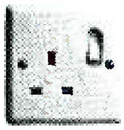
Wireless World

January 1973 20p

The semiconductor story

Accurate l.f. source

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.

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A GEC-Marconi Electronics Company

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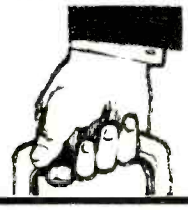

LEVELL

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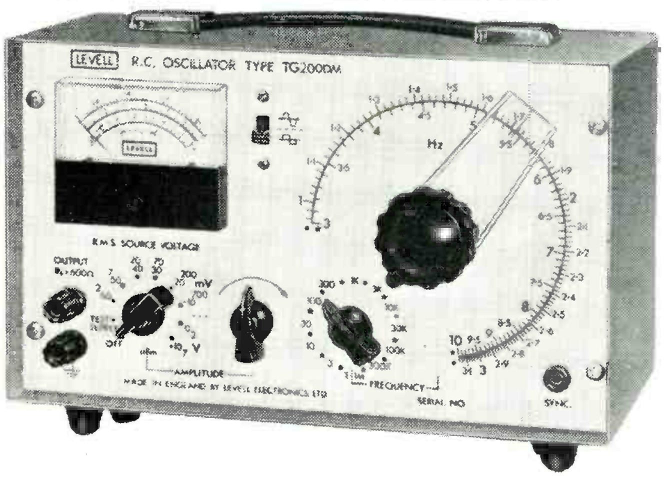
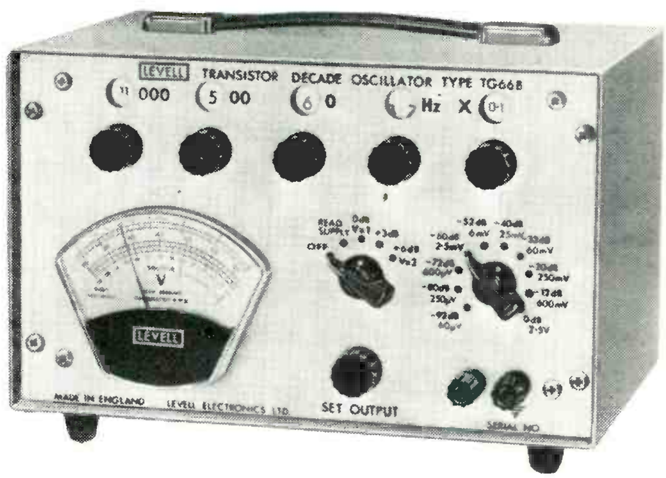


ANALOGUE

FREQUENCY	1 Hz to 1 MHz in 12 ranges. Acc. ± 2% ±0.03Hz.
SINE OUTPUT	7V r.m.s. down to <200µV with Rs = 600 Ω
DISTORTION	<0.1% to 5V, <0.2% at 7V from 10Hz to 100kHz.
SQUARE OUTPUT	7V peak down to <200µV. Rise time <150nS.
SYNC. OUTPUT	> 1V r.m.s. sine in phase with output.
SYNC. INPUT	±1% freq. lock range per volt r.m.s. input.
METER SCALES	0/2V, 0/7V & —14/+6dBm. on TG200M & DM only.
SIZE & WEIGHT	7″ high x 10¼″ x 5½″ deep. 10 lbs.

TG200	TG200D	TG200M	TG200DM
£42	**£45**	**£52**	**£55**
Sine O/P	Sine & Sq. O/P.	Sine O/P +meter.	Sine & Sq.O/P + meter.



DIGITAL

FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	±0.02Hz below 6Hz ±0.3% from 6Hz to 100kHz ±1% from 100 kHz to 300 kHz ±3% above 300 kHz.
SINE OUTPUT	5V r.m.s. down to 30µV with Rs = 600 Ω
DISTORTION	<0.15% from 15Hz to 15 kHz. <0.5% at 1.5Hz and 150kHz.
METER SCALES	2 Expanded voltage & —2/+4dBm.
SIZE & WEIGHT	7″ high x 10¼″ wide x 7″ deep. 12 lbs.

TG66B	TG66A
£120	**£150**
Batteries only.	Mains unit & batteries incl.

Prices include batteries with 400 hour life.
Mains power units £10 extra. Leather cases £6 extra.

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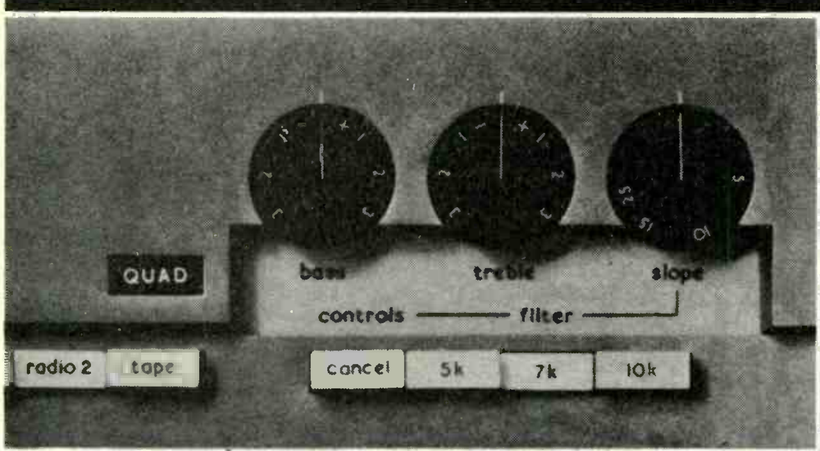
WW—004 FOR FURTHER DETAILS

numbers



Set up a QUAD 33 with +1 on the treble control, and you will obtain a response precisely defined; readily and accurately repeatable. This response has a shape rather different from most run of the mill tone controls and there are, as you may guess, good reasons for this.

Then as the listener is not expected to know just what a given response curve does to the signal off the record, we provide a button marked 'cancel'. This enables him to make a direct comparison with the original and so learn just which recording defects need what correction. A QUAD user gets the best out of every record – every time – and enjoys the music to the full.

QUAD

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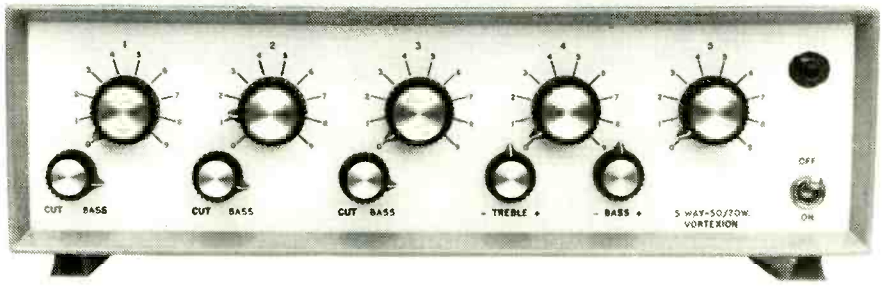
Vortexion

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.

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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.

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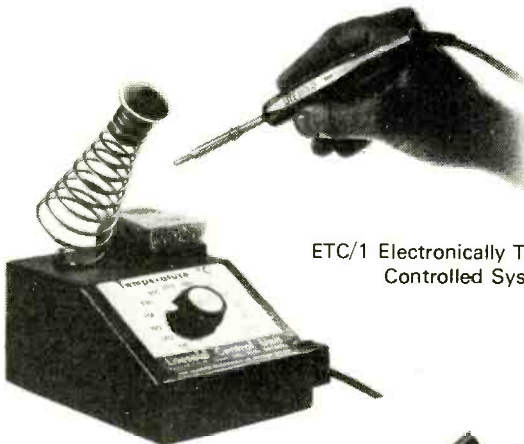

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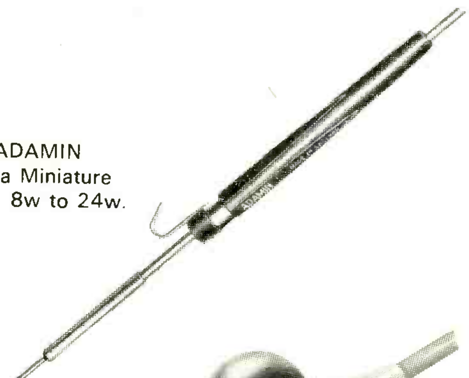

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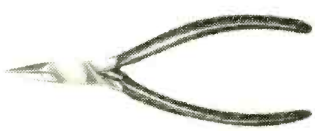

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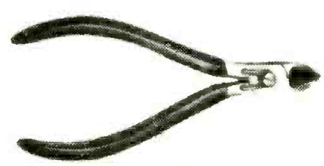

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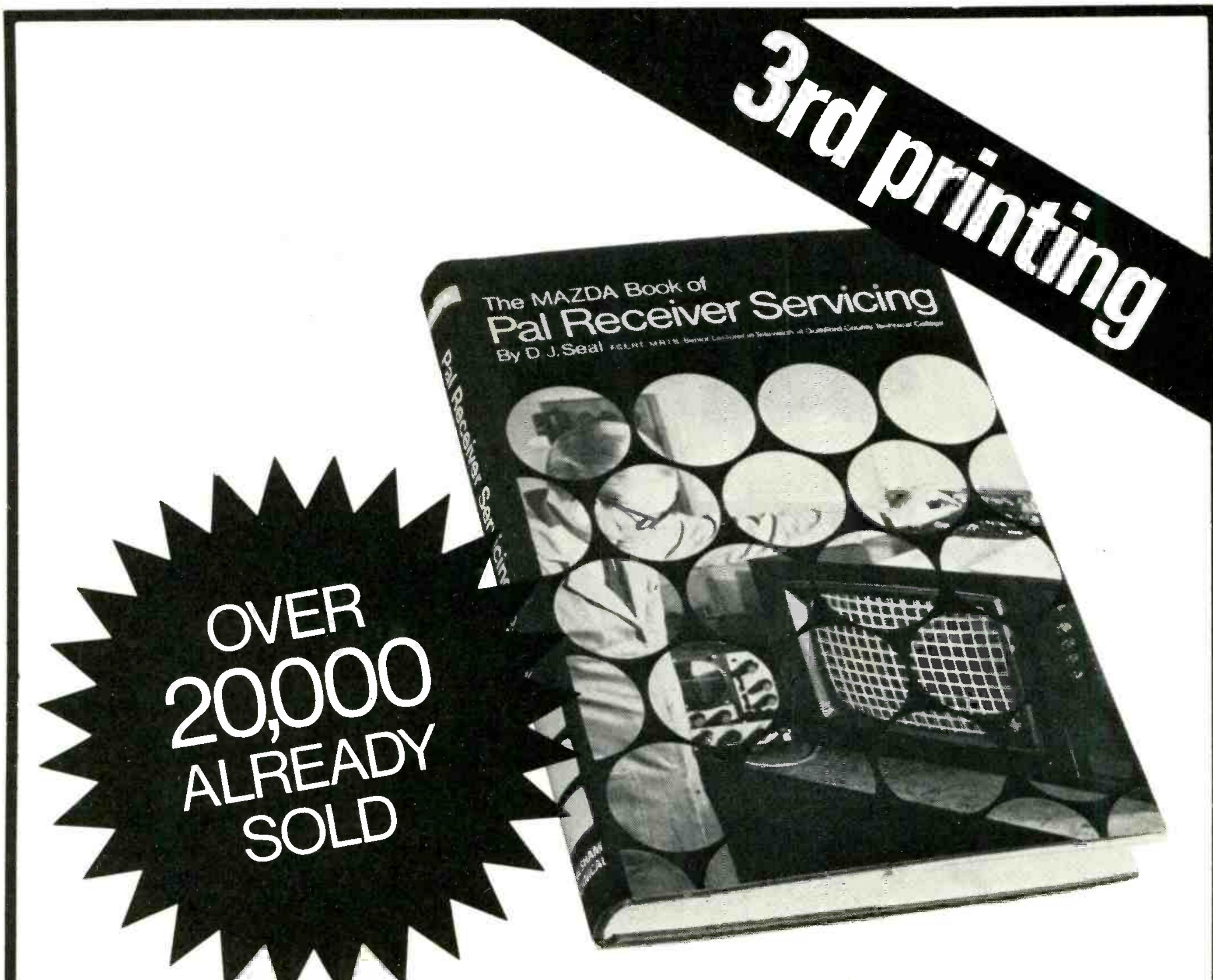

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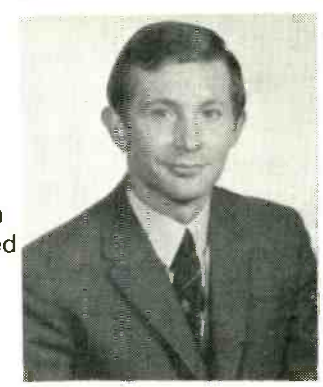
This book will be found invaluable for the revision of the colour TV elements in City and Guilds syllabuses and RTEB examinations.



The Author
David Seal, FSERT, MRTS is a Senior Lecturer in charge of the Television unit at Guildford County Technical College, Surrey. His practical grasp of television servicing problems derives, not only from his theoretical qualifications, but is firmly based on several years servicing experience updated by daily contact with his technician students.

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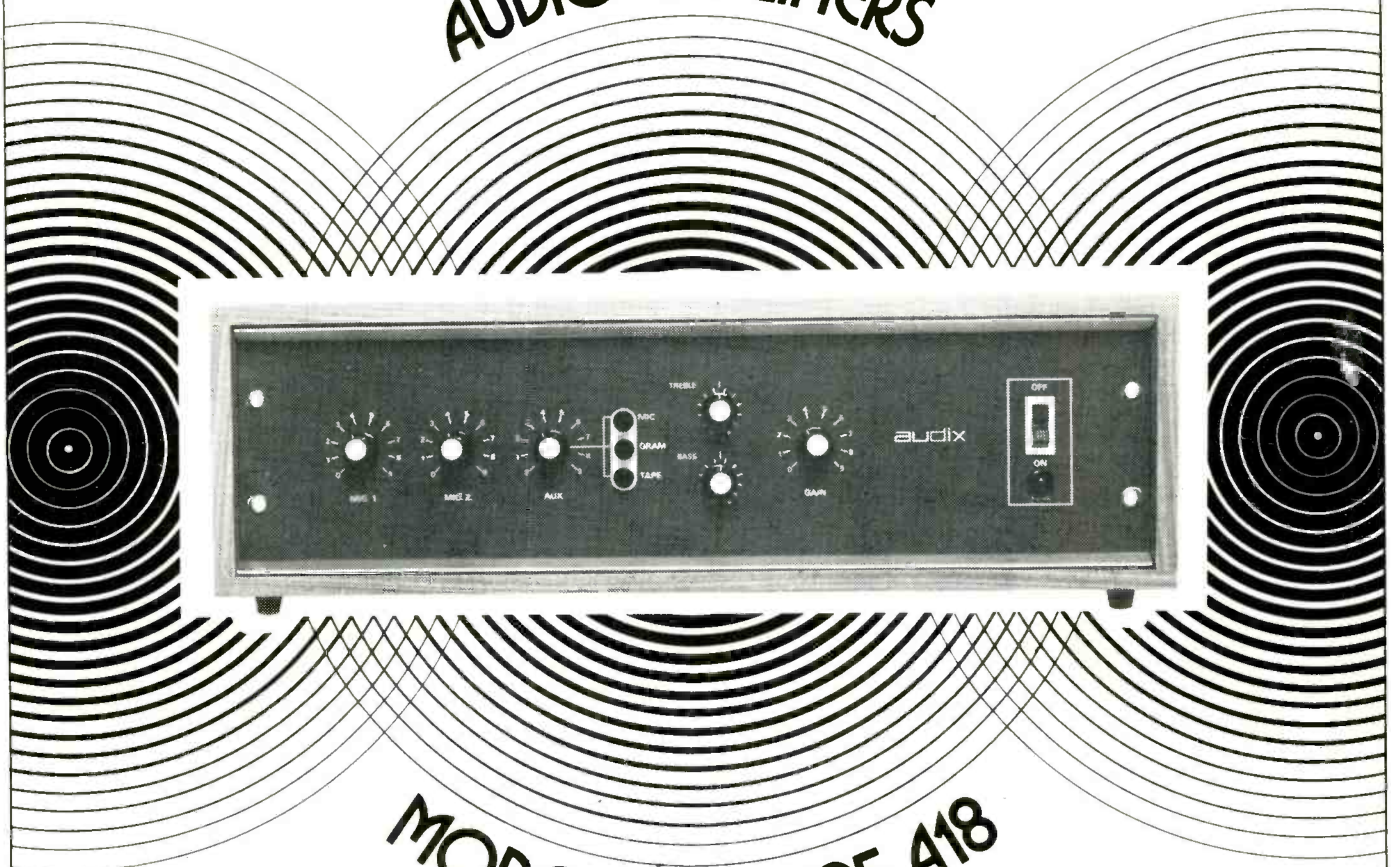

MODELS A80, A25, A18

The Model A80 Audio Amplifier illustrated is representative of the range of integrated amplifiers designed and manufactured by Audix for commercial applications such as factories, hotels, conference centres etc. Facilities for two low impedance balanced microphones and one switchable input for medium impedance microphone, tape recorder or gramophone are incorporated in this 60 watt r.m.s. amplifier. Outputs at 100V and 8 ohms are provided and are protected electrically against damage by short circuit, open circuit, inductive and capacative loads.

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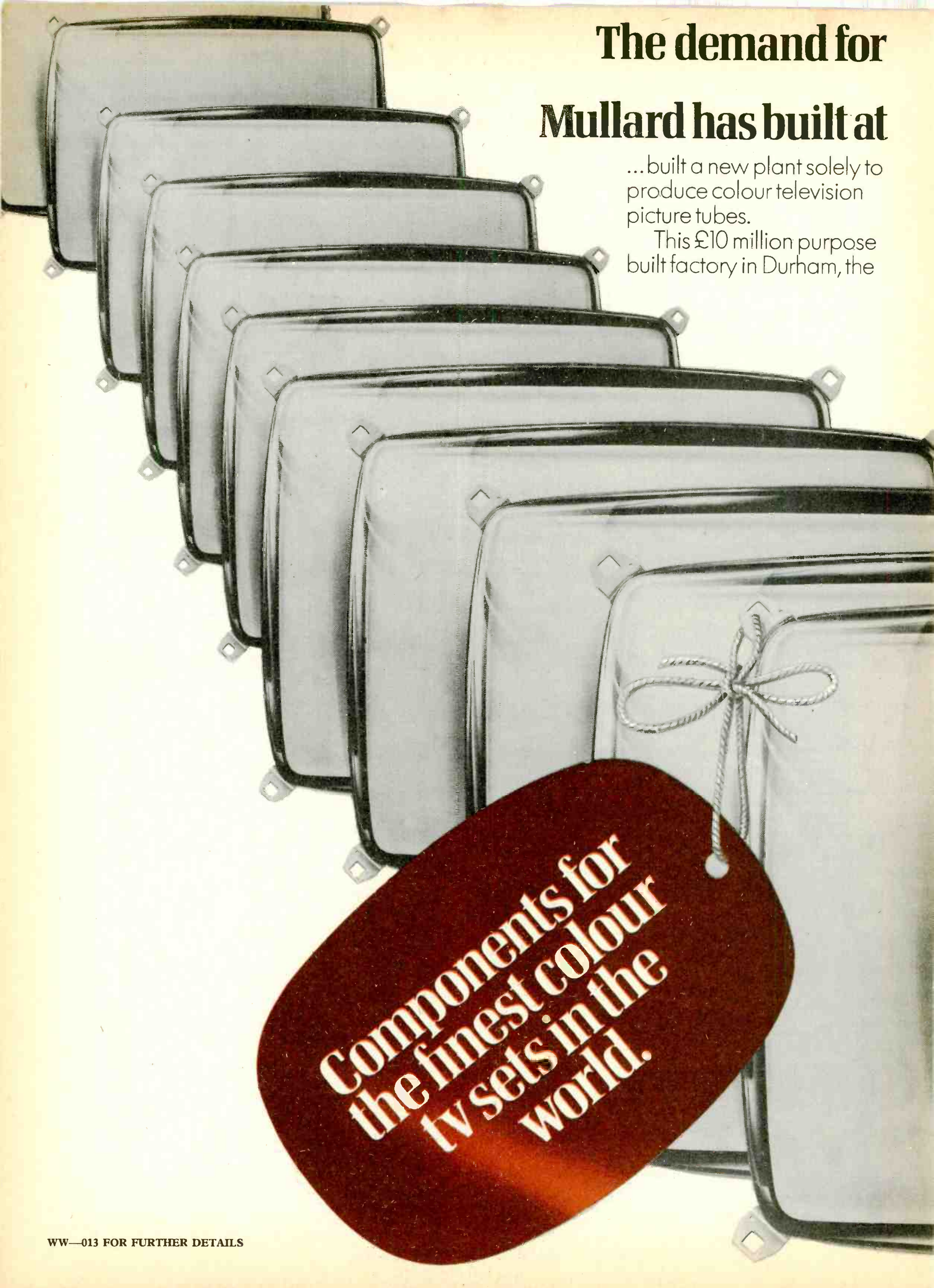
...built a new plant solely to produce colour television picture tubes.

This £10 million purpose built factory in Durham, the



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colour TV goes on growing

Durham to help you meet it...

most modern in the world, performs all the stages in the manufacture of colour tubes, from the delicate assembly of tube guns to the laying of over one million phosphor dots on the screen, making use of glass from Mullard's own glass factory at Simonstone.

Mullard ColourScreen tubes are designed for British transmission standards, helping setmakers to offer viewers a superb picture from the finest sets.

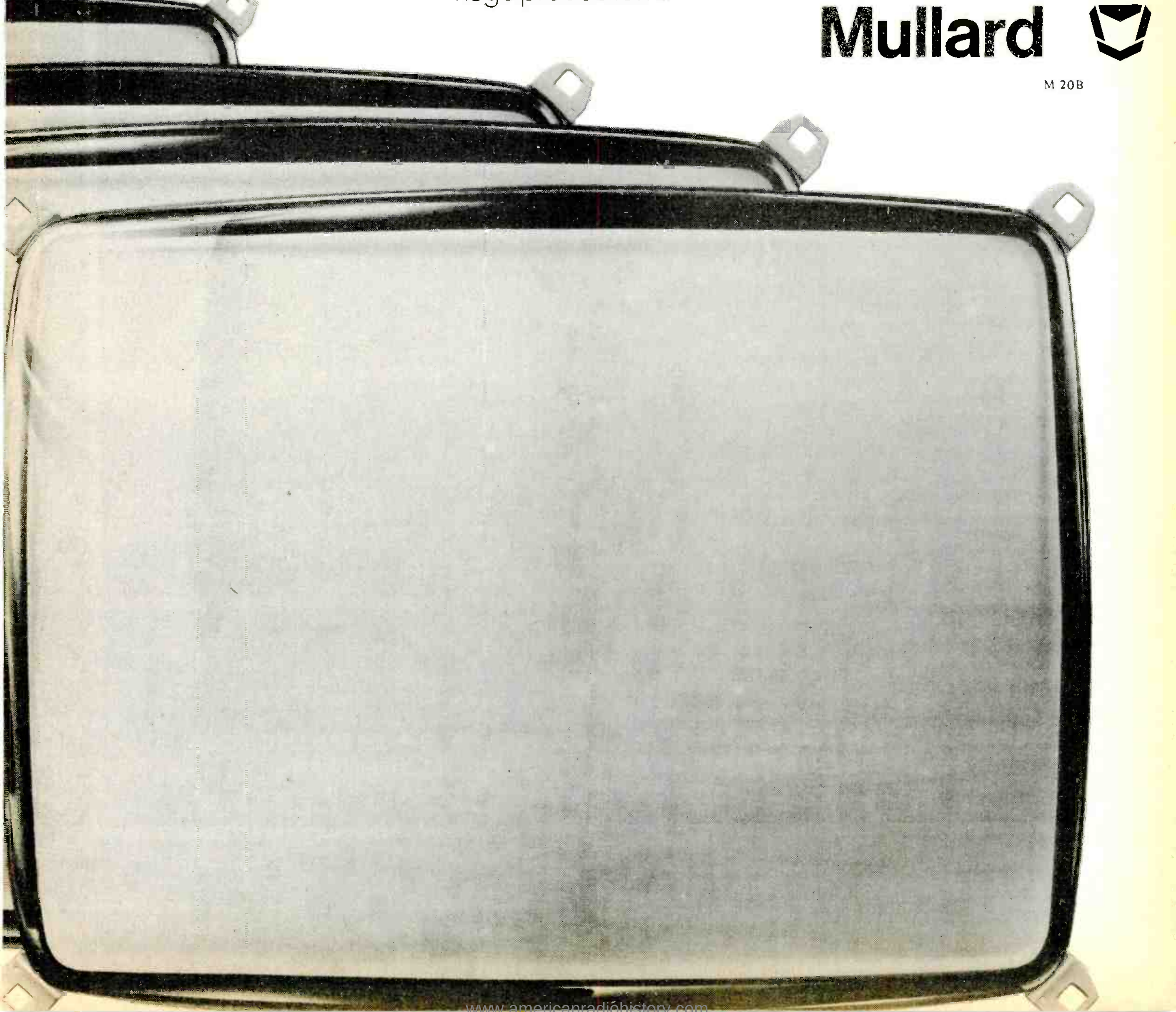
With its square corners, flat faceplate, constant colour registration and high light output, ColourScreen is not only the best, but will continue to be the biggest selling home produced tube. With investments like Durham supplementing the huge production at Simonstone, and also enabling Mullard to increase its already impressive export performance.

Mullard Durham started volume production of ColourScreen tubes ahead of schedule and will further increase its output in the months to come.

Helping you meet the huge demand for the finest colour TV sets in the world.

Mullard

M 20B



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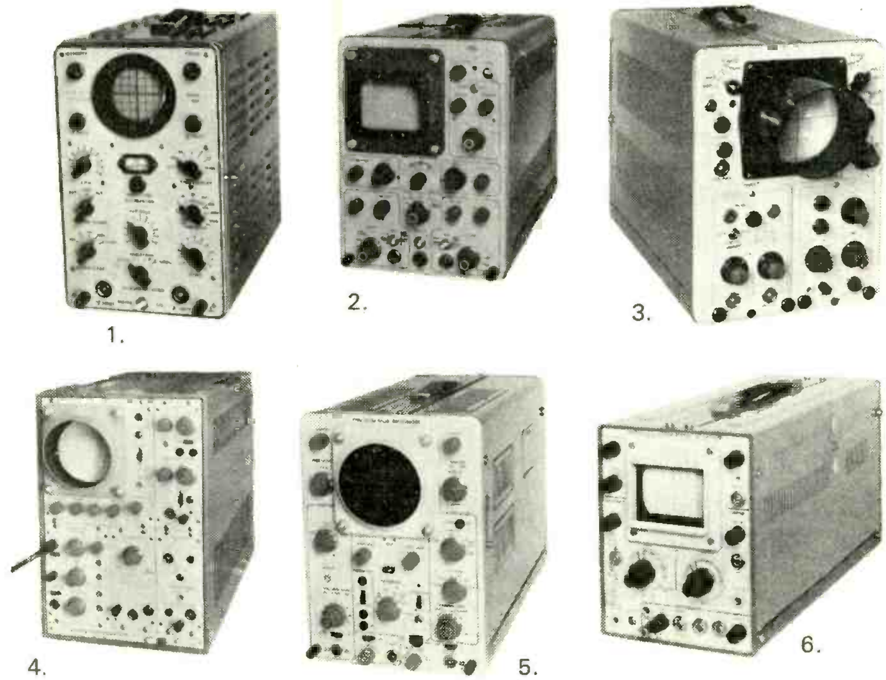

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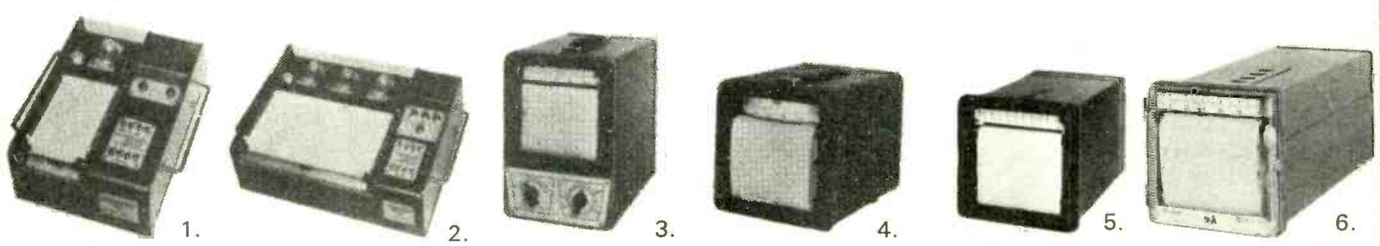
PEN RECORDERS



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Knife edge pointer.
48 ranges from 75mV to 750V and from 300μA to 7.5A.
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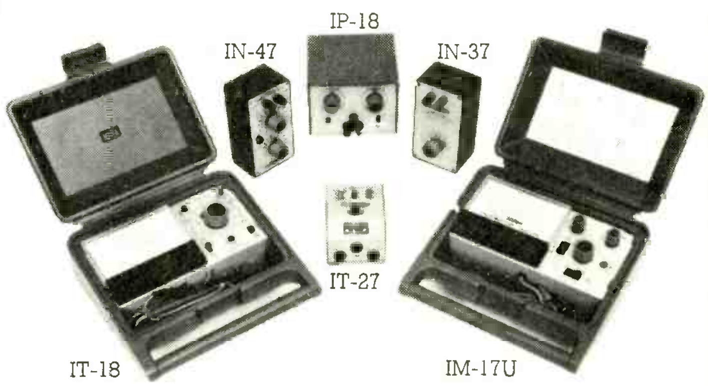

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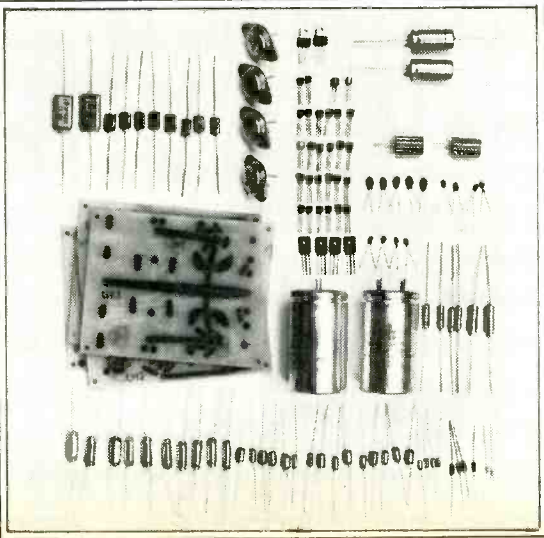

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and as ever, still the best of its kind in the world

In the Amcron DC.300 you will recognise what was formerly the Crown International DC.300. No other power amplifier in the world has such remarkable specifications. The change to Amcron was simply to avoid possible confusion of name identification. Nothing else has been altered. It might be that the DC.300 you order still shows 'Crown' on the front. It is of no significance. The Amcron remains the same thoroughbred in electronic engineering. Only the name has been changed and if you value perfection, it won't take long to remember.

● BRIEF SPECIFICATIONS

POWER	At clip point 340 watts RMS per channel into 4 ohms. 190 watts into 8 ohms per ch. Mono — more than 500 watts RMS into 8 ohms.
POWER RESPONSE	± 1dB from zero to 20 KHz at 150 watts RMS into 8 ohms per ch.
THD	0.02% at 300 watts RMS per ch. into 4 ohms.
I.M. DISTORTION	less than 0.1% from 0.01 watts to 150 watts RMS into 8 ohms per ch.
HUM & NOISE	100 dB below 150 watts RMS into 8 ohms per ch.
DAMPING FACTOR	Greater than 200 up to 1KHz.
PROTECTION	against short or open circuit and mis-matching.
INPUT SENSITIVITY	1.7V ± 2% at 10 KHz for 150 watts RMS into 8 ohms.
SIZE	19" x 7" high x 9¾" deep with front panel, suitable for rack mounting.

£360

AMCRON DC.300
TWO CHANNEL POWER AMPLIFIER

Eminently suitable for P.A. operation, laboratory and other precision controlled applications. There are other power amplifiers in the Amcron (formerly Crown International) range from two channel 60 watts RMS output to 1000 watts RMS single channel models as well as pre-amp I.C. 150.

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The SV-620 is ideal for any application where top level information and education are essential with a playing time of 76 minutes.

Full colour edit version now available.
This new unit allows insert and assembly edits with no loss of colour. Simple automatic tracking ensures trouble free edits. Designated the SV-620D, specifications are identical to the SV-620.

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- Very competitively priced for OEM quantities
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R55 2.5in (63.5mm) Scale length
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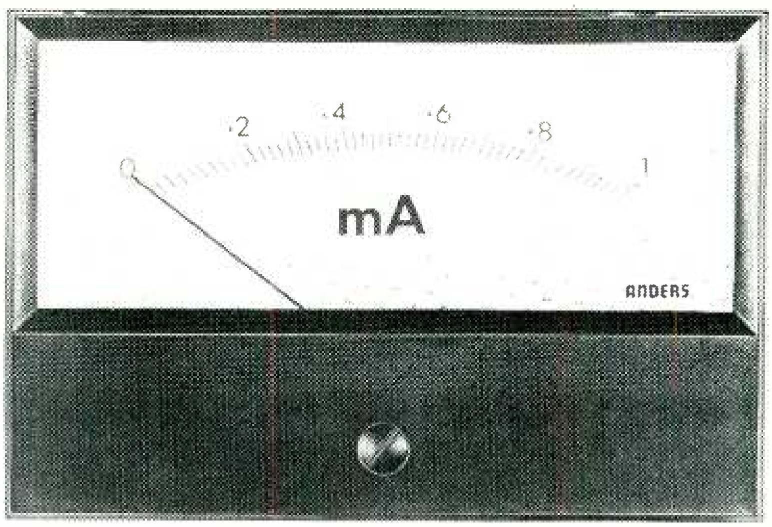
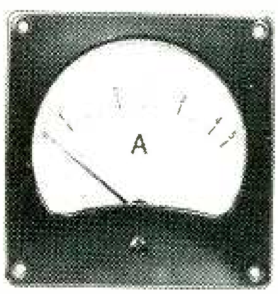


Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

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.

Profile 350 edgewise 4·3″ scale.
DC moving coil and AC moving coil rectified.
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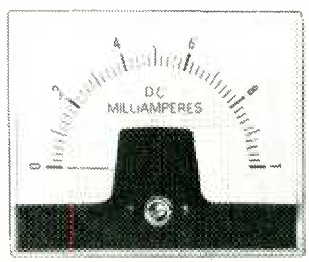
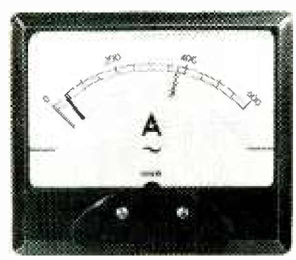
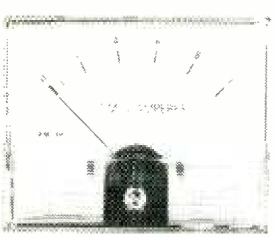


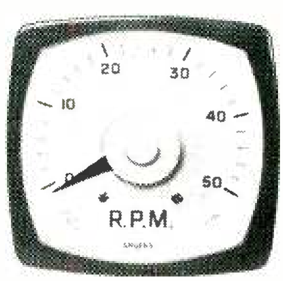
Crescent Long Scale 180°. 3 models, 4″, 5″, 6·25″ scales. DC moving coil and AC moving coil rectified. Clear plastic.



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



Kestrel Clear Front. 7 models, 1·3″—5·25″ scales. DC moving coil, AC moving coil rectified, AC moving iron.



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

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

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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.

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Go Hi-Fi yourself!

New Goodmans Din 20 loudspeaker kit — specially designed to give the D.I.Y. enthusiast excellent hi-fi reproduction at moderate cost.

This system has been thoroughly tested to Goodmans high standards. It will provide extremely satisfactory listening levels from amplifiers rated at 10 watts (per channel, in the case of stereo equipment) but it may also be operated from amplifiers of higher power.

The kit contains all parts needed to complete the system (except timber and other material for the cabinet itself) and has detailed, illustrated assembly instructions.

Contents

1. Bass unit 204 mm (8ins) diameter.
1. Dome HF radiator 25.4 mm (1 in) diameter.
1. Port tube.
1. Crossover panel with colour coded leads.
1. Terminal board.
1. Foam gasket.
1. Input lead complete with DIN plug and spade terminals.
   Acoustic wadding foam pad.
   Fixing screws and hardware.
   Cabinet template (on bottom of box).

Specification:
20 watts DIN, 4 ohms impedance, 8 ins bass unit, dome HF radiator, crossover frequency 4,000 Hz

For further details and the name of your Goodmans dealer, send the coupon now

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Please send me free leaflets on Constructors' equipment and the name of my Goodmans dealer.

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WW6

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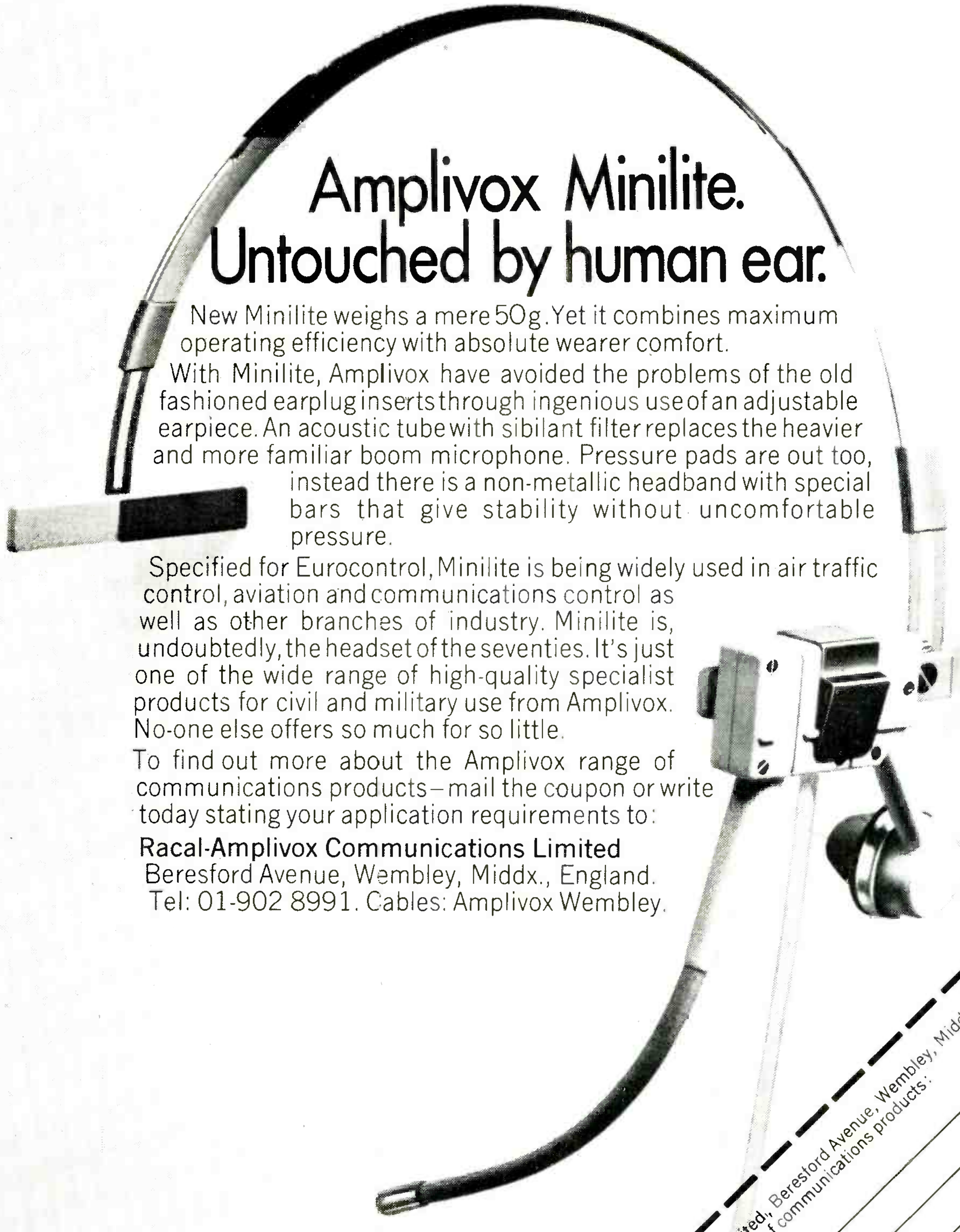

Amplivox Minilite. Untouched by human ear.

New Minilite weighs a mere 50g. Yet it combines maximum operating efficiency with absolute wearer comfort.

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Specified for Eurocontrol, Minilite is being widely used in air traffic control, aviation and communications control as well as other branches of industry. Minilite is, undoubtedly, the headset of the seventies. It's just one of the wide range of high-quality specialist products for civil and military use from Amplivox. No-one else offers so much for so little.

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Tel: 01-902 8991. Cables: Amplivox Wembley.

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Company

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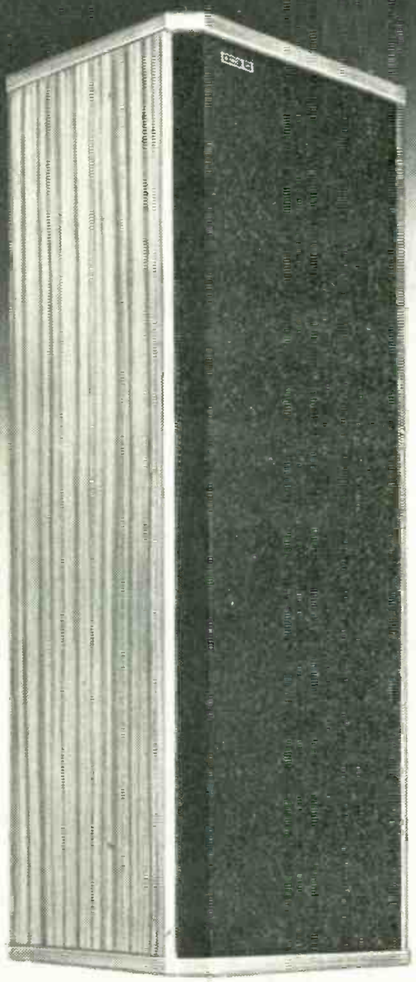
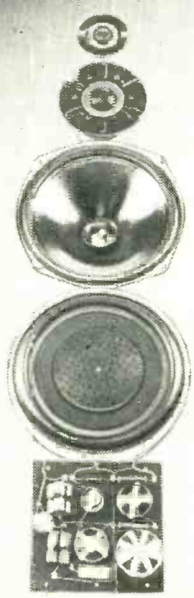
Ditton 66 Studio Monitor





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Weight 2·9 lbs

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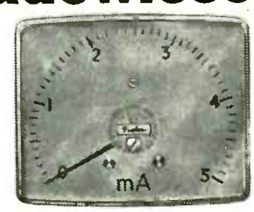
WW—030 FOR FURTHER DETAILS

240° of shadowless readings. That's the Taylor Fyneline 'Wide Angle' range.



Meet Taylor's new range of 'Wide Angle' panel meters. The 240° circular scale offers scale lengths of approximately twice that of similar 90° movements.

Model 38, illustrated here, is the smallest in the range with the scale length of 4⅜ in. and a panel width of little more than 2½ in. Find out more about the complete Fyneline range including our 'Standard' and 'Picture Frame' models. Write for data sheet now.

Taylor

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

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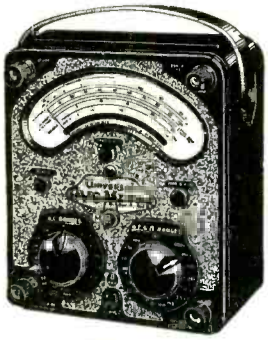

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The new Linstead Millivoltmeter.

Wide range, 5" scale length, 5"x5" bench space.

M2B This instrument is based on our popular M2A and has been completely redesigned mechanically for convenience in operating and attractive appearance.

The Panel layout has been designed to give maximum utilization without waste of area. By using a vertical styling valuable bench space is reduced. The case extends to protect the meter and terminals without affecting accessibility. The carrying handle will either sit neatly on top of the instrument when vertical or be used as a rest to allow operation in a sloping position. The battery (the readily available PP9) is accessible from behind a rear plate held by a single retaining screw.

Specification: A.C. 1.2mV FSD to 400V
D.C. 120mV FSD to 400V
in 20 ranges.

Further details about the new Linstead Millivoltmeter available on request.

Linstead means a good deal in electronics

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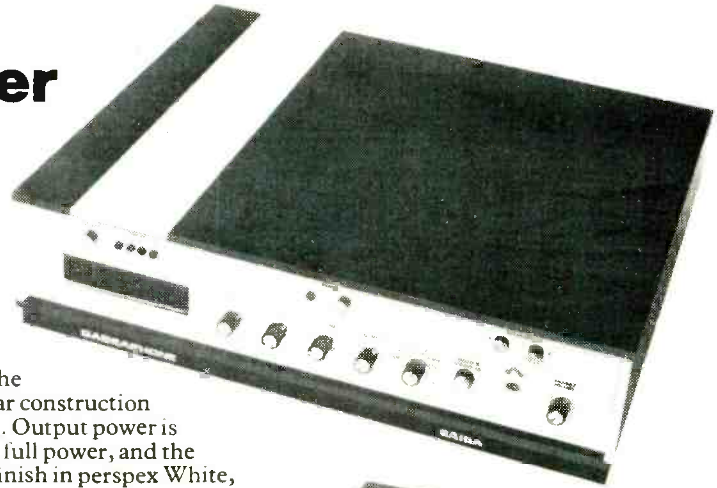
Telephone: 01-802 5144

WW—034 FOR FURTHER DETAILS

G GABRAPHONE Integrated Amplifier -Tape Players



Saida de Luxe A stereo amplifier of the highest quality performance with built-in 8-track cartridge player, housed in 18" cabinet. A unique feature is the electronic switching between signal sources, completely eliminating switch-contact noise and unwanted coupling between signal circuits. Input connection facilities for magnetic pick-up, radio tuner or other auxiliary signal source, together with a record/replay socket for external tape-deck. Dual loudspeaker circuits, with front-panel switching. The headphone socket has its own, independent, volume control. Modular construction is employed throughout, providing ready interchangeability of units. Output power is 12 watts RMS per channel into 8 ohms distortion less than 0.02% at full power, and the frequency response 25 Hz to 25 kHz ± 1 db. Outstanding styling – finish in perspex White, Black or Grey.

Saida Minor de Luxe Multi-input stereo amplifier with built-in 8-track stereo cartridge player for continuous entertainment. Large performance in small size – only 14" × 12" × 5". Inputs for magnetic pick-up and auxiliary signal source. Electronic switching between inputs, output 12 watts RMS per channel into 8 ohms. Available in perspex White, Black or Grey. Modular construction ensures ready interchangeability of units.

Amelia de Luxe Tape player – add-on unit. Provides playing facilities for 8-track stereo cartridges when combined with any stereo amplifier. Incorporates equalisation for tape replay characteristic and front-panel attenuator control to adjust output to suit amplifier used. Individual volume and tone control. Elegantly styled in Black, White or Grey perspex – matching the amplifiers and other units in Gabraphone range. Output 750 mVmax into 2,000 ohms. Also available without tone control.
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Valradio

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Type	Input	Output	Price
CR110/220/60RT	110/220	12v 5A smoothed or 24v 2.5A DC	£66.00
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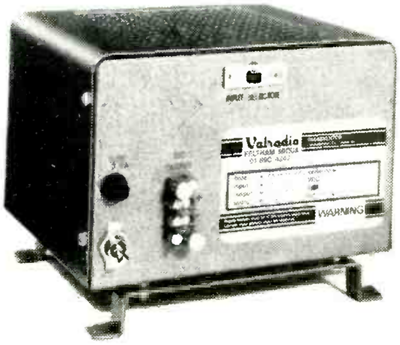
Other similar units available to operate from 12, 24, 32 & 50V DC and outputs of from 30W to 750W in square, sine wave or DC.



Send for information leaflet WC13.

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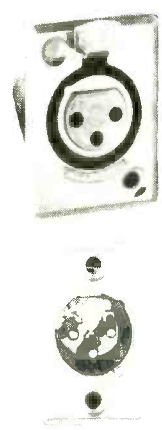
WW—036 FOR FURTHER DETAILS

Audio Connectors



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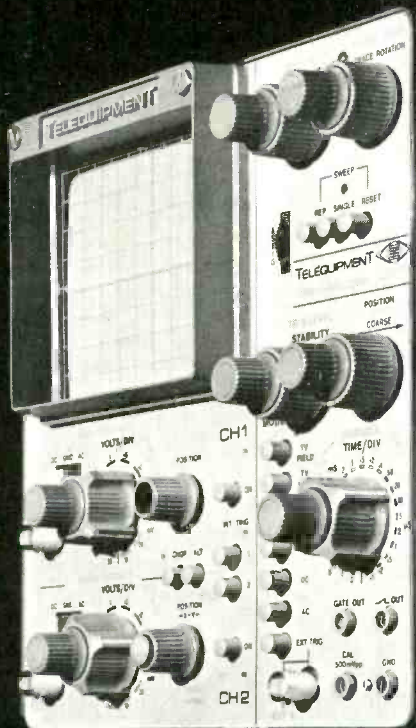
two new dual-trace oscilloscopes



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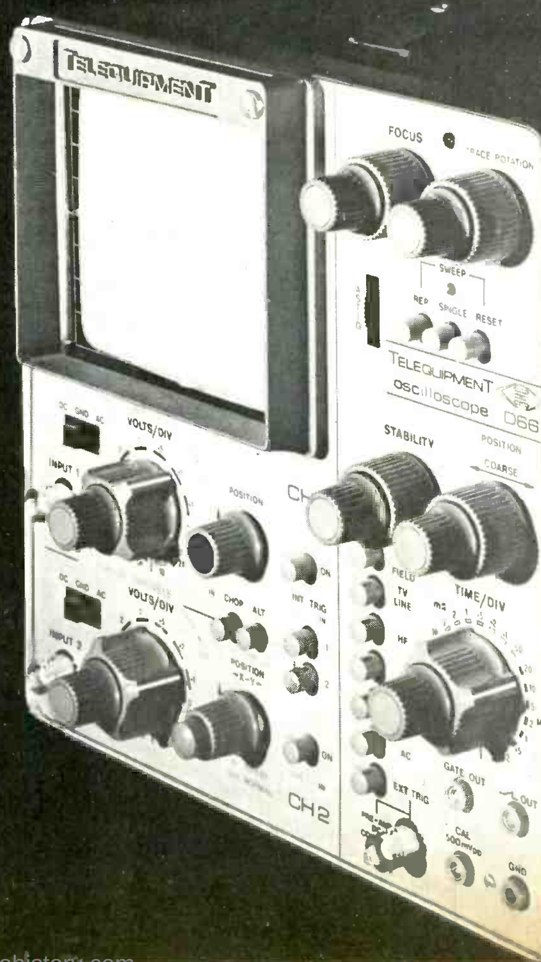

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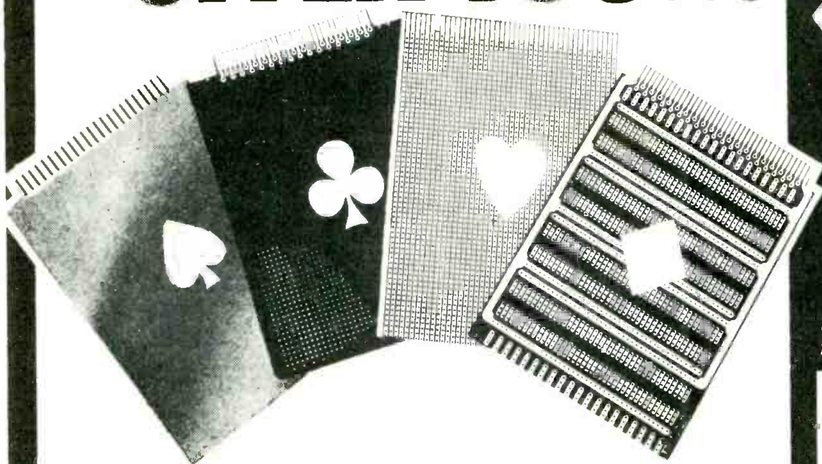

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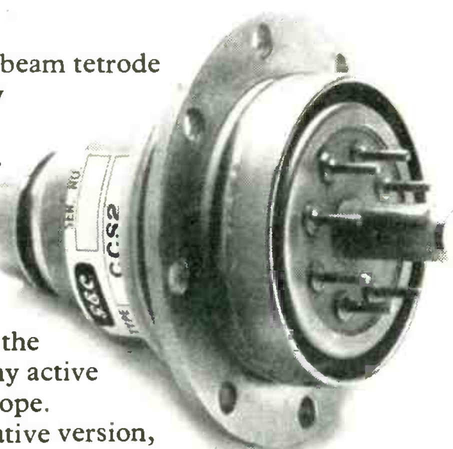

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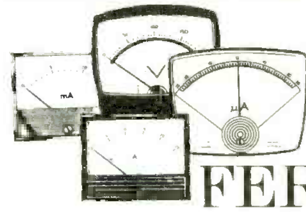

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Wireless World, January 1973

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TIMERS SWITCHES TRANSFORMERS VOLTAGE CONTROLS FOR IMMEDIATE DELIVERY

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FAMOUS "SLIDUP" & "SLIDTRANS" MODELS

1 amp	£7.00	C. & P. 37p
2.5 amp	£8.05	„ 57p
5 amp	£11.75	„ 67p
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12 amp	£23.60	„ 75p
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"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

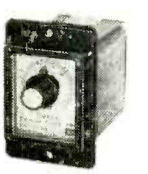
OMRON brand Synchronous Motor driven timer with single instantaneous and two timed changeover contacts. **MINIMUM** guaranteed electrical and mechanical 10,000,000 operations.

*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"

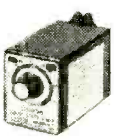
Easily adjustable from delay on energise to delay on de-energise. The OMRON ATS works on an air damped principle and can be adjusted between 0.200 secs with screwdriver adjustment. A precision snap action switch provides a 6A contact and minimum 1,000,000 ops life.
"One off" **£8.10**. In quantity **£5**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

LOW COST PANEL MOUNTING MINIATURE TIMER—"STPYMH"



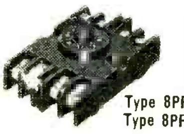
Plug-in timer for panel mounting. Synchronous Motor driven with auto-reset facility. Instantaneous and time limit contacts rated at 5A. This timer has fixed and moving pointers.
£8.40 "one off" **£5** in quantity.

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.

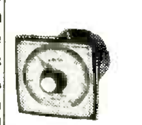
ELECTRONIC RECYCLING TIMER FOR CONTINUOUS ON/OFF OPERATION "TDA"

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"

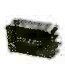


The OMRON timer type NSY features the modern "DIN" type square fixed dial. This attractive package has two time limit changeover contacts.
Stock range 110/240 VAC up to 28 hrs **£12.50** "one off" to **£8** in quantity

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.O. 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.O. 0.1mm. **£23** per 100; **£180** per 1000; **£850** per 5000.

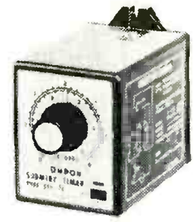
SIAL WITH LEAF SPRING
Subminiature 5amp microswitch of 56-180gm R.F. 14gm M.F. 0.8mm. **£27** per 100; **£220** per 1000; **£1000** per 5000.

SIAL 2 WITH ROLLERACTUATOR
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 MICROSWITCH.
15amp Microswitch with pushbutton 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.

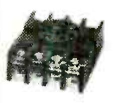
OMRON LIMIT SWITCHES

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

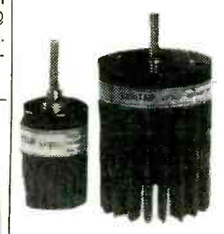
Famous I.M.O. Constant Voltage Stabiliser still only **£12.50** each.
FEATURES:
***200 watt rating**
***Input 240VAC ±20%**
±Output 240VAC±1%.

AT LAST OMRON FRONT CONNECTION SOCKETS—NOW SUPPLIED FROM STOCK



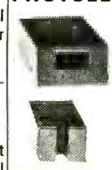
These new miniature sockets with screw terminal connections are only available through I.M.O. or authorised stockists. Moulding is UL approved and OMRON "know how" brings all the advanced features of a modern product.
PF083 (8 pin) **44p** each 1000 lots.
PF113 (11 pin) **58p** each 1000 lots.

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.
VP10C (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.

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Each of these bridges has ten decade ranges and can be used to measure any type of component or complex impedance. Transformer ratio-arms are used to cover a very wide range of measurement using a minimum number of standards which are set digitally. The three terminal facility provided by this type of bridge enables small values of capacitance or high values of resistance to be measured at the end of long lengths of cable. Components can also be effectively isolated electrically from a complex network allowing individual measurements to be made without disconnection from the circuit being necessary.

The world's most universal audio bridges

Wayne Kerr's B224 and B642

The B224 is a manually operated bridge, the resistive and reactive terms being independently set to a null indicated on the meter. A rechargeable battery is fitted in order to make the instrument portable.

The B642 balances itself automatically. The meters read real and quadrature terms and highly stable analogue outputs are provided which are directly proportional to capacitance and conductance above 10Ω impedance and also to inductance and resistance below 10Ω. One or two decades can be set to provide the first significant figures of the measurement, thereby increasing the meter sensitivity by 10 or 100 times. If a chart recorder is connected to the output of either term, drifts in component values to at least four significant figures can be observed.

SPECIFICATION

	B224 (Manual balance)		B642 (Autobalance)	
Frequency	1592Hz (internal) 200Hz – 50kHz (external)		1592Hz (internal) 200Hz – 20kHz* (external)	
Ranges for specified accuracy				
	0.1%	0.3%	0.1%	0.3%
C	100fF – 10μF	10μF – 10mF	1pF – 10μF	10μF – 10mF
G	1n℧ – 100m℧	100m℧ – 1k℧	10n℧ – 100m℧	100m℧ – 100℧
L	1mH – 10kH	100nH – 1mH	1mH – 10kH	1μH – 1mH
R	10Ω – 1GΩ	1mΩ – 10Ω	10Ω – 100MΩ	10mΩ – 10Ω

NOTE: 0.1% accuracy relates to parallel component measurements above 10Ω impedance. 0.3% accuracy relates to series component measurements below 10Ω impedance.

*Manual operation only.

For more information, write to the address below or phone Bognor Regis (02433) 4501

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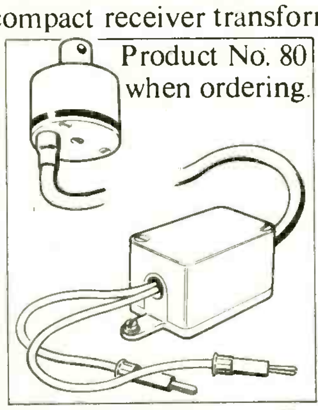
With the Aerialite Mastatic System you wouldn't know you were in a difficult reception area

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.



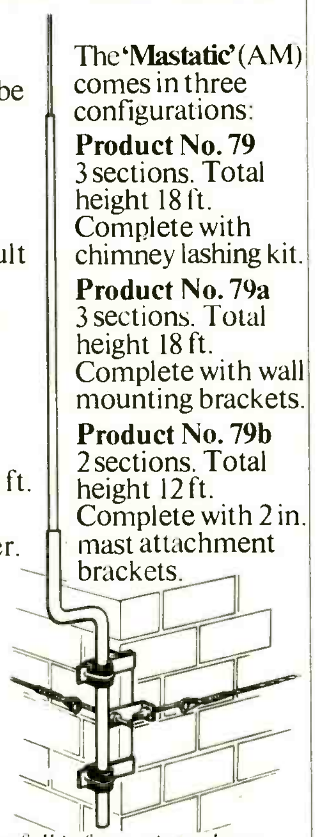
Product No. 80 when ordering.

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.



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Aerialite Aerials Ltd

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

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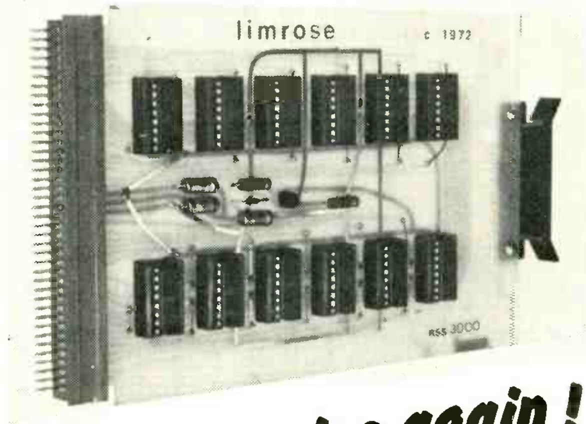
Random Access Memory Card

256 X 12 BITS £60



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Ready to use, fully decoded, on printed circuit card. Ideal as high-speed Random Access Store in your own computers, control systems, terminals etc. Requires only +5v and −9v power supplies. All inputs and outputs are TTL compatible and no clock is required. Outputs can be wired-OR for memory expansion.

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MODEL: TTR-21

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(150MHz, 1W)

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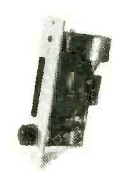
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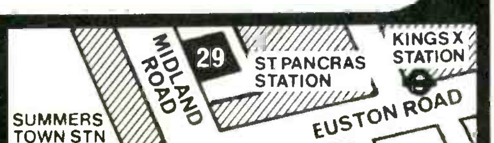

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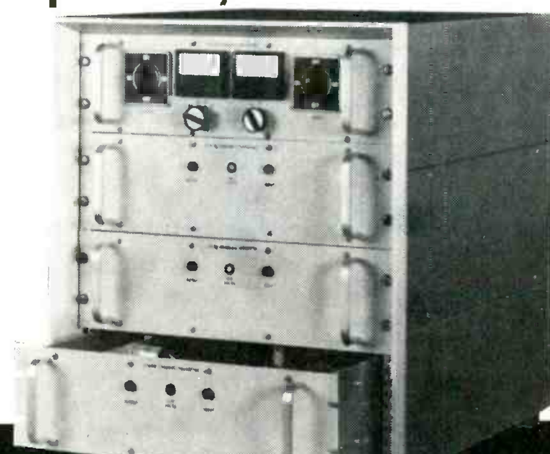

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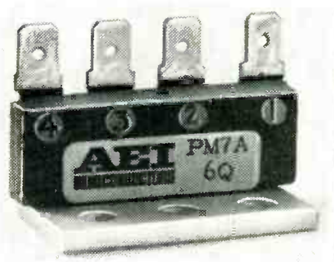

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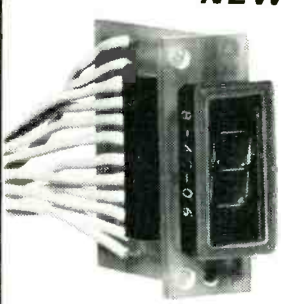

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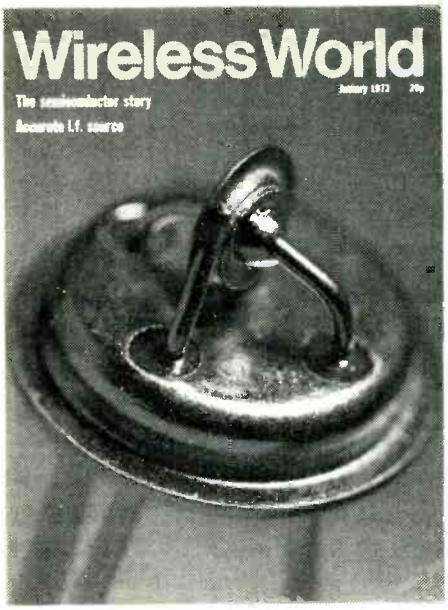
Wireless World

Electronics, Television, Radio, Audio

Sixty-third year of publication **January 1973** **Volume 79 Number 1447**



The Newmarket transistor shown on **our front cover** symbolizes the opening of the semiconductor story which begins in this issue. *(photographer Paul Brierley)*

Contents

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Publication date Feb. 2nd

Distortion reducer. An active feedback circuit which can be added to non hi-fi amplifiers to reduce total harmonic and intermodulation distortion, and hum, without loss of gain.

The Realm of Microwaves is the first part of a state-of-the-art review of the theory and application of microwaves. This first article reviews solid-state oscillators and subsequent parts will cover microstrip transmission lines, aerials and radomes, and radar systems.

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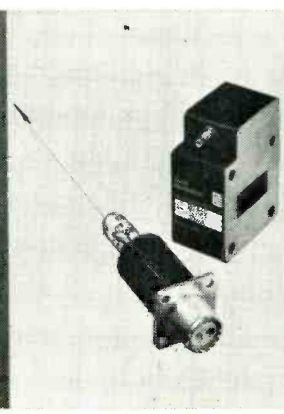

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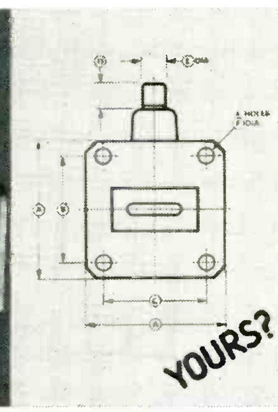

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Electronics Industry in the E.E.C.

By the time this issue appears Britain will be a member of the European Economic Community. Inevitably there are misgivings in the minds of many businessmen, engineers and laymen as to the so-called benefits entry into the common market will produce. We have been asked what effect it will have on the contents of *Wireless World*. The simple answer is — editorially, little, if any. We deal with new technologies as and when they are announced irrespective of the place of origin. Moreover, as we write for the individual engineer or technician it matters not whether he is in Asia, Africa, America or Europe. This fact is borne out by our overseas circulation which is in round figures 15,000, of which about 25% is on the Continent.

While entry into the Common Market may not directly affect the contents of the journal it could have major repercussions on this country's electronics industry. With tariff barriers removed, the door for imports into Great Britain will be wide open but the traffic could be two-way if we are ready and prepared to meet the challenge. In a recent contribution on "The future for the British electrical and electronics industry inside the E.E.C." at the I.E.E., Dr F. E. Jones, of Mullard, took a somewhat pessimistic view. This was not entirely because of the Continental threat but in view of the general influx of electronic products. He instanced that during 1972 more colour television sets came into the U.K. from Japan than from the whole Continent — E.E.C. and E.F.T.A.

Dr Jones quoted figures in support of his contention that during the 15 years of the E.E.C. there has not been any major increase in the flow of goods across the frontiers of "the seven". It would appear, therefore, that the British electronics industry has got to go into the market place and sell its wares — entry into the Common Market will not herald the millenium. Our goods must not only be competitive in price but readily available. Here surely is the nub. One of the reasons for the present influx of colour television receivers is because the British radio industry has been unable to meet the demand. The long delay in deliveries has meant that many customers bought imported receivers to ensure having their sets installed for Christmas. A similar story can be told of other sections of the industry.

"It would seem", said Dr Jones "that not much has happened in the 15 years since the formation of the E.E.C. that has been of great benefit to the electrical or electronic industries of Europe in putting them on a more competitive basis with the rest of the world. It would also seem that the full benefits . . . will not be felt until there is a federal government of Europe with a common currency and harmonization of taxes and social systems . . . but this is not in the foreseeable future, if at all."

Another aspect of our entry into the E.E.C. was highlighted by Mr J. E. Engels, chairman of Philips Electrical Industries, in a lecture at the I.E.R.E., incidentally, on the same evening as Dr Jones' I.E.E. lecture (lack of inter-institution consultation?). Mr Engels dealt with the subject of the electronic and radio engineer in the E.E.C., for the treaty of Rome states that member countries will not impede the flow of capital, goods or *people* across national boundaries. He set the scene, as it were, by saying "Universal brotherhood has not suddenly emerged; nor have all national struggles and competition suddenly evaporated. On the contrary, the rules of the game may have changed, but in essence the game is still the same. Within the rules of the Common Market agreements a great struggle is still going on to protect national and industrial interests. In many respects this industrial competitive struggle is more severe than it was before, because there are fewer tariff barriers".

One of the problems involved in the movement of people between countries is the differing standards of technical qualification. It is interesting therefore to learn that a new "super institution" for electrical/electronics engineers in Europe is proposed as a result of a recent convention of the National Electrotechnical Societies of Western Europe held in Zurich. Both the I.E.E. and the I.E.R.E. were represented and we await an official announcement on the outcome.

The Semiconductor Story

1: The new crystal triode

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

The paper which first announced the discovery of the transistor appeared in the *Physical Review* in July 1948. To c mmemorate the 25th anniversary of this event, *Wireless World* is publishing a series of four articles presenting a critical survey of the semiconductor industry, past and present, from the U.K. point of view. Part 1 describes the early development of germanium diodes and transistors, while parts 2 and 3 describe respectively the exploitation of the transistor and the integrated circuit to the present day. The final part discusses some of the problems, both technical and commercial, which have faced the industry in recent years. The roles of careful research, happy chance, technical skill and industrial pressure make a fascinating story of our times.

The new crystal triode, as the transistor was first called, seemed in 1948 to be poor competition for the Goliath sized valve manufacturing industry. But a veritable David it turned out to be! *Wireless World* reported the discovery in an article in October 1948, entitled "The Amplifying Crystal". How many people reading that report then realized its implications for the future? The transistor was the end result of research which started 140 years ago in 1833 with Michael Faraday. He noted that while most conductors have a positive temperature coefficient of resistance, a substance called silver sulphide had a negative coefficient. Thus a substance later to be classed as a semiconductor was identified. Rectification, photoconductivity and photo-e.m.f. effects were all observed before 1900. Theoretical work on semiconductors after Faraday's original discovery gathered momentum, so that, by the early 1930s, quantum mechanics was applied to the theory of conduction. Energy band diagrams, electrons and holes then started to be discussed. The stage was set for the discovery in America by J. Bardeen and W. H. Brattain of the transistor—a semiconductor triode. This was the first three-terminal semiconductor device which could amplify, and that was only 25 years ago. Now the impact of the transistor is universal, it has applications ranging from aviation and broadcasting to washing machines and Xerography.

Cat's whiskers

Semiconductor crystals were used in the early days of radio communications, the crystal rectifier being used as the detector in radio receivers. A typical detector was made by soldering or clamping a minute piece of the crystal in a small brass cup and the point contact made with a flexible wire called the cat's whisker, which was held in light contact with the crystal. The discovery of the thermionic triode by de Forest in 1907, and its subsequent developments, made the crystal rectifier obsolete in radio receivers. However, the point contact crystal could not be replaced for detecting and monitoring u.h.f. power. At the other end of the scale, at low frequencies, the copper oxide rectifier and selenium rectifier have been commercially successful, but they are however not point contact rectifiers. The rectification property of these is obtained by the contact of a thin film of semiconductor with the metal on which it is deposited. They are therefore termed contact rectifiers.

Wartime research

The second World War, like all military ventures, provided the cash to oil the wheels of research, so important at times of national emergency. It saw the development of radar, which gave a great impetus to u.h.f. crystal rectifier design. Research was concentrated on using silicon, germanium and boron. Boron prepared with selected impurities, i.e. "doped", showed sufficient conductivity to be of interest, but its typical characteristic curve was S shaped and symmetrical about the origin, thus the project was then dropped. Silicon showed great promise, being used for most of the commercially available devices. At this time the importance of starting with extremely pure silicon was appreciated. The "red-dot" crystal diode developed by the General Electric Company, for example, was derived from silicon crystals prepared from melts made from highly purified silicon powder, to which was added a fraction of a per cent of aluminium and beryllium. The resulting crystal could dissipate relatively large amounts of power without appreciably impairing its performance as a mixer. These were therefore known as "high-burnout" crystals.

The method of adjusting the cat's whisker at this time is interesting to note. The contact pressure was increased until a predetermined characteristic was obtained, and the cartridge was then tapped with a light mallet. Careful tapping caused the forward resistance to drop and the reverse resistance to rise. The cartridge was then impregnated with wax to provide mechanical stability and to make it impervious to water. Further work in 1943 led to high purity silicon, doped with only 0.001% boron, which produced an extremely good device and made prolonged tapping unnecessary. The small amount of the impurity needed indicates how material technology had to keep pace with the demands of the semiconductor device manufacturer. At this time, work on germanium led to the high-inverse voltage rectifier; so called because it could withstand up to 100V applied in the reverse direction. The doping agent used was tin, although it was found that similar effects could be obtained with some other elements. Germanium, however, could not compete with silicon above 30MHz. These methods of preparing the germanium crystal and polishing its surface were to be used later in the manufacture of the first transistor.

In 1946 H. Q. North showed that the point-contact used in these devices could be welded to the crystal surface, by passing a high density current (in the order of 10^7 amps/sq. in) for a short time through the contact point. Although this did not improve their performance, little was lost either. This technique too was later to be of value in three-terminal point contact devices.

Post war development

After World War II the immediate problems of survival gave place to the interests of commercial enterprise, and researchers were able to return to more general semiconductor problems, although under industrial patronage. Silicon and germanium were chosen for the research effort, because they are simpler to understand than most other semiconductors. A lot of expertise on these materials had been accumulated during the war, particularly in America. Fig. 1 shows the structure of silicon or germanium crystals. Each atom has four neighbours, all

*South East London Technical College.
†Twickenham College of Technology.

at the same distance from it, and all at equal distance from each other. Each atom and one of its neighbours is attached by an electron pair bond, which consists of sharing two electrons to form a stable bond. Each atom has four electrons available to form bonds (valence electrons), therefore the conditions are exactly right for the diamond structure of Fig. 1.

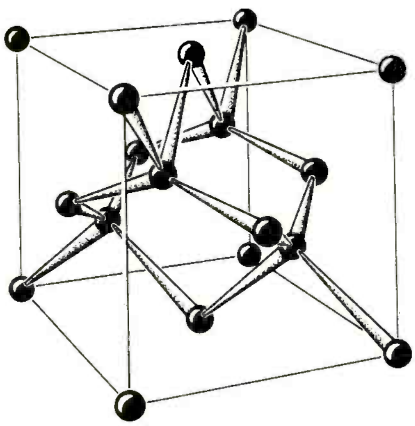


Fig. 1. The crystal structure of germanium and silicon.

The electronic properties are also dependent upon the electrons present in the bonding. By introducing impurities into the crystal the bonding can be modified. Therefore, the electronic properties can be tailored as required by the controlled addition of impurities. The unoccupied bonds on the extreme edge of a perfect crystal cannot be used by internal atoms, but they are capable of accepting electrons. These are called acceptor or surface states. Crystal defects and absorbed foreign atoms will have similar effects and also create surface states. It was the thorough investigation of these states that led to the somewhat accidental discovery of the transistor effect. It is strange that surface states are now something to be avoided in transistor manufacture, because they would provide a low impedance path to current flow that is controlled inside the material.

Amplification using semiconductors was first achieved by using the negative resistance characteristic of thermistors. As the current through the thermistor increased, the heat generated caused a reduction in the resistance, and hence a drop in the voltage. The frequency of operation is limited by the temperature which has to follow the current changes. However, by making the physical dimensions small and the thermal conductivities high, oscillations of up to 100kHz have been produced. Bell Telephone Laboratories' aim after the war was to produce a purely electronic, rather than thermal, semiconductor amplifier. The work was initiated by W. Shockley who directed work on investigating the modulation of the conductance of a thin film of semiconductor. The conductance was controlled by an electric field applied by an electrode insulated from the film. It was hoped that the conductance would be modified by changes in the surface states caused by the applied field. The experiment gave disappointing results, since only about 10% of the expected change in conductance occurred. The effect was explained by J. Bardeen who in 1947 proposed a double layer at the surface, formed by the charge in the surface states and the induced space charge. Further research was carried out to measure the characteristics of the surface states.

The transistor discovered

The effect of having the crystal surface immersed in a liquid was studied. The characteristics of a high-inverse voltage germanium rectifier with a field applied by an electrolyte were investigated by J. Bardeen and W. H. Brattain. They proposed that a portion of the current was being carried by holes flowing near the surface. When the electrolyte was replaced with a metal object, transistor action was discovered. The discovery was first published as a short letter to the editor of the *Physical Review* journal in July 1948. This marked the beginning of the transistor era. A more detailed paper was published in the following year.

The transistor is a semiconductor triode amplifier. The prefix "trans" designates the translational property of the device, while the root "istor" classifies it as a circuit element in the same general family with resistor, varistor, and thermistor. The transistor was commercially made in a similar form to the point contact diode, except for a second cat's whisker mounted very close to the first. The device is shown schematically in Fig. 2. A germanium ingot was

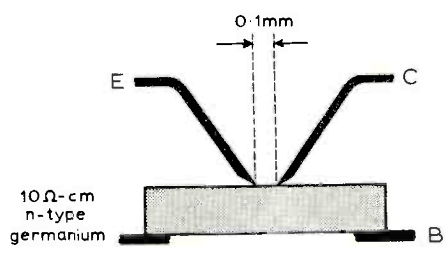


Fig. 2. Schematic of the point contact transistor.

prepared in the same manner as that used for the high inverse voltage diodes, and then a slice of this ingot was ground flat on both sides. The slice was copper-plated and tinned on one side, and diced into small squares with a diamond wheel. One of these squares was then sweated onto the brass base plug and the germanium surface treated. The unit was force fitted into a cylindrical cartridge, which had been shaped to accept the contact assembly. The contacts consisted of two 0.005in phosphor bronze wires, which had been bevelled and polished.

The characteristics of the thermionic diode and the semiconductor diode are fairly similar, and methods of adding a "grid" to control the current in the forward direction as had been achieved with the triode, were looked at. The transistor, however, is not operated in this quadrant, because the output is reverse biased in the high resistance direction. The current is enhanced and controlled by the forward biased emitter contact. This device was designated the type A transistor to distinguish it from possible future varieties. The transistor effect is the injection of holes into the n-type material by the emitter, which are collected as an increment of the collector current. The common terminal called the base electrode is physically the base of the crystal. Devices which operate on different principles, such as the field effect, have since been called transistors. Therefore, transistor electronics is used generally to describe the art of controlling electron movements in a solid, hence is sometimes called solid state electronics. One of the first point contact transistors to be manufactured in the United Kingdom is illustrated. The patent numbers

The G.E.C. crystal triode type GET 1, one of the earliest point contact transistors to be made in the U.K. The reverse of the packet, shown here with the transistor, carried a warning "To prevent permanent damage to the triode, it is recommended that whenever possible d.c. limiter resistors be placed in series with both emitter and collector . . . Great care should always be taken to connect supplies of the correct polarity to the electrodes."

show the advantage of a strong development facility, by using experience gained in the construction of point contact diodes to help in the manufacture of transistors. Patent number 591092, which was applied for in 1945, describes a method for holding the contact in place after construction. This is achieved by filling the cartridge with a wax-like substance which will harden on heating. The other patent number, 592659, was applied for in 1941, and deals with the preparation of the crystal and the subsequent treatment of its surface. The germanium had to have a spectroscopic purity of 99.95% for good results.

Transistor amplifiers

The journal *Audio Engineering* published an article in August 1948 entitled "Experimental Germanium Crystal Amplifier", only one month after Bardeen and Brattain's original letter. This described how to construct a germanium crystal amplifier—such was the rate of progress even in 1948. The article highlights the similarity between point contact diodes and the type A transistor because the construction starts with two diodes. They are dismantled and the crystal used, with the two whiskers carefully adjusted on the surface. Difficulty was experienced in finding active spots, due to the relatively impure crystals being used at that time. Manufacturers were aware of the need for high quality germanium. In 1946 the first extraction plant in the United Kingdom was built at Brimsdown for Johnson Matthey for the bulk production of germanium and other semiconductor materials.

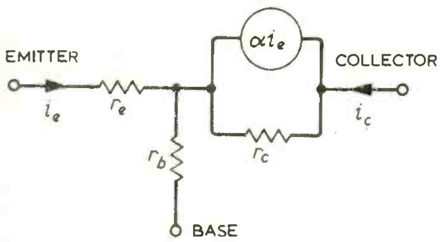


Fig. 3. Equivalent Tee circuit of a transistor.

The type A transistor can be represented by the equivalent circuit shown in Fig. 3, with the following average values for its parameters:

emitter resistance $r_e = 240\Omega$

base resistance $r_b = 290\Omega$

collector resistance $r_c = 19{,}000\Omega$

amplification factor $\alpha = 1.8$

Unfortunately the active area of the device is very small and hence the collector dissipation is only about 0.2W, although a power gain of 17dB with a power output of 5mW was achieved. The small size of the device, however, gives it a wide frequency response, with an upper limit of approximately 10MHz. It was soon noted that the transistor could be greatly improved by passing large reverse currents through the collector point. This technique, called forming, resulted in amplification factors as high as 5. This process was explained by the formation of a p–n hook at the collector which reduced the height of the potential energy hill at the collector, so allowing a considerable increase in the number of electrons diffusing from the collector into the floating p region.

The movement of holes was thought to be mainly confined to the surface region but in 1949 J. N. Shive proved that the flow of charges could be through the bulk of the material. This was shown by constructing the double surface transistor, which was produced with germanium in the shape of an acutely tapered wedge, the two contacts being opposite each other near the thin edge. This transistor was developed into the coaxial transistor which was much easier to manufacture. Here the germanium was cut into a pill shaped cylindrical wafer with a dimple ground into the centre of both sides, so that the thickness of the centre was only a few thousandths of an inch. The emitter and collector contacts then bear on opposite sides of the semiconductor in the dimples, and are arranged coaxially to fit into a cartridge. This method of construction avoided the problem of placing two spring contacts within a few thousandths of an inch of one another. The components used were similar to the parts used in the manufacture of point-contact rectifiers.

Junction transistors

In 1949 W. Shockley proposed that transistor action could be achieved with p-n junctions within a single crystal, thus breaking away completely from the surface effects of point contact devices. The device was therefore called a junction transistor. In principle it consisted of a bar of single crystal n-type germanium, for an n-p-n device. In the centre of the bar was formed a thin layer of p type germanium as part of the single crystal. Ohmic non-rectifying contacts were attached to each of the three regions, the outer two being the collector and emitter and the centre the base. The method of operation is essentially the same as the point contact, hence the electrodes have the same names, although the base is now in the middle. The equivalent circuit chosen for comparison is the same one as used for the point contact i.e. Fig. 3; the new values for the parameters are:

$$r_e = 25\Omega$$

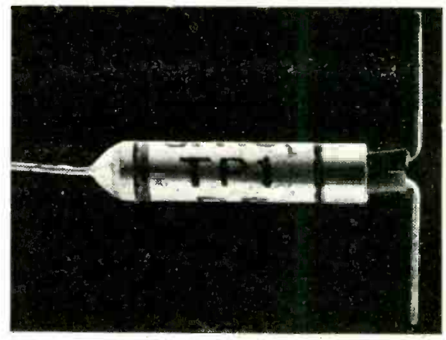
$$r_b = 250\Omega$$

$$r_c = 5\times10^6\Omega$$

$$\alpha = 0.95$$

The amplification factor α for junction transistors is less than unity, hence the amplification in common-base operation is due to the difference in impedance levels. A junction transistor was developed with a p-n hook collector, which acted similarly to the point contact transistor as far as the gain was concerned. This was achieved by a four-layer p-n-p-n device, but the transistor had a poor high-frequency response. Little further work was carried out, even though high amplification factors were obtained.

The first junction transistors were a great improvement over the point contact devices. Power gains of 40dB, with class A operation of 49% efficiency were achieved against 23dB gain and an efficiency of 30% for point contact transistors. The higher power gain is due to the increase in the output impedance, and the almost ideal characteristics show that the junction transistor can operate close to the 50% maximum for a class A amplifier. Junction transistors will operate with extremely low input power of around 0.6μW. This is about one ten-thousandth of the power required to operate the point contact transistor, or one millionth of the power to heat the cathode of a typical thermionic valve. Unfortunately the frequency of operation at that time was limited to about 1MHz. This was due to the time taken for the charge carriers to diffuse across the base. The equivalent effect in thermionic valves is the transit time, that is, the time taken by the electrons to travel from the cathode to the anode. The type of case used by S.T.C. for an early junction



The S.T.C. point contact transistor TP1 appeared about the same time as the G.E.C. GET 1. It was soon withdrawn and replaced by the TS 1, a junction transistor.

transistor is shown in the photograph. Although the TP1 device shown was a point contact transistor, it was made at the same time, and externally looks identical to the TS1 junction transistor.

Several methods have been used to improve the high-frequency response of junction transistors. The most obvious answer is to reduce the base width; this is limited, however, by the problem of punch through. A second contact added to the base by Wallace *et al* in 1952 effectively reduced the base area and the base resistance. This increased the cut-off frequency to about 50MHz. Further improvements were realized by advances in material technology, in particular by the diffusion process which started in 1952, and by the production of extremely pure silicon. The purification was achieved by zone refining. This process is based upon the relatively high rate of diffusion of impurities in the molten zone of a crystal, compared with the much slower rate in the solidification zone. The raw single crystal is passed slowly through a localized radio-frequency heating coil. The crystal within the coil is in the molten state, and on passing through the coil re-solidifies into a single crystal again. The impurities tend to remain in the molten region and therefore are swept to the end of the crystal. The process is repeated several times. The end with the impurities is discarded and the concentration of impurities in the main section can be reduced to about 10^{17} atoms/cu.m.

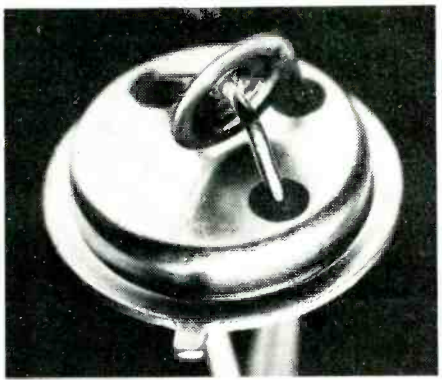
Field effect

The field effect transistor experiments that failed were the beginning for the point contact and junction transistors. In 1952 W. Shockley proposed a unipolar field effect transistor which overcame the earlier problems of surface states. The point contact and junction transistors are called bipolar because charge carriers of both signs are involved. In the field effect the controlled conductance between input and output terminals results from changes in the number of carriers of one type, hence the name unipolar. The field effect transistor has several advantages, the most important being the high input impedance. The input is a reverse biased p-n junction, and the depletion layers created control the conductance through the channel. The difference in operation is reflected in the names for the electrodes, the emitter and collector being called the source and drain respectively. The controlling electrode is now called the gate instead of the base. It was not until fairly recently that the technology needed to be able to mass produce these devices has been developed. In the meantime the junction transistor has built up a commanding lead.

Circuit design

Early work on transistor circuit design tended to start with a well tried thermionic valve circuit, and then modify it for use with transistors, even though the parameters are radically different. The grounded cathode triode is a voltage amplifying device with a high input impedance and a relatively low output impedance. Conversely the grounded base transistor is a current amplifier with a low input impedance and a relatively high output impedance. The early papers on transistor circuit design referred to the transistor's characteristics as peculiar, because they were different to those of a valve. On looking further at the parameters, it was noted that, if the roles of current and voltage were changed over, the devices were similar enough for quantitative designs starting from the valve circuits. This background led to the circuit performance of transistors being less than they might have been, until designers began to take account of the transistor's peculiarities and use them to advantage. One of the major advantages which would be unheard of with valves is the use of complementary circuitry, allowed by having n-p-n and p-n-p transistors.

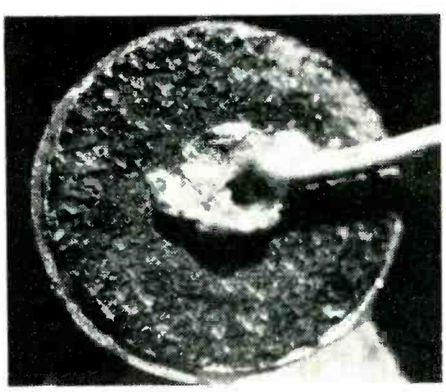
The small size and ruggedness of transistors opened new fields and their small power requirements meant that the components used with them could be miniaturized also. The type A transistor of 1949 occupied one-fiftieth of a cubic inch, with a collector voltage of 30V. In 1952 the junction transistor could be fitted into one five-hundredth of a cubic inch with a collector voltage of 2V. Bell Telephone Laboratories studied the problem of manufacturing complete circuit packages under an American Signal Corps contract in 1952. At that time the package of a laboratory circuit model required about one-tenth the space and power of an equivalent package built with thermionic valves. The importance of designing sub-sections of a system, which would be used in quantity, and manufacturing them as packages was realized from the beginning of the transistor's development, and has been a goal ever since.



A modern germanium alloy junction transistor still in production at Newmarket Transistors. The emitter lead is in the foreground and the base lead at the right connects to a metal disc in which the semiconductor pellet is held.

The general manufacture of transistors began in 1952, after Bell Telephone Labs. held a symposium, where they offered know-how to all who wanted it for the price of an admission ticket ($25,000). The era of the practical transistor had now begun. Photographs show the construction of an early alloy junction and the progress achieved since then by comparison with a modern alloy junction transistor. The successive developments to improve the parameters and to find transistor structures, which lend themselves to easier manufacture are related in part 2 "The search for the best transistor". The originators of transistor electronics, J. Bardeen, W. H. Brattain and W. Shockley were awarded the Nobel prize for physics in 1956 in recognition of their work in the theory of semiconductors, when it was beginning to be recognized that they had not just invented the transistor, but had laid the foundations of the world-wide multi-million pound microelectronics industry.

(To be continued)



A photomicrograph of an early medium power germanium alloy junction transistor. The pellet of impurity and the emitter lead connected to it are clearly shown in the centre of the picture.

Bibliography

1. "The amplifying crystal", *Wireless World*, October 1948.
2. Bardeen, J., "Surface states and rectification at a metal semiconductor contact", *Phys. Rev.*, 71, pp. 717–727, 15 May 1947.
3. Bardeen, J., and Brattain, W. H., "The transistor, a semiconductor triode", *Phys. Rev.*, 74, pp. 230–231, 15 July 1948.
4. Shockley, W., "The theory of p-n junctions in semiconductors and p-n junction transistors", *Bell. Sys. Tech. Journ.*, 28, pp. 435–489, July 1949.
5. Shockley, W., "Electrons and holes in semiconductors", Van Nostrand, 1950.
6. Morton, J. A., "Present status of transistor development", *Bell Sys. Tech. Journ.*, 31, pp. 411–422, May 1952.
7. North, H. Q., "Properties of welded germanium rectifiers", *Journal of Applied Physics*, pp. 912–923, Nov. 1946.

Sixty Years Ago

An uneasiness in the Marconi Company when share prices fell considerably is reflected in a statement issued by the company and reproduced in the January 1913 issue of *The Marconigraph*. It referred to opinions which had been expressed suggesting that "continuous waves would in the future supersede the spark system". The announcement from the secretary of the comapny continued "As these statements and opinions are liable to mislead shareholders and cause them some uneasiness, I am instructed to inform you that Mr. Marconi himself tested continuous wave systems many years ago, and experimented with them during the greater part of 1907 at the Poldhu station. As a result of these experiments he learned the advantages and disadvantages pertaining to continuous waves, and eventually arrived at a compromise between the continuous wave and spark systems, combining the best points of both. This resulted in material changes in his system for long distance work, and new and important improvements were patented by him in 1907, which are mainly responsible for the progress since made in long-distance wireless telegraphy. These inventions, which materially modify the spark system, seem to be surprisingly little known, notwithstanding the lectures delivered by Mr. Marconi .... when he made statements relating to the use he was making of continuous waves, semi-continuous waves and the elimination of the spark."

Corrections

L. Nelson Jones, author of the article "I.C. Peak Programme Meter" in the November 1972 issue, has informed us of an error in the specification of the meter. The scale marking division seven represents a level of +12dBm (not 14dBm) with a peak input voltage of 4.38V. The undefined f.s.d. reading usually corresponds to around 5.37V peak. This calibration fault is easily corrected by changing the value of R_{14} to $100k\Omega$, and Key Electronics, suppliers of the kit, are sending all those who have kits, a replacement resistor together with a copy of the amended handbook.

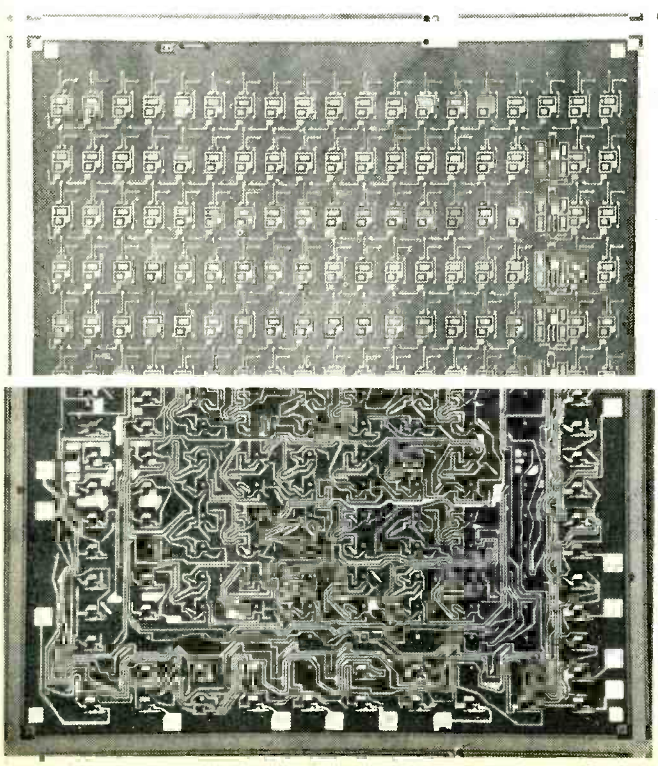
We regret an error exists in the circuit diagram (Fig. 1) of the **"Mobile/Portable Power Unit for H.F. Transceiver"** published in our December issue. The conductor between the base terminal of transistor Tr_2 and ground should be omitted otherwise the catastrophic failure of this device will occur.

News of the Month

New i.c. concept

The development of integrated circuits from the first small devices to the latest l.s.i. techniques has been recorded in the pages of this journal over the past few years, and now Ferranti have added to the extensive range of application techniques available to the designer. In 1969 an announcement was made concerning a new process called collector diffusion isolation (c.d.i.), a technique using bipolar devices and an isolation technique based on the diffusion of isolation areas in a p-type substrate. First discovered by Murphy and Glinski of Bell Laboratories and reported in *Wireless World,* Nov. '71 issue, it has significant advantages over m.o.s. since only five masking operations are required. A typical cross-section of a c.d.i. structure reveals two more significant features. First the power and earth connections are made through the semiconductor material itself, thus eliminating the need for multi-layer aluminization to provide for these connections, and second, all signal connections can be made in the single final layer of metal.

Such a structure lends itself ideally to the new concept from Ferranti; that of an "uncommitted" logic array (u.l.a.) which is illustrated in the top half of the accompanying split photograph. The u.l.a. consists of 200 bipolar devices without the final metal connecting layer. From this a custom-built i.c. can be produced quickly and cheaply by adding an aluminium connecting layer to suit any logic design requirement. By standardizing the type and number of resistive elements and leaving these also in an uncommitted state, simple linear circuits can be additionally devised, thus giving greater versatility. An example of the appearance of the u.l.a. after the metal layer is applied is shown in the bottom section of the photograph. The technique is very much cheaper for short production runs than l.s.i., though if the demand should rise unexpectedly for any particular unit, it becomes a very simple matter to convert to conventional l.s.i. techniques. For about £1250 Ferranti can undertake to produce five tested prototype samples to a customer's own logic requirements, full production prices being from £12 to £20 dependent upon quantity. The value of this system lies in the fact that u.l.a. slices can be stockpiled and small quantity runs below 100 readily produced at economical prices. Applications are seen in coin vending machines and automatic machine control among a variety of others. The final package can be made available in 24, 28 or 40 pin moulded or ceramic d.i.l.



Logic array shown in an uncommitted format (top) and after the final metal array has been added.

Etching solution controls i.c. windows

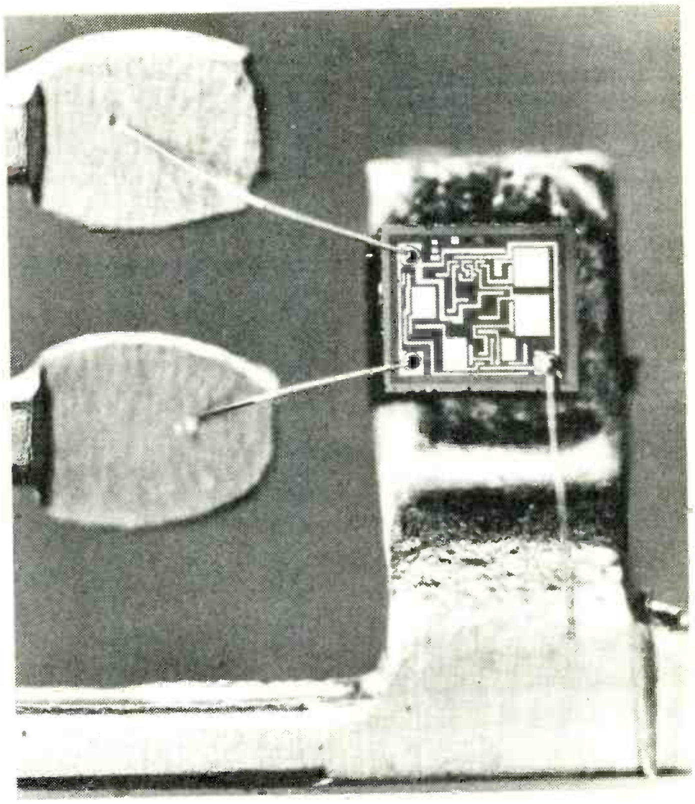
A solution to control the etching angle and depth of deeply etched areas in silicon wafers, has been developed by Bell-Northern, of Ottawa, Canada. Silicon wafers form the base material for most integrated circuits and normally the etched bottom is flat or slightly concave and the cross-section is often enlarged or cut away by lateral undercutting of the mask. With the new etching solution the sides of the etched "window" or "well" are substantially straight and normal to the surface of the main body of material. In addition, the profile of the bottom of the etched area can be varied from slightly convex to a situation in which the edges are etched into deep grooves, while limited etching occurs in the central portion, depending on the etchant composition. By varying the amount of arsenic trioxide in the etching solution (refluxing orthophosphoric acid), the preferential etching can be varied considerably. Increasing slightly the quantity of trioxide will change the profile from concave to a centre "island" surrounded by deep grooves. At a certain point of concentration, the solution starts to leave the surface pitted and preferential etching substantially disappears.

The deep grooving effect would lend itself to electrical isolation since grooves can be etched down to a p-type layer through an n-type epitaxial silicon layer. One of the advantages is that the wall goes down straight regardless of the crystal orientation of the silicon. Oxidation of the silicon wafer after the preferential edge etch results in the grooves being completely filled with silicon dioxide and hence provides dielectric isolation of adjacent devices.

Components Board reorganized

The Electronic Components Board is being reorganized and, with effect from 1st January, the constituent associations responsible for active electronic components cease to exist as separate entities. The two Groups of VASCA,* covering professional valves and tubes and semiconductor devices, become product groups of the new organization, and a third product group will be responsible for domestic valves and television tubes, taking over the function of the B.V.A.† There will be two categories of members, (a) direct members, being companies engaged in the U.K. in the manufacture and sale of electronic components, and who are approved by the council of the Board, who will pay a subscription direct to the E.C.B. and (b) corporate members, who will be members of the Radio and Electronic Component Manufacturers' Federation, which will pay a block subscription to the E.C.B. on their behalf. The R.E.C.M.F. will therefore continue as a separate autonomous but affiliated, organization. The recently appointed chairman of the E.C.B. is Sir Ronald Melville.

·Electronic Valve & Semi-conductor Manufacturers' Association.
†British Radio Valve Manufacturers' Association.



Latest Ferranti c.d.i. chip, type ZN414 pictured here can be used as the basis for a simple t.r.f. receiver. Circuit shown provides 70dB of power gain, consumes 1mA and with 30% modulation has a distortion of 2%. The collector diffusion isolation process developed by Ferranti is a bipolar technique, which also has the low-cost production advantage of m.o.s. i.cs — see page 526 November 1971 issue.

London Component Show

Space applied for at the London Electronic Component Show to be held at Olympia, for four days from 22-25 May this year, already accounts for two-thirds of the total space available. The number of companies from whom applications have been received to date is approximately 300. Providing an indication of the wide appeal of the show is the number of exhibitors, at present totalling over 60, who will be making their first appearance at the show. Overseas representation to date, approximately 20% of all intending participants, includes exhibitors from Austria, Canada, France, West Germany, Holland, Hungary, Italy, Switzerland and U.S.A. and the U.S.S.R.

The 1973 show will be the 23rd in the series and the third since it went international. As the first major United Kingdom professional electronics exhibition to be held after the formation of the expanded European Economic Community, this event should play a major part in stimulating and consolidating overseas trade. The London Electronic Component Show is sponsored by the Radio and Electronic Component Manufacturers' Federation and is organized by Industrial Exhibitions Ltd.

Thin film laser switch

A light switch for use with lasers has been devised by Bell Laboratories scientists. The switch may be useful in future tiny optical circuits for placing phone calls and other information on a laser beam, capable of carrying many times more information than the present transmission media, such as wire conductors, coaxial cable and microwave radio links.

The magnetically controlled switch, which can modulate light passing through a thin, single-crystal garnet film, could form the heart of a miniature circuit in an optical communication system. The light switch measures about ¾in across in its present experimental form, but could be made even smaller. The main components of the switch are a magnetic thin film of single crystal garnet through which the light is guided, and a tiny electric circuit used to impose the required information on the light beam. When a minute current is passed through the circuit a magnetic field is produced which causes the light beam in the film to change its polarization and hence the direction in which the light is refracted as it is coupled out of the film by means of a prism. Information can be impressed or coded on the light beam by switching the beam in or out of its original path in a controlled pattern of light pulses.

Two videophones have been incorporated in the communal aerial television system installed at the Teleng factory in South Ockendon.

Super heat conductors for i.cs

The principle of heat pipe operation has been known for a long time but only recently have production problems been overcome, resulting in a variety of forms and applications. Jermyn Manufacturing have introduced a range of super heat pipes, plates and strips all working on the heat pipe principle. When one end of the pipe is heated, a fluid in the pipe evaporates and travels along the tube to its cooler end. There it condenses (giving up its heat to a suitable heat dissipator, such as a heat sink attached to the pipe) and the condensate returns to the hot end of the pipe by capillary action. A cyclic process is thus set-up, which will continue as long as there is a small temperature gradient between the ends of the pipe. This process is efficient, with a temperature gradient down the pipe of 2.5°C per foot. The main manufacturing problem has been the extreme cleanliness necessary in fitting an internal fine mesh "wick" to produce the capillary action. Super heat plates, strips, sinks etc, all operate in exactly the same way. A heat plate for example may be considered as a heat pipe squashed flat. The result of this is a tendency to equalize the temperature of the whole area of the plate (the temperature gradient across its surface not exceeding 0.5°C). An interesting application of this high-efficiency heat radiator has been made by Jermyn, who are producing flat, thin strips of heat conductors on which arrays of integrated circuits can lie to ensure uniform operating temperature of all the devices.

Europe's first geostationary satellite

A group of major European companies, the Star Consortium, led by British Aircraft Corporation Electronic and Space Systems, has been awarded a new satellite contract by the European Space Research Organization following two years of competitive studies. The contract, worth £254,000, is for the detailed definition study of GEOS, Europe's first geostationary satellite. The study will last three months, and lead to the award of the main development contract to the Star Consortium. B.A.C. is the prime contractor. GEOS is programmed for launch in 1976, when it will carry scientific experiments into geostationary Earth orbit 22,300 miles above the equator to measure d.c. and a.c. electric and magnetic fields and also particle densities and distributions.

Giant mobile transmitting and receiving mast

One of the problems associated with outside broadcasting is beaming signals clear of local obstructions. To cope with this problem, Eagle Engineering, of Warwick, have designed two 100ft masts to meet requirements made by the B.B.C. The masts are for use mainly in the London region and are the tallest mobile units in the U.K. suitable for microwave link. Each mast is in four telescoping sections. The lower pair are extended by the action of a hydraulic ram, the upper pair by means of a system of differential cables and pulleys. With two 4ft diameter microwave dish aerials and associated transmitters mounted on the masts – without the use of guy cables — the maximum safe operational wind speed has been shown to be in the order of 35-40 m.p.h.

Transmitters for independent radio stations

The first group of independent local radio stations recently announced by the Independent Broadcasting Authority is to go on the air with transmitters of standard design. The order, placed with Marconi's, is for the supply of a total of .47 transmitters; eight pairs of 1kW v.h.f./f.m. and 21 1kW m.f. units, two 125W v.h.f./f.m. pairs and six 10kW m.f. equipments. All the transmitters are standard Marconi units and those operating in pairs will have automatic changeover facilities. From the first consideration of the commercial broadcasting network, both m.f. and v.h.f. coverage were considered essential, and all five of the designated new stations will broadcast simultaneously on v.h.f. and medium frequencies. An eventual total of 60 independent radio stations will cover an estimated 75% of the population of the country.

International Apprentice Competition

The United Kingdom will be sending a team of craft apprentices to the International Apprentice Competition in Munich during August 1973. Among the crafts represented in the British team will be industrial electronics and television servicing. The U.K. Steering Committee is now accepting entries for the initial selection competitions. Enquiries and application forms for entry may be obtained from Mr. C. A. Thompson, City of Bath Technical College, James Street West, Bath BA1 1UP. There is a £10 entrance fee for each initial selection competitor.

B.B.C. local radio transmitting stations

The following table lists transmitting frequencies, radiated power and polarization of the B.B.C. m.f. and v.h.f. local radio transmitting stations. Powers marked with an asterisk are to be increased at a later date and the carriers of several v.h.f. stations will change during the next few months, as indicated in the last column. In addition, the m.f. services at Derby and Nottingham will open later, as will the v.h.f. and m.f. service of Radio Carlisle.

		m.f.			v.h.f.		
Station	Metres	MHz	kW	MHz	kW	Poln.	MHz (later)
Birmingham	206	1.457	1*	95.6	5.5	H	
Blackburn	351	0.854	1*	96.4	1.5	S	
Brighton	202	1.484	1	95.8	0.5	H	95.3
Bristol	194	1.546	2	95.4	5.0	H	95.5
Carlisle	397	0.755	—	95.6	5.0	H	
Derby	271	1.115	—	96.5	5.5	S	
Humberside	202	1.484	2	95.3	4.5	H	96.9
Leeds	271	1.106	1	94.6	0.14	H	92.4
Leicester	188	1.594	0.5	95.2	0.3	S	95.1
London	206	1.457	20	95.3	16.5	H	94.9
Manchester	206	1.457	1*	95.1	4.0	S	
Medway	290	1.034	1	97.0	5.5	H	96.7
Merseyside	202	1.484	2	95.8	5.0	H	
Newcastle	206	1.457	2	95.4	3.5	H	
Nottingham	197	1.520	0.5	94.8	0.3	S	95.4
Oxford	202	1.484	0.5*	95.0	4.5	H	95.2
Rotherham	—	—	—	95.05	0.01	H	
Sheffield	290	1.034	1	88.6	0.03	H	97.4
Solent	301	0.998	1	96.1	5.0	H	
Stoke-on-Trent	200	1.502	1	94.6	2.5	H	96.1
Teesside	194	1.546	0.25	96.6	5.0	H	

A.P.A.E. annual exhibition

The annual exhibition of the Association of Public Address Engineers is to be held at the Bloomsbury Centre Hotel from 13-15th March. It opens on the Tuesday morning at 12.30 and closes at 6.00 p.m. On subsequent days the doors open at 10.00 a.m. This year is the 25th anniversary of the A.P.A.E. and a number of historical exhibits will be shown from the Association's collection. Lectures will be given at intervals in the City room. Tickets are available free of charge from exhibitors or the secretariat, 6 Conduit St., London W1R 9TG.

B.B.C. exhibition

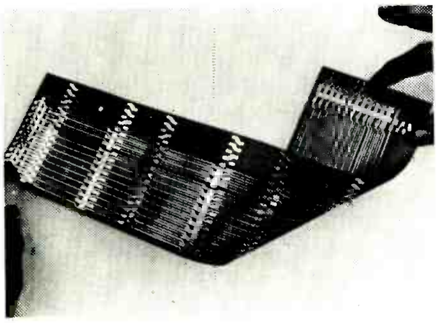
A final "news-worthy" note is that well over 65,000 people visited the technical exhibition staged at Mullard House, London, to commemorate the B.B.C's 50th anniversary.

Electronica in Retrospect

An impression of this biennial exhibition

After 63,000 visitors had visited the seven-day exhibition of the international electronic components industry, held at Munich in November, it closed and was voted a great success by most who participated. Held biennially, each event has been a little larger, a little better. The variety of products shown makes it difficult to select any particular aspect, but probably one of the most visually striking was the increasingly important part that light is playing in all areas of electronics. Evidence of this was seen on such stands as Jena Glaswerk Schott & Gen and Corning Glass, who were displaying a range of optical glasses and, more importantly, several examples of fibre optic applications. Light-emitting diodes were very much in the forefront of many of the semiconductor manufacturers' product displays and these appeared in a variety of colours from the commonly available red to yellow and green.

Plessey, who were strongly represented in a large and elegant stand, were demonstrating a high brightness yellow l.e.d. generating 34,000 cd/m^2 at a current of 250mA. Ferranti, showing products in two of the halls, were demonstrating their own expertise in producing green and red emitting GaP material ready for packaging into individual lamps or segment displays. Other examples of the use of l.e.ds were to be found on the Siemens and Texas Instruments stands where a range of opto-electronic couplers, consisting of an l.e.d. and a photo-transistor sealed in a common package, were shown. These devices find common application where a degree of isolation is required between t.t.l. systems and the ground potentials, or to drive s.c.rs controlling power machinery. Another interesting application is inclusion of opto-isolators in the feedback elements of a switching mode power supply, where error signals can be safely returned to the early stages of the control unit which may be affected by fluctuations originating in the mains supply.



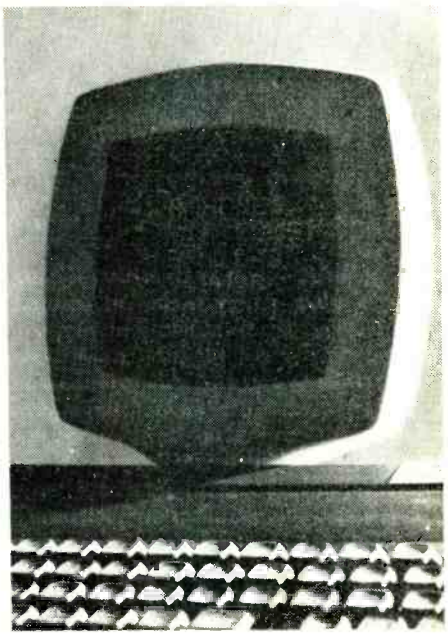
Typical of a large number of printed circuit types was this flexible version produced by Schoeller & Co. Electronik GmbH.

Several stands featured displays of laser equipment, much being designed for educational experimental purposes. An interesting application demonstrated by Spindler and Hoyer KG was the use of an optical laser measuring bench for improving the definition of electron microscope photographs. This idea involves the illumination of a transparency by a coherent light beam from a laser; the transmitted light then undergoes an optical Fourier transform followed by spot frequency filtering and a second transform to reconstitute the image. By selection of the spot frequency filters, definition of any particular aspect of the original picture can be improved.

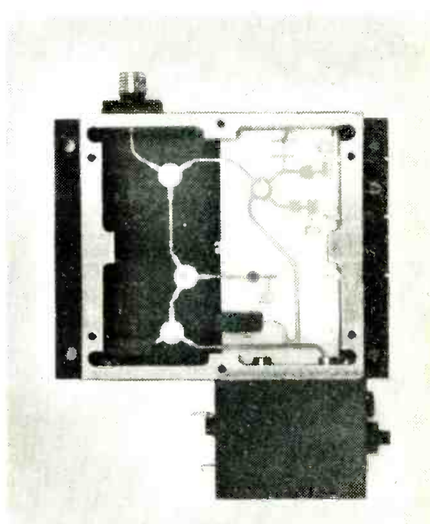
Larger display units

A flat panel display unit shown on the Thomson-CSF stand attracted considerable interest, as did several other products from this company. Called the Pavane panel, it is available in three principal forms – as a high resolution display with 400 points per square centimetre (illustrated) and suitable to accommodate from 200 to 2000 characters, or in a semi-transparent form with a rear face available for the superimposition of projected images, or in a two- or three-colour unit of medium resolution. Having a high writing speed and digital X-Y access, the panel is also suitable for two-way computer "dialogue" with a light or electric pen.

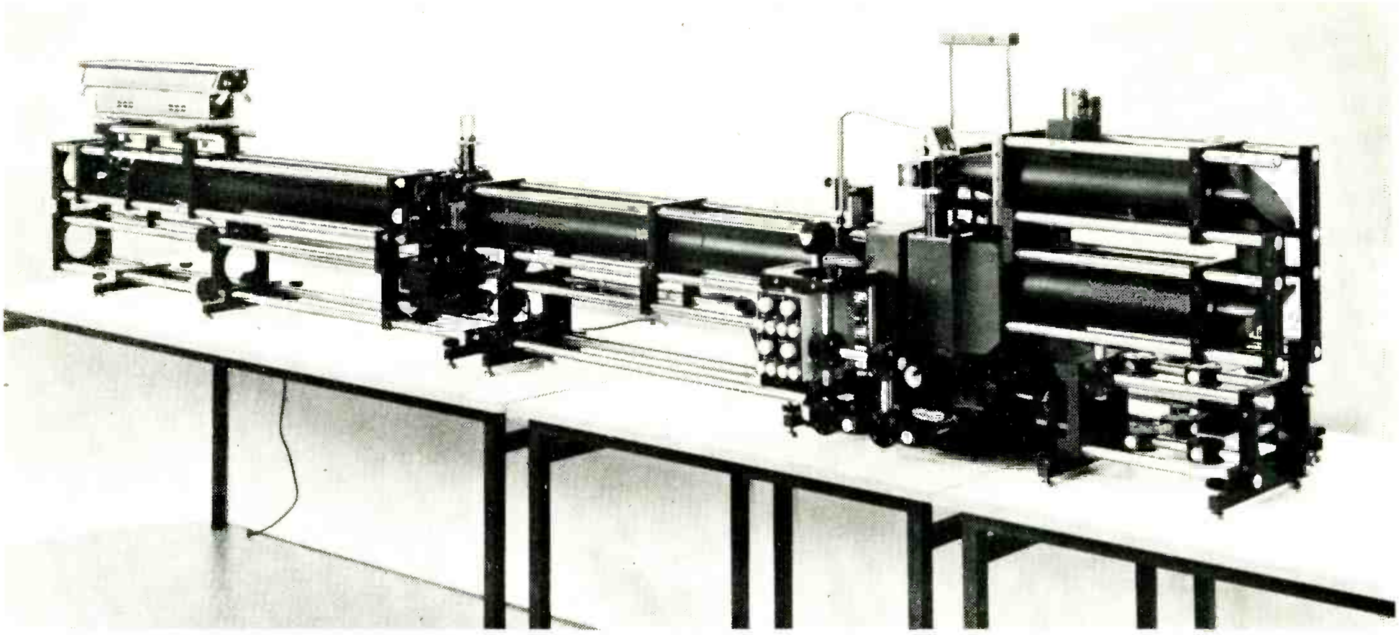
Also shown on the stand was a novel display tube with what is called a multi-colour penetration screen. Since the resolution and brilliance of conventional shadow mask tubes are somewhat limited for instrumentation applications, a new technique has been developed where three layers of material are coated on the inside of the tube face. These consist of two



An example of the Pavane panel used as a computer terminal readout device.



Typical of the new ideas in microwave integrated circuits shown at the Fair was this example from MESL.



The laser optical measuring bench made by Spindler & Hoyer

separate fluorescing phosphors of either a different colour or different persistence, separated by a barrier layer. Low energy electrons of about 9keV excite the first phosphor but are prevented from further penetration by the barrier. Higher energy electrons (17keV) will penetrate the barrier to excite the second phosphor. Using red and green phosphors, a range of colours including orange and yellow can be produced with intermediate beam energy. Tubes of this type are now being made up to a 19in size in a variety of screen coatings. A similar product was exhibited by the M-O Valve Company on the joint EEV and M-OV stand.

The Ferranti Feedraft used to automatically generate p.c. masters, i.c. masks and other drawings.

Liquid crystal display

Finally on the subject of visual display, liquid crystals appeared in several units shown around the exhibition. Notable examples were those manufactured by the joint company of Swarowski-AMI and also by Electrovac. The last-mentioned company markets the cells under the brand name Nemocell and provides two versions enabling transmitted or reflected light to be utilized. With an operating voltage of 15 to 50V and a digit height of 12mm, applications can be seen in channel number displays for television sets, digital clocks and other units where large alpha-numeric displays are desirable.

Although test instruments were not considered to be part of the components exhibition, at least one complete oscilloscope, of rather novel design, was exhibited. Made by the American company Nicolet Instrument Corporation, it is called a digital oscilloscope. Essentially it is a low-frequency storage oscilloscope making use of a non-volatile digital memory. The advantage of this form of storage is that it eliminates the danger of difficult focus or brightness settings causing potential phosphor burning, and the signal resolution is extended to one part in 4096. An X-Y plotter output is available, giving the extra facility of a permanent trace of the stored signal and an additional alpha numeric display on the screen together with a crosshair marker gives the time and voltage co-ordinates at the intersection.

Applications for integrated photodiodes were to be seen on two stands, those of the British company IPL Ltd and Ing. Erich Sommer, a distributor for Reticon Corporation of America. On both the diode arrays were being used to meet a number of needs including component measurement to fine limits and also a possible use in facsimile transmission. The IPL unit was made up as a line scan camera system consisting of a self scanned diode array mounted behind a custom lens assembly. A second unit called the driver and recharge signal processor unit couples to the camera and the only other requirement is for a d.c. supply. Arrays of 50 to 256 photodiodes can be arranged in any specified length. Reticon were also displaying linear arrays, but had extended their product range to include area arrays of up to 1024 diodes.

A useful feature of the Reticon line scanner is that the i.c. includes the shift register used to operate m.o.s. switches which connect diodes to the video line.

This report covers only a fraction of the interesting range of products at the 1972 Electronica exhibition, which, surely, now ranks in importance with the Hanover Fair.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Doppler effect in loudspeakers

Perhaps I might be permitted to sum up the recent correspondence on Doppler effect in loudspeakers.

The fact that distortion due to the Doppler effect exists in loudspeakers was clearly demonstrated nearly thirty years ago by Beers and Belar, who measured objectively the distortion from various loudspeakers when radiating pure tones, and showed that the distortion obeyed the laws they had predicted. Doppler distortion from loudspeakers has also been assessed subjectively by Moir, again using pure tones, this time in a live room, and he has shown that very small orders of distortion are audible, a figure of 0.001% being quoted for the most critical carrier and modulating frequency used. What then do we make of the statement in my previous letter that Doppler distortion from three differing types of B.B.C. monitoring loudspeaker is inaudible, even at their maximum rated powers, in spite of the fact that the distortion figures exceed that given by Moir? The difference is that I was speaking of distortion under programme conditions, not when using pure tones. It has been shown by Stott and Axon[1] that for flutter, which is just another form of Doppler distortion, the ear can be no less than 38dB more sensitive to the most critical combination of tone and flutter frequency than it is to the corresponding distortion of the most critical type of programme at the same flutter frequency (5Hz), both being listened to on a wide-range loudspeaker in a live room. This difference reduces somewhat to 29dB for a flutter rate of 50Hz which would represent roughly the lower frequency limit of most loudspeakers. These figures are enormous, but in fact they can be confirmed qualitatively by every-day experience. If we take a tape machine whose flutter is *completely inaudible* on programme, record on it a continuous tone of 2kHz and play it back, the resulting frequency modulation is not only just audible, it is *gross*, thus confirming that there is a very large difference in the sensitivity of the ear to this form of distortion for the two types of signal.

One other point should be made. In a given size of loudspeaker unit careful design will reduce the amplitude non-linearity due to the spider-surround combination or the magnetic field. No such cure is available for Doppler distortion. If the size of the cone, the frequency limits and the sound power are fixed, the level of Doppler distortion follows automatically. Curves showing the minimum sound levels for various size radiators before Doppler distortion is audible in a 2000 ft^3 room are given in a paper to be published, in the *Journal of the Audio Engineering Society*.

H. D. Harwood,
B.B.C. Research Dept.,
Kingswood Warren,
Surrey.

1. Stott, A. and Axon, P. E., *Proc. I.E.E.* Pt. B, No. 5, September 1955, 0. 643.

Feedback amplifiers

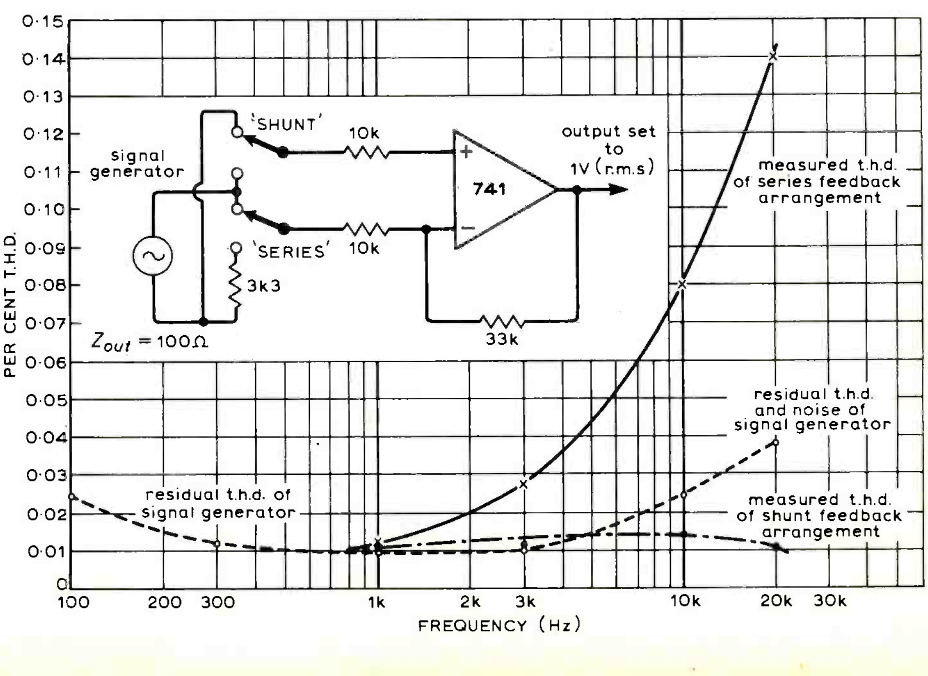
I have read with great interest the further letter from Mr Walker in your November issue (p. 520) and I would like to express my gratitude to him for the light which his analyses have cast upon the noise characteristics of feedback amplifiers, and for the several obscurities which he has resolved.

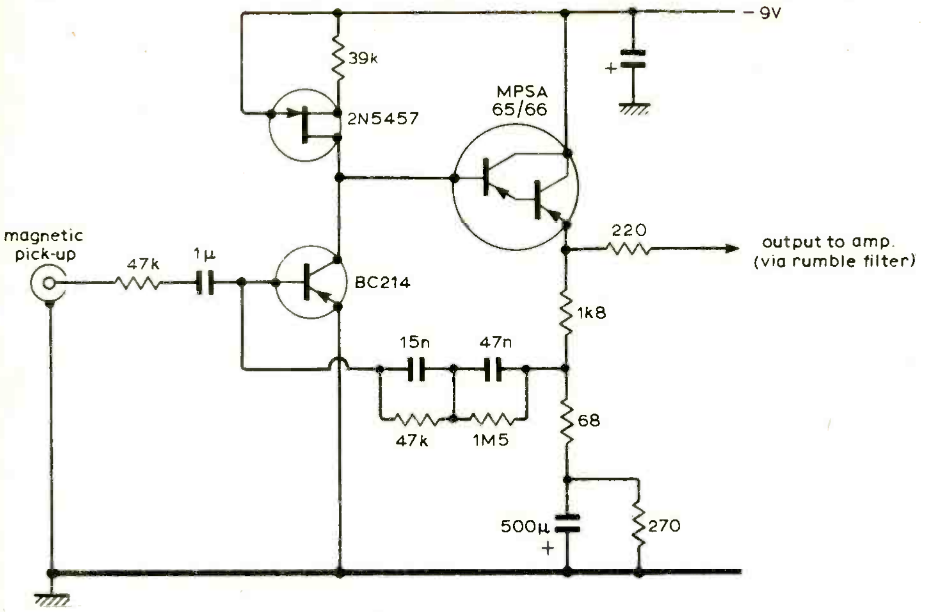
It is not in dispute that the series negative feedback configuration offers the lower noise—this is evident in practice, and is the reason why it is (almost) universally adopted in commercial 'hi-fi' equipment. The normal transistor circuit of commerce has however some snags, as pointed out by Dr A. R. Bailey[1], myself[2] and others. Since it is not in the nature of human experience that one ever gets anything entirely for nothing, even when these snags are removed by careful engineering there will still be some ways in which the series feedback arrangement (which is better in respect of input noise figure) is less good than the shunt feedback configuration (which is worse in this respect). I contend that these aspects are harmonic distortion and input (common mode) overload.

As a demonstration of the first of these points, to which I referred in my letter in the August issue as 'transfer non-linearity' between the two inputs of an operational amplifier, I have shown in Fig. 1 the performance of a 741 type operational amplifier (which has a very high—90dB—common mode rejection ratio, and an extremely high —100dB—low frequency open loop gain) as a simple $\approx \times 3$ feedback amplifier in the series and shunt feedback configurations, at 1 volt r.m.s. output. It is clear that if one set a target t.h.d. figure of 0.02%, the series feedback system would not meet this specification at frequencies above 2kHz because of common mode failure, in spite of the massive amount of negative feedback supposedly available.

By contrast, in the shunt feedback arrangement, the measured t.h.d. does not worsen at h.f. because the whole of the amplifier element is within the feedback loop. The apparent fall of t.h.d. beyond 5kHz is due to the limited h.f. response of the 741 acting to filter out some of the predominantly third harmonic distortion originating in the generator.

In the case of the input R.I.A.A. equalizing circuit using a shunt feedback arrangement, which I described in my preamplifier (July 1969) and was analysed by Mr Walker in





his May 1972 article, the characteristics for which this was optimized were low harmonic distortion (of the order of 0.01%) and effective rumble filtration, these being qualities which I judged then, and now, to be valuable. However, as an example of what can be done in getting both low noise and low distortion with a shunt feedback system, the p-n-p 'Liniac' shown in Fig. 2 (and Fig. 6b, *Wireless World* Sept. 1971, p. 439) has a measured input noise of $0.6\mu V$, a t.h.d. $< 0.02\%$, and an effective noise figure of -72dB with respect to 5mV input.

J. L. Linsley Hood,
Taunton,
Somerset.

1. Bailey, A. R., *Wireless World*, December 1966.
2. Linsley Hood, J. L., *Gramophone*, February 1971, p. 1383.

Peak programme meter

One welcomes the Nelson-Jones design for a PPM (November issue)—for in these days of universal meters on tape machines (rather than the old magic eye level indicators, which could be made to behave like a PPM) one is often in doubt as to the meaning of wildly twitching pointers. However, the design could have been made even more useful.

I would have thought it would have been comparatively easy to make the electronics play the part of the special ballistics of the specified meter. At first sight, it seems unreasonable to ask the electronics to control the overshoot of a meter point—but, in fact, there is no need. Why not slow the rate of rise of the pointer to the point where overshoot is not significant? After all, even with the correct movement—or the inertia-less magic eye—it was not possible to take any remedial action once the device had indicated 'overload'. Really the level indicator is of the 'oops sorry' variety, rather than the 'if you don't turn it down a bit it'll overload'. This latter function is an interpretive one provided by the brain. So it matters not if, say, the pointer takes half a second to reach its indication provided it gives a correct indication of what happened half a second ago.

Armed with such a circuit, one could then modify most of the flickering nasties fitted to tape machines today, to give an indication that would be useful, repeatable, and even interpretable. Back to the bench please Mr Nelson-Jones! More power to your elbow (soldering iron?).

Richard Oliver,
Denmark Hill,
SE5 8ED.

The author replies:

First, I would not entirely agree that the PPM is an 'oops sorry' device, since certainly in many recording applications the recording engineer will know what is coming either from previous rehearsal or the score, or both, and it was originally for this purpose that the new circuit was designed. I do, however, agree with you about the nasty little twitching pointers of the VU meters fitted to so many tape recorders, they make my eyes ache.

While I agree with you that because a thing is well established it is not a good reason for continuing with it if something better or simpler comes up, I would point out that the present PPM meter movement is the result of many years of practical experience both on the part of Ernest Turner Instruments and the B.B.C. and has passed the test of time and much experiment. I would point out that when monitoring with a PPM, one is not necessarily hearing the sound also, and a very slow meter movement would I think give a false impression of the sound being monitored. To make use of your idea for using normal meter movements it would be necessary to modify the circuit of my PPM unit to enable the circuit to retain the charge put into the capacitor for a period of some tens of milliseconds (irrespective of peak level), so that sufficient time would elapse before the circuit started to discharge in order that the meter could catch up. I think that the circuit complication added by this extra would probably outweigh any cost saving coming from using a cheaper standard movement. I have not so far worked out the circuit modifications needed but an initial look leads me to estimate that the circuit complexity would probably be at least doubled.

Finally I would point out that I developed the circuit given in the November article specifically to update the standard PPM, and not to attempt to improve the art as such. So sorry Mr Oliver but I shall not be going back to the bench to radically change the design just yet, as I really cannot see any advantage in doing what you suggest. To sum it up *I do believe* the meter needs a fast dynamic response to meet the needs of the recording and broadcasting engineer, just because the instrument *is* more than an 'oops sorry' device—at any rate it is to the engineers I know.

Sorry we don't agree on this, but please do not be put off trying the idea; it will certainly be better than the wildly twitching pointers to which you refer, and for applications where you genuinely do not know what is coming it may help a lot.

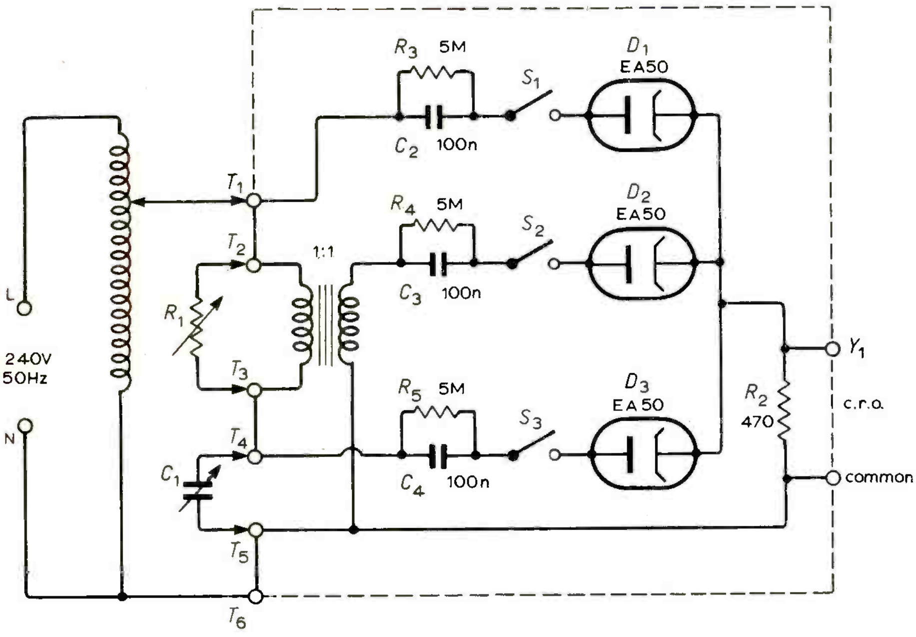
L. Nelson-Jones.

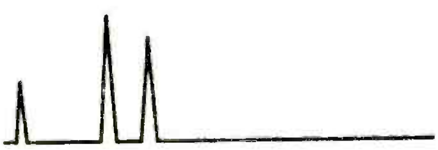
Displaying phasor diagrams

I was interested to read the article 'Displaying Phasor Diagrams' (August issue) by A. R. Carruthers and J. H. Evans. As the author of the first article quoted in their references, I congratulate them on their design. Their article reminded me of another scheme I tried after writing the article they mention. It did not attempt to display a phasor diagram on a c.r.o. but to suggest the idea of phase difference by showing changes in the displacement between pips on a horizontal timebase when the values of *R* or *C* were changed in a series *RC* circuit. The simplicity of the scheme might appeal to some teachers.

In Fig. 1, the output of a variac is applied to terminals T_1 and T_6. The components of the *RC* circuit are connected to appropriate terminals. We are concerned with three alternating voltages; V_{supply}, V_R and V_C. So that we can work with reference to a common point, we use a 1:1 isolating transformer. Each voltage is applied to a diode and an *RC* circuit; current flows through the diode only when the voltage in question reaches its positive peak value. Whenever current flows through a diode, a positive spike is developed across R_2, which is common to the three diode circuits. The timebase of the c.r.o. thus shows three spikes, the one on the left corresponding to the voltage which leads the other two. Fig. 2 shows the timebase.

When R_1 is reduced (and the output of the variac is kept constant) the amplitude of the central pip remains constant; the left





pip is reduced and the right increased. But a more important feature is that the displacement between pips changes in accordance with the changes in the phase angles in the phasor diagram.

When the equipment was made many years ago, it was convenient to use EA50 diode valves, which were plentiful just after the war. I suppose nowadays it would be more convenient to use semiconductors. As far as I remember, I used a 1–10μF decade capacitor box for C_1; and a 500-Ω variable resistor for R_1. To identify the spikes, each diode had a switch. With all switches closed, there were three spikes. If S_1 (in the circuit for V_{supply}) was opened, a spike disappeared. We could thus relate the central spike to V_{supply}.

The simplicity of the scheme might appeal to some, but a warning should be given about its use and the method I described in *Electronic Engineering* in 1951. I must confess that in the long run I was disappointed at the lack of effect of these visual aids. For my students, they did not open gates of perception previously closed: there was a mysterious black box, mysteriously drawing diagrams on a c.r.o. which had some resemblance to the mysterious diagrams in their textbooks. Two mysterious diagrams resembling one another were still mysterious. I started experimenting with v.l.f. oscillators and with coils rotating at 6 rev/min in magnetic fields, in attempts to teach a.c. theory by slow-motion demonstrations (some of which have been described in *W.W.*)

The Carruthers-Evans circuit would seem to be valuable basis for a laboratory measuring instrument and for a teaching aid in a College of Technology. My experience, in teaching a.c. theory to elementary students in a technical college, suggests that schemes for drawing phasor diagrams on a c.r.o. are not as effective as slow-motion demonstrations. But of course the two techniques are not exclusive; there is no reason why we should not start with slow-motion (using centre-zero meters) and go on to phasor diagrams on a c.r.o.

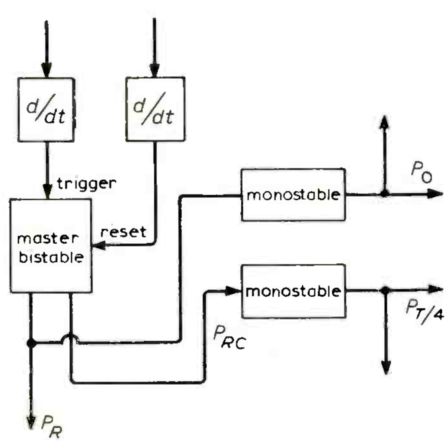
T. Palmer,
Kew,
Surrey.

The authors reply:

We thank Mr Palmer for his comments, which are clearly based on some considerable experience in teaching circuit theory. The unit described was not intended to be used as the means of teaching a.c. theory, but as a method of reinforcing what had already been taught. It was used to provide short video-tape recording inserts in lectures to demonstrate (with the aid of a black box) the 'dynamic' behaviour of real engineering circuits by variation of component values as opposed to the 'static' descriptions provided with a blackboard or overhead projector.

Regrettably two errors have occurred in the diagrams. The amended form of Fig. 3 is shown below. In the circuit of the master bistable we used a 2S745 rather than the 'overpowering' 2N1210.

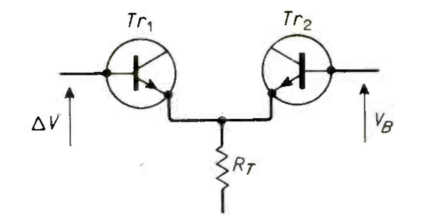
A. R. Carruthers
and J. H. Evans.



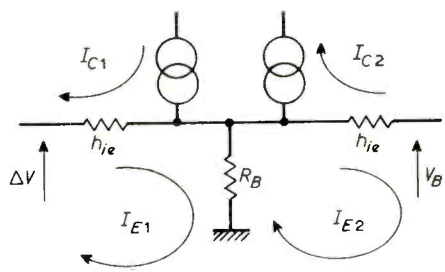
Special-purpose amplifier

Mr Cocking's interesting article on the 'long tailed pair' amplifier (June 1972 issue), raised some points on deriving the input resistance of such an amplifier.

There are two main approaches to the problem. The first is to derive an expression from basic principles utilizing the diagrams shown in Fig. 1, and summing around the two emitter loops.



$I_E - I_C = I_B \simeq I_E/h_{FE}$



small signal equivalent circuit

If $V_B = 0$, there is no feedback and $R_{in} = \dfrac{\Delta V}{I_{B1}}$ is given by $h_{ie}+(h_{ie}/h_{fe}R_E) \approx 2h_{ie}$. If $V_B = \Delta V$ then the open loop gain is infinite. This gives $R_{in} = h_{ie}+2h_{fe}R_T$, which is approximately the value given by Mr Cocking. For the case of a finite open loop voltage gain of A_{OL} we put $V_B = \Delta V\left(1-\dfrac{1}{1-A_{OL}\beta}\right)$ where β is the feedback factor (this means that the input difference voltage is $\dfrac{\Delta V}{1-A_{OL}\beta}$ giving the usual output of $\dfrac{\Delta V A_{OL}}{1-A_{OL}\beta}$). This gives us

$$R_{in} = \frac{\dfrac{h_{ie1}{}^2}{h_{fe}} + 2h_{ie}R_T}{\dfrac{h_{ie1}}{h_{fe}} + \left(\dfrac{1}{1-A_{OL}\beta}\right)R_T}.$$

Taking the values quoted in the article with $h_{ie\,typ} = 50\text{k}\Omega$, $h_{fe\,typ} = 200$ both for the BC107 at 100μA we derive $A_{OL} = 375$ by the usual simplified h-parameter analysis. As $\beta = -1/10$ we have $R_{in} = 2.84\text{M}\Omega$.

A much simpler approach which gives

good results is to assume R_T is infinite. The resistance is then $2h_{ie}(1-A_{OL}\beta)$, where $2h_{ie}$ is the resistance without feedback. This gives 3.85MΩ. Then parallel with $2h_{fe}R_T$ to account for the finite value of R_T. This gives 10.8MΩ giving finally 2.83MΩ. On the analytic expression

$$R_{in} = \frac{2h_{ie}R_T}{\frac{h_{ie}}{h_{fe}} + \frac{R_T}{1-A_{OL}\beta}}$$

using Mr Cocking's formula of $2h_{fe}R_T$ gives 10.8MΩ, a factor of over 3 out. The value of 865kΩ given in the article seems strangely amiss.

S. Cahill,
Queen's University,
Belfast.

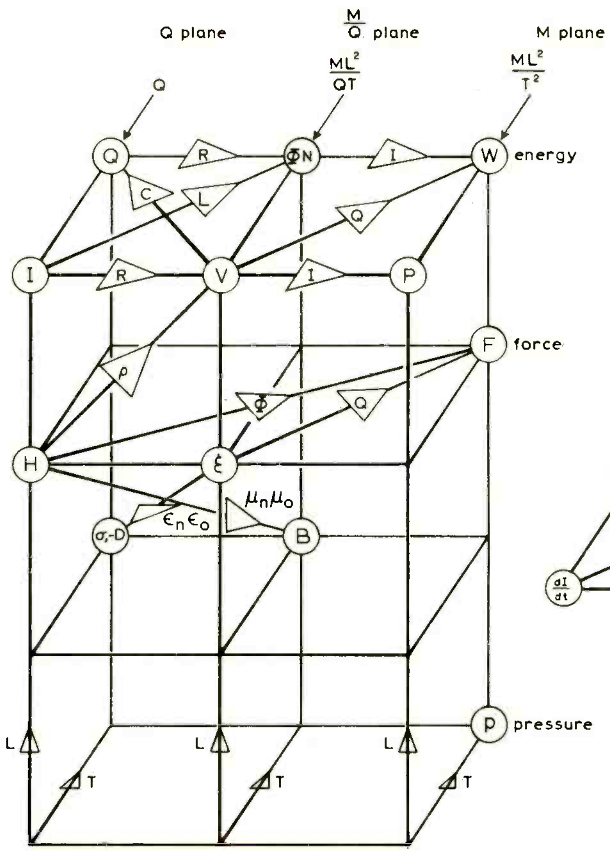
The author replies:

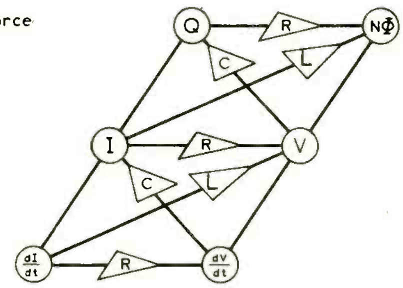
I agree that something has gone wrong with the figures for the input resistance of the amplifier discussed in my article. Unfortunately, I cannot now trace how they arose. It is many months since I wrote the article; in itself that would not matter, but my preparatory notes and numerical calculations for it cannot now be found. I can, therefore, only apologize for the numerical error.

The important thing about the input resistance, which I did not perhaps bring out adequately in my article, is that it is a very ill-defined quantity. It depends in greater or lesser degree on h_{ie} and h_{fe} of all transistors; h_{fe} varies greatly from one specimen to another of a given type of transistor and h_{ie} varies with the emitter current. As the current division ratio between Tr_1 and Tr_2 depends on many factors, it follows that in this circuit h_{ie} for these two transistors is also highly variable.

Because of these things the amplifier should normally be driven by a source of comparatively low impedance. Alternatively, the input resistance can be defined by a shunt resistor (which can be the base-bias network of Tr_1) which is small in comparison with the actual input resistance of Tr_1 itself.

W. T. Cocking.





Unified dimensional display

I was very interested in Mr Baldock's article 'Unified dimensional display' (March 1972) in which he plots the dimensions of all units on four planes, the position of a unit on a plane being fixed by the L and T content of its dimension.

I developed similar planes (see upper figure) from a flow chart after reading an article 'What is a magnetic field?' by J. J. Mathews in the *I.E.E. Students' Quarterly Journal*, June 1963.

Mr Baldock and I have, however, aligned our planes in different ways.

My alignment for the electrical units forms a pattern which places Q and V as shown in the lower figure. $Q \times V$ and $I \times \Phi N$ represent energy. C represents a device which stores energy by the distortion of the Q distribution, and L a device which stores energy by the inertia of Q.

Q is therefore taken as the key unit. Because of the method of construction, all other units in the pattern are fixed by the key unit.

The devices may be lumped, giving a tuned circuit, or distributed in a line or volume.

All branches of mechanical engineering, such as sound, satellites, gyroscopes, etc., are covered by two sets of four of the same patterns for which the key units are: L (length) to powers of 0, 1, 2 and 3, and the same powers of L divided by T.

For example, with key unit L^0 representing radians, the devices are a twisting shaft and a flywheel, μ is replaced by the reciprocal of the shear modulus of elasticity, and so on.

Different units having the same dimension will appear in different patterns; all devices and the dimensions of linking units such as mechanical impedance (R) and μ will be different in each pattern even for the same material.

Numbers are not usually associated with dimensions, but can be inserted into the patterns for particular cases.

Only heat and temperature do not fit the pattern. It is known that heat × temperature equals energy, and as at one time it was thought that temperature had no dimension, heat was equated to energy. This is equivalent to calling charge energy, and gives rise to numerous difficulties in heat engineering. It is now known that temperature has a dimension, and so heat is not equivalent to energy.

To make these two fit the pattern, heat must be a key unit with a basic dimension, say H; dimension of temperature becomes energy/H.

By analogy with the Periodic Table of Elements a suitable name appears to be the Periodic Pattern of Units. After learning the pattern, one can perform calculations in any branch of engineering if one knows the key unit and the constants and sizes of the materials being used.

D. L. Clay,
Coventry.

The author replies:

Mr Clay's display system raises some intriguing possibilities, but would, I suggest, be most readily understood by advanced students, although the separate diagram showing E/M quantity relationships is both straightforward and quite comprehensive. But, in general, I would prefer to omit the diagonal multipliers between quantities in a fully integrated display relating several physical fields, since otherwise it would tend to become rather congested. However, I would like to see the proposed 'periodic pattern of units' illustrated explicitly before commenting further. Another variation was suggested by Mr F. P. Rickard, of New Zealand, using M, L, T dimensions for the ampere, enabling both it and the coulomb to be displayed directly with some of the electromagnetic units within one plane.

My own scheme was evolved to relate quantities in accordance with the SI system, now used exclusively in the more progressive educational establishments. I know of at least one—The Lady Eleanor Holles School at Hampton, Middlesex—which has adopted the particular format I described as an aid for both comprehension and retention of quantity relationships.

With any display involving dimensional relationships, anomalies are likely to arise if a high level of sophistication is sought.

Concerning Mr Clay's difficulties as regards the incorporation of 'heat' within his periodic pattern, I am not clear as to the meaning he attaches to the term. In B.S. 3763:1970, *quantity of heat* is equated with energy and work, whereas *heat capacity* is defined as quantity of heat divided by thermodynamic temperature, the latter being taken as a base quantity. As for charge, in academic circles this is regarded as analogous to mass.

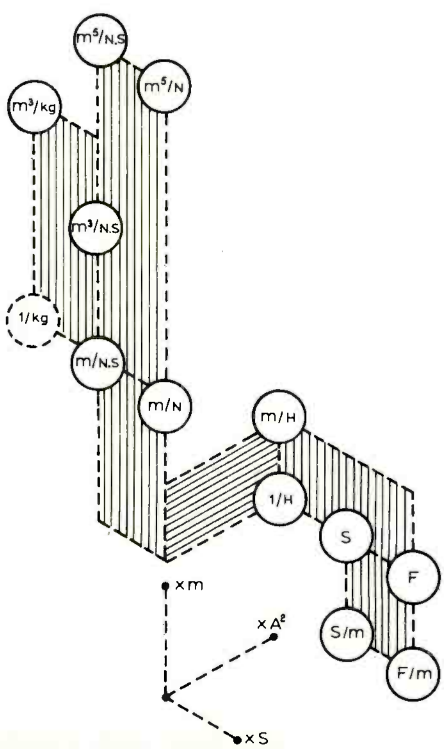
Some quantities may have the same dimensional description, but differ completely in *character*. A familiar case in the mechanical field is the disparity between work and moment of force, or torque. Work has the joule as its unit, given by a force of 1 newton acting through a distance of 1 metre along its direction of application. The unit of torque arises when 1 newton of force acts at right angles to a 1 metre radius of application, but its unit is the newton metre. This conflict can be resolved by regarding torque as work per unit angle. Unfortunately, angles (plane or solid), according to B.S. 3763, may be regarded either as dimensionally independent quantities or mere ratios, whichever is most convenient!

While discussing dimensional displays, it is notable that with the admittance field, named quantities* (depicted in reciprocal form in Figs. 2 and 5 of the March 1972 article) are relatively sparse as compared with those used in the impedance field. In fact, the latter has 30 dimensional positions directly associated with named quantities, as against only 12 of admittance form. As far as I am aware, the reciprocal of mass has not been given a generally accepted appellation, although the term 'reciprocal mass' is used in the semiconductor field. So, in Fig. 5 of my display, it would presumably be acceptable to replace '1/permittivity' by the description 'reciprocal permittivity'.

Some doubts have been raised as to the value of exploring dimensional relationships. Many are of negligible interest, but it is salutary to put oneself in the place of a scientist in, say, 1841, ten years after Faraday's fundamental discoveries concerning electromagnetic induction. Given the dimensional equality [permeability] × [permittivity] = [(slowness)^2], where slowness = 1/velocity, it would have appeared meaningless, yet later became of outstanding significance following Maxwell's mathematical prediction of the feasibility of electromagnetic wave propagation over a wide spectrum.

Returning to the present, is it not possible that a relationship shown by my display such as [mass] × [elastance] = [(magnetic vector potential)^2] may also hint as to the existence of some form of field so far unobserved?
R. N. Baldock.

*Note. The quantities admittance, conductance and susceptance now have the unit siemens, symbol S, instead of the unit mho.



Noise

As a final comment on the colour connotations associated with random noise of various spectra, so clearly expounded by Mr H. D. Harwood in the November issue in reply to my earlier letter, may I now be credited with the origination of the term 'black noise'? I hope this will be accepted as implying equal absence of integrated energy per cycle bandwidth!
R. N. Baldock,
Harrow,
Middlesex.

Seeing in the dark

I should be most grateful if I might be allowed some space in your columns over which I might trail my coat to see if some of the broadcasters and/or television camera manufacturers will jump onto it.

Let me first make some relevant statements which I believe to be accepted universally.

1. The human eye operates over a luminance range of about 10^{10}, but at any instant its operating range is much smaller, being well satisfied with a contrast range of about 10^2, a range which the broadcasters can satisfy when the operating conditions are very favourable. The 10^2 range can thus slide over a range of about 10^8.

2. Television cameras are available which can operate to provide this 10^2 range anywhere within the 10^{10} range over which the eye can operate, but whereas the gain of the camera can be adjusted almost instantaneously, the 'gain-control' of the eye has a time-constant of many minutes.

3. Conditions of flicker, tube design and ambient lighting in the home fix the position in the 10^{10} range of the eye where the 10^2 range of reproduction must be located. This means that the 'gain-control' of the eye operates only over a very small range when viewing television, but the gain control of the camera operates over a very wide range from shot to shot. For instance when cutting from say a shot of a brilliantly lit interior to one of a dark alleyway the two peak brightnesses of the reproductions are similar, in the latter case the peak brightness typically being provided by a street lamp and occupying only a small proportion of the picture area.

4. The human eye possesses a high degree of acuity to luminance changes under conditions of high luminance but a low degree of acuity under conditions of low luminance.

5. The human eye is colour conscious only under conditions of high luminance, everyone being colour-blind under conditions of low luminance.

Having stated the premise upon which my queries are based, I would now like to ask the broadcasters/manufacturers two questions. The first is based upon 4 above. Should there not be a succession of low-pass filters of successively lower cut-off frequency brought into circuit as the camera gain control is advanced? The second is based upon 5 above. As the gain control is advanced should not the gain of the chrominance channel be reduced relative to that of the luminance channel?

If these conditions are not met, then it would appear that when viewing scenes which are shot under conditions of low luminance the viewer will be presented via the television channel with information which he would not see under conditions of direct viewing of the scene, and thus the reproduction appears to be unnatural.

I should be pleased to hear or read of any fallacy in my argument.
Roy C. Whitehead,
Polytechnic of North London,
London N7.

Power supply units—a plea

May I please make via your columns an appeal to the manufacturers of stabilized power units?

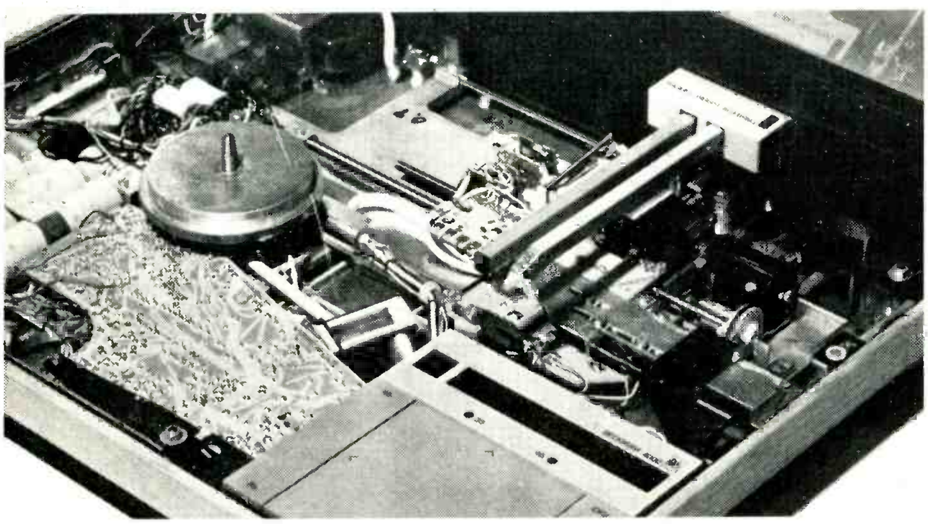
The normal commercial unit carries a moving-coil meter and a meter switch which is marked VOLTS/AMPS. The switch is nearly always used in the VOLTS position but occasionally someone moves it to the AMPS position and leaves it there. On the next occasion that the unit is used, the user, accustomed to having the meter set to the VOLTS position, turns up the amplitude control in an endeavour to produce the expected meter deflection. If the load impedance is high he will probably destroy the load before realising his error. (No, I have not blown up any i.cs, yet!).

The solution would appear to be the use of a switch which has a locking action in the VOLTS position and is nonlocking in the AMPS position.
Roy C. Whitehead,
Polytechnic of North London,
London, N7.

An Electronic Turntable

The London Audio Fair can usually be reckoned to produce one or two innovations. Unique among those shown this year was an electronically controlled parallel tracking turntable produced by Bang and Olufsen, of Denmark.

The photograph, which shows the Beogram 4000 with its top covers removed, illustrates some of the more basic details of the deck itself. Most significant is the use of a tangential arm which moves the pickup cartridge in a straight line from the edge to the centre of the record. Using such a system —not new in itself—has produced a number of advantages which have not only permitted the use of a semi-automated electronic control unit, but also improved the potential reproducing performance of the unit. Inherent in the design of a conventional arm is the difference in tracking angles with respect to the groove tangent, made by the reproducing and recording styli. In an effort to reduce this error to a minimum, the conventional reproducing arm is bent at an angle; however, this gives rise to a mechanical reaction producing a force which drives the stylus against the inner face of the record groove. Some form of compensation, known as bias, is applied to balance out this force but it is an extremely difficult factor to accurately nullify and thus most systems are somewhat of a compromise. In adopting the tangential arm, the need for bias compensation is eliminated since the arm can be made straight and thus does not produce any side thrust. In addition, because the reproducing stylus is made to track in precisely the same fashion as the cutter, distortion can be reduced.



The interior of the B & O 4000 showing the parallel tracking arm and its slide carriage.

Two arms are carried on a "slide" which runs on two rails and is driven through a worm gear by a small servo motor. One of the two arms contains a lamp and photocell which serve to detect the edge of the record as the slide moves across the turntable. Since the turntable itself consists of a polished metal surface broken with radial black plastic spokes, the detected reflection produces a varying output from the photocell rather than the steady signal resulting from the reflection off a disc surface. In this way there is no chance of the stylus being lowered onto the turntable platter itself, in the event of the machine being started without a record being loaded. Two states can thus be generated by the detector arm sensor: an alternate shift of level indicating no record, and a d.c. level indicating the presence of a record.

A second sensing system is fitted to the pickup arm. This provides an output indicating angular errors in the position of the arm. As the stylus is carried across the record by the groove, of necessity the slide must be moved in sympathy to keep the arm at an exact tangent to the groove. Attached to the horizontal arm pivot is a

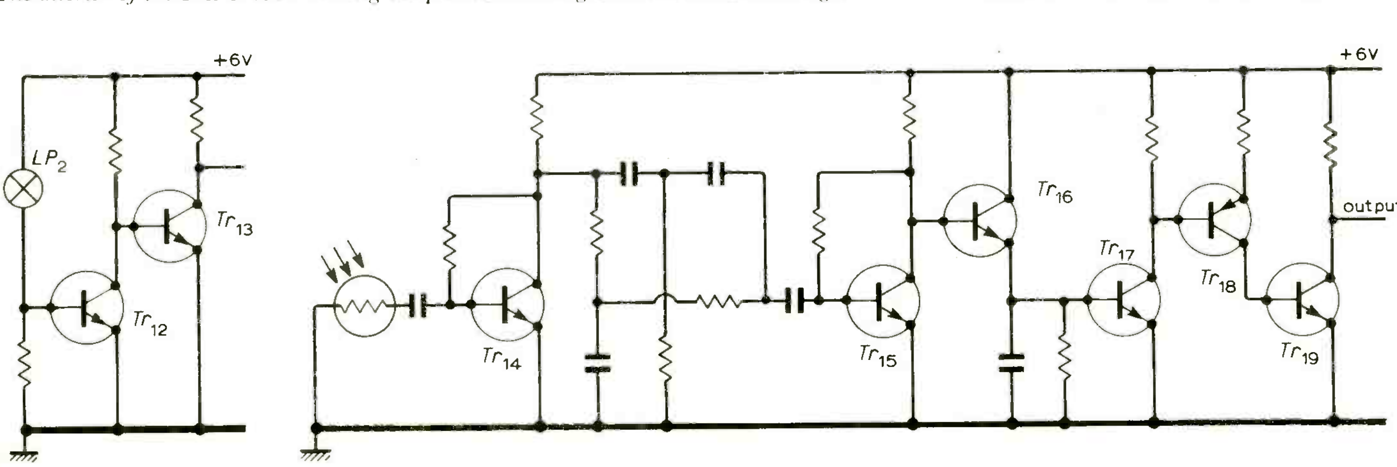


Fig. 1. Detector arm servo amplifier. This circuit produces a two-state output to drive the control switching logic.

small shutter above which is fitted a small lamp and below, to each side, a photocell. Any deviation of the arm from its correct tangential position will partially obscure one or other of the photocells, producing an unbalanced output from the sense system which can then be used to operate the servo control and the motor to correct the situation. Using such an arrangement ensures that angular error in the arm is less than 0.04°.

Servo control circuits

The output of the photocell sensor in the detector arm is fed via a capacitor to the base of transistor Tr_{14} (Fig. 1) which is d.c. biased. Since the output from the photocell has a frequency of 13–18Hz with no record present, it is easy to differentiate between this and a spurious signal generated by, say, the flicker of a mains driven room light. Such a selection is in fact achieved by the use of a notch filter between Tr_{14} and Tr_{15}, tuned to 100Hz. After integration of the signal from Tr_{15} by the emitter resistor and capacitor of Tr_{16}, the level obtained is applied to the base of Tr_{17}, turning it on and drawing its collector voltage down to near 0V. This in turn switches on both Tr_{18} and Tr_{19} giving a low (0V) output from the sensor amplifier. Since the presence of a record beneath the detector arm produces a d.c. level from the detector, the capacitor at the base of Tr_{14} prevents any change of level at the first transistor and the circuit remains inactive, thus giving a high (6V) output.

In the event that the lamp becomes defective in the detector arm, two additional transistors, Tr_{12} and Tr_{13} are used to provide a logic output which is dependent upon current flow in the lamp. If the lamp fails, the control logic circuits prevent the arm being lowered.

The servo control of the arm slide is equally sophisticated and is described with reference to Fig. 2. By using a d.c. servo motor, a differential drive circuit can be used throughout, and although the motor can be driven at high speed with the pickup raised, this description of the circuit operation will be confined to the normal groove tracking mode. When the arm is in the lowered position the 24V supply is connected via contacts to the two photocells; these in turn operate the two servo power amplifiers and a voltage of about 12V appears at each side of the motor. If the pickup arm moves towards the centre of

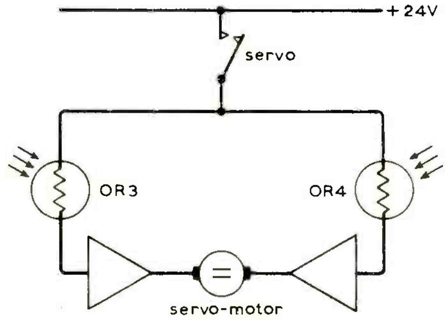
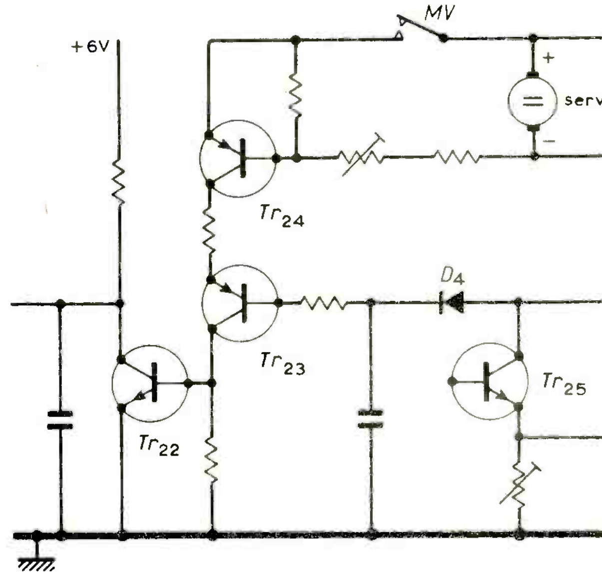


Fig. 2. Block diagram of the servo control from the photo-detectors used to sense angular errors in the arm.

Fig. 3. The circuit used to generate the logic signals for end-of-record operation.



the record photocell OR_3 receives a greater light level than OR_4, throwing the circuit out of balance and causing the servo to drive the slide until the balanced condition is reached. Additional circuitry provides for automatic arm raising should manual tracking be required by the operation of one of the turntable controls.

End-of-record sensing is also tied in with the servo motor control since in the original design concept it was felt that mechanical techniques would have placed a strain on the stylus. In addition, since there is no recognized standard for the diameter of the last groove on a record, some method was needed which did not rely upon this parameter to signal the restoration of the slide to start position. Fig. 3 shows how this was achieved. When the stylus tracks the last groove of the record, the mechanical contact MV will have been operated by the slide position to connect the servo motor to the sense transistor Tr_{24}. Due to the rapid increase of pitch in the run-off grooves of the record, the voltage driving the servo will be unusually high, thus turning on Tr_{24} and Tr_{23}. Transistor Tr_{22} is in turn operated by the increase in voltage across its bias resistor and thus a logic low is produced to operate the "arm raise" system. In the event of a manual "fast inward track" being ordered by the operation of one of the turntable controls, the collector of Tr_{25} is held high and thus diode D_4 blocks the base current of Tr_{23} to prevent premature setting of the restoration logic control.

Logic control system

Devising the logic control for the turntable must start with an analysis of the various operations required to operate the deck. Since a certain amount of manual control can be exercised from switches actuated by pressure plates on the top panel, the commands issued by these will be listed first.

1. Turntable speed. The turntable will revolve at 33⅓ r.p.m. in the absence of any commands to the contrary being issued by either a speed selector switch, or an automatic decision based on record diameter being taken by the detector arm logic. The higher speed of 45 r.p.m. can also be selected from a manual switch. In the event that 33⅓ r.p.m. is selected by manual control and the record is intended to be played at 45 r.p.m., the unit will not automatically correct, but will remain at the lower speed until a second manual command is made to alter speed.

2. Arm lift. This can be initiated at any point during the playing of a disc.

3. Arm lower. Used when lowering the stylus into a preselected groove. The logic circuits bar lowering the arm onto anything but a disc.

4. Fast and slow track in. These commands are initiated by a two-pressure switch, light pressure for a slow tracking motion, heavier pressure for a faster tracking. In the event that this command is initiated when the arm is lowered, the arm raising control is operated first.

5. Fast and slow track out. A similar two-pressure switch is used here and also provision is made for automatic arm raising before the tracking commences. In addition if the arm is tracked out to the normal rest position, the turntable is automatically turned off.

The next consideration is the automatic commands that need to be generated. These are:

1. Track in (fast). When the turntable is started by pressing the 'on' switch, the arm slide will track in until the edge of a record is found by the detector.

2. Arm tracking stop, arm lower. This command is initiated by the detector logic on finding the edge of the record.

3. Groove tracking mode. The servo is driven under the command of the servo amplifier and logic commands are not used.

4. End of record, arm lift, fast track to rest position, turnoff. This sequence is started by the voltage sensor connected to the servo motor.

These control functions are all undertaken by a number of i.cs connected to provide six flip-flops, a wired-OR and three single wired gates. Unfortunately lack of space precludes describing the switching techniques employed in this novel turntable, suffice it to say that this is probably the most complex to appear on the market.

Circards — 4
A.C. Measurements

Introducing the fourth set of Circards on peak, mean and precision rectification

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

Measurement of direct voltages is straightforward. A moving-coil meter has good linearity of deflection against direct current in the meter, and the use of parallel and series resistors (shunts and multipliers) allows such meters to give full-scale readings to cope with a wide range of voltages and currents. For very small direct voltages and currents, d.c. amplifiers may be interposed between source and meter, and such amplifiers may also be used to optimize the input resistance of the system, i.e. to minimize loading effects.

For a.c. signals the biggest difficulty can be deciding which parameters of the signal to measure—mean, peak or r.m.s. for example. The issue is further complicated by the need to cope with a range of frequencies so broad that, for example, techniques suitable for high-frequencies result in impossibly long measurement times at very low frequencies.

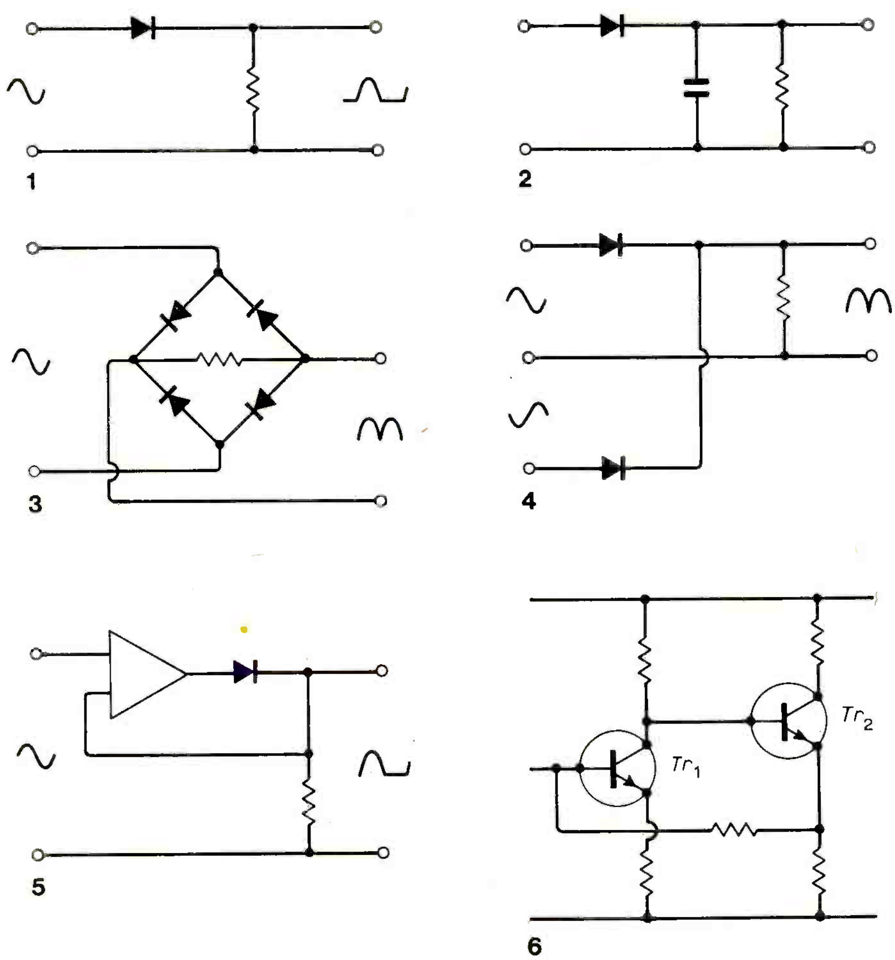
There is a dearth of sensitive, accurate and low-cost types of meter movement capable of responding directly to a.c.; moving-iron instruments for example require much higher power for a given deflection than moving-coil instruments of comparable quality, while the deflection is a non-linear function of the current being measured. Hence in most cases the a.c. waveform is first processed in such a way that a reading may be obtained on a d.c. meter, which reading is proportional to a desired parameter of the waveform. A basic process employed is that of rectification, where the output voltage (or current) is limited to one polarity regardless of the input.

Half-wave rectification (Fig. 1) gives an output which is ideally equal to the input when the latter is positive, and an output which is zero when the input is negative. The ideal diode would pass zero current for all conditions when the anode is negative with respect to the cathode, and have zero p.d. when the polarity is reversed. In practical circuits, while the former ideal is closely approximated to by modern silicon diodes, the diode p.d. in conduction is around 0.5 to 0.8V. The output waveform becomes progressively more distorted as the amplitude of the input voltage is reduced, and for inputs below one volt the output is negligible, i.e. accurate rectification is particularly difficult at low amplitudes. Some improvement is possible by the addition of a second diode biased in such a way that the rectifying diode is brought to the edge of conduction prior to the appearance of a signal.

If a moving-coil milliammeter is placed in series with the load resistance, then the meter current becomes proportional to the average value of the half-wave rectified voltage, provided the frequency is high enough to overcome needle vibration. Such a reading is half that due to a full-wave rectified voltage for symmetrical waveforms such as sine, square and triangular waves. An average reading may also be obtained by feeding the rectified voltage through a low-pass filter to eliminate the a.c. component. Such a modification is necessary where the direct voltage is to be monitored by a digital voltmeter, to provide a digital reading of the mean value of the rectified input.

A direct voltage may be obtained directly as in Fig. 2. The capacitor charges on each positive peak of the input, losing some of that charge between peaks into the resistance of any load. To minimize such losses and make the output a more accurate

*All with Paisley College of Technology.



Fourth set of Circards illustrates techniques of peak, mean and precision rectification. Half-wave, 1 and 2, and full-wave circuits, 3 and 4, can be used to give either mean or peak measurements. Errors due to diode voltage drops can be reduced by putting the diode in a feedback loop, 5, but use of an amplifier limits h.f. accuracy, avoided by using a simple amplifier, 6, with bridge rectifier/meter in the feedback path.

measure of the repetitive peak input voltage, the time-constant is made much longer than the period of the input signal. Too great a ratio will not allow the capacitor voltage to decay sufficiently rapidly to observe any decay in input peak voltage that may occur during the measurement. Again real diodes introduce a forward-voltage drop that mitigates against accuracy for small inputs.

Full-wave rectification is necessary where the negative and positive portions of the wave may be different. A secondary advantage can be that for symmetrical waves, a full-wave peak detector has its capacitor charge restored twice per cycle, i.e. the time for discharge and hence the ripple is approximately halved. As for half-wave rectifiers, the full-wave circuits could be used for indicating mean or peak values. (The latter would indicate only the largest peaks for an unsymmetrical signal.)

Two methods are available. Bridge rectification as in Fig. 3 requires four diodes to channel current through a load in a given direction regardless of the polarity of the applied potential. Alternatively, the provision of equal but anti-phase drives to a pair of diodes again gives single polarity to the load with each diode contributing on alternate half cycles—Fig. 4. The anti-phase voltage may be provided by a transformer or by an inverting amplifier.

In the above the assumption has been that the rectified waveform would be applied to a measuring device such as a moving-coil meter. Waveform distortion short of that causing significant meter reading error is then unimportant. Where it is required to retain full information on the rectified waveform then a precision rectifier has to be devised, i.e. one in which the rectification process is not burdened by the large errors due to diode voltage drops. Placing the diode(s) in the feedback path of an amplifier allows the effect of the diode p.d. on the output to be reduced by any desired amount.

Fig. 5 shows one version of a precision half-wave rectifier in which, for positive going inputs, the amplifier output is driven positive until it causes the diode to conduct and forces the output voltage to equal the input (or rather to differ from it by a very small p.d. which includes the amplifier offset voltage and a small contribution given by the diode p.d. divided by the amplifier open-loop gain).

The basic circuit shown meets the precision requirements, and in addition minimizes source loading while being capable of supplying normal operational amplifier currents to the load. Many variations are possible leading to: precision half- and full-wave circuits, alternatively known as absolute-value circuits; precision peak detectors and mean-reading circuits.

The use of amplifiers imposes a limit to the upper frequency of operation, which limit is accentuated by the non-linear nature of the circuitry, e.g. the amplifier slew-rate limitation defines the minimum time taken to switch the diode from its non-conducting to conducting state. The precision of the rectification process is more difficult to achieve at higher frequencies and many circuits accurate to a few millivolts at 100Hz are seriously in error at 10kHz. Similar limitations are apparent in any negative feedback system having non-linear elements in the feedback path.

For very high-frequency applications one solution is to construct suitable high-frequency amplifiers of standard design and incorporate a bridge rectifier/meter combination in the feedback path. The simpler designs using the minimum number of transistors are based on circuits such as the d.c. feedback pair of Fig. 6 with the meter circuitry either between Tr_2 collector and Tr_1 emitter, or between Tr_2 emitter and Tr_1 base. Alternating-current coupling of the input signal is then necessary as the direct input voltage cannot be zero in this circuit. The method can be extended to multi-transistor circuits and the feedback network can be located to increase or decrease the input impedance. The lowest frequency of operation is dictated by the largest value of capacitors used, and by the degree of damping of the meter movement.

To extend the frequency downwards, peak detection is usually used, i.e. with a large capacitor to store the peak voltage and minimal discharge current for the period between peaks.

At very low frequencies ($\ll$1Hz) an alternative method is the use of an integrator during a single complete half-cycle or cycle with separate measurement of the time to allow determination of the mean value of the waveform during that cycle.

The amplitude of an a.c. waveform is most frequently quoted in r.m.s. (root mean square) terms, i.e. the instantaneous voltage or current value is squared, the mean value over a complete cycle (or half-cycle) is taken and the square root of that mean value is obtained. It is the r.m.s. value of a voltage that allows calculation of the mean power dissipated in a resistive load, as the power in a resistive load due to an a.c. waveform of V in r.m.s. terms is identical to that due to a direct voltage of V.

It is common for instruments which truly measure the mean rectified or peak values of waveforms to have scales calibrated in terms of the corresponding r.m.s. value for a sine-wave. Hence for non-sinusoidal waveforms the readings fail to give a correct measure of either r.m.s., mean or peak, except where power measurements are concerned, e.g. power fed to a loudspeaker. There is considerable advantage in calibrating the instrument directly in terms of the parameter measured, though this set of Circards includes examples of instruments which incorporate such form factors. True r.m.s. meters are a very different matter. Three common classes depend on

- thermocouples generating an e.m.f. dependent on the power dissipated in a load
- non-linear amplifiers approximating to square-law characteristics where the output can be averaged to give a mean-square reading. A second squaring circuit in the feedback path of a following amplifier gives a square-root action
- multipliers in which the output is proportional to the product of two inputs; if the voltage to be measured is simultaneously fed to both inputs, the output is again proportional to the square of the input.

The first method is applied to r.f. signals where the power available is sufficient, and where the use of amplifier/rectifier combinations would introduce errors because of frequency limitations. It is a specialized field and depending as it does largely on the transducer is not covered in this series. The second method requires careful control of the non-linear characteristics for high accuracy to minimize all terms other than second-order; the networks are often obtained as ready-made units from the makers of instrumentation amplifiers. Methods using the square law characteristics of f.e.ts belong to this general class.

The third method can be achieved by using the logarithmic characteristics of semiconductor p-n junctions and by combining several junctions so that their p.ds may be added and/or subtracted functions of the form $(\log V_1 + \log V_2 - \log V_3 - \log V_4)$ may be obtained, i.e. outputs dependent on $V_1 V_2 / V_3 V_4$. These circuits can be made the basis of multipliers, or for $V_1 = V_2 = V_{in}$ and $V_3 = V_4 =$ constant, a square-law circuit results. A practical example is included that allows a meter reading proportional to the mean square of an alternating voltage, i.e. a meter that can be calibrated linearly in terms of the power delivered by that voltage to a given load.

High-standard Low-frequency Source

A portable instrument incorporating an i.c. phase-locked loop and utilizing the B.B.C. 200kHz Droitwich transmission

*by J. M. Osborne**

The instrument described here was built as an exercise to evaluate the potentialities of the phase-locked loop for the reception of a frequency standard. The instrument consists of a phase-locked loop i.c. stage followed by a chain of i.c. dividers as shown in Fig. 1. The p.l.l. stage is locked to the 200kHz carrier of the B.B.C. Radio 2 transmitter at Droitwich. The carrier frequency is maintained to an accuracy of ± 5 in 10^{10}. So long as lock is held, this sets the standard for the instrument.

The main use for this instrument would be the calibration and standardizing of audio oscillators, signal generators and as a source of clocking pulses. The pulses could be used for timing watches; ticks picked up by a microphone on one trace of a c.r.o. display compared with pulses from the instrument on another trace would enable a watch to be set precisely and quickly. With a little modification this type of instrument could operate the gate on a frequency meter. In this application, with a digital counter, the accuracy should be better than with an instrument using a crystal oven.

Circuit

A block diagram of the phase-locked loop system[1,2] is shown in Fig. 2. The 200kHz signal is fed from a ferrite rod aerial to a phase comparator together with the output of a local voltage controlled oscillator (v.c.o.). The comparator output voltage, which depends in magnitude and polarity on the relative phase of the inputs, is filtered, amplified, limited and used to control the v.c.o. frequency in such a sense as to bring it into lock with the signal from the aerial. Thus the v.c.o., whose output is a square

*Westminster School, London.

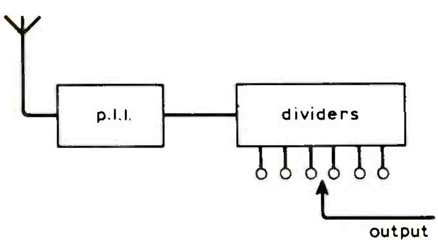


Fig. 1. Block diagram of the low frequency source.

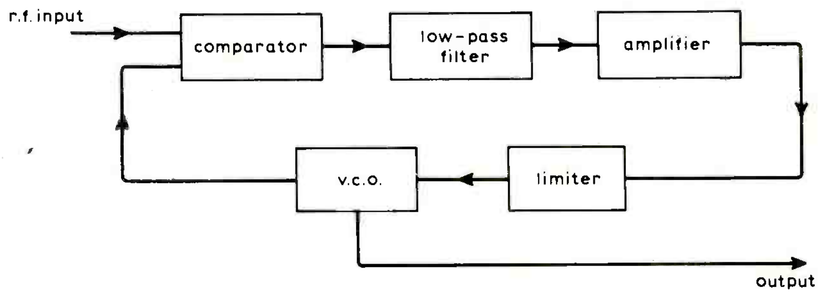


Fig. 2. The main functions of the NE561B phase locked loop i.c.

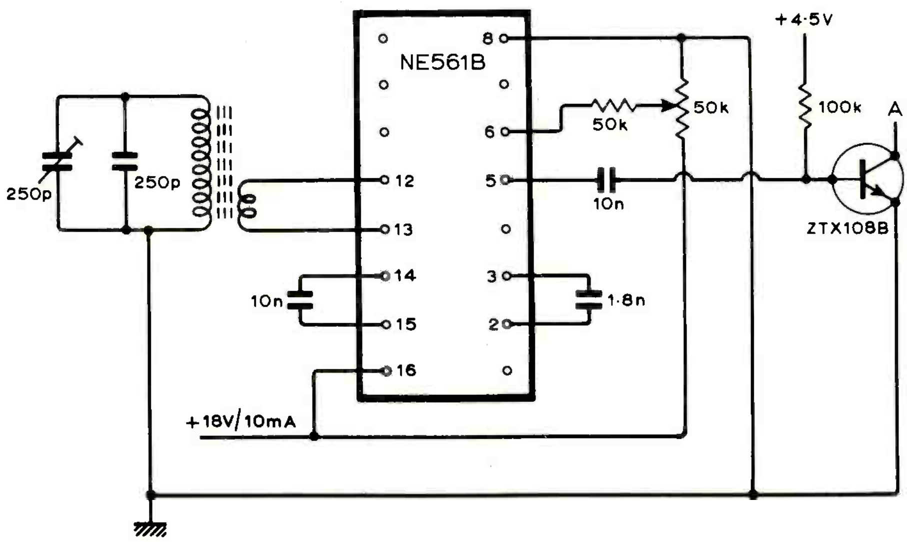


Fig. 3. The circuit of the p.l.l. stage.

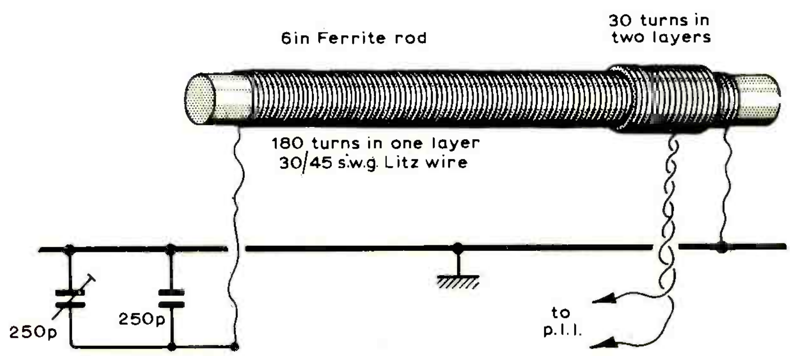


Fig. 4. Coil winding for the ferrite rod aerial.

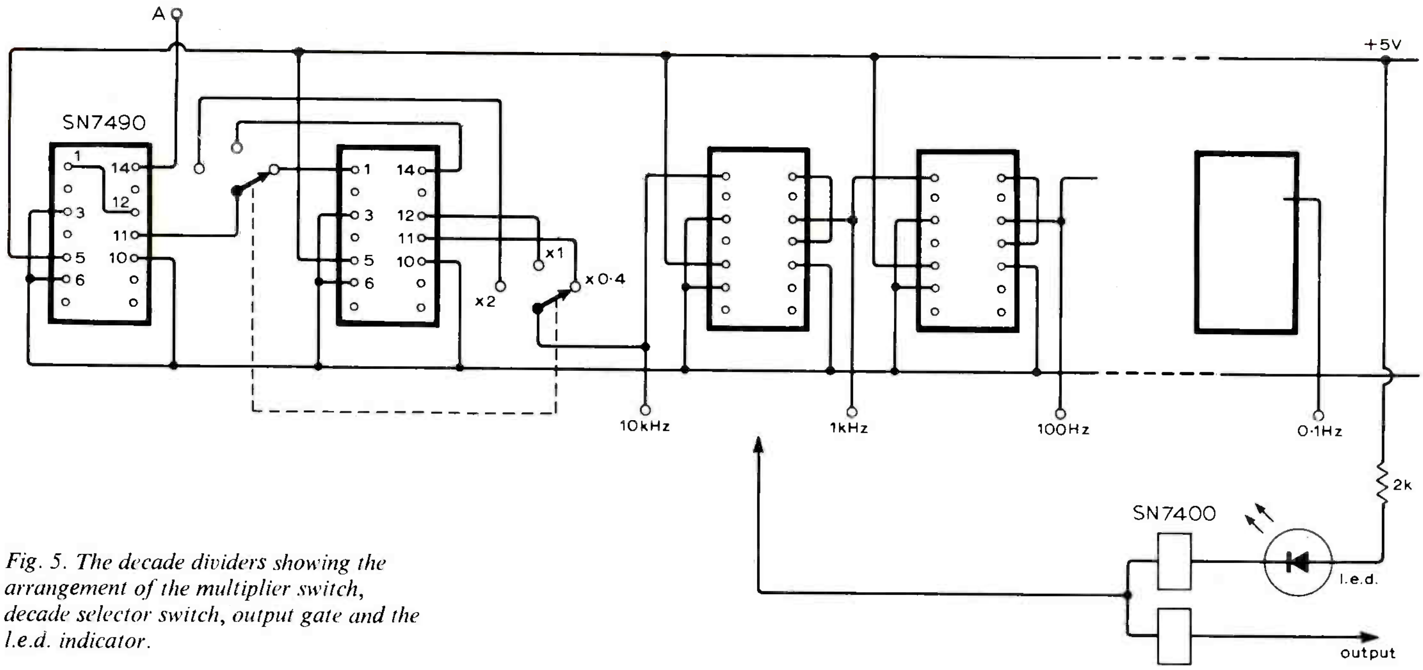


Fig. 5. The decade dividers showing the arrangement of the multiplier switch, decade selector switch, output gate and the l.e.d. indicator.

wave, ideal for operating t.t.l., runs at exactly 200kHz.

As the required r.f. input is small, 1 to 10mV being suitable, no amplification is needed in areas receiving a large signal from Droitwich. The pick-up by the ferrite aerial under typical conditions in London is adequate to provide lock, but an amplifier might be needed at distances over 150 miles from the Droitwich transmitter. A domestic transistor radio tuned to the l.w. Radio 2 programme gives a rough indication of signal strength in a building.

The p.l.l. i.c. used (Fig. 3), a Signetics NE561B, has a balanced input of about 4kΩ impedance. This would be an unsatisfactory load for the aerial and so a coupling coil is used to match it to the p.l.l. The coil, being free of earth, does not interfere with the internal bias arrangements of the integrated circuit. Litz wire is used in the final version of the aerial coil, the dimensions being given in Fig. 4. Winding over the whole length of the ferrite rod gives the maximum pick-up. The complete aerial is contained in a 1-inch Paxolin tube which also serves as a handle. It is retained by Paxolin sheet about 2 inches above the aluminium box which contains the rest of the instrument. The coupling coil leads and earthy end of the tuning coil enter one end of the box while the live lead from the coil enters from the other. The trimmer and fixed tuning capacitor are just inside the box at this end remote from the p.l.l. This minimizes stray pick-up from the v.c.o. which could interfere with the lock.

The other components associated with the p.l.l. are a 0.01μF low-pass filter, a 1.8nF timing capacitor of the v.c.o. which sets the free running frequency at approximately 200kHz, and a potentiometer for fine tuning of the v.c.o. by adjusting the potential of pin 6. The v.c.o. output from pin 5 is about 0.6V pk–pk and 6.5V above chassis. For interfacing with t.t.l., it is convenient to use capacitor coupling to a transistor switch. The transistor is a Ferranti ZTX108B.

Setting up the p.l.l.

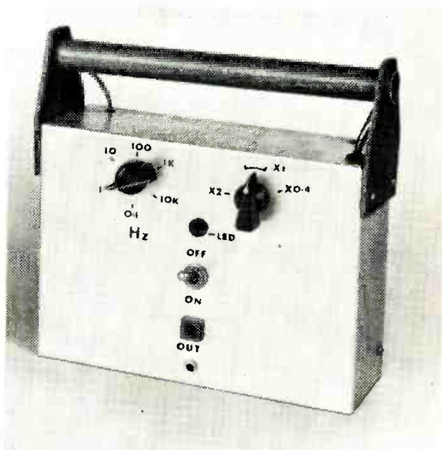
There are two preset controls, an aerial trimmer and the v.c.o. fine tune potentiometer. A transistor radio near the instrument will pick up stray radiation from the v.c.o. If the aerial coil is disconnected or substantially detuned to avoid locking, the free running frequency can be made to beat with Radio 2 by adjusting the potentiometer. This is set for a low audio beat note. Next, with the aerial connected, the trimmer is adjusted until the loop locks, as evidenced by the abrupt change to zero beat. The aerial should now be turned until the lock is just lost. Further adjustment of the trimmer may result in the lock being regained. By repeating this process, optimum tuning can be obtained.

The dividers

The phase-locked loop is followed by a chain of SN7490 decade dividers. Switches, which should be break-before-make types, then select the required output. The first switch (Fig. 5) operates on the second divider to select ×1 (straight through), ÷2, or ÷5. As the first i.c. divides by ten, the switch selects 20kHz, 10kHz and 4kHz. The switch positions are marked ×2, ×1 and ×0.4. The other switch selects successively from the rest of the chain and is marked 10kHz (straight through), 1kHz, 100Hz and so on. To square up the output of the dividers a simple gate is incorporated (part of an SN7400) before the output terminal. Another gate in parallel drives an l.e.d. as an indicator lamp. This can be seen to flash at 10Hz and less. While this indicates that the dividers are functioning it does not necessarily imply that the p.l.l. is locked.

Construction notes

A 16-pin d.i.l. socket for the p.l.l. and all other i.cs and components may be soldered to two strips of Veroboard, which are supported on the switch and battery wires. The circuits and batteries are contained in an aluminium box, and the 18V at 10mA



The prototype low frequency source, showing controls and ferrite rod aerial used as a handle.

supply comes from two PP7 batteries on one side of the box while the t.t.l. i.cs are provided with 4.5V at 150mA by a single 126 battery. Strictly the t.t.l. requirement is 5V but they work happily on 4.5V provided the battery is replaced before the voltage on load drops to 4V.

References

1. J. M. Osborne, 'The Phase Locked Loop', *Short Wave Magazine*, Vol. XXX, No. 1, March 1972.

2. T. D. Towers, 'Elements of Linear Microcircuits', *Wireless World*, August 1971, p. 397.

1973 Conferences & 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)
Apr. 9-13 Earls Court
Physics Exhibition
(Inst. Physics, 47 Belgrave Sq., London SW1X 8QX)
Apr. 9-13 Earls Court
LABEX International
(U.T.P. Exhibitions, 36-37 Furnival St., London EC4A 1JH)
Apr. 25-27 Chelsea College
B.A.S. Spring Meeting
(British Acoustical Society, 1 Birdcage Walk, London SW1H 9JJ)
May 22-25 Olympia
London Electronic Component Show
(Industrial Exhibitions, Commonwealth House, New Oxford St, London WC1A 1PB)
June 5-8 Earls Court
International Marine Exhibition (IMEX)
(Brintex Exhibitions, 3 Clements Inn, London WC2A 2DB)
June 5-8 Earls Court
International Marine and Shipping Conference (IMAS)
(Institute of Marine Engineers, 76 Mark Lane, London EC3R 7JN)
June 25-29 Royal Lancaster Hotel
Film '73
(Paul D. McGurk, B.K.S.T.S., 110-112 Victoria House, Vernon Place, London WC1B 4DJ)
Oct. 1-3 Savoy Place
Organization and Management of Computer Based Control and Automation Projects
(I.E.E., Savoy Place, London WC2R 0BL)
Oct. 22-27 Olympia
Audio Fair
(International Audio Festival & Fair, Dorset House, Stamford St, London SE1 9LU)
Oct. 23-25 Savoy Place
Radar — Present and Future
(I.E.E., Savoy Place, London WC2R 0BL)
Nov. 12-14 Savoy Place
Digital Instrumentation
(I.E.E., Savoy Place, London WC2R 0BL)

BIRMINGHAM
July 10-12 University of Birmingham
Video and Data Recording
(I.E.R.E., 9 Bedford Sq, London WC1B 3RG)
Sept. 16-22 University of Aston
Switching and Signalling in Telecommunications
(I.E.E., Savoy Place, London WC2R 0BL)

BOURNEMOUTH
Apr. 11-14 The Pavilion
Marketing Communications Tomorrow
(Electromation Exhibitions Ltd., Cleveland House, 344A Holdenhurst Road, Bournemouth)

BRIGHTON
Jan. 9-11 The Metropole
Componex
(Evan Steadman and Partners, 4 Lyewood Common, Withyham, Hartfield, Sussex)
Apr. 5 & 6 University of Sussex
European Co-operation in Research and Technology
(Research and Development Society, 47 Belgrave Sq, London SW1X 8QX)
June 19-21 The Metropole
Microwave 73
(Microwave Exhibitions and Publishers Ltd., 21 Victoria Rd, Surbiton, Surrey)

CAMBRIDGE
Apr. 2-4 The University
Computer Aided Control System Design
(I.E.E., Savoy Place, London WC2R 0BL)
Sept. 6-9 King's College
Royal Television Society Convention
(RTS, 166 Shaftesbury Avenue, London WC2H 8JH)

CARDIFF
Sept. 12-14 Traherne Hall, UWIST
Physics of Semimetals and Narrow-Gap Semiconductors
(Inst. Physics, 47 Belgrave Sq, London SW1X 8QX)

COLCHESTER
Apr. 2-5 University of Essex
Software Engineering for Telecommunication Switching Systems
(I.E.E., Savoy Place, London WC2R 0BL)

HULL
Apr. 11-13 The University
Teaching of Electronic Engineering in Degree Courses
(Dr. F. W. Stephenson, Department of Electronic Engineering, The University, Hull HU6 7RX)

LANCASTER
Apr. 9-11 The University
Thin Films
(Inst. Physics, 47 Belgrave Sq, London SW1X 8QX)

LIVERPOOL
Apr. 15-18 The University
To be Continued — Education and Training
(I.E.E.T.E., 2 Savoy Hill, London WC2R 0BS)

MANCHESTER
Jan. 3-5 The University
Solid State Physics
(Inst. Physics, 47 Belgrave Sq, London SW1X 8QX)

NEWCASTLE UPON TYNE
Apr. 10-13 The University
Atomic and Molecular Physics
(Inst. Physics, 47 Belgrave Sq, London SW1X 8QX)
July 3-5 The University
Scanning Electron Microscopy Systems and Applications
(Inst. Physics, 47 Belgrave Sq, London SW1X 8QX)

NOTTINGHAM
Apr. 10-12 The University
Datafair 73
(British Computer Society, 29 Portland Place, London W1)
July 9-12 The University
Maintenance Management
(Society of Electronic and Radio Technicians, 8-10 Charing Cross Road, London WC2H 0HP)
Sept. 10 & 11 The University
Solid State Devices
(Inst. Physics, 47 Belgrave Sq, London SW1X 8QX)

SOUTHAMPTON
Sept. 23-26 The University
Optical Properties of Thin Films
(Inst. Physics, 47 Belgrave Sq, London SW1X 8QX)

TEDDINGTON
Feb. 20 & 21 National Physical Lab.
Precision and Accuracy in Pressure and Force Measurement
(Inst. Physics, 47 Belgrave Sq, London SW1X 8QX)

UXBRIDGE
Apr. 30-May 2 Brunel University
Instrumentation in Vacuum Processes
(Inst. Physics, 47 Belgrave Sq, London SW1X 8QX)

WARWICK
July 16-19 The University
Software for Control
(I.E.E., Savoy Place, London WC2R 0BL)

OVERSEAS (JAN.-APR.)
Feb. 14-16 Philadelphia
International Solid-State Circuits
(I.E.E.E., 345 East 47th St, New York, N.Y. 10017)
Feb. 20-22 Rotterdam
A.E.S. Convention
(Herman A. O. Wilms, Zevenbunderslaan 109, B-1190 Vorst-Brussels)
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. 20-Apr. 5 Peking
British Industrial Technology Exhibition
(Tek Translation & International Print, 11 Uxbridge Rd, London W12 8LH)
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.)
Apr. 3-5 Dayton
Military Airborne Video Recording
(Society of Photo-optical Instrumentation Engineers, P.O. Box 288, Redondo Beach, Calif. 90277)

Magnetism and Magnetic Units

Understanding the basic relationships, with special reference to SI units

by "Cathode Ray"

The other day I saw—on 'Nationwide', I believe—something about a shopkeeper who persisted in doing business in £sd. (Even he admitted that he wouldn't actually refuse decimal coins. What he thought of paint by the litre and timber by the metre, assuming he was a DIY man, wasn't revealed, probably because his opinion of them wouldn't have been unusual enough to rank as news.)

SI* units, or at least those included in the mksA system, have been with us far longer than decimal coinage. The mks (metre-kilogram-second) system was proposed by Prof. G. Giorgi as long ago as 1901, and although more than 30 years passed before much notice was taken of it, when the break came (as it did in electrical engineering—after the addition of the ampere—more than 20 years ago) the change-over was much faster than the most optimistic had expected. Yet there is still a pocket of resistance that goes on using cgs units though all others have stopped. I mean the people concerned with magnets and magnetism.

Practically everybody *uses* magnets, in such things as loudspeakers, magnetic pickups and microphones, tape heads and television receivers for example, but not many are so much involved with them as to have to use magnetic units, or, more correctly perhaps, units of magnetism. May be it is because these are a relatively small group, confined largely to Sheffield†, completely single-minded in their devotion to the task of producing ever better magnets, that they are out of touch with the rest of the technological world in this (to them) unimportant matter. Like the Japanese sergeant found in some remote spot in Indonesia, they don't know that the (units) war has been over for 20 years. To be fair, one must admit that there are other possible reasons for this backwardness. It is all very well for the rest of the technological world to be self-righteous about their own acceptance of SI units; their volts and amps and watts and even henries were completely unaffected by the change. In so far as magnetic magnitudes have to be considered by some, this was usually a small part of their whole world and the new units could be accepted without too much upheaval. But for specialists in magnetism, cgs units were part of their tradition, and much greater mental adjustment was required. And even now, when challenged they can claim more than mere mental inertia as an excuse: with some justification they can retort that reckoning flux density per square metre is not strikingly appropriate in this day and age of microelectronics. Square centimetres are much nearer the mark, especially in the loudspeaker magnet trade. Their reasonableness in pleading against the inconvenience of having to specify a typical magnet flux as, say, 0.0015 webers may at this point be adulterated by a certain amount of low commercial cunning, since 150,000 maxwells is much better calculated to impress potential customers. Another argument that will undoubtedly be raised is the convenience of the cgs permeability of air being equal to 1, instead of $4\pi/10^7$ as in SI.

So the magnet trade at least may be hard to convince. Perhaps a better line to take with them than extolling the virtues of SI (which they will have difficulty in seeing, even if they want to see them, which is unlikely) is the negative approach—to point out that there is no more future for cgs units than for £sd coinage. Their sons—and daughters—are being brought up on SI, and most fathers don't like to be seen as squares in their own business. And even their hi-fi customers, looking up the current loudspeaker lists as I am just now, may soon be wondering what these gauss and maxwells—and even 'lines'—are. When the magnet men realize they are talking an archaic language to the new generation of big money spenders they will change.

The readers I have in mind are not the members of the magnet trade, nor the young who know only SI, but those who were brought up on cgs and are not yet too handy with SI, together with all who are hazy about magnetic quantities of any kind and their relationships to the familiar amps and volts and ohms.

So first of all I will show how magnetic circuits correspond to electric circuits. I know that this is an extremely unoriginal procedure, found in nearly all the elementary books. I used it myself in the September 1947 issue, but even if you had been born by then you would hardly remember it. And I know that superior persons, looking for a chance to demonstrate their superiority, will point out that this is a false analogy, since magnetic flux corresponds to electric flux, not current. But practically nobody outside the classroom, and few of those inside it, are really familiar with electric flux and elastance. It is a basic principle of teaching that the obscure should not be explained in terms of the more obscure. So I'm going to liken magnetic flux to electric current, with the warning that there is a more perfect analogy to come later.

I hopefully assume that everyone who is still with us understands Ohm's Law. No; I'm not thinking of the pedantic aspects of it that were my subject in the August 1953 issue and can be seen to this day in "Second Thoughts on Radio Theory". All I mean is the relationship between volts, ohms and amps ($I = E/R$), and how resistance depends on the dimensions and resistivity of the circuit or part of a circuit concerned. So, in Fig. 1, the resistance of the bit of wire is

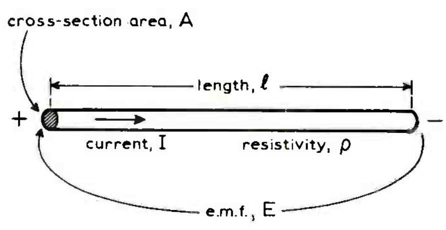


Fig. 1. Ohm's law applied to a piece of wire to find the current flowing through it, given the dimensions and resistivity of the wire and the e.m.f. applied to it.

directly proportional to its length l and to the resistivity ρ of the metal, and inversely proportional to the cross-sectional area A:

$$R = \frac{\rho l}{A} \qquad (1)$$

This is true whatever the units of R, l and A. But the value of ρ depends on those units. In SI the basic unit of length is the metre, so ρ is the resistance between two opposite faces of a metre cube of the material, and in the equation l must be in metres and A in square metres, or metres^2 as we are encouraged to write it. There is nothing to stop

*Système Internationale d'Unités.

†To forestall indignant retorts, or even physical assault, from citizens of Sheffield, I would assure them that I have no wish to bring their city into contempt. By all accounts it is an admirably progressive one, not least in the reduction of atmospheric pollution.

us reckoning A in square millimetres (mm^2) if we prefer, so long as we allow for this deviation by dividing by 10^6. For ordinary circuit materials ρ is a constant at any one temperature, which is more or less what Ohm was on about. (He didn't know anything about volts, amps, or even ohms.) For metals ρ increases slightly as the temperature rises. For a lot of other things it falls. And for electronic devices it depends mainly on V or I, but of course Ohm knew nothing about them.

One must admit that this resistance formula (1) is not very often used in practice. The resistance of wire is given in tables, and the resistance of resistors is shown by the colour code they bear. If in doubt one can easily measure the resistance with the usual multirange meter. The resistances of electronic devices cannot be calculated by the formula, because ρ is unknown; anyway, one is not usually interested in their resistances as such so much as in the varying relationship between E and I, given by characteristic curves. The main purpose of eqn. 1 is to provide a clear picture of how units of resistance depend on circuit dimensions.

So much for the recapitulation. Now for the analogy. To change over to a magnetic circuit, for electromotive force E volts put magnetomotive force F amps (yes!), for current I amps put magnetic flux Φ webers (Wb), for resistivity ρ put reluctivity ν, and for resistance R ohms put reluctance S amps per weber (A/Wb). (Note: ohms could be called volts/amp, which would make the resemblance of form still closer. Incidentally, in specifying the full-scale current drain of voltmeters, their manufacturers call amps ohms per volt, but in this case the reason is unknown.)

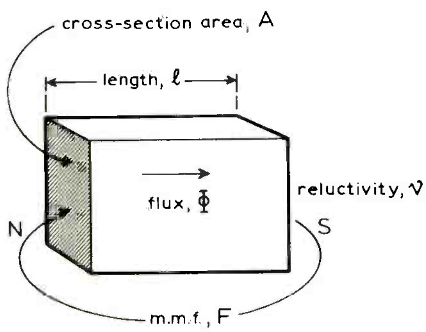


Fig. 2. This is a magnetic analogue of Fig. 1, showing how the magnetic flux in a block of (say) iron can be calculated.

In Fig. 2 we have, say, a piece of iron such as a pole-piece forming part of a magnetic circuit. Following the same reasoning as for Fig. 1 we get

$$S = \frac{\nu l}{A} \qquad (2)$$

In both diagrams A has deliberately been made constant throughout the length l to avoid bringing in mathematical complications that would distract attention from the main principle. Although for our theoretical purposes A and l could have been made the same sizes in Fig. 2 as in Fig. 1, in practice magnetic circuits are generally made short and fat because (1) the object is usually to make Φ as large as possible, and (2) whereas the resistivity of the space surrounding an electric circuit is usually high enough for practically no current to leak into it, reluctivity is never very low so leakage of magnetic flux could be considerable in a long narrow circuit. There is no such thing as a magnetic insulator.

In case anyone is puzzled by reluctivity it might be helpful to reveal that it is the reciprocal of the better known permeability, μ; i.e., $\nu = 1/\mu$. If you prefer you can put permeability in Fig. 2 and substitute the corresponding quantity conductivity, γ, in Fig. 1. But I thought we might make a bad start if we encountered this rather unfamiliar quantity so soon.

Permeabilities or reluctivities, take your choice, are almost the same for all materials —including empty space—other than those called ferromagnetic, for which μ can be many thousands of times greater and varies enormously according to the degree of magnetization. In fact, such materials correspond very much to electronic devices in electric circuits; characteristic curves are needed, and electronic current and magnetic flux are both limited by saturation.

Before we can tackle magnetic units we have to consider how Φ and F, and other magnetic quantities not shown in Fig. 2, are related to current and voltage. We must make perfectly sure we don't confuse these *relationships* with the *analogy* we have just been considering. It would have been better if we could have illuminated magnetic quantities in Fig. 2 by some analogy with totally unrelated quantities, say the flow of tomato chutney along a pipeline on its way to the bottling department; but chutney-motive force is not a sufficiently familiar concept to come within our basic principle of education, and there are other flaws in the analogy. It happens that Ohm's Law is clearer and simpler and better known than any other valid analogy I could call to mind. But now, having I hope got a clear picture of Fig. 2, let us forget about Fig. 1.

We all know that when an electric current flows it sets up a magnetic field around itself (Fig. 3). And that the strength of this field is directionally proportional to the current. Does it depend on anything else? As a one-time famous broadcaster would so rightly have said, it all depends on what you mean by a magnetic field. I've used the term as vaguely as I suspect many people, even some readers of *Wireless World*, think about it. That is exactly why I'm trying to clarify the matter. There are various approaches, but as we have already established a magnetic 'Ohm's Law' let us begin there, without stopping yet to explain exactly what is meant by a magnetic field.

Whatever it is it can be supposed to be caused by what we already know as a magnetomotive force, hereafter to be abbreviated to m.m.f. in line with e.m.f. It in turn is caused by electric current, and depends on nothing else. That is, if you follow the modern practice and count the total current around which the m.m.f. is considered. So if there are 50 wires close together, each carrying 0.1A (usually because the wire is wound into a 50-turn coil) the effective current is 5A. Formerly one would have said 5 ampere-turns. The main object of SI being to exclude all illogical constants in the relationships between the basic units, the SI unit of m.m.f. has been so chosen that it is numerically equal to the current that creates it. That is why the name of the unit of m.m.f. is the same as that for the basic unit of current—the ampere.

M.m.f. is not directly useful, but only as a cause of magnetic flux; just as e.m.f. is not directly useful for creating magnetism, but only as a means of making the current flow. And just as the amount of current a given e.m.f. will cause to flow in a circuit is decided by the resistance of the circuit, so

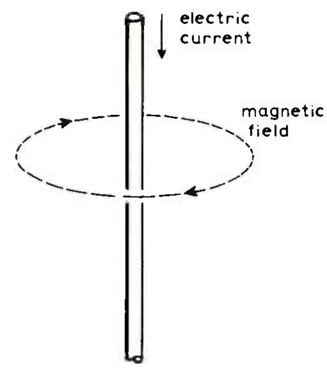


Fig. 3. The basic relationship between an electric current and a resulting magnetic field

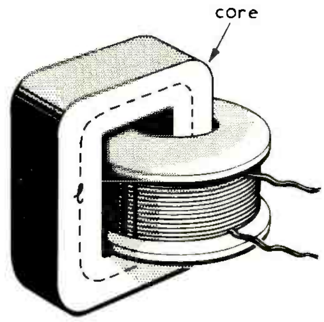


Fig. 4. Here the magnetic circuit linked with a current-carrying coil is assumed (for simplicity) to be confined to a high-permeability core of uniform cross-sectional area A and mean length l.

the amount of flux a given m.m.f. will cause in a magnetic circuit is decided by the reluctance of that circuit. In practice one usually looks at it from the other end: knowing that a certain amount of flux has to be provided, how much m.m.f.—in terms of current and number of turns—is needed?

This can be quite difficult. The shape of a magnetic circuit is usually decided by what it is for. In any case the whole circuit around the current cannot be of the ideal rectangular shape shown in Fig. 2. Assuming that one wants to produce the maximum flux for the minimum m.m.f.—in other words to have as little reluctance as possible—eqn. 2 shows that we would choose one of the special alloys with a very low ν, or high μ. Makers of these alloys supply data showing the values of μ under various conditions. One of the many forms of core made of such materials is shown in Fig. 4. It is quite possible to make A constant throughout, or nearly so; and although l varies according to distance from the centre an average figure can be used, and so the reluctance of the whole circuit can be calculated reasonably well.

It is seldom as simple as this. Very often, as in electric motors and generators, loudspeakers and moving-coil meters, the flux has to pass through an air gap to be of any use. When the gap is of such a shape that A and l are constant, its reluctance can easily be calculated, μ for air being known very accurately, though one has to allow for edge effects. Because μ for the core is usually so enormous in comparison, the core reluctance can sometimes be neglected, so letting one off the problem of ascertaining it. Another help is to remember that just as resistances in series add up, so do reluctances, and one can split up the magnetic circuit into separate parts, each needing a certain m.m.f. to carry a given flux. (This is analogous to Kirchhoff's voltage law.)

You may be bursting to tell me that most of the magnets in which *Wireless World* readers are likely to be interested are permanent magnets, for which no current is needed. Actually they too require current to cause the required m.m.f., but the molecules of the magnet material itself are so aligned that the electrons circulating in them constitute the necessary current. (In all other materials the alignment is random or in direct opposition, so the magnetic effects of these tiny currents cancel out.) One would have to be rather unusually bright at physics to predict the effective m.m.f., but fortunately the suppliers of permanent magnets also provide all the necessary data. The units used are (or should be) the same as for electromagnets; the theory is too much to push in here and now, and in any case can be understood more easily when we have covered magnetism generally. I may get around to it later, but meanwhile if you can see the March 1961 issue you will find it all there.

If you look up magnet or magnet core data you are likely to find most of it in terms of B and H, with Φ and F and S hardly mentioned, if at all. Even μ may not be specified directly, although it seems to be the most important factor in reluctance. To understand these omissions, let us take a look at a curve of Φ against F for some magnetic material such as iron (Fig. 5). The slope of this curve will be Φ/F. Our magnetic 'Ohm's Law' is

$$\Phi = \frac{F}{S} = \frac{F\mu A}{l}$$

So $$\frac{\Phi}{F} = \frac{\mu A}{l} \qquad (3)$$

The dimensions of the piece of iron, A and l, being fixed, we see that the slope is proportional to μ. To find the actual value of μ we would have to multiply the slope by l and divide by A. This way of presenting the data is silly, because we are not interested in the figures for the piece of iron that the manufacturer's lab people happened to use for their tests, but in the properties of that particular material, which we can then use to tell us about a piece of the size and shape we might want to use. One way would be to measure a unit cube of the material, so that l and A were both $=1$. But this would restrict the method of measurement very inconveniently, especially with SI units, for a metre cube of iron weighs about 8 tons.

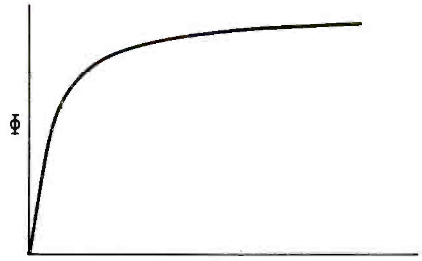


Fig. 5. A graph of flux against m.m.f. for a ferromagnetic material would apply to only one particular size and shape. But by suitable choice of scales of flux density against magnetic field strength the same graph is made to apply to that material in any size and shape.

A better idea is to have units that will refer to unit dimensions of the material. So instead of Φ, the total flux, we use the flux passing through unit cross-sectional area: the flux density, denoted by B, in Wb/m^2, called teslas (T); and what is called magnetizing force or magnetic field strength, H, in A/m. Rearranging eqn. 3 we get

$$\frac{\Phi}{A}\cdot\frac{l}{F} = \mu$$

So $$\mu = \frac{B}{H} \quad \text{or} \quad B = \mu H$$

For the reason just explained I didn't bother to provide Fig. 5 with scales, but if B is written in place of Φ and H in place of F then numerical scales would apply to that material in general, regardless of size or shape. (There are exceptions, called anisotropic materials, 'anisotropic' meaning that their properties are not the same in all directions, like wood having different properties along and across the grain.)

Sometimes one comes across data curves showing μ directly in terms of H or B. From the typical B/H curve shape in Fig. 5 we can see that the permeability (=slope) begins high and continues so over a range, beyond which it falls off rapidly towards a certain flux density, called saturation, which is not much more than for air. Under these conditions there would be a lot of leakage flux outside the iron.

Since most magnetic data and calculations are in terms of B and H, referring back to Fig. 1 we may wonder why the same policy is not adopted there, replacing current by current density and e.m.f. by electric field strength. Well, if I had started from the more strictly appropriate analogy, comparing magnetic fields with electric fields, that is just what one would do. Because one is interested in electric fields mainly in non-conducting spaces (inside a cathode-ray tube, for example) current is replaced by electric flux, which is treated like magnetic flux and reduced to flux density or displacement. For an overall grasp of electric and magnetic theory it is very helpful to consider this analogy in detail, but I assumed that from a more practical standpoint most people are familiar with electric circuits and would like to be clearer about magnetic circuits *and* fields.

While we are on about fields we might look again at Fig. 3. If the current flowing through the wire (or group of wires) is called I, we now know that the m.m.f. F encircling the wire—at *any* distance from it—is equal to I, both I and F being reckoned in amps. But because the path length around—call it l again—is proportional to the distance r from the axis of the wire, being in fact equal to $2\pi r$, the m.m.f. is spread over a greater circular length as the distance from the current is increased. So the magnetic field strength

$$H = \frac{F}{l} = \frac{I}{2\pi r}$$

In words, it is inversely proportional to the distance from the current that causes it. We are assuming—in case you didn't know—that the whole of the space around the wire has the same permeability and contains no currents or magnets to upset the cylindrical distribution of field around the wire.

If your information on magnetism was obtained some time ago you may have been wondering why I've about come to the end of this exposition without having ever mentioned 'unit magnetic pole'. Most of the books used to base their treatment of magnetism on it. The more honest of them admitted that no such things exist, which is why I've ignored them. It is rather different with the analogous electrical concept, unit electric charge at a point, because electrons and protons are as near as you like mobile point charges. Another item that has been perhaps conspicuous here by its absence is the 'line of magnetic force', so much used in 'explaining' magnetic fields. They don't exist either, and can be actually misleading if they are allowed to convey the impression that the spaces between are any less magnetic than the lines themselves. But, like the lines cartoonists draw radiating from persons experiencing intense emotion, they at least help one to visualize something that does exist. In particular, they show on a diagram the directions along which a magnetic field acts; for example, in Fig. 3, in circular paths around the current. If there were such things as mobile magnetic poles of negligible size, these are the paths along which they would be moved.

No; I haven't forgotten that I set out to enlighten any who are still groping in cgs twilight. The fact that cgs units don't fit in with the familiar electrical units such as volts and amps has already been mentioned as one of their disadvantages. Another is the fact that there are two cgs systems of units, one based on unit electric charge and the other on unit magnetic pole, and their units differ from one another and from the practical units by factors usually of many millions. Another snag is that unit charge and unit pole were each said to give rise to a flux of 4π units. The reason for this apparently odd choice was that unit flux density was defined to exist at unit distance from the unit point source of flux. The surface area of the sphere of unit radius is 4π units, so if the flux emerging through unit area of the surface is 1 the total flux must be 4π. By starting on this basis, the originators of the cgs systems eliminated the factor 4π precisely where one ought to find it—in a situation of spherical geometry. The result was that the factor 4π, expelled from where it rightly belonged, broke out in places where its presence could not be justified by the geometry; for example, in the formula for a parallel-plate capacitor.

And in the relationship between current and m.m.f. My electrical engineering tutor, whenever a student was stuck at a problem, sat down opposite him, scribbled on a sheet of paper with a circular motion to represent a current-carrying coil; then repeatedly smiting its interior with the point of the pencil to represent end views of lines of force, hissed 'Magnetomotive force is point four pi times the current enclosed!' This relationship took into account the irrational 4π and the fact that the electromagnetic cgs unit of current was 10A. Nowadays even the densest student should be able to retain the SI relationship 'Magnetomotive force is equal to the current enclosed' without having to be constantly reminded of it.

Fig. 4 shows that interrelated current and magnetic flux are like adjacent links of a chain. We have considered how current in the coil causes an m.m.f. linking the current path. Faraday's greatest discovery was that a *change* in magnetic flux causes an e.m.f. linking the flux path. The electromagnetic unit of e.m.f. was quite logically defined as that induced when interlinked flux was changing at unit rate (1 maxwell) per second. But unfortunately this turned out to be $1/10^8$V, or 0.01μV, which is small even by circuit noise standards. The electrostatic cgs unit of e.m.f., by contrast, is about 300V, because the ratio between the units of e.m.f. in the two systems is equal to the speed of light in centimetres per second. To the uninitiated this might seem as irrelevant as the diameter of the earth or the price of beer. The connection lies in the fact that in both cgs systems the permeability and permittivity of empty space (μ_0 and ε_0) are both fixed as 1. Now one just can't have it both ways like this. The reason is that the speed of light (**c**) is equal to $1/\sqrt{\mu\varepsilon}$ for the medium in which it is travelling, so in space is $1/\sqrt{\mu_0\varepsilon_0}$. The only way to make μ_0 and ε_0 both 1 is to choose units of length and time such that $\mathbf{c} = 1$. If the second is retained as the unit of time, then the unit of length must be 299,792,800 metres. Anyone who proposed this as the standard would have no political future.

The inevitable result of making unit length 1cm at the same time as $\mu_0 = \varepsilon_0 = 1$ was the emergence of two cgs systems, depending on whether μ_0 or ε_0 was chosen as basic, in which units of the same quantities differed by factors of **c** or $\mathbf{c}^2$. And the real values of μ_0 and ε_0, which actually are related to **c**, had to be hidden away in the sizes of the various units. So most of them are wildly impractical. The emcgs unit of resistance, for example, is 0.001 microhm, while the escgs unit is about a million megohms. SI works on a different principle. By changing over to the metre and kilogram for length and mass, and using the ampere as the unit of current, all the 'practical' electrical units became parts of it, and new magnetic units emerged from them on the same principles. And so the SI unit of m.m.f. is equal to the current enclosed instead of 0.4π times it. And when the magnetic flux is changing at unit rate per second the e.m.f. induced along a linked path is 1 volt.

Does this mean that π no longer appears in electromagnetic equations? Not at all; it means it appears where it logically ought to —as 2π in cylindrical geometry and 4π in spherical geometry, but not in rectangular geometry. The cgs systems were as confusing as a system of measures would be in which the unit of length was such as to make the surface area of a sphere one unit of length-squared.

Of course there is always a snag. Instead of the convenient values of 1 for space permeability and permittivity we have $4\pi/10^7$ and approximately $1/(36\pi \times 10^9)$ respectively. So π and large powers of 10 get back in by the rear entrance! However, it is easier to remember these two values than to have to remember the correct constants for innumerable formulae. If dirt has to be swept under carpets, it is better to have it swept under two already dirty ones if we can rely on there being none anywhere else. There is even something to be said for μ_0 and ε_0 not being 1. When they were, students were often led to suppose that H and B were more or less the same thing and μ just a multiplier to take account of the properties of magnetic materials. Then they got into difficulties with the dimensions of equations.

What, then, are the dimensions of μ and ε? The best clue to ε is the way the capacitance between two parallel plates is calculated. It is proportional to A, the area of the space between the plates, and to ε, the permittivity of whatever occupies that space. And it is inversely proportional to l, the (uniform) distance between the plates. (Edge effects are neglected, or counteracted in some way.) So in any regular system of units

$$C = \frac{A\varepsilon}{l}$$

Therefore

$$\varepsilon = \frac{Cl}{A}$$

In SI units, C is in farads, l in metres and A in metres². So ε is farads × metres ÷ metres², or farads per metre. Going back to the electrical circuit analogy, we would find in the same way that conductivity (γ) was in siemens (formerly mhos) per metre, and $1/\gamma$ (=resistivity, ρ) was ohm-metres. An alternative that used to be used was ohms per metre cube, and similarly for the other things; but this looks as if it restricted the measurement to a piece of a particular shape and size of the material tested.

As the analogue for capacitance is inductance we start to get at μ from there. The inductance (L) of a coil—say the one in Fig. 4—is equal to the flux linked with it when unit current flows through it. If we neglect flux in the surrounding air, and use eqn. 3 we have, when F is one unit and Φ is therefore equal to L,

$$\mu = \frac{Ll}{A}$$

So μ is in henries per metre.

To sum up, here is a table of the SI magnetic units:

Quantity	Symbol for quantity	Unit	Abbrevn. for unit		emcgs equivt.
Magnetomotive force	F	Ampere	A	In practice, the ampere-turn	0.4π gilberts
Magnetic field strength	H	Amp. per metre	A/m	$= F/l$	$4\pi 10^{-3}$ oersteds
Magnetic flux	Φ	Weber	Wb	$= AB$	10^8 maxwells
Flux density	B	Tesla	T	$= \mu H$	10^4 gauss
Permeability	μ	Henry per metre	H/m	$= B/H$	$10^7/4\pi$ greater
Permeability of space	μ_0	Henry per metre	H/m	$= 4\pi 10^{-7}$	ditto (=1)

PUBLICATION DATE

We regret it has not yet been possible for us to get back to publishing on the third Monday of the preceding month. The February issue will not, therefore, appear until February 2nd.

A 200-MHz Counter Prescaler

An add-on unit to extend frequency measurement

by D. J. Taylor, B.A., G8ARV/G6SDB/T*

Direct digital frequency measurement has come well within the amateur's price range this last year due to the introduction of ultra fast logic intended for high volume computer applications. As these circuits are produced by several manufacturers, price competition has resulted in savings for the amateur too. With only £5 worth of integrated circuits, it is possible to build a prescaler which combines 2mV low-frequency sensitivity with a 200MHz measurement ability. Here such a prescaler is described and there are three possibilities for its use:

- As an add-on unit for heterodyne or similar frequency meters, where the indicated readings are multiplied by four to obtain the true frequency.
- As an additional unit for a home-built frequency counter, where the timebase can be modified to include a scaling factor of four.[1]
- With an additional divide-by 25 circuit (not described here) so that the net frequency division is by 100 times. As the output frequency does not exceed 2MHz, this would be suitable for direct reading with an older vintage of counter.

The range of i.cs which form the basis of the described design, is the Motorola MECL 10000. This is an e.c.l. (emitter coupled logic) family introduced in 1971 which uses current steering rather than saturated transistor switching. This technique avoids the delays normally associated with transistor charge-storage mechanisms.[2]

Current steering logic has various advantages:

- It can drive 50Ω lines directly.
- It generates fewer supply line transients because of the balanced nature of the circuit.
- Each gate consists of a differential amplifier, which makes interfacing to analogue signals easier than with t.t.l.

The price to be paid for these advantages is a higher power consumption noticeably in the "pull-down" resistors required on the emitter follower outputs.[3] However, the basic gate has a power-speed product (a parameter used by semiconductor manufacturers to sell their devices) second only to that of low-power Schottky t.t.l. which is very much more expensive at this time and availability is poor. Practical advantages of the MECL 10000 series are, the fastest operating speed per pound, ease of electrical operation, and good availability.

Using only two i.cs this prescaler simply takes a low-level sinewave signal, amplifies it to the levels required by the logic circuit which then divides the frequency by four.

Pre-amplifier, limiter and divider

The MC10116 (IC_1, Fig. 1) is a triple line-receiver which consists of three wideband differential amplifiers, each having a voltage gain of 16 (differential input to output). A possible way to use this device is as a pre-amplifier (two stages) and a Schmitt trigger. However, this results in a poorer low-frequency sensitivity and a lower high-frequency limit than can be achieved. A better way to use this i.c. is as a broad-band limiting amplifier, using differential interconnection between the stages. In this way a sensitivity of a few millivolts at 10MHz and about 100mV at 200MHz can be achieved.

The MC10131 (IC_2, Fig. 1) is a dual D-type flip-flop which in this circuit is used as a toggle-bistable to give a frequency division of four times. It can drive loads directly and is guaranteed to toggle at 150MHz.

At the time of writing the following one-off prices were quoted MC10116 – £1.12, MC10131 – £3.93, making the total semiconductor cost £5.05.

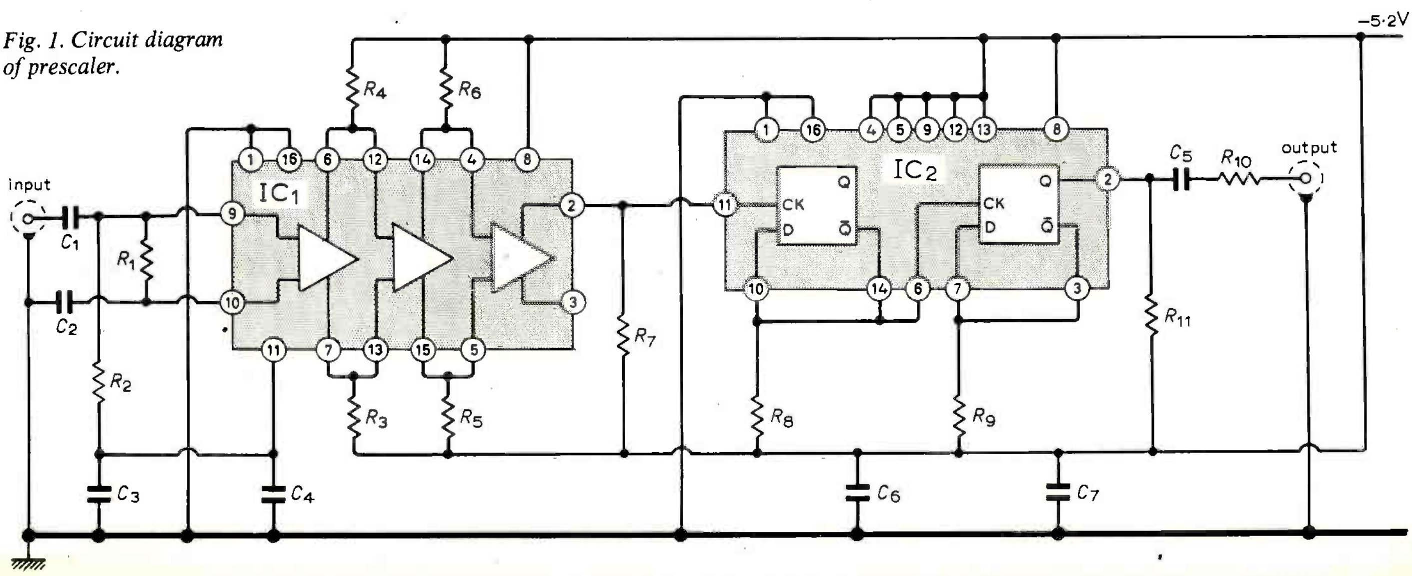
Circuit details

The input has been designed to match either 50 or 75Ω, the expected source being a small search coil which can couple to the apparatus under test. As will be seen from the circuit diagram this is achieved by altering one resistor R_1, which is 82Ω for 75Ω input and 56Ω for 50Ω input. The off-set voltage produced across this resistor serves to prevent the prescaler being too sensitive at low frequencies, where noise and external signal pick-up may become a problem.

The intermediate amplifiers are termin-

*Jesus College, Cambridge.

Fig. 1. Circuit diagram of prescaler.



ated by 680Ω resistors to the negative supply, this value of resistor giving adequate bandwidth. The final stage uses a lower value resistor (R_7), as experiments have shown that this triggers the divider more satisfactorily and makes the waveform at that point easier to monitor.

The toggle speed is limited by the first bistable and not the bandwidth of the preamplifier which only determines the input sensitivity. The bistable itself uses a similar low value of termination resistor (R_8) for the first stage which is speed critical. Note that the complementary output $\bar{Q}$, does not need a terminating resistor for bistable operation as an extra emitter follower is included inside the device for feedback.

The output can feed either terminated or unterminated lines. If a terminated line is used, the matching resistor R_{10} should not be included and R_{11} should be decreased to 220Ω. The output will be about 800mV peak-to-peak. For unterminated lines, R_{10} absorbs the reflection produced by the open circuit, and the voltage at the open circuit is also about 800mV peak-to-peak. However, this voltage level will no longer be suitable for driving further e.c.l. circuits, as it consists of both forward and reflected waves.

The input stage of the prescaler is not protected against transients, but back-to-back Schottky-barrier diodes, MBD101 or similar, could be connected across R_1 if required.

Components List

R_1	56Ω	C_1	10nF
R_2	1k	C_2	10nF
R_3	680Ω	C_3	47nF
R_4	680Ω	C_4	100pF
R_5	680Ω	C_5	10nF
R_6	680Ω	C_6	47nF
R_7	270Ω	C_7	100pF
R_8	270Ω		
R_9	1.5k	IC_1	MC10116
R_{10}	43	IC_2	MC10131
R_{11}	680 or 220Ω		

Construction

As with any circuit operating at 200MHz, lead lengths should be kept as short as possible. In the prototype this was achieved by using the lid of a tobacco tin as a ground plane and mounting the devices, pins uppermost, directly against the metal surface. This also gave some degree of heat-sinking. A photograph of this prototype is shown in Fig. 2. The layout was kept as simple as possible, with the decoupling capacitors having as short a lead length as could be reasonably achieved.

The MECL 10000 series are designed to work with positive earth and have two V_{CC} pins, 1 and 16 in this case. These are grounded as close to the package as possible. The prescaler is envisaged as a small accessory unit and the use of an insulated case in which the unit will fit, will remove any problems of earth polarity incompatibility.

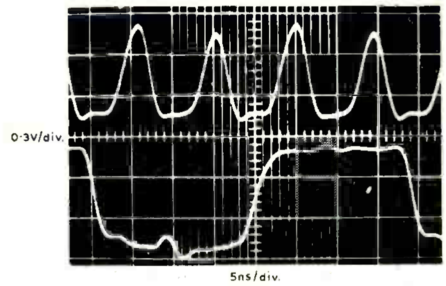


Fig. 4. 100MHz oscilloscope traces: top, pin 2, IC_1; bottom, pin 2, IC_2. Input level 16mV, h.t. 5V.

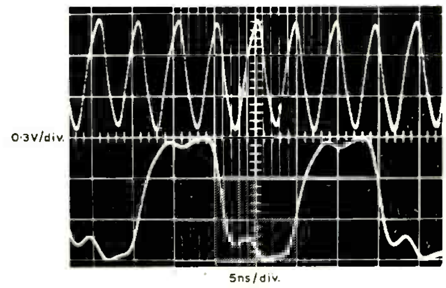


Fig. 5. 200MHz oscilloscope traces: top, pin 2, IC_1; bottom, pin 2, IC_2. Input level 125mV, h.t. 5.5V.

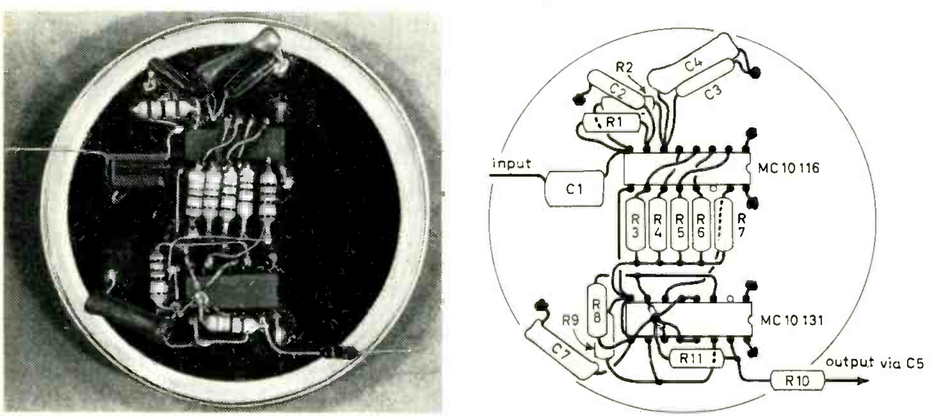


Fig. 2. Prototype construction technique showing component positions.

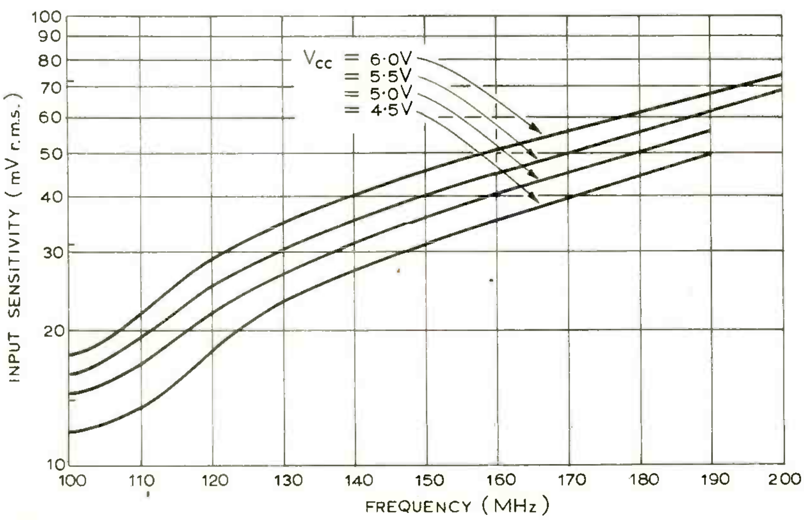


Fig. 3. Measured sensitivity for input frequency.

Performance

An r.f. signal generator, Marconi TF995A/2M, was fed into the input, providing excitation between 10 and 200MHz. Voltages at pin 2 of each i.c. were monitored with a Tektronix sampling oscilloscope, model 661, with a ×10, type P6032 probe.

Fig. 3 shows the minimum voltage to provide satisfactory triggering against frequency over the range 100 to 200MHz with various d.c. supply voltages as a parameter. Signal input voltages are source e.m.f., so that 100mV plotted means 50mV p.d. or 140mV peak-to-peak. Over the range covered, higher supply voltages produced slightly faster toggling but reduced the sensitivity slightly. However, performance is largely independent of supply voltage. At 145MHz, between 28 and 45mV were required, an e.m.f. easily bled-off even a low power transmitter (45mV e.m.f. corresponds to a power requirement of 10μW when referred to 50Ω).

Waveforms for operation at 100MHz and 200MHz, are shown in Fig. 4 and Fig. 5 respectively with horizontal scale of 5ns/div and vertical scale of 0.3V/div. The sub-harmonic is clearly visible on the 100MHz trace, this being a generator imperfection. The distortion on the output waveforms is due to coupling between the two halves of the dual flip-flop package.

References

1. 'Some Improvements in Digital Frequency Measurement Techniques', D. J. Taylor, *Radio Communication*, May 1972, p. 288.
2. 'Electronic Devices & Circuits', Millman & Halkias, McGraw-Hill, 1967, p. 259.
3. 'General Information MECL 10000 Series', Motorola Inc., 1971, sheet O.3–4.
4. 'A 5V Logic Power supply', D. J. Taylor, *Wireless World*, March 1972.

Twin-ribbon Speaker

*by A. E. Falkus**, B.Sc.(Eng), F.I.E.E.

The large majority of domestic loudspeaker assemblies use moving-coil units for the bass and mid-range. For the higher audio frequencies however, a number of different types are employed.

An ideal high-frequency unit would have:

1. A linear response between 1.5 and 20kHz.
2. A polar distribution of 90° in a horizontal plane throughout the range.
3. No resonances, colourations and other forms of distortion throughout the range.
4. Efficiency equal to the average mid-range and bass speaker.
5. Power handling ability of 30 watts.
6. A uniform input impedance at all working frequencies.
7. A reasonable cost comparable with mid-range and bass units.
8. No external power supply.

The first three of these requirements are essential. For a practical system the parameters outlined in sections 4, 5 and 6 are important, whereas those of sections 7 and 8 are desirable. In many ways the ionophone principle is the most attractive. Unfortunately, to produce an ionic unit to meet the first six of our requirements, although technically possible, is too expensive to be a commercial proposition. The electrostatic principle has many adherents but fails on its inability to meet the requirement of a linear response over the desired range, having a uniform impedance—and, of course, a power supply is required.

By far the commonest form of high-frequency speaker in use at present has some form of dome-shaped diaphragm with moving-coil drive. This dome may be of a hard material, in which case it will fail our third requirement. Alternatively, the dome may be of a comparatively soft material with high internal losses. Here efficiency is sacrificed for reduced resonances but this can be recovered by the use of a more powerful magnet. Nevertheless, residual resonances are always present. It is also difficult to meet our first requirement in a single unit.

Ribbon loudspeakers re-examined

When recently considering a replacement for the Ionofane, the above considerations led to a re-examination of the ribbon principle. The main drawback that has been associated with ribbon speakers is lack of sensitivity. Experimental models soon showed however, that provided the flux density is high enough, the efficiency and power handling capacity can be realized by a $\frac{1}{4}$in ribbon with horn loading.

The first ribbon speaker we built which gave the required performance had a large block built up from slabs of anisotropic ferrite magnet material with suitable pole pieces as shown in Fig. 1. The ribbon had an exponential horn with a cut off at 575Hz. This unit met all our requirements except that it was expensive. At low sound levels the quality was indistinguishable from the Ionofane while the maximum output was 20dB higher than that at which the Ionofane became overloaded. Further, improved performance at the low-frequency end of the range permitted the cross-over frequency to be reduced to 1500Hz enabling a mid-range speaker to be dispensed with.

The problem thus resolved itself into one of a magnet design to produce a comparatively high flux density in a 9/32in wide gap at a reasonable cost.

The magnet system shown in Fig. 1 suffers from the defects of being too expensive, is heavy and clumsy and the volume of the air space below the ribbon is insufficient to permit the speaker to reproduce satisfactorily the lower end of its frequency range.

The big problem in designing an economic magnet system for a ribbon speaker is that the total leakage flux between the pole pieces near the actual air gap will be many times the useful flux in the gap itself.

For example, if we apply the formula for magnet efficiency (*W.W.* Jan. 1960, p. 41)

$$E = \frac{T}{T+3.5G} \times 100\%$$

For a $\frac{1}{4}$in wide ribbon, T, the depth of gap, may be 3/32in and G, the width, 9/32. The efficiency thus becomes:

$$E = \frac{\frac{3}{32}}{\frac{3}{32}+3.5\times\frac{9}{32}} \times 100\% = 8.7\%$$

Any configuration of the magnet parts that would increase the proportion of the useful flux to the leakage flux is therefore well worth exploring.

It occurred to the writer that an improved magnet efficiency could be obtained by using a central magnet pole of square cross-section and mounting four ribbons around it, one parallel to each face, thus, in effect, using as much as possible of the inevitable leakage. This arrangement is shown in Fig. 2. A sample unit was built but the assembly of the ribbons proved very difficult. A simplified design using two ribbons,

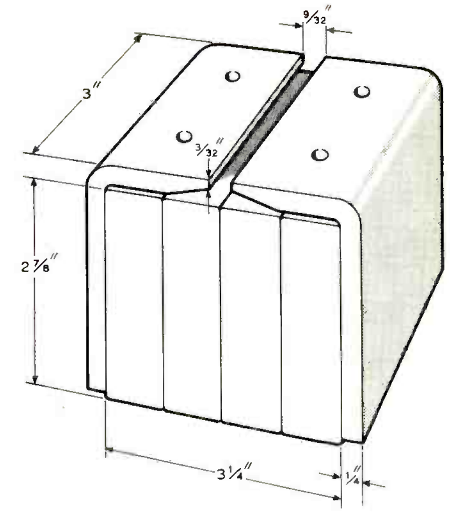


Fig. 1. The ceramic block magnet used in the prototype ribbon speaker.

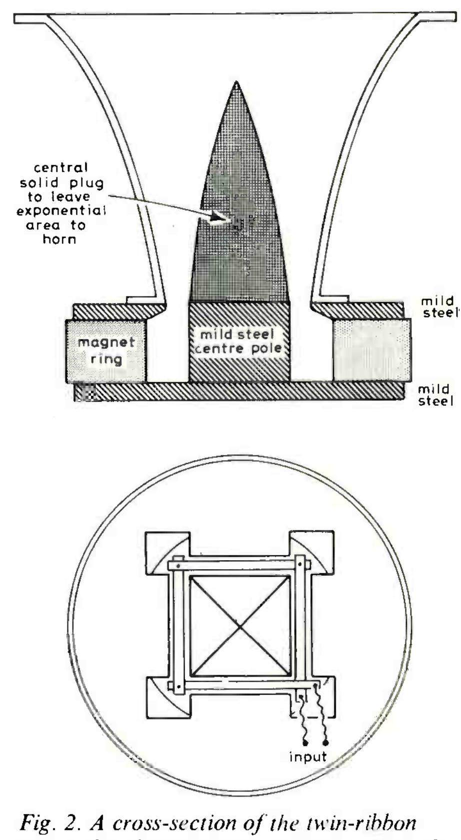


Fig. 2. A cross-section of the twin-ribbon unit and a plan view with the horn removed.

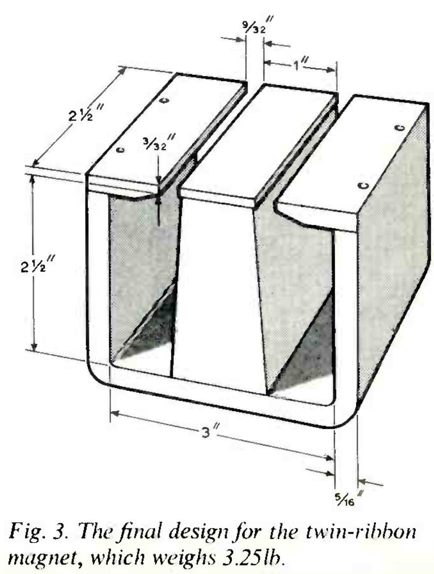


Fig. 3. The final design for the twin-ribbon magnet, which weighs 3.25lb.

*Fane Acoustics Ltd.

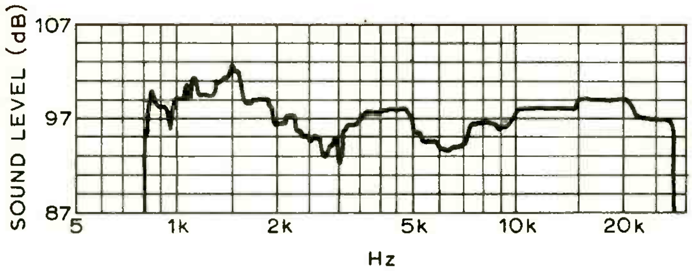


Fig. 4. Response of the unit under 'living room' conditions. Mic 1m on axis, input 4V to transformer, level relative to 0.0002 dynes/cm^2.

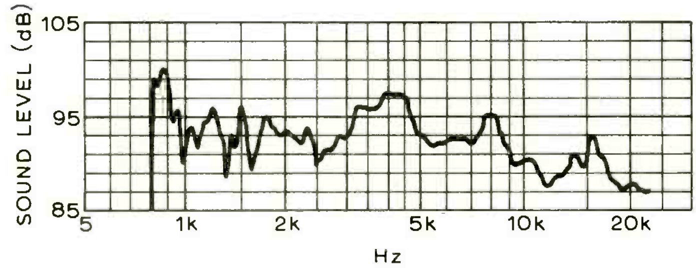


Fig. 5. Response of unit taken under same conditions as for Fig. 4 but with microphone at 0.5m and 45° off axis.

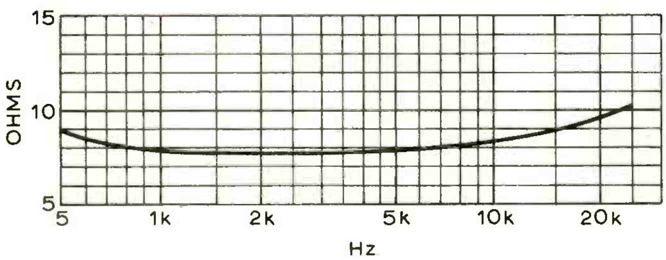


Fig. 6. Input impedance of the unit measured across the transformer primary with cross-over unit disconnected.

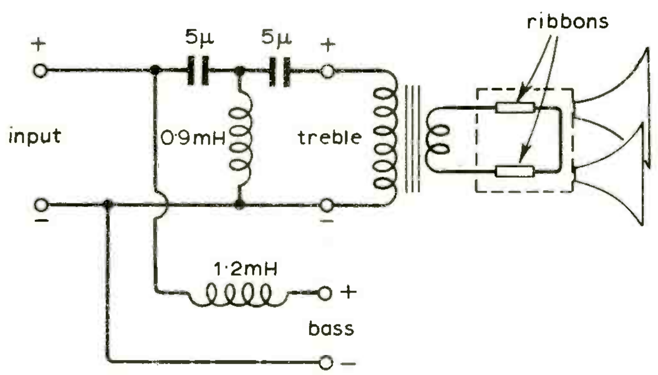


Fig. 7. The cross-over network.

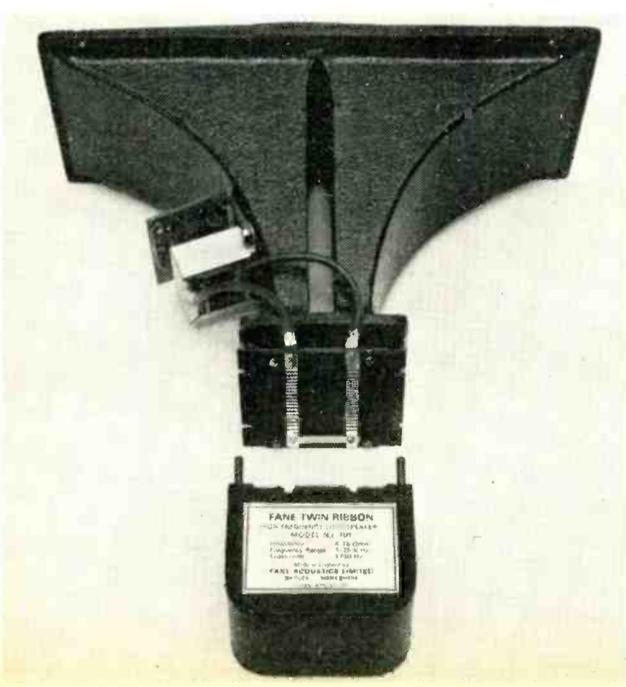


Fig. 8. A view of the completed commercial unit showing the layout of the ribbons.

one to each side of the longer faces of a rectangular section metal alloy magnet, was satisfactory, however, and this forms the basis of the twin-ribbon speaker.*

Twin-ribbon design

The twin-ribbon magnet is shown in Fig. 3. A central block of fully columnar magnet alloy is mounted in a 5/16in thick mild steel yoke. The magnet block is capped with a 3/32in mild steel pole tip $2\frac{1}{2} \times 1$in and the magnet system is completed by two chamfered top plates. The tapering section of the magnet block is desirable since leakage flux is leaving it all the way up and reduction of the section keeps the magnet material working near its *BH* max point.

The two ribbons are mounted on a bakelite panel so that they are located in the air gaps, one each side of the central magnet. Each has an effective length of $2\frac{1}{2}$in and they work in phase so that the total working length of ribbon is 5in. The ribbons are $\frac{1}{4}$in wide and 0.0003in thick and transversely corrugated. They are acoustically loaded with twin horns formed in a single casting and have an exponential law with a cut-off frequency of 550Hz. The ribbons are fed from a double-wound transformer at one end of the magnet, their further extremities being connected together.

This speaker will handle an input of 30W r.m.s. and produce a sound level at the mouth of the horn of 115dB. A response curve measured under living-room conditions is given in Fig. 4, and it will be seen that on the axis it is within $\pm$3dB from 800Hz to 21kHz. At 45° from the axis in a horizontal plane there is a small fall off above 10kHz which reaches 4dB at 20kHz (see Fig. 5). The ribbon presents an entirely resistive load to the transformer but there is a small leakage inductance in the transformer of about 0.06mH causing a slight impedance rise with frequency. It will be seen however from Fig. 6 that between 500Hz and 17kHz the impedance is between 7.8 and 9.0Ω.

For normal use the speaker is mounted with the ribbons side by side which results in a good horizontal dispersion of the higher frequencies. As with all ribbon loudspeakers care must be exercized to prevent low-frequency signals reaching the ribbons. A small fraction of a watt at 100 or 200Hz can cause large movements, which may cause permanent stretching of the ribbon. For this reason the twin-ribbon speaker has a built-in network crossing over at 1700Hz. The circuit of this is shown in Fig. 7. The components are mounted on a printed circuit board carried on brackets from the ribbon transformer. The spaces behind the ribbons, inside the magnet assembly, are filled with sound absorbent material and sealed with plates at each end of the magnet yoke. The twin-ribbon speaker may thus be mounted in the same enclosure as a bass unit.

A photograph of the complete speaker is shown in Fig. 8. The overall dimensions are width 13in, height 6in, depth 10in, and the weight is 10lb.

*Patent applied for.

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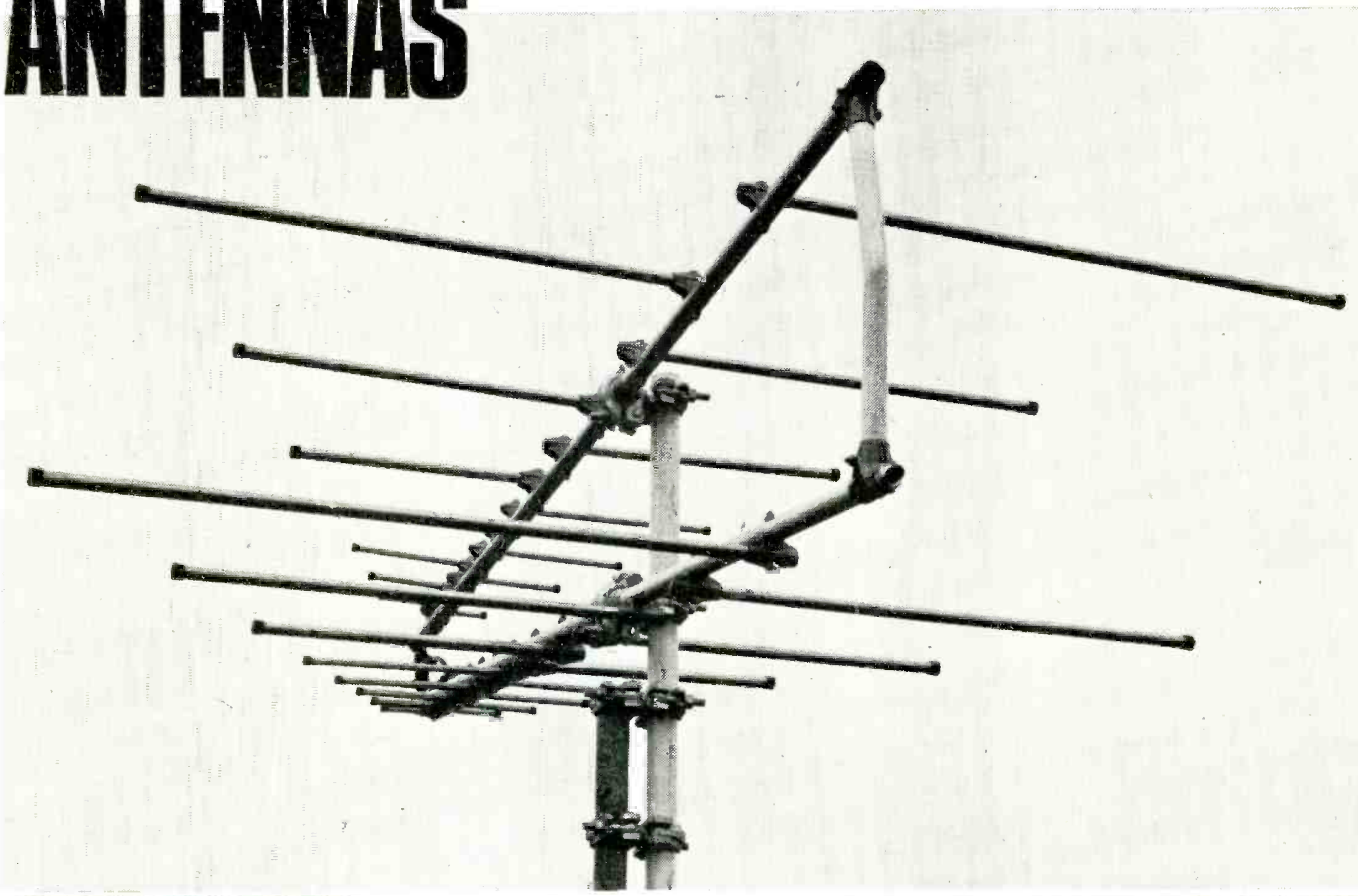

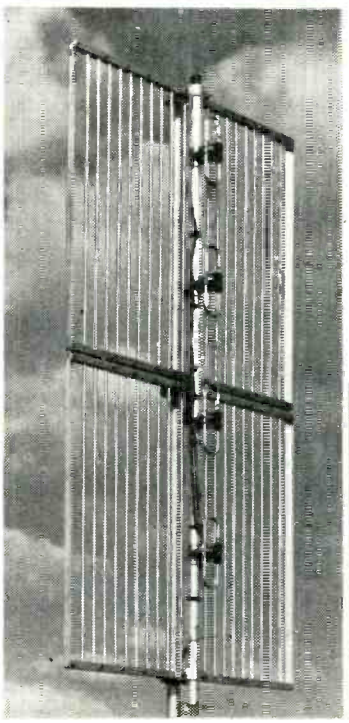

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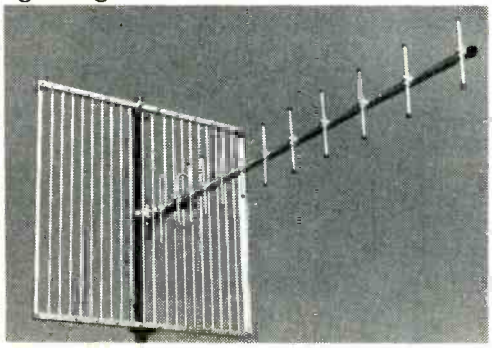

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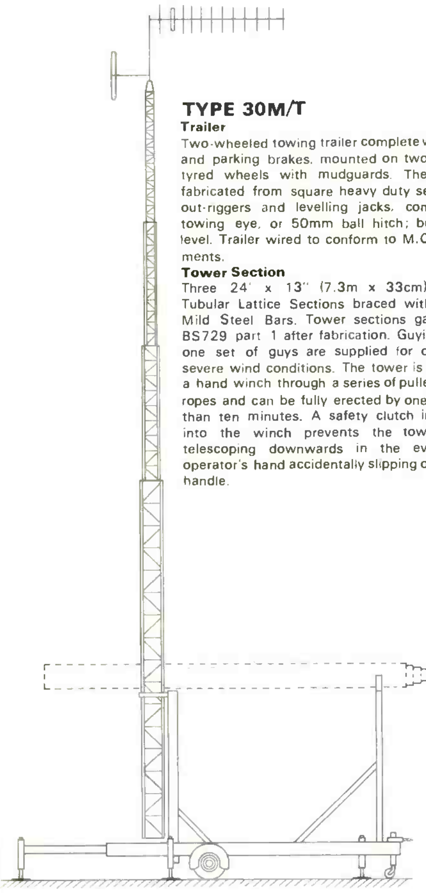


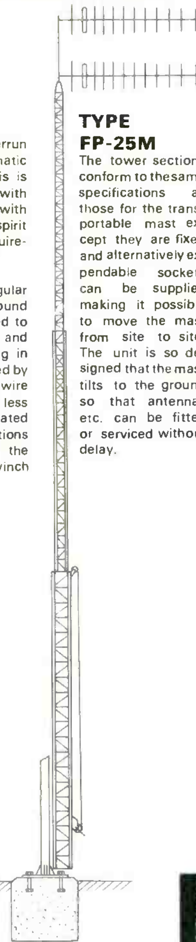
TYPE 30M/T

Trailer

Two-wheeled towing trailer complete with overrun and parking brakes, mounted on two pneumatic tyred wheels with mudguards. The chassis is fabricated from square heavy duty sections with out-riggers and levelling jacks, complete with towing eye, or 50mm ball hitch; built-in spirit level. Trailer wired to conform to M.O.T. requirements.

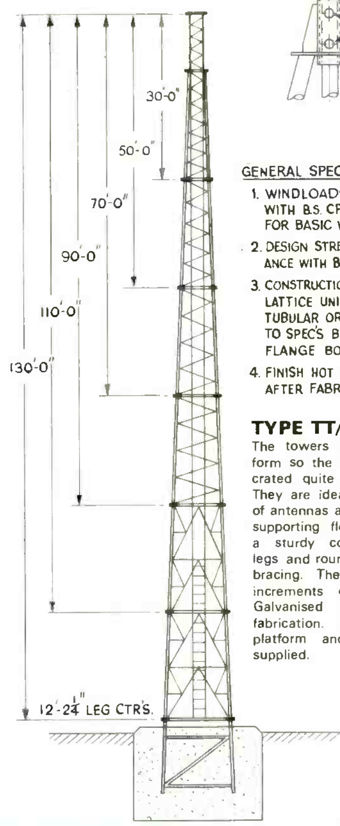
Tower Section

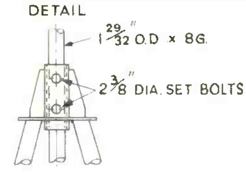
Three 24' x 13" (7.3m x 33cm) Triangular Tubular Lattice Sections braced with ⅝" Round Mild Steel Bars. Tower sections galvanised to BS729 part 1 after fabrication. Guying lugs and one set of guys are supplied for operating in severe wind conditions. The tower is operated by a hand winch through a series of pulleys and wire ropes and can be fully erected by one man in less than ten minutes. A safety clutch incorporated into the winch prevents the tower sections telescoping downwards in the event of the operator's hand accidentally slipping off the winch handle.



TYPE FP-25M

The tower sections conform to the same specifications as those for the transportable mast except they are fixed and alternatively expendable sockets can be supplied making it possible to move the mast from site to site. The unit is so designed that the mast tilts to the ground so that antennas etc. can be fitted or serviced without delay.





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2. DESIGN STRESSES GENERALLY IN ACCORDANCE WITH BS 449 & LATEST AMENDMENTS.
3. CONSTRUCTION IN TRIANGULAR PREFABRICATED LATTICE UNITS HAVING TUBULAR LEGS AND TUBULAR OR SOLID ROUND BRACING IN STEEL TO SPEC'S BS 4360 & BS 4. ALL UNITS FLANGE BOLTED.
4. FINISH HOT DIP GALVANISED TO BS 729 AFTER FABRICATION.

TYPE TT/V

The towers are designed in breakdown form so the sections can be bundled or crated quite economically for exporting. They are ideal for supporting a number of antennas and can be easily adapted for supporting floodlights, etc. They are of a sturdy construction having tubular legs and round mild steel bars for lattice bracing. The towers are fabricated in increments of 20' and 15' lengths. Galvanised to BS729 part 1 after fabrication. As an optional, working platform and access ladder can be supplied.

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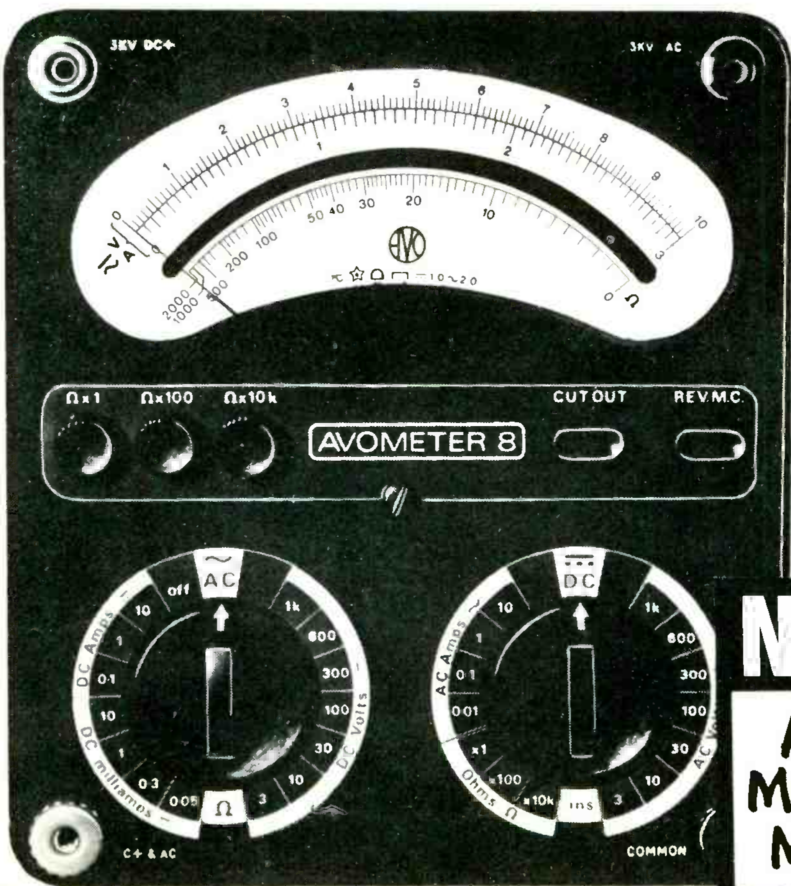

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Circuit Ideas

Faster slewing rate with 741 op-amp

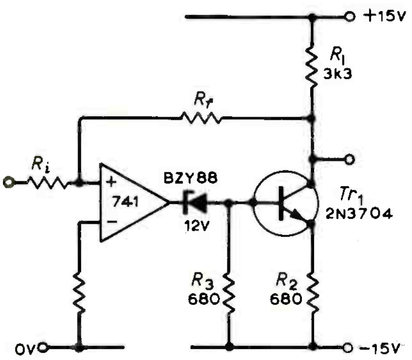
The circuits shown enable slewing rates in excess of that offered by a standard 741 operational amplifier to be achieved. A single transistor amplifying stage is fed from the output of the operational amplifier. If the transistor stage provides a gain of G, then to achieve a given output voltage swing, V, the operational amplifier output voltage swing must be V/G. Both voltage swings occupy the same time, but the swing from the transistor stage is G times that from the operational amplifier. Therefore the slewing rate at the transistor stage output is G times that at the operational amplifier output.

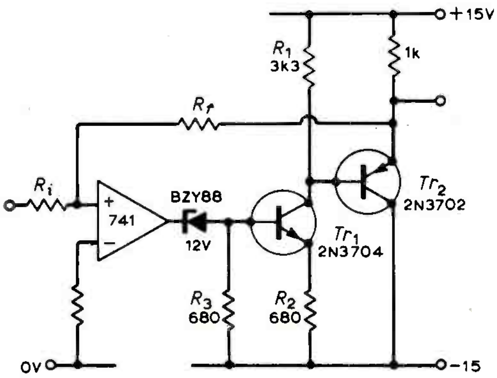
Resistor R_1 must be chosen with regard to the desired output impedance and the current available from the supply. Resistor R_2 is then made equal to R_1/G, where G is the desired stage gain. To utilize the available voltage swing the design should be such that the collector of Tr_1 is at zero volts when the output of the i.c. is at zero volts, assuming the loop is not closed by R_f. If the collector and emitter currents of Tr_1 are assumed to be equal, then the current through the transistor is V_{cc}/R_1. Therefore the drop across R_2 and Tr_1 base-emitter is $V_{be} + (V_{cc}R_2/R_1)$. Hence the voltage to be dropped by the zener diode is

$$V_{cc}-(V_{be}+V_{cc}\,R_2/R_1).$$

These calculations need only be approximate because any errors are virtually eliminated when the loop is closed. Resistor R_3 is required to provide sufficient current for the zener diode to operate correctly. Output impedance may be reduced further by the addition of an emitter follower but R_f must then be taken to its emitter (second circuit). Note that R_f is returned to the non-inverting input because of the additional inversion due to Tr_1. Component values given in the circuit increase the slewing rate by a factor of five. Gains of up to 20 have been used.

L. Short,
Wokingham.



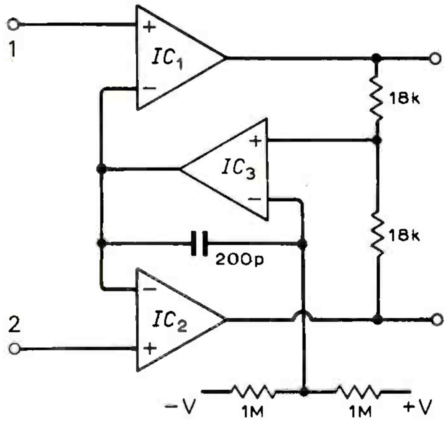


Differential input and output with op-amps

This circuit uses three op-amps to provide an amplifier with differential output as well as differential input. It was designed to drive a meter with a signal of either polarity when a centre-tapped power supply was not available, but could have other uses.

The 18-kΩ resistors form a potential divider across the outputs of the complete amplifier. The voltage at the non-inverting input of IC_3 is therefore the average of the two output potentials. The divider consisting of the two 1-MΩ resistors maintains the inverting input of IC_3 at a fixed potential; IC_3 acts to keep its inputs nearly equal, as it forms part of a negative feedback loop, and therefore the average of the two output potentials, i.e. the common mode output, is determined by the resistor values.

To obtain negative differential feedback with the circuit as shown, output 1 should be connected to input 2 and output 2 to input 1, in both cases via a suitable resistor. If it is more convenient, the connections to the inputs of each op-amp could be reversed, in which case the feedback connections would be output 1 to input 1, and output 2 to input 2.



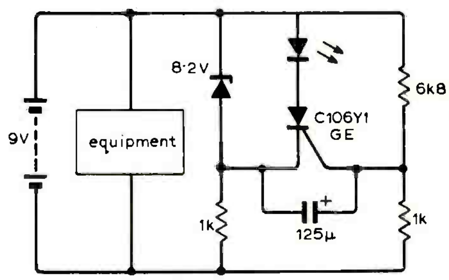
If IC_1 and IC_2 are combined in a dual op-amp, then p.c. board space will be saved, and differential temperature drift reduced. I used a 741 for IC_3 and a 747 (dual 741) for i.cs 1 and 2.

A. D. Monstall,
Edinburgh.

Low battery voltage indicator

This circuit was devised to indicate when the voltage of the battery fell below a minimum acceptable value during a long period of use.

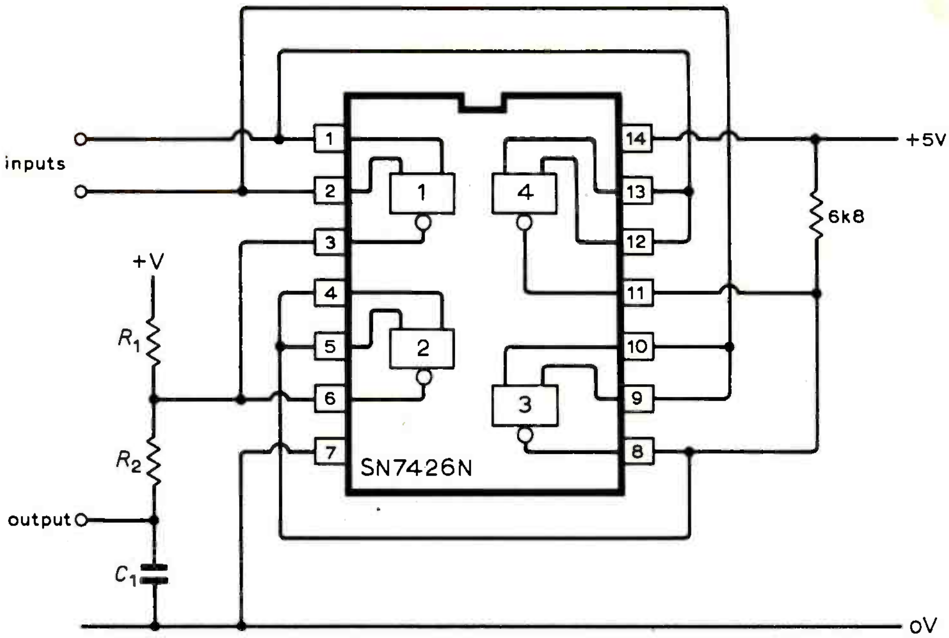
The design is for a 9-volt version, but can easily be adapted to suit any supply voltage. In this particular case the l.e.d. lights up when the supply voltage falls to 8.3V — this minimum voltage is determined by choice of circuit components. The l.e.d. used is a Hewlett-Packard 5082-4440 available from Integrex. The zener diode is a BZY85 C8V2 400mW, but in this circuit its avalanche point is only 7.7V due to the low current drawn. The circuit draws about 2.5mA normally, and 7mA when the thyristor conducts. The 125-μF capacitor



is included to prevent pulses triggering the thyristor as capacitors charged.

P. C. J. Parsonage,
Whangarei,
New Zealand.

Inexpensive p.s.d.



A digital phase-sensitive detector with an output swing of up to 15 volts can be constructed for as little as 40p, using one SN7426N quadruple two-input nand-gate i.c. and a few passive components. The relationship between phase difference and d.c. output level is absolutely linear, so the circuit may find application in the construction of low-cost phase-lock loops and in phase-shift keyed demodulation.

The required logic function for phase detection is that of exclusive–or, i.e. '0' output for similar input levels and '1' output for dissimilar inputs, achieved by connecting the SN7426N as shown. Gate 1 gives the 'nand' function, while gates 3 and 4 act as inverters with their outputs combined by sharing a common load resistor. This combined output is fed to gate 2, inverted, and combined with that of gate 1, again by sharing a common load resistor.

The waveform produced by the detector is a rectangular wave whose mark-space ratio is proportional to the phase difference between the input square waves. This rectangular wave is applied to a low-pass filter formed by R_2 and C_1, whose values should be chosen to suit the operating frequency and required output resistance. As the SN7426N has high-voltage open-collector outputs, the voltage for the common load resistor R_1 may be chosen to give the required output swing, to a maximum of 15 volts. Note that the open-collector outputs are rated to sink a maximum current of 16mA.

This whole circuit function could, of course, be achieved by using one circuit of a SN7486N quadruple two-input exclusive–or, but this would require the use of an external transistor to achieve an output swing of greater than 2.5 volts, as well as being more expensive.

R. A. Harrold,
Leicester.

Reducing distortion by 'error add-on'

The conventional virtual earth amplifier must by its nature have an error at its output, V_A (upper part of first circuit). The basis of this new circuit is to recognize that a measure of this error appears at the input of A_1, and when fed to A_2 an error 'add-on' signal is produced. The output between V_A and V_B is then composed of the error in the output signal V_B added to the distorted original signal V_A to produce an output very much closer to the ratio R_2/R_1 than in the conventional case. What error add-on does for amplifiers is to use the second load terminal, normally earthed, to do something useful.

Gain is $(V_A+V_B)/V_{in} = G_1+G_2G_1/A_1$, where

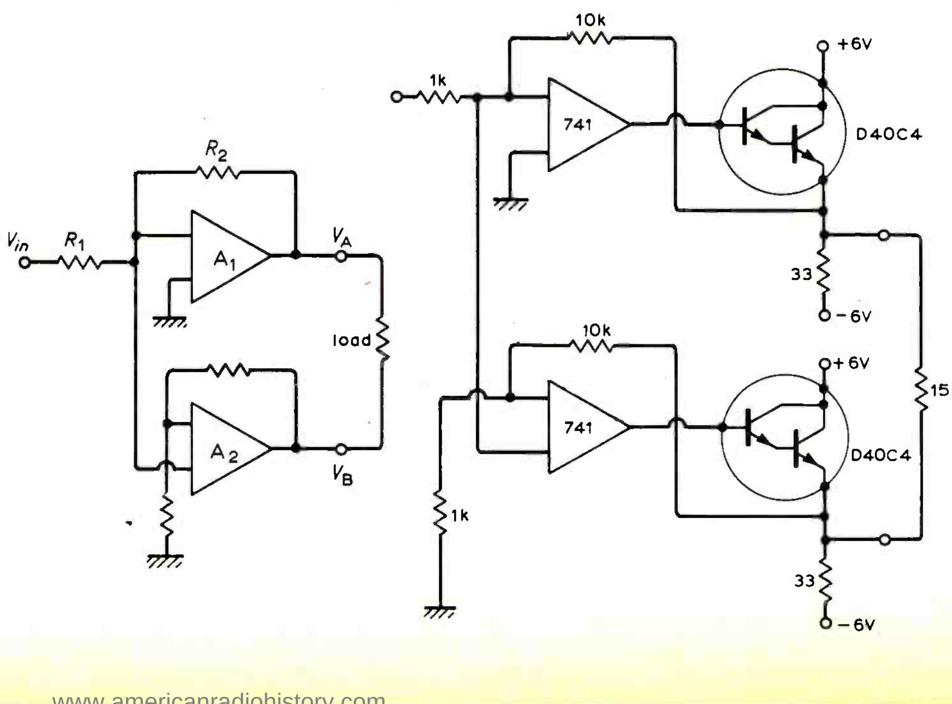
$$G_1 = \frac{A_1R_2}{R_2+R_1(1+A_1)}$$

and $$G_2 = \frac{A_2}{1+A_2R_3/(R_3+R_4)}$$

The circuit has been built and demonstrated using the values shown. When slightly overloaded the results show very clearly how the principle works. Resistor R_2 was adjusted but in practice a 1% resistor could be used. It is hoped to publish more details later, but intuitively I feel that the open-loop gain improves at 12dB/octave compared with 6dB for the conventional case. Of interest is the hope of solving problems such as loudspeaker distortion which negative feedback fails to cope with adequately. A microphone might be placed in front of the main loudspeaker to produce an error add-on signal for a separate error add-on loudspeaker.

Indeed in principle a chain of microphones and speakers could be employed to reduce distortion to any amount although in practice this might be difficult to achieve.

A. Sandman,
Lincoln's Inn Fields,
London, WC2.



Experiments with operational amplifiers

7. Using transistors for logarithmic conversion

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

Bipolar transistors, operated under appropriate conditions, behave logarithmically. An operational amplifier transistor feedback circuit may be used to perform logarithmic conversion. Converters using this principle assume a transistor characteristic described by the equation

$$V_{EB} = -E_o \log_{10} \frac{I_c}{I_o} \qquad (7.1)$$

where I_c is the collecter current in amps, I_o is a constant at constant temperature, its value is typically 10^{-12}A, E_o is a constant at constant temperature, its value approximately 60mV at 27°C, and V_{EB} is the emitter base voltage.

The equation holds for a wide range of collector current values provided that the collector base voltage of the transistor is held at zero.

Because of the temperature dependence of the terms I_o and E_o simple logarithmic converters using single transistors give accurate logarithmic conversion only if the temperature is held constant. The effect of temperature changes may be considerably reduced by balancing the temperature variation of one transistor against that of a second transistor; such temperature compensation requires the use of an extra operational amplifier. Experimental circuits for investigating the action of simple log converters and temperature compensated converters are suggested in what follows.

A circuit suitable for investigating the performance of a simple logarithmic converter is illustrated in Fig. 7.1. Negative feedback is applied to the operational amplifier through a diode connected transistor Tr_1. The circuit is suitable for positive input voltages. Diode D is connected in parallel with the logging transistor to protect the transistor against the excessive inverse voltage which would arise if an input signal of wrong polarity were inadvertently applied. Negative input signals may be logged by reversing connections on both transistor and diode. Resistor R_E is connected in series with the logging transistor to reduce the effective loading on the amplifier output at the higher values of feedback current.

If we assume that the base current of the transistor is negligibly small compared with the collector current, the feedback current may be equated to the collector current. The output voltage of the amplifier provides the transistor emitter base voltage and we may write:

$$e_o = V_{EB} = -E_o \log_{10} \frac{I_c}{I_o} \qquad (7.2)$$

where $I_c = I_f = \frac{e_i}{R}$.

Note that the output voltage from the circuit is taken from the emitter of the logging transistor and not from the output terminal of the amplifier, pin 6.

The response equation for the circuit may be verified by applying a range of input voltages and measuring and recording input and output signals. If the widest logging range possible with the circuit is to be realized it is necessary to separately balance both the input voltage offset and the bias current of the amplifier. In making these adjustments the transistor with its protective diode are disconnected from the circuit and a large value resistor (say 1MΩ) is connected in their place.

Input offset voltage is balanced first. This is done by shorting pin 2 to earth and adjusting the offset voltage balance potentiometer for zero amplifier output. Once input offset voltage has been balanced the short on pin 2 is removed. The input voltage to the circuit is set to zero and the bias current potentiometer is adjusted so that the amplifier output is again zero. The logging transistor with its protective diode should now be connected back into the circuit.

In investigating the logging range of the circuit input voltages in the range, say, 0.1mV to 10V will be found suitable. A typical set of experimental results is given in the table below.

Output voltage e_o	Input voltage e_i	$\log_{10} e_i$
0.32V	10^{-4}V	−4
0.35V	8.8×10^{-4}V	$\bar{4}.95 = -3.05$
0.4V	4.7×10^{-3}V	$\bar{3}.66 = -2.34$
0.45V	3×10^{-2}V	$\bar{2}.48 = -1.52$
0.5V	0.21V	$\bar{1}.32 = -0.68$
0.55V	1.6V	0.20
0.6V	10V	1

Results may be plotted graphically as in Fig. 7.2 in order to show the logging range. The graph should be used to deduce values for the constants E_o and I_o of eq. (7.2).

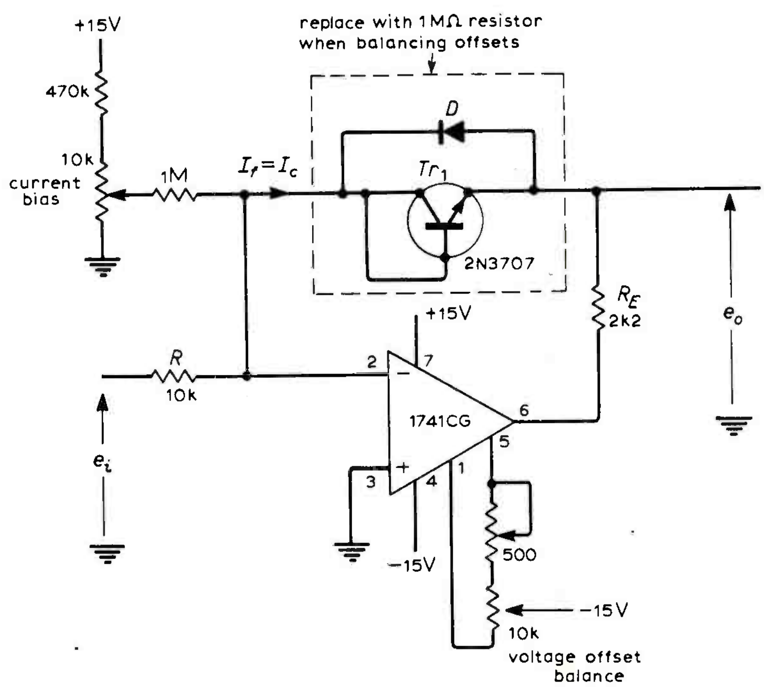


Fig. 7.1. A simple logarithmic converter.

*Department of Physics, Liverpool Polytechnic.

Interchanging the position of the input resistor and logging element in the circuit of Fig. 7.1 gives the circuit shown in Fig. 7.3. This circuit may be used to perform an antilog conversion. The circuit accepts positive input signals. Diode connection of the transistor allows the same transistor to be used for either positive or negative input signals, by connecting the transistor into the circuit in the appropriate direction.

It is not necessary to separately balance input offset voltage and bias current; an adjustment of the 10kΩ balance potentiometer for zero output with zero input is sufficient.

Input voltages in the range say 200mV to 600mV should be applied and values of input voltage and output voltage should be recorded. A graph of the input voltage against the log of the output voltage should be drawn.

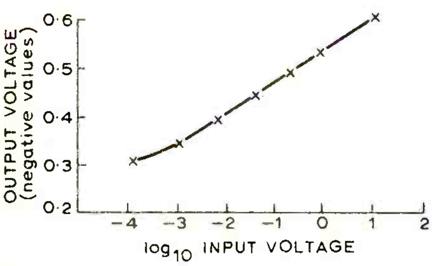


Fig. 7.2. Plot of experimental results from Fig. 7.1 converter.

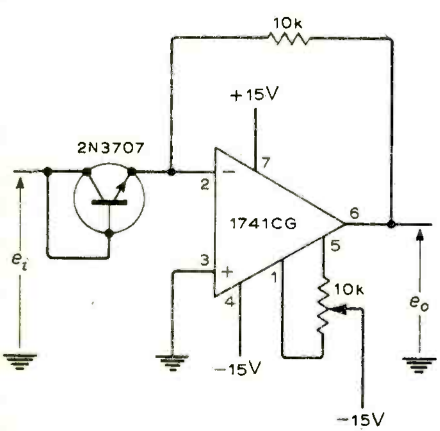


Fig. 7.3. A simple antilog converter.

A circuit for a temperature compensated log converter is given in Fig. 7.4. The circuit uses two operational amplifiers and two logging transistors. The output voltage of amplifier A_1, attenuated by the resistive divider R_3, R_4 provides the emitter base differential voltage between transistors Tr_1 and Tr_2 and

$$e_o \frac{R_3}{R_3+R_4} = V_{EB} - V_{EB2} \qquad (7.3)$$

V_{EB2} is controlled by the negative feedback round amplifier A_2. The feedback forces it to take on that value which will cause the collector current $I_{c2} = I_2$ to flow in transistor Tr_2. Negative feedback round amplifier A_1 forces V_{EB1} to take on that value which will cause the collector current $I_{c1} = I_1$ to flow in transistor Tr_1.

Substituting V_{EB} values from eq. (7.1) into eq. (7.3) and rearranging gives

$$e_o = -\frac{R_3+R_4}{R_3} E_o \log_{10} \frac{I_{c1}}{I_{c2}} \frac{I_{o2}}{I_{o1}} \qquad (7.4)$$

where

$$I_{c1} = I_1 = \frac{e_1}{R_1} \text{ and } I_{c2} = I_2 = \frac{e_2}{R_2}$$

The output is compensated against the marked temperature dependence of the transistor I_o terms, since for matched transistors the I_o terms cancel. Even if the transistors are not perfectly matched it is found that for transistors of the same type the ratio I_{o2}/I_{o1} remains fairly constant with change in temperature. The linear temperature dependence of the term E_o, which, together with resistors R_3 and R_4 determines the scaling factor, may be compensated by using a temperature sensitive resistor for R_3.

If the greatest possible logging range is required the input offset voltage and bias current of amplifier A_1 should be balanced, using the procedure outlined for the simple log converter of Fig. 7.1.

The input signal to be logged is applied at e_1 and a fixed collector current I_{c2} set by e_2 and R_2 is passed through transistor Tr_2.

In a practical temperature compensated log converter it is usual to return the e_2 input to the positive supply and to choose the value of R_2 so as to give a required value of I_{c2}. The value used for I_{c2} determines the value of I_{c1} and hence e_1 required for zero crossing of the output of amplifier A_1.

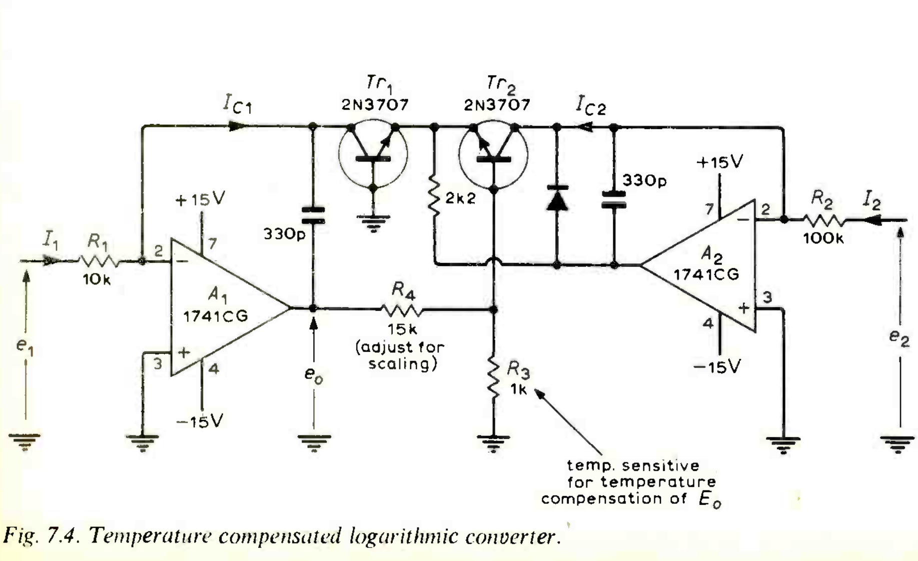


Fig. 7.4. Temperature compensated logarithmic converter.

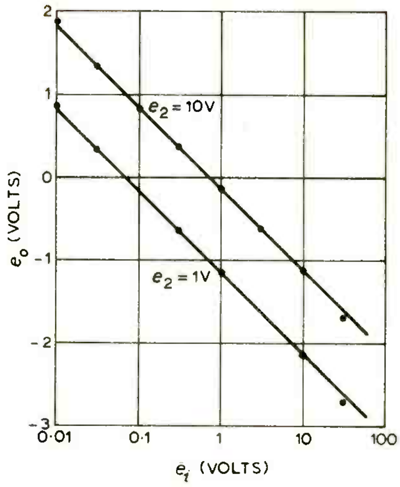


Fig. 7.5. Plot of experimental results from Fig. 7.4. circuit.

If very small input signals are not to be used and one merely wants to take measurements in order to explore the action of the circuit it is not necessary to balance amplifier A_1 offsets. The output voltage should be measured for a range of values of e_1. This should be done for several fixed values of the reference current I_{c2}. Results are conveniently displayed by plotting the output voltage against the log of the input voltage (or input current). The slope of these graphs is equal to $\frac{R_3+R_4}{R_3} E_o$. Values of R_3 and R_4 are normally chosen to give an output voltage change of 1V per decade of input current change.

Experimental results obtained with the circuit of Fig. 7.4 are shown graphically in Fig. 7.5. The results were obtained with two settings of e_2, 1 volt and 10 volts, corresponding to $I_{c2} = 10^{-5}$A and 10^{-4}A respectively. Note that zero crossing of the output occurs in each case when I_{c1} is slightly less than I_{c2}. This is because of a mismatch in transistor I_o terms. The results indicate a value $I_{o1}/I_{o2} \approx 0.8$ for the two transistors used. In both sets of results accuracy of log conversion falls off for values of the input voltage less than 10mV. The range of the circuit can be extended by balancing the offsets of amplifier A_1.

The effect of fixing the current $I_1 = I_c$ at some reference value and applying a varying input signal to the e_2 terminal should be tried. This gives log conversion without sign inversion, but the e_2 input is not suitable for very small signals. Transistor Tr_2 does not give accurate logarithmic conversion for very small currents because its collector base voltage is not zero.

Note that all op-amp transistor feedback log converters will accept only single-polarity input signals. The circuit of Fig. 7.4 is suitable for positive input signals. If one wishes to perform a logarithmic operation on a negative input signal the n-p-n transistors Tr_1 and Tr_2 should be replaced by a suitable p-n-p type (say 2N 4058).

The circuitry in Fig. 7.4 may be rearranged to give a circuit which will per-

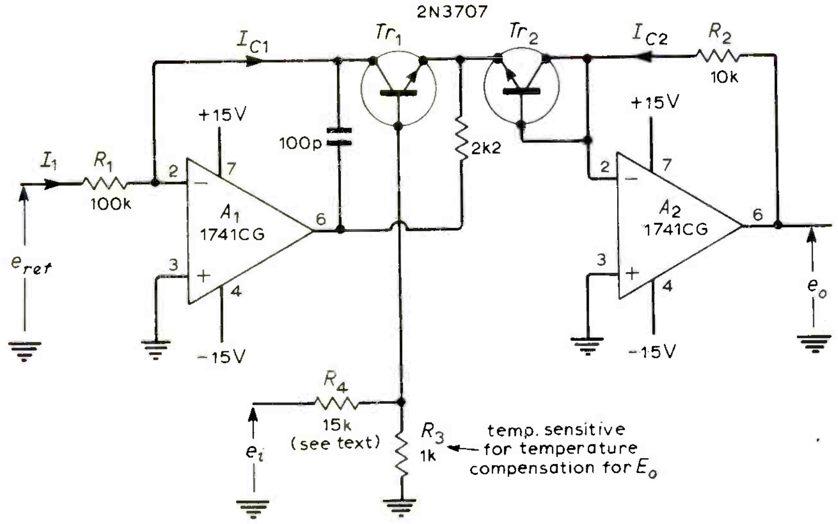


Fig. 7.6. Temperature compensated antilog converter.

form an antilog conversion, as illustrated in Fig. 7.6.

The input signal to the circuit, attenuated by the resistive divider, R_3, R_4, provides the emitter base differential voltage between transistors Tr_1 and Tr_2 and

$$e_i \frac{R_3}{R_3+R_4} = V_{EB2} - V_{EB1} \qquad (7.5)$$

Negative feedback round amplifier A_1 forces V_{EB1} to take on that value which will cause the current $I_1 = I_{c1}$ to flow as a collector current in transistor Tr_1. If I_1 is held constant as a reference current V_{EB1} is constant and V_{EB2} varies directly with e_i. Voltage V_{EB2} determines the collector current, I_{c2}, of transistor Tr_2. Negative feedback round amplifier A_2 forces I_{c2} to flow through resistor R_2 and amplifier A_2 gives an output voltage $e_o = I_{c2}R_2$.

Substitution of V_{EB} values from eq. (7.1) into eq. (7.5) gives

$$e_i \frac{R_3}{R_3+R_4} = E_o \log_{10} \frac{I_{c1}}{I_{c2}} \frac{I_{o2}}{I_{o1}}$$

Where $I_{c1} = I_1\, e_{ref}/R_1$ and $I_{c2} = e_o/R_2$

Thus $$I_{c1} \frac{I_{o2}}{I_{o1}} \frac{R_2}{e_o} = 10^{e_i \frac{R_3}{R_3+R_4} \frac{1}{E_o}}$$

Values of R_3 and R_4 are normally chosen so that

$$\frac{R_3}{R_3+R_4} \frac{1}{E_o} = 1.$$

R_3 may be made temperature dependent in order to compensate for the temperature dependence of E_o. With these values of R_3 and R_4

$$e_o = I_{c1} \frac{I_{o2}}{I_{o1}} R_2\, 10^{-ei}$$

If $I_{o1} = I_{o2}$ the multiplying factor

$$I_{c1} \frac{I_{o2}}{I_{o1}} R_2$$

may be made equal to a desired constant c by choosing e_{ref}, R_1 and R_2 so that $e_{ref}(R_2/R_1) = c$. This makes $e_o = c\ 10^{-ei}$.

The value of the constant c must, of course, not be made greater than the output

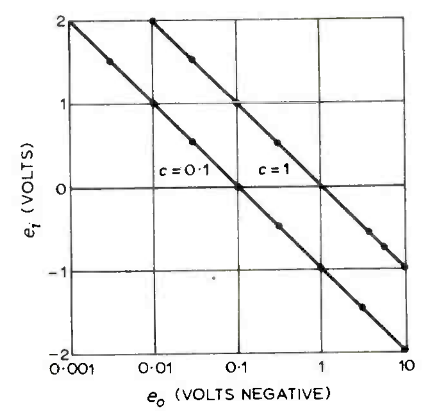


Fig. 7.7. Plot of experimental results from Fig. 7.6 circuit.

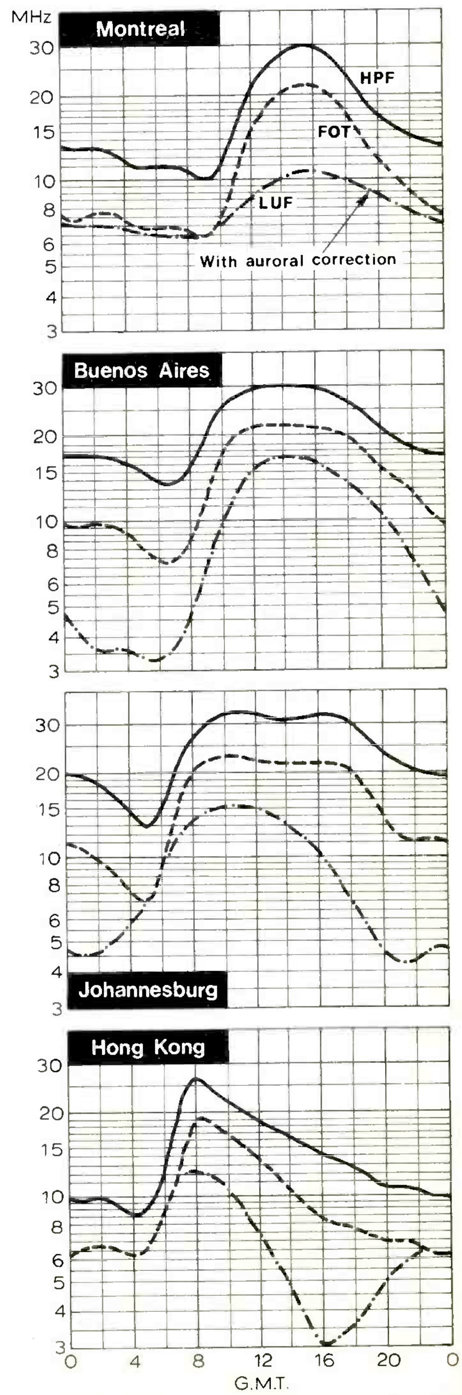
voltage capability of the amplifier. To allow for transistor mismatch and to avoid the use of close tolerance resistors the following experimental setting-up procedure may be adopted. Set e_i to zero and adjust e_{ref} or R_1 to make the output of amplifier A_2 exactly c volts. Apply an input signal of minus one volt and trim the value of resistor R_4 to make the output of amplifier A_2 exactly $10c$ volts. Experimental results obtained with the circuit are shown graphically in Fig. 7.7. The two sets of results are for $c = 1$ and $c = 0.1$. No offset balance was employed. Balancing amplifier A_2 offsets may be expected to extend the range of the circuit.

(To be continued)

Op-amp log and antilog converters may be combined in order to generate many non-linear functions. The circuits are connected together in such a way that they perform the operations normally involved in logarithmic computation. The remainder of Experiment 7 will deal with log circuits for multiplication, division and the generation of powers.

H.F. Predictions — January

HPF (highest probable frequency) is the frequency above which the probability of a skywave path existing is less than 10% and FOT (from the French, optimum traffic frequency) is the frequency below which the probability is greater than 90%. LUF (lowest usable frequency) is the frequency above which the probability of exceeding the desired signal-to-noise ratio is greater than 90%. FOT is an old established term but something of a misnomer as the true optimum, at which the product of skywave and signal probabilities is a maximum, is found to be the geometric mean of FOT and LUF. As the charts, which are prepared by Cable & Wireless, have a logarithmic frequency scale this optimum is easily placed by eye at midway between the FOT and LUF curves.



Meter for Blind Students

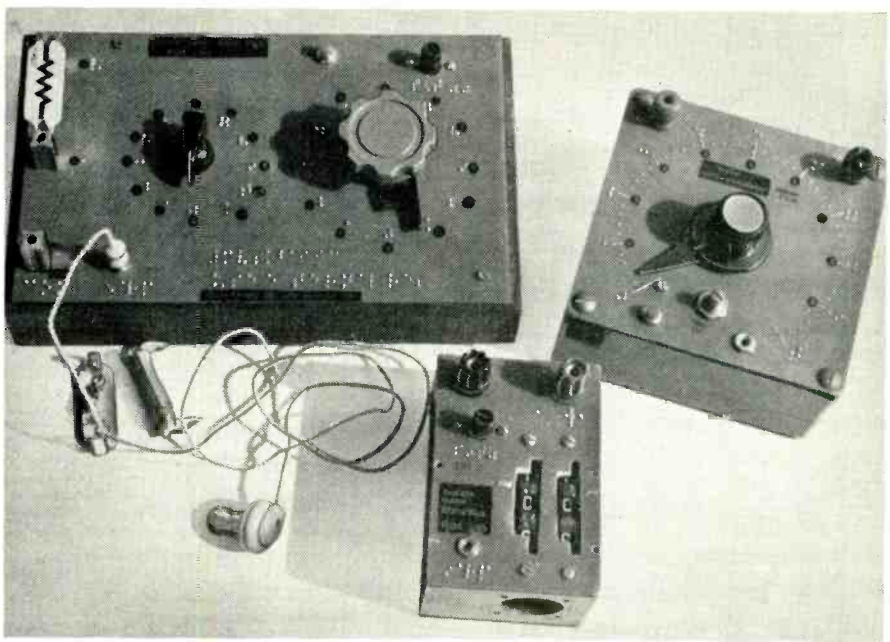
Aural-tactual indication for d.c. measurements

by R. S. Maddever, M.A., D.Phil.*

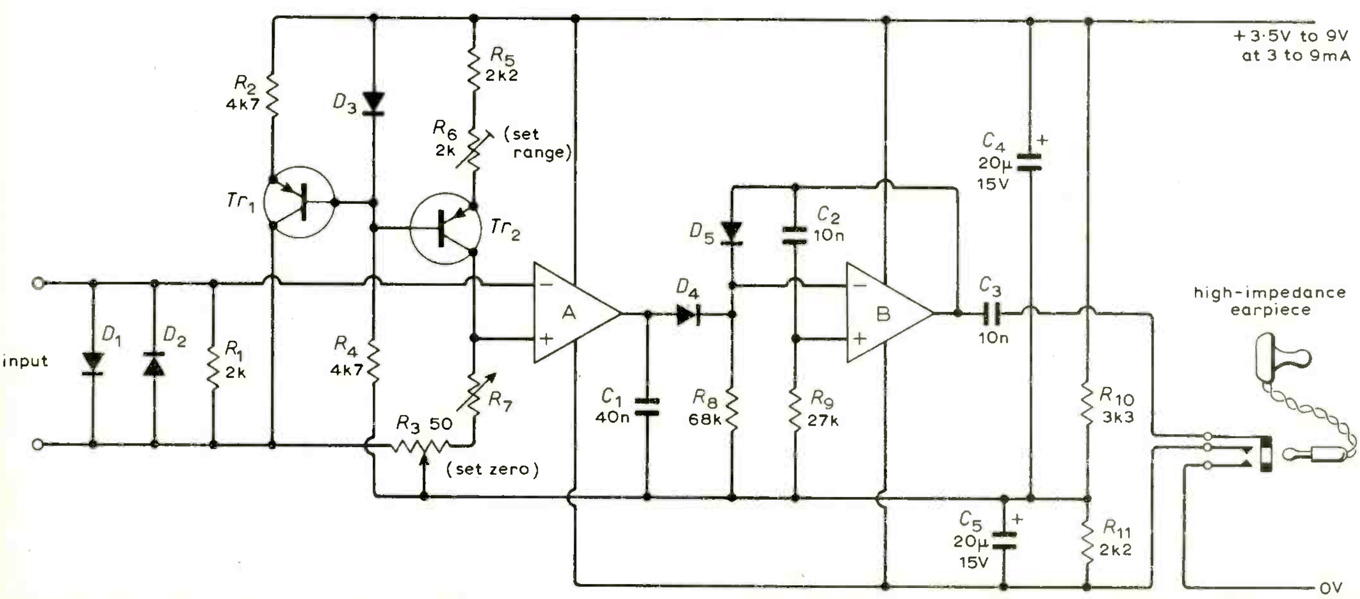
This instrument for blind students is designed to convert an electrical input into an audible indication, as a direct replacement for a moving-coil meter. With a designed range of 0 to 100mV and an input resistance of 2kΩ, a 10°C change in temperature or a 30% change in battery voltage produces an output change of less than 3%. Tactual 'readout' can be by pointer on a circular scale or by decade switches. With the last-mentioned the reading precision is 1% of full scale.

A variable reference voltage is produced by changing the resistance R_7 in series with the constant current generator Tr_2. An operational amplifier, *A*, compares this reference voltage with the voltage to be measured across R_1. If the reference voltage is greater than the input voltage the amplifier output is positive and thus allows a second operational amplifier, *B*, connected as a free running multivibrator, to function and produce sound in an earpiece. If the reference voltage is lower than the input voltage, amplifier *A* output is negative and the multivibrator inoperative. By merely reversing the input leads to the first op-amp the audio output can be obtained when the

*Geelong Grammar School, Corio, Australia.



Three instruments with different types of 'readout'.



Circuit of the aural-tactual meter. Transistors are germanium types, e.g. OC45, OC71; op-amps Motorola 1435; diodes silicon types, e.g. BA100, OA200, IN914.

reference is below the input, if this is preferred.

Thus, in use, R_7 is adjusted, either by potentiometer or by switches, until oscillations are about to begin, and the input voltage is then known to be practically the same as that read off the variable reference voltage scale. The input terminals will be similar to those of a 50 microamp, 100mV moving-coil meter, so that conventional shunts and series resistors may be switched in to form an 'audible multimeter'.

The Motorola 1435 dual op-amp requires a centre-tapped voltage supply. To achieve this and still allow the supply to be switched on by the insertion of the earpiece, resistors R_{10} and R_{11} are used, with decoupling capacitors C_4 and C_5. The value of R_{11} is smaller than R_{10} because the current from the positive supply is greater than that from the negative supply due to the constant current generator. Silicon diodes D_4 and D_5 isolate the functions of the two op-amps. The multivibrator frequency may be altered by changing C_2 or R_9.

The base of Tr_2, a germanium transistor, is held at about 700mV below the positive supply line by the silicon diode D_3. Since the emitter-base voltage is about 300mV, the current through it stabilizes so that a further 400mV is dropped across the emitter load, R_5 and R_6. Thus by varying R_6 the collector current is adjusted to produce the required maximum reference voltage across R_7 at its full scale value. Temperature compensation is afforded by the fact that the temperature coefficients of the voltage across the diode and V_{BE} for Tr_2 are similar and thus tend to cancel each other out. R_4 is chosen so that even at the lowest supply voltage the bias current through D_3 is several times the currents in the bases of Tr_1 and Tr_2. To allow zero setting with no input, Tr_1, R_2 and R_3 are added. Silicon diodes D_1 and D_2 are for input protection.

R_7 can be either a wire-wound potentiometer or a series of switched resistors. In each case the maximum resistance is made 1kΩ, and hence R_6 is adjusted to produce a current of 100 μA in the collector of Tr_2.

Instruments using both methods of varying R_7 are shown in the photograph. Front panels are made from copper clad board. Braille figures and letters were put in with resist paint or dots from pressure sensitive sheets such as Letraset. Ordinary lettering was also put in to aid sighted instructors. After etching, the Braille dots were further raised with solder. Before removing the pressure sensitive ordinary letters to expose the copper, the areas around the letters were painted black with a cellulose lacquer. This provides excellent contrast for the copper lettering. The largest instrument uses Locktronic posts and resistors (A. M. Lock & Co. Ltd.) so that blind students may easily insert shunts and series resistors.

The author is grateful to Churchill College, Cambridge, for the award of a Schoolmaster Fellow Commonership during the holding of which these instruments were developed, and to Mr. S. Stephenson, of Worcester College for the Blind, who brought the need of such instruments to his attention and arranged for several to be tested.

"B.B.C. Engineering — 1922-1972"

We consider that this monumental work* by Edward Pawley demands more than our normal notice under "Books Received". This 570-page volume, which incidentally weighs some 3½ lb, contains well over 300,000 words and so much information that it would be invidious to highlight any one section.

As the history of broadcasting in the U.K. falls fairly naturally into the following six periods the book has been divided into these six chapters:

1. The experimental era preceding the formation of the British Broadcasting Company in 1922.
2. The lifetime of the British Broadcasting Company: 1922-6.
3. The formative period of the British Broadcasting Corporation, from its foundation in 1927 until the outbreak of war.
4. The war years: 1939-45.
5. The period of post-war reconstruction: 1946-55.
6. The years of expansion, from 1956 onwards.

Although, inevitably, names (many of which became household words) are prominent in the story, Mr Pawley has dealt with the developments of broadcast engineering rather than the personalities concerned.

A complete picture ("warts and all") of British broadcasting from the earliest experiments before the setting up of the original British Broadcasting Company to the latest colour television techniques is painted. The work is extremely well documented with something like 550 references.

One aspect of broadcasting in the U.K. which may not be generally known becomes obvious on reading the book. It is that the B.B.C. has played a major part in the international field of broadcasting. Another little known contribution is the part played by B.B.C. engineers in the 1939-45 war effort. In the section covering the war years one learns what technical juggling was concealed by such code names as "washtub", "dartboard", and "domino". The first of these names was given to the medium-wave transmissions to guide home-ward bound bombers after raids. Dartboard created a strong jamming signal used on the medium-wave band to confuse enemy night fighters who were being given information in a Forces programme broadcast from Stuttgart. The Alexandra Palace television transmitter was used, under the code name domino, to disable the navigational system developed by the Luftwaffe and known as Y-Gerat.

An interesting aspect of broadcast engineering is emphasized by the author in his foreword. He points out that many of the techniques used in broadcasting are common to other branches of electronics and other forms of radio communication but "broadcasting differs from them in one way that has had a profound effect upon its development: the receiving part of a broadcasting system — a vitally important part – is not under the control of the broadcasters". One result of this peculiarity is that the problem of obsolescence imposes a severe restraint on development as no improvement can be made at the transmitter unless either it is planned and announced so far ahead that existing receivers are worn out before the change takes place or that it is made in such a way that there is no deterioration in reception using existing receivers.

The many and varied achievements of the B.B.C. engineers are well documented in this volume and is in itself a tribute to their work over the past 50 years.

* "BBC engineering" 1922-1972, by Edward Pawley, BBC Publications, 35 Marylebone High St., London, W1M 4AA. Price £7

Announcements

Racal-Mobilcal Ltd, Reading, Berkshire, have announced a contract for military radio equipment valued at £1.8M. The equipment includes the "Syncal", "Squadcal" and "Comcal" h.f. mobile radiotelephones.

A customer service laboratory for thick-film materials has been opened by the **Du Pont Company (U.K.) Ltd,** at Hemel Hempstead, Herts. The service is intended for European customers and possesses equipment for the manufacture and testing of thick-film components.

The consortium of AEG-Telefunken, Aeritalia and the British Aircraft Corporation has been awarded the contract for design, development and manufacture of the **Radome** (radar transparent nose cone) requirement for the Panavia multi-role combat aircraft.

Jermyn Distribution, Vestry Estate, Sevenoaks, Kent, have been awarded a franchise to handle the range of Siferrit pot cores manufactured by Siemens.

EMI Electronics and Industrial Operations, Blyth Road, Hayes, Middlesex, has introduced a computerized spectral calibration service for users of its photomultiplier tubes.

A vacation school intended to familiarize engineers and scientists in industry and education with modern methods and philosophies in the measurement of physical quantities will be held at the University College of North Wales, Bangor, from 8th to 13th April 1973. The school on Electronic instrumentation will be organized by the Electronics Division of the Institution of Electrical Engineers, Savoy Place, London, WC1.

New Zealand Broadcasting Corporation has ordered two complete mobile sets of outside broadcast colour TV equipment, including Mark VIII automatic colour cameras, from Marconi Communication Systems Ltd, Marconi House, Chelmsford CM1 1PL.

Ultra Electronics (Components) Ltd, Fassetts Road, Loudwater, Bucks, have signed an agreement to represent Ouest Electronic Connecteurs, of France, in the distribution of connectors and related components.

A contract to provide a new **telecommunications link** with France is included in a transmission equipment order placed by the British Post Office with GEC Telecommunications Ltd, P.O. Box No. 53, Coventry CV3 1HJ.

Two short courses entitled **"Video recording"** and **"Time sharing computer systems"** are to be held at Norwood Technical College, Knight's Hill, London, SE27 OTX. Video recording is a seven-week course from 18.30 to 20.30 each Monday commencing 12th February; fee £3.00. Time sharing is a six-week course from 18.30 to 20.30 each Tuesday commencing 13th February; fee £2.25.

Books Received

Semiconductor Diode Lasers, by Ralph W. Campbell and Forrest M. Mims, is written for experimenters and engineers as a broad introduction to the semiconductor laser and its applications. It simplifies the theory of laser action and deals briefly with the historic development of lasing materials and methods of excitation and discusses the relationship between non-coherent light emissions, as from l.e.ds, and coherent light emissions which characterize the semiconductor injection laser diode. The book continues with an informative section showing commercial device manufacturing techniques, covering the geometry of single diode construction and high-power, multi-element arrays. The remaining chapters are devoted to the practical applications and circuitry used with these devices, demonstrating the simplicity of pulse generators, modulators, power supplies, detectors and receiving systems. Pp.192. Price £1.90. W. Foulsham & Co. Ltd, Yeovil Road, Slough, Bucks.

Compatibility and Testing of Electronic Components, written by C. E. Jowett, is designed to meet the needs of engineers and technologists working in the fields of component reliability, quality control, production and test development. It covers this vast subject in a clear, concise manner, providing detailed information on manufacturing and testing methods and generating an understanding of compatibility between materials, processes and differing environmental conditions. The subject matter deals with practically all aspects of integrated circuits, thick- and thin-film devices, capacitor and deposited resistor technology, hybrid microelectronics, miniature encapsulated relays and flexible film wiring. The remaining chapters are concerned with techniques involved in reliability screening, environmental and life testing, component stress testing and detection of incompatibilities. Pp.345. Price £6.00. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

Field Effect Transistors has been edited by N. R. Bijlsma and P. Burwell of Elcoma Publications in conjunction with E. G. Evans of Mullard's Central Technical Service. It is designed to familiarize the potential user of f.e.ts with the operating principles, characteristics and terminology of these devices in such a way that the special properties offered, can be recognized and utilized to advantage. This is achieved by discussion of the relative structures and principles involved in both junction and insulated-gate, field-effect transistors. Development is from triode technology, enhancement and depletion modes of operation, to tetrode or dual-gate forms of construction. Electrical properties are dealt with and the closing chapter describes circuit configurations and typical applications. Pp.131. Price £1.80. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

Dielectrics, by P. J. Harrop, is the title of a work on a topic which has been neglected to a certain extent even though great advances have been made on the subject of material science. The author has attempted to bring up to date the subject of dielectric materials used in electrical/electronic engineering, using a minimum of the large amount of tedious mathematical analysis normally associated with material physics. The book develops from a section of background information, which summarizes the classic capacitive properties of dielectrics, into the nature of matter which effect classification of the numerous types of material media. The text continues with an extensive survey dealing with the modern forms of dielectric and discusses the relative merits of forms and techniques employed in the fabrication of components. Finally, testing and measurement techniques are reviewed dealing with the basic parameter evaluation of both solid and liquid dielectrics. Pp.155. Price £3.50. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

Techniques of Circuit Analysis, by G. W. Carter and A. Richardson, is written primarily for undergraduate students of electrical and electronic engineering, though it will also be found useful to physicists. It provides instruction and practice in the methods of analysis which are essential in solving electrical circuit problems. A notable inclusion is the analysis of distributed circuits and transmission lines under transient as well as steady state conditions. Laplace transforms, matrix algebra, Fourier integrals and the complex plane are explained with worked examples used to illustrate the methods described. Each chapter concludes with a set of exercises. Pp.548. Price £5.00. Cambridge University Press, Bentley House, 200 Euston Road, London NW1 2DB.

Thick Film Circuits, by G. V. Planer and L. S. Phillips, aims to assemble the basic ideas and data required to enable the reader to understand and assess the capabilities of thick film technology in relation to his own particular requirements. It is also designed as a reference book for those already involved in this area, or who have a more general interest in electronic packaging developments. A selection of the chapter headings are: applications, substrates, conductor and resistor patterns, printed capacitor and insulating layers, printing and firing procedures, hybrid circuits, trimming and test procedures, environmental protection, and circuit design concepts. Pp.152. Price £4.00. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

Transistor Audio and Radio Circuits, for radio receivers, record players, tape recorders and hi-fi equipment, is the second edition of a publication by Mullard. This edition incorporates many new circuits that take advantage of developments which have occurred since the first edition was published. These include new audio amplifiers, a radio receiver and amplifiers using integrated circuits. In addition to the designs for 10W and 25W audio amplifiers, there are now three new circuits for 15W, 35W and 50W amplifiers. A pre-amplifier for these new circuits is also included. Methods of protecting these amplifiers from short circuits are discussed and suitable circuits given. Another addition to the book is a chapter on loudspeakers. This considers the choice of speaker for a particular application and the characteristics of the speaker required. Enclosures for speakers and some general rules for construction are discussed. Pp.281. Price £1.80. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

Broadcasting in Britain 1922-1972, by Keith Geddes, is an illustrated, brief account of the engineering aspects of broadcasting from the formation of the British Broadcasting Company to the present era of television broadcasting and digital and stereophony techniques. Pp.63. Price 45p. Her Majesty's Stationery Office (Science Museum Publications), 49 High Holborn, London WC1V 6HB.

Hi-Fi Year Book 1973 is a complete directory for pickups, motor units, tuners, amplifiers, microphones, recorders, speakers and cabinets. Brief specifications and prices of each product are provided. A section giving manufacturers' and dealers' addresses is also included and introductory articles cover the subjects of specifications, cassettes, loudspeakers and four-channel stereo techniques. Pp.464. Price £1.50. IPC Electrical-Electronic Year Books Ltd, Dorset House, Stamford Street, London SE1 9LU.

BBC Engineering is published approximately four times a year and is a record of B.B.C. technical experience and developments in radio and television broadcasting. The October 1972 edition, number 92, is centred around a history of B.B.C. engineering 1922-1972 and an article covering the first five years. A further principal article is entitled "Acoustic Modelling of Studios and Concert Halls". Pp.36. Price 40p (post free). Annual subscription £1.50. B.B.C. Publications, 35 Marylebone High Street, London W1M 4AA.

Transistor Circuit Design, by Laurence G. Cowles, is a reference manual of practical transistor circuits with design procedures and formulae covering d.c. to microwaves, small signals to high-power circuits related to discrete components and integrated circuits. Pp.344. Price £6. Prentice-Hall International Publisher, Durrants Hill Road, Hemel Hempstead, Herts.

Beginner's Guide to Television (5th edition), by Gordon J. King, deals with basic principles, TV transmission and reception, test cards and receiver controls, relay TV and communal aerials, colour and closed-circuit TV and video-tape recording. Pp.211. Price £1.60. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

A Simple Transistor D.C. Multimeter

*by J. D. Pahomoff**

A meter for high impedance measurements in transistor circuits

This short, but interesting article was received from one of our Russian readers and was inspired by the Linsley-Hood design we published in June 1972. A certain small amount of editing was undertaken but every effort has been made to preserve the original character of the author's manuscript which we feel adds to the interest of the article.

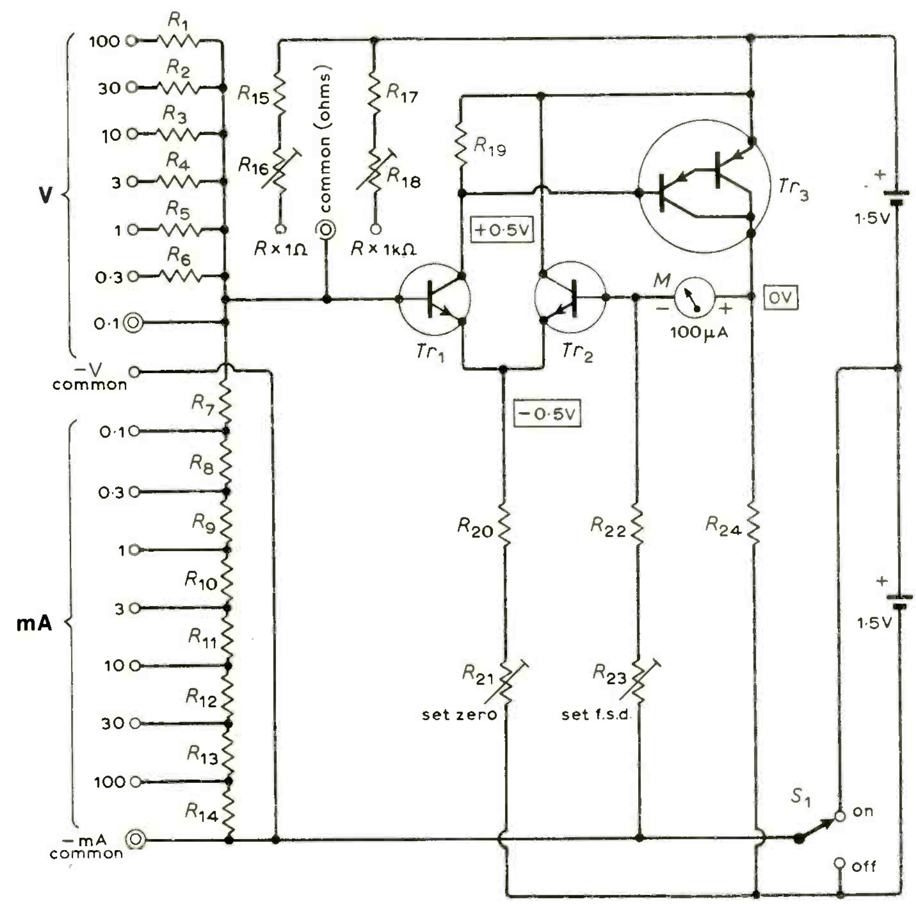


Fig. 1. Complete circuit diagram of the simple transistor d.c. multimeter.

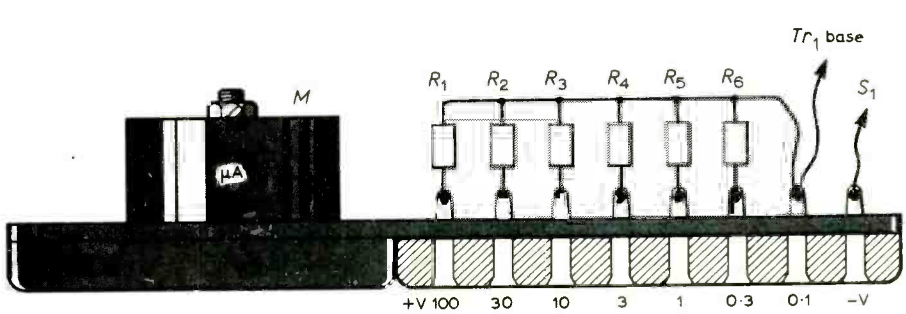


Fig. 2. Construction of the voltage multiplier.

In spite of its principal simplicity, the final circuit diagram of the multimeter as suggested by Mr. Linsley Hood is too complicated especially for the beginner, because of many switches. I think that the simpler variant of this multimeter, described later, will find popularity among the readers of the magazine. Such a multimeter can be wired up during one week-end. To make the construction of the multimeter more simple all the switches are omitted and substituted for small sockets ($\frac{1}{8}$ in. diameter or less).

Circuit

The suggested revised circuit of the d.c. transistor multimeter is shown in Fig. 1. First of all the voltage multiplier is changed so that all the voltage ranges have single individual separate resistors from R_1 to R_6 inclusive. It's more convenient both for wiring and calibration.

The current multiplier is also slightly changed, the first and the last ranges being omitted. All the ranges for measurements of voltage and current are the same: 100–30–10–3–1–0.3–0.1. Only two ranges for measurements of resistance are left unchanged, as it is quite enough for most of the practical purposes. Each ohms range has its individual potentiometer (R_{16}, R_{18}). The variable resistor R_{21} in the tail load of Tr_1 and Tr_2 serves as a 'set zero' adjustment. The variable resistor R_{23} serves to set full scale deflection.

In order to switch off the multimeter there is a switch S_1. In the position 'OFF' transistor bases of Tr_1 and Tr_2 acquire the zero potential, that's why the current could not flow.

Construction

Construction of the d.c. multimeter is not critical and it can be made in every way possible. It is suggested that the instrument case may be made of Paxolin. The construction of the voltage multiplier is shown in Fig. 2 and current multiplier in Fig. 3. Part of the current multiplier, for example R_{11}–R_{14}, may be wire wound. Each of these wire resistors must be correctly checked with Wheatstone bridge. Resistors from R_{10} to R_7 can be selected among the preferred value series. For example, in the case of the 67Ω resistor R_{10}, in the current chain

*Moscow, U.S.S.R.

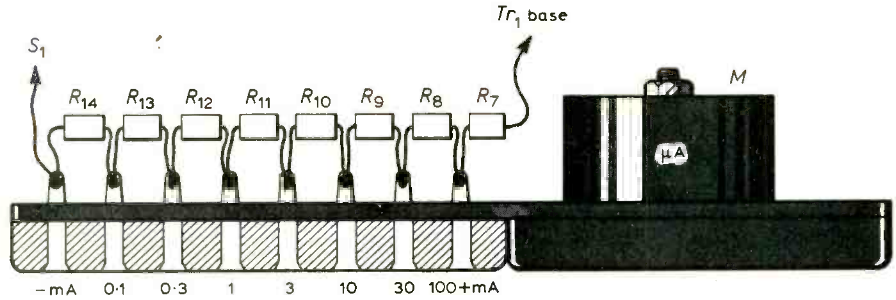


Fig. 3. Construction of the current multiplier.

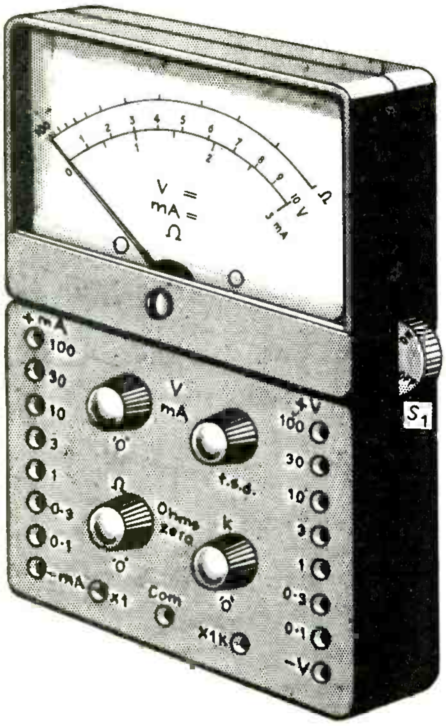


Fig. 4. Position of the main parts of the multimeter.

(multiplier), it can be selected as 68Ω—1%; R_9, 220Ω—5% 230 ohm, etc.

The position of the main parts of the multimeter is shown in Fig. 4. All the additional information can be found in the previous article by Mr. Linsley Hood, *Wireless World*, June 1972, pp. 279–280.

Components list

Resistors

R_1	50M	R_{13}	2.3
R_2	15M	R_{14}	1
R_3	5M	R_{15}	100
R_4	1.5M	R_{16}	100 preset
R_5	450k	R_{17}	120k
R_6	100k	R_{18}	50k preset
R_7	49k	R_{19}	47k
R_8	670	R_{20}	18k
R_9	230	R_{21}	10k preset
R_{10}	67	R_{22}	680
R_{11}	23	R_{23}	500 preset
R_{12}	6.7	R_{24}	3.3k

Transistors

Tr_1, Tr_2	BC184L
Tr_3	MPSA65

Developments in Surface Acoustic Wave Technology

Eighty-six years ago, Lord Rayleigh discovered the surface acoustic wave effect by which a signal can be propagated and remain on the surface of a material. Instantaneous examination of the propagating waveform in spatial terms gives access to a real time signal which can be sampled or modified. Such a facility extends the designer's armoury where conventional electronic or electro-magnetic circuits are unsuitable. Perhaps the most important of the applications for this type of phenomenon is in practical delay circuits for frequencies from 10 to 400MHz and delays up to 50μs.

Conversion of electrical to acoustic energy, and the reverse, is achieved by using interdigital transducers consisting of two sets of interleaved metal fingers spaced one-half of an acoustic wavelength apart. The resonant frequency of this electromechanical pattern is obtained from dividing the s.a.w. (surface acoustic wave) velocity by the finger spacing, and if a signal of such a frequency is applied across the fingers, then a surface wave will be launched down the piezoelectric substrate. Since the s.a.w. is non-dispersive, the information content can be accurately preserved, and in addition the transduction is reciprocal so the same finger pattern will regenerate an electric signal from the s.a.w. Bandwidth of the finger array can be simply adjusted by alteration of the number of finger pairs, and electrical impedance determined by the choice of radiating aperture.

In addition to making use of the delay properties by selection of the material used for the piezoelectric substrate — and, of course, the separation of the transducer arrays, the designer can use the same type of element array to make bandpass filters with very small changes in the techniques employed. Tapped delay lines can also be readily devised, and a recent new application has been found for surface acoustic wave devices in f.m. pulse compression filters.

With such a variety of applications already realized for the s.a.w. device, it is small wonder to find that even more advanced projects are planned for the future. Several companies are experimenting with the s.a.w. devices, Microwave and Electronic Systems Ltd, in a recent statement, outlined some future products.

Future development prospects

An example of one of the devices predicted is the linear frequency discriminator. This consists of two filters having triangular insertion loss characteristics of equal width, but offset by a frequency difference equal to half the separation of stop band. Positive or negative slope discrimination over bandwidths and frequencies difficult to deal with using conventional design techniques may be easily accommodated using the s.a.w.

Adaptive non-linear convolvers may not be familiar to too many. They use the non-linear interaction of the s.a.w. signal with a reference signal propagating in the opposite direction. The resultant signal at the sum frequency has a very low or even zero velocity (comparable to a standing wave) and can thus be integrated over considerable time periods using a capacitor. The basic mathematical process offered is that of convolution, but correlation is achieved by making the reference signal the reverse of the incident signal.

Finally, the s.a.w. device offers excellent possibilities for the synthesis of highly stable oscillations at v.h.f. and beyond. In practice the actual stability is not as good as conventional quartz crystal oscillators, but there is the advantage of being able to operate at fundamentals of 400MHz and provide the additional facility of electronic tuning over a range of up to 1 part in 10^3 with small sacrifice in stability.

Currently, principal substrate materials employed in the production of s.a.w. devices are bismuth germanium oxide, with a surface wave velocity of 1.6×10^3 m/s, lithium niobate having a velocity of propagation 3.5×10^3 m/s. aluminium nitride, 5.8×10^3 m/s and finally the more familiar ST-cut X propagating quartz having a s.a.w. velocity of 3.1×10^3 m/s.

Design Criteria for Logic Power Supplies

by R.B.D. Knight, M.A., D. Phil, M.I.E.E.*

The features required from a power supply intended for integrated circuit logic are examined. Criteria are stated which, applied to the design or selection of supplies, will improve both economy and reliability of equipment.

Since their introduction in the late fifties, power supply modules have become considerably more refined. Ever smaller variations in output voltages are quoted for changes in load, temperature, time and mains input. Current limiting and protection against voltage transients are often offered as integral parts of the design or as optional extras. It was natural that the designers of logic systems should seek supplies for their circuits from the wide range of standard units available from a large number of manufacturers. The choice made was more important than it appeared at first sight because a unit misguidedly selected on the basis of price, size or an irrelevant technical feature may well have had subtle snags which caused apparently inexplicable i.c. failures and so gave poor equipment reliability.

For reasons of low cost and the wide variety of circuit functions available, 74 series t.t.l. logic working from a nominal 5V supply is very popular. It is generally known from manufacturers' data sheets and applications information that for correct operation:

- The supply voltage must be between 4.75 and 5.25V (industrial) or 4.50 and 5.50V (military grade),
- The supply voltage must not exceed 7.0V,
- No voltage exceeding 5.5V may be applied to a logic input, and
- Every 5 to 10 packages must be decoupled by a capacitor of 0.01 to 0.1μF having good r.f. properties.

It is less easy to find out that:

- Voltage transients exceeding the stated maxima even for a fraction of a microsecond can cause degradation even if catastrophic damage does not ensue.
- Slow changes in supply voltage, e.g. 1V/ms, within the normal limits, are tolerable.
- When the "totem-pole" output stage (see Fig. 1) switches, a heavy current pulse results from the non-conducting transistor switching on before the conducting transistor switches off. This pulse has a duration of the order of a nanosecond and is the reason for decoupling groups of i.cs.
- The supply must be free from fast transients and these must not be induced by the current pulses through the totem-pole.
- Conductors longer than 25cm or so behave as transmission lines and not as short circuits to pulses having the rise times to which t.t.l. circuits are sensitive.

Properties of stabilized supplies

The arrangement generally used in the design of stabilized power supplies is shown in Fig. 2. An amplifier compares the output voltage with a zener reference and develops a control signal which is applied to a series element. The higher the gain of the loop the lower is the output impedance at d.c. and the greater the immunity from changes in mains input. The use of remote sensing connections as shown, enables a low output impedance to appear at a point physically distant from the supply. However, this low impedance is only demonstrated at d.c. and low frequencies. In order to be stable the supply must be designed so that the loop gain of its control system must fall with frequency in a controlled manner. This results in an output impedance which rises with frequency. This rise is controlled by the capacitor C_2 in Fig. 2.

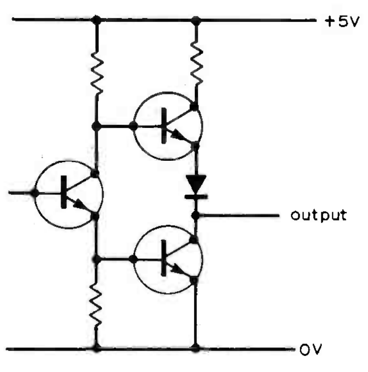


Fig. 1. "Totem-pole" output stage.

The higher the loop gain of the system the more difficult it becomes to control its frequency response. A low gain design giving modest performance can be stabilized by a single time constant, but high gain designs require two or even more shaping circuits. Inescapably associated with these is a relatively high phase shift at certain frequencies which results in ringing in response to sudden changes in load current. Even worse, transient response is likely if remote sensing is employed as a further time constant is added, as shown in Fig. 3. Resistors R_3 and R_4 represent the resistances of the leads between the power unit and the load: C_3 is the total capacitance at the load end and is largely made up by the decoupling capacitors distributed amongst the i.c. packages. The inductances of the leads, L_1 and L_2, may also be significant. All these parameters are outside the control of the power supply designer, but an inescapable part of the loop which he is trying to design to be stable! The selection of a supply module having an outstanding performance in the conventional sense in

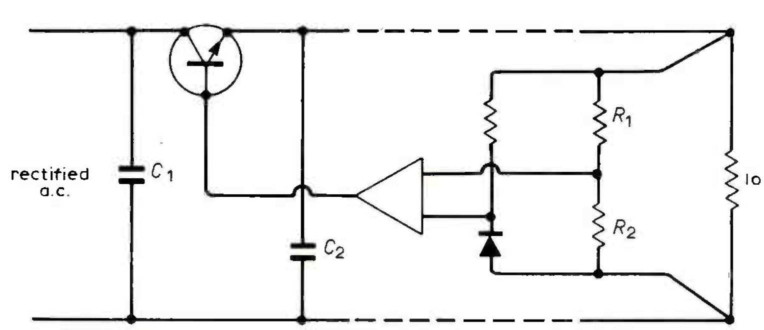


Fig. 2. Series stabilized power supply.

*Measurement consultant to Semitron Ltd.

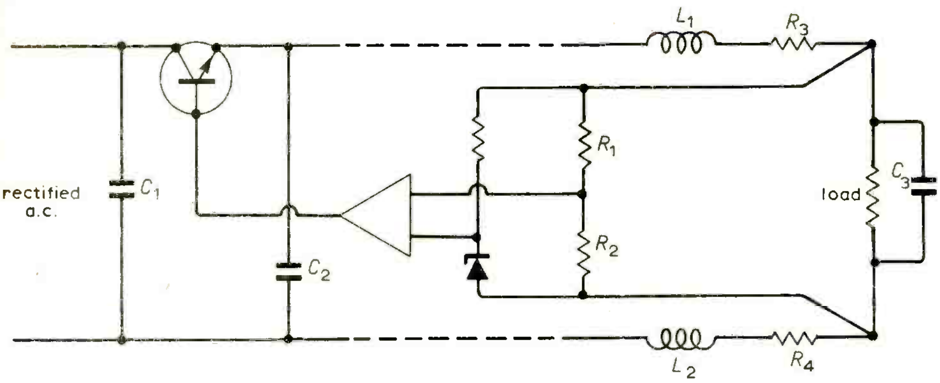


Fig. 3. Supply with long output leads.

the belief that this will ensure that there are no problems in this area is therefore a serious mistake. If anything, the reverse is likely to be true.

Voltage transient protection. A small rise in voltage at the output of a supply based on Fig. 2 causes the series element to be cut off, giving the unit a very high output impedance. If, for example, the 5V rail is accidentally shorted to one at a higher voltage or touched by a charged object such as an unearthed soldering iron there is nothing to prevent an excessive potential reaching the logic circuits. If the series device should fail and become a short circuit the output voltage will rise dangerously and cause extensive damage to the logic devices. To reduce these weaknesses, thyristor "crowbar" circuits are often added. The principle of these is shown in Fig. 4. These do not give such satisfactory protection as is often imagined. The switch-on time of most thyristors is of the order of microseconds and the firing circuit adds more delay between the appearance of an excessive voltage and the thyristor becoming effective.

When the mains supply is switched on unpredictable voltage conditions exist throughout the stabilizer and crowbar circuits. These also vary with the exact instant during the supply waveform when the switch is closed. Any bounce in the switch further complicates the situation. Under these conditions it is possible for an even larger and longer voltage transient to occur at the output and not be restrained by the "protection" circuit.

Current limiting. If an excessive current is drawn from a power supply its output voltage will fall. This fall may be related to the current in various ways, as shown in Fig. 5. Curve 1 shows considerable foldback, i.e. the output current falls greatly when the supply is overloaded. This brings the danger of lockout states if the load line representing all the logic elements intersects the characteristic at three points. A typical t.t.l. load line is shown dotted in Fig. 5 as curve 2. Much less favourable load lines, such as curve 3, have been reported by Kalb.† However, such extreme cases as he reports were concerned in circuit studies and should not be observed among devices from reputable manufacturers' production runs.

†"Design Considerations for a t.t.l. Gate", Jeff Kalb, National Semiconductor Corp. publication TP-6.

Curve 4 in Fig. 5 shows a modest amount of foldback which would be unlikely to permit lockout conditions to arise. Curve 5 demonstrates the characteristic of a supply which transfers from a constant voltage to a constant current mode. For comparison, the relationship for a simple shunt zener regulator (Fig. 6) is shown in the figure as curve 6. The use of foldback current limiting is attractive to the power supply designer as this leads to a reduction of the dissipation in the series element under conditions of short-circuits and other heavy loads on the output. This can make possible the use of a smaller heat sink or fewer series transistors. However, it is obvious from Fig. 5 that the more re-entrant is the overload characteristic the more probable it is that equipment will fail to function due to having fallen into a lockout condition. At best it may be necessary to use a power module rated at a current significantly higher than the useful load to ensure that there is only one crossing of the load line and limiting characteristic. The supply least likely to give this problem is the simple shunt zener regulator.

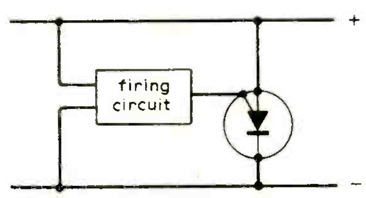


Fig. 4. Thyristor "crowbar" protection circuit.

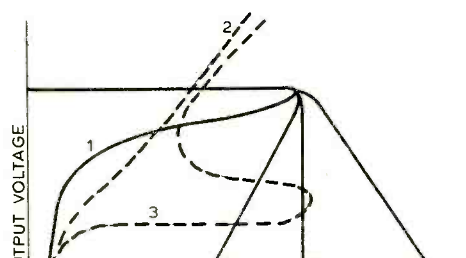


Fig. 5. Characteristics of supplies and loads. 1. Supply with considerable foldback 2 & 3. t.t.l. load lines. 4. Supply with slight foldback 5. Supply having constant current characteristic. 6. Shunt zener stabilizer.

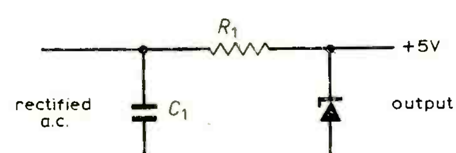


Fig. 6. Shunt regulator using zener diode.

Recommended design approach

Obviously a supply must always provide an output voltage between the required limits. This is not, however, a stringent design feature. It is essential for a power supply intended for logic circuits to have a controlled transient response in order to be free from significant ringing or overshoot. These are more important than the transient response time itself. The transient performance must not be degraded by the addition of unspecified amounts of additional capacitance across the supply terminals, even at the end of long leads. These requirements are best met by a simple design. The resulting regulation against mains input and output load changes, though poor by power supply industry standards, can readily be arranged to be tolerable by logic elements, allowing in addition for ripple and voltage drop in wiring. Remote sensing is not needed for relatively low currents and is indeed a disadvantage owing to the extra difficulty of obtaining the required transient response. However, when the voltage drop in the cables between the supply module and the load is likely to exceed 100mV, the advantage of eliminating this outweighs the problems which result.

The current limiting characteristic is not too critical although it is essential to ensure that this is crossed only once by the load line of the circuits being driven by the supply. Undoubtedly the less re-entrant this is the more certainly the supply is compatible with any logic elements. Over-voltage protection is very desirable, but to be truly effective must operate very much faster than any thyristor circuit. A zener diode, being a single sharp junction device, gives far superior limiting. Devices having the essential sharp knee, well defined breakdown voltage, very low slope resistance and high surge power ratings have been designed for this application and are now readily available. These devices provide, for the first time, the possibility of effective protection of integrated circuits from damage due to voltage transients. To avoid delays in the operation of the protection due to transmission line effects the device should be installed close to the logic elements. A large heat sink is not mandatory, since the dissipation is negligible under normal conditions. If a sustained excess voltage occurs, due to a short circuit to a higher voltage rail or a short-circuited series element in the power supply, the dissipation in the protecting device may be excessive. If the device then fails it will almost certainly become a short circuit, continuing to protect the integrated circuits. Repairs are therefore limited to the power supply area and costly searches through the logic circuits for elements which may be only slightly damaged are still avoided. The shunt stabilizer of Fig. 6 inherently provides fast protection against voltage spikes.

Other logic families. The demands which 74 series t.t.l. makes from its power supplies apply to the high speed 74H versions, with somewhat greater emphasis. Slower families give less of a current pulse problem but m.o.s. in particular, is very prone to damage by voltage transients. All widely used logic integrated circuits are able to tolerate $\pm 5\%$ total voltage excursions. Many are unaffected by $\pm 10\%$. The same general principles should therefore be applied in the provision of power supplies for all current types of digital integrated circuits.

Conclusions

Comparison of the properties of standard stabilized power modules and the requirements of logic elements reveal that the supplies give a very well defined voltage, which the integrated circuits do not need, and no protection from voltage transients. Even power supplies with thyristor crowbar circuits may allow, or even cause, dangerous transients.

The specification of sophisticated power supply units for integrated circuit logic is not only uneconomic but also unsatisfactory. Local decoupling of devices, in accordance with device manufacturers' recommendations, should be provided to supply pulse currents without delay due to transmission line effects. The supply module must not oscillate and must have a suitable response to transient currents whatever the total value of capacitance connected at the remote end of the supply leads. The regulation and ripple are not critical, but the total voltage excursions must be within the limits specified for the logic family. A simple shunt zener regulator meets all the requirements and is a practical solution for all currents for which suitably specified zener diodes with the required power rating are available. Overvoltage protection is strongly advised, particularly where series stabilization is utilized in the supply design. This should be obtained by the use of the special zener diodes now available for this purpose. Zener protection can also be added to existing system designs with advantage.

British participation in ESRO-4

The latest spacecraft from the European Space Research Organization is that of ESRO-4 which was launched by a four-stage, solid-propellant Scout rocket on 21st November, at NASA's Western Test Range in California. There are five experiments on board, one of which was mounted by the Mullard Space Science Laboratory, Dorking, Surrey, and supported by the Science Research Council. The prime function of this British experiment is to measure ion (charged atom) density, temperature and composition of the Appleton or F-layer of the ionosphere.

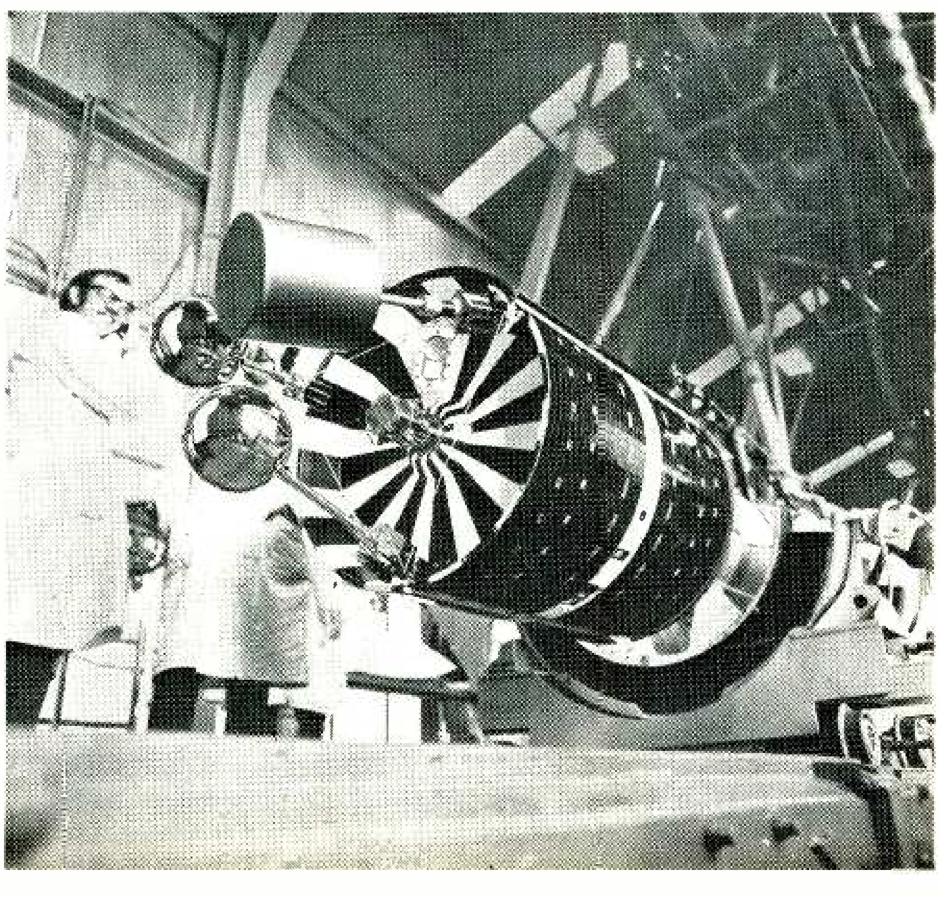
On the satellite structure three sensors are used for measurement, one of which is a gridded, spherical, ion-collecting probe 20cm in diameter fitted to the end of one of three, 1.3 metre folding booms. The booms perform two functions, one of which is to de-spin the craft after orbit insertion, and the other to position the ion probe clear of the space-charge which will surround the vehicle.

The electrical potential of the probe is swept repeatedly from positive to negative enabling it to act as an ion mass spectrometer. On the same boom as this probe, but very close to the craft, is a smaller sphere of 1cm diameter designed to collect residual electrons and, therefore, to define the spacecraft's absolute potential in space. This feature allows the correct interpretation of the mass spectrometer readings to be obtained.

A third probe, 10cm in diameter, carried on a boom 0.35 metre in length and mounted axially at the base of the satellite, has a constant charge applied with respect to the spacecraft, which serves as a type of calibrator against which the apparent ion density can be continually checked. The charge is adjusted to represent the mid-range value at the beginning of each potential sweep of the spectrometer probes, so that short period fluctuations in ion current can be detected down to the order of 2%, whatever the residual ion density.

The spacecraft was planned to have a nearly polar orbit with altitudes varying from an apogee of 1100km to a perigee of 280km. Spin rate before orbit insertion was about 150 r.p.m. and after the operation of the de-spin booms it would have been reduced to 65-70 r.p.m. There are five different attitudes planned for the various experiments which are acquired by a command operated magnetic torquer. The prime contractor for this scientific satellite was Hawker Siddeley Dynamics under contract from the European Space Research Organization.

Spacecraft ESRO-4 on a test rig in California



World of Amateur Radio

Hobby for the well-heeled?

Is amateur radio becoming a high-cost hobby demanding little from its adherents other than a willingness to pay out hundreds of pounds for factory-built equipment? This is a question which can be guaranteed to rouse strong feelings. But certainly the number of amateur "shacks" containing equipment costing £500 or even well over £1000 is now quite high. Amateur communication receivers range up to more than £250; many transceivers are around this figure (though de luxe models such as the CX7A are about £1000); linear amplifiers around the £150 mark; r.f. speech clipping units possibly £50; electronic keyer say £25; beam aerials and towers, virtually no limit; and so on. All this seems a long way from the 0-v-1 ("straight") receivers and the two-band, 10-watt transmitters of the 'thirties, or the surplus HRO and home-built a.m./c.w. transmitter of 20 years ago.

Undoubtedly many amateurs are concerned at this transition from a do-it-yourself and self-training activity to what is increasingly a cheque-book hobby, though some of us continue to find much interest in what are virtually "junk-box" stations. It is still possible to put an amateur station — particularly a c.w. station — on the air for under £25.

Easier licences?

A similar, and related, debate in amateur circles is about the constant pressure in many countries to make it simpler to obtain amateur licences. To quote a guest editorial in *Break-In* (New Zealand): "At the present time there seems to be a great hue and cry to lower the requirements to become an amateur radio operator . . . we feel that quality will always count more than quantity". The writer notes the outcry against having to learn the "archaic" Morse code and the arguments against formal radio theory examinations, and the feeling that amateurs form an "exclusive club" without regard for the many who wish to participate in the hobby.

The writer quotes an amateur in Japan (where it has been made very easy to obtain a first licence) as suggesting that "many now get a licence after a short course, buy equipment, send off application for station licence, get on the bands for enjoying long chats with girl friends . . . and then sell their equipment".

The editorial points to the value of c.w. and theory examinations, not only for their own use, but also as a way of ensuring that a licence is valued as something which requires effort to obtain. Certainly most of us who struggled (against our wishes) to learn c.w. operation have subsequently never regretted making the effort.

Yet the following comments were received on 3.5 MHz from a Chesterfield amateur: "I find most days not one c.w. station using the band — often day after day it is the same until the evening, no c.w. but tons of s.s.b. proving the band is open . . . I tested Top Band (1.8 MHz) to find out how much it is used in daytime for c.w. I gave a series of CQ calls across eight hours per day for five days. Not one c.w. station came back".

Amateurs and BBC-50

The amateur's role in the early days of broadcasting received at least partial recognition during the recent BBC-50 celebrations, though one missed any account of the broadcasting by amateurs in the period 1920 to 1923 or what was virtually the start of Empire broadcasting by the late Gerald Marcuse, G2NM.* The successful joint I.E.E.-R.S.G.B. lecture by G. R. M. Garratt, G5CS, though full of fascinating detail of the historic events between 1896 and 1901 was placed well before the more controversial love-hate relationship between amateurs and the early B.B.C.

One historic document, the 1921 petition presented to the P.M.G. by the Wireless Society of London and signed by 65 local societies, appears to have been lost for ever, despite the efforts in the early 1940s by Arthur Milne, G2MI, to preserve the petition which he found in Post Office archives marked for destruction. Fortunately he made a photocopy of the document though the original now seems to have vanished for ever. The petition addressed to the Rt. Hon. F. G. Kellaway asked that regular "wireless telephony" transmissions be made, and foresaw the educational value of wireless as well as its use for entertainment.

Contest Notes

A well-known call-sign appears at the top of the list in the recent 1.8 MHz contest: G6UW, call of the Cambridge University Wireless Society (operated by D. I. Field, G3XTT). Leading scorer in a recently introduced "under 18" section was A. McHale, G4AMH. Revised dates for a number of 1973 contests have been announced by the R.S.G.B.: National Field Day June 2-3; S.S.B. National Field Day July 14-15; Diamond Jubilee h.f. contest, May 12-13 (telephony) and May 19-20 (c.w.). But one must query the action of the R.S.G.B. in organizing for its Diamond Jubilee h.f. events (covering 1.8 to 30 MHz) a contest in which "only contacts between stations in the British Isles will count" in view of the efforts over many years to discourage the use of such bands as 14 and 21 MHz for semi-local contacts. A most curious way of marking 60 years of service to the amateur movement!

The A.R.R.L. continues to issue large numbers of Worked All Continents awards: of 1846 certificates issued in one year, 881 were endorsed for s.s.b., 12 for r.t.t.y., 51 for 3.5 MHz operation and four for 1.8 MHz. A number of these awards have recently been issued for slow-scan television.

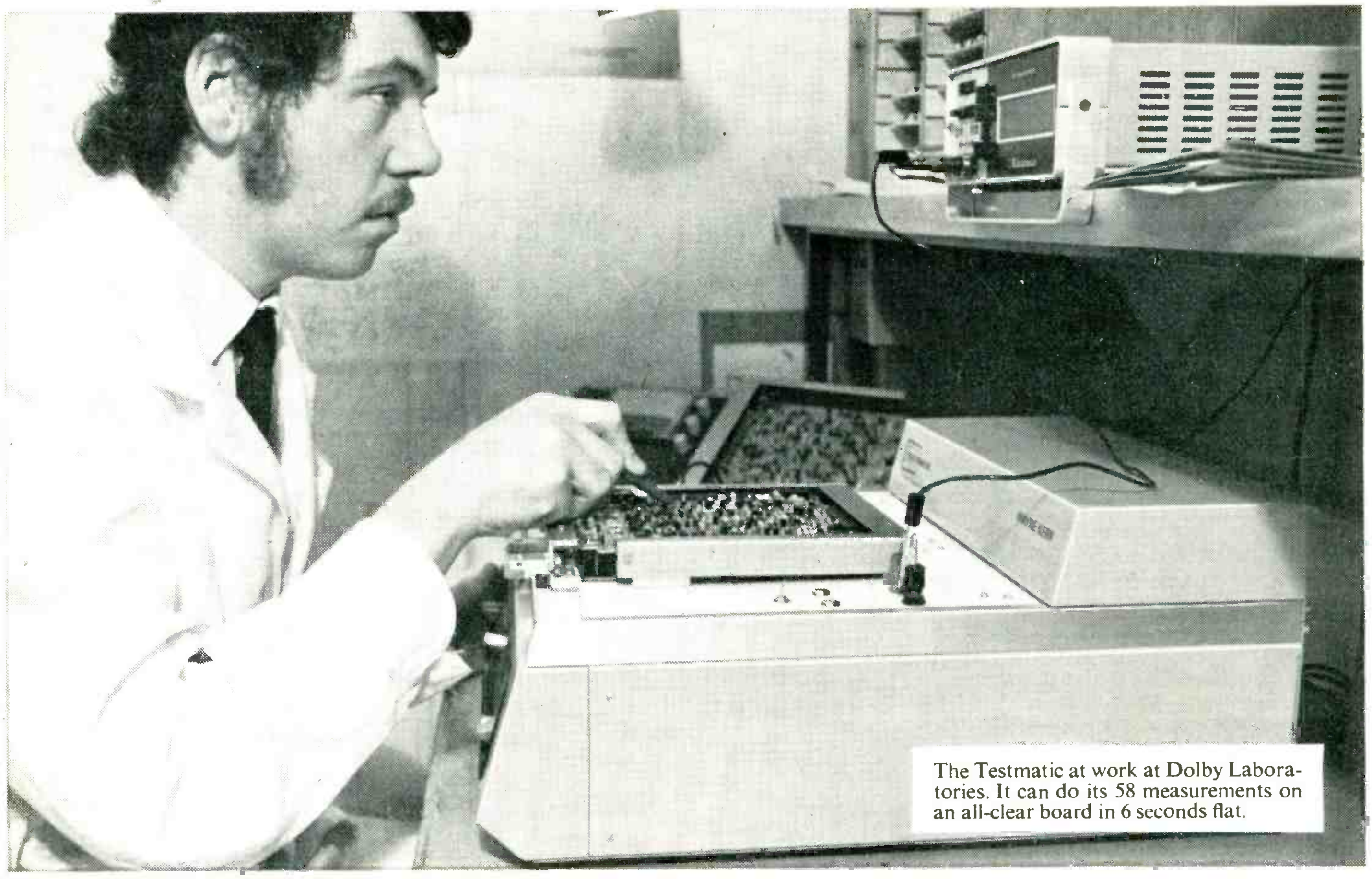
Of the 31 awards for 1.8 MHz operation issued up to November 1972, Stew Perry, W1BB, reports that seven were to amateurs in England (G6GM, G3PU, G3OQT, G3PQA, G3BBP, G3FPQ and G3LIQ), two to Scottish amateurs (GM3YCB, GM3WDF) and one in Northern Ireland (GI6TK).

*Recognition is given by Edward Pawley in his recent book "BBC Engineering 1922-1972" — Ed.

In brief

Three American organizations and the Cornish Amateur Radio Club are to mark the 70th anniversary of the opening of "CC", the original Marconi transatlantic station in the United States at Cape Cod on January 19, 1903. Special amateur stations will operate from the original sites at Cape Cod and Poldhu. . . . Efforts are being made to establish a new society in the Denby Dale district of Yorkshire and a meeting will be held on January 24 at the local Pie Hall (details J. Clegg, G3FQH, 8 Hillside, Leak Hall Lane, Denby Dale, Huddersfield). . . . Sound advice on the cure of TV and audio breakthrough is given in a new 100-page "Television Interference Manual" by Barry Priestley, G3JGO (published by R.S.G.B. at 90p including postage) which emphasizes that the main problems are those arising from the social difficulties created between the amateur and the viewer. . . . "The Amateur is balanced" — so runs the A.R.R.L.'s amateur's code — but a recent enquiry to the League makes one wonder: "I am going on a honeymoon to Florida and would appreciate advice on what 2-metre f.m. frequencies would be most practical to operate"!

Pat Hawker, G3VA



The Testmatic at work at Dolby Laboratories. It can do its 58 measurements on an all-clear board in 6 seconds flat.

'If the Wayne Kerr Testmatic did not exist, it would have been necessary for us to invent it'

Dave Peacock, Head of the Test Department, Dolby Laboratories Inc.

The heart of a Dolby System noise reduction unit is a small but complex circuit board. In six-by-seven inches are assembled no fewer than 507 resistors, capacitors, diodes and transistors.

On that score alone, fault-finding is a major operation. And as Dolby's policy is to make all processors interchangeable, they have to guarantee the stability of every part of the circuit. So their electronic checkout procedure entails 58 separate DC measurements.

Said Dave Peacock, head of the Test Department: 'An interesting thing about our board is that it is specifically designed to suit the Testmatic. We began by making a thorough search of the market to see if there was a testing machine that would suit us. Had the Testmatic not existed, we should have had to invent something very like it ourselves.

'How has it done? Well, on average we get about 2·5 faults a board. Half of these are DC faults. Thanks to Testmatic, finding and correcting them take only 10 percent of our electronic checkout effort.

'We've costed it, and we know it has saved us more than £1,000 in a year – using the TM60 for a mere 2½ hours a day. But we're stepping up output, so next year the saving should be even more impressive.

'Any teething troubles? . . . I wouldn't say so. We hit a small snag about a year ago but the Wayne Kerr service was so prompt that the whole thing was really a non-problem . . .'

The Wayne Kerr Testmatic TM60 — for testing circuit boards, cableforms, sub-assemblies. For more information call Bognor Regis (02433) 4501 or write to the address below.

WAYNE KERR
Durban Road, Bognor Regis, Sussex PO22 9RL

A member of the Wilmot Breeden group

WW—082 FOR FURTHER DETAILS

New Products

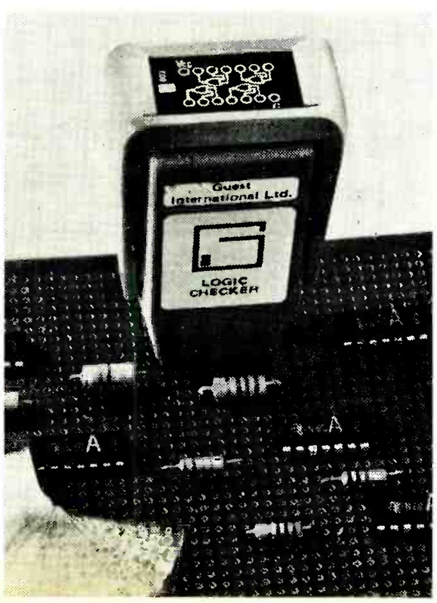
Tester for transistors and diodes

An addition to the Semitest family of i.c. testers is the Semitest V. Manufactured by Rohde & Schwarz, it is battery-operated and permits measurement of the static characteristics of transistors (current gain, leakage current, break-down voltage up to 15V), diodes (leakage current, forward voltage) and zener diodes. The Semitest V may also be used for function tests on thyristors, resistance measurements and insulation checking in the range of 100 to $10^{10}\,\Omega$. The instrument contains two voltage generators (± 0 to 10V and ± 0.5 to 15V, error $\pm 3\%$ ± 15mV, I_{max} 10mA), a constant-current generator (10μA to 10mA, error $\pm 3\% \pm / 1\mu$A. Error limits on meter amp. $\pm 3\% \pm 0.2$nA and 10mV to 30V ($\pm 3\% \pm 10$mV). U.K. agents. Aveley Electric Ltd, Roebuck Rd., Chessington, Surrey.

WW302 for further details

I.C. logic checker

Manufactured by the Industrial Components Division of Guest International Ltd, a new logic checker features an l.e.d. display. The unit is suitable for use with all d.i.l. integrated circuits having 16 leads or fewer. It can check t.t.l. or d.t.l. gates, flip-flops, counters, shift registers, decoders, adders, etc. Input impedence corresponds to a single t.t.l. load and there is no interference with the circuit under test.



The logic checker automatically takes its power supply from the i.c. terminals and requires no other external power connection. A particularly useful feature is the clip-on plate showing the logic circuit connection within the i.c. which is placed over the display in order to establish both the circuit and the operating conditions. All logic states can thus be quickly assessed. Price is £23.50. Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey CR4 7JA.

WW309 for further details

Interface logic AND driver

An 8-pin, d.i.l., i.c. device, for high-current, high-speed switching operation, is a dual peripheral position AND driver manufactured by SGS/ATES. Designated T75451A, it can be used in systems that employ t.t.l. and d.t.l. logic, and is designed to meet requirements such as high-speed logic buffer, power driver, relay driver, lamp driver, m.o.s. driver and memory driver. The T75451A is said to be free from latch-up and has diode-clamped inputs to simplify system design. Maximum output sinking current is 300mA at a guaranteed output low voltage of 0.7V, and 100μA of leakage current is guaranteed at 30V output. SGS/ATES, 20041 Agrate Brianza, Milan, Italy.

WW313 for further details

Transistor Arrays

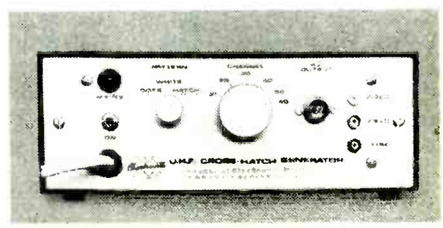
Five transistor arrays are now available from the Semiconductor Division of the Sprague Electric Co. These devices are of monolithic construction and combine the attributes of silicon integrated circuits with the design flexibility and accessibility of discrete devices. Designated the ULS-2045H, ULN-2046A, ULN-2054A, ULN-2081A and ULN-2082A, the arrays are especially useful in applications requiring matched thermal and electrical parameters.

The first two types consist of five n-p-n transistors, with two connected as a differential pair; type ULN-2054A of six n-p-n transistors connected to form two independent differential amplifiers; and the last two types, each of seven n-p-n transistors connected in the common-emitter and common-collector configuration respectively. All types are well suited for a variety of applications in low-power systems in the d.c. to v.h.f. range. Sprague Electric (UK) Ltd, 159 High Street, Yiewsley, West Drayton, Middx.

WW311 for further details

Crosshatch generator

The Checkmate crosshatch generator, made by Industrial Electronic Products Ltd, is available from Manor Engineering. Its "test card" chequered border permits rapid TV picture adjustment of linearity, crystal controlled crosshatch, dot and white field patterns are obtained by use of digital i.c. logic. Complete synchronizing

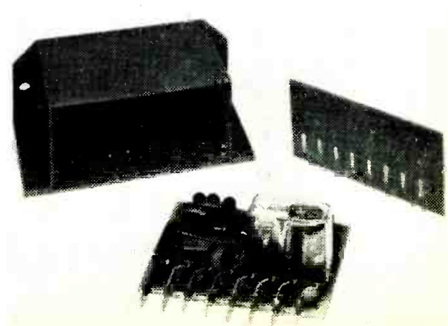


and blanking waveforms are provided, with 2:1 interlace. The generator's r.f. output tunes continuously over u.h.f. TV channels 21 to 65, obviating the need to disturb receiver push button settings. A stabilized power supply is included. Manor Engineering, The School House, Crookham Common, Newbury, Berks. RG15 8EJ.

WW 305 for further details

Component housing

A small, compact and inexpensive electronic component housing is announced by Logikontrol Ltd. Made of high impact polystyrene, it measures 90 × 50 × 37mm including mounting flanges and has an internal volume of 10cc. Among various features, it can accommodate two printed circuit boards on which miniature mains transformers and relays may be mounted. Printed circuit fast-



on connectors and the snap-fit lid eliminate the need for a special plug and socket. Available in five different colours from Logikontrol Ltd., 17 Little Edward Street, London NW1 4AT.
WW319 for further details

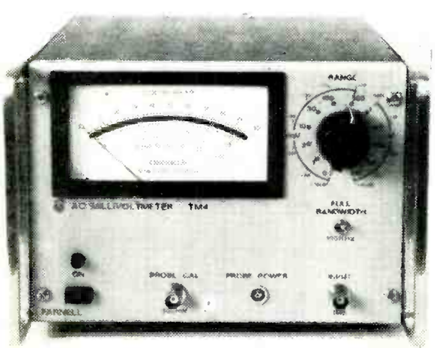
Wide-angle viewing l.e.d.

The Litronix RL 21 light-emitting diode announced by Guest International features an extra large radiating area and high luminance at a current of just 20mA.

This l.e.d. is i.c. compatible and designed for front-panel mounting, using either matt black or clear plastic clips which are supplied free. The terminations are rectangular section making them suitable for either soldering or wire-wrapping. It is suitable for wide-angle viewing and the standard device is available in a diffused red moulded package. Clear red, diffused white, or clear packages are also available. Power dissipation at 25°C is 200mW and recurrent forward current is 1A max. Continuous forward current is 100mA max. Guest International Ltd, Nicholas House, Brigstock Road, Thornton Heath, Surrey CR4 7JA.
WW321 for further details

A.C. voltmeter

The new TM4 voltmeter from Farnell measures a.c. from 300μV to 100V f.s.d. at frequencies up to 33MHz. The instrument has a high input impedance minimizing test circuit loading. Loading can be reduced still further by using a passive or active oscilloscope probe. Probe compensation facilities are provided and an output



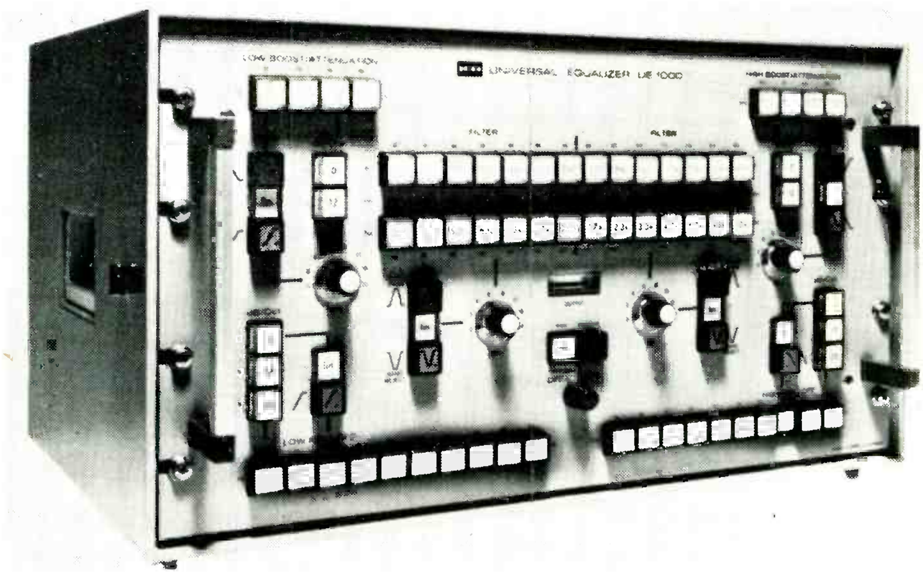
is available on the front panel to power the active probe. A switched filter is provided to remove unwanted and irrelevant high-frequency signals and noise when making low-frequency measurements. An output capable of driving a pen recorder is provided. The instrument is housed in a grey case with satin-chrome handles and has a retractable tilt stand. The U.K. price is £80. Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorks, LS22 4DH.
WW328 for further details

A.F. filter system

The Universal Equalizer UE 1000, now available from F.W.O. Bauch Ltd., contains eight a.f. filters, combined in six logically arranged equalizer modules. Corresponding to separate functions, these modules permit, through simple control adjustment, the introduction of one, all or groups of filters into the audio signal path.

Features of the UE 1000 include extended cross-over, limiting and cut-off frequencies, as well as improved roll-off slopes of 12, 24 and 36dB/octave, previously only available as 12 or 24dB/octave. The UE 1000 provides distortion-free processing of high signal a.f.-input levels up to a maximum of +22dBm corresponding to 10V, with in-built overload indication and protection. Frequency range is from 20Hz to 20kHz, while distortion is less than 0.3% even at +22dBm.

Operation of the "linear" or "equalizer" switches permits the audio signal to be fed unchanged to the audio input, or through the equalizer stages, respectively. The equalizer switch can also be operated during use, for subjective comparison of the reproduction quality in both "linear" and "equalizer" positions. The UE 1000 is self-contained in a standard 19in assembly for rack or surface mounting. F.W.O. Bauch Ltd., 49 Theobald Street, Boreham Wood. Herts. WD6 4RZ.
WW317 for further details



Touch tuning i.cs

Siemens have now introduced in the U.K. their touch sensitive tuning i.cs which replace the mechanical push-buttons on TV tuners. With a mere touch of a finger, channels can be selected and indicated. For even greater convenience a low-cost remote control unit could be used for channel changing, using only a single wire. The new i.c. is also applicable in any similar electronic equipment, i.e. test stations in factories or electronic push-button control in lifts etc. The new unit should improve the reliability of TV and radio channel selection systems where varicap tuners are used, for it has been found that the main failure occurs with the mechanical push-button unit, due mainly to oxidation of the switch contacts.

Only a low-voltage supply is required permitting either the use of inexpensive filament lamps for channel indication or opening up possibilities for future designs with gallium-arsenide diodes, or perhaps even liquid crystals. Because of the low voltage concept, it is also unnecessary to isolate the touch-system from the mains supply or use rectified mains, thus saving additional expensive high ohmic value resistors with high voltage capability. But perhaps even more important, it permits the circuit to meet the safety requirements of BS 9000, which is in preparation.

Two types are available — the SAS 560 and the SAS 570. Each consists of four similar stages, and up to twelve channels are possible for television use. The SAS 560, a basic 4-stage unit, features an internal memory, which ensures that when the receiver is switched on, channel one is always selected. This could be tuned to the viewer's preferred station. The price of one circuit in production quantities is around 35p.

The input of the i.c. is very sensitive and still works when the resistance of the finger is more than 100MΩ. There are two independent outputs for each channel — one to switch the varicap supply, the other to switch the indicator lamps, and on export sets, the u.h.f./v.h.f. band switch.

A remote control system for channel switching could be connected to the i.c. Selection would be performed by stepping through the channels and stopping on the one required. Siemens Ltd, Great West House, Great West Road, Brentford, Middx.

WW304 for further details

Thick-film potentiometer

Coutant Electronics Ltd are manufacturing a thick-film focus potentiometer, complete with resistive divider chain, for use in colour television sets. The potentiometer is claimed to offer many advantages over the conventional component employed at present, such as improved reliability, smaller size, better resistance to environmental extremes and superior long-term stability.

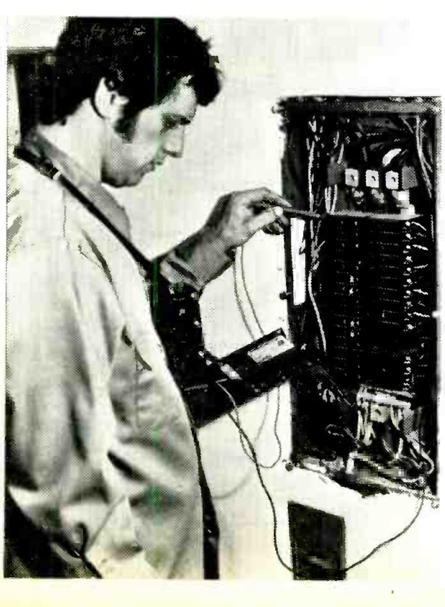
The unit is designed for o.e.m. use and consists of two high-value printed resistors and a central printed potentiometer track all connected in series. Resistor values are 19.7MΩ± 5% (h.t. end), 29.4MΩ tracking to within ±5% (potentiometer) and 20.1MΩ± 15% (earthy end). Although the normal operating voltage is 9kV it will withstand 15kV across the complete chain, or 9kV across any two terminals with the control knob in any position, without damage or flashover occurring. It is claimed that resistance will stay within 2% of the nominal value for a minimum of 100 rotational cycles or for changes due to temperature.

The values of resistance have been chosen to make the unit compatible with any current production colour television tubes. Most important for domestic equipment, the moulded polypropylene case (measuring 65mm long × 42.8mm wide) not only protects the printed resistors from the ingress of atmospheric impurities but also is said to have an extremely good resistance to flame. Coutant Electronics Ltd., 3 Trafford Road, Reading, Berks.

WW315 for further details

Circuit tracing device

A simple device for identifying electrical circuits and tracing wires has been introduced by Thomas & Betts. It is claimed that the method makes it possible for a single operator to identify and mark circuits safely in less time than it usually takes two men to do the same job by conventional means. The instrument, called the E-Z-Coder circuit tracer, consists of a meter unit, a test block with 12 leads, and a carrying case designed to leave the operator's hands free. Circuits are identified by comparing the resistances of the individual leads connected through the test block, readings being taken off a 90° ohms scale.

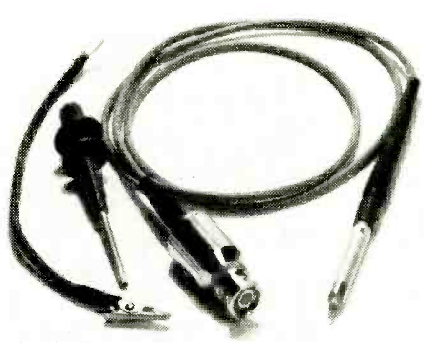


Accurate readings are ensured by calibration of the meter prior to use. The adjustment screw is recessed to prevent accidental movement, and the clarity of the scale reduces the possibility of error. Power for the instrument is supplied by a 1.4V mercury cell with a life of about two years. The circuit tracer is fitted with a 'hot line' indicating light to warn the user of any live circuit. Protective insulation shrouds the 36in long test leads in case of contact with a live wire. By using more test blocks wired in series it is possible to check up to 156 wires in groups of twelve. Thomas & Betts Ltd., Greenhill House, 90–93 Cowcross Street, London EC1M 6JR.

WW 308 for further details

Passive probe kit

Electroplan Ltd have introduced a passive probe kit to their accessories range. Known as the GE81600, the kit consists of 10:1 and 1:1 attenuator heads, a compensating lead assembly, a spring plunger body with hook tip and a detachable earth lead.



Using the 10:1 attenuator head, the probe may be used from d.c. to 70MHz and can be compensated for use with instruments having an input impedance of 1MΩ in parallel with 20 to 60pF.

For low-level signals, the 1:1 attenuator head can be used from d.c. to 5MHz and no compensation adjustments are necessary. The GE81600 passive probe kit is available from Electroplan Ltd, P.O. Box 19, Orchard Road, Royston, Herts. Price £9.00, quoting ordering code 15-44.

WW312 for further details

Wire stripper and cutter

Bib Sales Division of Multicore Solders Ltd. have introduced a new wire stripper and cutter. Case hardened, with ground cutting surfaces, the wire stripper adjusts to most standard sizes of wire and is fitted with a handle opening spring to facilitate repetitive wire stripping. A handle locking catch is fitted at the top of the wire stripper to keep the jaws closed when not in use. Recommended retail price of 75p. Bib Sales Division, Multicore Solders Ltd., Hemel Hempstead, Herts.

WW 307 for further details

Low-cost digital multimeter

Fluke International Corporation have announced the 8000A, a low-priced multimeter which is guaranteed over the temperature range 15-35°C. It will measure a.c. and d.c. volts to 1200V, a.c. and d.c. current to 2A and resistance 20MΩ.

The following is a brief specification:

d.c. voltage	±(0.1% + 1 digit)
a.c. voltage	±(0.5% + 2 digits)
d.c. current	±(0.3% + 1 digit)
a.c. current	±1.0% + 2 digits)
ohms	±(o.2% + 1 digit)

Overload protection on the various functions: voltage ranges to 1200V r.m.s., current ranges to 2A r.m.s. (fused) and ohms to 230 volts. Size: 2.5 × 8.5 × 10.0in. Weight: 7lb with battery pack (optional). Fluke International Corporation, Garnett Close, Watford WD2 4TT.

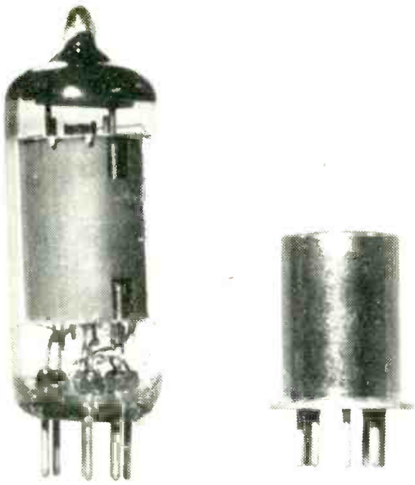
WW314 for further details

Semiconductor valve

Tens of millions of valves are still in use outside the consumer industry. In radar and communications, broadcasting and instrumentation, regular replacement of these valves is essential due to their limited life and characteristic degradation during service. Now a solid state valve replacement, called the Fetron, has been introduced which, in many applications, can be plugged directly into the valve socket without the need for major circuit modification.

GDS Sales, who are stocking the first Fetrons to be marketed in the U.K., say that the advantages of the new device include extremely long life (estimated by Teledyne Semiconductor, the manufacturers, at over 1,000,000 hours), no microphony, zero warm-up time, reduced heat dissipation due to the absence of the valve's heater, no degradation of transconductance, and built-in internal shielding.

First Fetrons to be available are the TS12AT7 and TS6AK5. These are intended to replace the 12AT7 and 6AK5 respectively in most amplifier circuits. The TS12AT7 consists of two high-voltage f.e.ts and the TS6AK5 a cascode



connected f.e.t. pair. Amongst the valves which it is claimed can be replaced by the TS6AK5 are the EF90, EF95, and EF95F.

At this stage, GDS say that the pentode Fetron should not be considered a plug-in replacement for the valve in oscillator circuits because of the absence of a screen grid. For specific oscillator service, the screen can be simulated by the inclusion of a *RC* network in the package, but such devices are not yet standard products.

Fetrons are extremely rugged. The case of the current devices is a deep-drawn steel cap welded to a large header. Before welding, the case is evacuated and back-filled with dry nitrogen.

Both the TS12AT7 and TS6AK5 are available from GDS stocks and cost, in quantities of 100 and above, £5.25 and £4.75 respectively. GDS (Sales) Ltd., Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.
WW 306 for further details

Corrosion inhibitor

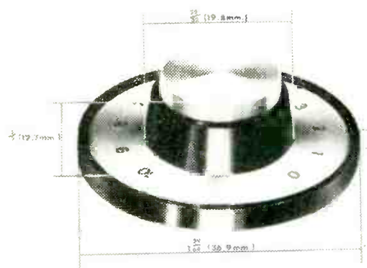
'Vapor-Strip', which prevents the formation of rust, salt corrosion, mildew and mould, is now available overseas through the manufacturer's (Northern Instruments) exclusive export distributor, Singer Products Company Inc., New York.

'Vapor-Strip' looks and feels like a piece of grey sponge rubber with an easily removable adhesive backing. When this backing is removed and the strip is applied to a clean surface, chemicals are released, which prevent corrosion, reduce acid damage and prevent gum and varnish formation while helping to remove old deposits. One small Vapor-Strip will protect 2500 cubic inches (41000 cc) for over two years of normal use. It has no deleterious effect on commonly used plastics, rubbers, paints and adhesives, while preventing fungus growth.

Leather, cloth, engine gaskets and similar materials were incubated under extreme fungus-producing conditions for 16 weeks at 70°F (21°C). With 'Vapor-Strip' protection, there was no evidence of any damage; untreated samples were almost covered with mould and mildew and frequently rotted away. The product is practically odourless. Normal packaging consists of two $\frac{7}{8} \times 2\frac{1}{2}$in 'Vapor-Strips' in a blister type card, with suggested uses and complete directions. Custom sized strips, for special applications, are available to order. Singer Products Company Inc., One World Trade Centre, Suite 2365, New York, N.Y.10048, U.S.A.
WW322 for further details

Knob assembly

A new knob, dial and escutcheon assembly with an alternative plain or customer designed legend dial has been introduced by Bulgin. Designed for push fitting to $\frac{3}{16}$in flattened shafts, the knob and



escutcheon are polished black with smooth sides. The decor cap and dial are spin finished alloy. A. F. Bulgin & Co. Ltd., Bye-Pass Road, Barking, Essex.
WW326 for further details

V.H.F. signal generators

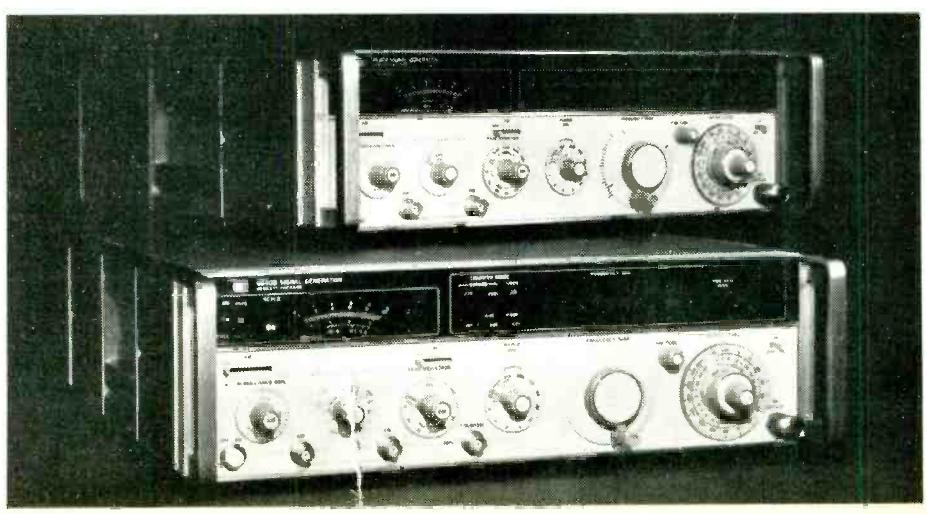
Low-noise, broad-frequency coverage and precision modulation are claimed as the foremost attributes of two new a.m./f.m. signal generators from Hewlett-Packard. Covering 450kHz to 550MHz with calibrated modulation and +19 to −145dBm output levels, they can perform complete r.f. and i.f. tests on virtually any kind of v.h.f. receiver.

Both units deliver low-noise signals with a wideband signal/noise ratio better than 140dB/Hz and non-harmonic and sub-harmonic outputs that are down more than 100dB. Close-in noise, critical in mobile radio adjacent-channel selectivity tests, is specified at −130dB/Hz at 20kHz offset.

One version of the new signal generator, model 8640A, has a slide-rule tuning dial with 0.5% frequency accuracy and drift of less than 10 p.p.m. per 10 minutes. The other, model 8640B, has a six-digit l.e.d. display (useful separately as a 550MHz frequency counter) and a built-in phase-lock synchronizer to achieve output stability of better than 5×10^{-8} per hour; i.e. synthesizer stability.

Even when the 8640B is locked, the spectral purity and same precision f.m. of the unlocked mode is preserved. This permits meaningful tests on narrowband and crystal-controlled receivers. Provision is also made for locking to an externally applied 5MHz standard for even higher stability, or for locking two 8640Bs together for various two-tone tests. In the unlocked mode, the built-in counter can display the generator's frequency to a resolution of 100Hz at 500MHz and 0.1Hz at 500kHz. The counter can also measure external signals between 20Hz and 550MHz, eliminating the need for separate frequency measuring equipment in many test applications.

Except for the counter and lock features, the overall performance of the 8640A and 8640B signal generators is identical. Power output is calibrated from +19 to −145dBm (2V to .013V) and levelled to ± 0.5dB. The maximum output of +19dBm permits high level tests on receiver i.f. strips, amplifiers, and mixers without additional power amplification. Accurate low level measurements down to −145dBm have been assured through r.f.i. shielding and use of an accurately calibrated step attenuator. The output level is displayed on both a direct reading dial and a built-in meter that autoranges for high resolution. Other facilities available are modulation of the c.w. with independent a.m. and f.m. sources that are metered and calibrated for all r.f. output frequencies and levels. The a.m. is adjustable from 0 to 100% with the bandwidth, accuracy and low incidental f.m. required for the most stringent a.m. measurement applications. Distortion is



1% at the 50% modulation setting and 3% at 70% a.m. Provision is also made for external pulse modulation with pulse widths down to 1 sec.

The f.m. mode provides calibrated and metered deviation that remains constant with frequency or band changes. Peak deviations to at least 0.5% of carrier frequency are available. Important for accurate narrowband f.m. measurements, there is negligible frequency shift from the c.w. to f.m. mode and no degradation in spectral purity. With the 8640B in the phase-locked mode, full f.m. capability is preserved at modulating rates from 50Hz to 250kHz, producing accurate f.m. with the carrier stability of a crystal oscillator. The standard internal modulating tones are 400 and 1000Hz for both a.m. and f.m. Hewlett-Packard Ltd., 224 Bath Road, Slough, Bucks. SL1 4DS.

WW325 for further details

Ultrasonic air transducers

Two piezo-electric ultrasonic transducers made by H. D. A. MacDonald and designated type UT40T and UT40R, are designed for 40-kHz transmitting and receiving applications, respectively. Obtainable as matched pairs, with the matching achieved to within 100Hz, the specifications quoted are:

UT40T

Sensitivity (0dB = 1μbar/V/m)	> 3dB
Frequency	40 ± 0.9kHz
Impedance	200Ω
Capacitance	1400 ± 20%pF
Selectivity	70
Max. applied voltage	7V
Temperature range	−15 to +65°C

UT40R

Sensitivity (0dB = 1V/μbar)	> −64dB
Frequency	40 ± 0.9kHz
Impedance	70kΩ
Capacitance	1400 ± 20%pF
Selectivity	60
Temperature range	−15 to +65°C

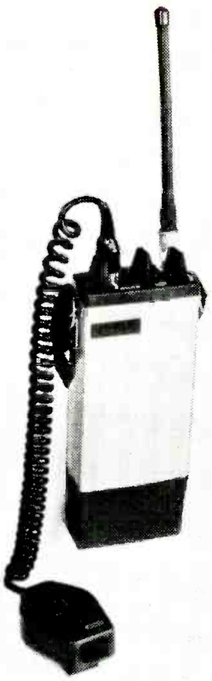
Priced at £3.95 for a single pair, discounts are offered for quantity orders. H. D. A. MacDonald, 100 Clarendon Road, Ashford Middlesex TW15 2QD.

WW301 for further details

V.H.F./U.H.F. amplifier

Microwave International (U.K.) Ltd, have announced a range of solid-state broad-band power amplifiers, covering 225-400MHz, which have been developed for use in transceivers. One, the Model WA2240, finds application as a power amplifier for sweepers and many test set-up applications. These units have been used successfully as drivers for the testing of high-power r.f. circuitry in network analyzer systems.

The modules are designed with 50Ω to 50Ω input/output impedance, and are factory aligned. The Model WA2240 is available in power output ranges from 5 to 100 watts and may be ordered with signal gain from 10 to 50dB. It is also available with electronic output protection against poor and varying load v.s.w.rs. Specifications for the Model WA2240 wide-band amplifier are:



Frequency	225-400MHz
Instantaneous bandwidth	175MHz
Power output	5W at 1A 20W at 2A 60W at 6A 100W at 12A
Power input	1 or 10mW
Second harmonic	−30dB minimum
Input v.s.w.r.	2:1 max. 1.5:1 typical
Load v.s.w.r.	2:1 maximum
Spurious output	−50dB minimum
Supply voltage	+28V d.c.

Microwave International (U.K.) Ltd, 33-37 Cowleaze Road, Kingston upon Thames, Surrey.

WW329 for further details

V.H.F.-A.M. radiotelephone

Dymar Electronics have introduced a rugged, weatherproof amplitude-modulated v.h.f. personal portable radiotelephone (type 980) for general purpose short-range land communications. Single- or two-frequency simplex service is provided with three channels spaced within a bandwidth of 1.0MHz. Channel spacing is either 12.5 or 25kHz and the frequency range is 68 to 174MHz.

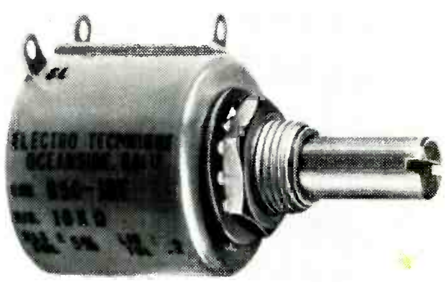
Transmitter characteristics include: r.f. power output, 500mW into 50 ohms; up to 100% modulation; modulation response, with +1dB and −3dB relative to 1kHz between 300Hz and 2.5kHz; and modulation distortion, less than 10% at 1kHz and 5% modulation (typically 5%). Receiver characteristics include: sensitivity, 1.6ΩV e.m.f.; selectivity, not less than 70dB adjacent channel rejection; spurious responses, attenuated at least 60dB relative to wanted signal; a.g.c., less than 10dB increase in a.f. output for an increase in signal from 1.6μV to 100mV e.m.f.; a.f. output, 100mW. A choice of aerials is available — helical, whip or trailing wire.

Depending on the battery used, the type 980 weighs between 0.6kg and 0.75kg (approximately 1lb 5oz and 1lb 10oz). Dimensions are 208 × 84 × 39mm (approximately 8 × 3¼ × 1½in). Dymar Electronics Ltd, Colonial Way, Radlett Road, Watford, Herts.

WW316 for further details

10-turn potentiometer

A miniature precision 10-turn potentiometer, only ¾in long, and ⅞in diameter, is now available from Kynmore Engineering Co. Ltd. The new model is known as the ET-850. The case is made of high-temperature moulded plastic and the internal slip-rings and the external solder terminals are of heat-treated beryllium copper with gold plating.



Standard linearity is 0.25% and temperature stability 70 p.p.m. /°C. Standard resistance values are: 100, 200, 500, 1000, 2000, 5000, 10k, 20k, 50k and 100k ohms. End resistance is 0.25% or 1 ohm, whichever is the larger. Kynmore Engineering Co. Ltd., 19 Buckingham Street, London WC2N 6EQ.

WW 303 for further details

H.V. Darlington hybrid

A new high-gain, high-voltage, dual Darlington hybrid circuit has been announced by RCA Solid State-Europe. The HC3100 contains two Darlington circuits, both of which are electrically isolated from the package so that the unit can be mounted directly on a chassis. It incorporates protective diodes for the logic drive circuit, diodes for commutating inductive loads and operates from power supplies up to 120V. The HC3100 can be used in regulators as well as such applications as hammer, solenoid, and stepper motor drivers. The case is an 8-pin variant of the TO-3 hermetic package. RCA Ltd., Sunbury-on-Thames, Middx.

WW320 for further details

About People

Dr. Frank E. Jones, M.B.E., F.R.S., managing director of Mullard Ltd. has retired but joined the board of Philips Industries Ltd on January 1st. Dr. Jones, who is 58, joined the Mullard board in 1956 as technical director and was appointed managing director in 1962. He graduated at King's College, London, and entered the scientific civil service in 1940 and was at one time head of experimental physics research at the Telecommunications Research Establishment of which he later became deputy chief scientific officer. He left T.R.E. in 1952 to become deputy director of the Royal Aircraft Establishment, Farnborough. In 1967 he was elected a Fellow of the Royal Society for his work on radar and infra-red technology and "his outstanding technological leadership in an advanced industry". Dr. Jones is succeeded as managing director of Mullard by **Jack C. Akerman** who has been with Mullard since 1936. In 1967 he was appointed a director of Associated Semiconductor Manufacturers Ltd., an associated company of Mullard Ltd. He took over as head of Mullard's Consumer Electronics Division in 1969. He has been commercial director and a member of the Mullard board since 1970.

Peter Rainger, B.Sc., F.I.E.E., head of the Research Department of the B.B.C., has received the David Sarnoff Gold Medal Award for 1972 from the Society of Motion Picture and Television Engineers. He was given the award "for his pioneering development of all-electronic television standards conversion techniques together with numerous other important contributions to television technology". Mr. Rainger, a graduate of London University, was head of the B.B.C. Designs Department from 1968 to 1971, and since November 1971 has been head of the B.B.C. Research Department.

Dr. William Shockley who with Drs. W. H. Brattain and J. Bardeen received the 1956 Nobel Prize in Physics for the invention of the junction transistor, is to visit the U.K. in February to deliver a lecture at the Institution of Electrical Engineers. Dr. Shockley's lecture on 14th February will be the highlight of a week of celebrations to commemorate the 25th anniversary of the discovery of the transistor. Dr. Shockley, who was born in London in 1910, joined Bell Telephone Laboratories in 1936 where he was director of transistor physics when he left in 1956. He was with Beckman Instruments for a few years before occupying the chair of engineering sciences in the Department of Electrical Engineering at Stamford University. He rejoined Bell Labs in 1965.

Among the recent recipients of Royal Society Medals are **Sir Nevill Mott,** F.R.S., emeritus professor of physics in the University of Cambridge and senior research fellow, Imperial College of Science and Technology, London, who receives the Copley Medal "for his original contributions over a long period to atomic and solid state physics". The Hughes Medal has been awarded to **Dr. B. D. Josephson,** F.R.S., reader in physics, University of Cambridge, "for his discovery of the remarkable properties of junctions between superconducting materials." Readers may recall that Dr. Josephson, wrote on superconducting devices in our October 1966 issue. Except for a short time spent in the Physics Dept. of the University of Illinois as research assistant professor, Dr. Josephson has been at Trinity College, Cambridge, since 1957. He graduated in 1960.

David Hawkins, 33, has been appointed sales manager of Blueline Electronic Components. Previously he was an account executive with ITT Components Group, having joined ITT from Telcon Magnetic Cores Ltd in 1970.

David Griffin, M.I.E.R.E., marketing manager of Motorola Semiconductors Ltd, has been appointed director of product promotion and planning, Europe. He moves to Geneva in January. Mr. Griffin, who is 38, was with Texas Instruments, Bedford, from 1957-62 and with Celdis immediately prior to joining Motorola in 1964. He is succeeded as marketing manager, U.K., by **Mike Ward,** who is 36 and has been with Motorola for the past six years.

John Bishop, M.I.E.R.E., has joined GEC-Elliott Process Automation Ltd as manager of its Telemetry and Supervisory Systems Division at Leicester. Mr. Bishop graduated from the University College of Southampton where he studied electronics. In the mid fifties he spent three years with GEC in Coventry and for the past ten years has been sales manager with Serck Controls Ltd.

Geoff Gamble, who joined Brookdeal nearly four years ago and earlier this year was promoted to chief applications engineer, has become marketing manager. Prior to joining Brookdeal, Mr. Gamble was for three years an engineer in the Radio Systems Division of Plessey.

David Letheren, B.Sc., a graduate of University College, London, has joined the m.o.s. applications team at Emihus Microcomponents Ltd, at Weybridge, Surrey. Mr. Letheren, who is 32, joins Emihus from Bell Punch Company, where he was an m.o.s. design engineer. Previously, he was with Decca Radar Ltd, working at the Hersham research laboratory on analogue and digital radar systems.

Orbit Controls Ltd, of Cheltenham, have appointed **Michael E. Cosens** to the new post of field sales manager. He joined Orbit from The Plessey Company where he was European sales manager of the Memories Division. Previously Mr. Cosens, who is 36, was general sales manager of Fabritek Inc., responsible, from London, for world marketing and sales outside the U.S.A.

Tom Ivall, M.I.E.R.E., technical editor of *Wireless World* since 1965, will become editor on the retirement of **Harold Barnard** in April.

Geoff Hammond, B.Sc., recently became applications engineer with Brookdeal Electronics Ltd, the signal recovery instrumentation manufacturers of Bracknell. His post carries the responsibilities of providing a technical back-up service for the sales engineers, dealing with customers' technical and experimental enquiries and the writing of application notes. Immediately prior to his appointment Mr Hammond was a research student at the City of London Polytechnic preparatory to writing a thesis for his Ph.D.

Ian Clinksales, who has joined GDS Sales Ltd as sales manager, has over thirteen years' experience in the semiconductor industry, both in the United Kingdom and Scandinavia. He was latterly with Motorola Semiconductors Ltd where he held the position of industrial sales manager. From 1962 to 1971 he was with SGS-Fairchild, having previously been with Texas Instruments.

Alan Smith has been appointed sales manager of Best Electronics (Slough) Ltd, the recently launched subsidiary of GDS Sales Ltd. He has been with GDS since 1969.

Tom E. Zombory-Moldovan, M.Sc., F.I.E.E., has become technical director of GEC-Elliott Industrial Controls Ltd. Mr Zombory-Moldovan, a British citizen aged 45, was educated in Hungary and served an engineering apprenticeship with Standard Telephone Company in Budapest. After leaving Hungary in 1956 he joined the staff of Manchester University and was awarded his M.Sc. degree in 1960. This was followed by five years as head of advanced electronics in the Power Protection and Meter Department of Associated Electrical Industries Ltd (now part of the GEC organization). Immediately prior to his new appointment Mr Zombory-Moldovan was technical manager of the Plessey Numerical Control Co. Ltd.

On the retirement of **R. A. H. Penney,** the Marconi International Marine Co. has appointed **K. Pope** as London manager (sales). Mr Penney was a seagoing radio officer from 1927, when he joined the company, until 1945 when he was transferred to the shore technical staff. His shore appointments include contracts representative based on Newcastle, manager, northern area (contracts division), and London sales manager since 1968. Mr Pope, the new London manager (sales), joined the seagoing staff of Marconi Marine as a radio officer at the end of the war. Since 1962 he has been joint manager of the London Office.

Marconi International Marine Co. have also announced the appointment of **David Bowker** as its representative in North America. He succeeds **John Older** who has returned to the United Kingdom. Mr Bowker began his career with Marconi Marine as a seagoing radio officer in 1960. He served at sea until 1964 when he transferred to the company's shore staff as a technical sales assistant in the export sales division. He served from 1969 to 1971 as the company's U.S.A. representative and has recently been marine director of the Norsk Marconikompani.

January Meetings

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

LONDON

3rd. I.Phys. — One-day meeting on "On-line computers for laboratory experiments" at 9.45 at Imperial College, SW7.

4th. IEE — Kelvin lecture "Conduction in amorphous materials — theory and applications" by Prof. Sir Nevill Mott at 17.30 at Savoy Pl., WC2.

9th AES — "Monitoring in multi-track recording" by R. W. Swettenham at 19.15 at the IEE, Savoy Pl., WC2.

10th. IEE/IERE — Colloquium on "Microcomputers and electronic calculating aids" at 14.30 at the IERE, 9 Bedford Sq., WC1.

10th. IEE — Discussion on "Active antennas and steerable arrays for communications" at 17.30 at Savoy Pl., WC2.

15th. IEE — "Cold cathode electron emission" by R. Brander at 17.30 at Savoy Pl., WC2.

17th. R. I. Navigation — "Situation display: marine radar" by P. O. Prior at 17.00 at Royal Inst. of Naval Architects, 10 Upper Belgrave St., SW1.

17th. IEE — "Traffic control and surveillance on motorways" by K. W. Huddart and J. T. Duff at 17.30 at Savoy Pl., WC2.

17th. IEE — "Solid-state displays devices" by Dr. C. Hilsum at 17.30 at Savoy Pl., WC2.

18th. IEE — "The relationship between research, development and marketing" by I. Barron at 17.30 at Savoy Pl., WC2.

18th. RTS — Panel discussion on "Why digital?" at 19.00 at I.B.A., 70 Brompton Rd., SW3.

23rd. SERT — "The introduction of flight data recording systems" at 19.00 at the IBA Conference Room, 70 Brompton Rd., SW3.

24th. R. I. Navigation — Discussion on "The use of Omega for air and sea navigation" at 15.00 at Royal Aeronautical Soc., 4 Hamilton Pl., W1.

24th. IERE — "Media: A continuous digital process control system" by J. R. Halsall and I. J. Kirby at 18.00 at the IERE, 9 Bedford Sq., WC1.

25th. IEE — Colloquium on "The properties of evaporated semiconductor films" at 10.00 at Savoy Pl., WC2.

30th. IERE — Colloquium on "Fixed and variable resistors" at 10.00 at Harkness Hall, Birkbeck College, Malet St., WC1.

AYLESBURY

11th. IEE/RAeS — "The Skynet satellite communication system" by Air Commodore F. C. Padfield at 19.30 at Kermode Hall, R.A.F., Halton.

BATH

17th. IERE — "Medical electronics" by K. Riley at 19.00 at Bath University, Room 2E.3.1.

BELFAST

16th. IERE — "Practical aspects of air traffic control" by W. J. Eames at 19.00 at Cregagh Technical College, Montgomery Rd.

BIRMINGHAM

8th. IEE — "50 years of B.B.C. engineering" by J. Redmond at 18.00 at the MEB Offices, Summer Lane.

10th. RTS — "The development of u.h.f. television" by L. G. Dive at 19.00 at B.B.C. Broadcasting Centre, Pebble Mill Rd.

24th. IERE — "Some recent developments in v.h.f. mobile radio by J. D. Parsons at 19.15 at City of Birmingham Polytechnic, North Centre, Franchise St., Perry Bar.

BRADFORD

11th. IERE — "The 8500 colour television receiver concept" by A. Martinez at 19.00 at the Technical College.

BRIGHTON

30th. IEE Grads. — "The engineer in Parliament hy A. Palmer at 19.30 the University of Sussex, Falmer.

CAMBRIDGE

11th. IEE — "Electronic aids to night vision" by Dr. P. Schagen at 18.30 at the University Engineering Department, Trumpington Street.

25th. IERE/IEE — "Vocoder techniques" at 18.30 at the University Engineering Laboratories, Trumpington St.

25th. IEE/IERE — "Future advances in h.f. communications systems" by M. H. Gross at 18.30 at The University Engineering Laboratories, Trumpington St.

CARDIFF

10th. IERE — "Man-computer interface for process control" by K. E. Morgan at 18.30 at U.W.I.S.T.

CHATHAM

31st. IERE — "High-fidelity sound reproduction" by R. West at 19.00 at the Medway College of Technology.

CHELMSFORD

17th. IEE/IERE — "Beam indexing colour television systems" by Dr. J. A. Turner at 18.30 at King Edward VI Grammar School, Broomfield Rd.

GUILDFORD

24th. IERE — "Review of solid-state microwave devices" by J. G. Summers at 18.30 at University of Surrey.

KINGSTON UPON THAMES

16th. IEE Grads. — "Making electronic music" by G. Rodgers at 18.30 at Kingston Polytechnic, Penrhyn Rd.

LEICESTER

17th. IERE — "Application of integrated circuits" by A. Potton at 18.45 at the Lecture Theatre "A", Physics Block, Leicester University.

LETCHWORTH

16th. IEE — "The Open University and technological education" by Dr. D. I. Crecroft at 19.45 at the College of Technology.

LIVERPOOL

22nd. IEE — "Computer-aided design of integrated circuits" by A. Cranswick at 18.30 at the Lecture Theatre, Dept. of Electrical Engineering, University of Liverpool.

MALVERN

8th. IEE — "Tomorrow's world in telecommunications" by W. J. Bray at 19.30 at the Abbey Hotel.

17th. IERE — "Electronics education and the Open University" by J. A. Myers at 19.30 at Abbey Hotel.

MANCHESTER

18th. IERE — "Electronic control of small a.c. motors" by P. Bowler at 18.15 at Renold Building, UMIST.

22nd. IEE — Faraday lecture "Navigating — land, sea, air and space" by A. Stratton at 19.30 at the Free Trade Hall.

23rd. IEE — Faraday lecture "Navigating — land, sea, air and space" by A. Stratton at 14.30 and 18.30 at the Free Trade Hall.

NEWCASTLE-UPON-TYNE

10th. IERE — "Recent developments in nucleonics and scanning systems as applied to medicine" by J. W. Haggith at 18.00 at Ellison Building, the University.

NEWPORT, Mon.

17th. IEETE — "Electronics in the modern car" by C. S. Rayner at 19.30 at Newport & Monmouthshire College of Technology, Allt-yr-yn Avenue.

PORTSMOUTH

30th. IEE Grads — "Angels, birds and radar" by Dr. E. Eastwood at 19.00 at Portsmouth Polytechnic.

READING

18th. IERE — "Visual telecommunications systems — a reiview of some technical problems" by I. Macdiarmid at 19.30 at the J. J. Thomson Laboratory, University of Reading, Whiteknights Park.

SOUTHAMPTON

17th. IEETE — "Hi-Fi" by R. West at 19.30 at the Polygon Hotel, Cumberland Pl.

31st. IERE — Colloquium on "Electrons in cars" at 16.00 at the University.

STAFFORD

23rd. IEE — "Military applications of electronics" by D. Cawsey and T. K. Garland-Collins at 19.00 at N. Staffs Polytechnic, Beaconside.

Sunderland

18th. IEETE — "Computers — techniques and applications" by R. A. Selby, B. Meech and M. Todd at 19.30 at Priestman Building, Sunderland Polytechnic, New Durham Rd.

TAUNTON

17th. IEE — "Micro-electronic logic circuits" by Dr. A. T. Johns at 19.45 at the County Hotel.

WORTHING

16th. IEE — "Electronic performance testing of motor vehicles" by C. D. Freeman at 18.30 at Worthing College of Further Education.

Literature Received

For further information on any item include the WW number on the reader reply card

ACTIVE DEVICES

A new range of Passivated, Assembled, Circuit Elements (PACE-packs) manufactured by International Rectifier, Hurst Green, Oxted, Surrey, is described in leaflet E2716. The modules described, utilize passivated diode and thyristor junctions in various configurations to form isolated power controllers rated for 250V r.m.s. at 25 and 42.5 amperes WW401

A 12-page technical booklet describing a complete range of encapsulated, thick film, voltage regulators and over-protection units is available from Coutant Electronics Ltd, 3 Trafford Road, Richfield Estate, Reading, Berks WW402

Data sheets on the Q400A and Q400B series of photo-conductive cells having spectral responses of 570nm and 690nm, respectively, are:

Sheet 3290 (Q400A) WW403
Sheet 3291(Q400B) WW404

Joseph Lucas (Electrical) Ltd, Electronic Products Group, Mere Green Road, Sutton Coldfield, Warwickshire.

"Thyristors and Diode Stacks" is the subject of a 28-page brochure which provides information on aluminium fabricated cooling-fins and semiconductors covering the range 10-700 amperes. AEI Semiconductors Ltd, Carholme Road, Lincoln LN1 1SG WW405

Modular, universal active filter elements is the subject of a brochure containing nomographs and filter response curves for the design of bandpass, highpass and lowpass responses, maximally flat and elliptical function forms. Kinetic Technology Inc., 3393 De La Cruz Boulevard, Santa Clara, California 95050 ....WW406

A catalogue of electronic components entitled "Sensors" providing electrical data on optoelectronic devices and temperature and magnetically sensitive resistors has been received from Siemens Ltd, Great West House, Great West Road, Brentford, Middlesex, TW8 9DG WW407

"Buyers Guide to Integrated Circuits" lists the type numbers and nearest equivalents of m.o.s., linear and digital integrated circuits from Texas Instruments, Signetics, General Instrument Microelectronics and Plessey stocked by S.D.S. Components Ltd, Gunstore Road, Hilsea Trading Estate, Portsmouth, Hants. PO3 5JW WW408

PASSIVE DEVICES

Data about Elcor Isoformers, which are isolation transformers intended for use in low-noise and medical electronics where maximum interference and leakage protection is required, is available from Aveley Electronics Ltd, Roebuck Road, Chessington, Surrey KT9 1LP WW409

Five technical bulletins describing models TP-101, 102, 103, 104 and 105 wide band (0.5-1500MHz), fast rise-time (0.18ns), low-loss (0.4dB) r.f./pulse transformers in flat-pack form, were received from Anzac Electronics, 39 Green Street, Waltham, Massachusetts 02154 ....WW410

A leaflet contains a full specification and description of a new type of miniature, p.t.f.e. covered, probe and socket from Sealectro Ltd, Walton Road, Farlington, Portsmouth, Hants. PO6 1TB ..WW411

A short-form catalogue describing precision coaxial and waveguide components covering the range d.c. to 18GHz manufactured by Maury Microwave Corporation was sent to us by Tony Chapman Electronics Ltd., 3 Cecil Court, London Road, Enfield, Middlesex WW412

New miniature servo-controlled a.c. voltage stabilizers for laboratory or industrial application providing distortionless control at power ratings between 180VA and 720VA, are described in a leaflet from Claud Lyons Ltd, Valley Works, Hoddesdon, Herts WW413

Data on types "VK", ceramic capacitors (1pF to 1 F), "VY", porcelain capacitors (0.24pF to 10nF), "Vee Jem", chip capacitors (1pF to 470nF) and a new low-cost Phenolic dipped range, is available in a condensed catalogue from Vitramon Europe, Wooburn Green, Bucks WW414

Type 3W1, precision decade capacitor having direct in-line readout over the range 0.001 to 1.099 F, with an accuracy of $\pm 0.5\%$ in 0.001 F steps, is the subject of engineering bulletin 90,606 from Sprague Electric Company, North Adams, Massachusetts 01247 ....WW415

APPLICATION NOTES

Two application notes received concerning power transistors discuss:

The basic performance characteristics and specific circuit design detail related to the application of transistors 2N6104/2N6105 in broadband u.h.f. power amplifiers. AN6010 .... WW416

A testing programme used to determine the capability of the 2N3055 power transistor design to withstand thermal cycling over a wide range of operating conditions. AN4783 ....WW417

RCA/Solid State Europe, Sunbury-on-Thames, Middlesex.

An application report on Motorola's new emitter-coupled logic family, MECL 10,000 series, which features non-saturated switching functions for very high-speed operation with load driving capability, has been produced by GDS (Sales) Ltd., Michaelmas House, Salt Hill, Bath Road, Slough, Bucks WW418

"1N821 and B2X90 series of high-stability reference diodes" is the title of application note TP1339 which compares the performance of standard-cell reference sources against that of semiconductor diodes. Formulae are given for the calculation of stabilization factor and curves show the performance of a number of circuits described. Instrument and Control Electronics Division, Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD WW419

EQUIPMENT

A remotely controlled, digitally tuned, microwave-receiving system (model 3600) covering 0.5 to 18GHz and developed by American Electronics Laboratories Inc., is described in a brochure from C.T. (London) Electronics Ltd., Sutherland House, Sutherland Road, Walthamstow, London E17 6BU WW420

A brochure summarizing, the characteristics of autobalanced component measuring bridges with diagrams explaining the principles for both manual and automatic operation, was received. It provides brief specifications of the five different types of bridge manufactured by Wayne Kerr Company Ltd, Durban Road, Bognor Regis, Sussex PO22 9RL WW421

A loose-leaf binder received, contains numerous information sheets dealing with "Data and Telegraph Equipment". It covers signal test equipment, message generators, code converters/regenerators, receiver/demodulators, tonekeyers and selectors, tape readers and message storage equipment. Plessey Company Ltd, Sopers Lane, Poole, Dorset BH17 7ER WW422

Leaflets describing trip amplifiers, with input sensitivities ranging from 10mV to 300V and 10 A to 1A intended for industrial control systems also, low-cost miniature power supplies with output voltages in the range 4V to 24V d.c. are:

ICD2 (amplifiers) WW423
PS8 (power supplies) WW424

Farnell Instruments Ltd., Sandbeck Way, Wetherby, Yorks LS22 4DH.

COMMUNICATIONS

A booklet, containing technical descriptions and specifications of the various v.h.f. and u.h.f. transmitter-receivers available for mobile radiotelephone service, is entitled "Over 70 years of mobile radio" and is available from Marconi Communications Systems Ltd, Marrable House, Great Baddow, Chelmsford, CM2 7QW WW425

Information sheets about the various aspects of business radio including features such as telephone answering and personal paging services, are available in a wallet form from Air Call Ltd, 176/184 Vauxhall Bridge Road, London S.W.1 ....WW426

GENERAL INFORMATION

A complete list of production tools to metric standards (mm) suitable for the manufacture of solder washers, discs and rings, has been received from Enthoven Solders Ltd, Dominion Buildings, South Place, London EC2M 2RE WW427

Automation system architure and its involvement in the electronics/automation industry is the subject of a booklet from Warren Point Ltd., Prospect Place, Welwyn, Herts. WW428

Tefzel insulated wire, said to have excellent mechanical and high temperature properties combined with high chemical resistance and light weight, is specified in a data sheet from Permoid Ltd., Manchester M4 7JX WW429

A catalogue dealing with all the necessary component parts needed by the enthusiast for a build-it-yourself electronic organ, was received from Elvins Electronic Musical Instruments, 8 Putney Bridge Road, London S.W.18 ....WW430

The 500-page 1973 catalogue and price list including diodes, thyristors, transistors, i.cs, resistors, relays, switches, potentiometers, r.f. connectors and accessories, is available from G.D.S. (Sales) Ltd., Michaelmas House, Salt Hill, Bath Road, Slough Bucks WW431

Nearly 8000 components and accessories are listed in a 240-page catalogue and price list from Home Radio (Components) Ltd, 234-240 London Road, Mitcham, Surrey CR4 3HD. Price 50p plus 20p postage.

Gardners line up

Line Matching Transformers from Standard to Super Fidelity

It's easy to choose the right Line Matching Transformer from the five Gardners ranges.

The Super Fidelity Series, with a frequency response of 10Hz to 80kHz – 0·5dB, gives the widest possible bandwidth for high accuracy instrumentation and recording applications.

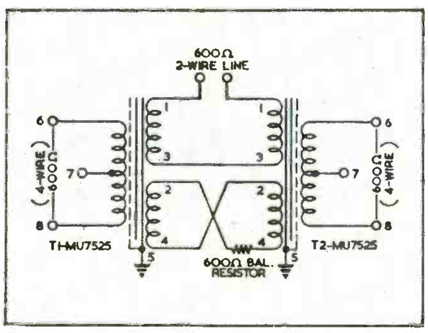
Then there's the Wide and Extra Wide-band ranges. Outstanding performers with a frequency range 30Hz – 20kHz or more – for the 0·5dB points. Used a lot by broadcasting and recording companies throughout the world.

The Miniature and Standard ranges provide excellent bandwidth for most purposes, 30Hz – 22kHz for the 1·0dB points.

Except for the very smallest in the range, all Gardners Line Matching Transformers are fully magnetically shielded, giving very high hum rejection ratios.

Prices start from £2·61 (recommended retail price) and all types are usually available from stock.

Complete technical information is given in brochure GT.5 'Audio Frequency Transformers' which we'll be glad to send on request.



So accurate is the balancing of the windings on some of these transformers that, when used as pairs in a hybrid circuit (as illustrated) we can guarantee a rejection of better than —55dB over the frequency range 50Hz to 10kHz and normal rejection of up to —75dB may be expected.

Gardners

Specialists in Electronic Transformers

GARDNERS

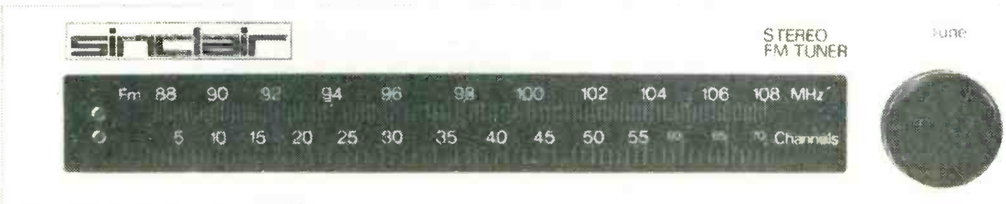
TRANSFORMERS LIMITED

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

WW—083 FOR FURTHER DETAILS

Sinclair Project 60

Project 60 Stereo FM Tuner



Built and tested.
Post free.
£25

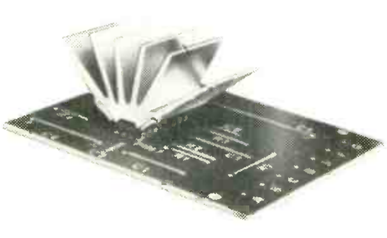
with phase lock-loop principle

Amongst the many advanced electronic features to be found in this remarkable stereo tuner, use of the phase lock loop principle ensures standards of audio quality better than from any other method of detection yet used. Varicap diode tuning, accurately formed printed circuit coils, an I.C. in the special stereo decoder section and switchable squelch circuit for silent tuning between stations contribute to the unsurpassed performance of this tuner, irrespective of price consideration. But the Project 60 FM Stereo Tuner is far from expensive – indeed, it offers fantastic value for money and will bring the thrill of stereo radio to many who previously may not have been able to afford it. The tuner may be used with any good system as well as Project 60, but if you use it with other Project 60 modules, you will find the matching front panels particularly impressive in appearance as well as function.

SPECIFICIATIONS

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 × 150mV R.M.S. max. (typically 2 × 50mV. stereo)
Operating voltage: 25–30V DC at 100mA.
Indicators: Stereo on : tuning.
Size: 93 × 40 × 207mm.

Super IC.12 Integrated circuit high fidelity amplifier



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

SPECIFICATIONS

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

Manual available separately 15p post free.

With FREE printed circuit board and 40 page manual.
£2.98 Post free

Project 605

The easy way to buy and build Project 60

Project 605 is one pack containing one PZ5, two Z30's, one Stereo 60 and one Masterlink. This new module contains all the input sockets and output components needed together with all necessary leads cut to length and fitted with neat little clips to plug straight on to the modules. Thus all soldering and hunting for the odd part is eliminated. You will be able to add further Project 60 modules as they become available adapted to the Project 605 method of connecting.

Complete Project 605 pack with comprehensive manual, post free **£29.95**

Everything you need to assemble a superb 30 watt high fidelity stereo amplifier without having to solder.

sinclair

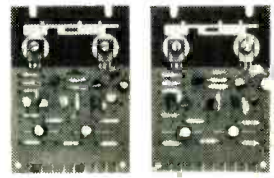
Sinclair Radionics Ltd, London Road, St. Ives, Huntingdonshire PE17 4HJ. Tel: St. Ives 64311

the world's most advanced high fidelity modules

Z.30 & Z.50 power amplifiers

Built, tested and guaranteed with circuits and instructions manual. **Z.30 £4.48** **Z.50 £5.48**

The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to provide unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at 15w (8Ω) and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and are intended for use principally with other units in the Project 60 range. Their performance and design are such, however, that Z.50s and Z.30 may be used in a far wider range of applications.

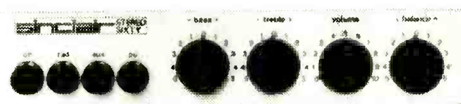


SPECIFICATIONS *(Z.50 units are interchangeable with Z.30s in all applications).*— Power Outputs: **Z.30** 15 watts R.M.S. into 8 ohms using 35 volts: 20 watts R.M.S. into 3 ohms using 30 volts. **Z.50** 40 watts R.M.S. into 3 ohms using 40 volts. 30 watts R.M.S. into 8 ohms using 50 volts. **Frequency response:** 30 to 300,000Hz ± 1dB. **Distortion:** 0.02% into 8 ohms. **Signal to noise ratio:** better than 70dB unweighted. **Input sensitivity:** 250mV into 100 Kohms (for 15w into 8Ω). For speakers from 3 to 15 ohms impedance. **Size:** 14 x 80 x 57mm.

Stereo 60 Pre-amp/control unit

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

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.

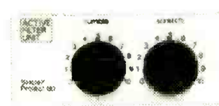


SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV. correct to R.I.A.A. curve ± 1dB 20 to 25,000 Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE + 12 to —12dB at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

A.F.U. High & Low Pass Filter Unit

Built, tested and guaranteed. **£5.98**

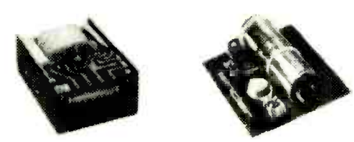
For use between Stereo 60 unit and two Z.30s or Z.50s. The unit is very easily mounted and is unique in that the cut-off frequencies are continuously variable. As attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. There are two filter sections – rumble (high pass) and scratch (low pass). H.F. cut-off (—3dB) variable from 28KHz to 5KHz. L.F. cut-off (—3dB) variable from 25Hz to 100Hz. Distortion at 1KHz (35V. supply) 0.02% at rated output. Operating voltage from 15 to 35V. Current 3mA. **Size:** 66 x 40 x 90mm.



Power Supply Units

Designed specifically for use with the Project 60 system of your choice. Use PZ.5 for normal Z.30 assemblies and PZ.6 or PZ.8 where a stabilised supply is essential.

PZ.5 *30 volts unstabilised* **£4.98**
PZ.6 *35 volts stabilised* **£7.98**
PZ.8 *45 volts stabilised (less mains transformer)* **£7.98**
PZ.8 *mains transformer* **£5.98**



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.

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100-0-100µA	£3·70
500µA	£3·50
1mA	£3·40
20V. D.C.	£3·40
50V. D.C.	£3·40
300V. D.C.	£3·40
1 amp. D.C.	£3·40
5 amp. D.C.	£3·40
300V. A.C.	£3·40
VU Meter	£4·15

Type SD.830 82·5mm × 110mm Fronts

50µA	£2·75	10mA	£2·50
50-0-50µA	£2·70	50mA	£2·50
100µA	£2·70	100mA	£2·50
100-0-100µA	£2·70	500mA	£2·50
200µA	£2·70	1 amp	£2·50
500µA	£2·55	5 amp	£2·50
1mA	£2·50	10 amp.	£2·50
5mA	£2·50	5V. D.C.	£2·50
		10V. D.C.	£2·50
		20V. D.C.	£2·50
		50V. D.C.	£2·50
		300V. D.C.	£2·50
		15V. A.C.	£2·75
		300V. A.C.	£2·75
		VU Meter	£3·00

Type SD.640 63·5mm × 85mm Fronts

50µA	£2·60	500mA	£2·35
50-0-50µA	£2·55	1 amp.	£2·35
100µA	£2·55	5 amp.	£2·35
100-0-100µA	£2·55	10 amp.	£2·35
200µA	£2·55	5V. D.C.	£2·35
500µA	£2·35	20V. D.C.	£2·35
1mA	£2·35	50V. D.C.	£2·35
5mA	£2·35	300V. D.C.	£2·35
10mA	£2·35	15V. A.C.	£2·40
50mA	£2·35	300V. A.C.	£2·40
100mA	£2·35	VU Meter	£2·70

Type SD.460 46mm × 59.5mm Fronts

50µA	£2·40	500mA	£2·15
50-0-50µA	£2·35	1 amp.	£2·15
100µA	£2·35	5 amp.	£2·15
100-0-100µA	£2·35	10 amp.	£2·15
200µA	£2·35	5V. D.C.	£2·15
500µA	£2·20	10V. D.C.	£2·15
1mA	£2·15	20V. D.C.	£2·15
5mA	£2·15	50V. D.C.	£2·15
10mA	£2·15	300V. D.C.	£2·15
50mA	£2·15	15V. A.C.	£2·30
100mA	£2·15	300V. A.C.	£2·30
		VU Meter	£2·55

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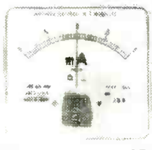
Type MR.85P. 4¼in. × 4⅞in. fronts.



50µA	£3·95	10mA	£3·10
50-0-50µA	£3·40	50mA	£3·10
100µA	£3·40	100mA	£3·10
100-0-100µA	£3·30	500mA	£3·10
200µA	£3·30	1 amp.	£3·10
500µA	£3·20	5 amp.	£3·10
500-0-500µA	£3·10	15 amp.	£3·10
1mA	£3·10	30 amp.	£3·20
1-0-1mA	£3·10	20V. D.C.	£3·10
5mA	£3·10	50V. D.C.	£3·10
		150V. D.C.	£3·10
		300V. D.C.	£3·10
		15V. A.C.	£3·10
		300V. A.C.	£3·10
		8 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.

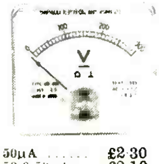
50µA	£3·40	10V. D.C.	£2·20
50-0-50µA	£2·85	20V. D.C.	£2·20
100µA	£2·85	50V. D.C.	£2·20
100-0-100µA	£2·75	300V. D.C.	£2·20
500µA	£2·55	15V. A.C.	£2·30
1mA	£2·20	300V. A.C.	£2·30
5mA	£2·20	8 Meter 1mA	£2·30
10mA	£2·20	VU Meter	£3·50
50mA	£2·20	1 amp. A.C.*	£2·20
100mA	£2·20	5 amp. A.C.*	£2·20
500mA	£2·20	10 amp. A.C.*	£2·20
1 amp.	£2·20	20 amp. A.C.*	£2·20
5 amp.	£2·20	30 amp. A.C.*	£2·20

Type MR.65P. 3¼in. × 3¼in. fronts

50µA	£3·70	10V. D.C.	£2·40
50-0-50µA	£3·00	20V. D.C.	£2·40
100µA	£3·00	50V. D.C.	£2·40
100-0-100µA	£2·90	150V. D.C.	£2·40
200µA	£2·90	300V. D.C.	£2·40
500µA	£2·65	15V. A.C.	£2·55
500-0-500µA	£2·40	50V. A.C.	£2·55
1mA	£2·40	150V. A.C.	£2·55
5mA	£2·40	300V. A.C.	£2·55
10mA	£2·40	500V. A.C.	£2·55
50mA	£2·40	8 Meter 1mA	£2·60
100mA	£2·40	VU Meter	£3·70
500mA	£2·40	50mA A.C.*	£2·40
1 amp.	£2·40	100mA A.C.*	£2·40
5 amp.	£2·40	200mA A.C.*	£2·40
10 amp	£2·40	500mA A.C.*	£2·40
15 amp.	£2·40	1 amp. A.C.*	£2·40
20 amp.	£2·40	5 amp. A.C.*	£2·40
30 amp.	£2·55	10 amp. A.C.*	£2·40
50 amp.	£2·75	20 amp. A.C.*	£2·40
5V. D.C.	£2·40	30 amp. A.C.*	£2·40

Send for illustrated brochure on SEW Panel Meters. Discounts for quantities.

Type MR.38P. 1 21/32in. square fronts.



50µA	£2·30	150mA	£1·75
50-0-50µA	£2·10	200mA	£1·75
100µA	£2·10	300mA	£1·75
100-0-100µA	£1·95	500mA	£1·75
200µA	£1·95	750mA	£1·75
500µA	£1·80	1 amp.	£1·75
500-0-500µA	£1·75	2 amp.	£1·75
1mA	£1·75	5 amp.	£1·75
1-0-1mA	£1·75	10 amp.	£1·75
2mA	£1·75	3V. D.C.	£1·75
5mA	£1·75	10V. D.C.	£1·75
10mA	£1·75	15V. D.C.	£1·75
20mA	£1·75	20V. D.C.	£1·75
50mA	£1·75	50V. D.C.	£1·75
100mA	£1·75	100V. D.C.	£1·75
		150V. D.C.	£1·75
		300V. D.C.	£1·75
		500V. D.C.	£1·75
		750V. D.C.	£1·75
		15V. A.C.	£1·85
		50V. D.C.	£1·85
		150V. A.C.	£1·85
		300V. A.C.	£1·85
		500V. A.C.	£1·85
		8 Meter 1mA	£1·85
		VU Meter	£2·30

Type MR.45P. 2in. square fronts.

50µA	£2·50	5 amp.	£1·85
50-0-50µA	£2·30	10V. D.C.	£1·85
100µA	£2·30	20V. D.C.	£1·85
100-0-100µA	£2·05	50V. D.C.	£1·85
200µA	£2·05	300V. D.C.	£1·85
500µA	£1·95	15V. D.C.	£2·00
500-0-500µA	£1·85	300V. D.C.	£2·00
1mA	£1·85	8 Meter 1mA	£2·05
5mA	£1·85	VU Meter	£2·50
10mA	£1·85	1 amp. A.C.*	£1·85
50mA	£1·85	5 amp. A.C.*	£1·85
100mA	£1·85	10 amp. A.C.*	£1·85
500mA	£1·85	20 amp. A.C.*	£1·85
1 amp.	£1·85	30 amp. A.C.*	£1·85

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100µA	£3·30	300V. A.C.	£2·70
100-0-100µA	£3·20	VU Meter	£3·75
200µA	£3·20		

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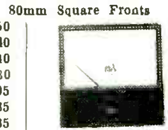
Type MR.65. 3½in. square fronts.

25µA	£3·85	1 amp.	£2·15
50µA	£3·00	5 amp.	£2·15
50-0-50µA	£2·60	15 amp.	£2·15
100µA	£2·60	30 amp.	£2·15
100-0-100µA	£2·50	50 amp.	£2·15
500µA	£2·45	5V. D.C.	£2·15
500-0-500µA	£2·15	10V. D.C.	£2·15
1mA	£2·15	20V. D.C.	£2·15
1-0-1mA	£2·15	50V. D.C.	£2·15
5mA	£2·15	150V. D.C.	£2·15
10mA	£2·15	300V. D.C.	£2·15
50mA	£2·15	30V. A.C.*	£2·20
100mA	£2·15	50V. A.C.*	£2·20
500mA	£2·15	150V. A.C.*	£2·20
		300V. A.C.*	£2·20
		500mA A.C.*	£2·15
		1 amp. A.C.*	£2·15
		5 amp. A.C.*	£2·15
		10 amp. A.C.*	£2·15
		20 amp. A.C.*	£2·15
		30 amp. A.C.*	£2·15
		50 amp. A.C.*	£2·15
		VU Meter	£3·40
		50 mV D.C.	£2·40
		100mV D.C.	£2·40

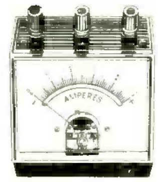
Type S.80 80mm Square Fronts



50µA	£3·50	5 amp. D.C.	£2·85
50-0-50µA	£3·40	300V. A.C.	£2·85
100µA	£3·40	VU Meter	£3·70
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		

SEW EDUCATIONAL METERS

Type ED.107



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1-0-1mA	£4·85	Dual range	
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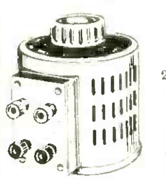

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40 Amp	£82·50

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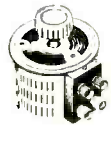
2.5 Amp	£8·05



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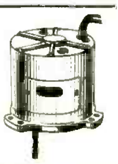

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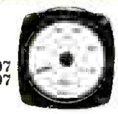

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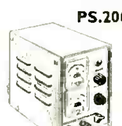

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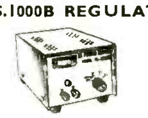

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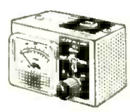

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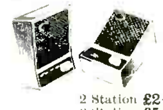

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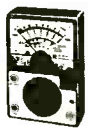

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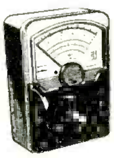

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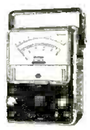
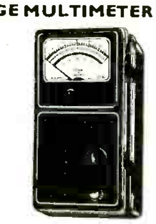
HIOKI MODEL 750X
50,000 o.p.v. 43 ranges 0-0.3 to 1,200v. D.C. 0-3 to 1,200 v. A.C. 0-30μA/300mA. 0-3K/30 meg. ohms. —10 to +17 db. **£78·97.** Post 20p.



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.

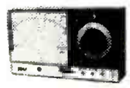
RUSSIAN 22 RANGE MULTIMETER



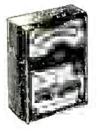
Model U437 10,000 o.p.v. A first class versatile instrument manufactured in U.S.S.R. to the highest standards. Ranges: 2·5/10/50/250/500/1000v D.C. 2·5/10/50/250/500/1000v A.C. D.C. Current 100 wA/1/10/100 mA/1A. Resistance 300 ohms/3/30/300K/3MΩ. Complete with batteries, test leads, instructions and 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.



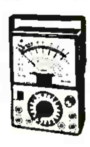
MODEL TH-12
20,000 o.p.v. Overload protection. Slide switch selector.
0/·25/2·5/10/50/250/1000V. D.C.
0/10/50/250/1000V. A.C.
0/50μA/25/250mA D.C.
0/3K/30K/300K/3 meg. —20 to +50db.
£4·97. Post 15p.

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.

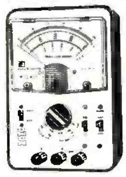


HIOKI MODEL 700X
100,000 O.P.V. Overload protection. Mirror scale. ·3/·6/1·2/1·5/3/6/12/30/60/120/300/600/1200 VDC. 1·5/3/6/12/30/60/150/300/600/1200 VAC. 15/30vA/3/6/30/60/150/300 mA. 6/12 AMP DC. 2K/200 K/2 Meg/20 megohm. —20 to +63db. **£13·50.** Post 20p.

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.

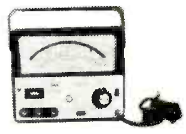
U4312 MULTIMETER
Extremely sturdy instrument for general electrical use. 667 o.p.v. 0/·3/1·5/7·5/30/60/150/300/600/900 VDC and 75mV. 0/·3/1·5/7·5/30/60/150/300/600/900 VAC. 0/300μA/1·5/6/15/60/150 600MA/1·5/6 AMP. D.C. 0/1·5/6/15/60/150/600MA/1·5/6 AMP. A.C. 0/200 Ω/3K/30K Ω. Accuracy DC 1%. AC 1·5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions. **£9·50.** Post 25p.

Selected TEST EQUIPMENT



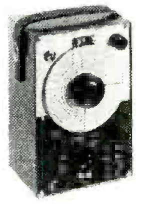
FTC-401 TRANSISTOR TESTER
Full capabilities for measuring A. B and ICO. NPN or PNP. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads.
£7·50. Post 20p.

Model S-100TR MULTI-METER/TRANSISTOR TESTER 100,000 o.p.v. MIRROR SCALE/OVER-LOAD PROTECTION
0/·12—·6/3/12/30/120/600 V DC.
0/6/30/120/600 V. AC.
0/12/600μA/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.

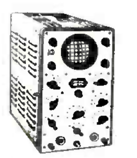
RF-300 AF/RF SIGNAL GENERATOR



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.

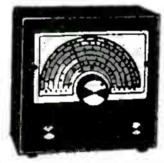


CI-5 PULSE OSCILLOSCOPE
For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth 10MHz. Sensitivity at 100KHz VRMS/mm. .1–25; HOR. AMP. Bandwidth 500KHz. Sensitivity at 100KHz. V RMS/mm. .3–25; Preset triggered sweep 1–3,000μsec.; free running 20–200,000Hz in nine ranges. Calibrator pips. 220 × 360 × 430mm. 115-230V. A.C. operation. **£39·00.** Carr. paid.

TO-3 PORTABLE OSCILLOSCOPE, 3" TUBE

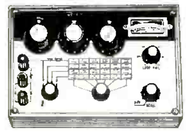
Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps —1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 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 × 3½in. Complete with instructions and leads. **£7·97.** Post 25p.

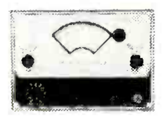
TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.



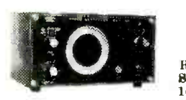
A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1μH—111 HENRIES. 6 Ranges — 2%. C. 10PF ± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100μA. Meter indication. 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.

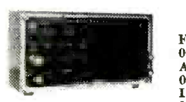
BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR
Sine 18-200,000 Hz; Square 18-50,000 Hz



Output max. + 10 dB (10 K ohms). Operation internal batteries. Attractive 2-tone case 7½in. × 5in. × 2in.
Price **£17·50**
Carr. 17p.

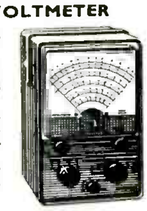


MODEL MG-100 SINE SQUARE WAVE AUDIO GENERATOR
Range: 19-220,000 Hz Sine Wave 19-100,000 Hz Square Wave. Output Sine or Square wave 10v. P. to P. Size 180 × 90 × 90mm. Operation 220/240v A. C.
£17·50. Post 37p.



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.
Additional Probes available: R.F. **£2·12** H.V. **£2·50.**

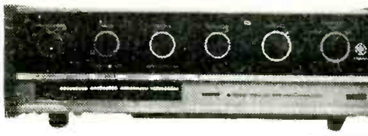
MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER
Sensitivity 330 ohms/Volt A.C. and D.C. Accuracy ·5% D.C. 1% A.C. Scale length 165mm.
0/300/750μA/1·5/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 AMP. D.C.
0/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 AMP. A.C.
0/75/150/300/750mV/1·5/3/7·5/15/30/75/150/300/750V. 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



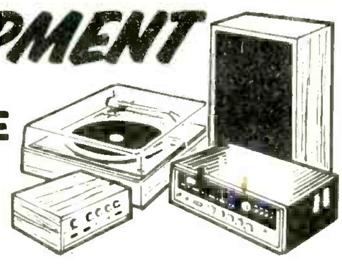
17 + 17 watts rms stereo amplifier with inputs for Magnetic and Crystal phono, Tuner, Tape, Aux. and Tape Monitor. Outputs for two pairs of stereo speakers and Tape. Stereo headphone socket. Full range of controls including loudness control, scratch filter etc. Size 13in. × 9½in. × 3¾in Unrepeatable offer—limited stocks!

List price £59·50
OUR PRICE **£39·95**
Carriage 50p.

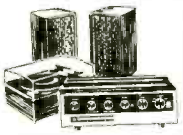
HI-FI EQUIPMENT

SAVE UP TO 33⅓% OR MORE

SEND S.A.E. FOR FULL DISCOUNT PRICE LISTS AND PACKAGE OFFERS



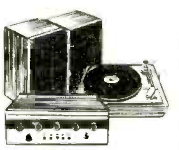
NIKKO TRM 50 SYSTEM



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

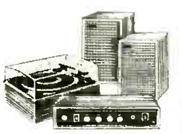
LEAK DELTA 30 SYSTEM



Leak Delta 30 stereo amplifier, Goldring GL75, plinth, cover and G800 cartridge. Pair of Leak 150 speakers and all leads.

OUR PRICE **£121·50** Carr. & Ins. £1·50

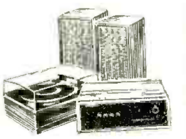
AMSTRAD 8000 II SYSTEM



Amstrad 8000 II 7 + 7 watt amplifier. BSR MP60, plinth and cover, Goldring G800 cartridge, pair of Apollo speakers and all leads.
Amplifier only, £14·50. Carr. 50p.

OUR PRICE **£48·25** Carr. £1·00

AUDIOTRONIC LA.1700 SYSTEM



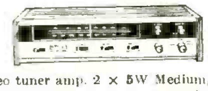
17 + 17 watt stereo amplifier. Garrard AP76 with Goldring G800 cartridge, teak veneered plinth with cover and a pair of Wharfedale Linton 2 speakers in matching teak.

OUR PRICE **£92·95** Carr. & Ins. £1·50

Matching LT1700 AM/FM Stereo Tuner £39·00 if purchased with above system.

SUPER MONEY SAVING OFFER!

TELETON R.4300L

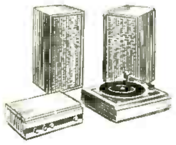


3 waveband stereo tuner amp. 2 × 5W Medium/Long/Stereo FM. Full range of controls. Input for tape or ceramic cartridge.

List over £50·00 OUR PRICE **£27·50** Post 50p

CREDIT TERMS
AVAILABLE FOR CALLERS
Access — Buy it with Access
BARCLAYCARD welcome here

WHARFEDALE LINTON SYSTEM



Wharfedale Linton Amplifier, Linton Turntable, pair of Linton 2 speakers and all leads.

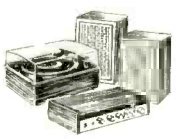
OUR PRICE **£105·00** Carr. & Ins. £1·25

TELETON CR10T/RG42 SYSTEM

Teleton 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

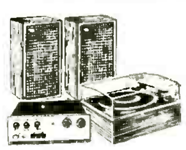


Teleton SAQ206B 8 + 8 watt amplifier. BSR MP60, plinth and cover. Goldring G800 cartridge, pair of Apollo speakers and all leads.

OUR PRICE **£55·95** 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, £50·95 extra if required.

SPECIAL PURCHASE!

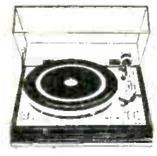
FERGUSON 3414 STEREO TUNER AMPLIFIER TURNTABLE UNIT

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 G800H 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

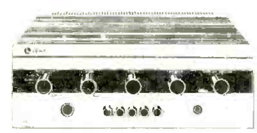
SAVE £££s

PHILIPS GA308 TRANSCRIPTION TURNTABLE



2 speeds 33⅓ and 45 r.p.m. Lighweight 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 50p.
GA308 PU with GP400 stereo magnetic cartridge (List £47·65) OUR PRICE £29·95. Post 50p.
LIMITED NUMBER ONLY!

LEAK BARGAINS



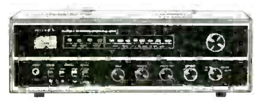
LIMITED OFFER!
ALL STOCKS BRAND NEW AND GUARANTEED

Delta 30	£45·95
Delta 70	£55·95
Delta FM	£55·95
Delta AM/FM	£67·95
Delta 75	£127·50
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.	£23·35
RA310 Amp.	£35·95
RA610 Amp.	£48·25
RX150 Receiver	£48·95
RX200 Receiver	£60·95
RX400 Receiver	£70·95

Post 50p extra any item.

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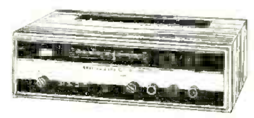

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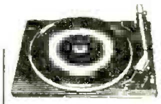

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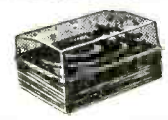

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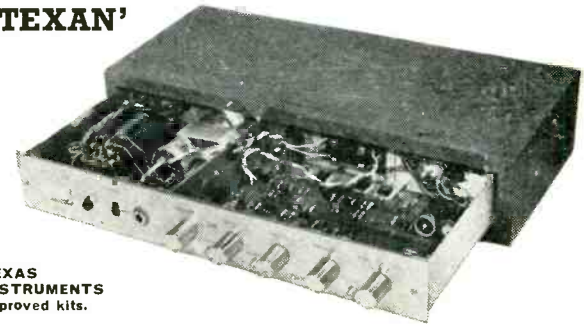

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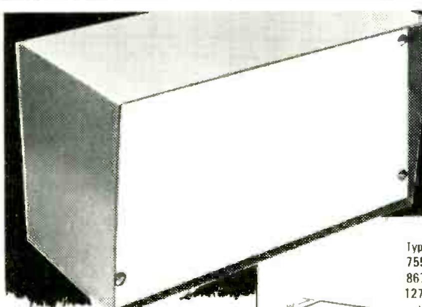

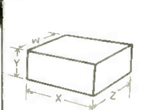

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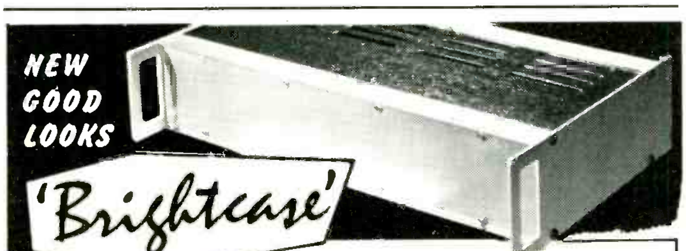

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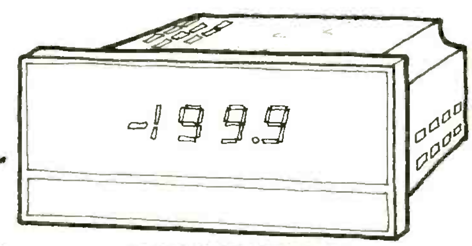

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MINIATURE GEARED MOTORS. 240V. a.c. 1 r.p.m., 1/5 r.p.m. 2in. dia. 1½in. deep. 80p + 10p p.p.

MECHANICAL FILTERS 455kHz. Type HF 445–30W. Kokusai. £5 Inc. post.

HIGH QUALITY TRIMMER CAPACITOR (beehive). Phillps Type B04-2004 5-29pF. 25p + 5p p.p.

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Hundreds of miscellaneous connectors, multipole plugs and sockets at our Surplus Warehouse.

MULTITURN TRIMPOTS. MEC, Bourne, Painton, Reliance, Amp., etc. 10, 25, 100, 250, 500, 1K, 2K, 2K5, 5K, 10K, 20K, 25Kohm. 60p + 5p p.p.

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A.M. RECEIVER INTEGRATED CIRCUIT
MULLARD TYPE TAD100
The circuit incorporates the mixer, oscillator, i.f. amplifier, a.g.c. and audio pre-amplifier stages.
Complete with data sheet and recommended M.W./L.W. circuit diagram. £1·25 inc. post.
470kHz. Ceramic resonator suitable for above circuit 35p inc. postage.
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VIBRATORS. Plessey Type 12.1.4.SD. 12V., XC354. 24V. 50p + 10p p.p.

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Clare Elliot 12V. 200 ohm; 24V. 675 ohm; 110V. 9100 ohm. 2p.c/o. Size ⅞in. × ¾in. × ⅜in. 75p + 10p p.p.
Siemens/Varley/STC Plastic Covered. 14V. 240 ohm; 20-47V. 1250 ohm; 24V. 15000 ohm; 28V. 5800 ohm. 4p.c/o. Size 1⅛in. × 1⅛in. × ¾in. 50p + 10p p.p.
Siemens High Speed Relay. 12V. 145 + 145 ohm; 24V. 500 + 500 ohm; 48V. 1700 + 1700 ohm. 1p.c/o. Size 2½in. × 1½in. × ¾in. 75p + 10p p.p.
STC Miniature Sealed Relay 24V. 700 ohm. 2p.c/o. Size 2in. × 1¼in. × ¾in. 60p + 10p p.p.
Plessey Sub-min. Relay. 6-12V. 250 ohm. 2p.c/o. Size 1½in. × 1in. × ⅝in. 50p + 10p p.p.
Londex 240V. a.c. Relay 2p.c/o. H.D. contacts 60p + 10p p.p.
Magnetic Devices 12V. 2p. make H.D. contacts. 60p + 10p p.p.
Hundreds of miscellaneous GPO, Sealed, Latching, Miniature relays at our Surplus Warehouse.

1% ¼W. 50ppm. METAL FILM RESISTORS. Painton Type PMF 60, 68, 94, 140, 150, 180, 200, 240, 300, 360, 470, 560, 620, 720, 820, 1K, 1K2, 1K3, 2K, 2K4, 2K5, 2K7, 100K, 150K, 200K, 300K, 430K.
*½W. 1K, 500K, 1Mohm 6p each. 25 of 1 value 3p each + 5p p.p.
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Full range of Veroboard and Edge Connectors in stock. S.A.E. for list.

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All components new and unused.
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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	0·17	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	0·60	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	0·65	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	0·80	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	0·14	2N699	0·45	2N2906A	0·18	2N3702	0·10	2S301	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	2S302A	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	2S302	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	2S303	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	2S304	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	2S305	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	2S306	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	2S307	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	2S321	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	2S322	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	2S322A	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	2S323	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	2S324	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	2S325	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	2S326	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	2S327	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	2S701	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	TI843	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	BD123	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	0·25	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	IS021	0·10
BY130	0·16	OA58L	0·21	IS951	0·06

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Plastic Encapsulated
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100v RMS	37p ,,
400v RMS	46p ,,

Size 15 mm × 6 mm.

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50	For	1·00
100	For	1·75
500	For	7·50
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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.

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	£p	£p	£p
100	30	50	76
200	50	60	90
400	70	75	1·10

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U 3	75 Germanium Gold Bonded Sub-Min. like OA5, OA47	0·50
U 4	40 Germanium Transistors like OC81, AC128	0·50
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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	—
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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
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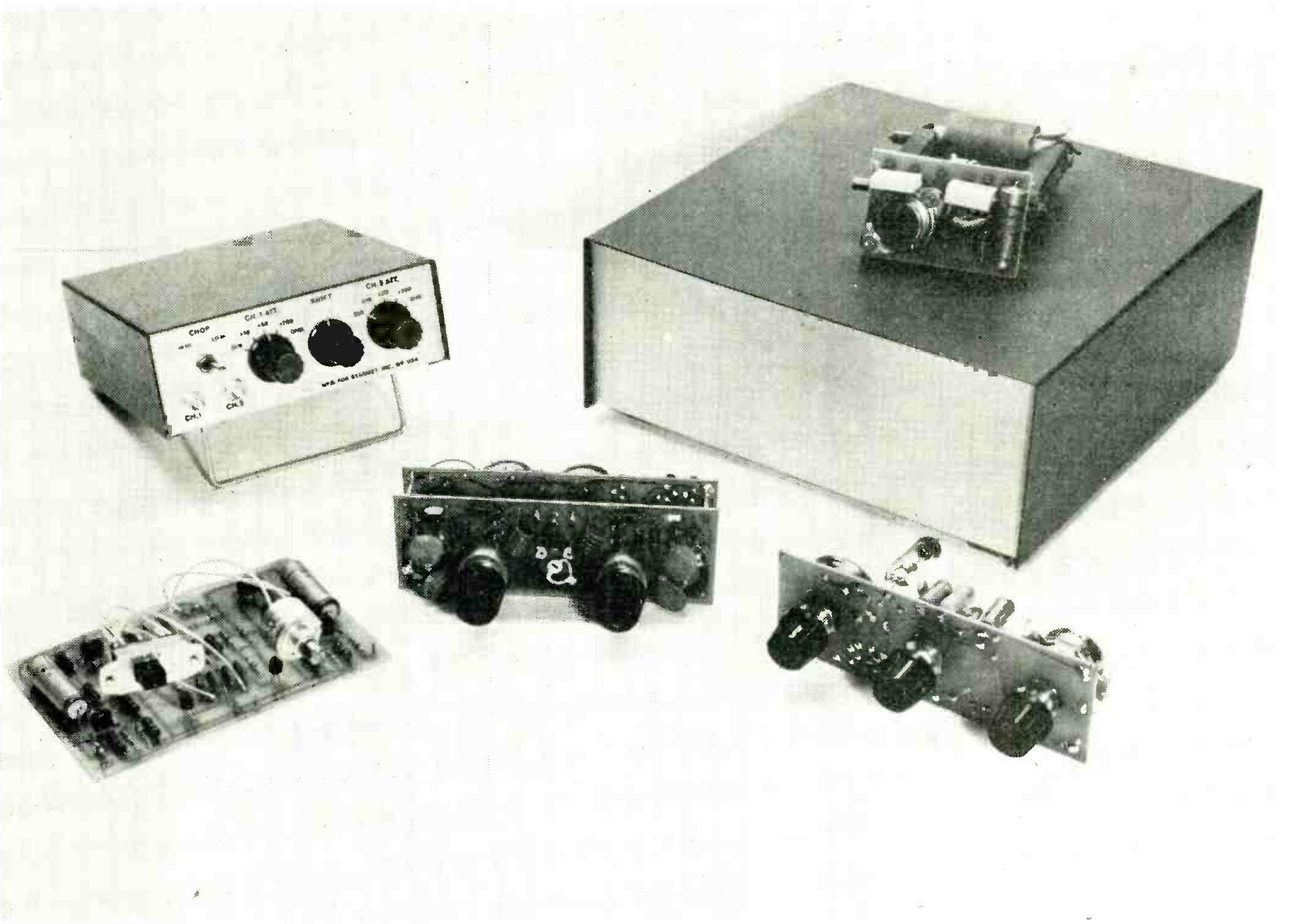

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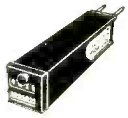

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SIEMENS/VARLEY PLUG-IN. Complete with transparent dust covers and bases. 2 pole c/o contacts **35p** ea ; 6 make contacts **40p** ea.; 4 pole c/o contacts **50p** ea. 6-12-24-48v types in stock.

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. ¼ oz. 1 make 3/12v. **40p.** ea.

SILICON BRIDGES. 100 P.I.V. 1 amp. (⅜×⅜×⅜ in.) **30p.** 200 P.I.V. 2 amp. **60p.**

CIRCUIT BREAKERS (3 pole) 15 amp. Dorman & Long 'Loadmasters' **£1·50.** P.P. 25p.

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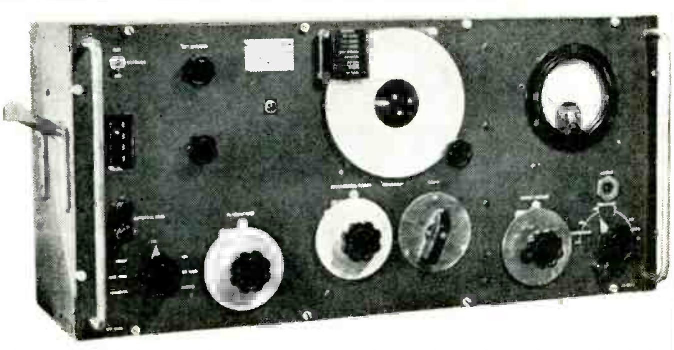
ROMFORD 44473 **RM7 9DD**



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. Second hand 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. at 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 carr.; OR BC-221 (as received from Ministry), good condition, less charts, **£8·50** + £1. carr.

CANADIAN HEADSET ASSEMBLY: Moving coil headphones 100Ω with chamois leather earmuffs. Small hand microphone complete with switch and moving coil insert. New condition, £2 each + 25p post.

HEADSET ASSEMBLY TYPE NO. 10: Moving coil headphones and microphone. (Similar to above) new cond. **£1·75** + 25p post; or second-hand cond. **£1·25** + 25p post.

HEADSET ASSEMBLY: with lightweight boom microphone. Good secondhand cond. **£3** a pair, 25p post.

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NO. 16 HAND MICROPHONE: With carbon insert, lead and plug. **£1** + 25p post.

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MAINS TO 27V 500mA STABILISED | **A.C. MAINS/27V DC POWER SUPPLY UNIT** | **£3·75 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" × 10" × 6" deep. Our price, brand new in carton with circuit, only £3·75 (P.Pd. U.K.).

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AERIAL DIRECTION INDICATING KIT This set comprises a pair of Magslips to provide remote indication of aerial azimuth and comprises a transmitter and receiver. The transmitter is directly coupled to the remote aerial and the receiver can be mounted at the control point, to provide immediate and continuous indication of aerial position. Supply voltage required is 50v 50Hz and the price £5·75. (P.Pd.) Including a pointer for the receiver. The suggested use of these items would include a mains operated, geared motor to drive the aerial, controlled from the position to which is fed back position information by the magslip link. Transformers to provide 50v 50Hz from 240v A.C. £1·95 each. (P.Pd.).

PLANNAIR. Axial Flow Fans (with mounting) Type 6PL-122-331 Mk. 2 6", 2,800 r.p.m. 400v. 3ph 50Hz. New and boxed—£18 (C.Pd. U.K.).

DOWTY ROTOL VALVES 07402YB33. We have just received a few of these difficult to obtain items. P.O.A.

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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.)

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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).

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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.

TIME SWITCH Smiths type TT.10/KD. 0/10 minutes. Contacts 2-pole, 250v 50Hz—£2·25. (P.Pd.)

KLAXON GEARED MOTORS 240v. 50Hz. 1 r.p.m. 2 lbs./in.—£5·25. (C.Pd.) Ditto. 110v.—£4·75. (C.Pd.)

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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.

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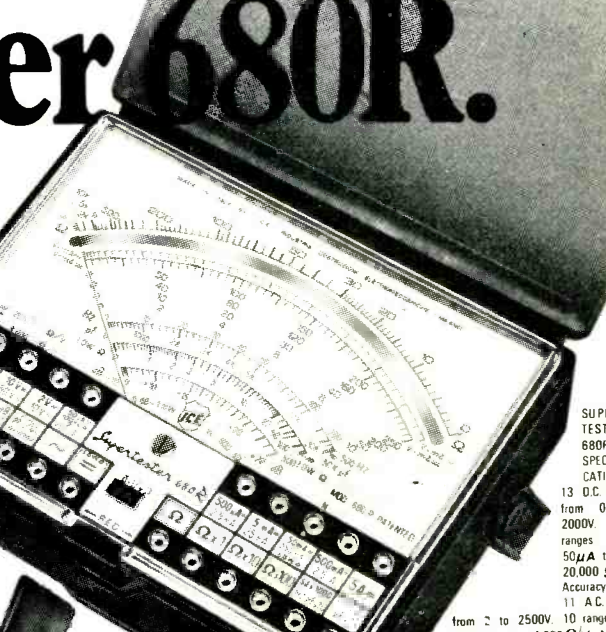

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The Supertester 680R is a completely new concept in measuring instruments. In itself a high quality test meter with eighty ranges on a 128mm mirror backed scale, it is also the basis of a complete measurement system. With the addition of the appropriate accessories it can measure a wide range of values including light, temperature, gauss and phase sequence. And there are other accessories to greatly extend the 680R's range. The 680R System offers many advantages over conventional test meters including tremendous versatility and economy.

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Amperclamp For measuring a.c. currents from 250mA to 500 amps. **£11.95**

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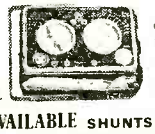

Transistor Tester For transistors and diodes. **£11.00**

SUPERTESTER 680R SPECIFICATION: 13 D.C. ranges from 0.1 to 2000V. 12 ranges from 50μA to 5A 20,000 Ω/A Accuracy 1%. 11 A.C. ranges from 2 to 2500V. 10 ranges from 250μA to 4,000Ω/V. Accuracy 2%. **Resistance**: 6 ranges from 0.5Ω to 100MΩ. **Reactance**: 1 range of 0-10M. **Frequency**: 2 ranges of 0-50 and 0-5000 Hz. **Output Volts**: 9 ranges from 10 to 2000V. **Decibels**: 10 ranges from −24 to +70dB. **Capacitance**: 6 ranges 4 ranges from 20 to 20,000 mfd from internal battery and 2 ranges from 50,000 to 500,000pF using mains. £18.50 complete with case and probes.

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Laskys

LASKYS — NEW DOLBY SYSTEM NOISE REDUCTION UNIT

The new Lasky's NOISE REDUCTION UNIT uses the famous DOLBY 'B' system to provide users of semi professional and cassette recorders with a way to increase performance at low tape speeds by reducing tape hiss by 3dB at 600Hz rising to 6dB at 1200Hz and 10dB for all frequencies above 3000Hz. The unit is ideal for replay of pre-recorded tapes and cassettes now being issued in the DOLBY 'B' format. Controls are provided for input levels and noise reduction on record and replay. 2 meters are fitted for instant checking of DOLBY level. Off tape monitoring is provided by the replay input button when used with 3 head machines. Brief specification. Frequency response: 20Hz to 15KHz ± 1dB 19KHz 35dB. Channel separation: 50dB at 1KHz. Signal to noise: better than 70dB (ref 580mV). Power requirements: 200/250V. AC 40/60Hz. Size 15½x9x3½in.

LASKYS PRICE **£32.50** POST FREE IN U.K.

Audiotronic 6 Pole Quadraphonic Decoder

This new Audiotronic Decoder is a fully transistorised system to reproduce 4-channel sound from SQ records and 4-channel discrete sources. It performs the CBS SQ matrix decoding function on SQ encoded programme material (adopted by the majority of the world's manufacturers). from disc, tape or FM radio. The four signals, when reproduced through four amplifiers and four speakers, will be presented as left, right and front, left and right back information. Switching is provided for: SQ recording and FM Broadcasts. "Ambient" for enhanced 2-channel sound by synthesizing four channels, normal stereo: 2- and 4-channel record and playback. The master volume control allows overall level to be set plus a rear control for front to back balancing. BRIEF SPEC. Input Imp 40K ohms. Output Imp. 300 ohms. Freq. Resp. 4Hz — 100KHz. Freq. Sep. 60dB. Rear Sep. 20dB. Power Req. AC 240V 50/60Hz. Size: 180 (W) x 55 (H) x 220 (D) mm.

LASKYS PRICE £22.50 C. & P. 35p

FERGUSON 3414 COMPACT SYSTEM

The 3414 is a compact FM stereo receiver fitted with a B.S.R. Auto/Manual turntable and Goldring G800H cart. Inputs for Tape play and Auxiliary and outputs for tape and headphones. Controls for volume, bass, treble and balance. The FM Tuner section has 5 pre-settable push buttons. Stereo broadcast indicator beacon. SPEC. Power Output 15 watts per channel into 4 ohms. Freq. Resp. 30-25KHz. Harmonic Dist. Less than 0.5% @ 1KHz. Power Req. AC 120-240V 50/60Hz. Size 56.5 (L) x 38 (W) x 18.5 (H) cm. Walnut veneer finish.

Complete with pair of Philips RH.402 speakers.

The Philips RH.402 Speakers include one 7" woofer and one 1" tweeter. Power 20W r.m.s.

£79.00

Philips RH.402 Speakers available separately at **£21.50 pair.**

PACKAGE
Ferguson 3414 Compact with a pair of Lasky's Criterion Mk. X speakers.

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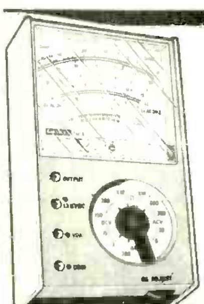
LEAK TRUSPEED Mk III

Made to sell for £69.50

A low speed (250 r.p.m.) synchronous 12-pole hysteresis motor (100-130V. or 200-250V), gives constant turntable speed independent of mains voltage fluctuations. Speeds: 33⅓ r.p.m. and 45 r.p.m. Wow: less than 0.15%. Flutter: less than 0.02%. Isolated pick-up arm and balanced turntable mounting greatly reduced acoustic feedback. Cast aluminium turntable. The antistatic turntable mat holds all diameters of record correctly and drives them from the rim thus eliminating slipping caused by bowed or warped records. Size: 12⅝in x 15¾in x 7½in. inc. cover. COMPLETE WITH ARM. TEAK PLINTH. AND TINTED PERSPEX COVER AND SHURE M75/6 CARTRIDGE.

LASKYS PRICE C. & P. **£47.50**

Leak Truspeed on walnut base with cover — less arm and cartridge. A snip for the Hi-Fi enthusiast. **£29**



EXCLUSIVE TM-5

5K/ohms/V MULTIMETER

Another pocket multimeter from Laskys providing top quality and value. The Slimline impact resistant case size 4⅞x2⅛x1⅜in fitted with extra large 2⅞in square meter. Readability is superior on all ranges, making this an excellent instrument for servicing transistorised equipment. Recessed click stop selection switch. Zero ohms adjustment. Buff finish with crystal clear meter cover.

Spec.: ● DC/V: 3-15-150-300-1200 at 5K/ohms/V. ● AC/V: 6-30-300-600 at 2.5K/ohms/V. ● DC Current: 0-300uA. 0-300mA. ● Resistance: 0-10K/ohms. 0-1m/ohms. ● Decibels 10dB to 16dB. ● Complete with battery and test leads.

LASKYS PRICE **£2.45** C & P. 35p

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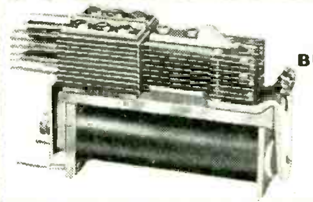

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MEGGERS. 500 volts, range 0-1,000 Meg. ohms—infinity, metal case, in good working order **£15** each. Post **40p.**
PORTABLE VOLTMETERS 160 volts AC/DC moving iron 8 in. Mirror scale in polished wood case with hinged flap 9¾ in. by 8¾ in. by 3¾ in., only **£5** each, post **70p,** resistance supplied to extend range to 320 volts (scale reading ×2) **50p** extra.
VOLTMETERS 2 in. flush round AC/DC with fixing clip 0-20 or 0-40 volts **£2** each. 0·5 amp same price. 10 MA **£1·50** each, all post paid.
FREQUENCY METERS. 45/55 c.p.s. 230 v. A.C. 6 in. dia. flush round **£10.** Post **70p.**
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VEEDER-ROOT COUNTERS with zero reset 800 counts per minute. 6 figures. 110 v. A.C. **£5** post paid.
STROBOSCOPE FORKS 125 CYCLES, £1 each, post paid.

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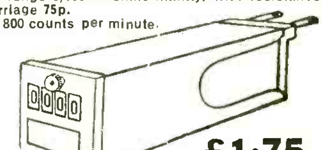

3⅛ in. × 1 in. 10 counts per second, with 4 figures. The following D.C. voltages are available, 6 v., 12 v., 24 v., 50 v., or 100 v. Also supplied with auxiliary contacts, normally open 40p extra.

£1·75

MINIATURE BUZZERS, 12 volts, with toneadjuster **40p** each as illustrated
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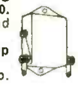

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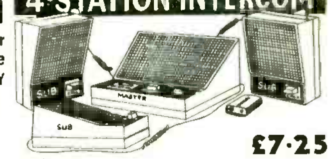

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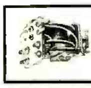

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Dimensions: 8¾W×3¼×10¼ inches

Maximum Input: 60V p-p less than 10 sec. 20V p-p continuous
Power Requirement: 100/110/117/200/234V AC 18VA or 12-14·5 VDC 1A

As main U.K. distributors of Yaesu Musen transmitters, receivers, etc. we hold extensive stocks of spares and have full service facilities.

*Your 'ONE-STOP' single source of all YAESU equipment plus MASTS, TOWERS, ROTATORS, ANTENNAS.

WESTERN ELECTRONICS (U.K.) LTD.,
OSBORNE ROAD, TOTTON, SOUTHAMPTON, SO4 4DN
Tel.: TOTTON 4930 or 2785 Cables: AERIAL, SOUTHAMPTON

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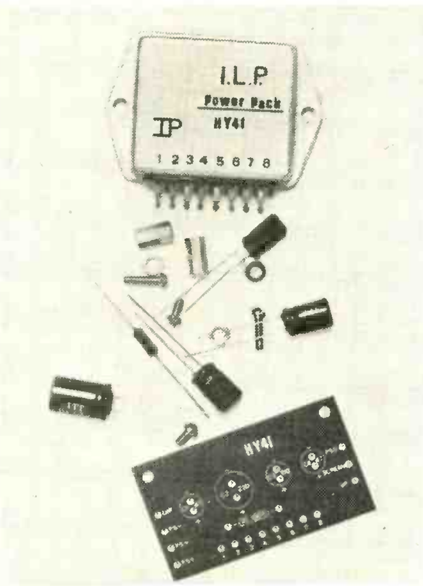
I.L.P. (Electronics) Ltd



THE HY41

The HY41 supersedes the popular HY40 introduced by ILP last year. This highly improved module achieves true High Fidelity with a dramatic reduction in distortion (typically 0.05% at 1KHz into 8 ohms!) and is electronically and mechanically compatible with the HY40.

With this important improvement the HY41 retains all of the quality characteristics found in the earlier version and P.C. board, Resistor, Capacitors, Hardware Mountings and comprehensive manual are included in the basic kit. No further components are required to construct a complete power amplifier of extremely high performance sufficiently versatile to provide power not merely for Hi-Fi but also for public address systems and industry.

The free manual gives a full circuit diagram of the HY41 and its various applications including a complete stereo amplifier.

Like its predecessor the HY41 is based on conventional and proven circuit techniques developed over recent years.

OUTPUT POWER: British Rating 40 WATTS PEAK, 20 watts R.M.S. continuous.
LOAD IMPEDANCE: 4–16 ohms.
INPUT IMPEDANCE: 30K ohms at 1KHz.
VOLTAGE GAIN: 30db at 1KHz

TOTAL HARMONIC DISTORTION: less than 0.15% (typical 0.05%) at 1KHz.
FREQUENCY RESPONSE: 5Hz–50KHz ± 1db.
SUPPLY VOLTAGE: ± 22.5volts D.C.
SUPPLY CURRENT: 0.8 amps maximum.

PRICE: inc. comprehensive manual, P.C. board, five extra components and P. & P.:–
MONO: £4.90 **STEREO: £9.80**

UNIQUE HYBRID PRE-AMPLIFIER

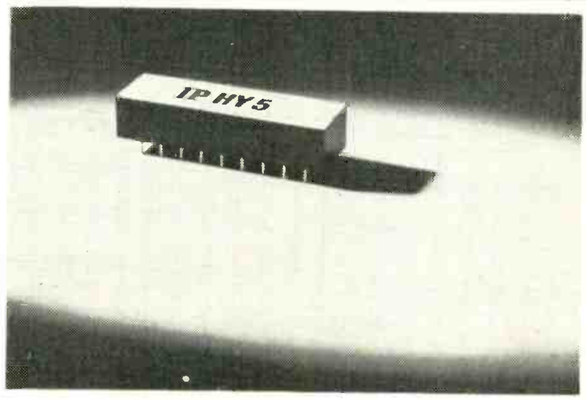
The HY5 has rapidly established a position in the WORLD as the sole hybrid pre-amplifier to contain all feedback and equalization networks within an integrated pre-amplifier circuit.

Supplied with the HY5 are two stabilizing capacitors and by the addition of volume, treble and bass potentiometers it is ready for use.

Internally the HY5 provides equalization for almost every conceivable input, the desired function is achieved by use of a multi-way switch or by direct interconnection.

Two distinctive features of the HY5 are its inbuilt stabilization circuit, allowing it to be run off any unregulated power supply from 16–25 Volts and a balance circuit which, when linked by a balance control to a second HY5, forms a complete stereo pre-amplifier.

Specifically and critically designed to meet exacting Hi-Fi standards, the HY5 combines extremely low noise with a high overload capability. When used in conjunction with the HY41 and PSU45 forms a completely intergrated system.

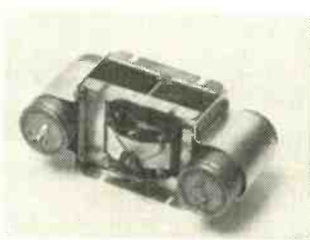


INPUTS
Magnetic Pick-up (within ±1db RIAA curve) 2mV. 47K Ω
Tape Replay (external components to suit head). 4mV. 47KΩ
Microphone (flat) 10mV. 47K Ω
Ceramic Pick-up (equalized and compensatable) 20–2000mV. variable.
Tuner (flat) 250mV. 100K Ω
Auxiliary 1 250mV. 47K Ω
Auxiliary 2 2–20mV. 100K Ω

ACTIVE TONE CONTROLS (Baxendall)
Treble ± 12db.
Bass ± 12db.
INTERNAL STABILIZATION
Enables the HY5 to share an unregulated supply with the Power Amplifier.
SUPPLY VOLTAGE
16–25 volts

SUPPLY CURRENT
6mA approx.
OVERLOAD CAPABILITY
better than 26db on most sensitive input infinite on tuner and auxl.
OUTPUT NOISE VOLTAGE: 0.5mV.

PRICE: **MONO: £3.60** **STEREO: £7.20**



POWER SUPPLY PSU45

The versatile P.S.U.45 is designed to supply your HY41's +HY5's in stereo or mono format.

Specification

Input: 200–240 Volts.
Output: ± 22.5 Volts at 2 amps.
Overall Dimensions: L. 7"; D. 3.8"; H. 3.1"

PRICE: **£4.50 inc. P. & P.**

CROSSLAND HOUSE · NACKINGTON · CANTERBURY · KENT

CANTERBURY 63218

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SERVICE TRADING CO

Postage and Carriage shown below are inland only. For Overseas please ask for quotation. We do not issue a catalogue or list.

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

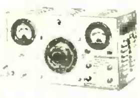
1 AMP Special discount for quantity
OPEN TYPE (Panel Mounting)
½ amp £4·75 1 amp £7·00 2½ amp £8·05

L.T. TRANSFORMERS

All primaries 220-240 volts.

Type No.	Sec. Taps	Price	Carr.
1	30, 32, 34, 36 v. at 5 amps	£4·68	35p
2	30, 40, 50 v. at 5 amps	£6·88	35p
3	10, 17, 18 v. at 10 amps	£4·95	35p
4	6, 12 v. at 20 amps	£6·43	50p
5	17, 18, 20 v. at 20 amps	£7·28	50p
6	6, 12, 20 v. at 20 amps	£6·88	50p
7	24 v. at 10 amps	£5·23	35p
8	4, 6, 24, 32 v. at 12 amps	£7·15	50p
9	6 and 12 v. at 10 amps	£3·75	35p

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit

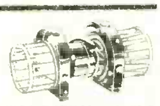


Input 220/240 v. A.C. Output Continuously variable 0-36 v. A.C./D.C. Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused Ideally suited for Lab. or Industrial use. £68 plus £2 p. & c.

MOTOROLA MAC11/6 PLASTIC TRIAC 400 PIV 10 AMP

Now available EX STOCK supplied complete with full data and applications sheet. Price £1·05 plus 7p P.&P. Suitable Diac 30p (RCA40583).

DOUBLE ENDED BLOWER UNIT

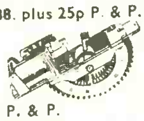


Powerful, continuously rated, 2 speed. Blades easily removable. Either 6 or 12 volt D.C. operation. Price £1·75 P. & P. 25p.

POWER RHEOSTATS

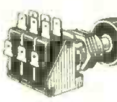
(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES:**
100 WATT 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm ·7a., 500 ohm ·45a., 1k ohm 280mA., 1·5k ohm 230mA., 2·5k ohm ·2a., 5k ohm 140mA., Diameter 3¼in. Shaft length ¾in. dia. 15/32 in., **£1·65.** P. & P. 7½p.
50 WATT 1·12/10/25/50/100/250/500/1K/1·5K/2·5K/5K ohm. All at **£1·15**, P. & P. 7½p.
25 WATT 10/25/50/100/250/500/1K/1·5K/2·5K/3·5K ohm. All at **90p**, P. & P. 7½p.
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. **£5·88.** plus 25p P. & P.
6 BANK 25 WAY FULL WIPER
25 ohm coil, 24 v. D.C. operation. **£6·50**, plus 25p P. & P.
8 BANK 25 WAY FULL WIPER
24 v. D.C. operation. **£7·63**, plus 25p 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 ⅝ 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.

50 in 1 ELECTRONIC PROJECT KIT

50 easy to build Projects. No soldering, no special tools required. The Kit includes Speaker, meter, Relay, Transformer, plus a host of other components and a 56-page instruction leaflet. Some examples of the 50 possible Projects are: Sound level Meter, 2 Transistor Radio, Amplifier etc., etc. Price **£7·75.** P. & P. 30p.

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 **£6·30** plus 25p P. & P.

NEW INDUSTRIAL KIT
Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor. Adjustable 1-80 f.p.s.. approx. ½ output of Hy-Lyght. Price **£10·50.** 50p 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 **£12·00.** P. & P. 50p.

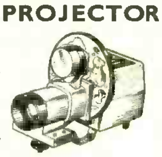
'SUPER' HY-LIGHT KIT
Approx. 4 times the light output of our well proven Hy-Lyght strobe.
Incorporating, Heavy duty power supply.
Variable speed from 1-13 flash per sec.
Reactor control circuit producing an intense white light.
Never before a Strobe Kit with so HIGH an output at so LOW a price. ONLY £20·00 plus 75p P. & P.

ATTRACTIVE, ROBUST, FULLY VENTILATED METAL CASE specially designed for the Super Hy-Lyght Kit including reflector, **£7·00.** P. & P. 45p.
FOR HY-LYGHT STROBE incl. reflector, **£4·00.** P. & P. 45p.
7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price **53p** and 13p P. & P. or post paid with kits.

RAINBOW STROBE FOUR LIGHT CONTROL MODULE

In response to numerous requests, we now offer a mains operated fully isolated short-circuit-proof ready-built module, with variable flash rate. It will operate four of our Hy-Lyght or Super Hy-Lyght Strobes in either 1, 2, 3, 4 sequence; 2+2; or all together. Fantastic effects with or without colour filters. Modules can be connected together to operate 8 or 12 Strobes. Will work on long runs of up to 50 yards, so that your Strobes can be spaced out for maximum effect. Size of module is 5×6×1½in. easily fitted into your own equipment, or into a separate case. Thoroughly tested and reliable. Complete with full connection instructions. Price: **£18·50** plus 25p P. & P. Send S.A.E. for details.

COLOUR WHEEL PROJECTOR



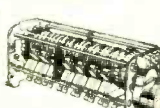
Complete with oil filled colour wheel. 100 watt lamp. 200/240V AC. Features extremely efficient optical system. **£18·50** +35p P. & P.
6 INCH COLOURWHEEL
As used for Disco lighting effects, etc. Price **£5·75** inc. p. & p.

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 **£16·00.** P. & P. 50p. Spare bulb **£7·00** P. & P. 30p.

BLACK 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.

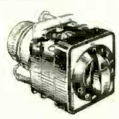
HONEYWELL PROGRAMME TIMERS



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 **£5·75** + 25p. P. & P.
10 cam model **£4·75** + 25p. P. & P.
2 cam model with 15 r.p.m. motor **£1·75** + 25p. P. & P.

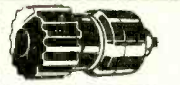
SIMPLE 12 CAM PROGRAMMER with 4 adjustable cams and 8 that may be profiled to individual requirements. Available with 15 or 13 r.p.m. motor **£3·50**—25p. P. & P.

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. **£1·75** P. & P. 25p.

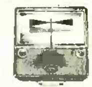
INSULATED TERMINALS



Available in black, red, white, yellow, blue and green. New 10p each. Post paid. Minimum order 6.

METER BARGAINS

BALANCE/LEVEL METERS



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 *NEW* SIEMENS PLESSEY, etc.

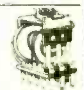
MINIATURE RELAYS AT COMPETITIVE PRICES

1	2	3	4	1	2	3	4
32	3-6	2 c/o	63p*	700	6-12	1c/oHD	50p*
280	9-12	2 c/o	73p*	700	16-24	6 M	63p*
700	16-24	4 M 2 B	63p*	700	20-30	6 c/o	75p
700	16-24	4 c/o	78p*	1250	24-36	4 c/o	63p*
700	12-24	2 c/o	63p*	2500	36-45	6 M	63p*
410	10-18	4 c/o	73p	2400	30-48	4 c/o	50p
700	15-35	2c/oHD	73p*	9000	40-70	2 c/o	50p*
				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.

'DIAMOND H' 230 VOLT A.C. RELAYS (Unused)



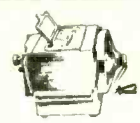
Three sets c/o contacts rated at 5 amps. Price 50p. P. & P. 10p. (100 lots £40·00 incl. P. & P.)

230 VOLT A.C. RELAYS M.f.g. 'Keyswitch'
One set c/o contacts rated at 7·5 amps. Boxed. Price 40p. P. & P. 5p. (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 Post paid.
30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3,200 ohm coil. Size only 1×⅞×½ in. 43p post paid.

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.

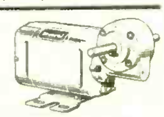
5 RPM A/cw	3 RPH A/cw	20 RPH cw
1 RPH A/cw	6 RPH cw	
2 RPH cw	12 RPH c/w	

cw = Clockwise. A/cw = Anti-clockwise

Fraction of makers' price. All at 75p incl. P. & P

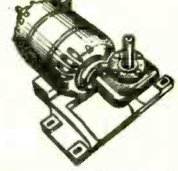
REVERSIBLE SPLIT PHASE MOTOR
250 r.p.m. 100-115/210-240V AC. 2 in. × 1 in. Ideal for rim-drive models, display etc. Extremely powerful for size including small capacitor. 75p. post paid.

PARVALUX



Type: SD1.S/86896/0J
230/250v. A.C. 50 r.p.m. 7 lb/ins. Continuously rated. Less base £6·00 P. & P. 30p.
TYPE: SD1.S/89400/OM
230/250v. A.C. 50 r.p.m. 22 lb/ins. Continuously rated. Incl., base £7·00 P. & P. 30p.
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. **£6·30**, P. & P. 50p.

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: **£1·75** P. & P. 25p.

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

SERVICE TRADING CO.

ALL MAIL ORDERS, ALSO CALLERS AT:
57 BRIDGMAN ROAD, CHISWICK, LONDON, W4 5BB. Phone: 01-995 1560
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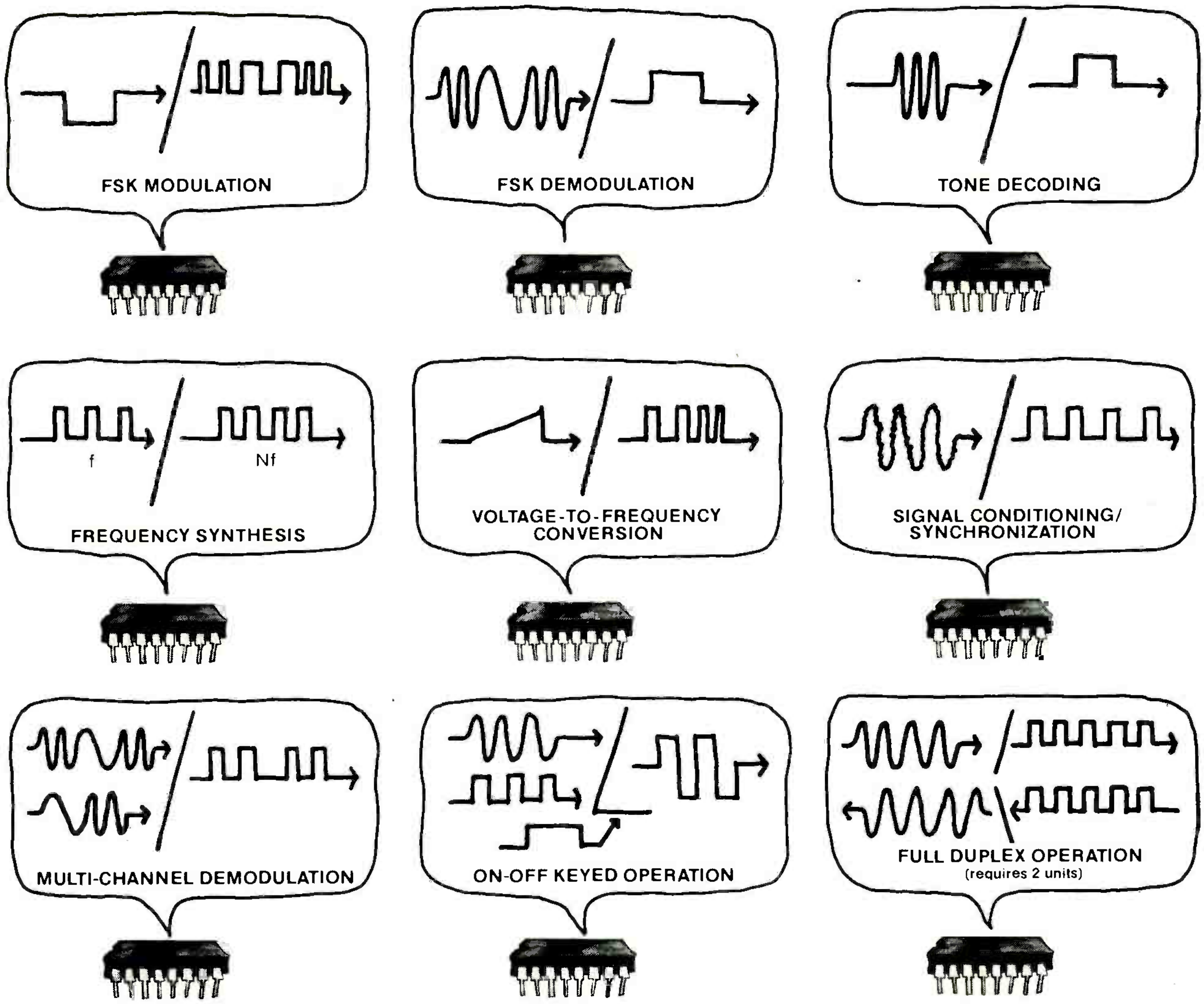
SHOWROOMS NOW OPEN
AMPLE PARKING

PERSONAL CALLERS ONLY
9 LITTLE NEWPORT STREET, LONDON, WC2H 7JJ,
Tel.: 01-437 0576

XR-210 IC MODEM BECAUSE . . .



If you're a systems or circuit designer interested in Modems, we think you'll want to listen to our new XR-210 integrated FSK Modulator/Demodulator.

The XR-210 brings you the highest level of component and functional integration in any Modem circuit on the market. It has an internal phase detector, voltage controlled oscillator, high-speed comparator and an RS-232C compatible output driver. The integration of these functions allows you to cut two-thirds to four-fifths of the components you'd otherwise use in a discrete Modem design.

As a designer, you get less complicated systems, improved device matching and better overall performance, and promise of a fairly painless way to prototype your Modems.

Manufacturing people like this circuit because it reduces component count. Reliability is enhanced because of the XR-210's integration of many components onto a single silicon chip. And Exar gives off-the-shelf delivery.

The XR-210 uses an internal Phase-Locked Loop system and operates at 5 to 26 volts at 0.5 Hz to 20 MHz. It's especially well suited for 103 (300 Baud) and 202 (1800 Baud) type data sets.

EXAR SPEAKS YOUR LANGUAGE

PRICE EACH: XR-210

QUANTITY		
	1-24	£5.25
	25-99	£4.85
	100 up	£4.25

RASTRA ELECTRONICS LTD.

275-281 King Street · Hammersmith · London W6 9NF · Tel. 01-748 3143/2960 · Telex 24443

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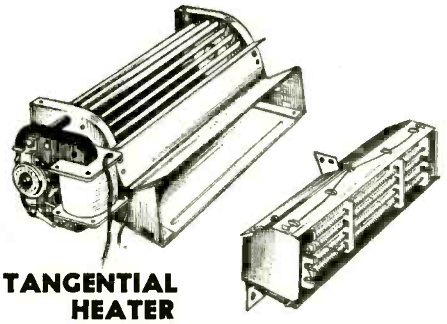
LINDAIR (ELECTRO-TECH) LTD.

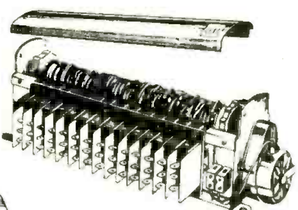


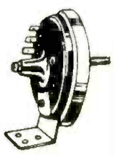
TANGENTIAL HEATER

Silently driven bya shaded pole Mycalex motor. Compact, powerful and quiet running with aluminium impeller (outlet 5¾ × 1½). Mains voltage. PLUS matching heater unit with spiral element. May be switched for 500 or 1,000 watts.

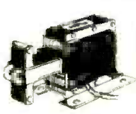
PRICE ONLY P. & P. 40p. **£1·60**

PROGRAMME TIMER BY HONEYWELL
A bank of 15 micro-switches are each independently operated by 15 pairs of cams which in turn are individually adjustable to give switching periods of zero to 12 seconds with infinitely variable combinations. A mains synchronous motor drives the cam shaft at 1 rev. per 12 seconds (5 R.P.M.). Designed originally for vending machines at a cost of £15·00 plus. Many applications where continuous sequence programmes are required, such as lighting effects etc. New in original maker's cartons. First class value at **£5·75** plus 25p P. & P.





"GOYEN" PRESSURE SWITCH—Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. ½ p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube 3/16" dia. Projection 11/16". Overall size dia. 3⅛", depth 2" plus 11/16" (air tube). **£1·25.**



"SORENG" MAINS SOLENOID. 1" travel, 18 lb. pull (approx.). Size: 2¼" long × 2⅜" × 2⅞" high. Powerful **£1·75.** P. & P. 25p.

"DAVENSET" MAINS SOLENOID. 1" travel. 8 lb. pull (approx.). Size: 2¼" long × 2 1/16" × 2" high. Similar in appearance to "SORENG" **£1·25.** P. & P. 25p.

MAINS SOLENOID BY MAGNETIC DEVICES LTD. A beautifully constructed solenoid at half normal price. A two-sided bracket is incorporated for vertical or horizontal mounting. Size: 2" × 1½" × 1⅓". Pull is approx. 2 lb., plunger travel 1½". Fixing eye takes up to ⅛" bolt. Plunger non-captive. New in original maker's boxes. 75p each, plus 25p P. & P. Large number available, special price for quantity.

"HONEYWELL" MICROSWITCHES
Two and three bank, manual push. Ideal for vending machines, etc. Each bank comprises a change-over rated at 15 amps 240v. A.C. The through-panel mounting assembly is in heavy polythene surmounted by black knob. Neck dia. ⅝". 2 bank **40p.** 3 bank **55p.**

CURRENT FLOW INDICATOR

Ideal for all types of battery operated equipment (portable machines, tape recorders, etc.). Four white segments appear when current flows. Coil is 600Ω 6/12v. Drawing only 8 ma on function. Neat in appearance. Size: dia. 1⅞" × 11/16" deep. Fixing centres 1⅛". **£1·25** each. Carr. Paid.

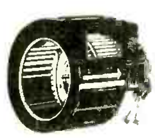
ERNEST TURNER 800µa METER
160Ω movement, 2" case, elliptic plastic front. Green-Red-Green uncalibrated scale. **£1·50** each. Carriage Paid.

Unless otherwise stated—all items are NEW and UNUSED. Postal or carriage charges are for Great Britain only.
We welcome orders from established companies, educational depts., etc. All orders under £2·50, cash with order please.

MICRO-LITES

Wonderful engineering—micro miniature incandescent lamp small enough to pass through the eye of a needle! 1,000's of uses. Will operate from the output of a transistor. Rating: 1·5v. 10-15ma. Size 4·4 × 1·4mm. dia. Leads 22mm. These fantastic lamps have a life expectancy of 1,000 hrs. **OUR PRICE**

£3·25 per doz. Free p. & p.



"PRECISION FAN CO." (Smiths Industries) DOUBLE ENTRY CENTRIFUGAL FAN/BLOWER.—This is a beautifully balanced, particularly quiet running unit giving approx. 90 cubic ft./min. The motor is a 2 pole shaded pole 240v. Mycalex, drawing only 240ma. on run. Weight 2¼ lb. Sizes: Case dia. 3·1", width (case only) 3·125 in., width overall (inc. motor) 5·25 in., aperture 3·125 in. by 1·85 in. Offered well below makers price at **£2·95** P. & P. 25p.

BRAND NEW FERRANTI LIGHT EMITTING DIODE
(GALLIUM ARSENIDE)
TYPE ZME 60
95p EACH. FREE P. & P.
Ferranti Data Sheet supplied.
Please note these are brand new devices and not Seconds or Rejects and are current Ferranti Stock.

DOUGLAS TRANSFORMERS
Full range in stock
For details please phone 01-402 5589

SEEN THIS?

THIS IS THE ONLY WAY WE COULD ILLUSTRATE THIS FABULOUS ITEM!

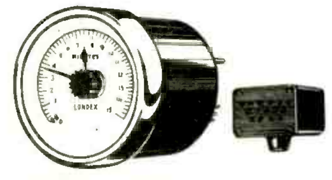
NORPLEX the famous American fibre-glass copper-clad laminate. Finest quality with Woven Glass base of Epoxy-resin. Excellent mech. and elec., conductive properties. Heat Resistant. Ideal for P.Cs., etc. THIS IS A SPECIAL PURCHASE AND ONLY AVAILABLE WHILE STOCKS LAST. Sizes: 12" × 12": 24" × 12": 24" × 24": FULL SHEET 43" × 37" (11 sq. ft.). Single sided copper with thicknesses of 1/32", 1/16", 3/32", also Double sided 1/32", 1/16", 3/32". **PRICE ONLY £1 per sq. ft. £8 per full sheet.** P. & P. 25p up to 4 sq. ft. Over 4 sq. ft. (cut sizes only) Post FREE. Full sheets post by rail G.B. only £1 one or more sheets.

FURTHER BULK PURCHASE
SILVANIA MAGNETIC SWITCH
NOW COMPLETE WITH REFERENCE MAGNET!
A magnetically activated switch. Vacuum sealed in a glass envelope. Silver contacts normally closed, rated 3 amp at 120v, 1½ amp at 240v. Size (approx.) 1 7/16" long × ¼" dia. Ideal for Burglar Alarms, Security systems, etc., and wherever non-mechanical switching is required. **New Lower Price. Only £2·10** for 12. **£8** for 50 or **£15** for 100 complete with magnet.

NOW OPEN
OUR NEW COMPONENTS SHOP
315 EDGWARE ROAD, LONDON W.2.

ADVANCE CONSTANT VOLTAGE TRANFORMER. Type CVS 750A. Input 190-260 v. 50 Hz. Output 240 v. r.m.s. Load 750 watts. Size: 18 3/16" × 7 1/16" × 8¾" high. Weight 68 lb. **£47·50,** Carriage £2·50 G.B. only.
ATLAS MIDGET PANEL LAMPS unrivalled for indication purposes requiring a brilliant but tiny light source. Available with flange cap or wire ended in the following ratings: Capped: 6v. ·1A., Uncapped: 4v. ·25A., 6v. ·1A., 6v. ·2A. £1·20 per dozen or boxes of 50 at **£4** per box.

LT. TRANSFORMERS. Prim. 220/240v. Sec. 0-5 10-15-20v. at 2 amps. **£1·25** P. & P. 15p.
Prim. 200/240v. Sec. 0-1-56-58-60 at 3·5 amps plus 0-90 at 100 ma. Wax impregnated with screw term. blocks. Weight 10 lbs. **£3·60** plus 40p P. & P. Prim. 220/240v. Sec. 0-13 at 1·5 amp. **63p.** P. & P. 15p.
"HONEYWELL" V3 Series. Flush micro-switch 10 amp. c/o. The side panel is insulated. End plate size: 2" × 8". **£1·50** per doz. Carr. Paid.



SYNCHRONOUS AUTO-RESET PROCESS TIMER by LONDEX LTD.

Type IMP Mk. 2.
Brand New and Boxed
These well known timers are already in world-wide use and are perfect for Industrial Electronic Timing, and for all machine control timing problems. Repetitive accuracy better than 0·5% of full scale setting. Two or more can be interconnected to give control of a series of processes. 230/250v. 50 Hz. also available 60 Hz. 15 minutes full scale, 15 secs. per division. Driven by self-starting sync. motor. Contact rating 5 amp at 250v. a.c. Incorporates solenoid operated clutch. Also, lever actuated micro switches. Normal price probably in excess of £16. Complete with multi-pin connector as illustrated.

OUR PRICE ONLY £6·50

BRAND NEW RELAYS by "SCHRACK" (Perspex enclosed).

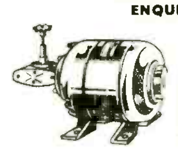
"RA" SERIES 4 changeover: 24V AC, 48V AC, 48V DC, 110V DC. Price **70p** each. **£7·50** per dozen.

"RL" SERIES 3 changeover: 220V AC 10 amp. **£1·00** each. **£1·50** per dozen.

"RN" SERIES 2 changeover: 6V AC 5 amp, 12V AC amp, 24V AC 5 amp. Price **75p** each. **£7·50** per dozen.

"RN" SERIES 3 changeover: 24V AC 5 amp, 48V DC 5 amp, 110V DC 5 amp, 12V AC 5 amp, 48V AC 5 amp, 110V AC 5 amp, 220V AC 5 amp. Price **88p** each. **£8·75** per dozen.

OTHER TYPES IN STOCK
ENQUIRIES WELCOMED



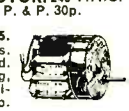
GEARED MOTORS
"Parvalux" Reversible 100 RPM Geared Motor. Type S.D.14, 230/250v. A.C. 22 lb./in. ⅜" spindle. 1st class condition. **£7·50** each. P. & P. 50p. Also limited number only as above. **Brand New. £12·50** each. P. & P. 50p.

MYCALEX. Open frame shaded pole motors 240v. 50Hz. 7 rpm. 28 lb./in. 80 rpm. 12 lb./in **£2·25** each. P. & P. 25p.

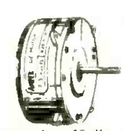
BRAND NEW "GRYPHON" BROOK REVERSIBLE MOTORS. Type TE 230/250v. 50Hz. 1 Ph. ·083 h.p. 1,380 rpm. 0·96 amps at full load, ½" spindle. This is a superbly constructed, standard-footmounted unit, with the extra facility of reversal by remote switching. Weight 16 lb. 10 oz. Offered in original maker's packing at approx. half price. **£7·50.** Carr. 75p.

MAINS INDUCTION MOTOR. Open frame, 3/16" spindle, weight ¾ lb. Powerful. **88p** each. P. & P. 12p.

MAINS SHADED POLE MOTOR. 240 V.A.C. 1½" Stack. 3/16" Spindle. **£1·50.** P. & P. 30p.



"CROUZET" TYPE 955. 115/240v. 50Hz. 47/48 watts. 3 rpm. Stoutly constructed. Size: 2 11/16" dia. × 3¼" long, plus spindle 1" × ¼" dia. Anti-clock. **£2·75.** P. & P. 25p.



AMPEX 7·5v.D.C.MOTOR. This is an ultra-precision tape motor designed for use in the AMPEX model AG20 portable recorder. Torque 450GM/CM. Stall load at 500ma. Draws 60ma on run. 600 rpm ±5% speed adjustment, Internal AF/RF suppression, ¼" dia. × 1" spindle, motor 3" dia. × 1⅝". Original cost £16·50. **Our price £4·25.** P. & P. 25p. Large quantity available (special quotations). Mu-metal enclosure available 75p each.

HARWIN. Tapped (6 Ba) high voltage "stand off" insulators, length ¾", tapped (8 Ba) ⅝" long. **£2·00** per 100. Carriage Paid.

NIFAM WEATHER PROOF 3 PIN CONNECTORS. Suitable for Trailers, etc. 1 Fixed section and 1 free. P. & S. interchangeable rating (approx.) 3 amp at 240V, 10/12 amp at 12V. **£1·25** pair. Free P. & P.

VINKOR POT CORE ASS. TYPE LA.2103 (core LA.2100). Normal price £1·48. Our price **75p** each. Special quote for quantity.

SLIDER SWITCHES. 3 amp. type D.P.D.T. 1" × 7/16" × ½" deep. 1 amp type 3 P.D.T. ⅞" × 7/16" × 7/16" deep. **£1·25** per doz. Either type or mixed as required. Carriage Paid.

We would like to announce that ELECTRO-TECH SALES have now become members of the LINDAIR GROUP which will mean an expansion programme giving a comprehensive and streamlined service. Whatever your electronic or electro-mechanical requirements—contact us first, maybe we can help. We also welcome trade enquiries.

315 EDGWARE ROAD, LONDON, W.2 **BUSINESS HOURS 9 A.M.—6 P.M. MON. TO SAT. TEL: 01-723 5667**

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.

PHOTOMULTIPLIERS. Type 931A—£2·25 ea.

SINE TO SQUARE WAVE CONVERTOR. 20Hz to 250KHz. 9 volt operation. Sine wave input 1 to 2 volts, output 0-2 volts peak to peak. Completely assembled fibre glass board. £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.

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: 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 1¾×5¼ 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 2¼×6¾ 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.

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.

BINARY DECADE DIAL UP SWITCHES. Brand new. Finger tip. Engraved 0-9. Gold plated contacts. Size 1⅞" high, 2$\frac{1}{16}$" deep, ½" wide, £1·50 ea.

LIGHT EMITTING DIODES (RED)
from Hewlett-Packard
Brand new 38p each
Holder—1p ea. Information—5p

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.

4 DIGIT RESETTABLE COUNTERS. 1000 ohm coil. Size 1½×¾×4¼ in. As new, by Sodeco of Geneva. £2·50 ea. As above but 350 ohm. £3·50 ea.

TRANSFORMERS. All standard inputs.

STEP DOWN ISOLATING trans. Standard 240v AC to 55-0-55V 300W, £3 ea. P. & P. 35p.

Transformer Size 2¼ × 1⅝ × 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.

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.

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

SOLARTRON 711S.2 D.B. DC—9 mc/s. In fine condition £50.

SOLARTRON 643 DC—15 mc/s. Good condition £50.

SOLARTRON DC—10 mc/s. CD513—£40. CD513.2—£42·50. CD523S—£45.

SOLARTRON CT316 (D300 range) DC—6 megs. £20.

COSSOR 1049 Mk. IV. DB. £35.

All carefully checked and tested. Carriage £1·50 extra.

MARCONI

Noise Gen. TF1106. £40. Carr. £1·50.
Vacuum tube Voltmeter TF1041A, £35; 1041B, £45.
Wide Range Oscillator TF 1370 and TF 1370A, 10 c/s-10 mc/s from £140.
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.
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TF 144G Signal Generator. Serviceable. Clean £15. In exceptional condition £25. Carr. £1·50.
TF 885 Video Oscillator Sine/Square £35. Carr. £1·50.
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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. Complete £20. Carr. £1.

AIRMEC

Signal Generator type 701. £25. Carr. £1·50.
AIRMEC Generator type 210 £120. Carr. £1·50.

E.M.I. Oscilloscope type WM16. Main frame £125. Choice of Plug in 7/2 OC—24 mc/s x 2 £35; 7/1 DC—40 megs £25. Differential unit available from £40.
E.M.I. WM8. DC to 15 mc/s. Complete with plug in pre-amp, from £40.

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, 1⅞" 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 £3·25 incl. carriage.

SPECIAL OFFER

SELECTED B.C. 221 Recalibrated to Ministry Specification in brand new condition, complete with circuit, only £27·50. 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.

MULLARD ELECTROLYTICS
2200MFD 100V
10A (50°C)
75p each
BRAND NEW BOXED
10 off — 60p each

47000 MFD 40V 28A
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LARGER REDUCTION FOR QUANTITY

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.

COSSOR D.B. Scopes—some models from £15.

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 ¼ and ½ 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.

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.

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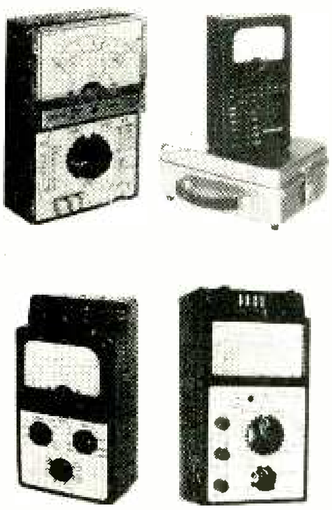
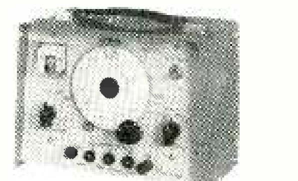


TRANSISTORIZED AUDIO SINE-WAVE OSCILLATOR TYPE G3-36



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6AT6	0·38
6AU5GTA	1·25
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6EA8	0·65
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6F5	0·75
6F6G	0·45
6F11	0·50
6F13	0·50
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6X4	0·40
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6Y6G	0·80
6Z4	0·50
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7B6	0·75
7B7	0·70
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10D1	0·65
10D2	0·55
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12SJ7	0·50
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DF91	0·30
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DF96	0·50
DH76	0·50
DH81	0·70
DH101	0·70
DK40	0·65
DK91	0·45
DK92	0·70
DK96	0·60
DL66	1·25
DL68	0·70
DL91	0·30
DL92	0·40
DL93	0·45
DL95	0·60
DL96	0·55
DM70	0·60
DM71	0·60
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HL94	0·60
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KT44	0·70
KT45	2·00
KT66	2·35
KT71	0·60
KT76	0·60
KT88	2·25
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PCL82	0·35
PCL83	0·65
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PCL800	1·10
PCL801	0·95
PCL805	0·50
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PF86	0·70
PF818	1·00
PFL200	0·65
PL33	0·40
PL36	0·55
PL38	0·65
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PL83	0·45
PL84	0·40
PL302	0·95
PL504	0·75
PL508	0·90
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PX4	3·00
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PY31	0·35
PY33	0·63
PY80	0·40
PY81	0·30
PY82	0·35
PY83	0·38
PY88	0·40

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SP2	0·85
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U19	3·50
U20	0·75
U25	0·85
U26	0·65
U31	0·70
U37	6·50
U50	0·45
U52	0·40
U76	0·40
U78	0·40
U191	0·75
U201	0·50
U281	0·55
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U404	0·70
U801	0·80
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UB41	0·65
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UBL1	0·70
UBL21	0·70
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UCH21	0·60
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UF89	0·40
UL41	0·65
UL84	0·43
UM4	0·60
UM84	0·30
UU5	0·75
UY1N	0·50
UY11	1·00
UY41	0·48
UY82	0·50
UY85	0·40
VLS631	2·30
VP41	0·75
VP133	1·00
VR75/30	0·48
VR105/30	0·40
VR150/30	0·40
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VU111	0·75
VU120	1·00
VU133	0·75
W729	0·75
X65	0·60
X66	0·60
X76M	0·60
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Advertisements accepted up to 12 p.m., FRIDAY, JANUARY 19th, for the FEBRUARY issue, subject to space being available.

Computer careers where life means more!

Join Burroughs and you can have an exciting computer career and live on the threshold of the Scottish Highlands. You can commute from excellent residential areas, enjoy golf, angling, ski-ing and yachting and send your children to excellent schools and universities in the area. You can work on viable research and development programmes in an expanding environment in the computer and peripheral field. Due to expansion we have vacancies for

SENIOR ELECTRONIC ENGINEERS

Experienced in electronics packaging and the design of digital and M.O.S./L.S.I. circuits and power supplies.

Applicants should have an Honours degree and experience in the above field.

Excellent salaries and relocation expenses will be offered.

Apply in writing to: Engineering Recruitment Officer.
Burroughs Machines Limited,
Cumbernauld, Scotland.

Burroughs
CUMBERNAULD SCOTLAND

Middlesex Polytechnic

Enfield Microlectronics Centre

Short Practical Courses in 1973

These day and evening courses which have become well-known and popular in previous years are being offered again together with new courses designed to cater for modern technology and industrial trends.

- ★ **Integrated Circuit Technology**
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- ★ **Hybrid Microelectronics and Thick Films**
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In every case emphasis is put on practical experience for the participant.

For full details and application forms contact The Admissions Office, (Enfield Short Courses Dept. W.W.1), Middlesex Polytechnic, P.O. Box 40, Enfield, Middlesex EN3 4SF. Tel: 01-804 8131.

2243

H.M. GOVERNMENT COMMUNICATIONS CENTRE
has vacancies for

COMMUNICATION OPERATORS

Posts are available entailing watchkeeping on a rota basis providing secure employment with superannuation benefits. There are prospects of service abroad. It is essential to be able to drive a car.

QUALIFICATIONS. Selected candidates will be invited to interview and test and will be required to:
(a) Send and receive morse at 25 w.p.m.
(b) Display knowledge of radio theory, maintenance and repair to the equivalent standard of:
i PMG—Class 1
or ii The Maritime Radiocommunications General Certificate
or iii City and Guilds Course 49.
The ability to touch-type on a standard teleprinter keyboard is desirable.

AGE. Candidates should generally be aged 30 or under.

SALARY. Starting salary according to age and experience.

APPLICATIONS. With personal details, qualification and experience to:
The Personnel Officer (Communication Operators),
H.M.G.C.C.,
Hanslope Park, Near Wolverton, Buckinghamshire.

[2272

BROMLEY GROUP HOSPITAL MANAGEMENT COMMITTEE

ELECTRONICS MAINTENANCE TECHNICIAN

for the acceptance, testing and maintenance of a variety of electronic control and communication equipment and electro-medical apparatus.

Salary £1,896 by increments to £2,448. Applicants must hold, as a minimum, O.N.C. or O.N.D. in Electronics or Light Current Electrical Engineering or the City & Guilds Final Certificate in Telecommunications Engineering. Practical experience in industry or the armed services is essential; hospital experience an advantage but training with manufacturers possible. Own transport, for which mileage is payable, essential.

Applications, with details of training, experience, age, etc., and naming two referees, to reach the Group Engineer "Bassetts", Starts Hill Road, Farnborough, Kent (Tel.: Farnborough 53333) not later than 21st January, 1973. No accommodation available for married applicants.

[2237

Shore jobs for Radio Officers.

If you'd like a job ashore, at a United Kingdom Coast Station, the Post Office will start you off on £1,350 –£1,710, depending on age, with annual rises up to £2,310 (compulsory pension contributions are included in these amounts). In addition you would receive payments that can be as much as £300 or more a year for attendances during evenings, nights, Saturday afternoons and Sundays. Opportunities also exist for overtime.

There are good prospects for promotion to higher posts.

You will need to be 21 or over, with a 1st Class Certificate of Competence in Radiotelegraphy issued by the Postmaster General, or the Ministry of Posts and Telecommunications, or a Radiocommunication Operator's General Certificate issued by the Ministry of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic.

Find out more by writing to: The Inspector of Wireless Telegraphy, IMTR, Wireless Telegraph Section, Union House, St. Martins-le-Grand, London, EC1A 1AR.

Post Office Telecommunications

L 36

THAMES CONSERVANCY

Applications are invited for the following posts in the Chief Engineer's Department at Reading:—

ELECTRONICS ENGINEER

(Salary S.O. Grade 1—2 - £2565 to £3324 p.a.)

who will be required to lead a sub-section applying engineering science in the field of Water Resources. The person appointed should be a corporate member of an appropriate Engineering Institution, and will be involved in the following work:—

(i) the establishment of a major system of telemetry monitoring hydrological parameters throughout the Thames Basin;
(ii) the progressive development of electric analogue models of hydrological systems;
(iii) the development of hydrometric instruments;
(iv) digital computer application.

Knowledge and experience of telecommunications and telemetry is essential, whilst post graduate qualifications and experience of computer programming would be an advantage.

ELECTRONICS TECHNICIAN

(Salary AP 2—3 - £1530 to £2100 p.a.)

required for the maintenance of a system of telemetry throughout the Thames Basin, the repair of Hydometric instruments and the construction of electric analogue models. O.N.C. in Electrical Engineering or City & Guilds Electronics Technician's Certificate desirable. Previous experience of telemetry would be an advantage.

Applications should be submitted in writing, giving details of age, marital status, qualifications and experience, to the undersigned as soon as possible.

E. J. BRETTELL, Chief Engineer,
Chief Engineer's Headquarters,
Thames Conservancy,
De Bohun Road, READING, Berks.

[2242

TELEVISION ENGINEER

required
to join a small but enthusiastic team
operating a

Television Unit for Horseracing

If you have an HNC, City & Guilds, or equivalent qualification and have experience in operating and maintaining outside broadcast television equipment and VTRs together with a willingness to travel and to work in a demanding field

THEN

THIS COMPANY OFFERS YOU

1 the opportunity to join an organisation that is forward looking and is planning to develop and expand in the field of television and electronics

2 a job that is located in varied surroundings on British racecourses

3 a basic salary of between £2,500-£2,750 plus expenses when on location.

If you are interested please write or telephone for a Company form to Mr. F. .T. Dixon, Racecourse Technical Services Limited, 88 Bushey Road, London SW20: Tel.: 01-947 3333.

[2241

REDIFON is consolidating its resources in Crawley.
REDIFON, having recently won some large orders, is enjoying a large expansion programme.
REDIFON offers attractive opportunities and competitive salaries.
In particular in our new look Customer Service Department we require:—

TECHNICAL AUTHORS

Redifon require T.A.'s for its flight simulation projects. This is varied and interesting work in a highly sophisticated industry. Some knowledge of electro-mechanical and electrical systems is necessary; a digital techniques background would be advantageous. Though formal authorship qualifications are not necessary, clarity of expression and a maintenance experience background are desirable.

CHECKER/PROOF READER

(Air publications and Civil manuals, technical proposals, etc.)
Check laymark camera copy against draft material for errors, layout and general quality of work.

EDITORIAL ASSISTANT (Paste-up Artist)

Responsible for preparation of material for printing Civil manuals to R.F.S.L. requirements and for printing air publications to prescribed requirements. Involves the recording, preparing of artwork and re-touching of original artwork. The submission of artwork text and illustrations, mounting of negatives on masking sheets and pasting up line illustrations in text as necessary.

SPARES PROVISIONING CLERK

Responsible for receiving and preparing spares orders, liaising with customers, suppliers, shipping, etc., despatch follow up and organising appropriate records. Good customer approach necessary. Ability to read parts lists and identify electrical electro-mechanical details. Training will be given.

SPARES SCHEDULING CLERK

To assemble detailed break-down data and associated information from which spares lists and recommendations are produced. Production of documentation to plan and time scale. Knowledge of electrical electro-mechanical parts needed.

Apply Personnel Officer, REDIFON FLIGHT SIMULATION LIMITED, Gatwick Road, Crawley, Sussex.
Telephone Crawley 28811

1966 THE QUEEN'S AWARD TO INDUSTRY

REDIFON

A Member Company of the Rediffusion Organisation

1966 THE QUEEN'S AWARD TO INDUSTRY

OPPORTUNITIES AT DYMAR

Continued expansion at Dymar Electronics has produced the following interesting positions—

ELECTRONIC ENGINEER

An electronic development engineer is required to join a team of young enthusiasts engaged in the design of a new generation of HF communications and associated equipment. Qualifications should be at least to HNC level, although special consideration will be given to relevant experience. Familiarity with the design of medium power transmitters would be an advantage.

INSTRUMENT TEST ENGINEER

A test engineer is sought to assume responsibility for final testing of the company's range of instruments. A wide selection of products provides interesting and challenging work for an engineer with experience in this specialist field.

Salaries, which will be commensurate with experience, will be negotiable and there are attractive fringe benefits.

Written applications, giving brief career details, should be sent to:
G. C. Holden, Chief Engineer HF Division, Dymar Electronics Limited, Colonial Way, Hertfordshire WD2 4LA.

DYMAR **the name in radiotelephones**

2280

LEEDS (ST JAMES'S) UNIVERSITY HOSPITAL MANAGEMENT COMMITTEE

A new post has been established for an

X-Ray Maintenance Technician (Medical Physics Technician III)

at St James's Hospital

The duties of the successful candidate will include maintenance, repair and development of X-Ray, machinery. Opportunities exist for developing knowledge and skills by attending courses, conferences and exhibitions.

A full Medical Physics Department is being set up and prospects may exist in other fields. Salary scale £1,602-£2,076.

Whitley Council Conditions of service. Applications in writing stating age, experience etc. and giving the names of two referrees to the Group Personnel Manager, St James's Hospital, Leeds LS9 7TF as soon as possible.

[2239

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.

Applications 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

92

City of London Polytechnic

TECHNICIAN

A vacancy now exists for a Technician in the Psychology Section of the Sir John Cass School of Science and Technology. Candidates should be suitably qualified, preferably in electronics, and must be able to construct and operate a wide range of apparatus for use in the investigation of Human Behaviour. Experience in the development and fault-tracing of circuits would be an added advantage.

Salary scales:
Junior Technician £666 (at age 18 years) to £1,125.
Technician £1,107 (at age 21 years) to £1,557.
Starting salary depending upon age, qualifications and experience.
Plus London Weighting Allowance of £174 per annum.

Apply in writing, giving full details and with the names and addresses of two referees, to Dr. I. N. Balanescu, Principal Lecturer in Charge of Psychology, City of London Polytechnic, Central House Annexe, Whitechapel High Street, London E1 7PF. Telephone 01-283 1030. Extension 486. [2158

FAULT FINDERS

British Radio Corporation is one of the industry's leading manufacturers of unit/audio equipment for distribution both in this country and to a thriving export market. In order to cope with the continuing expansion it is necessary to engage additional technical staff.

Applicants for these positions must be capable of diagnosing faults in radio, radiogram and hi-fi equipment, and will preferably hold an appropriate Electronics qualification and will already have experience in this field. Successful candidates will be offered an excellent rate of pay and promotion prospects.

Written applications in the first instance to:

PERSONNEL MANAGER,
BRITISH RADIO CORPORATION LTD.,
43/49 FOWLER ROAD,
HAINAULT,
ILFORD,
ESSEX

[2252

TECHNICAL WRITERS

Do you want an attractive salary and a choice working location in South Germany near Stuttgart? The world's leading manufacturer of precision electronic test and measurement equipment and systems offers these and other outstanding benefits to the Technical Writers who join our technical publications group. You may qualify if you have a sound background in electronics and are an experienced writer, preferably in both service and promotional fields, some knowledge of German would also be advantageous. Please write or phone (reverse charges).

HEWLETT hp PACKARD

Hewlett-Packard GmbH, 703 Böblingen, Herrenberger Str. 110, Germany, Telephone 07031/6671.

2268

H.F. Development Engineers

International Marine Radio Company is a member of a world-wide organisation, and is a Company leading in the design and manufacture of radio communications equipment for marine applications.

We require development engineers at both senior and junior levels to work on new projects for H.F. single sideband receivers and transmitters.

These positions require a sound knowledge of radio communications circuit design, and some development experience on equipments for the M.F. and H.F. bands would be an advantage.

Candidates should preferably be qualified to either HNC or degree standard, but the ability to demonstrate a professional outlook and to make an immediate contribution to the projects by working independently and accepting the responsibility this entails will be our major requirement.

Apply by telephone or in writing to The Personnel Manager, International Marine Radio Company Limited, 1 Peall Road, Croydon. CR9 3AX. Telephone 01-684 9771.

ITT Marine

2244

Television Engineers

Thames Television has vacancies for Television Engineers to work in the Central Technical area of their Euston Studios in London.

Candidates aged 20 to 30 should have a knowledge of, and an interest in, all aspects of colour television engineering and preferably be educated to HNC standard.

Initial salaries will be related to previous experience and range from £2,058 per annum to £2,890 per annum.

Please apply in writing, giving brief details of age, qualifications and experience.

The Personnel Officer,
Thames Television Limited,
Teddington Lock,
Teddington,
Middlesex.

THAMES

2274

★ ★ ARTICLES FOR SALE ★ ★

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PCF 805

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OUR ASSTD. BOX 100 OF TOP TWENTY INCLUDES VALVES FROM A, B, and C.

SEND PO, CHEQUE or MO to:

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Telephone 01-653 4863 or 01-656 0374

2279

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00	14p	20	14p	86	40p
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Mail Order Only. C.W.O. P. & P. 7p. 10% Discount on 25+.

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PRIMAX *Soldering* **GUN**

INSTANT HEAT 6 Seconds!

Can also be used To cut and seal P.V.C. Plastics, Nylon Rope etc:—
60 Watt Gun @ 108/- p & p 5/-
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NEW fully electronic voice operated Auto-fade unit.

NOW with built-in Mic. pre-amp for Auto music fade system.

£6·00 per kit. **£8·75** ready to use.

NEW quality stereo pickup Pre-amps with tone controls.

NOW on 90mm. square fibre glass board (for MAG., CER. or CRYS.).

£9·00 per kit. **£12·00** ready to use.

NEW expandable audio mixer cabinets.

NOW offer economical low cost system.

Please add 25p for postage and packing.

S.A.E. for details.

PARTRIDGE ELECTRONICS 23-25 HART ROAD BENFLEET, ESSEX SS7 3PB

[2269

CUT THE COST OF SERVICING WITH LONG LIFE TOSHIBA VALVES

LOOK AT THESE PRICES AND MAKE YOURSELF POUNDS MORE PROFIT

Type	Goods	P. Tax	Total
DY.87	22.0	6.5	28.5
DY.802	22.0	6.5	28.5
EB.91	14.5	4.0	18.5
ECC.82	24.0	7.0	31.0
EF.80	25.0	7.0	32.0
EF.183	29.5	8.5	38.0
EF.184	29.5	8.5	38.0
EH.90	27.0	7.5	34.5
PC.900	22.5	6.5	29.0
PCC.89	31.5	9.0	40.5
PCC.189	33.5	9.5	43.0
PCF.80	27.0	7.5	34.5
PCF.86	33.0	9.5	42.5
PCF.801	34.5	10.0	44.5
PCF.802	33.0	9.5	42.5
PCL.82	30.0	8.5	38.5
PCL.84	26.5	7.5	34.0
PCL.85	30.5	8.5	39.0
PCL.86	30.0	8.5	38.5
PFL.200	41.5	12.0	53.5
PL.36	45.5	13.0	58.5
PL.84	22.0	6.5	28.5
PL.504	45.0	13.0	58.0
PL.508	50.0	14.5	64.5
PL.509	80.0	23.0	103.0
PY.88	25.5	7.5	33.0
PY.500A	50.0	14.5	64.5
PY.800	23.0	6.5	29.5

Valves packed individually in labelled White boxes.
Subject to settlement discount 5% of "Goods" content 7 days and 2% monthly.

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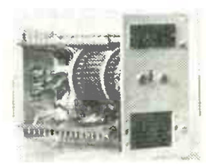
Write or 'Phone COMBINED PRECISION COMPONENTS (PRESTON) LTD. 3 Moor Park Avenue, Preston PR1 6AS, Lancashire. Tel: Home Sales Division, Preston 0772 56347. Export Division Preston 0772 54157. Telex 67129.

New Price List from 11th October '72



REED UNITS

Contains 31 1½A 250V reeds mounted round a drum with magnet inside, also resistors, plugs etc. Only £1 (25p); 2 for £1.65 (35p). Ferric Chloride 1lb 40p (15p); 10lbs £3.50 (40p). BC107-8-9 8p or 14 for £1. 2N3055 35p; 709C 25p; 741C 25p; 723C 40p; 2N1613 12p; 2N3819 26p; CASED AMPLIFIERS. 4 valve, 2 watts o/p for 20μV i/p 7 x 4" 3 ohm speaker, also non-standard single motor solenoid operated tape deck. All in polished oak-faced cabinet. £3 (£1) Resistor packs: 300 5% 60p (15p); 200 5% Hi-stab 60p (12p). 100 1% & 2% 60p (8p): 100 Metal oxide 60p (8p): One of each £2 (25p). 3W 5% R's 270, 470, 6k8, 15k, 27k, 33k, 82k, 100 for 50p (25p). Meters: 2½" 500V dc 40p (10p); 2½" 10V ac 40p (10p). Others available, state requirements. Crofon Light guide, 64 fibre £1 per meter. TEST GEAR: TF144g £12; TF142D £10; TF142E £14; BSR Audio Oscillator 0-16kHz £9; Decade Res. 0-11110 ohms £7.50. All post extra.

Post in brackets, small parts 3p; SAE List, details.

GREENWELD (W9) 24, Goodhart Way, W. Wickham, Kent.

Tel 01-777 2001 up to 10.30pm. Shop at 21 Deptford Broadway SE8, open Sats. Tel 01-692 2009.

UNISELECTOR SWITCHES

24 volt, 10 position, 3 bank, c/w suppressing condenser and supplied c/w base plug in jacks. Uniselector only, **£1·25**, p. & p. 25p. C/w base plug in jack, **£1·65**, p. & p. 25p. Ditto, as above, 12 position, 3 bank. Uniselector only, **£1·35**, p. & p. 25p. C/w base plug in jack, **£1·75**, p. & p. 25p.

Ditto, as above, 25 position, 6 bank. This uniselector is fitted to a front panel and has a distribution board fitted in the rear and is wired from the uniselector to the distribution panel. Limited number only. **£2·75** each, p. & p. 50p.

24 volt, Radiospares type 22, relays c/w bases, fitted to small panel (2 per panel), **60p** per pair, p. & p. 15p.

Glass Fibre plug in digital boards. New. Designed to take divide by 10 I.C's and nixi tube IC driver, c/w CCT instructions, **28p** each, p. & p. 3p.

New Numerical 0-9 Indicator tubes, c/w data, **£1·35** each, p. & p. 6p.

Plastic Holders designed to hold the above tube and will fix to the PCB as above, **8p** each, p. & p. 4p.

G. T. F. ELECTRONICS

9 Ernle Road, Calne, Wilts. SN11 9BT.

Phone: Calne 3360.

2273

SITUATIONS VACANT

BOOKS

TENDERS

SITUATIONS VACANT

SENIOR ENGINEER required by Continental Radio, T.V. and Audio manufacturers, experienced in general servicing problems. Location London, N.1. Attractive salary for the right man. Write Mr. A. Massing, Europhon (Radio & Television), 70 Caledonian Road, London, N.1. Tel: 01-837 3045. [2251

BBC requires RADIO TELEGRAPHY OPERATOR for its MONITORING SERVICE near Reading. Duties involve operation of radio receiving apparatus, including Radio Teletype terminal equipment, monitoring of plain language Morse transmissions, research listening duties (including schedule checking and band scanning), and correcting, logging and routing of incoming material. Essential qualifications are: Ability to type international Morse code in plain language at 25 w.p.m., aural or visual recognition of signalling codes used in communication systems, operational experience of modern receiving equipment and understanding of radio propagation and frequency usage. Perfect hearing. Candidates will be expected to attend for Morse typing and signal recognition test. Salary £1,554 p.a. x £93 to £2,019 p.a. max. plus 12½% shift allowance. Write for application form to Personnel Officer, BBC, Caversham Park, Reading RG4 8TZ enclosing addressed foolscap envelope. [2245

FIRST class Radio and Audio Engineer required for one of Britain's largest photographic and radio importers. Good conditions, excellent prospects, L/Vs. Apply Mr. Vassie, 253 8031. [2246

JAPANESE Radio importers require experienced engineers for servicing transistor radios, etc. Part or Full Time. Tel.: 01-628 6157. [2258

MARINE Radio Installation Engineer to fit and service SSB and VHF Radio Telephones, Radar and Automatic Pilots to yachts of all types anywhere in U.K. Must be based in or near London. Vehicle including personal use provided. The applicant must work on his own initiative and be capable of some mechanical engineering as well as woodwork. Knowledge of boating a great advantage. Telesonic Marine Ltd., 243 Euston Road, London, NW1 2BT. 01-387 7467. [2230

MANAGER/SENIOR Salesman required for busy Television, Radio and all Electrical Appliance Showroom. Must be fully experienced in all leading appliances. Wages from £2,000 p.a. Banstead area. Tel. Victor Towler & Co. Ltd., 399 3476/7/8. [2259

SITUATIONS WANTED

RADIO/ELECTRONICS technician, 26 years, married, is open to offers of permanent or contract employment in UK or overseas. Living 30m south of London, but willing to travel anywhere. 7 years experience in vhf/uhf communications and industrial electronics, driving licence holder and radio amateur. Distinction C & G Electronics Servicing (Final). Reliable and practical man, capable of working on own initiative on the design, construction, commissioning and maintenance of radio and electronics equipment. Looking for an out of the ordinary situation, incorporating both bench and field work, where abilities will be recognised. prospects are good, and the remuneration £2,000 per annum plus. Box No. WW 2265.

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AARVAK ELECTRONICS. 3-channel sound-light converters. £17. Strobes, £16. Rainbow Strobes, £132.—74 Bedford Avenue, Barnet, Herts. 01-449 1268. [19

AMATEUR computer constructors' newsletter. S.A.E. M. Lord, 7 Dordells, Basildon, Essex. [2266

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

COMPONENT Kits for magazine projects, constructor services, components. All at very low prices. Send S.A.E. for lists. Audio and Control Engineering, 30 Baker Street, London, W1M 2DS. [2255

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IF you can't buy it, perhaps we can make it for you. Send us your problems or specifications and we will do our best to send a quote by return of post. Try our high speed service for your design problems, particularly those encountered in the use of I.C. logic. We also service and repair laboratory test equipment, 'scopes, sig. gens., etc. at very reasonable rates. Barnes Electronic Services, 20-24 Beaumont Road, Chiswick, London, W.4. [2256

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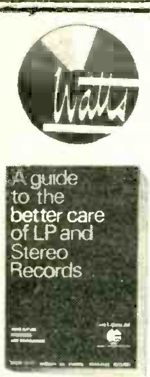

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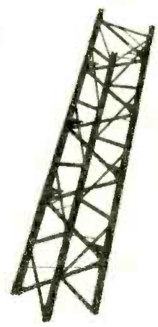

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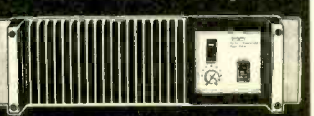

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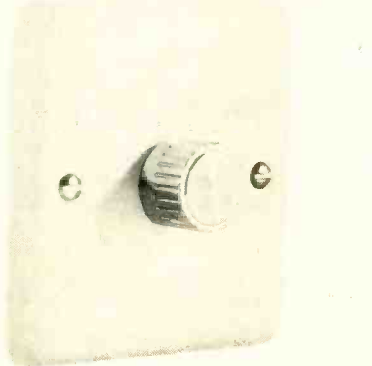

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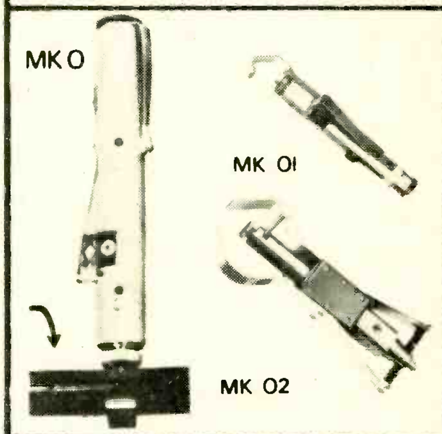

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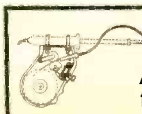

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