	30A
50	0·04	0·05	0·05	0·07	0·14	0·21	0·60
100	0·04	0·06	0·05	0·13	0·16	0·23	0·75
200	0·05	0·09	0·06	0·14	0·20	0·24	1·00
400	0·06	0·13	0·07	0·20	0·27	0·37	1·25
600	0·07	0·16	0·10	0·23	0·34	0·45	1·86
800	0·10	0·17	0·11	0·25	0·37	0·55	2·00
1000	0·11	0·25	0·14	0·30	0·46	0·63	2·50
1200	—	0·33	—	0·38	0·57	0·75	—

POWER TRANS BONANZA!

GENERAL PURPOSE GERM. PNP

Coded GP100. BRAND NEW TO-3 CASE. POSSIBLE REPLACE:—OC25-28-29-30-35-36. NKT 401-403-404-405-406-430-451-452-453. TI3027-3028, 2N250A 2N456A-457A-458A, 2N511 A & B. 2G220-222, ETC. VCBO 80V VCEO 50V IC 10A PT. 30 WATTS Hfe 30-170.

PRICE	1-24	25-99	100 up
	43p each	40p each	36p each

SILICON High Voltage 250V NPN
TO-3 case. G.P. Switching & Amplifier Applications. Brand new Coded R 2400 VCBO 250/VCEO 100/IC 6A/30 Watts. HFE type 20/fT 5MHZ.
OUR PRICE EACH:

1-24	25-99	100 up
50p	45p	40p

2N3055
115 WATT SII POWER NPN 50p EACH.

SILICON 50 WATTS MATCHED NPN/PNP
BIP 19 NPN TO-3 Plastic. BIP 20 PNP. Brand new. VCBO 100/VCEO 50/IC 10A. HFE type 100/ft 3mHZ.
OUR PRICE PER PAIR:
1–24 prs. 60p 25–99 prs. 55p 100 prs. 50p

AD161/162 *PNP*
M/P COMP GERM TRANS. OUR LOWEST PRICE OF 55p *PER PAIR*

SILICON PHOTO TRANSISTOR
TO-18 Lens end NPN Sim. to BP × 25 and P21. BRAND NEW. Full data available. Fully guaranteed.

Qty.	1-24	25-99	100 up
Price each	45p	40p	35p

F.E.T.'S

2N3819	35p	2N5458	50p
2N3820	50p	2N5459	40p
2N3821	35p	BFW10	40p
2N3823	30p	MPF105	40p

JUMBO COMPONENT PAKS

MIXED ELECTRONIC COMPONENTS

Exceptionally good value

Resistors, capacitors, pots, electrolytics and coils plus many other useful items. Approximately 3lbs in weight. Price incl. P. & P. £1·50 only.

A LARGE RANGE OF TECHNICAL AND DATA BOOKS ARE NOW AVAILABLE EX. STOCK. SEND FOR FREE LIST.

BI-PAKS NEW COMPONENT SHOP NOW OPEN WITH A WIDE RANGE OF ELECTRONIC COMPONENTS AND ACCESSORIES AT COMPETITIVE PRICES—

18 BALDOCK STREET (A10), WARE, HERTS.
TEL. (STD 0920) 61593.
OPEN MON.-SAT. 9.15 a.m. to 6 p.m., FRIDAY UNTIL 8 p.m.

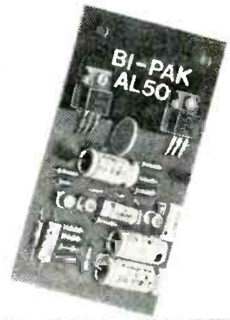
-the lowest prices!

74 Series T.T.L. I.C'S

BI-PAK STILL LOWEST IN PRICE FULL SPECIFICATION GUARANTEED. ALL FAMOUS MANUFACTURERS

	1	25	100+		1	25	100+		1	25	100+
SN7400	0·15	0·14	0·12	SN7450	0·15	0·14	0·12	SN74123	£2·80	£2·70	£2·60
SN7401	0·15	0·14	0·12	SN7451	0·15	0·14	0·12	SN74141	0·67	0·64	0·58
SN7402	0·15	0·14	0·12	SN7453	0·15	0·14	0·12	SN74145	£1·50	£1·40	£1·30
SN7403	0·15	0·14	0·12	SN7454	0·15	0·14	0·12	SN74150	£3·00	£2·70	£2·50
SN7404	0·15	0·£4	0·12	SN7460	0·15	0·14	0·12	SN74151	£1·00	0·95	0·90
SN7405	0·15	0·14	0·12	SN7470	0·29	0·26	0·24	SN74153	£1·20	£1·10	0·95
SN7406	0·35	0·31	0·28	SN7472	0·29	0·26	0·24	SN74154	£1·80	£1·70	£1·60
SN7407	0·35	0·31	0·28	SN7473	0·37	0·35	0·32	SN74155	£1·40	£1·30	£1·20
SN7408	0·18	0·17	0·16	SN7474	0·37	0·35	0·32	SN74156	£1·40	£1·30	£1·20
SN7409	0·18	0·17	0·16	SN7475	0·45	0·43	0·42	SN74157	£1·90	£1·80	£1·70
SN7410	0·15	0·14	0·12	SN7476	0·40	0·39	0·38	SN74160	£1·80	£1·70	£1·40
SN7411	0·25	0·24	0·23	SN7480	0·67	0·64	0·58	SN74161	£1·80	£1·70	£1·60
SN7412	0·35	0·31	0·28	SN7481	£1·20	£1·15	£1·10	SN74162	£4·00	£3·75	£3·50
SN7413	0·29	0·28	0·24	SN7482	0·87	0·86	0·85	SN74163	£4·00	£3·75	£3·50
SN7416	0·43	0·40	0·38	SN7483	£1·10	£1·05	0·95	SN74164	£2·20	£2·15	£2·10
SN7417	0·43	0·40	0·38	SN7484	£1·00	0·95	0·90	SN74165	£2·25	£2·20	£2·15
SN7420	0·15	0·14	0·12	SN7485	£3·60	£3·50	£3·40	SN74166	£3·50	£3·25	£3·00
SN7422	0·50	0·48	0·45	SN7486	0·32	0·31	0·30	SN74174	£2·30	£2·20	£2·10
SN7423	0·50	0·48	0·45	SN7489	£5·50	£5·25	£5·00	SN74175	£1·60	£1·50	£1·40
SN7425	0·50	0·48	0·45	SN7490	0·67	0·64	0·58	SN74176	£2·50	£2·40	£2·30
SN7427	0·45	0·42	0·40	SN7491	£1·00	0·95	0·90	SN74177	£2·50	£2·40	£2·30
SN7428	0·70	0·65	0·60	SN7492	0·67	0·64	0·58	SN74180	£2·00	£1·60	£1·40
SN7430	0·15	0·14	0·12	SN7493	0·67	0·64	0·58	SN74181	£5·50	£5·00	£4·75
SN7432	0·45	0·42	0·40	SN7494	0·77	0·74	0·68	SN74182	£2·00	£1·80	£1·60
SN7433	0·80	0·75	0·70	SN7495	0·77	0·74	0·68	SN74184	£3·50	£3·25	£3·00
SN7437	0·64	0·62	0·60	SN7496	0·87	0·84	0·78	SN74190	£1·95	£1·90	£1·85
SN7438	0·64	0·62	0·60	SN74100	£1·65	£1·60	£1·55	SN74191	£1·90	£1·85	£1·80
SN7440	0·15	0·14	0·12	SN74104	0·97	0·94	0·88	SN74192	£1·95	£1·90	£1·85
SN7441	0·67	0·64	0·58	SN74105	0·97	0·94	0·88	SN74193	£2·00	£1·80	£1·75
SN7442	0·67	0·64	0·58	SN74107	0·40	0·38	0·36	SN74194	£2·70	£2·60	£2·50
SN7443	£1·30	£1·25	£1·20	SN74110	0·55	0·53	0·50	SN74195	£2·00	£1·90	£1·80
SN7444	£1·30	£1·25	£1·20	SN74111	£1·25	£1·15	£1·10	SN74196	£1·80	£1·70	£1·60
SN7445	£1·80	£1·77	£1·75	SN74118	£1·00	0·95	0·90	SN74197	£1·80	£1·70	£1·60
SN7446	0·97	0·94	0·88	SN74119	£1·35	£1·25	£1·10	SN74198	£5·50	£5·00	£4·50
SN7447	£1·00	0·97	0·95	SN74121	0·40	0·37	0·34	SN74199	£5·50	£5·00	£4·50
SN7448	£1·00	0·97	0·95	SN74122	£1·40	£1·30	£1·10				

The AL50 HI-FI AUDIO AMPL
50W pk 25w (RMS)
0·1% DISTORTION! HI-FI AUDIO AMPLIFIER

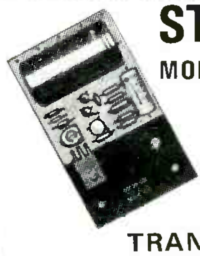


- Frequency Response 15Hz to 100,000—1dB.
- Load—3, 4, 8 or 16 ohms. • Supply voltage 10-35 Volts.
- Distortion—better than 0·1% at 1kHz.
- Signal to noise ratio 80dB.
- Overall size 63 mm × 105 mm × 13 mm.

Tailor made to the most stringent specifications using top quality components and incorporating the latest solid state circuitry conceived to fill the need for all your A.F. amplification needs.
FULLY BUILT—TESTED—GUARANTEED.

BRITISH MADE. only £3·25 each

STABILISED POWER
MODULE SPM80 £2·95



AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £1·95 p. & p. 25p

NUMERICAL INDICATOR TUBES

MODEL	CD66	GR116	3015F Minitron
Anode voltage (Vdc)	170min	175min	5
Cathode Current (mA)	2·3	14	8
Numerical Height (mm)	16	13	9
Tube Height (mm)	47	32	22
Tube Diameter (mm)	19	13	12 wide
I.C. Driver Rec.	BP41/14 141	BP41 or 141	BP47
PRICE EACH	£1·70	£1·55	£1·90

All indicators 0·9 + Decimal point. All side viewing. Full data for all types available on request.

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	1·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	35mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	1·5mV into 50KΩ	Signal/noise ratio	better than +65dB
		Input overload	+26dB
		Supply	+35 volts at 20mA
		Dimensions	292 × 82 × 35 mm

All input voltages are for an output of 250mV.
Tape and P.U. inputs equalised to RIAA curve within ±1dB from 20Hz to 20kHz.

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £23.00 FREE p.&p

only £11·95

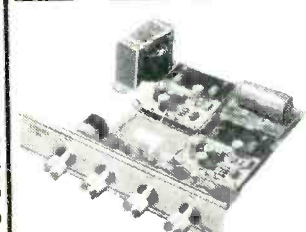
INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No. Contents	Price	Pak No. Contents	Price	Pak No. Contents	Price
UIC00 = 12 × 7400	0·50	UIC46 = 5 × 7446	0·50	UIC86 = 5 × 7486	0·50
UIC01 = 12 × 7401	0·50	UIC47 = 5 × 7447	0·50	UIC90 = 5 × 7490	0·50
UIC02 = 12 × 7402	0·50	UIC48 = 5 × 7448	0·50	UIC91 = 5 × 7491	0·50
UIC03 = 12 × 7403	0·50	UIC50 = 12 × 7450	0·50	UIC92 = 5 × 7492	0·50
UIC04 = 12 × 7404	0·50	UI351 = 12 × 7451	0·50	UIC93 = 5 × 7493	0·50
UIC05 = 12 × 7405	0·50	UIC53 = 12 × 7453	0·50	UIC94 = 5 × 7494	0·50
UIC06 = 8 × 7406	0·50	UIC54 = 12 × 7454	0·50	UIC95 = 5 × 7495	0·50
UIC07 = 8 × 7407	0·50	UIC60 = 12 × 7460	0·50	UIC96 = 5 × 7496	0·50
UIC10 = 12 × 7410	0·50	UIC70 = 8 × 7470	0·50	UIC100 = 5 × 74100	0·50
UIC13 = 8 × 7413	0·50	UIC72 = 8 × 7472	0·50	UIC121 = 5 × 74121	0·50
UIC20 = 12 × 7420	0·50	UIC73 = 8 × 7473	0·50	UIC141 = 5 × 74141	0·50
UIC30 = 12 × 7430	0·50	UIC74 = 8 × 7474	0·50	UIC151 = 5 × 74151	0·50
UIC40 = 12 × 7440	0·50	UIC75 = 8 × 7475	0·50	UIC154 = 5 × 74154	0·50
UIC41 = 5 × 7441	0·50	UIC76 = 8 × 7476	0·50	UIC193 = 5 × 74193	0·50
UIC42 = 5 × 7442	0·50	UIC80 = 5 × 7480	0·50	UIC199 = 5 × 74199	0·50
UIC43 = 5 × 7443	0·50	UIC81 = 5 × 7481	0·50		
UIC44 = 5 × 7444	0·50	UIC82 = 5 × 7482	0·50	UICXI = 25 Assorted 74's	1·50
UIC45 = 5 × 7445	0·50	UIC83 = 5 × 7483	0·50		

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

The STEREO 20



The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5·5 cm This compact unit comes complete with on/off switch, volume control, balance, bass and treble controls. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet.

Output power 20w peak	Input 1 (Cer.) 300mV into 1M
Freq. res. 25Hz-25kHz	Input 2 (Aux.) 4mV into 30K
Harmonic distortion	Bass control ±12dB at 60Hz
typically 0·25% at 1 watt	Treble con. ±14dB at 14kHz

£12·25 free p. & p.

NEW COMPONENT PAK BARGAINS

Pack No.	Qty.	Description	Price
C 1	250	Resistors mixed values approx. count by weight	0·50
C 2	200	Capacitors mixed values approx. count by weight	0·50
C 3	50	Precision Resistors 1%, mixed values	0·50
C 4	75	⅛th W Resistors mixed preferred values	0·50
C 5	5	Pieces assorted Ferrite Rods	0·50
C 6	2	Tuning Gangs, MW/LW/VHF	0·50
C 7	1	Pack Wire 50 metres assorted colours	0·50
C 8	10	Reed Switches	0·50
C 9	3	Micro Switches	0·50
C10	15	Assorted Pots & Pre-Sets	0·50
C11	5	Jack Sockets 3 × 3·5mm 2 × Standard Switch Types	0·50
C12	40	Paper Condensers preferred types mixed values	0·50
C13	20	Electrolytics Trans. types	0·50
C14	1	Pack assorted Hardware—Nuts/Bolts, Grommets etc.	0·50
C15	4	Mains Toggle Switches, 2 Amp D/P	0·50
C16	20	Assorted Tag Strips & Panels	0·50
C17	10	Assorted Control Knobs	0·50
C18	4	Rotary Wave Change Switches	0·50
C19	3	Relays 6—24V Operating	0·50
C20	4	Sheets Copper Laminate approx. 10" × 7"	0·50

Please add 10p post and packing on all component packs, plus a further 10p on pack Nos. C1, C2, C19, C20.

RTL MICROLOGIC CIRCUITS

	Price each 1-24	25-99	100 up
Epoxy TO-5 case uL900 Buffer	35p	33p	27p
uL914 Dual 2i/p gate	35p	33p	27p
uL923 J-K flip-flop	50p	47p	45p

Data and Circuits Booklet for IC's Price 7p.

DUAL-IN-LINE IC's. TWO Ranges PROFESSIONAL & NEW LOW COST.

PROF. TYPE No.	1-24	25-99	100 up.
TSO 14 pin type	30p	27p	25p
TSO 16	35p	32p	30p
LOW COST No.			
BPS 14	15p	13p	11p
BPS 16	16p	14p	12p

LINEAR I.C.'s—FULL SPEC.

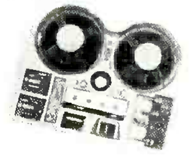
Type No.	Price 1-24	25-99	100 up
BP 201C—SL201C	63p	53p	45p
BP 701C—SL701C	63p	50p	45p
BP 702C—SL702C	63p	50p	45p
BP 702—72702	53p	45p	40p
BP 709—72709	36p	34p	30p
BP 709P—µA709C	36p	34p	30p
BP 710—72710	44p	42p	40p
BP 711—µA711	45p	43p	40p
BP 741—72741	75p	60p	50p
µA703C—µA703C	28p	26p	24p
TAA 263—	70p	60p	55p
TAA 293—	90p	75p	70p
TAA 350	170p	158p	150p
S.G.S. EA1000 £2·63			

ROCK BOTTOM PRICES LOGIC DTL 930 Series I.C's

Type No.	Price 1-24	25-99	100 up
BP930	12p	11p	10p
BP932	13p	12p	11p
BP933	13p	12p	11p
BP935	13p	12p	11p
BP936	13p	12p	11p
BP944	13p	12p	11p
BP945	25p	24p	22p
BP946	12p	11p	10p
BP948	25p	24p	22p
BP951	65p	60p	55p
BP962	12p	11p	10p
BP9093	40p	88p	35p
BP9094	40p	38p	35p
BP9097	40p	38p	35p
BP9099	40p	38p	35p

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only).

SYSTEM 12 STEREO



Each Kit contains two Amplifier Modules, 3 watts RMS, two loudspeakers, 15 ohms, the pre-amplifier, transformer, power supply module, front panel and other accessories, as well as an illustrated stage-by-stage instruction booklet designed for the beginner. Further details available on request.

ONLY £16·95 FREE p. & p.

All prices quoted in new pence Giro No. 388-7006
Please send all orders direct to warehouse and despatch department

BI-PAK

P.O. BOX 6, WARE · HERTS

Postage and packing add 10p. Overseas add extra for airmail. Minimum order 50p. Cash with order please.

Guaranteed Satisfaction or Money Back

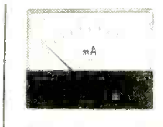
SEW PANEL METERS

USED EXTENSIVELY BY INDUSTRY, GOVERNMENT DEPARTMENTS, EDUCATIONAL AUTHORITIES, ETC.

● LOW COST ● QUICK DELIVERY ● OVER 200 RANGES IN STOCK ● OTHER RANGES TO ORDER

CLEAR PLASTIC PANEL METERS

Type SW.100 100 × 80mm



50µA	£3·80
50-0-50µA	£3·80
100µA	£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
50-0-50µA	£2·70
100µA	£2·70
100-0-100µA	£2·70
200µA	£2·70
500µA	£2·55
1mA	£2·50
5mA	£2·50
10mA	£2·50
50mA	£2·50
100mA	£2·50
500mA	£2·50
1 amp	£2·50
5 amp	£2·50
10 amp.	£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

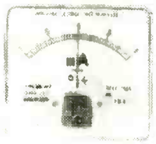
50µA	£2·60
50-0-50µA	£2·55
100µA	£2·55
100-0-100µA	£2·55
200µA	£2·55
500µA	£2·35
1mA	£2·35
5mA	£2·35
10mA	£2·35
50mA	£2·35
100mA	£2·35
500mA	£2·35
1 amp.	£2·35
5 amp.	£2·35
10 amp.	£2·35
5V. D.C.	£2·35
20V. D.C.	£2·35
50V. D.C.	£2·35
300V. D.C.	£2·35
15V. A.C.	£2·40
300V. A.C.	£2·40
VU Meter	£2·70

Type SD.460 46mm × 59.5mm Fronts

50µA	£2·40
50-0-50µA	£2·35
100µA	£2·35
100-0-100µA	£2·35
200µA	£2·35
500µA	£2·20
1mA	£2·15
5mA	£2·15
10mA	£2·15
50mA	£2·15
100mA	£2·15
500mA	£2·15
1 amp.	£2·15
5 amp.	£2·15
10 amp.	£2·15
5V. D.C.	£2·15
10V. D.C.	£2·15
20V. D.C.	£2·15
50V. D.C.	£2·15
300V. D.C.	£2·15
15V. A.C.	£2·30
300V. A.C.	£2·30
VU Meter	£2·55

✻ MOVING IRON—
ALL OTHERS MOVING COIL
Please add postage

Type MR.85P. 4¼in. × 4¼in. fronts.



50µA	£3·95
50-0-50µA	£3·40
100µA	£3·40
100-0-100µA	£3·30
200µA	£3·30
500µA	£3·20
5000-500µA	£3·10
1mA	£3·10
1-0-1mA	£3·10
5mA	£3·10
10mA	£3·10
50mA	£3·10
100mA	£3·10
500mA	£3·10
1 amp.	£3·10
5 amp.	£3·10
15 amp.	£3·10
30 amp.	£3·20
20V. D.C.	£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 2½in. square fronts.

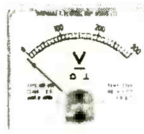
50µA	£3·40
50-0-50µA	£2·85
100µA	£2·85
100-0-100µA	£2·75
500µA	£2·55
1mA	£2·20
5mA	£2·20
10mA	£2·20
50mA	£2·20
100mA	£2·20
500mA	£2·20
1 amp.	£2·20
5 amp.	£2·20
10V. D.C.	£2·20
20V. D.C.	£2·20
50V. D.C.	£2·20
300V. D.C.	£2·20
15V. A.C.	£2·30
300V. A.C.	£2·30
S Meter 1mA	£2·30
VU Meter	£3·50
1 amp. A.C.*	£2·20
5 amp. A.C.*	£2·20
10 amp. A.C.*	£2·20
20 amp. A.C.*	£2·20
30 amp. A.C.*	£2·20

Type MR.65P. 3½in. × 3¼in. fronts

50µA	£3·70
50-0-50µA	£3·00
100µA	£3·00
100-0-100µA	£2·90
200µA	£2·90
500µA	£2·65
500-0-500µA	£2·40
1mA	£2·40
5mA	£2·40
10mA	£2·40
50mA	£2·40
100mA	£2·40
500mA	£2·40
1 amp.	£2·40
5 amp.	£2·40
10 amp	£2·40
15 amp.	£2·40
20 amp.	£2·40
30 amp.	£2·55
50 amp.	£2·75
5V. D.C.	£2·40
10V. D.C.	£2·40
20V. D.C.	£2·40
50V. D.C.	£2·40
150V. D.C.	£2·40
300V. D.C.	£2·40
15V. A.C.	£2·55
50V. A.C.	£2·55
150V. A.C.	£2·55
300V. A.C.	£2·55
500V. A.C.	£2·55
S Meter 1mA	£2·60
VU Meter	£3·70
50mA A.C.*	£2·40
100mA A.C.*	£2·40
200mA A.C.*	£2·40
500mA A.C.*	£2·40
1 amp. A.C.*	£2·40
5 amp. A.C.*	£2·40
10 amp. A.C.*	£2·40
20 amp. A.C.*	£2·40
30 amp. A.C.*	£2·40

Send for illustrated brochure on SEW Panel Meters. Discounts for quantities.

Type MR.38P. 1 21/32in. square fronts.



50µA	£2·30
50-0-50µA	£2·10
100µA	£2·10
100-0-100µA	£1·95
200µA	£1·95
500µA	£1·80
500-0-500µA	£1·75
1mA	£1·75
1-0-1mA	£1·75
mA	£1·75
5mA	£1·75
10mA	£1·75
20mA	£1·75
50mA	£1·75
100mA	£1·75
150mA	£1·75
200mA	£1·75
300mA	£1·75
500mA	£1·75
750mA	£1·75
1 amp.	£1·75
2 amp.	£1·75
5 amp.	£1·75
10 amp.	£1·75
3V. D.C.	£1·75
10V. D.C.	£1·75
15V. D.C.	£1·75
20V. D.C.	£1·75
50V. D.C.	£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
50-0-50µA	£2·30
100µA	£2·30
100-0-100µA	£2·05
200µA	£2·05
500µA	£1·95
500-0-500µA	£1·85
1mA	£1·85
5mA	£1·85
10mA	£1·85
50mA	£1·85
100mA	£1·85
500mA	£1·85
1 amp.	£1·85
5 amp.	£1·85
10V. D.C.	£1·85
20V. D.C.	£1·85
50V. D.C.	£1·85
300V. D.C.	£1·85
15V. D.C.	£2·00
300V. D.C.	£2·00
S Meter 1mA	£2·05
VU Meter	£2·50
1 amp. A.C.*	£1·85
5 amp. A.C.*	£1·85
10 amp. A.C.*	£1·85
20 amp. A.C.*	£1·85
30 amp. A.C.*	£1·85

EDGWISE METERS

Type P.E.70. 3 17/32in. × 1 15/32in. × 2¼ in. deep.

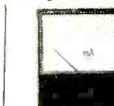
50µA	£3·40
50-0-50µA	£3·30
100µA	£3·30
100-0-100µA	£3·20
200µA	£3·20
500µA	£3·05
1mA	£2·70
300V. A.C.	£2·70
VU Meter	£3·75

"SEW" BAKELITE PANEL METERS

Type MR.65. 3½in. square fronts.

25µA	£3·85
50µA	£3·00
50-0-50µA	£2·60
100µA	£2·60
100-0-100µA	£2·50
500µA	£2·45
500-0-500µA	£2·15
1mA	£2·15
1-0-1mA	£2·15
5mA	£2·15
10mA	£2·15
50mA	£2·15
100mA	£2·15
500mA	£2·15
1 amp.	£2·15
5 amp.	£2·15
15 amp.	£2·15
30 amp.	£2·15
50 amp.	£2·15
5V. D.C.	£2·15
10V. D.C.	£2·15
20V. D.C.	£2·15
50V. D.C.	£2·15
150V. D.C.	£2·15
300V. D.C.	£2·15
30V. A.C.*	£2·20
50V. A.C.*	£2·20
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

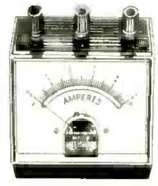
Type S.80 80mm Square Fronts



50µA	£3·50
50-0-50µA	£3·40
100µA	£3·40
100-0-100µA	£3·30
500µA	£3·05
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

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
100µA	£5·10
1mA	£4·85
50-0-50µA	£5·10
1-0-1mA	£4·85
1A D.C.	£4·85
5A D.C.	£4·85
10V D.C.	£4·85
20V D.C.	£4·85
50V D.C.	£4·85
300V D.C.	£4·85
Dual range 500mA/5A D.C.	£5·10
5V/50 V D.C.	£5·10

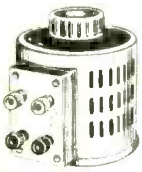
POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing. ¼in. dia. shafts. Bulk quantities available.

25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. **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

"YAMABISHI" VARIABLE VOLTAGE TRANSFORMERS

Excellent quality • Low price • Immediate delivery

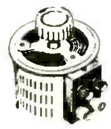


MODEL S-260
General Purpose
Bench Mounting

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-260 B Panel Mounting

1 Amp	£7·00
2.5 Amp	£8·05



Please add postage
ALL MODELS

INPUT 230 VOLTS, 50/60 CYCLES
OUTPUT VARIABLE 0-260 VOLTS

Special discounts for quantity

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
3000 W	£35·00	P. & P. £1

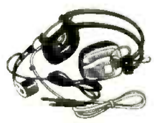
230 VOLT A.C. 50 CYCLES RELAYS

Brand new. 3 sets of changeover contacts at 5 amp rating. **50p** each Post 10p (100 lots £40). Quantities available.

MCA. 220 AUTOMATIC VOLTAGE STABILISER

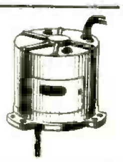
Input 88-125 VAC or 176-250VAC. Output 120VAC or 240VAC. 200VA rating. **£11.97.** Carr. 50p.

BH.001 HEADSET AND BOOM MICROPHONE



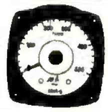
Moving coil. Ideal for language teaching, communications. Headphone imp. 16 ohms. Microphone imp. 200 ohms. **£4·62.** Post 15p.

230V/240V SMITHS SYNCHRONOUS GEARED MOTORS



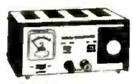
Built-in gearbox. All brand new and boxed. 30 RPH CW; 2 RPH CW; 20 RPH CW; 2 RPH ACW; 30 RRH CW. **50p** each. Post 12p.

240° WIDE ANGLE 1mA METERS



MW1·6 60mm. square **£3·97**
MW1·8 80mm. square **£4·97**
Post extra.

RP214 REGULATED POWER SUPPLY

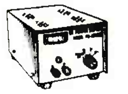


Solid state. Variable output 0-24V DC up to 1 amp. Dual scale meter to monitor voltage and current. Input 220/240V AC. Size 185 × 85 × 105mm. **£8·97** Post 25p.

PS.200 REGULATED P.S.U.

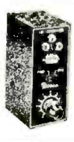
Solid state. Variable output 5-20 volt D.C. up to 2 amp. Independent meters to monitor voltage and current. Output 220/240 V. A.C. Size 7¼" × 5¼" × 3½". **£14·97.** Post 25p.

PS.1000B REGULATED P.S.U.



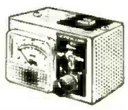
Solid state. Output 6-9 or 12 V. D.C. up to 3 amps. Meter to monitor current. Input 220/240 V. A.C. Size 4" × 3½" × 6½". **£11·97.** Post 25p.

LB4 TRANSISTOR TESTER



Tests PNP or NPN transistors. Audio indication. Operates on two 1.5v batteries. Complete with all instructions etc. **£4·50.** Post 20p.

LB3 TRANSISTOR TESTER



Tests ICO and B. PNP/NPN. Operates from 9v. battery. Complete with all instructions etc. **£3·95.** Post 20p.

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.

HOMER INTERCOMS

Ideal for home, office, stores, factories, etc. Supplied complete with batteries, cable and free instructions.

2 Station **£2·97.** Post 15p.
3 Station **£5·25.** Post 15p.
4 Station **£6·62.** Post 17p.

Send SAE for list of Semi Conductors and Valves

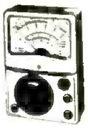
G. W. SMITH & Co. (Radio) Ltd.

Also see next three pages

MULTIMETERS for EVERY purpose!

TS60 POCKET MULTIMETER
High-precision at low-cost. Ranges: D.C. 15V., 150V., 1,000V. (10,000 opv). A.C. 15V. 150V., 100V. (1,000 opv).
D.C. Current 150mA. Resistance 100k/ohms. **£1·85.** Post 15p.

MODEL 1092 Testmeter.
5,000 O.P.V.
0/3/15/150/300/1200 V. D.C.
0/6/30/300/600 V. A.C.
0/300μA/300 MA
0/10K/1 meg Ω
Decibels —10 to +16 db
£2·75 each. Post 15p.



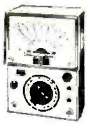
HIOKI MODEL 720X
20,000 O.P.V. Overload protection 5/25/100/500/1000 VDC. 10/50/250/1000 VAC. 50μA/250 mA. 20K/2 meg ohm. —5 to +62db. **£4·97.** Post 15p.

HIOKI MODEL 730X
30,000 O.P.V. Overload protection. 6/30/60/300/600/1200 VDC. 12/60/120/600/1200 VAC. 60 μA/30 mA/300 mA. 2K/200K/2 megohm. —10 to +63 db. **£6·50.** Post 15p.

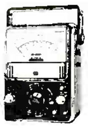
MODEL TE-12
20,000 O.P.V. 0/0·6/6/30/120/600/1,200/3,000/6,000v. D.C. 0/6/30/120/600/1,200v. A.C. 0/60μA/6/60/600mA. 0/6K/600K/6Meg./60 Meg. Ω 50pF. 0·2mFd. **£5·97.** Post 17p.

MODEL TE-200
20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000V. D.C. 0/10/50/250/1,000V. A.C. 0/50 μA/250 mA. 0/60K/6 megΩ. —20 to +62 db. **£3·95.** Post 15p.

MODEL 500 30,000 O.P.V. with overload protection, mirror scale. 0/.5/2.5/10/25/100/250/500/1,000 v. D.C. 0/2.5/10/25/100/250/500/1,000 v. A.C. 0/50μA/5/50/500 mA. 12 amp. D.C. 0/60/K/6 meg/60 meg Ω. **£8·87.** Post paid.



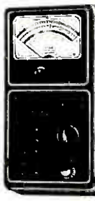
HIOKI MODEL 750X
50,000 o.p.v. 43 ranges 0-0.3 to 1,200v. D.C. 0-3 to 1,200 v. A.C. 0-30μA/300mA. 0-3K/30 meg. ohms. —10 to +17 db. **£8·97.** Post 20p.



HT100B4 MULTIMETER
Features A.C. current ranges. 100,000 o.p.v. Mirror Scale, Overload protection.
0/·5/2·5/10/50/250/500/1000 V DC.
0/2·5/10/50/250/1000 V AC.
0/10/250MμA/2·5/25/250 MA/10 Amp DC.
10 Amp AC.
0/20K/200K/2MEG/20MEG. — 20 + 62 db.
£12·50. Post 25p.

370 WTR MULTI METER
Features A.C. current ranges.
20,000 o.p.v.
0/·5/2·5/10/50/250/500/1000 V DC.
0/2·5/10/50/250/500/1000 V AC.
0/50μA/1/10/100MA/1/10 Amp DC.
0/100MA/1/10 Amp AC.
0/5K/50K/500K/5MEG/50MEG.
— 20 + 62 db.
£15. Post 25p.

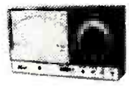
RUSSIAN 22 RANGE MULTIMETER



Model U437 10,000 o.p.v. A first class versatile instrument manufactured in U.S.S.R. to the highest standards. Ranges: 2·5/10/50/250/500/1000v D.C. 2·5/10/50/250/500/1000v A.C. D.C. Current 100 wA/1/10/100 mA/1A. Resistance 300 ohms/3/30/300K/3MΩ. Complete with batteries, test leads, instructions and sturdy steel carrying case.
Our Price **£5·97.** Post 25p.

ROUND SCALE TYPE PENCIL TESTER MODEL TS.68

Completely portable, simple to use pocket sized tester. Ranges: 0/3/30/300v A.C. and D.C. at 2,000 o.p.v. Resistance 0-20K ohms. Only **£1·97.** Post 13p.



LT601 MULTIMETER
New style 20,000 o.p.v. pocket multimeter.
5 / 25 / 50 / 250 / 2500V. D.C.
10/50/100/500/1000V. A.C.
50μA/250mA. 6K/6 meg ohms. —20 to +22db.
£3·75. Post 20p.

MODEL TH-12
20,000 o.p.v. Overload protection. Slide switch selector.
0/·25/2·5/10/50/250/1000V. D.C.
0/10/50/250/1000V. A.C.
0/50μA/25/250mA D.C.
0/3K/30K/300K/3 meg. —20 to +50db.
£4·97. Post 15p.

MODEL TE-300 30,000 O.P.V. Mirror scale, overload protection 0/.6/3/15/60/300/1,200 V.D.C. 0/6/30/120/600/1,200 V.A.C. 0/30μA/6mA/6 OmA/300mA/600mA. 0/8K/80K/800K/8 meg. -20 to + 63 db.
£5·97. Post 15p.

MODEL PL436. 20kΩ/Volt D.C. 8kΩ/Volt A.C Mirror scale. ·6/3/12/30/120/600V D.C. 3/30/120/600V A.C. 50/600μA/60/600 mA. 10/100K/1 Meg/10 meg Ω. —20 to +46db. **£6·97.** Post 12p.

TMK MODEL TW-50K
46 ranges, mirror scale, 50K/Vol. D.C. 5K Volt A.C. D.C.: Volts ·125, ·25, 1·25, 2·5, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.C. Volts: 1·5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.C. Current: 25, 50μA, 2·5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance: 10K, 100K, 1 MEG, 10 MEGΩ. Decibels: —20 to +81·5 db. **£8·50.** Post 17p.

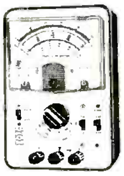
MODEL K228A
Taut band suspension. Overload protection. Polarity reversing switch.
30,000 o.p.v. 50/0/·5/2·5/15/250/500/1000/2500V D.C.
0/15/50/150/500/1000V. A.C.
0/50μA/5/50/150/500mA/5A D.C.
0/3K/300K/3 meg. **£8·95.** Post 20p.

HIOKI MODEL 700X
100,000 O.P.V. Overload protection. Mirror scale, ·3/·6/1·2/1·5/3/6/12/30/60/120/300/600/1200 VDC. 1·5/3/6/12/30/60/150/300/600/1200 VAC. 15/30vA/3/6/30/60/150/300 mA. 6/12 AMP DC. 2K/200 K/2 Meg/20 megohm. —20 to +63db.
£13·50. Post 20p.

MODEL C-7080 EN
Giant 6in. mirror scale.
20,000 o.p.v.
0/·25/1/2·5/10/50/250/1000/5000V. D.C.
0/2·5/10/50/250/1000/5000V. A.C.
0/50μA/1/10/100/500mA/10 amp. D.C.
0/2K/200K/20 meg. —20 to +50 db.
£13·95. Post 35p.

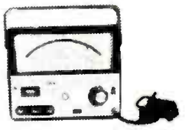
U4312 MULTIMETER
Extremely sturdy instrument for general electrical use. 667 o.p.v. 0/·3/1·5/7·5/30/60/150/300/600/900 VDC and 75mV. 0/·3/1·5/7·5/30/60/150/300/600/900 VAC. 0/300μA/1·5/6/15/60/150 600MA/1·5/6 AMP. D.C. 0/1·5/6/15/60/150/600MA/1·5/6 AMP. A.C. 0/200 Ω/3K/30K Ω. Accuracy DC 1%. AC 1·5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions. **£9·50.** Post 25p.

Selected TEST EQUIPMENT



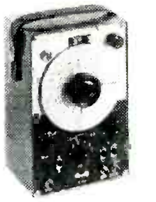
FTC-401 TRANSISTOR TESTER
Full capabilities for measuring A, B and ICO. NPN or PNP. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads.
£7·50. Post 20p.

Model S-100TR MULTIMETER/TRANSISTOR TESTER 100,000 o.p.v. MIRROR SCALE/OVERLOAD PROTECTION
0/·12—·6/3/12/30/120/600 V DC.
0/6/30/120/600 V. AC.
0/12/600uA/12/300MA/12 Amp. DC.
0/10K/1 MEG/100 MEG.
— 20 to + 50 db. 0·01 —·2 mfd.
Transistor tester measures Alpha, beta and Ico. Complete with batteries, instructions and leads.
£13·50. Post 25p.



MODEL 449A IN CIRCUIT TRANSISTOR TESTER
Checks true A.C. beta in/out.
Checks Icbo.
Checks diodes in/out.
Checks SCR etc.
Beta HI 10-500.
LO2-50.
Icbo 0-5000μA. 220/240V. A.C. operation.
£17·50. Post 25p.

RF-300 AF/RF SIGNAL GENERATOR



All transistorised, compact, fully portable.
AF sine wave 18Hz. to 220KHz.
AF square wave 18Hz. to 100KHz.
Output sine/square 10v. P-P. RF 100KHz. to 200 MHz. Output 1v. maximum. Operation 220/240v. A.C.
Complete with instructions and leads. **£29·95.** Post 50p.

TE-20 D RF SIGNAL GENERATOR
Accurate wide range signal generator covering 120 Kc/s-500 Mc/s on 6 bands. Directly calibrated Variable R.F. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. **£15.** Carr. 37p. Size 140 × 215 × 170 mm.

MODEL L-55 FET V.O.M.
Input impedance 10 meg. ohms.
0/·3/1·2/6/30/120/600V. D.C.
0/3/12/60/120/600V. A.C.
0/120μA/120mA. D.C.
0/1K/100K/10 meg/100 meg ohms. **£15·97.** Post 25p.

CI-5 PULSE OSCILLOSCOPE
For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth 10MHz. Sensitivity at 100KHz VRMS/mm. ·1-·25; HOR. AMP. Bandwidth 500KHz. Sensitivity at 100KHz. V RMS/mm. ·3-·25; Preset triggered sweep 1-3,000μsec.; free running 20-200,000Hz in nine ranges. Calibrator pips. 220 × 360 × 430mm. 115-230V. A.C. operation. **£39·00.** Carr. paid.

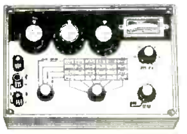
TO-3 PORTABLE OSCILLOSCOPE. 3" TUBE

Y amp. Sensitivity. ·1v p-p/CM. Bandwidth 1.5 cps—1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook **£40·00.** Carr. 50p.

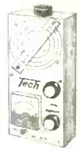
RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPE
5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. × 4in. C.R.T. Calibrated triggered sweep from ·2 μ/sec. to 100 milli-sec. per cm. Free running time base 50 c/s-1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. **£87** Carr. paid.

TE-16A Transistorised Signal Generator. 5 ranges 400kHz—30mHz. An inexpensive instrument for the handyman. Operates on 9v battery. Wide easy to read scale. 800kHz modulation. 5¼ × 5¼ × 3¼in. Complete with instructions and leads. **£7·97.** Post 25p.

TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.

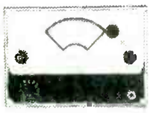


A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1μH—111 HENRIES. 6 Ranges — 2%. C. 10PF±1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7¾" × 5" × 2". **£20.** Post 25p.



MODEL TE.15 GRID DIP METER
Transistorised. Operates as Grid Dip, Oscillator, Absorption Wave Meter and Oscillating Detector Frequency range 440Kc/s—280Mc/s in 6 coils. 500μA Meter. 9V. battery operation. Size 180 × 80 × 40mm.
£12·50. Post 20p.

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR
Sine 18-200,000 Hz; Square 18-50,000 Hz



Output max. + 10 dB (10 K ohms). Operation internal batteries. Attractive 2-tone case 7½in. × 5in. × 2in.
Price **£17·50**
Carr. 17p.

MODEL MG-100 SINE SQUARE WAVE AUDIO GENERATOR
Range: 19-220,000 Hz Sine Wave 19-100,000 Hz Square Wave. Output Sine or Square wave 10v. P. to P. Size 180 × 90 × 90mm. Operation 220/240v A. C.
£17·50. Post 37p.

MODEL AT201 DECADE ATTENUATOR
Frequency range: 0-200KHz.
Attenuator: 0-111db., 0·1db. step.
Impedance 600 ohms.
Max. input power 30dbm.
Size 180 × 90 × 55mm. **£12·50.** Post 37p.

TE-65 VALVE VOLTMETER

High quality instrument with 28 ranges.
D.C. volts 1.5-1,500 v.
A.C. volts 1.5-1,500 v.
Resistance up to 1,000 megohms.
220/240v. A.C. operation
Complete with probe and instructions. **£17·50.** Post 30p.
Additions. Probes available: R.F. **£2·12** H.V **£2·50.**

MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER
Sensitivity 330 ohms/Volt A.C. and D.C. Accuracy ·5% D.C. 1% A.C. Scale length 165mm.
0/300/750μA/1·5/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 AMP. D.C.
0/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 AMP. A.C.
0/75/150/300/750mV/1·5/3/7·5/15/30/75/150/300/750V. D.C.
0/750mV/1·5/3/7·5/15/30/75/150/300/650V. A.C.
Automatic cut out. Supplied complete with test leads, manual and test certificates. **£49.** Post 50p.

G. W. SMITH & Co. (Radio) Ltd.
Also see opposite page and next two pages

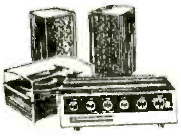
FANTASTIC OFFER!

NIKKO TRM 50 STEREO AMPLIFIER

17 + 17 watts rms stereo amplifier with inputs for Magnetic and Crystal phono, Tuner, Tape, Aux. and Tape Monitor. Outputs for two pairs of stereo speakers and Tape. Stereo headphone socket. Full range of controls including loudness control, scratch filter etc. Size 13in. × 9¼in. × 3⅞in. Unrepeatable offer—limited stocks!

List price £59 50
OUR PRICE **£39·95**
Carriage 50p.

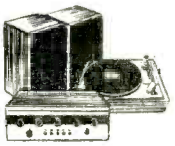
NIKKO TRM 50 SYSTEM



Nikko TRM50 17+17 watt stereo amplifier, BSR MP60, plinth and cover, Goldring G800 cartridge, pair of Linton 2 speakers and all leads.

OUR PRICE **£104·90** Carr. & Ins. £1·50

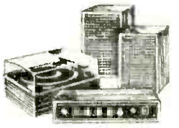
LEAK DELTA 30 SYSTEM



Leak Delta 30 stereo amplifier, Goldring GL75, plinth, cover and G800 cartridge. Pair of Leak 150 speakers and all leads.

OUR PRICE **£123·50** Carr. & Ins. £1·50

AMSTRAD 8000 II SYSTEM

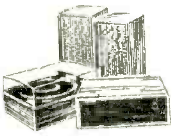


Amstrad 8000 II 7 + 7 watt amplifier. BSR MP60, plinth and cover, Goldring G800 cartridge, pair of Apollo speakers and all leads.

OUR PRICE **£48·25** Carr £1·00

Amplifier only, £16·95. Carr. 50p.

AUDIOTRONIC LA.1700 SYSTEM



17 + 17 watt stereo amplifier. Garrard AP76 with Goldring G800 cartridge, teak veneered plinth with cover and a pair of Wharfedale Linton 2 speakers in matching teak.

OUR PRICE **£92·95** Carr. & Ins. £1·50

Matching LT1700 AM/FM Stereo Tuner £41·50 if purchased with above system.

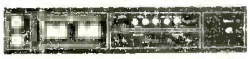
SUPER MONEY SAVING OFFER!

TELETON R.4300L

3 waveband stereo tuner amp. 2 × 5W Medium Long/Stereo FM. Full range of controls. Input for tape or ceramic cartridge.

List over £50·00 OUR PRICE **£27·50** Post 50p

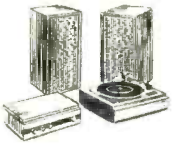
DOLBY SYSTEM NOISE REDUCTION UNIT



Improves the performance of cassette and semi-professional recorders. Reduces tape hiss by 3dB at 600 Hz, 6 dB at 1200 Hz and 10 dB for all frequencies above 300 Hz. Controls for input levels and noise reduction on record and replay. 2 meters for Dolby level. Off tape monitoring. Frequency response: 20 Hz to 15kHz ± 1 dB 19 kHz — 35 dB. Size 15¾" × 9" × 3¼". A.C. 200/250 V.

OUR PRICE **£32·50** Carr. 50p.

WHARFEDALE LINTON SYSTEM



Wharfedale Linton Amplifier. Linton Turntable, pair of Linton 2 speakers and all leads.

OUR PRICE **£106·00** Carr. & Ins. £1·25

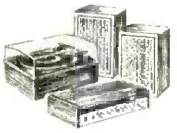
LINTON RECEIVER SYSTEM £155·00. Carr. & Ins. £1.50

MONOTONE 6750 SYSTEM

Monotone 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 **£35·50** Carr. £1·00

TELETON SAQ206B SYSTEM

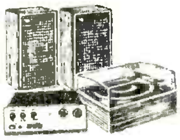


Teleton SAQ206B 8 + 8 watt amplifier, BSR MP60, plinth and cover, Goldring G800 cartridge, pair of Apollo speakers and all leads.

OUR PRICE **£54·40** Carr. £1·50

Amplifier only, £22·95. Post 50p.

TRIO KA 2000A SYSTEM



Trio KA 2000A 16 + 16 watt amplifier. BSR MP60, plinth and cover, Goldring G800 cartridge, pair of Denton 2 speakers and all leads.

OUR PRICE **£79·95** Carr. £1·25

Matching Trio KT 1000A AM/FM stereo tuner, £50·97 extra if required.

SPECIAL PURCHASE!

FERGUSON 3414 STEREO TUNER AMPLIFIER TURNTABLE UNIT

10 + 10 watts rms. Five push buttons with separate scales for pre-tuning to desired FM station. Housed in a handsome walnut finished cabinet with BSR P128/MP60 record deck with Goldring G800II stereo magnetic cartridge. Offered complete with cover and a pair of matching Medway speakers, size 18" × 11" × 8".

TODAY'S VALUE AT LEAST £125! OUR PRICE **£75** Carr. & Ins. £1·50

Also available
Ferguson 3408 Stereo Tuner Amp £37·50
Ferguson 3415 Stereo Tuner Amp £52·50
Ferguson 3416 4-track stereo Tape Deck £49·95
P & P 50p extra

HI-FI EQUIPMENT

SAVE UP TO 33⅓% OR MORE

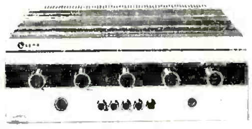
SEND S.A.E. FOR FULL DISCOUNT PRICE LISTS AND PACKAGE OFFERS

SAVE £££s

PHILIPS GA308 TRANSCRIPTION TURNTABLE

2 speeds 33⅓ and 45 r.p.m. Lightweight tubular counter-balanced arm. Belt driven low speed synchronous motor. Viscous damped pick up lift/lower device. Complete with teak plinth and hinged cover.
GA308 less cartridge (List £36·55) OUR PRICE £24.50. Post 75p.
GA308 PU with GP400 stereo magnetic cartridge (List £47·65). OUR PRICE £29·95. Post 75p.
LIMITED NUMBER ONLY!

LEAK BARGAINS



LIMITED OFFER!
ALL STOCKS BRAND NEW AND GUARANTEED

Delta 30	£46·05
Delta 70	£57·95
Delta FM	£57·95
Delta AM/FM	£69·95
Delta 75	£129·95
Leak 150, pair	£37·50
Leak 250, pair	£47·95
Leak 600, each	£33·95

Post 50p extra each item.

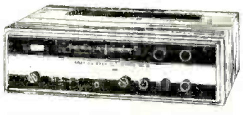
ROTEL BARGAINS!

ALL BRAND NEW AND GUARANTEED

RA210 Amp.	£22·50
RA310 Amp.	£34·95
RA610 Amp.	£51·95
RX150 Receiver	£45·95
RX200 Receiver	£57·50
RX400 Receiver	£70·95

Post 50p extra any item.

AKAI BARGAINS!



MODEL AA6300 AM/FM STEREO TUNER AMPLIFIER

20 + 20 watts rms. Inputs for magnetic and ceramic cartridge and tape. Frequency response 20-40,000Hz. Bass, treble, volume and loudness controls. Frequency range FM 88-108MHz. AM 535-1605kHz. Headphone socket. Output for two pairs of speakers. 17¼" × 5¼" × 13¼". List Price £123·85.

OUR PRICE **£79·95** Post 75p

AKAI AA8030 Receiver £106·95 Post 75p.
AKAI AA8080 Receiver £144·95 Post 75p.
AKAI AA8500 Receiver £175·00 Post 75p.

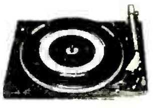
CREDIT TERMS

AVAILABLE FOR CALLERS

Buy it with Access — BARCLAYCARD welcome here

RECORD DECKS

(Post 50p.)



B.S.R. McDONALD	
C114 Mini	£4·97
C129 Mono	£6·50
C137	£8·35
MP60	£9·50
610	£12·95
810	£31·25
210/TPD3	£8·75
MP60/G800	£12·95
MP60/TPD1	£16·05
MP60/TPD1/G800	£19·50
MP60/TPD2	£14·35
610/TPD1	£18·95
510/TPD1	£17·95
HT70	£13·99
HT70/G800	£17·25
HT70/TPD1	£20·35
HT70/TPD1/G800	£23·90
810 Plinth/Cover	£9·25
CONNOISSEUR	
BD1 Kit	£10·90
BD1 Chassis	£13·60
BD1/SAU2/Plinth/C	£33·10
BD2/SAU2/Chassis	£25·95
BD2/SAU2/Plinth/C	£33·85
GARRARD	
2025 T/C Ster.	£8·50
SP25 III	£10·25
SP25 III/GP104 Ceramic	£10·25
SP25 III/M75-6	£15·95
SP25 III Module/M75-6	£23·50
SL65B	£13·75
AP76	£17·95
AP76 Module/M75-6	£33·80
SL72B	£21·95
SL95B	£32·25
401	£25·95
Zero 100A	£38·95
Zero 100S	£36·95
Zero 100S Mod./M93-E	£52·60
AP96 Module/M75-6	£38·75

GOODMANS	
TD100 Teak	£51·95
TD100 White	£58·25
GOLDRING	
GL69/2	£18·50
GL72	£20·95
GL72/P	£27·50
Plinth 69/72	£7·02
Lid 72	£3·25
GL75	£26·95
GL75P	£35·25
Plinth 75	£7·35
LID 75	£3·60
G99	£19·25
GL85P/C	£56·95
G101P/C	£20·50
LEAK	
Delta T'table	£52·50
MICRO-SEIKI	
MR111	£29·50
MR111 Plinth & Cover	£9·50
PHILIPS	
GA105	£16·95
GA160 Teak	£27·00
GA308 Teak	£24·50
GP308 PU Teak	£29·95
GA212	£56·75
PIONEER	
PL12D	£34·50
PL15C	£51·35
PLA35	£82·65
PL50	£111·85
PL41D	£118·50
PL61	£119·95
THORENS	
TD125 II	£66·50
TD125AB II	£99·95
TX25	£6·95
TD160C	£56·95
TD150A II	£35·95
TD150AB II	£39·95
WHARFEDALE	
Linton Turntable	£26·95

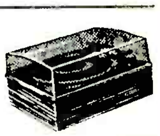
PLINTHS & COVERS

(Post 75p)

Budget SP25 etc.	£3·20
Budget AP76/Zero 100S	£4·50
Budget B.S.R.	£3·25
SME 2000 System	£34·50

RECORD DECK PACKAGES

(Post 75p).



Decks supplied with stereo cartridge ready wired in plinth with cover.

Garrard 2025TC/9TAHCD	£12·75
Garrard SP25 III/G800	£18·50
Garrard SP25 III/M75-6	£18·50
Garrard SP25 III/M44-7	£19·75
Garrard SP25 III/M44-E	£20·95
Garrard SP25 III/M55E	£22·40
Garrard AP76/G800	£27·95
Garrard AP76/M75-6	£30·25
Garrard AP76/M55E	£30·50
Garrard AP76/M75EJ	£32·50
Garrard AP76/G800E	£30·75
Garrard AP76/M44E	£30·50
Garrard AP76/M75ED	£38·95
B.S.R. McDonald MP60/G800	£17·50
B.S.R. McDonald MP60/M44-7	£18·95
B.S.R. McDonald MP60/M44-E	£19·95
Goldring GL75/G800	£39·50
Goldring GL75/G800E	£42·50

SPECIAL PURCHASE!

NEAT G30J STATIC BALANCE PICK-UP ARMS

Identical specification to NEAT G30 arm but with two-tone chrome and black finish. Complete with head shell, pick up rest and plug in phono leads.
BRAND NEW—FULLY GUARANTEED.
ONLY £8·95. Post 25p.

G.W.SMITH & CO (Radio) LTD

Personal Callers Welcome - All Branches Open 9-6 Mon. to Sat.

10 TOTTENHAM CT. RD. LONDON, W.1 Tel: 01-637 2232
27 TOTTENHAM CT. RD. LONDON, W.1 Tel: 01-636 3715
257/258 TOTTENHAM CT. RD. LONDON, W.1 Tel: 01-580 0670
3 LISLE STREET, LONDON, W.C.2 Tel: 01-437 8204
34 LISLE STREET, LONDON, W.C.2 Tel: 01-437 9155
311 EDGWARE ROAD, LONDON, W.2 Tel: 01-262 0387

All Mail Orders to— 11-12, Paddington Green, London, W.2. Tel: 01-262 6562

G. F. MILWARD
ELECTRONIC COMPONENTS

Wholesale/Retail: 369 Alum Rock Road, Birmingham B8 3DR. Tel. 021-327 2339

Special Offer ! ! !

MULLARD ELECTROLYTIC CAPACITORS

071 and 072 Series

Type No.	Working Voltage Vdc.	Capacitance uF	Max. Ripple Current at 50°c	Weight	Price
071 15332	16	3300	2·4 amps	1oz	**15p**
071 15472	16	4700	3·9 amps	1oz	**17p**
071 15682	16	6800	5·8 amps	1½oz	**22p**
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**

Type No.	Working Voltage Vdc.	Capacitance uF	Max. Ripple Current at 50°c	Weight	Price
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

Type No.	Working Voltage Vdc.	Capacitance uF	Max. Ripple Current at 50°c	Weight	Price
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	16,000	8oz	**20p**
104 90003	20	39,000	16oz	**30p**
102 16802	25	8,000	7oz	**25p**
104 17562	40	5,600	5oz	**25p**
104 90001	45	20,000	16oz	**50p**
104 18332	63	3,300	5oz	**25p**

Not over	Ordinary Parcels
1½lb	16p
2lb	21p
4lb	25p
6lb	29p
10lb	37p
14lb	47p
18lb	57p
22lb	67p

A further 10% discount on lots of 100 of any one type. *Please calculate the weight of your order and include appropriate postage.*

REMEMBER THE VAT-MAN COMETH ! ALL PRICES INCREASE APRIL 1st !

£1 — 100 ¼-½ WATT RESISTORS, 100 CERAMIC CAPACITORS, 100 DIODES — PACK No. 1

£1 — 100 RESISTORS, 100 CERAMIC CAPACITORS, 100 POLYSTYRENE CAPACITORS — PACK No. 2

£1 — 1 VERO-BOARD CUTTER, 5 2½ in. x 1 in. x ·15 BOARDS, 50 SQ. INS. "ODD PIECES" VERO — PACK No. 3

£1 — 100 RESISTORS, 100 CERAMIC CAPACITORS, 50 MULLARD POLYESTER CAPACITORS — PACK No. 4

£1 — 20 ASSORTED UNUSED MARKED, TESTED TRANSISTORS. BC108 ETC. — PACK No. 5

£1 — 1 TRANSISTORISED SIGNAL TRACER KIT, 1 TRANSISTORISED SIGNAL INJECTOR KIT — PACK No. 6

£1 — 6 COMPUTER PANELS CONTAINING MASSES OF DIODES, TRANSISTORS, INDUCTORS, RESISTORS & CAPACITORS — PACK No. 7

£1 — 100 RESISTORS, 100 CAPACITORS (ASSORTED TYPES) — PACK No. 8

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
Epoxy-Resin	
75mm × 100mm	22p
100mm × 150mm	44p
150mm × 200mm	88p
Plain Fibre Glass Board, copper-clad one side 12" × 6"	45p
Bakelite Laminate Board, 1·57mm thick, copper-clad one side 1 sq. foot	50p

THIS MONTH'S BARGAIN!

We have a huge number of heavy current rectifiers and thyristors, all new, some ready mounted on large heat-sinks. Call, inspect, name your own price—we may accept! Must clear—space needed.
Also a number of very costly speed-controls for motors up to 40HP. New, mostly boxed, all offered for about one-tenth of original price!
Send S.A.E. for full list of pre-VAT offers!

G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 15p.

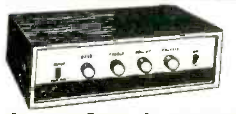
NEW BRANCHES NOW OPEN
SUNDERLAND STOCKPORT AND COVENTRY

BIRMINGHAM 30-31 Gt. Western Arcade
BLACKPOOL (Closed Wed.)
(Agent) O & C Electronics, 227 Church St.
BRADFORD 10 North Parade (Closed Wed.)
COVENTRY 17 Shelton Sq. Opens Jan.
DARLINGTON 19 Northgate (Closed Wed.)
DERBY 26 Osmaston Rd. (Closed Wed.)
EDINBURGH 101 Lothian Road (Closed Wed.)
GLASGOW 326 Argyle St. (Closed Tues.)
HULL 7 Whitefriargale (Closed Thurs.)
LEEDS 5-7 County (Mecca) Arcade, Briggate (Closed Wed.) Tel. 28252
LEICESTER 32 High St. (Closed Thurs.)
LIVERPOOL 73 Dale St. (Closed Wed.)
LONDON 238 Edgware Rd., W2 (Closed Thurs.) Tel. 723 1629
MANCHESTER 60a Oldham St.(Closed Wed.)
MIDDLESBROUGH 106 Newport Rd. (Closed Wed.) Tel. 47096

RSC HI-FI CENTRES LTD

MAIL ORDERS to:
106 HENCONNER LANE, LEEDS 13.
Terms C.W.O. or C.O.D. Postage 25p extra under £2. 30p extra over £2, or as stated. Trade supplied. S.A.E. with enquiries.
EXPORT ENQUIRIES WELCOMED
BRANCHES OPEN ALL DAY SATURDAYS AND OPERATE A 5-DAY WEEK
MAIL ORDERS NOT TO BE SENT TO SHOPS.

NEWCASTLE 24 Newgate Shopping Centre (Closed Wed.) Tel. 21469
NOTTINGHAM 19 Market St. (Closed Thurs.)
SHEFFIELD 13 Exchange St. (Closed Thurs.)
STOCKPORT 8 Little Underbank Tel. 480 0777
SUNDERLAND 5 Market Square (Closed Wed.)



R.S.C. G66 MkII 6+6 WATT STEREO AMPLIFIFIER

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 **£11·50** OR FACTORY BUILT IN TEAK VENEERED CABINET **£14·99**

R.S.C. SUPER 30 MkIII HIGH FIDELITY STEREO AMPLIFIER

BUILD AN AMPLIFIER WORTH APPROXIMATELY DOUBLE THE KIT PRICE INCLUDING CABINET
Only high grade components by leading manufacturers

- Push Button Selector Switching
- Jack Socket for Headphones
- Neon Indicator
- Satin Silver Finish Metal Fascia
- Solid State Circuitry
- Twenty Silicon Transistors
- Four Diodes, Four Rectifiers

Send S.A.E. for full descriptive leaflet

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. 65p Cabinet if req. £5 extra **£25**

FACTORY BUILT UNIT INC. CABINET with 12 months' guarantee. Or Dep. £7 and 9 monthly payments £3·99 (Total £42·91) **£38·75**

R.S.C. STEREO FM TUNER NOW AVAILABLE. Visually matches Super 30 Mk. III at **£44·95**

FANE ULTRA HIGH POWER LOUDSPEAKERS

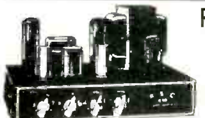
Power Rating R.M.S. continuous. 2 years guarantee. Carr. free

12" 'POP' 50 50 Watts — 15 Ω 13,000 Gauss **£10·90**
Or Dep. £2 and 9 monthly payments £1·20 (Total £12·80) Pair suitable for all purposes.

15" 'POP' 60 60 Watts — 8/15 Ω 14,000 Gauss **£12·90**
Or Dep. £3·30 and 9 monthly payments £1·30 (Total £15·00)

18" 'POP' 100 100 Watts — 8/15 Ω 14,000 Gauss **£22·95**
Or Dep. £6·00 and 9 monthly payments £2·20 (Total £25·80)

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 £1·90 FACTORY BUILT with 12 months' guarantee. Or Dep. £4 and 9 monthly payments £2·10 (Total £22·90) S.A.E. for leaflet **£19·75**

FANE SPEAKERS 'POP' 25/2

12" 25 WATT **£6·75**
Dual Cone. 15 ohms NOT for Bass Guitar. Or Dep. £1·25 and 9 monthly payments 75p (Total £8·00)

HI-FI SPEAKER ENCLOSURES

Teak veneer finish. Pleasing design. Acoustically lined. All sizes approx.
JE8 16 × 11 × 9 in. Pressurised. Gives excellent results with 8 in. Hi-Fi Speaker. **£5·35**
SE8 for optimum results with any 8 in. Hi-Fi Speaker. 22 × 15 × 9 in. **£6·47**
SE10 outstanding performance with Hi-Fi 10-in. speaker. 24 × 15 × 10 in. Ported. **£6.74**
SE12 for high grade results with 12 in. Hi-Fi speaker and Tweeter. 25 × 16 × 10½ in. Pressurised. **£7·87**

R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impreg where necessary. Primaries 200-250v. 50 Hz. Screened

MIDGET CLAMPED TYPE 2½ × 2½ × 2¼in.

250v., 60mA, 6.3v. 2a.	99p
250-0-250v., 60mA, 6.3v. 2a.	£1·05

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a.	£1·40
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·20
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·20
300-0-300v. 130mA, 6.3v. 4a., c.t., 6.3v 1a. For Mullard 510 Amplifier	£2·65
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·20
350-0-350v. 150mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·65
425-0-425v. 200mA, 6.3v. 4a. c.t., 5v. 3a.	£4·95
425-0-425v. 200mA, 6.3v. 4a., c.t., 6.3v. 4a., c.t., 5v. 3a	£5·10
450-0-450v. 250mA. 6.3v. 4a., c.t., 5v. 3a.	£5·50

TOP SHROUDED DROP-THROUGH TYPE

250-0-250v 70mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·35
250-0-250v. 100mA, 6.3v. 3.5a.	£1·55
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a.	£1·60
350-0-350v. 80mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·65
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·20
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·20
300-0-300v. 130mA, 6.3v. 4a. c.t. 6·3v. 1a. Suitable for Mullard 510 Amplifier	£2·60
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·20
350-0-350v. 150mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·60

FILAMENT or TRANSISTOR POWER PACK Types 6.3v. 1.5a. 49p; 6.3v. 2a. 54p; 6.3v. 3a. 76p; 6.3v. 6a. £1·30; 12v. 1a. 55p; 0-9-18v. 1½a. £1·10; 0-12-25-42v. 2a. £1·76; 12v. 3a. or 24v. 1.5a. £1·35;
CHARGER TRANSFORMERS 0-9-15v. 1½a. 99p; 2½a., 110p; 3a., 125p; 5a., 145p; 6a., 165p; 8a., £2.
AUTO (Step UP/Step DOWN) Transformers 0-110/120v., 200-230-250v. 50-80 watts 110p; 150w., 190p; 250w., 275p; 500w., 575p.

OUTPUT TRANSFORMERS

Standard Pentode 5,000 Ω to 7,000 Ω to 3 Ω	50p
Push-Pull 8 watts EL84 to 3 Ω or 15 Ω	83p
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15 Ω	£1·37
Push-Pull EL84 to 3 or 15 Ω 10-12 watts	£1·35
Push-Pull Ultra Linear for Mullard 510, etc.	£2·20
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15 Ω	£1·99
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15 Ω	£3·30

BATTERY/MAINS CONVERSION UNITS

R.S.C. BM1 battery eliminator completely replaces 1·5v. and 90v. Radio batteries where normal 200-250v. AC mains is available.
Complete Kit with diagram **£3·25** Ready for use **£3·75**

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.) **£3·85**
Cast Chassis REMARKABLE VALUE 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. 80? 8" unit, 303 Pressure Tweeter, Printed circuit, inductive capacitive cross-over, acoustic filling, panels, screws, etc.
Response 30-20,000 Hz ONLY **£9·95** Post free

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	£2·88
HF 102D	10"	10W	£3·40
HF 120	12"	15W	£4·50
HF 120D	12"	15W	£4·99
HF 126	12"	15W	£5·75
HF 126D	12"	15W	£6·25

Please state impedance required. 3 or 8-15 ohm.

HI-FI SPEAKER SYSTEMS

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. 30p **£5·95**
Audiotrine 125K with extra sensitive 15,000 Gauss 12 in. speaker. **£6·95**

TRANSFORMERS

MAINS ISOLATING SERIES

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	1·61	30
100	60	3	8	8·9 × 8·0 × 7·7	2·39	36
61	100	5	12	10·2 × 8·9 × 8·3	2·62	52
30	200	9	8	12·0 × 10·3 × 10·0	4·39	52
62	250	12	4	9·5 × 12·7 × 11·4	5·80	67
55	350	15	0	14·0 × 10·8 × 12·4	7·77	82
63	500	27	0	17·1 × 11·4 × 15·9	11·20	*
92	1000	40	0	17·8 × 17·1 × 21·6	20·63	*
128	2000	63	0	24·1 × 21·6 × 15·2	34·10	*
129	3000	84	0	21·6 × 21·6 × 20·3	53·34	*
190	6000	178	0	31·1 × 35·6 × 17·1	87·52	*

440V 300VA ISOLATOR, Primary 440V Secondary 240V, Centre Tapped Screened and Shrouded, £9·43. 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	0·85	22
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	1·66	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	2·00	36
66	300	6	0	10·2 × 10·2 × 9·5	,, ,,	3·89	52
67	500	12	8	14·0 × 10·2 × 11·4	,, ,,	5·78	67
84	1000	16	0	11·4 × 14·0 × 14·0	,, ,,	10·49	82
93	1500	28	9	13·5 × 14·9 × 16·5	,, ,,	15·20	*
95	2000	40	0	17·8 × 16·5 × 21·6	,, ,,	19·84	*
73	3000	45	8	17·4 × 18·1 × 21·3	,, ,,	26·99	*

TOTALLY ENCLOSED 115V AUTO TRANSFORMERS

115V 500 Watt totally enclosed auto transformer, complete with mains lead and two 115V outlet sockets. £7·85. P & P 67p
Also available a 20 Watt version. £1·67. P & P 22p.

LOW VOLTAGE SERIES (ISOLATED)
PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps. 12V	Amps. 24V	Weight lb	oz	Size cm.	Secondary Windings	£	P & P p
111	0·5	0·25		12	7·6 × 5·7 × 4·4	0-12V at 0·25A × 2	0·85	22
213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	1·01	22
71	2	1	1	9	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·33	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	1·86	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	2·24	42
108	8	4	5	4	10·0 × 8·3 × 8·2	0-12V at 4A × 2	2·48	52
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	2·94	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	4·54	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	5·78	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	10·67	82
226	60	30	34	0	17·0 × 14·5 × 12·5	0-12V at 30A × 2	19·61	*

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	1·01	22
79	1·0	2	0	7·0 × 6·4 × 6·0	,, ,,	1·35	36
3	2·0	3	2	8·9 × 7·0 × 7·6	,, ,,	2·01	36
20	3·0	4	6	10·2 × 8·9 × 8·6	,, ,,	2·48	42
21	4·0	6	0	10·2 × 10·0 × 8·6	,, ,,	2·94	52
51	5·0	6	8	12·1 × 10·0 × 8·6	,, ,,	3·66	52
117	6·0	7	8	12·1 × 10·0 × 10·2	,, ,,	4·36	52
88	8·0	10	0	14·0 × 11·7 × 10·0	,, ,,	5·64	67
89	10·0	12	2	14·0 × 10·2 × 11·4	,, ,,	7·14	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	1·33	30
103	1·0	2	10	8·3 × 7·3 × 7·0	,, ,,	1·94	36
104	2·0	5	0	10·2 × 8·9 × 8·6	,, ,,	2·69	42
105	3·0	6	0	10·2 × 10·2 × 8·3	,, ,,	3·65	52
106	4·0	9	4	12·1 × 11·4 × 10·2	,, ,,	4·83	52
107	6·0	12	4	12·1 × 11·1 × 13·3	,, ,,	7·14	67
118	8·0	18	9	13·3 × 13·3 × 12·1	,, ,,	9·32	97
119	10·0	19	12	16·5 × 11·4 × 15·9	,, ,,	11·68	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	1·35	36
126	1·0	3	0	8·9 × 7·6 × 7·6	,, ,,	1·88	36
127	2·0	5	6	10·2 × 8·9 × 8·6	,, ,,	2·94	42
125	3·0	8	8	11·9 × 9·5 × 10·0	,, ,,	4·48	52
123	4·0	10	6	11·4 × 9·5 × 11·4	,, ,,	5·78	67
120	6·0	16	12	13·3 × 12·1 × 12·1	,, ,,	8·37	82
122	10·0	23	2	16·5 × 12·7 × 16·5	,, ,,	13·85	*

LEAD ACID BATTERY CHARGER TYPES
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		1·34	30
5	4·0	3	11	10·2 × 7·0 × 8·3	Please note, these units do not include rectifier.	2·03	42
86	6·0	5	12	10·2 × 8·9 × 8·3		3·07	52
146	8·0	6	4	8·9 × 10·2 × 10·2		3·49	52
50	12·5	11	14	13·3 × 10·8 × 12·1		5·20	67

All ratings are continuous. Standard construction: open with solder tags and wax impregnation. Enclosed styles to order.

TRANSISTORS
TO MANUFACTURERS' FULL SPECIFICATIONS

BC107/108/109 9·0p each	2N 3055 68p each with mica and bushes	AD 161/162 60p pair with mica and bushes
25+ 7·5p	25+ 55p	25+ 55p
100+ 6·5p	100+ 45p	100+ 50p
500+ 6·0p	500+ 40p	500+ 45p
Minimum order 10 pieces this range.		1000+ 40p

★ Quantity prices on application

Also stocked: SEMICONDUCTORS · VALVES
MULTIMETERS · MAINS KEYNECTOR
ELECTROSIL METAL OXIDE RESISTORS

*Carriage via B.R.S

BARRIE electronics
11 MOSCOW ROAD, QUEENSWAY
LONDON W2 4AH Tel: 01-229 6681/2
NEAREST TUBE STATIONS: BAYSWATER, QUEENSWAY

WW—091 FOR FURTHER DETAILS

ELECTRONIC ORGAN DIVIDER BOARDS built to high industrial/computer spec. 5 octave set **£15.** Complete with connection data and oscillator details.

COPPER LAMINATE P.C. BOARD
8½×5½×1/16 in. **12½p** sheet, 5 for **50p**
11×6½×1/16 in. **15p** sheet, 4 for **50p**
11×8×1/16 in. **20p** sheet, 3 for **50p**
Offcut pack (smallest 4×2 in.) **50p** 300 sq. in.
P&P single sheet **4p.** Bargain packs **10p**

SPEAKERS AND CABINETS

E.M.I. 13×8 in. (10 watt) with two tweeters and cross-over 3/8/15 ohm models. **£3·75.** P.P. 25p.

E.M.I. 13×8 in. base units (10 watt) 3/8/15 ohm models **£2·25.** P.P. 25p.

E.M.I. 6½ in. rnd. 10 watt Woofers. 8 ohm.1 3,000 gss **£2·25.** P.P. 15p.

E.M.I. 20 watt (13×8 in.) with single tweeter and "X-over" 20 Hz to 20,000 Hz. Ceramic magnet 11,000gss. **£8.** P.P. 40p. 20 watt base unit only. **£6.** P.P. 40p.

CABINETS for 13 × 8 in. speakers manufactured in ¾ in. teak-finished blockboard. Size 14 × 10½ × 9 in. **£5** ea. P.P. 40p.

20W. CABINET. 18 × 11 × 10 in. **£6.** P.P. 50p.

PRECISION A.C. MILLIVOLTMETER (Solartron) 1·5m.v. to 15v: 60db to 20db. 9 ranges. Excellent condition. **£22·50.** P.P. £1·50.

V.H.F. POWER TRANSISTORS TYPE PT4176D (2N4128). 24 watt 175 MHz. **£1·50** ea. S.A.E. for spec

MINIATURE UNISELECTORS (A.E.I. 2203A.), 3 bank, 12 position, non-bridging wipers. **£4·25** ea. Brand new Complete with base.

TEN TURN POTENTIOMETERS (Colvern) 5000 ohm **£1·50** complete with 10T dial.

VACUUM PUMPS (Metrovac GS 24). Complete with ⅓ h.p. 240v. A.C. motor. New condition. **£35.** (S.A.E Literature.)

PAINTON WINKLER SWITCHES. 1 pole 15 way 2 bank. (G.P. contacts and wipers). **£1·25** ea.

BULK COMPONENT OFFER. Resistors/Capacitors. All types and values. All new modern components. Over 500 pieces **£2.** (Trial order 100pcs. 50p.) We are confident you will re-order

BERCO WIRE-WOUND POTS. New individually boxed. 200 ohm 25 watt **50p**: 725 ohm 50 watt **75p**: 300 ohm 100 watt **£1** ea.

HIGH-SPEED MAGNETIC COUNTERS. 4 digit (non reset) 24 or 48v. (state which) 4 × 1 × 1 in. **35p.** P.P. 5p.
5 digit (non reset) 6v. d.c. (2½ × 1½ × 1½ in.). **75p.** P.P. 5p.
3 digit (Reset) 48v. 4×1×1 in. **£1·75.** P.P. 5p.
5 digit (Reset) 12v. d.c. (2⅞ × 2 × 1 in.). **£3.** P.P. 5p.
6 digit (Reset) 12v. d.c. (2⅞ × 2 × 1 in.) **£3·50.** P.P. 5p.

HIGH CAPACITY ELECTROLYTICS
2,200µf. 100v. (1½ x 4in.) **60p.** 3,150µf. 40v. (1½ x 4in.) **60p.** 10,000µf. 25v. (1½ x 4½in.) **60p.** 10,000µf. 100v. (2½ x 4½in.) **£1.** 12,000µf. 40v. (2 x 4in.) **75p.** 16,000µf. 16v. (2 x 4in.) **60p.** 21,000µf. 40v. (2½ x 4in.) **£1.** Post and packing 5p.

LIGHT DIMMERS (2000 watt) Triac Controlled. 3½×2×1½ in. **£5·75** ea. P.P. 25p.

TRANSFORMERS

L.T. TRANSFORMER. (Shrouded) Prim. 200/250v. Sec. 20/40/60v. 2 amp. **£2** ea. P.P. 40p.
L.T. TRANSFORMER (CONSTANT VOLTAGE). Prim. 200/240v. Sec. 1. 50v. at 2 amp. Sec. 2. 50v. at 100 m/a **£3.** P.P. 50p.
L.T. TRANSFORMER. Prim. 240v. Sec. 0/25/50v. 2 amp. **£1·75.** P.P. 25p.
L.T. TRANSFORMER. Prim 220/240v. Sec. 13v. 1.5 amp. **65p.** P.P. 15p.
L.T. TRANFORMER. Prim. 115/240v. Sec. 10·5v. at 1 amp. c.t 28-0-28v at 2 amp. shrouded type. **£2.** P.P. 40p
2500 watt. ISOLATION TRANSFORMER (CONSTANT VOLTAGE). Prim. 190-260v. 50Hz. Sec. 230v. at 10·9 amps. **£30.** Carr. £2.
H.D. STEP-DOWN TRANSFORMER. Prim. 200/240v Sec. 117v at 19·8 amps. (2,300 watt). **£22·50.** Carr. £2.
H.T. TRANSFORMERS. Prim. 200/240v. Sec. 300-0-300v. 80 m.a. 6.3v. c.t. 2 amp. **£1·50** P.P. 40p. 350-0-350v. 60 m.a. 6.3v. c.t. 2 amp. **£1.** P.P. 25p.
STEP-DOWN TRANSFORMERS: Prim. 22/240v. Sec. 115v. Double wound 500w. **£5.** P.P. £1. 700w. (with filters) **£10.** P.P. £1. 500w. (metal cased with socket output) and overload protection. **£6·50.**
AUTO-WOUND. 75W. **£1.** P.P. 25p. 300W. **£1·50.** P.P. 50p 750W. **£6.** P.P.£1.
L.T. TRANSFORMER. Prim. 110/240v. Sec. 0/24/40v. 1·5A. (Shrouded type). **£1·50.** P.P. 25p.
HT/LT TRANSFORMER Prim. 240v. (tapped) Sec. 1. 500-0-500v. 150 m/a. Sec. 2. 31v. 5 amp. **£2·75** P.P. 50p.
HEAVY DUTY E.H.T. TRANSFORMER. Prim 0/110/240v. Sec. 1800v. 3·1 K.V.A. **£28.** Carr. £2 4K.V.A. model **£33.** Carr £2.

PRECISION CAPACITANCE JIGS. Beautifully made with Moore & Wright Micrometer Gauge. Type 1. 18.5pf. to 1,220pf **£10** each Do 2 9·5pf. to 11.5pf. **£6** each.

MULTICORE CABLE (P V C.).
6 core (6 colours) 3 screened, 14/0048. **15p.** yd. 100 yds. **£12·50.**
12 core (12 colours) **15p.** yd. 100 yds. **£12·50.**
24 core (24 colours) **20p.** yd. 100 yds. **£17·50.**
30 core (15 colours) **22½p.** yd. 100 yds. **£18·50.**
34 core (17 colours) **25p.** yd. 100 yds. **£20.**
Minimum order 10 yds.

TELEPHONE DIALS (New) £1 ea.

RELAYS (G.P.O. '3000'). All types. Brand new from **37½p** ea. 10 up quotations only.
EXTENSION TELEPHONES (Type 706) New/Boxed. **£5.** 50p.
RATCHET RELAYS. (310 ohm) Various Types **85p.** P.P. 5p.
UNISELECTORS (Brand new) 25-way 75 ohm. 8 bank ½ wipe **£3·25.** 10 bank ½ wipe **£3·75.** Other types from **£2·25.**

BLOWER FANS (Snail type) Type 1: Housing dia. 3½ in. Air outlet 1½ × 1 in. **£2·25.** P.P. 25p. Type 2: Housing dia. 6 in. Air outlet 2½ × 2½ in. **£4.** P.P. 50p. Both types 115/240v. A.C. (brand new).

POT CORES LA1/LA2/LA3 **50p** each

RELAYS

SIEMENS/VARLEY PLUG-IN. Complete with transparent dust covers and bases. 2 pole c/o contacts **35p** ea ; 6 make contacts **40p** ea.; 4 pole c/o contacts **50p** ea. 6-12-24-48v types in stock.

12 VOLT H.D. RELAYS (3×2×1 in.) with 10 amp. silver contacts 2 pole c/o **40p** ea.; 2 pole 3 way **40p.** P.P. 5p.

24 VOLT H.D. RELAYS (2×2×¾ in.) 10 amp. contacts. 4 pole c/o. **40p** ea. P.P. 5p.

240v. A.C. RELAYS. (Plug-in type). 3 change-over 10 amp contacts. **75p** (with base). P.P. 5p.

SUB-MINIATURE REED RELAYS (1 in. × ¼ in.) Wt. ⅛ oz. 1 make 3/12v. **40p.** ea.

SILICON BRIDGES. 100 P.I.V. 1 amp. (⅝×⅝×⅜ in.) **30p.** 200 P.I.V. 2 amp. **60p.**

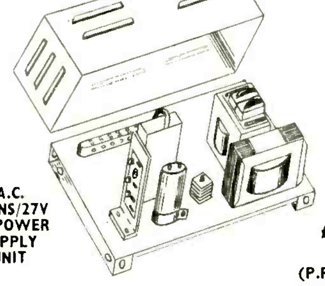
CIRCUIT BREAKERS (3 pole) 15 amp. Dorman & Long 'Loadmasters' **£1·50.** P.P. 25p.

PATTRICK & KINNIE
191 LONDON ROAD · ROMFORD · ESSEX
ROMFORD 44473 **RM7 9DD**

OVER 300,000 IN STOCK!

Multiway and R.F. Connectors by twenty different companies! Send us your detailed requirements quoting Nato numbers if known.

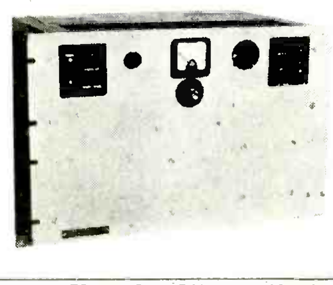
MAINS TO 27V 500mA STABILISED



A.C. MAINS/27V DC POWER SUPPLY UNIT

£3·85 EACH (P.Pd. U.K.)

A.C. MAINS to 27V D.C. POWER SUPPLY UNITS. These interesting 27V 0·5A units (will happily provide 700mA indefinitely) are built into an attractive grey-finished instrument case, provision being made for base or side mounting. Cable entry grommets are mounted in the base of the unit. The choke capacity smoothed output is solid state stabilised against variation in input voltage and output current, and input and output fuses with spares are fitted. The output operates a built-in S.P.C.O. relay to switch for instance an alarm circuit. Input voltage is 200-250V A.C. in 10V steps, while the transformer secondary carries two taps. All terminations to a Grelco block. There is adequate room for other equipment within the ventilated case, which is 12" x 10" x 6" deep. Our price, brand new in carton with circuit, only £3·85.



SPECIAL OFFER OF PROFESSIONAL HIGHEST GRADE POWER SUPPLIES!
Two types of rack mounting supplies are available both in absolutely mint condition complete with all valves, spare fuses etc.
Cat. W.25489 Ed.B. Dual outputs: 275v at 250mA D.C. and 6·3v at 10A A.C. Fitted switched 2" sq. panel meter to monitor output voltage and current. The unit carries A.C. input and H.T. output panel fuses. The H.T. supply is derived from a tapped input transformer with output taps at 310-450v in 10v steps and the L.V. supply from a separate transformer with tapped primary and secondaries of 6·4v 10A (C.T.) 5v 6A (C.T.) and 4v 8A. The H.T. output is double choke capacity smoothed (2 × 8H + 2 × 8µF). A bridge metal rectifier is employed. Provision is made for remote switching while a panel mounted H.T. switch is fitted. Beautifully finished in grey hammer stove enamel. Dimensions: Front panel 19" wide 10½" high 13½" deep behind F.P. Weight 66 lbs. Price **£13·00** C.P. England and Wales plus £1 extra carriage Scotland and N.I.
Cat. W.25495 Ed.B. Dual outputs: 275v at 250mA STABILISED and 6·3v 10A A.C. Fitted switched 2" square panel meter to monitor output voltage and current and 9 valve anode voltages. The unit carries A.C. input and H.T. output panel fuses. The H.T. supply is derived from a tapped input transformer with output taps at 410-550v in 10v steps and the L.V. supply from a separate transformer with tapped primary and secondaries of 6·4v 10A (C.T.) 5v 6A (C.T.) and 4v 8A. The H.T. output is series stabilised by 4 × KT66 valves. A bridge metal rectifier is employed. Separate H.T. switching is provided from the front panel. Fitted with full cover and beautifully finished in grey hammer stove enamel. Dimensions: Front panel 19" wide 12½" high 13½" deep behind front panel. Weight 63 lbs. Price **£19·50** C.P. England and Wales plus extra £1 carriage Scotland and N.I.

MIL SYNCHROS AVAILABLE EX-STOCK
In sizes 08, 11, 15, 16, 18 and 23 for 50, 60 and 400 Hz operation.
Synchro Control Transformers
Synchro Control Transmitters
Synchro Control Differential Transmitters
Synchro Torque Transmitters and Receivers
Synchro Resolvers

TANTALUM CAPACITORS We hold large stocks by S.T.C., T.C.C., Dubilier, Kemet, Plessey, G.E., etc., send for stock list with lowest prices for immediate delivery.

ETHER ELECTROMETHODS LOW INERTIA INTEGRATING MOTORS
Available ex-stock at extremely low prices. For 1·5, 6, 12 and 24V operation in stock.

VACTRIC SIZE 23 PULSE GENERATORS (Shaft Digitizers). Full details and price on application.

STAINLESS STEEL VACUUM CONTAINERS FOR LIQUIDS. Capacity 2 U.S. galls. fitted with delivery taps. Brand new in cartons—**£22·50** (C.Pd. U.K.).

400HZ INVERTERS. 27·5v 150A input, 115v 400Hz 2500VA output. Not new but in excellent condition; fitted with control box containing switchgear and voltage and frequency adjustment circuits. These are extremely small for their capacity only 16in long and 13in high overall including the control box which also carries the circuit diagram. **£29** (C.Pd. U.K. Mainld.)

MULTICORE PVC COVERED TELEPHONE CABLE 24 core **£22** per 100 yds, 12 core **£18** per 100 yds. 8 core **£12** per 100 yds. 4 core **£10** per 200 yds, 2 core **£3** per 100 yds. (All C.Pd. U.K. Mainland).

HEAVY DUTY PVC INSLTD. FLEXIBLE CABLE to DEF 12D Type 3 in following colours: violet, yellow, white, grey, green, orange, pink, red and brown 70/0076" conductors **£3·25** per 100 yds (P.Pd.) also with 40/0076" conductors in grey, violet, white, pink and red at **£2·50** per 100 yds (P.Pd.).

TRANSFORMER/RECTIFIER UNIT Comprising a 380-440v 3 phase. 50Hz input transformer and stud mounted silicon rectifiers. Output is 220v D.C. 15 amps. Ideal for operation of D.C. motors etc. **£27·50** (including carriage U.K. Mainland).

DRY REED INSERTS

Overall length 1·85" (Body length 1·1") Diameter 0·14" to switch up to 500 mA at up to 250V D.C. Gold clad contacts. 63p per doz. £3·75 per 100; £27·50 per 1,000; £250 per 10,000. All carriage paid.

Heavy duty type (body length 2") diameter 0·22" to switch up to 1A. at up to 250V. A.C. Gold clad contacts, £1·25 per doz., £6·25 per 100; £47·50 per 1000; £450 per 10,000. Changeover type £2·50 per doz. All carriage paid.

Operating Magnets 55p per doz. £4 per 100; £35 per 1000. All carriage paid.

SPECIALIST STOCKISTS OF SERVOMOTORS, SYNCHROS, MAGSLIPS & PLUGS & SOCKETS

Servo and Electronic Sales Ltd

Regd. Office: 45a HIGH STREET, ORPINGTON, KENT.
Post Orders and Technical enquiries to: "BAYS", HIGH ST., LYDD. KENT. Lydd 20252 (STD 0679)
Or 67 LONDON ROAD, CROYDON, SURREY (Retail and Instrument Repairs). Phone: 01-688 1512

MODERN TELEPHONES type 706. Two tone grey, £3·75 ea. The same but black, £2·75 ea. P. & P. 25p ea.

AS NEW type 706 **BLUE**, £5 ea. P. & P. 25p. Also **TOPAZE YELLOW** £4·50 ea. P. & P. 25p.

STANDARD GPO DIAL TELEPHONE (black) with internal bell, 87p ea. P. & P. 50p. Two for £1·50. P. & P. 75p. All telephones complete with bell and dial.

SINE TO SQUARE WAVE CONVERTOR. 5Hz to 250KHz 9 volt operation. Sine Input 1 to 15 volt—output 0 to 7 volts. Completely assembled with amplitude control and mark space preset. £2·25 ea. P. & P. 15p.

RELAYS

G.E.C. Sealed Relays High Speed 24V. 2m 2b—17p ea.

S.T.C. Sealed 2 pole c/o 700 ohms (24V), 15p ea. 12v 35p ea. 2,500 ohm (okay 24v)—13p ea.
S.T.C. Brand New 2 pole c/o 6800 ohm coil—15p ea.

CARPENTERS polarised Single pole c/o 20 and 65 ohm coil as new, complete with base 37p ea. Single pole c/o 14 ohm coil 33p ea.; Single pole c/o 45 ohm coil 33p ea.
Varley VP4 Plastic covers 4 pole c/o 5K—30p ea. 15K—33p ea.

POLARISED Relay 2 pole c/o 250 ohm and 250 ohm coils.—25p ea.

POTTER & BRUMFIELD 24V 4 pole c/o min relays. Clear Plastic. Brand New. 50p ea. P. & P. 10p.

POTENTIOMETERS

COLVERN 3 watt. Brand new, 5; 10; 25; 500 ohms; 1; 2·5; 5; 10; 25; 50k all at 13p ea.

MORGANITE Special Brand new, 2·5; 10; 100; 250; 500K; 2·5 meg. 1 in. sealed, 17p ea.

BERCO 2½ Watt. Brand new, 5; 10; 50; 250; 500 ohms; 1; 2·5; 5; 10; 25; 50K at 15p ea.

STANDARD 2 meg. log pots. Current type 15p ea.

INSTRUMENT 3 in. Colvern 5 ohm 35p ea.; 50k and 100K 50p ea.

BOURNS TRIMPOT POTENTIOMETERS. 10; 20; 50; 100; 200; 500 ohms; 1; 2; 2·5; 5; 10; 25K at 35p ea. ALL BRAND NEW.

RELIANCE P.C.B. mounting: 270; 470; 500 ohms; 10K at 35p ea. ALL BRAND NEW.

ALMA precision resistors 100K; 400K; 497K; 998K; 1 meg—0·1% 27p ea.; 3·25k, 5·6k, 13k-0·1% 20p ea.

VISCONOL EHT CAPACITORS

Size 1×2¼ ins.			Size 1⅛×5¼ ins.		
0·05mfd	2·5kV	50p ea.	0·01mfd	10kV	50p ea.
0·01mfd	5kV	40p ea.	0·002mfd	15kV	65p ea.
0·001mfd	10kV	50p ea.	0·0005mfd	20kV	60p ea.
Size 2⅛×6¼ ins.			0·1mfd	4kV	35p ea.
0·05mfd	8kV	50p ea.			

DUBILIER 0·1mfd 5 KV; 0·1mfd 7·5 KV; 0·25mfd 7·5 KV; 0·5mfd 5 KV all at 50p ea. P. & P. 15p.

MULLARD ELECTROLYTICS

2200MFD 100V
10A (50°C)
70p each
BRAND NEW BOXED
10 off — 60p each
100 off — 45p each

47000 MFD 25V 28A
60p each
P & P 10p

LARGER REDUCTION FOR QUANTITY

PHOTOCELL equivalent OCP 71, 13p ea. Photo-resist type Clare 703. (TO5 Case). Two for 50p.

BURGESS Micro Switches V3 5930. Brand new 13p ea.

TRANSFORMERS. All standard inputs.

STEP DOWN ISOLATING trans. Standard 240v AC to 55-0-55V 300W, £3 ea. P. & P. 35p.

Transformer Size 2½ × 1¾ × 2". Output 18 volt 1 amp with screen. Brand new. £1·00 ea. P. & P. 25p.

Neptune series 460-435-0 etc. 230 MA and 600-570-540-0 etc. 250 MA. £3·50 incl. post.

Neptune Series. Multi 6.3 volts to give 48V at 3.5 amps etc. £3·50 incl. P. & P.

Gard/Parm/Part. 450-400-0-400-450. 180 MA. 2×6·3v. £3 ea.

Transformer 250-80MA; 13V-1·2A and 6·3V-5A. £1·50. P. & P. 25p.

Neptune series 350-0-350V at 55 MA, separate winding 500-0-500V at 250 MA. £2·00 ea. Carr. £1 extra.

CHOKES. 5H; 10H; 15H, up to 120mA, 42p ea. P. & P. 17p Up to 250mA 63p. P. & P. 35p.
Large quantity LT, HT, EHT transformers.

FIRST TIME EVER at £42·50

Solartron CD 711S.2 Double Beam Oscilloscope DC—9 mc/s; 3 mv/cm; trigger delay; crystal calibrator; 4" flat faced tube. In good working condition. Carr. £1·50.

HARTLEY TYPE 13A ONLY £18·00

DOUBLE BEAM OSCILLOSCOPE

TB 2 c/s-750 kc/s. Band width 5·5 Mc/s. Sensitivity 33 Mv/cm. Calibration markers 100 kc/s and 1 Mc/s. A completely reliable general purpose oscilloscope. Supplied with CIRCUIT DIAGRAM and Mains lead. Carr. £1·50.

As above. Complete with all accessories. £25·00. Carr £1·50.

OSCILLOSCOPES

CT436 DB—6 mc/s. £65.

SOLARTRON 643 DC—15 mc/s. Good condition £40.

SOLARTRON DC—10 mc/s. CD513—£40. CD513.2—£42·50. CD523S—£50.

SOLARTRON CT316 (D300 range) DC—6 megs. £20.

COSSOR 1035 Qk. 3—£40.

All carefully checked and tested. Carriage £1·50 extra.

MARCONI

Noise Gen. TF1106. £40. Carr. £1·50.
Vacuum tube Voltmeter TF1041A. £27·50; 1041B, £35.
Wide Range Oscillator TF 1370, £100.
Deviation Meter TF934/2, £50 ea. Carr. £1·50.
Deviation type 719, £30 ea. Carr. 75p.
TF 1026 Frequency Meter £12·50. Carr. 75p.
TF 329 Magnification Meter. As new condition £60.
TF 195 Audio Generator £10. Carr. £1·50.
TF 801A Signal generator £45 ea. Carr. £1·50.
TF 886 Magnification Meter £45. Carr. £1.
TF 936 N. 5 Impedance Bridge from £50 ea. Carr. £1·50.
TF 144G Signal Generator. Serviceable. Clean £15. Carr. £1·50.
TF 885 Video Oscillator Sine/Square. £30. Carr. £1·50.
TF 885/1 £45. Carr. £1·50.

SOLARTRON

Stabilised P.U. SRS 151. £15. Carr. £1·50.
Stabilised P.U. SRS 152. £10. Carr. £1·50.
Precision Millivoltmeter VP252. £25. Carr. £1.
Oscillator type OS 101. £30. Carr. £1·50.

AVO

Electronic Testmeter CT 38, £17. Carr. £1.

AIRMEC

AIRMEC Generator type 210, £85. Carr. £1·50.

Test Gear listed is only a very small selection of our stock—please enquire regarding other items.

E.M.I. Oscilloscope type WM16. Main frame £100. Choice of plug in 7/2 DC—24 mc/s x 2 £35; 7/1 DC—40 mc/s £20; Differential unit available from £25.
E.M.I. WM8. DC to 15 mc/s. Complete with plug in pre-amp. from £45.

BECKMAN MODEL A. Ten turn pot complete with dial. 100k 3% Tol 0·25%—only £2·13 ea.

E.H.T. Base B9A in Polystyrene holder with cover. Brand new. 13p ea.

FIBRE GLASS PRINTED CIRCUIT BOARD. Brand new. Single sided up to 2½" wide × 15" ½p per sq. in. Larger pieces 1p per sq. in. Double sided. Any size 1p per sq. in. Postage 10p per order.

PANEL mounting lamp holders. Red or green. 9p ea. Miniature
PANEL mounting lamp with holders—10V 15MA 5p ea.

Standard **240V MOTORS** by **CITENCO** reduction gearbox to 19 r.p.m. reversible, £5 ea.
Also 57 r.p.m. and 114 r.p.m.

GYROS Large clear plastic topped. Type A £4 ea. P. & P. 75p.

Single pole 3-way 250 V AC 15 amp switch. 8p ea. P. & P. 5p. Large discount for quantity.

CLAUDE LYONS Main Stabilizer. Type TS-1L-5S0. Input 119-135 volts 47/65 cs. Output 127+/−0·25% 16 amps. £30. Carr. £2.

MAGNETRONS TYPE CV370. Brand new. Boxed. £8 ea.

KELVIN & HUGHES 4-channel multi-speed recorders complete with amplifiers. £45.

EVERSHED & VIGNOLES Recording paper. Brand new boxed. JL900H4 7" wide, 1¾" dia.25p roll.

ELECTRONICS TIMER UNITS—wall or bench mounting—2 Hybrid timer boards may be removed leaving excellent 12 Volt battery charger; DC Power supply etc. Information supplied. Price ONLY £2·50 ea. incl. carriage.

SPECIAL OFFER

SELECTED B.C. 221 Recalibrated to Ministry Specification in brand new condition, complete with circuit, only £25. Carr. £1·50.

TV MONITORS 14 inch by Epsylon. All valves and components readily available. Tested, guaranteed working. £20 ea. Carr. £1·50.

TEKTRONIX SCOPE TUBES. Brand New Boxed. Type T5330. Part No. 154-0180-00. 5 inch round flat face. Spiral PDA with side connectors for X & Y. Bases can be supplied at 50p. Circuit included. Price £12 ea. P. & P. £1·25.

E.H.T. POWER UNITS type 532/1617, 0-3kV. £15 ea. Carr. £1·50.
E.H.T. TRANSFORMERS (Standard Mains) 3 KV 600 MA. £20·00 ea. Carr. £1·50.
CAPACITORS
0·1MFD 50 KV working. £10 ea. Carr. £1·50.
0·1MFD 100KV working. £16 ea. Carr. £1·50.

INTERGRATED CIRCUIT test clip by AP Inc. Gold Plated clip-on. Brand New individually boxed. £1.00 ea. P. & P. 10p.

4 DIGIT RESETTABLE COUNTERS. 1000 ohm coil. Size 1½×1⅛×4½ in. As new, by Sodeco of Geneva. £2·50 ea. As above but 350 ohm. £3·50 ea.

DECADE DIAL UP SWITCH—5 **DIGIT.** Complete with escutheon. Black with white figures. Size 4" long × 1" high × 1¼" deep. Ex-Plessey. £2.50 ea. P. & P. 15p.

LIGHT EMITTING DIODES (RED)

from Hewlett-Packard
Brand new 38p each
Holder—1p ea. Information—5p

SANGO 50 micro amp meter. 2½" diameter. Ex brand new radiation equip. £1 ea. P. & P. 17p.

SEEING IS BELIEVING!

COLVERN TEN TURN POTS—ex eq. 50K at 60p ea. Complete with dial £1·50 ea. P. & P. 15p.

C.R.T.'s 5" type CV1385/ACR13. Brand new with spec. sheet. 63p ea. P. & P. 35p.

BASES for above 20p ea. P. & P. 15p.

VEEDER-ROOT 6 digit 48V resettable counters. 55p ea. Incl. P. & P.

Genuine **MULLARD** Transistors/Diodes. Tested and guaranteed. OC41, 42, 76, 77, 83; OA5, 10. All at 3p ea. OC23—10p ea.

CAPACITOR PACK—50 Brand new components only 50p. P. & P. 17p.

POTS—10 different values. Brand new.—50p. P. & P. 17p.

COMPONENT PACK consisting of 2—2 pole 2 amp push on/off switches; 4 pots, various, brand new; 250 resistors ½ and ¼ watt, many high stabs, etc. Fine value at 50p per pack. P. & P. 17p.

COMPLETE Printed Circuit **TRANSISTOR I.F.** strip 470 kc/s, audio out. Size 1⅝×4$\frac{1}{16}$×¾in. **ONLY** 75p. P. & P. 10p.
3000 Series relays—15 mixed values (new and as new, no rubbish) £1·00. P. & P. 37p.

DELIVERED TO YOUR DOOR 1 cwt. of Electronic Scrap chassis, boards, etc. No Rubbish. FOR ONLY £3·50. N. Ireland £2 extra.

LOOSE LEAF BINDERS. Blue plastic cover. 4 ring. Standard size. 4 for £1. P. & P. 35p. 25 for £5. Carr. £1.

TRIMMER PACK—2 Twin 50/200 pf ceramic; 2 Twin 10/60 pf ceramic; 2 min strips with 4 preset 5/20pf on each; 3 air spaced preset 30/100 pf on ceramic base. ALL BRAND NEW 25p the LOT. P. & P. 10p.

Panel switches DPDT ex eq. 10p ea.; DPST Brand new, 17p ea.; DPST twice, brand new 25p ea.

HEAVY DUTY 6 amp. 2 pole c/o—20p ea.

GRATICULES. 12 cm. by 14 cm. in High Quality plastic. 30p ea. P. & P. 5p.

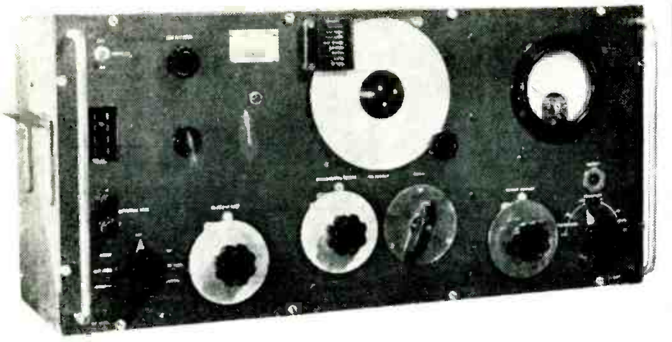
LISTS AVAILABLE: Valves; tubes; test gear; genera components.

Official Orders Welcomed, Gov./Educational Depts., Authorities, etc., otherwise Cash with Order

FOR CALLERS. Always a large quantity of components, transformers, chokes, valves, capacitors, odd units, etc., at 'Chiltmead' prices. Callers welcome 9 a.m. to 10 p.m. any day.

CHILTMEAD LTD

7/9 ARTHUR ROAD, READING, BERKS. (rear Tech. College) Tel.: Reading 582605/65916



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 × 12½ × 10 in. Secondhand condition. **£27·50** each, Carr. £1·50.

SIGNAL GENERATOR TYPE 902: (P.R.D.). A portable, general-purpose, broadband, microwave signal generator designed for testing and maintenance of aircraft radio and radar receivers in the SHF band. The RF output level is regulated by a variable attenuator calibrated in dbm. The frequency dial is calibrated in Mc/s. Provision is made for external modulation. Power Supply—115V, ±10% A.C., 50 c/s. Freq.—3650-7300 Mc/s. Internal Transmission—CW, Pulse, FM. External Transmission—Square Wave, Pulse. Power O/put—0.2 milliwatts. O/put Attenuator: −7 to −127 dbm. Load—50Ω. Price: **£135** each + £2 carr.

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.

CT150 Portable valve-tester suitable for testing a wide range of valves. Manufactured by Avo. **£55** each + £2 carr.

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/pyt 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** + F2100 carr.

TS-622URM 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. × 6¼in. 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.

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"Wx11"Hx14"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.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3·50** each, post 50p.

TS 622/URM 44 SIGNAL GENERATOR: Freq. range −7 to 11 GHz. O/put −10 to −127 dbm; CW, FM, Pulse. Direct reading. 115V, 50 c/s. **£185·00** each plus £2·00 carriage.

APN-1 INDICATOR METER, 270° Movement. Ideal for making rev. counter. **£1·25**, post 30p.

AIRCRAFT SOLENOID UNIT S.P.S.T.: 24V, 200 Amps, **£2** each, 30p post.

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.

CRYSTAL TEST SET TYPE 193: Used for checking crystals in freq. range 3000-10,000Kc/s. Mains 230V, 50c/s. Measures crystal current under oscillatory conditions and the equivalent parallel resistance. Crystal freq. can be tested in conjunction with a freq. meter. **£12·50** each, £1 carr.

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.**

R-361 RECEIVER: 225-400MHz. 1 preset channel crystal controlled. Superheterodyne, voice and CW. 230V 50c/s input. **£35** each. Carr. £1·50.

TS-130 TEST SET: Complete with RF Probe type 1019 Freq. 0·9-12·5KHz, and RF Probe type 1020 Freq. 0·3-1KHz. Also slotted line attenuator 1M-34/U. Freq. 0·3-4KHz; and connectors. **£45** each. £1 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.

POWER UNIT TYPE 24: (for R.216 Receiver) A.C. operated 100-125V or 200-250V, 50c/s. "As new" **£10** each. Carr. 75p.

FILTER VARIABLE BAND PASS NO. 1: Dual channel unit, each channel has variable slot frequency of 500-900Hz, 1200-1600Hz and band pass facility. 600Ω input/output, monitor input and high impedance output jacks. Standard rack mounting 3½in. deep panel. Mains operation 200-250V 50c/s. "As new" **£6·50** 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.

POWER SUPPLY: 230V a.c. input; 3000V @ 2·5mA; 4v @ 1 Amp, 300-0-300 200mA; 6V @ 7 Amp; 6V @ 3 Amp. With smoothing capacitors etc. **£10·00** each. £1·50 carr.

GEARED MOTOR: 24V D.C., current 150mA, output 1 rpm, **£1·50** each, 30p post. **ASSEMBLY UNIT** with Letcherbar Tuning Mechanism and potentiometer, 3 rpm, **£2** each 30p post. **SYNCHROS:** and other special purpose motors available. List 3p.

ACTUATOR UNIT: With 115V d.c. geared motor; o/put 12·5 rpm; torque 16 ins. oz; reversible; microswitches and potentiometer. **£3·50** ea. + 40p post.

DALMOTORS: 24-28V d.c. at 45 Amps, 750 watts (approx. 1hp) 12,000rpm. **£5** each, 60p post.

GEARED MOTOR: 28V d.c. 150 rpm (suitable for opening garage doors). **£4** each, 60p post.

MOTOR: 240V single phase, 2,400 rpm. 1/40 H.P. approx. Price **£1·75** each, 30p post.

CONDENSERS: 30 mfd 600 v wkg. d.c., **£3·50** each, post 50p. 15 mfd 330 v a.c., wkg., **75p** each, post 25p. 10 mfd 600 v. **43p** each, 25p post. 8 mfd 2500 v. **£5** each, carr. 63p. 8 mfd 600 v. **43p** each, post 15p. 8 mfd. 1% 300 v. D.C. **£1·25**, post 25p, 4 mfd 3000 v. wkg. **£3** each, post 37p. 4 mfd 2000 v. **£2** each, post 25p. 4 mfd 600 v., 2 for **£1.** 0·01 mfd MICA 2·5Kv, **£1** for 5, post 10p. Capacitor 0·125 mfd, 27,000 v. wkg. **£3·75** each, 50p post. 2·25 mfd 25 Kv. wkg. **£20** each, £3 carr.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps, **£2·50** each, carr. 75p.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 40 ohms at 2·6 amps; 500 ohms, 0·55 amps. Price (either type) **£2** each, 30p post each.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, **£4·50** each, carr. 75p.

AR88 RECEIVER: List of spares, **5p.**
TELEPRINTER EQUIPMENT, REPERFORATORS, READERS, and AUTO TRANSMITTERS ETC. Send for list, 5p.

If wishing to call at Stores, please telephone for appointment.

W. MILLS 3-B TRULOCK ROAD, LONDON, N17 OPG
Phone: 01-808 9213 and Wilstead 605 (STD. 023 044)

AVO TRANSISTOR AND DIODE TESTER TYPE CT537

The tester is a compact, simple to operate, direct reading instrument. Provision is made for the rapid and accurate measurement of transistor h_{fe} up to 1500 at a frequency of 1 kc/s and the measurement of leakage current between 1 μA and 400mA for both p.n.p. and n.p.n. low and medium power germanium or silicon transistors.

In Superb Condition, in original crates with full instructions, circuit diagram etc.
New Price £250 Plus OUR PRICE **£40.00 each**
Carriage £1.25

2 HZ to 20 MHZ SOLID STATE BEAM SWITCH

Completely assembled P.C. Board, ready to use on any standard commercial oscilloscope. Size $4\frac{3}{4}$" x $3\frac{1}{4}$". £9.25 each. P & P 25p. Completely encased with attenuators and BNC connectors £25.00 each.

20 HZ to 200KHZ SINE WAVE GENERATOR

In four ranges. Wien bridge oscillator, thermistor stabilised, amplitude control. 3 V peak to peak. Completely assembled P.C. board, ready to use. 9 to 15 V supply required. £4.85 each P & P 25p. SINE *AND* SQUARE WAVE version of above £6.85 each. P & P 25p.

TRANSISTOR INVERTOR

12V to 1.5 KV 2 MA AC. Size $1\frac{1}{2}$" x $2\frac{1}{2}$" x 4". £2.95 each P & P 25p.

WOBBULATOR

For displaying response of 10.7 MHZ (FM receiver I.F.'s) and 30-40 MHZ (TV I.F. alignment). Requires 6.3V AC and any general purpose oscilloscope. Instructions supplied. Completely assembled P.C. Board. £9.00 each P & P 25p

THE LOWER PRICED 'SCOPES SUITABLE FOR COLOUR TV SERVICING

SOLARTRON CD 711S. 2 DB (4" tube) 3 db at 7 MHZ. TB to 0.3 micro sec per cm X Gain times 10. Y amp 3 MV per CM both channels. £42.50 Carr. £1.50.

SOLARTRON CD 523S.2 SB (4" tube) 3 db at 10 MHZ. TB to 0.1 micro sec per cm plus times 5 expansion. Y amp 1 MV per cm. £50. Carr. £1.50.

CT 436 DB ($3\frac{1}{2}$" tube). 3 db at 6 MHZ. TB to 1 micro sec per cm. X gain times 10. Y amp 10 MV per cm both channels. £65. Carr. £1.50.

E.M.I. WM 8 SB with amp. (5" tube). 3 db at 15 MHZ. TB to 0.15 micro sec per cm. X gain times 3. Y amp 50 MV per cm. £45. Carr. £1.50.

CHILTMEAD LTD

7/9 ARTHUR ROAD, READING, BERKS. (rear Tech. College) Tel.: Reading 582605/65916

REFURBISHED CALIBRATION QUALITY INSTRUMENTS

Most of the instruments listed below are less than three years old and have been serviced regularly. All the instruments are available either ex-stock *or on short delivery* and at well below the manufacturer's list price and covered by a three months' warranty.

PRICE OF ANY OF THE EQUIPMENT LISTED BELOW WILL BE GIVEN ON WRITTEN REQUEST

OSCILLOSCOPES

COSSOR	CDU150	DC-35MHz. 5mV-20V/cm. £335.
	CDU120	DC-50MHz. £275.
DYNAMCO	7100	Main Frame. DC-30MHz.
	7200	Main Frame. 3Hz-15MHz. Batt/Mains.
EMI	101	DC-15MHz. 50mV/cm. Batt/Mains. Single Trace.
HEWLETT PACKARD	175A	Main Frame. DC-50MHz. £360.
	180A	Main Frame. DC-100MHz. Net Wt. 11·6 kg.
	181A	Main Frame. Vari-Persistence. 0·2s-1hr Storage.
	183A	Main Frame. DC-250MHz. Net Wt. 15 kg.
	1200A	DC-500kHz. XYZ. DC-500kHz. 100μV/Div.
MARCONI	TF2204	DC-15MHz. 50mV/cm. Batt/Mains. Single Trace. £325.
PHILIPS	PM 3250	DC-50MHz. 2mV-20V/Div. Dual Trace.
S.E. LABORATORIES	EM111	Main Frame. DC-30MHz. Mains. £185
SOLARTRON	CD1740	Main Frame. DC-50MHz.
TEKTRONIX	*422	Batt/Mains. Dual Trace. DC-15MHz. 1mV-20V/Div.
	*453	Dual Trace. DC-50MHz. 20mV-10V/Div.
	*453 (MOD127)	TV Sync. Sep. DC-50MHz. 10ns-5s/Div.
	*454	Dual Trace. DC-150MHz. 5ns-5s/Div.
	*502	Dual Beam. DC-100kHz. 100μV-20V/cm.
	*502A	Dual Beam. DC-1MHz. 100μV/cm to 100kHz. £345.
	*515A	Two Inputs. DC-15MHz. 50mV-20V/cm. £195.
	536	Main Frame. X-Y or Y-T. DC-11MHz. £295.
	545A	Main Frame. DC-33MHz. Delay TB. £325.
	545B	Main Frame. DC-33MHz. 20ns-5s/cm. Delay TB. £425.
	CA	Plug-in. DC-24MHz. Dual Channel. £59.50.
	D	Plug-in. DC-300KHz. Differential Inputs. £55.
	E	Plug-in. 0·06Hz.-60KHz. Differential (AC) £45.
	G	Plug-in. DC-20MHz. Differential Inputs £55.
	H	Plug-in. DC-15MHz. 5mV.-20V/cm. £49.50.
	K	Plug-in. DC-30MHz. 50mV.-20V/cm. £49·50
	L	Plug-in. DC-30MHz. 50mV.-20V/cm. £39.
	M	Plug-in. DC-20MHz. 4 channels £165
	T	Plug-in. Time Base 0·2μS.-2S/Div. £49
	W	Plug-in. DC-23MHz. 1mV.-50V/cm. £210.
	Z	Plug-in. Differential Comparator £165.
	568	Main Frame. Analogue/Digital Readout.
	230	Analogue Input Unit. 1.2.4.8. BCD O/P.
	575	Transistor Curve Tracer. Sens 1μA/Div.
	575	Hi Volts for Diode Breakdown Tests. £450.
	1L2	Spectrum Analyser Plug-in 10MHz-4.2 THZ £350.

COUNTERS AND TIMERS

DYMEC	DY 5796	Frequency Synchroniser. Use with 5200 series. £275.
HEWLETT PACKARD	3734A	3Hz-3MHz. 5 Digit. Input 100mV.
	5216A	3Hz-12·5MHz. 7 Digit. 8-4-2-1 "1" +
	5221A	5Hz-10MHz. 6 Digit. TB: Mains.
	5325B	0-20MHz. Time Int. 0·1μs-10^8s. 7 Digit.
	5245L	0-50MHz. 8 Digit. Stab: 3 in 10^9 per day.
	*5246L	0-50MHz. 8 Digit. Stab: 2 in 10^7 per month.
	5252A	Prescaler Plug-In. 0-350MHz. Input 100mV.
	5253B	Converter Plug-In. 50-512MHz. Input. 50mV.
ADVANCE	TC1	1 Meg. £65.
BECKMAN	IR-102	Infra-red spectrophotometer £450.

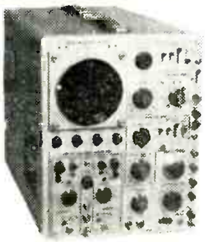
DYNAMCO type 2022S

Long scale D.V.M. and Ratiometer. The 2022 is a high accuracy long scale instrument operating on the potentiometric principle. It features a very high input impedance with exceptionally low current errors, an external scaling facility, seven operating modes and digital output.

Scale	39999
Range	10μV yo 2kV
Resolution	1 part in 40,000
Accuracy	Long term.. ±0·0025% of F.S.D. ±0·01% of reading
	Optimum.. ±0·0025% F.S.D. ±0·0025% of reading
Input impedance	>25,000 M ohm
C.M.R.	160 dB at DC, 120 dB at 50Hz } Typical
Including calibration certificate	£275·00

PULSE GENERATORS

ADVANCE	5002	50V. 0·1Hz-1MHz.
	PG5002D	50V/2·5kΩ. 0·1Hz-1MHz. W 0·1μs-1s.
E.H. RESEARCH	132AL	50V/50Ω. 5Hz-3·5MHz. RT. 12ns.
	139LB	10V/50Ω. 10Hz-50MHz. RT. 6ns.
	G710	5V/50Ω. 30Hz-50MHz. RT. 5ns.
HEWLETT PACKARD	213A	175mV/50Ω. W 2μs. RT. 100ps 100kHz.
	214A	100V/50Ω. W 50ns. 10ms. 10Hz-1MHz.
	8005A	5V/50Ω. W 30ns-3s. 0·3Hz-10MHz.
LYONS	PG2	10V/50Ω. 1Hz-16MHz. RT. 10ns.
	PG2E	1Hz-50MHz. RT. 10ns.
SYSTRON DONNER	101	10V/50Ω. 10Hz-10MHz. RT. 5ns.
	110B	10V/50Ω. 5Hz-50MHz. RT. 4ns.



TEKTRONIX	545	With delay time base £325.

DIGITAL VOLTMETERS

DANA	3800	Multimeter. 0·1% FS (LT). 3 Digit.
	5230/550	10μV-1kV. Max. Rdg. 119999. 0·02% Rdg. (LT).
	OPTION 01	AC CONV. 10μV-1kV. Mean 50Hz-100kHz.
	5330/600/75	1μV-1000V. Max. Rdg. 119999. 0·02% Rdg. (LT).
	5370/600/75	As for 5330. Both with Auto Range.
DYNAMCO	DM 2001 MK2	50μV-2kV. Max. Rdg. 19999. 0·05%.
	DM 2022S	10μV-2kV. Max. Rdg. 39999. 0·02% Rdg. (LT).
	2140/A1-B1	100mV-1kV. RMS. 30Hz-10kHz.
	2140/A1-B3	100mV-1kV. Mean. 30Hz-3kHz.
	2010	Price £750
HEWLETT PACKARD	400E	AC Converter RMS (Sine) 10Hz-10MHz.
	3400A	AC Converter. True RMS. 10Hz-10MHz.
	3440A	DVM. 4 Digit. Main Frame. 0·05% of Rdg.
	3442	Plug-In. 1mV-1000V. Z in 10·2MΩ.
	3444A	Plug-In Multifunction (10μV, 10nA, 0·1Ω).
	3445A	Plug-In. AC Converter. RMS (Sine).
ROHDE & SCHWARZ	UGWD	DVM 0-1kV and 20Hz-20kHz.
SOLARTRON	LM1420.2BA	10mV-500V. AC. Mean/RMS. Also DC (Below).
	*LM1420.2	2·5μV-1kV. Max. Rdg. 2999. 0·05% BCD O/P.
	LM1219	AC Converter 30mV-300V. Mean. 30Hz-10kHz.
	LM1480.3	5μV-2kV. Max. Rdg. 29999. 0·0083%. Auto/Range.
	LM1604	1μV-1kV. Max. Rdg. 19999. 0·015%. Auto/Range.
	LM1604/1605	AC. 10μV-750V. Mean. 30Hz-50kHz (and DC).
	LM1867	10μV-1kV. Max. Rdg. 101999. 0·004%.
KEINZLE	D1	Line Printer. 12 Digit £125.

SPECTRUM ANALYSERS

HEWLETT PACKARD	*8552A, 8553L	1kHz-110MHz. 50Hz Resolution.
	*8552A, 8554L	500kHz-1·25GHz. 50Hz Resolution
	*8552A, 8555A	10MHz-18GHz. 50Hz Resolution.
	*8552B, 8553B	1kHz-110MHz. 10Hz Resolution.
	*8552B, 8554L	500kHz-1·25GHz. 10Hz Resolution.
	*8552B, 8555A	10MHz-18GHz. 10Hz Resolution.
	8551B/851B	10MHz-40GHz. Sweep: 3ms-1s/Div.
POLARAD	289	10mHz.-62GHz. £2,450.
	* With 141S or 141T.	
TEKTRONIX	1L5	Plug-In. 50Hz-1MHz. Range 60db Log.
	L20	Plug-in. 10MHz-4·2GHz. Range 40db Log.
	1L20	Plug-In. 10MHz-4·2GHz. Range 40db Log.
	3L10	Plug-In. 1-36MHz. Range 50db Log.

SWEEP GENERATORS

HEWLETT PACKARD	8690B	Mainframe. 1%. Int/Ext. AM. Ext. FM.
	8693B/100	3·7-8·3GHz. 5mW. 'N' connectors.
MARCONI	TF1099	20MHz. 75Ω. 3V. Level to 0·25db.
ROHDE & SCHWARZ	SWOB 11	0·5-1200MHz with Det/Display.
	SWOB 111	0·1-1000MHz with Det/Display.

WAVE ANALYSERS

B & K LABS	1614	Variable B.P. Filter, 2Hz-163kHz. 75db.
RACAL	248A	5-300MHz.
	853	30kHz-30MHz. 75Ω. 1μV-1V/4V.
HEWLETT PACKARD	302A	20Hz-50kHz. R: 10Hz. 30μV-300V. FS.
	310A	1kHz-1·5MHz. Dynamic Range 75db.
	333A	5Hz-600kHz. Total Dist. Auto-Null.
	334A	5Hz-600kHz. Total Dist. AM Det.
MARCONI	TF 2330	20Hz-50kHz. Dynamic Range 75db.
	TF 2331	20Hz-20kHz. Total Distortion.

FUNCTION GENERATORS

HEWLETT PACKARD	3300A	0·01Hz-100kHz. Sine, Square. Triangle.
	3301A	Auxiliary Plug-In; Required for 3300A.
	3305A	Sweep Plug-In. Log, Manual and Programmable.
	3310A	0·0005Hz-5MHz. Multi-Mode. 50Ω or O/C.

SIGNAL SINE WAVE GENERATORS

ADVANCE	J1	15Hz-50kHz. 600Ω. 0·25-25V.
	H1	15Hz-50kHz. 200mV-20V.
	SG70	5Hz-125kHz. 600Ω. 4W.
GENERAL RADIO	1362	220-920MHz. 50Ω. 200-400mW.
	1363	56-500MHz. 50Ω. 100-500mW.
	1267A	Power Supply for 1362, 1363.
HEWLETT PACKARD	200CD	5Hz-600kHz. 600Ω. O/P 10V.
	204D	5Hz-1·2MHz. 80db att. O/P 5V in 600Ω.
	608C	10MHz-470MHz. 50Ω. AM.
	608E	10MHz-480MHz. 50Ω. Int/Ext AM.
	612A	450MHz-1230MHz. 50Ω. Int/Ext AM.
	618C	3·8-7·6GHz. 50Ω. FM/PM.
	620B	7-11GHz. 50Ω. FM/PM.
LEVELL	TG150M	1·5Hz-150kHz. 2·5V. 600Ω. Battery.
MARCONI	TF144H/4	10kHz-72MHz. 50Ω. Int/Ext. AM.
	TF801D/1	10-470MHz. 50Ω. Int/Ext. AM. Ext. P.M. £275.
MUIRHEAD	D880A	0·01Hz-11·2kHz. Decade. 2 Phase.
	D890	1Hz-111·1kHz. Decade. 5-25V/600Ω.
RADIOMETER	HO12ew3	B.F.O. 0-40kHz.
	HO32C	B.F.O. 10Hz-21kHz
ROHDE & SCHWARZ	MS100M	10kHz-100MHz. Decade. AM/FM.
	SBF	10Hz-10MHz. 0·1μV-10V.
	SLRC	2·3-7GHz. 0·3-3W. Int/Ext. PM.
	SLRD	0·275-2·75GHz. 3-35W.
	SLRE	6·7-12·7GHz. 0·5-3W.
	SMAI	0·5-1·8GHz. Int/Ext. PM, FM.
	SMBI	1·7-5·0GHz. Int/Ext. PM, FM.
	SMCI	4·8-12·6GHz. Int/Ext. PM, FM.
	BN414221	Modulator Plug-In for SMAI, SMBI, SMCI.
	SMDF	0·4-490MHz. AM/FM.
	SMFA	1·39-510MHz. AM/FM.
	SMLR	0·1-30MHz.
	SRB	10Hz-1MHz. R.C. Osc.
	SUB	50Hz-50kHz. R.C. Osc.
WAVEFORM	403B	1Hz-120kHz.
	510B	20Hz-1MHz.
WAYNE KERR	022D	10kHz-10MHz. 75Ω. O/P±0·5db

COMMUNICATIONS TEST EQUIPMENT

HEWLETT PACKARD	3701A	Microwave Link Analyser comprising:
	3702A	1, 1a, 1b. TV sub-carrier options available.
	3703A	Fully modified up to date.
	423A	Crystal Detector. 10KHz-12·4GHz. "N" Connector.
MARCONI	TF2091A	White Noise Test Set.
	TF2092A	12-2700 Channels F.D.M.
		RANGE OF FILTERS AVAILABLE.
RICHMOND HILL	TSP	TV Test Set. Sm² P. & P./Window Staircase. 525 lines.
	TSP	TV Test Set. Sm² P. & B./Window/Staircase. 625 lines.
SIEMENS	REL 3W 518	Selective Level Oscillator. 10KHz.-17MHz.
	REL 3D 335	Selective Level Meter. (Tracking with 3W 518).
	REL 3W 933	Sweep Attachment for 3W 518.
	REL 3W 937	Range Unit for 3W 933±8KHz to ±7·5MHz.
	REL 3B 939	Levelling Probe.
	REL 3D 346	Large Screen Level Tracer for Swept measurements.
	REL 3D 917	Amplifier for 3D 346 (db calibration).
	REL 3D 928	Marker Unit for 3D 346.
	REL 3B 2001	Line Modem Unit for remote sweep operation.
	REL 3K 53	Contact Fault Locator for microphoning tests.
	231-504	RF Voltmeter. 0–100V.
STC	74166	Milliwatt Test Set. DC and 30Hz–30MHz.
	74184B	Selective Level Meter. 60–1364KHz.
	74186C	Level Oscillator 30Hz–13KHz.
	74199	Selective Level Meter.
	74216	Noise Generator. 20Hz-4KHz. Flat or CCITT.
	74226B	Cable Test Set. 100Hz. Battery operated.
	74306A	Oscillator 10KHz-20MHz.
	74598A	Signalling Test Set. For In-traffic tests.
	74600	Range of Attenuators 0-0·9 to 0–90db.
WANDEL & GOLTERMAN	TFP842	Selective Level Oscillator 10KHz–14MHz.
	TFPM43	Selective Level Meter. 10KHz–4MHz.
	TFP875	Selective Level Oscillator. 300Hz–1·35MHz.
	TFPM76	Selective Level Meter. 300Hz 1·35MHz.
	VZM1	Diff. Phase/Gain Indicator. 625 lines PAL.
	VZM G1	Sampling Attachment.
STC	FIELD TELEPHONE	Torch battery powered. Hand Generator Calling.

ELECTRONIC BROKERS LIMITED

49-53 PANCRAS ROAD, LONDON NW1 2QB. TEL.: 01-837 7781. 'GRAMS: SELELECTRO, LONDON N.W.1

WW—099 FOR FURTHER DETAILS

SERVICE TRADING CO

Postage included in prices below are inland only. For Overseas please ask for quotation. We do not issue a catalogue or list.

MATSUNAGA VARIABLE VOLTAGE TRANSFORMERS

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.

Carriage Paid

BRAND NEW. All types.

50 AMP		
	0-260 v. at 1 amp	£7·00
	0-260 v. at 2·5 amps	£8·05
	0-260 v. at 5 amps	£11·75
	0-260 v. at 10 amps	£22·50
	0-260 v. at 15 amps	£25·00
	0-260 v. at 20 amps	£49·00
	0-260 v. at 25 amps	£58·00
	0-260 v. at 37·5 amps	£82·00
	0-260 v. at 50 amps	£98·00

1 AMP

Special discount for quantity

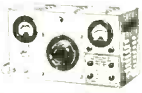
OPEN TYPE (Panel Mounting)
½ amp £4·75 1 amp £7·00 2½ amp £8·05

L.T. TRANSFORMERS

All primaries 220-240 volts.

Type No.	Sec. Taps	Price Incl. P.&P.
1	30, 32, 34, 36 v. at 5 amps	£5·03
2	30, 40, 50 v. at 5 amps	£7·23
3	10, 17, 18 v. at 10 amps	£5·30
4	6, 12 v. at 20 amps	£6·93
5	17, 18, 20 v. at 20 amps	£7·78
6	6, 12, 20 v. at 20 amps	£7·38
7	24 v. at 10 amps	£5·58
8	4, 6, 24, 32 v. at 12 amps	£7·65
9	6 and 12 v. at 10 amps	£4·10

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit

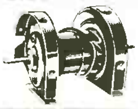


Input 220/240 v. A.C. **Output** Continuously variable 0-36 v. A.C./D.C. Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused Ideally suited for Lab. or Industrial use. **£70** incl. p. & c.

MOTOROLA MAC11/6 PLASTIC TRIAC 400 PIV 10 AMP

Now available EX STOCK supplied complete with full data and applications sheet. Price **£1·12** incl. P. & P. Suitable Diac 30p (RCA40583).

DOUBLE ENDED MOTOR UNIT

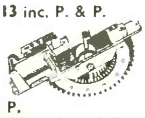


Powerful, continuously rated, 2 speed. Either **6** or **12 volt D.C.** operation. Price £2·00 incl. P. & P.

POWER RHEOSTATS

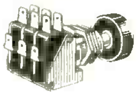
(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES:**
100 WATT 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm ·7a., 500 ohm ·45a., 1k ohm 280mA., 1·5k ohm 230mA., 2·5k ohm ·2a., 5k ohm 140mA., Diameter 3¼in. Shaft length ⅜in. dia. ¼in., **£1·73**, incl. P. & P.
50 WATT 1·12/10/25/50/100/250/500/1K/1·5K/2·5K/5K ohm. All at **£1·23**, incl. P. & P.
25 WATT 10/25/50/100/250/500/1K/1·5K/2·5K/3·5K ohm. All at **98p**, incl. P. & P.
Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia brass bush. Ideal for above Rheostats, **18p** ea.

UNISELECTOR SWITCHES—NEW



4 BANK 25 WAY FULL WIPER
25 ohm coil, 24 v. D.C. operation. **£6·13** inc. P. & P.
6 BANK 25 WAY FULL WIPER
25 ohm coil, 24 v. D.C. operation. **£6·75**, inc. P. & P.
8 BANK 25 WAY FULL WIPER
24 v. D.C. operation. **£7·88**, inc. P. & P.

'HONEYWELL' PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY

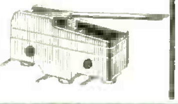


Each bank comprises of a change-over rated at 10 amps 240 volt A.C. Black knob 1 in. dia. Fixing hole ⅜ in. Prices: 1-bank **30p**, 2-bank **40p**, 3-bank **55p**. (Illustrated) Inc. P. & P. Special quotes for quantities.

VERY SPECIAL OFFER

MICRO SWITCH
5 amp. c/o contacts. Fitted with removable metal plate Ex P.O. 20 for **£1·00** inc. post (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 **£1.90** incl. P. & P.

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 **£6·55** 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 **£11·00**. incl. P. & P.

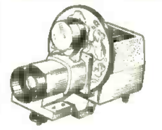
HY-LIGHT STROBE
Designed for use in large rooms, halls and the photographic field and utilizes a silica tube, printed circuit and a special trigger coil. Speed adjustable 1-20 f.p.s. Light output greater than many (so called 4 Joule) strobes. Price **£12·50**. incl. P. & P.

'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 £20·75, incl. P. & P.
ATTRACTIVE, ROBUST, FULLY VENTILATED METAL CASE specially designed for the Super Hy-Lyght Kit including reflector, **£7·45** incl. P. & P.
FOR HY-LYGHT STROBE incl. reflector, **£4·45** incl. P. & P.
7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price **66p** 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: **£18·75** 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. **£18·85**, incl. P. & P.
6 INCH COLOURWHEEL
As used for Disco lighting effects, etc. Price **£5·75** inc. p. & p.

BIG BLACK LIGHT

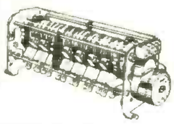
400 Watt. Mercury vapour ultra violet lamp. Outer bulb designed to absorb visible light and transmit u.v. rays. Extremely compact and powerful source of u.v. Inumerable industrial applications also ideal for stage, display, discos etc. P.F. ballast is essential with these bulbs. Price of matched ballast & bulb **£16·50**. incl. P.& P. Spare bulb **£7·30**, incl. P.& P.

BLACK LIGHT FLUORESCENT U.V. TUBES
4ft. 40 watt. Price **£5·80** incl. P. & P. (For use in standard bi-pin fluorescent fittings). MINI 9 inch 6 watt black light U.V. tube. **£1·45** incl. P. & P.

IMPORTANT

FROM APRIL 1st. V.A.T.
(at the standard rate)
MUST BE ADDED TO ALL PRICES

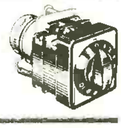
HONEYWELL PROGRAMME TIMERS



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 **£6·00** incl. P. & P.
10 cam model **£5·00** incl. P. & P.
2 cam model with 15 r.p.m. motor **£2·00** incl. P. & P.

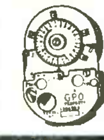
SIMPLE 12 CAM PROGRAMMER with 4 adjustable cams and 8 that may be profiled to individual requirements. Available with 15 or 13 r.p.m. motor **£3·75** incl. P. & P.

24 HOUR TIMER



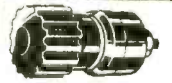
Can be adjusted to give a switching delay of between ½ hr. to 24 hrs. Driven by 200/250v. A.C. synchronous motor. 15 amp. c/o contacts. Mfg. Crater Controls Ltd. Supplied with scale calibrated 0-10 (2 hours per division) Brand new. **£2·00** incl. P. & P.

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, **£3·45**. 20 amp, **£3·95**. 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 **10p** each, incl. P. & P. Minimum order 6.

METER BARGAIN

BALANCE/LEVEL METERS

100-0-100 Micro Amp. Size 1½in. × 1½in. × ⅞in. Price only **75p** 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 **£1·75** incl. P. & P. 0-300V. A.C. **£1·90** incl. P. & P.

RELAYS

SIEMENS PLESSEY, etc.
MINIATURE RELAYS

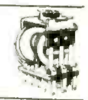
1	2	3	4	1	2	3	4
52	3-6	2 c/o	63p*	700	12-24	2 c/o	63p*
52	4-6	6M	63p	700	15-35	2c/oHD	73p*
52	4-6	4 c/o	78p	700	6-12	1c/oHD	50p*
150	6-12	4 c/o	78p	700	16-24	6 M	63p*
185	8-12	6 M	63p	700	20-30	6 c/o	75p
280	9-12	2 c/o	73p*	1250	24-36	4 c/o	63p*
410	10-18	4 c/o	73p	2500	36-45	6 M	63p*
600	9-18	2 c/o	63p	2400	30-48	4 c/o	50p
700	16-24	4M2B	63p*	9000	40-70	2 c/o	50p*
700	16-24	4 c/o	78p*	15k	85-110	6 M	50p*

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD=Heavy Duty. All Post Paid. (*including Base)

12 VOLT D.C. RELAY
Type 1: Three sets c/o contacts 5 amp. **78p** incl. P. & P. (Similar to illustration below).
Type 2: One set c/o contacts **60p** incl. P. & P.
Type 3: 4-8 volt 3 c/o HD, 67 ohm coil. **78p**. incl. P. & P.

SPECIAL OFFER.
700 ohm. 4 c/o Ex. new equipment. **£50·00** per 100 incl. bases (minimum 100).

'DIAMOND H' 230 VOLT A.C. RELAYS (Unused)



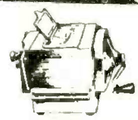
Three sets c/o contacts rated at 5 amps. Price **60p**. incl. P. & P. (100 lots **£40·00** incl. P. & P.)

230 VOLT A.C. RELAYS M.f.g. 'Keyswitch'
One set c/o contacts rated at 7·5 amps. Boxed. Price **45p**. incl. P. & P. (100 lots **£32·00** incl. P. & P.)

MINIATURE RELAYS
9-12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1 in.×⅞×½ in. Price **58p** incl. P. & P.
30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3,200 ohm coil. Size only 1×⅞×½ in. **43p** incl. P. & P.

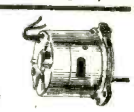
MINIATURE LATCHING RELAY
Mfg. by Clare-Elliott Ltd. (Type F) 2 c/o permanent latching in either direction. Coil 1150 ohm. 15-30 v. D.C. New **73p**, incl. P. & P.

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 **£28** carriage paid.
1,000 VOLTS, 1,000 megohms, **£34** carriage paid

230V/240V COMPACT SYNCHRONOUS GEARED MOTORS



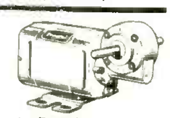
Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox.

5 RPM A/cw	3 RPH A/cw	20 RPH cw	Fraction of makers' price.
2 RPH cw	6 RPH cw	12 RPH cw	All at 75p incl. P. & P

cw=Clockwise. A/cw=Anti-clockwise

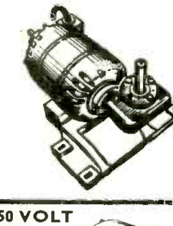
REVERSIBLE SPLIT PHASE MOTOR
250 r.p.m. 100-115/210-240V AC. 2 in. × 1 in. Ideal for rim-drive models, display etc. Extremely powerful for size **75p**. incl. P. & P. (including small capacitor.)

PARVALUX



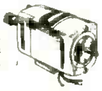
Type: SD1.S/86896/0J
230/250v. A.C. 50 r.p.m. 7 lb/ins. Continuously rated. Less base **£6·30** incl. P. & P.
TYPE: SD1.S/89400/OM
230/250v. A.C. 50 r.p.m. 22 lb/ins. Continuously rated. Incl., base **£7·30** incl. P. & P.
The above motors are new and unused.

PARVALUX TYPES SD19 230/250 VOLT AC REVERSIBLE GEARED MOTORS



30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. **Mounted on substantial cast aluminium base.** Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. **£6·80**, incl. P. & P.

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: £2·00 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** 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

Greatest ever sale in the history of Electronics!!

50% off

Oscilloscopes, Pen Recorders, Power Supplies, Signal Generators etc.

Still some bargains to clear—

PERSONAL CALLERS ONLY

CASH ONLY (no cheques accepted)

large range of Morse Equipment such as **Creed Model 75 Page Printers at only £25 (List £75)** and large range of Communication Receivers **including AR88 at £25 (List £80).** Thousands of others at large discounts

Open 6 days a week. Mon. to Sat. inclusive. 9 am to 5 pm

ELECTRONIC HOBBIES COMPANY

29 MIDLAND ROAD, LONDON, NW1

01-278 5577

WW—102 FOR FURTHER DETAILS

MARCONI

SIGNAL GENERATOR TF 801B/3/S. Range 12 Mc/s to 485 Mc/s. P.O.A.

TF1221 HETERODYNE UNIT. Frequency range: 2 Kc/s-100 Mc/s in seven ranges. P.O.A.

TF1345/2 COUNTER FREQUENCY METER with plug-in units up to 220 Mc/s. P.O.A.

OA.1094A/3 H.F. SPECTRUM ANALYSER with trolley and L.F. extension unit type TM6448. Frequency range: 3-30 MHz in nine bands. Selectivity: 6, 30, 150 Hz at 3 dB. Spectrum width: 0-3 kHz and 0-30 kHz in two ranges. Sweep duration: 0·1, 0·3, 1, 3, 10 and 30 sec. and manual control.

TF 144H SIGNAL GENERATOR. Frequency range: 10 kHz-72 MHz. Stability: 0·002%. High discrimination, plus crystal calibrator. Good r.f. waveform at all frequencies. Protected thermocouple level monitor. Price and spec. on request.

SO1 REMSCOPE Storage Oscilloscope with Trace Shifter type **TS1 (740/3).** Full spec. and price upon request.

AVO TRANSISTOR ANALYSER CT 446 £70 incl. carr.

CT436 OSCILLOSCOPE D.C. 6 Mc/s. **£65·00.**

NEUTRON COUNTING ASSEMBLY Mk 3NHA.

AMPLIFIER ASSEMBLY Mk. 112AA for Monitoring Equipment Type IN.C.A.

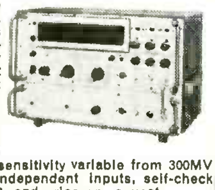
ALPHA COUNTER Mk. INH.
More information and Price on request.

L.F. SOLARTRON DECADE OSCILLATOR TYPE OS103.2. Frequency range: 0·01 c.p.s.—11·1 c.p.s. in steps of 0·01 c.p.s. with multipliers of 10, 100 and 1000 giving a maximum frequency of 11.1 Kc/s. Frequency accuracy ±1·5%. **£90.**

PATCH BOARD B21-49-01431L2A. GW46543. £45.
Also available plugs for the above in the following colours: red, blue, white and yellow. 5p each.

L.F. RESOLVED COMPONENT INDICATOR TYPE VP 253·2. This instrument will indicate, by means of two centre-zero 6-in. scale meters, the resolved components of a signal voltage with respect to the applied reference energisation. Frequency range: nominal range 0·5 c/s to 1 Kc/s. Accuracy of indication: ±3% of full scale on all ranges **£70.**

RACAL UNIVERSAL COUNTER/TIMER SA550 (CT488)



8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc. Full spec. and price on request.

OA 1094A/S H.F. SPECTRUM ANALYSER

Carrier range: 3 to 30 Mc/s. Sweep width: up to 30 Kc/s. 60 dB amplitude differences measurable. P.O.A.

BRAND NEW TRIMPOTS

HELIPOT: 10, 50, 100, 500, 5K, 10K, 20K, 25K ohm. **70p** each. **M.E.C.:** 100Ω **60p** each. **PAINTON:** 200, 500, 2Kohm. **60p** each. **RELIANCE:** 1KO-K. **45p** each. Discount for quantity.

BRAND NEW RELAYS BY "DIAMOND H". 4 P.D.T. relay. Coil-ohms 150, 26·5 V. **55p** each.

THERMOCOUPLES. Mineral Insulated Metal Sheathed. Conductors: Positive Nickel—Chromium. Negative Nickel—Aluminium. Conductor Diameter: ·011 inch nominal. Tolerance: ± 3°C. up to 400°C. ± ¾% between 400°C. and 1000°C. Length 3ft. 2in. (96 cm. approx.). **£2·25** post paid.

"WESTON" clear plastic meters 50-0-50μA type S.221.3.150 size 120 ×120 mm. **£2·50** postage included.
Also as above 20 V. M.C. size 60. × 60 mm. type S.2193.254. **£1·95** post paid.

TEKTRONIX OSCILLOSCOPES TYPES:
515A, 524AD, 543, 545, 545A, 545B.
Plug-in Units: CA, G, 1A1, 10A1. P.O.A.

QUANTIZATION DISTORTION TESTER. Checks a.f. to a.f. distortion of p.c.m. systems. Utilises system power supply. Output level: Variable in 1 dB steps, from —50 to +2 dBm. Accuracy: ±0·2 dB at +2 dBm, ±0·5 dB incremental. Quantization distortion: 0 to —40 dB in 0·5 dB steps. Meter indication: True r.m.s. Input impedance: 600Ω ±10% balanced.

AVO MODEL 3 VALVE TESTER

Enables comprehensive characteristics to be plotted, or measures valves on a simple good/bad basis. £55 incl. carr.

AVO CT 160 VALVE TESTER
As above but in portable valise form as illustrated. Price £65 incl. carr.

All Units calibrated to specification. Carriage extra for overseas orders.

JOHN CRICHTON
Electronic Equipment
558, Kingston Road, Raynes Park, London, S.W.20

Please phone 01-540 9534

Lasky's Audio·Tronics Catalogue 1973

The great 1973 edition of Lasky's famous Audio-Tronics catalogue is available – FREE on request. The 48 newspaper size pages – many in full colour – are packed with 1,000s of items from the largest stocks in Great Britain of everything for the Radio and Hi-Fi enthusiast, Electronics hobbyist, Serviceman and Communications Ham. Over half the pages are devoted exclusively to every aspect of Hi-Fi (including Lasky's budget Stereo Systems and Package Deals), Tape recording and Audio Accessories. See the great new Lasky's Credit Plan Scheme – enabling you to buy your ideal choice of equipment on easy terms.

FREE

Send this coupon with 15p for post and inclusion on our regular mailing list.

NAME ....

ADDRESS ....

....

.... WW1

LASKY'S RADIO LIMITED, 3-15 CAVELL STREET, LONDON E.1.

ATTRACTIVE
DISCOUNTS
ON VERY MANY ITEMS
WHEN YOU BUY FROM US

ELECTROVALUE
Electronic Component Specialists

RESISTORS—10%, 5%, 2%

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99 (see note below).	100 up
C	1/20W	5%	82 Ω–220K Ω	E12	9	8·	7
C	1/8W	5%	4·7 Ω–470K Ω	E24	1	0 8	0·7
C	1/4W	10%	4·7 Ω–10M Ω	E12	1	0·8	0·7
C	1/2W	5%	4·7 Ω–10M Ω	E24	1·2	1	0·9
C	1W	10%	4·7 Ω–10M Ω	E12	2·5	2	1·9
MO	1/2W	2%	10 Ω–1M Ω	E24	4	3	2 nett
WW	1W	10% ± 1/20 Ω	0·22 Ω–3·9 Ω	E12	7	7	6
WW	3W	5%	1 Ω–10K Ω	E12	7	7	6
WW	7W	5%	1 Ω–10K Ω	E12	9	9	8

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.

Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions on total value of resistor order.)

TRANSISTORS BY SIEMENS AND NEWMARKET

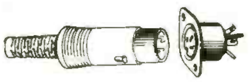
2N3055 npn silicon power **60p**
AC153K pnp germanium low power **25p**
AC176K npn germanium low power **23p**
AD161 npn germanium medium power **42p**
AD162 pnp germanium medium power **40p**
AF139 pnp germanium UHF **33p**
BCN107—**13p**; BC108—**12p**; BC109—**13p**] npn
BC167 —**10p**; BC168— **9p**; BC169—**10p**] npn
BC177—**15p**; BC178—**14p**; BC179—**15p**] pnp
BC257— **9p**; BC258— **8p**; BC259— **9p**] pnp
Standard groupings available.

BD135 npn medium power **26p**
BD136 pnp medium power **27p**

DIODES
OA90, OA91, OA95 each **6p**
OA200—**9p**; OA202—**10p**

Other semi-conductors
AC128—**21p** AF117—**24p**
BFY51—**20p**

DIN CONNECTORS by Hirshmann 4A rating

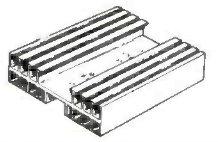


2 way loudspeaker	Socket	**10p**	Plug	**12p**
3 way audio	Socket	**10p**	Plug	**12p**
5 way audio 180°	Socket	**12p**	Plug	**15p**
5 way audio 240°	Socket	**12p**	Plug	**15p**
6 way audio	Socket	**13p**	Plug	**15p**

Lockable types, phono connectors, etc.

COVERS & HEATSINKS

T03 Transistor cover, clip-on **7p**
HEATSINK
Type 6W1 Extruded aluminium 1°C/W, undrilled **60p**



TOGGLE SWITCHES

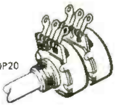
1011C SPST toggle **19p**; **409** DPDT toggle **28p.** (These are chrome plated, 2.5A rating). **7201** Sub-miniature DPDT 250V a.c./2A **48p**

TTL ICs

			Nett Prize
FLH101	(7400)		20p
FLH201	(7401)		20p
FLH191	(7402)		20p
FLH291	(7403)		20p
FLH211	(7404)		25p
FLH271	(7405)		25p
FLH381	(7408)		25p
FLH391	(7409)		25p
FLH111	(7410)		20p
FLH351	(7413)		35p
FLH121	(7420)		20p
FLH131	(7430)		20p
FLH141	(7440)		24p
FLL101	(74141)	(16)	£1·22
FLH281	(7442)	(16)	£1·16
FLH361	(7443)	(16)	£1·45
FLH371	(7444)	(16)	£1·45
FLH151	(7450)		20p
FLH161	(7451)		20p
FLH171	(7453)		20p
FLH181	(7454)		20p
FLY101	(7466)		20p
FLJ101	(7470)		45p
FLJ111	(7472)		32p
FLJ121	(7473)		45p
FLJ141	(7474)		45p
FLJ151	(7475)	(16)	45p
FLJ131	(7476)	(16)	45p
FLH221	(7480)		68p
FLH231	(7482)		87p
FLH241	(7483)	(16)	£1·32
FLH341	(7486)		33p
FLJ161	(7490)		80p
FLJ221	(7491 AN)		£1·28
FLJ171	(7492)		85p
FLJ181	(7493)		80p
FLJ231	(7494)	(16)	£1·13
FLJ191	(7495)		87p
FLJ261	(7496)	(16)	£1·48
FLJ301	(74100)	(24)	£1·64
FLJ281	(74104)		43p
FLJ271	(74107)		52p
FLK101	(74121)		48p
FLJ201	(74190)	(16)	1£·80
FLJ211	(74191)	(16)	£1·80
FLJ241	(74192)	(16)	£1·74
FLJ251	(74193)	(16)	£1·74

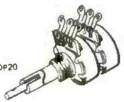
POTENTIOMETER carbon type

long spindles. Double wipers for low noise.
SINGLE GANG R20 linear 100Ω to 2·2MΩ, **12p**, JP20 Log, 4·7KΩ, to 2·2MΩ **12p.**



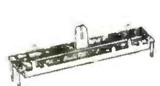
TYPE JP20

DUAL GANG linear 4·7KΩ to 2·2MΩ, **42p;** Dual gang log, 4·7KΩ to 2·2MΩ, **42p;** Log/antilog, 10K, 22K, 47K, 1MΩ only **42p;** Dual antilog, 10K only, **42p.** Any type with 2A D.P. mains switch, **12p** extra.
Only decades of 10, 22 & 47 available in ranges quoted.



TYPE DP20

DUAL CONCENTRIC DP20 in any combination of P20 values, **60p;** with switch, **72p.**
SKELETON PRE-SETS. Small high quality, type PR linear only: 100Ω, 220Ω, 470Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 470K, 1M, 2M2, 5M, 10MΩ. Vertical or horizontal mounting, **5p each.**



SLIDER POTS. In values from 4K7Ω to 1MΩ, linear or log, **26p each.** Escutcheon, light grey, **10p.** Knobs, flat, grip type, in 7 colour, **5p each.**

ELECTROLYTICS

Prices in pennies

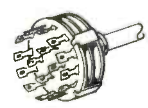
μF	3V	6.3V	10V	16V	25V	40V	63V	100V
0.47							7	7
1.0						7		7
2.2					7		7	7
4.7				7		7	7	7
10			7		7	7	7	7
22			7		7	7	7	7
47	7		7	7	7	7	8	12
100	7	7	7	7	7	8	12	18
220	7	7	7	8	9	10	17	26
470	7	8	9	9	12	17	24	41
1000	9	12	12	17	20	23	40	
2200	14	16	22	25	36	40		
4700	23	26	37	40				
10,000	37	40						

Smallest size 3·7mm x 12mm. Largest size 25·5mm x 41mm. Full ranges of many other types of capacitors stocked.

ROTARY SWITCHES

Radiospares Miniature Maka-switch (in assembly kit form). Shaft **48p.** Wafers, MBB—2P5W, 1P 11W; BBM1P12W, 2P6W, 3P4W, 4P3W, 6P2W, each **6p.**

Wavechange switches 1P12W, 2P6W, 3P4W, 4P3W, each **24p.**



KNOBS

(for 0.25 shafts)

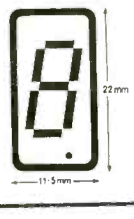
K.30/3 Solid aluminium 17mm.

F.14 skirt dia. 20mm. pack of 2 **32p**
F.13 skirt dia. 26mm. pack of 2 **38p**
F.12 skirt dia. 33mm. pack of 2 **40p**
F.19 engraved 20mm.—two **32p**
F.18 engraved. 26mm.—two **38p**
F.17 engraved. 33mm.—two **40p**

KB.4 Ribbed Skirt dia. 20mm. 4 in pack. **40p**

Very many other types in stock—see Catalogue.

Minitron DIGITAL INDICATOR



TYPE 3015F Seven segment indicator compatible with standard logic modules and power supplies. Figs. 0 9 from well illuminated filament segments to give character of 9mm height plus decimal point. Power requirement 8mA from 5V D.C. per segment. A limited number of alphabetical symbols also available. In 16 lead DIL case .. .. .. **£2·00**
Suitable BCD decoder driver type FLL121T nett **£1·36**
DIL Socket: 16 lead 30p. No. 3015G showing + or — and fig. 1 and decimal point £2·00.

DISCOUNTS

Available on all items except those shown with NETT PRICES. 10% on orders from £5 to £15. 15% on orders £15 and over.

TERMS OF BUSINESS

All items are offered for sale in accordance with our standard terms of business, a copy of which is available on request. Prices subject to alteration without notice. Enquiries from quantity users invited.

PACKING & POSTAGE

FREE in U.K. For mail orders for £2 list value and under, there is an additional handling charge of 10p.

VAT

Prices shown here DO NOT INCLUDE V.A.T. which will be charged in accordance with regulations.

USA CUSTOMERS

are invited to contact Electrovalue America, Box 27, Swarthmore PA 19081.

ZENER DIODES

Full range E24 values: 400m W: 2·7V to 36V, **14p each;** 1 W: 6·8V to 82V, **27p each;** 1·5W: 4·7V to 75V, **48p each. Clip** to increase 1·5 W rating to 3 watts (type) 266F) **4p.**

SIEMENS THYRISTORS

0·8A 400V, **48p;** 600V **66p.**
3A 400V, **52p;** 600V, , **76p.**

S-DEC

Unsurpassed for "breadboard work" can be used indefinitely without deterioration. Components just push into plug holes and connect automatically. Slot for control panel. 70 holes. **£1·44.**

T-DEC

For more advanced work with 208 contacts in 38 rows. Will take one 16 lead carrier. **£2·88.** (Carriers supplied separately.)

MAINS TRANSFORMERS

MT3 30V/2A plus 4 taps **£2·85**
MT103 50V/1A plus 4 taps **£2·55**
MT104 50V/2A plus 4 taps **£3·50**
MT127 60V/2A plus 4 taps **£3·80**
13T05 13V/½A, CT **£1·25**
28T05 12-12-2-0-2V/½A

IT SAVES YOU 25p TO START WITH

That's the price of the 96 page Electrovalue Catalogue (No. 6) and with it we give you a 25p refund exchange voucher on orders which come to **£5** or more. The Catalogue is packed with bargains in brand new guaranteed to makers spec. items plus I.C. circuit and schematic diagrams, transistor diagrams and specs, equivalent tables etc. Send 25p (plus 2½p VAT when operative) for Catalogue by return.

ELECTROVALUE LTD

(DEPT. WW.3), 28 ST. JUDES RD, ENGLEFIELD GREEN, EGHAM, SURREY, TW20 0HB
Hours: 9-5.30, 1.0 p.m. Saturdays. ***Phone: Egham 3603 Telex 264475***
Reg. offices at above address Business Reg. No. 1047769

VALVES

Valve	£	Valve	£	Valve	£
B12H	1·75	ECH200	0·62	KT88	2·40
CY31	0·35	ECL80	0·42	N78	1·75
DAF96	0·43	ECL82	0·35	OA2	0·35
DF96	0·45	ECL83	0·70	OB2	0·35
DK96	0·48	ECL86	0·40	PABC80	0·37
DL92	0·32	EF36	0·45	PC97	0·45
DL94	0·45	EF37A	1·25	PC900	0·47
DL96	0·45	EF40	0·50	PCC84	0·40
DM70	0·30	EF41	0·65	PCC89	0·50
DY86	0·33	EF80	0·25	PCC189	0·55
DY87	0·32	EF83	0·55	PCF800	0·75
DY802	0·48	EF85	0·35	PCF80	0·30
E88CC/01	1·20	EF86	0·30	PCF82	0·33
E180CC	0·42	EF89	0·28	PCF84	0·60
E181CC	0·90	EF91	0·30	PCF86	0·57
E182CC	1·20	EF92	0·35	PCF200	0·73
EA50	0·20	EF95	0·35	PCF201	0·73
EABC80	0·30	EF183	0·30	PCF801	0·45
EAF42	0·52	EF184	0·35	PCF802	0·50
EB91	0·18	EFL200	0·75	PCF805	0·80
EBC33	0·50	EL34	0·50	PCF806	0·70
EBC41	0·50	EL41	0·53	PCF808	0·85
ECC81	0·31	EL84	0·24	PCH200	0·70
EBF80	0·40	EL85	0·42	PCL81	0·47
EBF83	0·40	EL86	0·40	PCL82	0·35
EBF89	0·30	EL90	0·35	PCL83	0·60
ECC81	0·30	EL95	0·35	PCL84	0·42
ECC82	0·28	EL500	0·85	PCL85	0·42
ECC83	0·30	EM31	0·25	PCL86	0·43
ECC84	0·30	EM80	0·40	PFL200	0·61
ECC85	0·40	EM84	0·35	PL36	0·50
ECC86	0·45	EM87	0·70	PL81	0·48
ECC88	0·37	EY51	0·40	PL82	0·40
ECC189	0·52	EY86	0·40	PL83	0·42
ECF80	0·35	EY81	0·40	PL84	0·35
ECF82	0·35	EY88	0·40	PL500	0·73
ECF83	0·75	EZ40	0·50	PL504	0·75
ECF801	0·62	EZ80	0·25	PX4	2·50
ECF802	0·62	EZ81	0·27	PY33	0·60
ECH35	0·90	GZ34	0·58	PY80	0·35
ECH81	0·28	GZ37	0·70	PY81	0·35
ECH83	0·40	KT66	2·05	PY82	0·27
ECH84	0·45			PY83	0·35
				PY88	0·37
				PY800	0·40
				PY801	0·50
				QQVO 3-10	1·25

Valve	£	Valve	£	Valve	£	Valve	£	Valve	£	Valve	£
R17	0·48	UBF80	0·40	VR150/30	0·35	5B254M	2·20	6AQ5	0·35	6C4	0·30
R19	0·37	UBF89	0·35	Z801U	2·00	5B/255M	2·00	6AQ5W	0·50	6C6	0·25
STV 280/40	3·40	UCC85	0·40	Z803A	1·25	5R4GY	0·75	6AS6	0·37	6CH6	0·55
STV 280/80	9·00	UCF80	0·55	Z900T	0·95	5U4G	0·35	6AS7G	0·80	6CL6	0·49
TT21	3·30	UCH42	0·70	1L4	0·15	5V4G	0·45	6AT6	0·30	6D6	0·20
U25	0·72	UCH81	0·33	1R5	0·40	5Y4G	0·40	6AU6	0·25	6EA8	0·55
U26	0·72	UCL82	0·35	1S4	0·30	5Y3GT	0·35	6AX4GT	0·60	6F23	0·75
U27	0·50	UCL83	0·60	1S5	0·30	5Z3	0·55	6AX5GT	0·70	6F33	1·50
U191	0·70	UY41	0·50	1T4	0·22	5Z4	0·75	6B7	0·40	6H6M	0·20
U801	0·80	UF80	0·36	1X2A	0·40	5Z4GT	0·40	6BK7	0·60	6J4WA	0·75
UABC80	0·35	UF89	0·40	1X2B	0·50	6AB7	0·30	6BA6	0·25	6J5	0·40
UAF42	0·55	UL41	0·63	2K25	7·50	6AC7	0·30	6BE6	0·30	6J5GT	0·25
UBC41	0·46	UL84	0·40	3A4	0·35	6AH6	0·50	6BG6G	0·55	6J6	0·20
		UU5	0·55	3D6	0·15	6AK5	0·30	6BJ6	0·45	6J7G	0·35
		UY41	0·43	3Q4	0·45	6AK8	0·32	6BQ7A	0·60	6J7M	0·40
		UY85	0·40	3S4	0·35	6AL5	0·15	6BR7	0·85	6K6GT	0·56
		VR105/30	0·35	3V4	0·45	6AL5W	0·40	6BW6	0·85	6K7	0·32
						6AM6	0·30	9BW7	0·80		
						6AN8	0·50				

Valve	£	Valve	£	Valve	£
6K7G	0·20	30C15	0·70	6057	0·50
6K8GT	0·40	30C17	0·80	6060	0·50
6K25	0·70	30C18	0·70	6064	0·45
6L6M	1·50	30F5	0·80	6065	0·65
6SA7	0·40	30FL1	0·75	6080	1·50
6SA7GT	0·32	30FL12	1·15	6146	1·75
6SC7GT	0·25	30FL13	0·50	8020	2·25
6SG7	0·35	30FL14	0·83	9001	0·20
6SJ7	0·37	30L15	0·80	9002	0·25
6SJ7GT	0·32	30L17	0·80	9003	0·50
6SK7	0·46	30P12	0·80	9004	0·15
6SL7GT	0·32	30P19	0·77	9006	0·15
6SN7GT	0·32	30PL1	0·75		
6SQ7	0·39	30PL13	0·92	**C.R. Tubes**	
6SQ7GT	0·35	30PL14	0·90	VCR97	4·50
6V6G	0·17	35L6GT	0·50	VCR517R	5·50
6V6GT	0·40	35W4	0·35	VCR517C	7·50
6X4	0·30	36Z4GT	0·45	88D	9·00
6X5G	0·30	50C5	0·50	88J	9·00
6X5GT	0·37	50CD6G	0·60	88L	9·00
6Y6G	0·60	50EH5	0·60		
6-30L2	0·80	75	0·40	**Photo Tubes**	
6Z4	0·36	76	0·40	CMG25	2·75
7B7	0·45	78	0·40	931A	4·00
7Y4	0·60	80	0·50	6097C	17·50
9D6	0·37	723A/B	7·00		
11E2	2·80	803	3·25	**Special Valves**	
12AT6	0·30	805	12·00	CV2339	20·00
12AT7	0·30	807	0·50	JP9/7D	37·50
12AU7	0·29	813	4·00	K301	5·00
12AV6	0·38	832A	3·00	K305	12·00
12AX7	0·30	866A	0·80	K308	16·00
12BA6	0·37	931A	4·00	K337	16·00
12BE6	0·40	954	0·40	KRN2A	3·50
12BH7	0·27	955	0·25	WL417A	1·50
12C8	0·32	956	0·20	3J/92/E	37·50
12E1	2·70	957	0·30	5C22	18·00
12K5	0·55	991	0·40	714AY	4·00
12K7GT	0·40	2051	0·55	725A	16·00
12K8GT	0·45	5933	1·12		
12Q7GT	0·35				
12SG7	0·35				
14S7	0·75				
19AQ5	0·40				
19G3	4·25				
19G6	1·50				
19H4	5·00				
20P4	1·00				
25L6GT	0·40				

COLOMOR

THE VALVE WITH A GUARANTEE

SPECIAL OFFER O9J TUBE £2·50 p & p 50p

TRANSISTORS, ZENER DIODES

Type	£	Type	£	Type	£	Type	£	Type	£	Type	£
OA5	0·20	OC71	0·12	1N702-725	0·36	3N139	1·75	ASY67	0·48	CRS3/40	0·50
OA10	0·25	OC72	0·20	1N823A	1·30	3N140	0·97	BAW19	0·28	CS2A	0·65
OA70	0·10	OC73	0·30	1N4785	0·50	3N154	0·95	BC107	0·10	CV102	0·25
OA71	0·10	OC75	0·25	1ZMT5	0·35	3N159	1·45	BC108	0·10	GET103	0·23
OA73	0·07	OC76	0·25	1ZMT10	0·33	6FR5	0·45	BC113	0·10	GET115	0·45
OA74	0·07	OC81	0·20	1ZT5	0·67	12FR60	0·73	BC118	0·20	GET116	0·50
OA79 (6D15)	0·10	OC81D	0·20	1ZT10	0·63	40954	1·25	BCY72	0·15	GEX66	1·50
OA81	0·08	OC81DM	0·20	2G385	0·51	40595	1·25	BF115	0·25	NKT222	0·20
OA91	0·07	OC82	0·25	2G403	0·51	40636	1·25	BF173	0·20	NKT304	0·50
OA200	0·07	OC82DM	0·30	2N918	0·37	40668	1·25	BFY51	0·20	RAS310AF	0·33
OA202	0·10	OC83	0·25	2N1304	0·22	40669	1·40	BFY52	0·20	SD91S	0·26
OA210	0·25	OC83B	0·15	2N1306	0·25	AC126	0·25	BS	0·45	SD92S	0·31
OA211	0·30	OC84	0·25	2N1307	0·25	AC127	0·25	BS2	0·47	SD93S	0·32
OAZ200	0·56	OC122	0·50	2N2147	0·64	AC128	0·20	BSY29	0·25	SD94	0·21
OAZ201	0·50	OC139	0·25	2N2411	1·50	AC176	0·20	BU100	1·80	SD98S	0·46
OC16	0·50	OC140	0·40	2N2904A	0·25	ACY17	0·25	BYZ13	0·25	V405A	0·40
OC22	0·50	OC170	0·25	2N2989	4·00	ACY28	0·17	BYZ16	0·63	Z2A51CF	0·78
OC25	0·40	OC171	0·30	2N3053	0·20	AD149	0·50	CRS1/10	0·25	ZR11	0·33
OC26	0·25	OC172	0·37	2N3054	0·50	AD161	0·35	CRS1/20	0·38	ZR21	0·46
OC28	0·60	OC200	0·40	2N3055	0·64	AD162	0·35	CRS1/30	0·40	ZR22	0·42
OC29	0·60	OC201	0·75	2N3730	0·50	AF118	0·50	CRS1/35	0·43		
OC35	0·50	OC206	0·95	2N3731	2·75	AF127	0·20	CRS1/40	0·48		
OC36	0·56	1N21B	0·30	2N4172	0·50	AF139	0·30	CRS3/05	0·30		
OC38	0·42	1N25	0·60	8Z303	0·50	AF178	0·48	CRS3/20	0·38		
OC44	0·17	1N43	0·10	3F100	0·62	AF186	0·40	CRS3/30	0·43		
OC45	0·12	1N70	0·07	3FR5	0·32	ASY26	0·25	CRS25/025	0·55		
OC70	0·12	1N677	0·12	3N128	0·87	ASY28	0·25				

ZENER DIODES

All preferred voltage

½W	0·17
1W	0·37
1·5W	0·25
7W	0·40

MANY OTHERS IN STOCK including integrated circuits, C.R.T. and special valves. U.K. POSTAGE over £3 free, 5p for one valve plus 1p for each additional valve or transistor. C.O.D. 25p extra.

VALVES AND TRANSISTORS
Telephone enquiries for valves, transistors, etc., retail 743 4946; trade and export 743 0899.

MARCONI TEST EQUIPMENT

VALVE VOLTMETER TYPE TF 958. Measures AC 100mV; 20 c/s to 100 mc/s; DC 50mV to 100V, multiplier extends ac range to 1·5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. **£32·50.**

TF 1066 B/2 F.M. SIGNAL GENERATOR. Frequency range 400-555MHz in one band. Crystal calibration: 1MHz and 10MHz. Output: piston attenuator 0·1µV-100mV at 50 ohms. Int. mod. freq. 1 to 10kHz, ext. mod. freq. 100Hz to 100kHz. Freq. dev. up to 300kHz. **£250.** Carriage £1·50.

TF 1258A VHF SPECTRUM ANALYSER for analysis and measurement of Radar Equipment. Frequency range 190 to 230MHz with crystal check points. Sweep width 0·5 to 5MHz, output pulse delay (*a*) 85-175 µSec, (*b*) 0·7-1·4 mSec with ×1 and ×2 multiplier and ÷2, ×1, ×2 multiplier. Output 2µV to 20mV with ×10 multiplier. **£250.** Carriage at cost.

MUIRHEAD PHASEMETER. Type D729/AM and P.S.U. D729 A/S. Complete with manual, leads, as new **£200.**

TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT. For testing radar, nucleonics, 'scopes, counters, filters etc. **SPEC. TF 1400S.** Rep. frequ. 10Hz to 100 kHz, pulse width 0·1 to 100µ sec., delay −1·5 to +3000µ sec., rise time < 30N sec.

SPEC. TM 6600/S. As for TF1400S except pulse width 0·5 o 25µ sec, delay 0 to + 300µ sec. **£200.**

SIGNAL GENERATOR TYPE AN/USM-16 (MODEL BJ75A)
A precision HF/VHF signal generator embodying facilities seldom found or contained in one instrument, namely outputs **of CW/AM/FM and swept carrier,** in the frequency range **10 to 440 MHz.** Some of the features of the instrument are: **AUTOMATIC FREQUENCY STABILISATION** (locks output signal to selected frequency), **AUTOMATIC LEVEL CONTROL** (holds output constant ±1db) **INTERPOLATION OSCILLATION** (for precise tuning between crystal check points) **MARKERS** (for S.F.M.)
Brief specifications, Frequency 10 to 440MHz, RF output 0.1uV to 0.224V at 50 ohms. Modes of operation CW-HI, CW, CW (calibrated and stabilised), AM-400Hz and 1kHz and external, FM-400Hz and 1kHz and external 0.75 kHzdev., S.F.M. —x1, x10, x100, 0-75, 750 & 7500kHz dev. resp., P.M. —50 to 5000 pps at 1 to 30µsec. with int. or ext., 150 to 5000Hz rep rate. 3 meters for; mod. and dev., frequency discrimination pulse level output. Complete specification and price on application.

★ **Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.**

TF 801B/3/S SIGNAL GENERATOR. Spec. as for TF 801D/1/S except for minor circuit changes e.g. 1 and 2 MHz switched calibrator. P.O.A.

TF 801D/1/S SIGNAL GENERATOR: Range 10-485 MHz in five ranges. R.F. output 0·1 µV-lV source e.m.f. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator. 50Ω output impedance. Internal modulation at 1 kHz at up to 90% depth, also external sine and pulse modulation. Built-in 5MHz crystal calibrator. Separate R.F. and mod. meters. P.O.A.

TF 562B/3 Oscillator and Detector Unit.
TF 886A Magnification Meter.
TF 1226B
TF 1225A } White Noise Test Set.
TM 577A

TF 1104 VHF ALIGNMENT OSCILLOSCOPE combining sweep generator, markers etc. Frequency range 5kHz to 10MHz, 10MHz to 40MHz and 41 to 216MHz. Sweep width 500kHz to 10MHz, output 100$V to 10mV. Markers 0·5, 1 & 5MHz. Price on application.

HEWLETT—PACKARD 185A 800 MHz SAMPLING OSCILLOSCOPE WITH 188A DUAL TRACE PLUG-IN. Full spec. and P.O.A.

5248 COUNTER FREQUENCY MEASUREMENT: 10Hz to 10,1MH2. Accuracy ½ 1 count. Automatic positioning of decimal point. Period measurement: 0-10kHz, reads in seconds, milliseconds or microseconds, decimal point automatically positioned. Display on 6 neon lamp decades and 2 meters. Complete with manual and following plug-ins: **525A** 10 to 100MHz, **525B** 100 to 220MHz, **526A** video amplifier. Price on application.

540B TRANSFER OSCILLATOR. Extends range of 524 and 5245 series counters to 18 gHz, or on its own, measures frequencies below 4gHz with 0.5% accuracy.

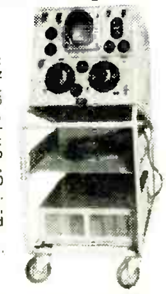
430C MICROWAVE POWER METER. Complete with **476A** bolo mount, **475B** tunable bolo, **BM16** waveguide, **£125.**

205AG AUDIO OSCILLATOR. Low distortion, 20 Hz to 200 kHz, metered and attenuated inputs and outputs enabling a very wide range of measurements to be made on amplifiers, filters, etc. **£145.**

200CD WIDE RANGE OSCILLATOR. 5 Hz to 600 kHz, **£60.**

BEST PRICES PAID FOR TEST AND COMMUNICATION EQUIPMENT. Single items or quantities. Private or Industrial.

SPECTRUM ANALYSER TYPEOA1094
Freq. range: 3 to 30MHz in 9 bands. Selectivity: 6 30 and 150Hz, at 3db. Spectrum width: 0-30kHz. Sweep Duration: 0.1, 0,3, 1, 3, 10 & 30 secs. Complete as illustrated, with manuals, etc. and **L.F. Adaptor.**
Price upon application.



TF 1370 R-C OSCILLATOR, SQUARE AND SINE WAVE. Freq.: Sinewave 10Hz-10MHz, squarewave 10Hz-100kHz. Direct output: sinewave: 0-31.6V rms., 10Hz-1MHz, squarewave: 0-73.2pp 10Hz-100kHz. Attenuator range: −50d8 to +10dB. Impedance: 75, 100, 600Ω. Price upon application.

BC 624 RECEIVER (Part of SCR 522 TX/RX) 100-156 mcs, no valves, requires separate PSU for 28V. £2.50. Carriage 50p.

H.F. ABSORPTION WATTMETER TF 957. Range: 1 to 100MHz, Power: 0, 1 to 25w, Impedence 52Ω on 1W range, 70Ω on 25W ange. £25.00. Carriage 75p.

TEKTRONIX OSCILLOSCOPES.
541A—33MHz, plug-in Y amps.
531-57—60MHz, separate P.S.U.
561A—10MHz, solid state, compact, takes the following plugs-ins: X, Y, differential, sampling, spectrum analyser.
PLUG-IN UNITS
CA—24 MHz dual trace 50MV-20V.
G—20 MHz differential 50MV-20V.
L—30 MHz fast rise time 5MV-20V.
D—High gain differential 1MV-50V.
N 600MHz sampling 10mV-cm.
R Transistor measurement.
P type callibration.
3A1—Dual trace 10mV-10V.
3B3—Delayed sweep time base.
134—P6021 probe and current probe amplifier, 1mA-15A p. & p., new and boxed, **£140.**
EQUIPMENT
162 wave form generator.
163 Pulse generator.

500/250W MEDIUM WAVE BROADCAST TRANSMITTERS. Price and details on application.

M.O. for ET 4336 TX (see description in previous issues) £8·50. P. & P. £1·50.

AR88 SPARES. We hold the largest stock in U.K. Write for list.

5 PHASE AUTO TRANSFORMER, wye input 400v, wye output 241.5/230/218.5v 50c 18kVA. Made by Westinghouse of USA. Brand new in original cases **£**65.00 including UK transport.

PLEASE NOTE

Unless offered as "as seen"

ALL EQUIPMENT

ordered from us is completely overhauled mechanically and electrically in our own laboratories

FOR EXPORT ONLY
TRANSMITTERS:
BC 610 Hallicrafters.
RCA ET 4336 also modified version of increased output to 700w.
COLLINS TYPE 231D 4/5kw., 10 channel, autotone and manual tuning. All above complete installation and spare parts.
TRANSCEIVERS
19, 19HP, 38, 62.
C-11 TRANSMITTERS
C-13 TRANSMITTERS

SOLARTRON
STABILISED AMPLITUDE SIGNAL GENERATOR TYPE DO905. Freq.: 350KHz-50MHz in 6 ranges. Output Amplitude: 40mV-10V pp, output impedance 52Ω. **£105.00.**

REMSCOPE TYPE 741 STORAGE OSCILLOSCOPE. On trolley, complete with plug-in trace shifter and two plug-in Y amplifiers. **£200** plus carriage.

HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.

R.F. METER 0-8 amp. 2¼" (U.S.A.) **£2·25** P. & P. 15p.

TELEQUIPMENT
S51T
0·1 to 50v per cm. Time base 1 u/sec-100 m/sec. £30.

METERS Full List of our very large stock of meters on request.

INTEGRATED CIRCUITS Texas SN 76131N Stereo pre-amp **£0·65.**

TR 1143 TRANSMITTER RECEIVER 100/126 mcs, requires separate PSU for 28V. Price **£12.00.** Carriage **£**1.50.

TELEPHONE TYPE "J" (Tropicalised) 10 line **MAGNETO TELEPHONE SWITCHBOARD**

100 line **AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD**

50 line **AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD**

Price of each of the above on application.

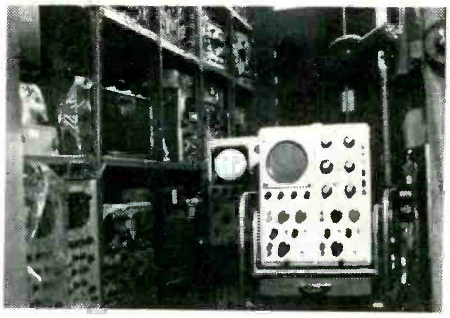
RADAR SCANNER ASSEMBLY TYPE C368 Parabolic assembly 17". Complete with motor for 26V 600W, etc. **£25·00.** Carriage £2·50.

★ **TELEPHONE ENQUIRIES** relating to **TEST EQUIPMENT** should be made to 01-748 8006 Extension 23. To view **TEST EQUIPMENT** please phone for appointment

COLOMOR (ELECTRONICS LTD.)
170 Goldhawk Rd., London, W.12
Tel. 01 - 743 0899

C. T. ELECTRONICS
267 ACTON LANE, LONDON, W.4 5DG
01-994 6275

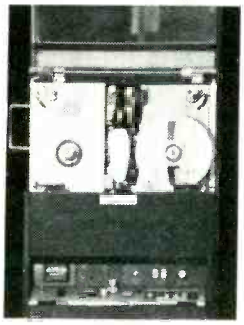
COMPONENTS AND TEST EQUIPMENT



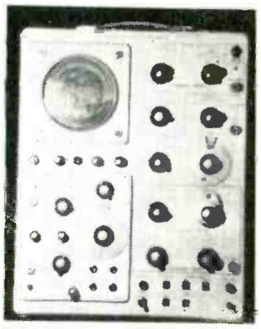
SURPLUS ELECTRONICS WAREHOUSE
20-24 Beaumont Rd, London, W.4 (1st floor)
NOW OPEN EVERY DAY 10 a.m.-5 p.m.
PUBLIC and TRADE WELCOME
Thousands of bargains at ridiculous prices: Oscilloscopes: Test Meters, Resistors, Capacitors, Components, etc., etc.

WANTED
SURPLUS TEST GEAR, COMPONENTS, SEMICONDUCTORS ETC.

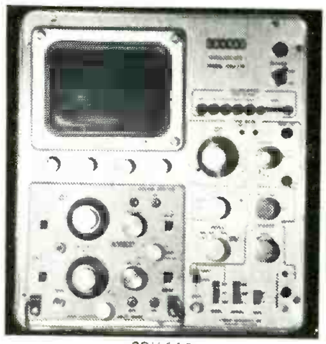
EDDYSTONE
770U **Communication receiver** . . . £240



SONY
PV-120UE **Broadcast Standard Video Taper Recorder** P.o.A.
2 in. Tape. 625 Lines. CCIR 2 Audio Channels.



EMI. WM16 . . . . . . From £125



CDU 110

COSSOR
CG.200 **Millimicrosecond Pulse Generator** . . . £45
CDU 110 **Double Beam Oscilloscope DC-20MHz.** Brand new, complete with manual £300
CDU 120 **Double Beam Oscilloscope DC-60MHz.** Brand new, complete with manual £450
CDU 150 **Double Beam Oscilloscope** DC-35MHz. Brand new complete with manual . . . £400

TEKTRONIX
545A **Oscilloscope DC-30Mhz** P.o.A.
661 **Sampling Oscilloscope** complete with 50 ohm. sampling unit type 4S1 plus Timing unit type 5T1A 1 GHz., 2mV./cm. Dual trace . . . P.o.A.
661 **Sampling Oscilloscope** complete with 50 ohm. sampling unit type 4S2A plus Timing unit type 5T3 3.9GHz., 2mV./cm. Dual trace . . . P.o.A.
536 **X-Y Oscilloscope**, DC-11MHZ P.o.A.
545 **Oscilloscope**, DC-30MHz . . . P.o.A.
551 **Oscilloscope.** Dual Beam. 27MHz . . . P.o.A.
107 **Square Wave Generator** £150
Plug-in Units available for the above oscilloscopes: Type B £45 G £65 H £65; 53/54B £50; 53/54E £60 C.A £95

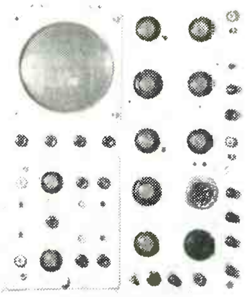
POLARAD
R-B **Microwave Receiver with R.F. Tuning Units** £680
RR-T 400-1000MHz (2 off)
RS-T 1900-4340MHz
T.S.A. **Spectrum Analyser and 2 Plug-in Tuning Units** P.o.A.

AVO
FP 5K **Oscilloscope Camera with Polaroid attachment** – suits all Tektronix Scopes £160
CT38 **Electronic Multimeter** £18
Valve Characteristic Tester £68

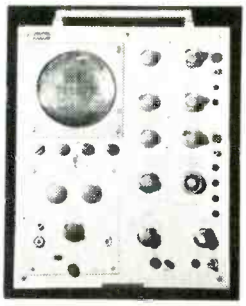
TELONIC
HD.3 **Sweep Generator 0-200MHz** £120

WAYNE-KERR
B.701 **VHF Admittance Bridge** . . P.o.A.
M.131 **Video Noise Level Meter** P.o.A.

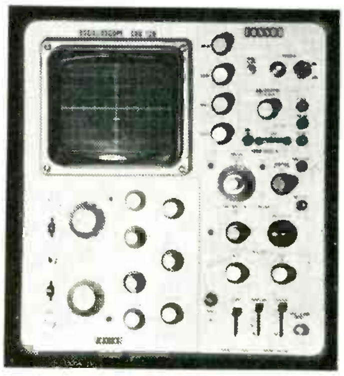
RATIO METER UNIT
Suitable for testing and calibrating attenuators mounted in Standard Signal Generators.
Frequency Range 0.1–3000MHz.
Brand new, complete with all accessories and full operating and maintenance manuals.
Original cost over £2,000. Only **£550.**



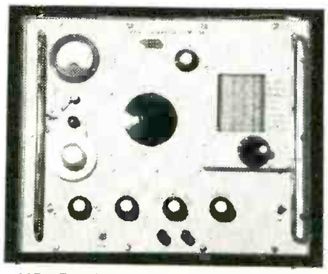
TEKTRONIX 545A



SOLARTRON
CD.1220 **Oscilloscope with Wide Band Plug-in** CX.1256. DC-40MHz. £190
CD.1220 **Oscilloscope with Differential High-gain Plug-in** CX.1258 £220

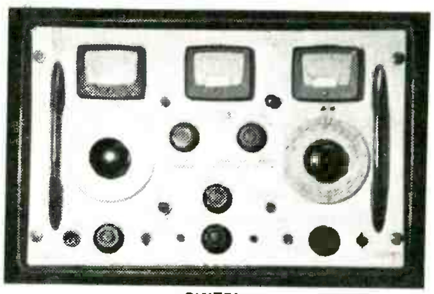


CDU 120

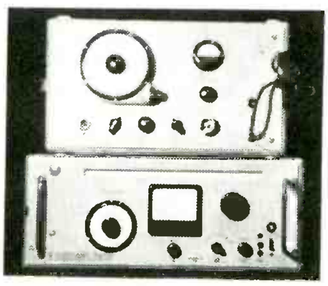


AIRMEC 201 SIGNAL GENERATOR £98

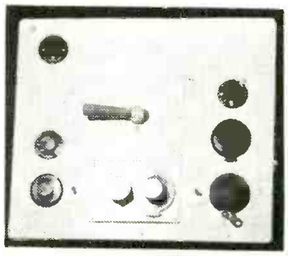
£325 . . . . . . **EDDYSTONE UHF RECEIVER**
500-1000 MHz.



CINTEL
36601 **Electrolytic Capacitance and Incremental Inductance Bridge** 0.1 µF-1000 µF: 0.01H-100H £80



RHODE AND SCHWARZ
SMLM-BN4105 **Power Signal Generator** 30-300MHz 60 ohms £290
ZDD-BN3562 **Z-G Diagraph** 300-2400MHz £650
USVF BN 15285/50 **Selective UHF Voltmeter** for TV Bands IV and V P.o.A.



SULLIVAN
Precision Capacitance Bridge P.o.A.

FULL RANGE OF ELECTRONIC COMPONENTS AT OUR RETAIL SHOP. OPEN 9.30-6. MON.-SAT.
267 ACTON LANE, LONDON, W.4.

APPOINTMENTS VACANT

DISPLAYED APPOINTMENTS VACANT: £9.00 per single col. inch.
LINE advertisements (run-on): 50p per line (approx. 7 words), minimum two lines.
BOX NUMBERS: 25p extra. (Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.)
PHONE: Allan Petters on 01-261 8508 or 01-928 4597

Advertisements accepted up to 12 p.m., THURSDAY, MARCH 8th, for the APRIL issue, subject to space being available.

MARCONI INSTRUMENTS LIMITED

ELECTRONIC TECHNICIANS

are required to work on calibration, fault-finding and testing of telecommunications measuring instruments. The work is varied and will enable technicians with experience of r.t. circuits to broaden their knowledge of the latest techniques employed in the electronics and telecommunications industries by bringing them into contact with a wide range of the most advanced measuring instruments embracing all frequencies up to u.h.f.

Entrants may be graded as Test Technicians, Senior Test Technicians or Technician Engineers according to experience and qualifications. Our servicing and production programme, geared to our recognised export achievement, provides employment combined with prospects of advancement, not only within these grades, but into other technical and supervisory posts within the Company at Luton and St. Albans.

Salaries are attractive and conditions excellent. A Pension Scheme includes substantial life assurance cover provided by the Company. Assistance with removal may also be given in appropriate cases. Please write or telephone, quoting reference WW 174 for application form to:

mi

Mr. M. Leavens, Works Manager
Telephone: Luton 33866, or
Mr P Elsip, Personnel Officer
Marconi Instruments Ltd
Longacres, St. Albans, Herts
Telephone: St. Albans 59292

Member of GEC-Marconi Electronics

1971 THE QUEEN'S AWARD TO INDUSTRY

2410

ATV NETWORK LIMITED

has a vacancy in BIRMINGHAM for an

ENGINEER

APPLICANTS should possess a good knowledge of television engineering, practical experience of broadcast equipment being an advantage. A knowledge of film projection equipment is desirable but not essential.

Salary will be in the range £1,938 to £2,318 per annum.

Application forms may be obtained by writing to:—

HEAD OF STAFF RELATIONS,
ATV NETWORK LIMITED,
ATV CENTRE,
BIRMINGHAM B1 2JP.

Please quote vacancy number 16.

[2426

PRODUCT ENGINEER (TELEVISION)

A vacancy is open at the Amersham (Bucks.) Distribution Centre of Thorn Television Rentals for an Inspector with a good knowledge of receiver and component test procedures and the servicing of colour and monochrome television sets.

The position offers an interesting variety of technical work directly concerned with the sampling and testing of television receivers and associated equipment for the purpose of maintaining a high standard of Quality Assurance.

Good salary according to age and experience. A comprehensive Company Pension and Insurance Scheme is available.

Apply in writing giving qualifications and experience to:—

BOX No. R/ST,
THORN TELEVISION RENTALS,
14 BERESFORD AVENUE, WEMBLEY, MIDDLESEX, HA0 1RJ

[2432

UNIVERSITY OF SOUTHAMPTON
DEPARTMENT OF CHEMISTRY

Electronics Technician

Applications are invited for the post of Technician (non-established) to operate a nuclear quadrupole resonance (NQR) spectrometer. Applicants should possess ONC or an equivalent qualification in electronics and have relevant general experience (specialised experience in NQR is not expected). If desired there will be opportunities for further study to obtain HNC. The salary will be on the Grade 3 scale £1,539 to ££1.794 per annum. Applications, in writing, stating age, qualifications and experience and giving the names of two referees, preferably previous employers, should be sent to the Deputy Secretary's Section (Ext. 2400), The University, Southampton, SO9 5NH, as soon as possible. Please quote reference WW/229/73/T.

[2421

electronic calibration engineers

The activities of G & E Bradley Ltd. include the development and manufacture of a unique range of electronic instruments and medical equipment. We also provide the most comprehensive maintenance, repair and calibration service in the U.K.

The continuing expansion of this service has created vacancies for Electronic Calibration Engineers who are capable of maintaining a wide range of telecommunications, radar, microwave, ECM systems and all types of electronic test equipment.

Practical experience in this work is of greater importance than academic qualifications, and competent engineers will be offered interesting, rewarding and well paid employment with good promotional prospects.

Salaries, related to experience will be in the range of £1,900 to £2,100 per annum.

BRADLEY electronics
A LUCAS COMPANY

For more details please telephone our Personnel Manager on 01-450 7811. G & E Bradley Ltd., Neasden Lane, London N.W.10. 2398

AGRICULTURAL RESEARCH COUNCIL INSTITUTE FOR RESEARCH ON ANIMAL DISEASES
COMPTON, NEWBURY, BERKSHIRE

ELECTRONICS TECHNICIAN

required to work on maintenance of scientific apparatus and design and manufacture of small prototype units as used in the microbiology and biochemistry fields. Experience in nucleonic counting equipment an advantage. Permanent position for a good practical man capable of working on his own. Hostel accommodation available. Salary ONC/HNC level £1,405 p.a. at age 20 to £1,850 p.a. at age 28, to a ceiling of £2,090 p.a. plus superannuation allowance of 5½%. Applications with curriculum vitae and names and addresses of two referees should be submitted to the Institute Secretary at the above address, quoting vacancy No. 143.

[2423

RADIO OFFICERS

DO YOU HAVE

- PMG 1
- PMG 11
- MPT
- 2 YEARS OPERATING EXPERIENCE

POSSESSION OF ONE OF THESE QUALIFIES YOU FOR CONSIDERATION FOR A RADIO OFFICER POST WITH THE COMPOSITE SIGNALS ORGANISATION

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on scale rising to £2,365 p.a.; commencing salary according to age — 25 years and over £1,664 p.a. During training salary also by age, 25 and over £1,238 p.a. with free accommodation.

The future holds good opportunities for established status, service overseas and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Application only from British-born UK residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

Full details from:

Recruitment Officer (TRO.2.)
Government Communications Headquarters
Room A/1105
Oakley Priors Road
CHELTENHAM Glos GL52 5AJ
Telephone: Cheltenham 21491 Ext 2270

MEDICAL PHYSICS TECHNICIAN III

required to join a small group concerned with servicing, development and research in medical electronics. Minimum qualification is ONC in electrical or electronic engineering plus appropriate electronics experience, preferably in a hospital.

Salary scale £1728 rising to £2205

Please apply in writing, naming two referees, to:

THE HOUSE GOVERNOR
THE LONDON HOSPITAL
(Whitechapel)
WHITECHAPEL,
LONDON, E1 1BB

[2405

ENGINEERS

Sound Development Ltd. require two young engineers to form part of small flexible team engaged in design and installation of professional audio and broadcast systems, and maintenance of own recording studios and mobile equipment. Must be prepared to turn hand and most things. Salary in region of £1,500 p.a.

Contact: Harry Day on 01-586 4488

[2443

Test and Quality Engineers

Expansion in EMI's Electronics and Industrial Operations at Hayes, Middlesex, has created a wide range of opportunities for both junior and experienced test and quality engineers in projects involving the most up to date techniques and facilities.

Vacancies exist in the following project areas:—

- ☐ Airborne and Ground Radar.
- ☐ T.V. Cameras and Studio Equipment.
- ☐ Defence Electronics Systems.
- ☐ Computerised X-Ray Equipment.
- ☐ Microelectronics.

We offer competitive salaries, a good contributory pensions scheme, plus real prospects for career development.

If you are aged at least 21, technically qualified, with previous electronics quality assurance experience, why not write or ring for an application form:—

R. N. L. Black, Personnel Department,
EMI Limited,
135 Blyth Road, Hayes, Middlesex.
Tel.: 01-573 3888, Ext. 2887

EMI International leaders in Electronics, Records and Entertainment.

Slough College of Technology
Department of Engineering

LECTURER I

IN RADIO AND T.V. SERVICING

Required to teach in Radio, T.V. and Electronics Mechanics and Technician Courses.

Applicants should hold CGLI Radio & T.V. Servicing Certificate and have had good industrial experience. Teaching experience desirable but not essential.

Salary on Burnham Technical Scale, viz. £1,500—£2,524 plus additions for qualifications and training. Removal expenses up to £115 may be paid in approved cases.

Further particulars and application forms obtainable from the Vice Principal, Slough College of Technology, Wellington Street, Slough SL1 1YG, to whom completed forms should be returned within 14 days of the appearance of this advertisement.

[2393

ANTENNA DESIGN
and
DEVELOPMENT ENGINEER

Electronic design and development engineers are required to join an expanding company engaged in the design and development of antenna systems and R.F. feeder line components. The work covers siting assessment, the design and manufacture of antennae and associated components and systems, function testing in the H.F., V.H.F., U.H.F. and Microwave spectrums.

We design, develop and manufacture antennae for use on aircraft in addition to ground and seaborne systems and applicants with some aircraft experience would receive early consideration. Applicants of all levels of qualifications and experience are required.

Salaries will be negotiable and commensurate with experience.

The company is situated in a delightful rural setting, one mile from Witney Oxfordshire.

Apply by letter:
H. R. Smith (Technical Developments) Limited,
New Mill, Crawley Road,
Witney, Oxfordshre.

[2417

INDIVIDUAL

To take an active part in expanding my small London based outfit. This is an excellent opportunity for a person who has a thorough technical background in audio. Must be willing to contribute in accordance with the demands of an exciting and challenging business manufacturing professional quality high power sound systems.

Substantial remuneration offered to the right person.

Write giving full background to:

MARTIN AUDIO LTD
JUBILEE STUDIOS
COVENT GARDEN
LONDON WC2 E8BE

[2428

MEDICAL ELECTRONICS TECHNICIAN

(preferably graduate with industrial experience)

To work in new Teaching Hospital and Medical School as part of team evaluating drugs in man under laboratory and clinical conditions. Successful applicant to operate and maintain a wide range of electronic monitoring equipment and will be encouraged to pursue research interests in the design field. Interest in computer techniques an advantage. Starting salary £1,752 plus London allowance.

Apply: The Secretary, Dept. of Pharmacology, Charing Cross Hospital Medical School (Fulham), Fulham Palace Road, London, W6 8RF.

[2442

Electronics Test Engineers

Pye Telecommunications of Cambridge and Haverhill have immediate vacancies for Production Test Engineers. The work entails checking to an exacting specification VHF/UHF radio-telephone equipment before customer delivery; applicants must therefore have experience of fault finding and testing electronic equipment, preferably communications equipment. Formal qualifications while desirable, are not as important as practical proficiency. Armed service experience of such work would be perfectly acceptable. Pye Telecommunications is the world's largest exporter of radio-telephone equipment and is engaged in a major expansion programme designed to double present turnover during the next five years. There are, therefore, excellent opportunities for promotion within the company. Pye also encourages its staff to take higher technical and professional qualifications.

These are genuine career opportunities in an expansionist company, so write or telephone without delay for an application form to:

Mrs A E Darkin at
Cambridge Works, Elizabeth Way, Cambridge CB4 1DW.
Telephone: Cambridge 51351.
or Mrs C Dawe at
Colne Valley Road, Haverhill, Suffolk.
Telephone: Haverhill 4422.

Pye Telecommunications Ltd

2413

SEMICONDUCTOR APPLICATIONS

FERRANTI

have vacancies in their

APPLICATIONS LABORATORY

for engineers to assist in the development and applications of descrete semiconductor devices.

AREAS OF RESPONSIBILITY:

- Engineering Service to Marketing
- Technical Liaison with Device Development
- Circuit Design
- Preparation of Application Reports
- New Product Evaluation
- Application Service to Customers

Qualifications required are a degree or HNC in Electronics or Applied Physics and a good knowledge of basic transistor circuitry.

Application forms may be obtained from **T. J. Lunt, Staff Manager, Ferranti Ltd., Hollinwood, Lancs.**
Please quote reference ES/JAW/W2414

Field Service Engineers
Hayes, Middlesex

EMI Service, the Installation and Maintenance Division for EMI Sound and Vision Ltd., requires experienced field service engineers for their Hayes based factory.

The positions require a sound electronics background and relevant experience in one of the following fields:–

- ☐ Marine Navigational aids including marine radar.
- ☐ Instrumentation tape recording system.
- ☐ Digital tape recording systems.
- ☐ Numerical control of machine tools.

Salaries are realistic and in each case will be related to individual capability and potential.

Please write or telephone for an application form, quoting "EMI Service" to: R. N. L. Black, Personnel Department, EMI Limited, 135, Blyth Road, Hayes, Middlesex. Tel. 01-573 3888 Ext. 2887

EMI

International leaders in Electronics, Records and Entertainment.

TEST ENGINEERS
Electronics — Hampshire
£1200 to £2000 per annum

We are part of one of the world's largest and fastest growing instrumentation groups.

We wish to recruit a number of technician engineers to test precision electronic instruments. Our products include digital voltmeters, oscilloscopes, data loggers, dynamic analysis instruments, high frequency synthesisers and radar systems.

Applicants should have an appreciation of electronics equivalent to an H.N.C. or Final C and G education and it is essential that they have a minimum of two years' industrial experience, testing similar equipment to that outlined above.

Application forms should be obtained from the Personnel Services Manager, The Solartron Electronic Group Limited, Victoria Road, Farnborough, Hampshire. Tel: Farnborough 44433

SOLARTRON
Schlumberger

Medicovision

We require the services of a young man to join a small team of television experts who are based at Welwyn Garden City and who spend some of their time giving educational demonstrations to members of the medical profession in various parts of the country.

We look for candidates with sound knowledge of black and white television and some experience with colour. They must be able to drive.

Pay and allowances will be in accordance with those expected from a major pharmaceutical company.

For further particulars and an application form please apply quoting reference MTV/H to the Personnel Officer

ROCHE

Roche Products Limited
Welwyn Garden City Hertfordshire

2425

CRANFIELD

Short Course on

MICROWAVE LABORATORY PRACTICE

7th–11th May 1973

A predominantly practical course of instruction in coaxial line, waveguide and mircostrip methods for scientists and engineers whose work is being influenced by the wider application of microwaves.

Past experience shows that the course is ideally suited to the needs of the non-electrical specialist as well as the electrical or electronic engineer about to enter the microwave field.

To ensure personal tuition and practice the number admitted to the course will be restricted to 16.

Fees covering tuition and full board and accommodation £50.

Further information from:

THE REGISTRAR (SHORT COURSES), CRANFIELD INSTITUTE OF TECHNOLOGY,
CRANFIELD, BEDFORD, MK43 0AL.
Telephone: Bedford 51551 (0234-51551), Ext. 284.
Telex: 825072.

[2407

CITY OF LONDON POLYTECHNIC

TECHNICIAN

A vacancy now exists for a Technician in the Department of Physics. Applicants must possess appropriate qualifications in the repair and maintenance of electronic equipment and should preferably have laboratory experience.

Salary (subject to review)

Within the range £1,137 (age 21) to £1,557 plus £174 London Weighting Allowance, according to age and qualifications.

Please write to the Head of the Department of Physics, City of London Polytechnic, 31 Jewry Street, London, EC3N 2EY, stating full details and enclosing the names of two referees.

[2389

THE UNITED LIVERPOOL HOSPITALS

Electronics Engineer (GRADUATE)

A graduate electronics engineer is required to join a small team in the Bio-Engineering and Medical Physics Unit (University of Liverpool and United Liverpool Hospitals) dealirfg with most aspects of medical electronics instrumentation in The United Liverpool Hospitals.

A successful applicant with suitable academic qualifications will be made an Honorary Research Assistant in the University and have the opportunity to undertake work leading to a higher degree.

Salary will be on the Whitley Council Scale for Medical Physicists (Basic Grade): £1278 (£1566 with 1st or 2nd class honours degree) rising to £2370 by annual increments.

Further information and application form obtainable from The Secretary, The United Liverpool Hospitals, 80 Rodney Street, Liverpool L1 9AP to be returned by 16th March, 1973.

ELECTRONIC SERVICE

Office Machine Company has the following vacancies:

1. Senior Service Engineer to assist Workshop Manager, must have experience of repairing digital printed circuit boards, preferably electronic calculators, good electronic knowledge and experience in a Service Department. Salary £2,000 plus and L.V.'s.
2. Workshop Service Engineers to repair calculator printed circuit boards. Good basic electronic knowledge required and experience in a Service Department. Salary £1,750 plus and L.V.'s.

Apply to:- **Mr. V. Knight,
Automatic Business Machines Ltd.,
Wyfold Road, Fulham, S.W.6.
Tel: 385 3311** [2394

BENCH SERVICE ENGINEERS

**Feltham — Ascot Road
Bedfont**

We require Bench Service Engineers with previous experience of TV (Monochrome and Colour), Radio, Hi-fi and Tape Recorders for our Central Service Division. Preference will be given to holders of City & Guilds qualifications, though sound practical experience may outweigh formal qualifications.

Earnings will be in the range £1,600–£2,200 depending on qualifications and experience. In addition there are L.Vs, a Staff Purchase Scheme and a Contributory Pension Plan. Hours are 9 a.m. – 5.30 p.m. Monday to Friday.

We would be interested to hear from experienced Engineers, who wish to work with products that are renowned for quality and reliability.

Write with details of past experience and current salary to:

Personnel Manager,

SONY (UK) LIMITED, Pyrene House, Sunbury-on-Thames, Middlesex.

SONY®

2424

Communications Associates Limited

have vacancies in our Internal Service Department and Test Department for qualified and experienced

ELECTRONIC TECHNICIANS

Please telephone Mr. Donaldson, Technical Manager, at Exeter 70333 for an appointment.

[2401

ALLOTROPE LIMITED — Audio Equipment Specialists

REPRESENTATIVE

Applicants should be fully conversant with studio mixing desks, microphones, and studio techniques.

Based London, W.1. Salary to match experience and qualifications.

Apply in writing to:

ALLOTROPE LIMITED, 90 WARDOUR STREET, LONDON, W1V 3LE. [2396

UNIVERSITY COLLEGE, GALWAY

ELECTRONICS SENIOR TECHNICIAN

required for Department of Physics. Duties include the construction and maintenance of electronic equipment and assisting in laboratories. Minimum qualification equivalent of Advanced City and Guilds Certificate and 3 years experience as a technician.

Salary: £1,737 to £2,013 with non-contributory pension scheme and 4 weeks holidays.

Written applications stating age, qualifications, experience and references should be sent to the Secretary, Department of Experimental Physics, University College, Galway, Ireland, before 15th March.

[2390

Multi-National Advertising Agency requires a

Technical Assistant or Assistant Engineer

to operate and maintain colour telecine and V.T.R. equipment.

Candidates should be between the ages of 22–30 and should have "C" and "G" Telecomms, or equivalent and preferably with experience on this type of equipment. Salary is negotiable.

JWT

Write to:
**Mr. R. Martin, J. Walter Thompson Co. Ltd.,
40 Berkeley Square,
London, W1X 6AD.
Telephone: 01-629 9496**

2395

SPANISH COMMUNICATIONS EQUIPMENT MANUFACTURER

Applications are invited from qualified design engineers specialized on:

a) Ground/Air Communications
b) TV Colour Transmitters
c) Side Band Transmitters

At least 5 years experience desirable. Company located in Madrid. Salary open.

Send resumé to:
NORTRON
Fernando el Católico, 63
Madrid 15
SPAIN

[2349

TECHNICAL TRAINING OFFICER
(COMMUNICATIONS)

The Company
We are an expanding company within the Pye of Cambridge Group and offer a wide range of products including public and private address systems, telephone equipment, time control, fire alarm and CCTV. Our field service engineers and technical salesmen are provided with an extensive support service which includes product training in a market of rapidly changing technology.

The Job
This is a new position to assist the Personnel and Training Department in the analysis of product training needs, and the development of means of meeting those needs including off the job instruction. The Training Officer will specialise in intercom and telephone systems.

The Man
Preferably with previous experience as a training officer or instructor
Will have an extensive knowledge of electronics
Preferably will have experience in the communications industry
Willing to spend time away from home
Age 28+

He will report to the Personnel Manager.

Please write giving brief details of your career and background to:
John Bell, Personnel Manager,
Pye Business Communications Limited,
Cromwell Road, Cambridge CB1 3HE.
Tel: Cambridge 45191 (Ext. 293/4).

Pye rely on people!

2434

South Africa
RADIO ENGINEERS

A well established British Company has an immediate requirement for SUPERVISORY staff in the Republic of South Africa, and invite applications from suitably qualified personnel with experience in the maintenance of short-wave broadcasting transmitters of up to 250 KW and associated equipment.

These appointments offer:
* Staff positions
* Attractive salaries
* Prospects of permanent employment in South Africa
* Free travel for families
* Settling in allowances
* Medical aid insurance scheme

Write giving brief details to Box Number WW 2436

PETERBOROUGH AND STAMFORD HOSPITAL MANAGEMENT COMMITTEE

Appointment of

X-RAY ENGINEER

To be based at Peterborough Hospital and become a member of a small team engaged upon the commissioning, maintenance and repair of a wide range of Diagnostic X-ray Apparatus.

Candidates should possess H.N.C. (Electronics) H.N.D. or equivalent but consideration will be given to suitable candidates with O.N.C. who are proceeding to a higher qualification.

Salary scale offered is:-

£1911 — £2508

Possession of a car is essential, travelling expenses being payable in accordance with the agreed scales for Health Services staffs.

Application forms and job description obtainable from the Group Engineer, Peterborough District Hospital, Thorpe Road, Peterborough, to be returned completed within fourteen days of the appearance of this advertisement.

[2387

TELEVISION

New, vigorous and successful television systems company very urgently requires dynamic sales and installation engineers. Successful applicants will join excellent team offering unlimited opportunities. Senior and middle grade men needed. Wide experience vital. Write or ring:

Technical Director,
TV EYE LTD.,
23 Victoria Street, Windsor, Berks.
Tel: Windsor 51966

[2427

MEN! £50 p.w. can be yours

Jobs galore! 144,000 new computer personnel needed by 1977. With our revolutionary, direct-from-America, course, you train as a Computer Operator **in only 4 weeks!**

Pay prospects? £2500 + p.a.
After training, our exclusive appointments bureau — one of the world's leaders of its kind — introduces you **FREE** to world-wide opportunities. Write or 'phone **TODAY**, without obligation.

London Computer Operators Training Centre
P15 Oxford House, 9-15, Oxford Street, W.1
Telephone: 01-734 2874
127, The Piazza, Dept. P15, Piccadilly Plaza, Manchester 1.
Telephone: 061-236 2935

2305

REPAIR/CALIBRATION ENGINEERS
£1850 to £2000

If you are an enthusiastic Electronics Test or Service Engineer in a rut come and talk to Jerry Cook about the wide range of Test Equipment you could help us repair and calibrate.

Contact:
J. D. COOK,
CALIBRATION SYSTEMS LTD.,
CAMBERLEY, SURREY.
Tel: Camberley 28121

[2435

APPOINTMENTS CONTINUED ON PAGE 99

★ ★ ARTICLES FOR SALE ★ ★

SITUATIONS WANTED

ENGINEER WITH WORKSHOP and delivery facilities seeks electronic asssembly or repair work, salary or contract. Suit small runs or modifications. Corbett, Ivy Cottage, Barham Green, Ipswich. [2319

ENGINEER that has developed a precision digital clock, that is interfacable with computers, desires either a sales agent, or a firm to manufacture and sell the unit under a licensing agreement. Write in English or German to Box No. WW 2419.

SITUATIONS VACANT

ASSISTANT Chief Electronics Engineer. Duties will include servicing all types of audio domestic appliances, plus sample spec. reports on imported Hi-Fi equipment, the use and familiarisation of test equipment. Experience on FM/MPX and tape recorder techniques is essential. Successful applicant will work in close liaison with the chief Service Engineer. Remuneration according to experience and qualifications. 3 weeks' holiday per year. Tel: 01-594 1473. Personnel Manager, Harris Overseas Ltd., Harvard House, 14 Thames Road, Barking, Essex. [2446

PERSONAL ASSISTANT with technical and commercial ability wanted for managing director of London TV rental business of the highest standing; established over 46 years. A suitable applicant would be trained to take increasing charge during the gradual retirement of the present managing director. Exceptional opportunity for keen and capable man. Write, stating age and details of background and career. Box No. WW 2416.

SMALL but rapidly expanding company requires Audio Electronics Designer to work on development of professional recording equipment for Motion Picture and TV Industry in a young and enthusiastic team. Salary by negotiation plus monthly profit sharing. Knowledge of studio and film industry techniques an advantage. Box No. WW 2391.

ESTABLISHMENT ENGINEER required by large university physics department to take charge of group responsible for electrical and mechanical services. Grad. I.E.E./C.E.I. Part 2 or equivalent plus wide-ranging experience and practical ability essential; age 30 to 40. Salary according to age on progressive scale rising to £3,825 p.a.; seven weeks' holiday p.a. plus public holidays; advantageous pension scheme. Possibility of one year tenancy of transit accommodation. Write for details and application form to Dr. A. J. Croft, Clarendon Laboratory, University of Oxford, Parks Road, Oxford. [2429

TECHNICIAN for Electronics Section concerned with medical educational television and audio tape recording. Starting salary up to £1,300 depending on qualifications and experience. Day release towards ONC can be arranged. Duties include operation and maintenance of equipment and tape duplicating. Further details wriee or phone J. Cooper, Audio Visual Communication Dept., British Medical Association, Tavistock Square, London WC1H 9JP. Tel: 01-387 4499. [2384

WANTED. Electronics Maintenance Engineer. To work with touring group. Interesting job. Qualifications or references required. Write Box No. WW 2430.

ARTICLES FOR SALE

AARVAK ELECTRONICS. 3-channel sound-light converters, £17. Strobes, £16. Rainbow Strobes, £132.—74 Bedford Avenue, Barnet, Herts. 01-808 9096. [23

★ ★ . COURSES ★ ★

LOUGHBOROUGH TECHNICAL COLLEGE
Principal: F. Lester, B.Sc., Ph.D., F.R.I.C.

Department of Electrical Engineering

Applications are invited for places in September 1973 on the following full-time course:-

DIPLOMA IN RADIO TELEVISION AND ELECTRONICS

Applicants for this three-year course should expect to gain 'O' level or good CSE grades in Mathematics and a Science subject and be keenly interested in electronics.
A large element of practical work and two periods of industrial placement are included. Students will also sit for Parts I and II of the City and Guilds Technicians Certificate in Radio, Television and Electronics.

Further details may be obtained from :
G. M. Allen, B.Sc.(Eng), D.L.C., C.Eng., M.I.E.E.
Head of Department of Electrical Engineering,
Loughborough Technical College,
Radmoor, Loughborough, Leicester, LE11 3BT
Tel: 5831
[2386

TRAIN FOR SUCCESS WITH ICS

Study at home for a progressive post in Radio, TV & Electronics. Expert tuition for C & G (Telecoms Techn's Cert and Radio Amateurs') RTEB, etc. Many non-exam courses including Colour TV Servicing, Numerical Control and Computers. Also self-build kit courses-valve and transistor.
Write for FREE prospectus and find out how ICS can help you in your career. ICS (Dept 734 E1), Intertext House, London SW8. [2296

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

become a RADIO-AMATEUR !

learn how to become a radio-amateur in contact with the whole world. We give skilled preparation for the G.P.O. licence

free! Brochure, without obligation to: .

BRITISH NATIONAL RADIO & ELECTRONICS SCHOOL P.O.BOX 156, JERSEY, CHANNEL ISLANDS

NAME : ______________________

ADDRESS : ______________________

WWB24

______________________ BLOCK CAPS please

APPOINTMENTS

AUDIO SYSTEMS DESIGNER

This progressive company, already leader in the design and installation of P.A. Systems for all aspects of the Leisure Industry, now requires an experienced, ambitious Audio Engineer to design and prepare P.A. System specifications and quotations for installations throughout the UK.

Situated in a rural area of Yorkshire, the company expects the successful applicant to be wholly familiar with current audio equipment, and developments within this field. Experience in reading and marking up of plans and drawings will also be an asset.

This is an exciting opportunity to command an attractive salary with all the usual fringe benefits including re-location allowance and high potential for advancement with a rapidly expanding organisation.

Apply in writing to:- The Personnel Manager,
Tunstall Byers & Co. Ltd.,
Moss Road Works, Askern,
Doncaster.
Tel. Doncaster 700531

Tunstall Byers Sound

A/D CONVERTOR. Input 999mV, output 999 TTL-compatible pulses, sampled 10 per second. Add + − 12V and 5V supply, display unit, for digital voltmeter etc. Uses stock IC's, plug in on 7 x 3in. card, £9. Write Box No. WW 2444.

ANAPR4Y RECEIVER. 40-1000 mHz fitted mains PP. & QD910 Solartron memory scope. Offers. Ring Byfield 60329. [2139

AVO's TRANSISTOR MEGGERS. Crank Meggers Continuity Tester at reasonable prices to clear P.O.A. Murphy U.H.F. low band R/T sets, 12V, Dash Mount 25/KCS complete less Xtals. Contact Worthing 205504. [2411

A1679 PULSE GENERATOR, TTL output, P.R.F. 10 mHz to 10 Hz. pulse width 50nS-50mS. Normal or compliment single shot, LED indicator. £18 inc. Batteries. Mains version £23. R. Palmer, 86 Willowfield, Harlow, Essex. [2415

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

D.E.A.C.s. New Surplus Stock. 9.6v 225 ma/H £3.00, 4.8v 225 ma/H £1.50. Mail Order Only. Horizon Systems, Park Hill, Ampthill, Beds. Phone Ampthill 2102. C.W.O. [2408

EMI WM16 oscilloscope DC-40 MHZ, two alternative plug-ins, manuals, £60. Creed 75 teleprinter 5-wire £25. Pye Cambridge AMIODV £30. Tel. Luton 25595. [2449

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

LENSES, prisms, mirrors, beamsplitters, telescopes, binoculars, microscopes. 3½p stamp brings you our 48 page lists. H. W. English, 469 Rayleigh Road, Hutton, Brentwood. Essex. [2147

METROPOLITAN VICKERS transformer. Serial No. T1074843. KVA 40. Volts (no load) 415/240. Amperes 55.6/96.2. Phases 3. Frequency 50. Apply with offer: Mrs. Pinckney, 45 Black Lion Lane, London, W.6. [2459

PRINTED Circuit Board in 6 widths: 2 in., 2½ in., 3 in., 3½ in., 4 in. and 5 in. x any length; 1/16 in. single-sided fibreglass, 2p per 3 sq. in. Double-sided 1p per sq. in. P & P 5p per order. SAE quotations for other sizes and quantity discounts.—J. Knopp, 11 Connaught Gardens, Braintree, Essex, CM7 6LY. Tel. Braintree 25254. [15

TF144G £12. CT 537 transistor & diode tester £35. No. 3 valve tester £25. Advance 15 to 30 volt 5 amp PSU £12.50. CT 82 Noise Generator £5. "The Bungalow", Triddles Farm, Plough Road, Smallfield, Surrey. Smallfield 2403. [2456

UHF TRANSISTORISED TUNERS 50p, VHF 40p. Untested. Radio Cabinets, unused, suitable ext. speaker cabinets, 50p. C. P. Trading, 15 Cavour Road, Sheerness, Kent. [2409

VACUUM is our speciality. New and second-hand rotary pumps, diffusion outfits, accessories, coaters, etc. Silicone rubber or varnish outgassing equipment from £40. V. N. Barrett (Sales) Ltd., 1 Mayo Road, Croydon. 01-684 9917. [29

VHF KIT 80-180 mHZ receiver, tuner, convertor. Transistorised, remarkable performance. £4 or s.a.e. for literature Johnssons (Radio), St. Martins Gate, Worcester. WR1 2DT. [13

VISIT auto traction, thousands of bargains in surplus radio equip., meters, motors, relays. TR/TX telephone equip., aircraft equip. S.A.E. enquiries 27A Arragon Road, Twickenham, Middx. 892 9489. [2340

VHF RADIO TELEPHONE EQUIPMENT. G.P.O. approved. Pye Cambridge Pye Vanguard. 12½ kc's. Working condition. High and low band £35 to £45. Export inquiries welcome. Spa-Radio, 337 High Street, Cheltenham, Glos. Phone 54303. [2376

60KHz MSF Rugby and 75 KHz Neuchatel Radio Receivers. Signal and Audio outputs. Small, compact units. Two available versions £35 and £60. Toolex. Bristol Road. Sherborne (3211), Dorset. [21

40,000 BULBS M.E.S. 4 volt 3 amp 11 m/m round £5 per 1,000 or offer for the lot. 5,000 S.B.C. 6 volt 36 watt double contact case lots of 216 £5 cge 75p or offer for the lot, quantities of 24 volt Headlight Lamps in stock. Wilkinson's, Longley Road, Croydon. 01-684 0236. [2420

ARTICLES WANTED

AVO 8 WANTED. Any condition. Any quantity. Send for packing INS. Huggett's Ltd., 2 Pawsons Road, W. Croydon, SY. [28

PLESSEY MK 4 etc. Painton & Pye Ether Connectors also clean Plessey cut offs. J.M.G. Electronics, 16A High Street, Crawley, Sussex. Crawley 37722. Smallfield 2403. [2457

WE PURCHASE

Electronic and Telephone Equipment and Components.

TOP PRICES PAID
for your redundant and surplus stock

T.W.C. LTD.
147 The Broadway, London, NW9 7EA
Telephone: 01-203 2814

[2402

PLUGS, SOCKETS, VALVES, Motors, Meters, Instruments, Semiconductors. Have Cash Will Travel Anywhere. S.E.S., 67 London Road, Croydon. 01-688 1512. [2313

RODENE stepper with reset required. Any voltage. Small or large quantities. Must be new. Write K.B. Automatics, 85 Kingsdale Gardens, Drighlington, Nr. Bradford, Yorkshire. Drig 2155. [2452

SURPLUS components and equipment wanted, especially resistors and capacitors. 01-777 2001. [2445

WANTED urgently Bleeper system preferably with aerial transmitter for minimum one mile radius operation, to handle up to 12 bleepers. Any make considered. Offers with full details to Ogden, Otley, Yorkshire LS21 1HX. Tel. 094 34 4531. [12

WANTED, all types of communications receivers and test equipment.—Details to R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [63

WANTED, televisions, tape recorders, radiograms, new valves, transistors, etc.—Stan Willetts, 37 High St., West Bromwich, Staffs. Tel. Wes. 0186. [73

WANTED Oscilloscope, 50MHz Bandwidth Double beam. D.C. amplifier, Sensitivity preferably 50mV Generator, 300-550MHz or to 1GHz. Phone details to: 572 0933. [2348

WIRELESS WORLD issues wanted July 1971 to June 1972 inclusive. J. R. Ault, 23 Newton Street, West Bromwich, B71 3RG. [2448

BOOKS

SHORT WAVE MAGAZINE, now in its 36th year and published monthly, covers the whole field of Radio Amateur transmission and reception including regular news features (DX, VHF, Clubs and SWL) and the design, construction and operation of AMATEUR Radio equipment of every type. Cover price 25p at newsagents. Specimen copy 30p post free, first class. Annual subscription £3.00 (or £2.75 second class posting) year of 12 issues.—Circulation Dept. (W) Short Wave Magazine Ltd., 55 Victoria Street, London SW1H 0HF. (Tel: 01-222 5341/2). [2385

WORLD RADIO TV HANDBOOK 1973, published December. £2.80, Post (first class) 10p. Order from David McGarva. Box 114F. Edinburgh EH1 1HP. [27

ESSENTIAL BOOKS

HOW TO MAKE WALKIE TALKIES FOR LICENSED OPERATION. Only 40p including postage.
GOVERNMENT SURPLUS WIRELESS EQUIPMENT HANDBOOK. Contains circuits, data, illustrations for British/USA receivers, transmitters, trans/receivers. With modifications to sets and test equipment. Latest impression £3·25 including postage.
PROBLEMS IN ELECTRONICS WITH SOLUTIONS. A must for the student, technician, engineer. 349 problems and how the answers are arrived at. Includes every type of problem likely to be found in electronics, including semi-conductors, amplifiers, aerials, filters, CRTs, computors, power supplies etc. 307 pages. Only 90p, postage 10p.
COSMIC RADIO WAVES. Start a new hobby—Radio Astronomy. This big book of 444 pages is an ideal handbook for the beginner and established enthusiast. Numerous photographs, illustrations and circuits. Published by Oxford University Press. £2·50. P. & P. 25p.
HANDBOOK OF SATELLITES AND SPACE VEHICLES. A comprehensive working handbook that provides access to the subject areas and problems important in system preliminary design. Extensive graphical and tabular data enables space scientists, technicians and engineers to acquire a greater working knowledge. An imposing book. 457 pages. £6·50, post free.

Available from: please
GERALD MYERS (WW)
Bookseller & Publisher
18 Shaftesbury Street, Leeds LS12 3BT
Extra postage for abroad. [86

BUSINESS OPPORTUNITIES

UNIQUE OPPORTUNITY to start own business exists in Highlands of Scotland, popular tourist spot, good train services to Glasgow and London. (1) ELECTRICAL and DOMESTIC REPAIRS. Constant demand. (2) COTTAGE MANUFACTURE of small electronic gadgets for sale by post. Cottage, all mod cons, for suitable applicant from end of August. Own car or van and some capital preferred; local and national backing for right men and women. Originality and ability to work unsupervised essential. For information write in confidence to Box No. WW 2381.

NATIONALLY known company in the field of Public Address require commissioning engineers for large and small installations, particularly suited to someone who likes to work very free-lance. Please write Box No. WW 2412.

CAPACITY AVAILABLE

AIRTRONICS LTD., for Coil Winding—large or small production runs. Also PC Boards Assemplies. Suppliers to P.O., M.O.D., etc. Export enquiries welcomed, 3a Walerand Road, London, SE13 7PE. Tel. 01-852 1706. [61

BATCH Production Wiring and Assembly to sample or drawings. Deane Electricals, 19B Station Parade, Ealing Common, London, W.5. Tel: 01-992 8976. [20

CAPACITY available to the Electronic Industry. Precision turned parts, engraving, milling and grinding both in metals and plastics. Limited capacity available on Mathey SP33 JIG BORER. Write for lists of full plant capacity to C.B. Industrial Engineering Ltd., 1 Mackintosh Lane, E.9 6AB. Tel. 01-985 7057. [14

DESIGN, development, repair, test and small production of electronic equipment. Specialist in production of printed circuit assemblies. YOUNG ELECTRONICS, 54 Lawford Road, London, N.W.5. 01-267 0201.

FOR ELECTRONIC assembly, wiring and complete inspection and testing facilities: Please contact Multiform Electronics Ltd., Teddington, Middx. TW11 9NN. Tel 01-977 9389 [2403

PRECISION injection moulding electronic industry short run specialists. Contact Jack Balzano Senior, C.B. Industrial Plastics Limited, 1 Mackintosh Lane, E9 6AB. Ring 01-985 7057. [18

PRINTED CIRCUITS, quick service, competitive prices, roller tinning, drilling etc. Short runs welcomed. Jamieson's, 1-5 Westgate, Bridlington, E. Yorks. Tel: (0262) 4738/77877. [2450

EDUCATION

CIE, AMSE, City & Guilds, etc. Thousands of exam successes. Postal courses in all branches of Engineering. Prospectus FREE. State subject of interest: BIET (Dept. ZL BWW 14), Aldermaston Court, Reading RG7 4PF. Accredited by CACC. [19

SCHOLARSHIPS
AWARDED BY THE
INSTITUTION OF ELECTRICAL ENGINEERS

The Council of the Institution of Electrical Engineers will consider for award this year Undergraduate and Postgraduate Scholarships with a maximum value of £600 per annum.
The closing rate for the receipt of applications is 1st May 1973 and late applications cannot be considered.
Full particulars of the conditions governing the award of these Scholarships may be obtined from:—
The Education and Training Officer at the Institution of Electrical Engineers, Savoy Place, London, WC2R 0BL.

[2431

NEW GRAM AND SOUND EQUIPMENT

GLASGOW.—Recorders bought, sold, exchanged; cameras, etc., exchanged for recorders or vice-versa.—Victor Morris, 343 Argyle St., Glasgow, C.2. [11

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

HRO Rx5s, etc., AR88, CR100, BRT400, G209, S640, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [65

SERVICE & REPAIRS

INSTRUMENT SERVICING—Multimeters (Avo, Taylor S.E.I.), Meggers etc. Quick and competitive guaranteed repairs. V. W. & E. Smith, 34 Hurst Mill Lane, GLAZEBURY, Warrington. Phone Leigh 6674. [19

SCRATCHED TUBES. Our experienced polishing service can make your colour or monochrome tubes as new again for only £2·75, plus carriage 50p. With absolute confidence sent to Retube Ltd., North Somercote, Louth, Lincs, or 'phone 0507-85 300. [30

SERVICE Sheets (1925-1971) for TV's, Radios, Transistors, Tape Recorders, Record Players, etc.; over 8,000 models available. S.A.E. enquiries: Hamilton Radio, 47 Bohemia Road, St. Leonards, Sussex. Tel: Hastings 29066. [17

SIGNAL generators, oscilloscopes, output meters, wave voltmeters, frequency meters, multi-range meters, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [64

TAPE RECORDING ETC.

IF quality, durability matter, consult Britain's oldest transfer service. Quality records from your suitable tapes. (Excellent tax-free fund raisers for schools.) Modern studio facilities with Steinway Grand.—Sound News, 18 Blenheim Road, London, W.4. 01-995 1661. [1954

YOUR TAPES TO DISC—Mono/Stereo. From £1.50. 4 Day Service—Vinyl Pressings. S.A.E. leaflet. Deroy Studios, High Bank, Hawk Street, Carnforth. Lancs. 2273. [70

TEST EQUIPMENT

NORDMENDE sine, square, wave generator SRQ 389 3HZ to MHZ brand new £85. List price £171. Nordmende distortion meter KM 394 brand new £85. List price £170. Nordmende asymetrical attenuator Box ELU 381. 0 to 900 MHZ brand new £60. List £72. Telequipment double beam oscilloscope model D53A DC to 15 MHZ. S/Hand as new perfect £200. Advance L.F. signal generator model 81A, 15HZ to 200 KHZ S/Hand as new perfect £45. Miracle Radio. Station Approach, Grays, Essex. Grays Thurrock 72066. [2454

TUITION

RADIO and Radar M.P.T. and C.G.L.I. Courses. Write: Principal, Nautical College, Fleetwood, FY7 8JZ. [72

VALVES WANTED

WE buy new valves, transistors and clean new components, large or small quantities, all details, quotation by return.—Walton's, 55 Worcester St., Wolverhampton. [62

CUT IT OUT...

Do you read Electrical Review over someone's shoulder ? Or hope to borrow a copy sometime ? Or depend on the office copy being passed on to you ? If you have any of these bad habits our serious advice is to cut it out – for your own good.

Comprehensive news coverage of projects, people and products . . . the latest in research and development . . . business trends, business opportunities . . . recruitment – you need to know about all these things – and refer to them.

And each month there is a special survey in which experts provide in-depth analysis of an important area of electricity supply and electrical equipment. Here are two examples of our surveys: Fire Protection and Alarm Systems — February 16; Industrial Control and Instrumentation – March 16.

Electrical Review isn't cheap but it's very good value for money indeed. Make sure you never miss a vital issue...

...BY CUTTING THIS OUT.

. . . sending it to us – and joining the club of the well-informed. I enclose £10.75 for a year's subscription (51 issues) of Electrical Review. Please send it to me at the address below.

NAME ....

ADDRESS ....

....

electrical review

To: IPC Electrical-Electronic Press Ltd. Electrical Review Room 28, Dorset House, Stamford Street, London SE1 9LU

WW

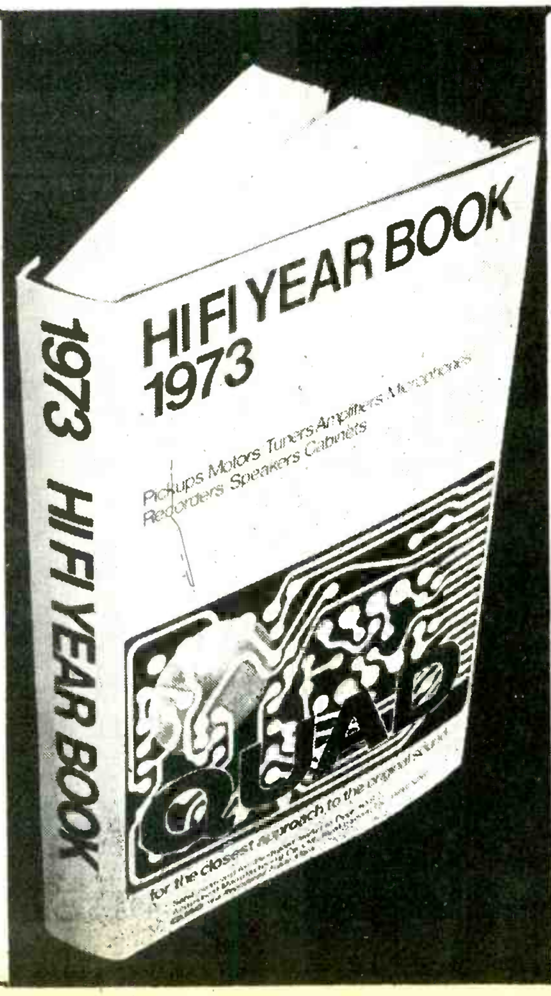
Company registered in England, registered number 677128, registered office — Dorset House, Stamford Street, London, SE1 9LU.

This book will make you a lot of money

. . . because it's the most comprehensive guide to the hi-fi scene going. And we're telling enthusiasts about it with big advertisements in the top audio and music journals. Which means there will be big demand. So order and display big, like you're in the book business. You won't regret it – but hang on to your personal copy!

HI-FI YEAR BOOK 1973

1-5 copies: £1.50 each plus 25p postage and packing
6+copies: £1.00 each post free.



Company Registered in England.
Registered number 522305.
Registered Office:
161/166 Fleet Street,
London, EC4P 4AA.

ORDER FORM

To: Cashiers, IPC Business Press (Sales & Distribution) Ltd., P.O. Box 147, 40 Bowling Green Lane, London EC1P 1DB.

Please send me ...... Copy(ies) of Hi-Fi Year Book 1973

I enclose remittance value £ ......

NAME (please print) ......

ADDRESS ......

Foundations of Wireless and Electronics

M. G. Scroggie BSc CEng FIEE

1970 Reprinting 1973 552 pages, illustrated

Cased 0 592 05961 8 £3.00

Limp 0 592 00041 9 £1.80

"To the uninitiated all we have to say is that if you are seeking a thorough grounding in radio theory with a minimum use of mathematics in a style which is easy to assimilate, then this is a sound investment. It should be at the elbow of every aspiring technician."

Electrical and Electronic Trader

8th Edition

Available from leading booksellers or:

The Butterworth Group

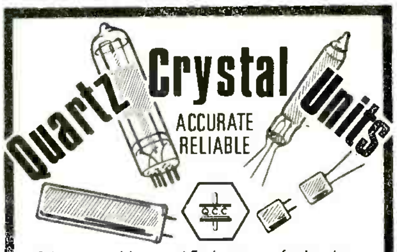
88 Kingsway, London WC2B 6AB

Showrooms and trade counter:

4-5 Bell Yard, London WC2

Bg

Quartz Crystal Units



ACCURATE RELIABLE

QCC

Private enquiries, send 5p in stamps for brochure

THE QUARTZ CRYSTAL CO. LTD.

Q.C.C. WORKS, WELLINGTON CRESCENT, NEW MALDEN, SURREY. 01-942-0334 & 2988

SYNTHESISER?

Build your own, using

Dewtron* PROFESSIONAL MODULES

(*Regd. Trademark)

VOLTAGE CONTROL amplifiers, oscillators, filters, and P-H-A-S-E.

MAN-SIZED PATCHBOARD, no cables

CASH SAVINGS by buying sets of modules, components, and keyboard.

ALL MODULES available separately.

Send S.A.E. for details or 15p for full musical catalogue.

D.E.W. Ltd., 254 Ringwood Rd., Ferndown, Dorset

Thanks to a bulk purchase we can offer

BRAND NEW P.V.C. POLYESTER AND MYLAR RECORDING TAPES

Manufactured by the world-famous reputable British tape firm, our tapes are boxed in polythene and have fitted leaders, etc. Their quality is as good as any other on the market, in no way are the tapes faulty and are not to be confused with imported, used or sub-standard tapes. 24-hour despatch service.
Should goods not meet with full approval, purchase price and postage will be refunded.

S.P.	3in.	160ft.	**10p**	5in.	600ft.	**30p**
	5¾in.	900ft.	**40p**	7in.	1,200ft.	**45p**
L.P.	3in.	225ft.	**12½p**	5in.	500ft.	**42½p**
	5¾in.	1,200ft.	**50p**	7in.	1,800ft.	**65p**
D.P.	3in.	350ft.	**22½p**	5in.	1,200ft.	**60p**
	5¾in.	1,800ft.	**80p**	7in.	2,400ft.	**£1·00**

Postage on all orders 7½p

COMPACT TAPE CASSETTES AT HALF PRICE

60, 90, and 120 minutes playing time, in original plastic library boxes.
MC 60 **45p** each. MC90 **62½p** each. MC 120 **92p** each

STARMAN TAPES

28 LINKSCROFT AVENUE, ASHFORD, MIDDX. Ashford 52136

WW—104 FOR FURTHER DETAILS

THE ONLY COMPREHENSIVE RANGE OF RECORD MAINTENANCE EQUIPMENT IN THE WORLD!

Send P.O. 15p for 48 page booklet providing all necessary information on Record Care.

CECIL E. WATTS LIMITED

Darby House
Sunbury-on-Thames, Middx.

THE TEXAN

HI QUALITY AMPLIFIER BY TEXAS

Booklet & Parts List 35p Post Incl.

FULL KIT OF PARTS	**£28.50**
or READY MADE	**£38.50**
PACK 1. RESISTORS	80p
PACK 2. SMALL CAPS	£1.50
PACK 3. LARGE CAPS	£1.40
PACK 4. SUNDRIES	£1.90
PACK 5. SWITCHES	90p
PACK 6. CONTROLS	£1.45
PACK 7. SEMI COND.	£8.25
PACK 8. TRANSFORMER	£4.95
PACK 9. P.C. BOARD	£2.50
PACK 10. CHASSIS, ETC.	£4.20
PACK 11. CABLES & LEADS	40p
PACK 12. TEAK CABINET	£2.75

Mail Order Charge 15p except where indicated

NOW ON DEMONSTRATION AT

TELERADIO HI FI

325/7, FORE ST., EDMONTON, LONDON, N.9. OPE. 01-807 3719

TRANSFORMER LAMINATIONS enormous range in Radiometal, Mumetal and H.C.R., also **"C" & "E" cores.** Case and Frame assemblies.

MULTICORE CABLE IN STOCK CONNECTING WIRES

Large quantities of miniature potentiometers (trim pots) 20 ohm to 25K. Various makes. Wholesale and Export only.

J. Black

OFFICE: 44 GREEN LANE, HENDON, NW4 2AH
Tel: 01-203 1855. 01-203 3033
STORE: LESWIN ROAD, N.16
Tel: 01-249 2260

SPECIALISED KITS

HIGH STANDARD LOW FREQUENCY SOURCE

(to article by J. M. Osborne, W.W. Jan. 73)

A Phase-Locked Loop designer approved kit to professional standards with Glass-Fibre P.C. Board, and all components including Hardware, case, etc. Full constructional details from the designer are included. Reference accurate to 2 parts in 10⁷! Probably the most economic high precision signal source available. Kit **£22·65.**
Extra for built and tested only **£6·55.**

FOR FM STEREO ENTHUSIASTS

The best decoder we know—The Motorola Phase-Locked Loop. No coils to align—just one pot to set and no instruments needed. Complete Kit **£3·40.** Built & Tested **£5·40.**
Version with PSU facilities on plug-in cord for positive rail of 12V or more (specify). Kit **£5·20.** Built & Tested **£7·30.**
Version with integral power supply for 240V A.C. input. Kit **£7·50.** Built & Tested **£9·70.**

Please note

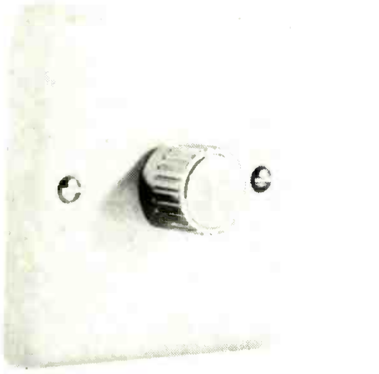
We are prepared to consider offering kits for any published article—send details for quotation. Our service is unique! ALL communications are acknowledged by return!
Send for our lists including clearance corner, enclose large S.A.E. please.
We welcome enquires and Trade supplied.
Order now for early delivery.

STUDIO ELECTRONICS

7 Coppice Hatch, Harlow, Essex
Tel. Harlow 25457

REGRET CALLERS **STRICTLY** BY PRIOR APPOINTMENT AT PRESENT.

Vary the strength of your lighting with a DIMMASWITCH



The DIMMASWITCH is an attractive and efficient dimmer unit which fits in place of the normal light switch and is connected up in exactly the same way. The white mounting plate of the DIMMASWITCH matches modern electric fittings. Two models are available, with the bright chrome knob controlling up to 300w or 600w of all lights except fluorescents at mains voltages from 200-250V, 50Hz. The DIMMASWITCH has built-in radio interference suppression.

Price: 600w—**£3.20.** Kit form—**£2.70.**
300w—**£2.70.** Kit form—**£2.20.**
All plus 10p post and packing.
Please send C.W.O. to:—

DEXTER AND COMPANY
4, ULVER HOUSE, 19 KING STREET, CHESTER CH1 2AH TEL: 0244-25883

As supplied to H.M. Government Departments, Hospitals, Local Authorities, etc.

WW—106 FOR FURTHER DETAILS

TRANSFORMERS

DOUGLAS GUARANTEED

12 or 24 Volts

Output V. & Amps.		Ref. No.	Price	P. & P.
12V x 2	250 mA x 2	MT111 CS*†	£0·91	9p
12V x 2	500 mA x 2	MT213 CT*†	£0·97	16p
12V x 2	1A x 2	MT 71 AT‡	£1·48	24p
12V x 2	2A x 2	MT 18 AT	£2·06	30p
12V x 2	3A x 2	MT 70 AT	£2·59	32p
12V x 2	4A x 2	MT 108 AT	£2·92	34p
12V x 2	5A x 2	MT 72 AT	£3·33	42p

30 volts. All tapped at 0-12-15-20-24-30 V.

Output Amps	Ref. No.	Price £	P.P.	Output Amps.	Ref. No.	Price £	P.P.
500 mA	MT 112 CT‡	1·12	16p	4A	MT 21 AT	3·10	40p
1A	MT 79 AT‡	1·55	29p	5A	MT 51 AT	4·31	42p
2A	MT 3 AT	2·23	30p	8A	MT 88 AT	6·32	50p
3A	MT 20 AT	2·64	32p	10A	MT 89 AT	7·19	50p

50 volts. All tapped at 0-19-25-33-40-50 V.

500 mA	MT 102 AT‡	1·45	24p	3A	MT 105 AT	3·91	41p
1A	MT 103 AT	2·00	32p	4A	MT 106 AT	5·06	41p
2A	MT 104 AT	3·10	32p	6A	MT 107 AT	7·47	50p

60 Volts. All tapped at 0-24-30-40-48-60 V.

500 mA	MT 124 AT‡	1·46	30p	2A	MT 127 AT	3·16	41p
1A	MT 126 AT	2·24	32p	3A	MT 125 AT	4·59	41p

AUTO-WOUND RANGE

Power output	Winding tapped at	Ref. No.	Price	P. & P.
20 VA	0-115-210-240	MT 113 CT	£0·89	16p
75 VA	,, ,,	MT 64 AT	£1·72	30p
150 VA	0-115-200-220-240	MT 4 AT	£2·15	32p
200 VA	,, ,,	MT 65 AT	£3·00	32p
300 VA	,, ,,	MT 66 AT	£4·00	32p
500 VA	,, ,,	MT 67 AT	£6·04	49p

SAFETY ISOLATORS. 105/120 V. or 200/240 V. In 105/120 CT or 200/240 CT Out.

VA	Ref. No	Price £	P.P.	VA	Ref. No.	Price £	P.P.
60	MT 149 AT*	2·24	32p	250	MT 152 AT*	6·21	52p
100	MT 150 AT*	2·73	32p	350	MT 153 AT*	8·17	62p
200	MT 151 AT*	5·02	42p	500	MT 154 AT*	12·00	72p

400 V. Output at 50 HZ. Ref. IT3 AT	Price	P. & P.
C-D Ignition system by R. M. Marston Esq.	£2·30	29p

EQUIPMENT RANGE

Sec. Output (r.m.s.)		Ref. No.	Price	P. & P.
3-0-3 V.	200 mA	MT 238 CS*†	£0·89	8p
9-0-9 V.	100 mA	MT 13 CS*†	£0·91	8p
12-0-12	50 mA	MT 239 CS*†	£0·91	8p
20-0-20	30 mA	MT 241 CS*†	£0·91	8p
0-20 x 2	300 x 2	MT 214 CT*‡	£1·21	16p
0-8-9 x 2	500 mA x 2	MT 207 CT*‡	£1·46	19p
0-15-20 x 2	500 mA x 2	MT 205 AT*‡	£2·12	29p
0-15-27 x 2	500 mA x 2	MT 203 AT*	£2·45	29p
0-15-27 x 2	1A x 2	MT 204 AT*	£3·42	30p
20-12-0-12-20	700 mA (d.c.)	MT 221 AT*	£1·11	26p

AT indicates open universal fixing with tags; **CT** is open U-clamp fixing with tags; **CS** is open U-clamp fixing with P.C. spills; * with interwinding screen; † untapped 240V Primary; ‡ Primary tapped at 210-240V; other Primaries tapped at 200-220-240V.

Over 200 types in stock through agents or direct. Send for list.
DOUGLAS ELECTRONICS INDUSTRIES LTD., (Dept. NO. 23,) Thames Street, LOUTH, Lincs. LN11-7AD

LOUDSPEAKER BARGAINS

Fane Pop 100 watt 18″ 8/15 ohms	£19·50
Fane Pop 60 watt 15″ 8/15 ohms	£11·15
Fane Pop 50 watt 12″ 8/15 ohms	£9·25
Fane Pop 25/2 12″ 25 watt 8/15 ohms	£5·40
Fane Pop 15 12″ 10 watt 8/15 ohms	£4·00
Baker Group 25 12″ 3, 8 or 15 ohms	£6·60
Baker Group 35 12″ 3, 8 or 15 ohms	£8·00
Celestion PS8 for Unilex	£2·35
EMI 13 x 8, 3, 8 or 15 ohms	£2·25
EMI 13 x 8, 3, 8 or 15 ohms	£2·60
EMI 13 x 8 twin tweeter 3, 8 or 15 ohms	£3·60
EMI 13 x 8 type 350 15 watt 8 ohms	£8·00
Richard Allan 8″ 3, 8 or 15 ohms	£2·35
Richard Allan 12″ dual cone 3 or 15 ohms	£2·50
Fane 8″ d/cone 808T 8 or 15 ohms	£2·85
Fane 8″ d/cone, roll surround, 807T 8 or 15 ohms	£3·50
Elac 9 x 5, 59RM109 15 ohms	£2·70
Elac 9 x 5, 59RM114 8 ohms	£2·70
Elac 6½″ d/cone 8 ohms	£2·25
Elac 6½″ d/cone, roll surround 8 ohms	£3·50
Elac 4″ tweeter 8 ohms	£1·50
Crossover for above (P & P Free)	£1·50
Goodmans 8P 8 or 15 ohms	£4·75
Goodmans 10P 8 or 15 ohms	£5·25
Goodmans 12P 8 or 15 ohms	£10·50
Goodmans 15P 8 or 15 ohms	£17·00
Goodmans 18P 8 or 15 ohms	£27·00
2″, 2½″ or 3″ 80 ohms	£0·65
Philips 5″ 8 ohms	£1·95
7 x 4 or 8″ x 5″, 3 or 8 ohms	£1·50
10″ x 6″ 3, 8 or 15 ohms	£2·00

FREE WITH ORDERS OVER £6—"HiFi LOUDSPEAKER ENCLOSURES" BOOK

All units guaranteed new and perfect

Prompt despatch, P & P 25p per speaker

Send for our free booklet "Choosing a speaker"

WILMSLOW AUDIO
(Dept. WW)
10 Swan Street, Wilmslow, SK9 1HF Cheshire

CLASSIFIED ADVERTISEMENTS

Use this Form for your Sales and Wants

To "Wireless World" Classified Advertisement Dept., Dorset House, Stamford Street, London, S.E.1

PLEASE INSERT THE ADVERTISEMENT INDICATED ON FORM BELOW

- **Rate: 50p (10/-) PER LINE. Average seven words per line. Minimum two lines.**
- **Name and address to be included in charge if used in advertisement.**
- **Box No. Allow two words plus 25p (5/-).**
- **Cheques etc., payable to "Wireless World" and crossed "& Co."**
- **Press Day March 8, 1973 for April, 1973 issue.**

NAME..

ADDRESS..

....

....

			REMITTANCE VALUE..................		**ENCLOSED**

Please write in block letters with ball pen or pencil. **CLASSIFICATION**.................. **NUMBER OF INSERTIONS**..........

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 90-100

A1 Factors ... 105
Acoustical Mfg. Co. Ltd. ... 10
Adeola Products Ltd. ... 30
Aerialite Aerials Ltd. ... 28
A.K.G. Equipment Ltd. ... 46
Amtron U.K. ... 16, 17
Ancom Ltd. ... 34
Anders Electronics Ltd. ... 26, 41
Anextra Ltd. ... 106
Audix B. B. Ltd. ... 14
Aveley Electric Ltd. ... 24
Avo Ltd. ... 30

Barrie Electronics ... 69
B. & W. Electronics ... 6
Bentley Acoustic ... 68
Bentley, K. J., & Partners Ltd. ... 105
B.I.E.T. ... 43
Bi-Pak Semiconductors ... 60, 61
Bi-Pre Pak Ltd. ... 67
Black, J. ... 104
Bradley, G. & E. Ltd. ... Cover iii
Brown, S. G., Comm. Ltd. ... 40
Bulgin, A. F. & Co. Ltd. ... 32
Bull, J. (Electrical) Ltd. ... 86
Butterworth & Co. (Pub.) Ltd. ... 105

Cambion Electronics ... 39
Cavern Electronics ... 74
Chiltmead Ltd. ... 75, 78, 106, 108
Colomor (Electronics) Ltd. ... 87
Consumer Microcircuits Ltd. ... *Readers Card*, 37
Crichton, John ... 84
Cryslon Electronics Ltd. ... 20
C.T. Electronics Ltd. ... 88
C.T.H. Electronics Ltd. ... 36

Deimos Ltd. ... 106
Dewtron ... 104
Dexter & Co. ... 107
Dixons Technical CCTV Ltd. ... 43
Douglas Electronic Industries Ltd. ... 107
Dymar Electronics Ltd. ... 2
Diamond H. Controls Ltd. ... 15

Eddystone Radio Ltd. ... 32
Electrolube ... 45
Electronic Brokers ... 72, 79, 106
Electronic Hobbies ... 84
Electroplan ... 83
Electrosil Ltd. ... 53
Electrovalue ... 85
English Electric Valve Co. Ltd. ... 51
Enthoven Solders ... 22
ESI Nuclear ... 58

Farnell Instruments Ltd. ... 35
Ferranti Ltd. ... 28
Fi-Comp Electronics ... 36
Fieldtech ... 15
Foulsham-TAB Ltd. ... 103
Future Film Developments ... 74

Gardners Transformers Ltd. ... 4
Goldring Mfg. Co. Ltd. ... 26
Goodmans Loudspeakers Ltd. ... 39
Grampian Reproducers Ltd. ... 106

Harris Electronics (London) Ltd. ... 45
Harris, P. ... 105
Hart Electronics ... 43
Hatfield Instruments Ltd. ... 45
Heath (Gloucester) Ltd. ... 11
Henrys Radio Ltd. ... 80
Henson, R., Ltd. ... 105

I.C.S. Ltd. ... 59
I.M.O. Precision Controls Ltd. ... 33
Industrial Exhibitions Ltd. ... 29
Industrial Sub-Assemblies Ltd. (I.S.A.) ... 106
Integrex Ltd. ... 68

J.E.F. Electronics ... 106
Jermyn Industries ... 40

Keytronics ... 106

Lasky's Radio Ltd. ... 84
Ledon Instruments Ltd. ... 45
Lennard Developments Ltd. ... 83
Levell Electronics Ltd. ... 1
Light Soldering Developments Ltd. ... 47
Limrose Electronics Ltd. ... 27
Linstead Electronics ... 27

Macfarlane, W. & B. ... 74
Macinnes Laboratories Ltd. ... 42
MacKarl Electronics (London) Ltd. ... 38
Marconi Instruments Ltd. ... Cover ii
Marriot Magnetics Ltd. ... 13
Marshall, A., & Sons (London) Ltd. ... 71
McKnight Crystal Co. ... 106
McLennan Eng. Ltd. ... 31
Millbank Electronics ... 19
Mills, W. ... 76
Milward, G. F. ... 66
Modern Book Co. ... 106
M.O. Valves ... 3, 5, 26, 44
Multicore Solders Ltd. ... Cover iv
Myall, W. H. ... 45

Nombrex Ltd. ... 28

Pattrick & Kinnie ... 70
Powertran Electronics ... 81
Practical Wireless ... 44

Quality Electronics Ltd. ... 36
Quartz Crystal Co. Ltd. ... 104

Racal Communications Ltd. ... 18
Rank Audio Products ... 50
Rola Celestion Ltd. ... 40
R.S.C. Hi-Fi Centre Ltd. ... 69
R.S.T. Valves Ltd. ... 73

Samsons (Electronics) Ltd. ... 83
S.D.S.A. ... 31
S.E. Laboratories (Eng.) Ltd. ... 8, 9
Service Trading Co. ... 82
Servo & Electronic Sales Ltd. ... 70
Shibaden (U.K.) Ltd. ... 20
Shure Electronics Ltd. ... 55
Sinclair A.R. ... 106
Sinclair Radionics Ltd. ... 54, 56, 57
S.M.E. Ltd. ... 23
Smith, G. W. (Radio) Ltd. ... 62, 63, 64, 65
S.N.S. Communications Ltd. ... 25
Sound 73 International ... 103
Sowter, E. A. ... 106
Special Product Distributors Ltd. ... 42
Starman Tapes ... 104
Strumech Eng. Ltd. ... 59
Studio Electronics ... 104
Sugden, J. E., Ltd. ... 36

Taylor Electrical Instruments Ltd. ... 42
Telcon Metals Ltd. ... 24
Teleprinter Equipment Ltd. ... 77
Telequipment Products (Tektronix U.K.) Ltd. ... 48, 52
Teleradio, The, Co. (Edmonton) Ltd. ... 104
Teonex Ltd. ... 7
Toyo Communication Equipment ... 58
Trannies ... 44

Valradio Ltd. ... 58
Vitavox Ltd. ... 73
Vortexion Ltd. ... 12

Watts, Cecil E. Ltd. ... 104
Wayne Kerr, The, Co. Ltd. ... 21
West Hyde Developments Ltd. ... 74
West London Direct Supplies ... 73
Weyrad (Electronics) Ltd. ... 72
Whiteley Electrical Radio Co. Ltd. ... 22
Wilkinson, L. (Croydon) Ltd. ... 83
Wilmslow Audio ... 107

Z. & I. Aero Services Ltd. ... 27, 34, 89

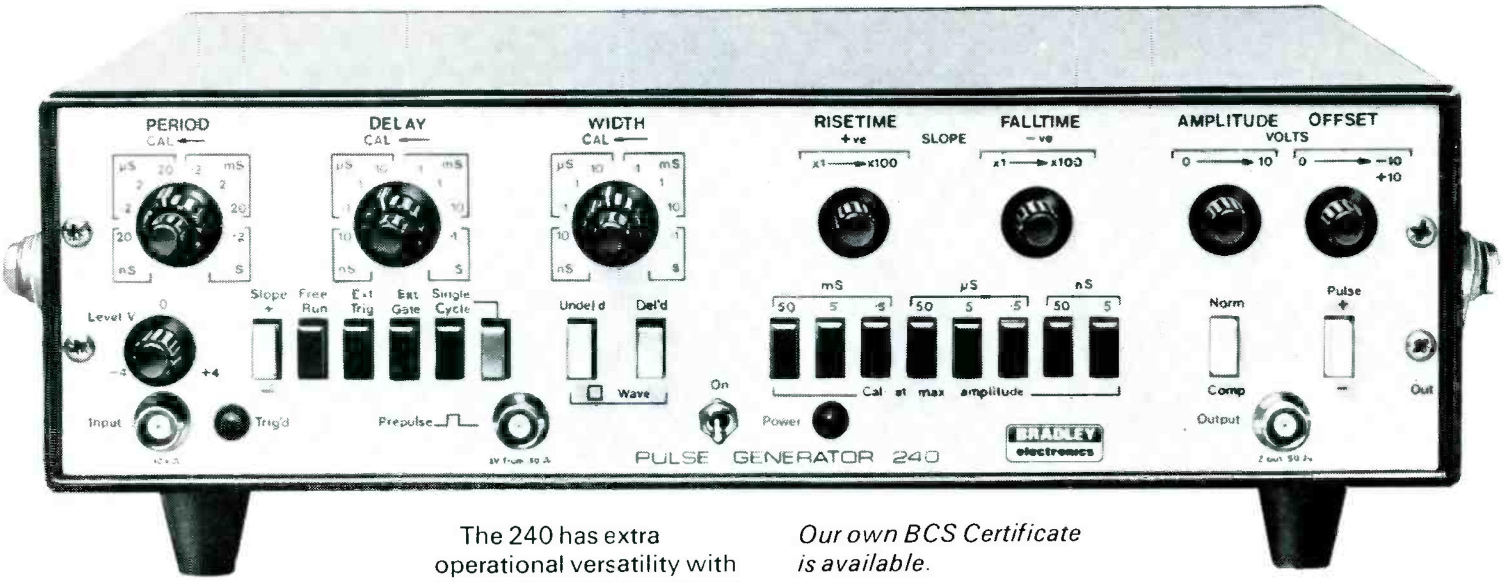
Printed in Great Britain by Southwark Offset, 25 Lavington Street, London, S.E.1, and Published by the Proprietors, I.P.C. Electrical-Electronic Press Ltd., Dorset House, Stamford St., London, SE1 9LU telephone 01-261 8000. *Wireless World* can be obtained abroad from the following: Australia and New Zealand: Gordon & Gotch Ltd. India: A. H. Wheeler & Co. Canada: The Wm. Dawson Subscription Service, Ltd.: Gordon & Gotch Ltd. South Africa: Central News Agency Ltd.: William Dawson & Sons (S.A.) Ltd. United States: Eastern News Co., 306 West 11th Street, New York 14. CONDITIONS OF SALE AND SUPPLY. This periodical is sold subject to the following conditions namely that it shall not without the written consent of the publishers first given be lent re-sold, hired out or otherwise disposed of by way of Trade at a price in excess of the recommended maximum price shown on the cover, and that it shall not be lent, re-sold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

0.5 Hz–50 MHz WITH VARIABLE RISE & FALL

Latest addition to the Bradley family of pulse generators, the Model 240 is a versatile, value-for-money pulse generator with output rise and fall times that can be varied between 5ns and 5s in any ratio up to 100 : 1.

High performance features include eight PRF ranges covering from 0.5Hz to 50MHz with pulse delays and widths from 10ns to 1s. Pulse amplitude can be varied from 0.5V to 10V while the baseline can be offset up to ±10V.

The Bradley 240 can be used to drive resistive or reactive loads of any magnitude. The internal 50 Ω source impedance may be switched out to provide ±10V into a 50 Ω load.



The 240 has extra operational versatility with six output modes including double pulse and square wave.

For external trigger there's an adjustable level control and slope selector which allows triggering off any point on the input waveform. This operates down to zero frequency in all modes with a trigger light to show correct operation.

There are many other high-performance features on the new Bradley 240, which costs just £230 in the UK. To find out about these, please telephone Ashley Stokes on 01-450 7811, extension 113. Or write to him at the address below.

Our own BCS Certificate is available.

G & E BRADLEY LIMITED,
Electral House, Neasden Lane,
London, NW10 1RR
Telephone: 01-450 7811
Telex: 25583

A Lucas Company

BRADLEY electronics

WW—002 FOR FURTHER DETAILS

The life and efficiency of any piece of electronic equipment can rest entirely on the solder used in its assembly. That is why for utmost reliability leading electronic manufacturers in the USA and in 106 other countries throughout the world insist on using Ersin Multicore Solder. It's the solder they have depended on for consistent high quality for more than 30 years.

If you are not already using Ersin Multicore Solder it must be to your advantage to investigate the wide range of Specifications which are available. Besides achieving better joints – always – your labour costs will be reduced and subsequently savings in overall costs of solder may be possible.

There are well over 1,000 Specifications, made to all International Standards to choose from, and here are just a few of the special solders that we manufacture:

Savbit Alloy – A copper loaded alloy to reduce copper absorption from copper wires and copper laminate when soldering and also reduces the wear of copper soldering iron bits.

High Melting Point Solder (H.M.P.) – Melting temperature liquidus 301°C for special applications where above average heat is experienced.

Low Melting Point Solder (L.M.P.) – for soldering ceramics or silver coated surfaces. Melting temperature liquidus 179°C.

Tin Lead Cadmium (T.L.C.) – special low melting point solder. Melting temperature liquidus 145°C.

Ultra Fine Gauges – for soldering miniature components and assemblies. In all standard wire gauges to 34 s.w.g. (0.23mm) in most alloys.

Solder Pre-forms – include solder tape, rings, washers, pellets. Cored or solid. Available in a wide range of specifications.

Solder Cream – for special applications.

For mass assembly of printed circuit boards EXTRUSOL High Purity extruded solder for solder baths and pots.

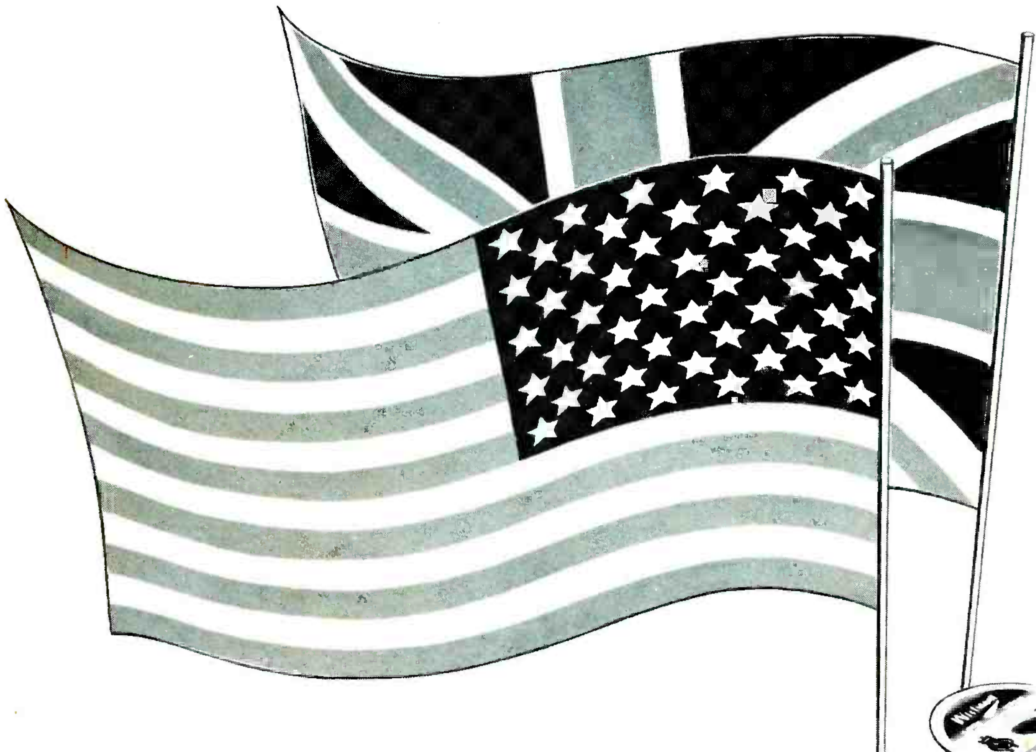
Compatible range of printed circuit chemicals and fluxes:

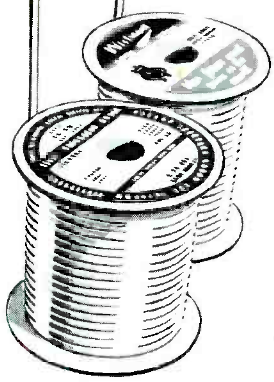
PC 2 Multicore Tarnish Remover
PC 90 Multicore Peeloff Solder Resist
PC 41 Multicore Anti-Oxidant Solder Cover
PC 80 Multicore Solvent Cleaner
PC 10A Multicore Activated Surface Preservative
PC 52 Multicore Protective Coating

and seven standard Multicore liquid fluxes available in one and 45 gallon containers.

Write for Technical Bulletins, on your Company's letterhead, for products which interest you to:

Multicore Solders Ltd.
Maylands Avenue,
Hemel Hempstead, Hertfordshire, HP2 7EP
Tel: Hemel Hempstead 3636 | Telex: 82363





Why have leading USA manufacturers specified British made Ersin Multicore solder for almost 30 years?