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Significant Form

The design engineers at **mi** all have to shape up to one essential fact: we consider good design to be all-important.

By good design we don't just mean an attractive outward form, however aesthetically pleasing it may be. We mean design that is right both outside *and* in. No cover-up jobs. No cosmetic operations. No makeshift solutions. Because whoever pointed out that beauty is more than skin deep knew what he was talking about.

The clean, compact, uncluttered lines of today's **mi** instruments signify more than good styling. They are the outcome of the most intensive application to the balance of form and function, of the eradication of any design that has failed to match our exacting standards.

In other words, they signify **mi**'s conviction that correct designing means correct functioning.

mi : THE STYLISTS

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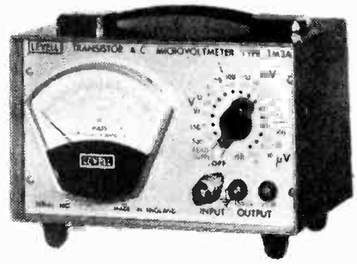
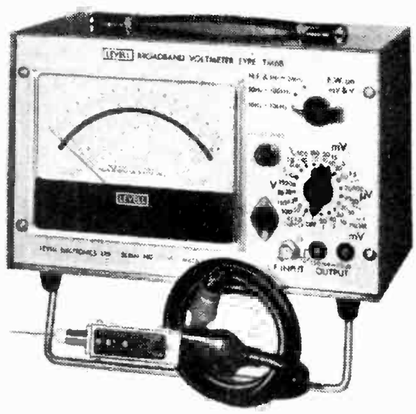
These highly accurate instruments incorporate many useful features, including long battery life. All A type models have 3¼" scale meters, and case sizes 5" x 7" x 5". B types have 5" mirror scale meters and case sizes 7" x 10" x 6".



A.C. MICROVOLTMETERS

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

type TM3A **£73** type TM3B **£88**



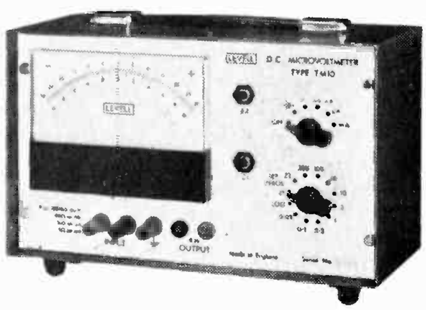
BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES: 1mV, 3mV, 10mV . . . 3V f.s.d. Acc. ± 4% ± 1% of f.s.d. at 30MHz. – 50dB, – 40dB, – 30dB to + 20dB. Scale – 10dB/+ 3dB rel. to 1mW/50 Ω. ± 0·7dB from 1 MHz to 50MHz. ± 3dB from 300kHz to 400MHz.

L.F. RANGES: As TM3 except for the omission of 15µV and 150µV.

AMPLIFIER OUTPUT: Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

type TM6A **£120** type TM6B **£135**



D.C. MICROVOLTMETERS

VOLTAGE RANGES: 30µV, 100µV, 300µV . . . 300V. Acc. ± 1%, ± 2% f.s.d., ± 1 µV. CZ scale.
CURRENT RANGES: 30 pA, 100 pA, 300 pA, 300 mA. Acc. ± 2%, ± 2% f.s.d., ± 2 pA. CZ scale.
LOGARITHMIC RANGE: ± 5µV at ± 10% f.s.d., ± 5 mV at ± 50% f.s.d., ± 500 mV at f.s.d.
RECORDER OUTPUT: ± 1V at f.s.d. into > 1kΩ

type TM10 **£73**

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VOLTAGE RANGES: 3µV, 10µV, 30µV . . . 1kV. Acc. ± 1% ± 1% f.s.d. ± 0·1 µV. LZ & CZ scales.

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Prices include batteries and U.K. delivery. V.A.T. extra. Optional extras are leather cases and mains power units. Send for data covering our range of portable instruments.

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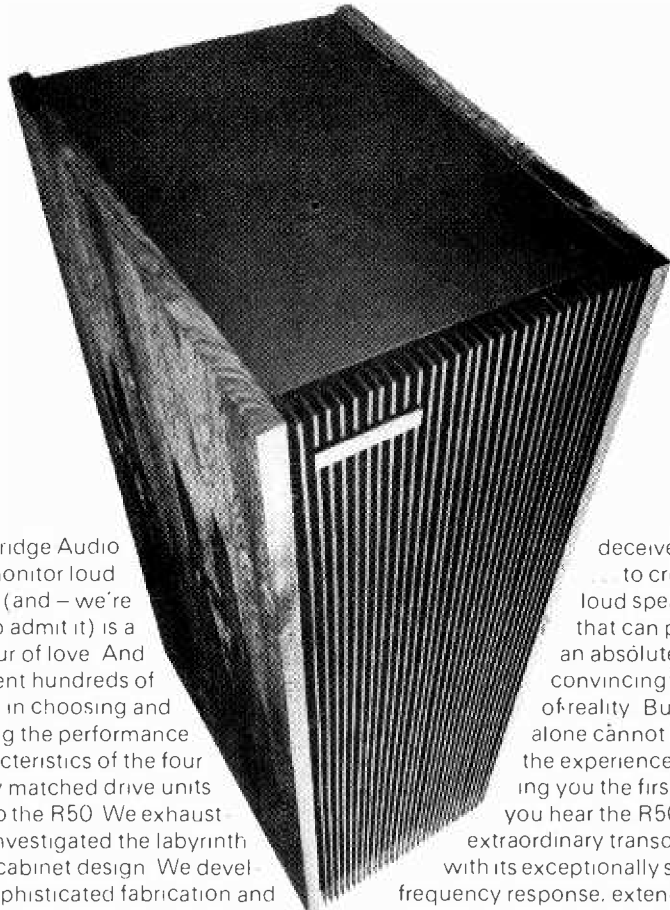

Our Cambridge Audio R50 monitor loud speaker (and – we're proud to admit it) is a true labour of love And we've spent hundreds of hours in choosing and evaluating the performance characteristics of the four critically matched drive units that go into the R50 We exhaustively investigated the labyrinth paths of cabinet design We developed sophisticated fabrication and testing techniques. in production we even go as far as to hand test and select each individual capacitor in the cross-over network In short, nothing is spared in our single minded effort to deceive you ... to create a loud speaker that can produce an absolutely convincing illusion of reality But words alone cannot convey the experience awaiting you the first time you hear the R50. This extraordinary transducer with its exceptionally smooth frequency response, extended bass, superb high frequency dispersion and extremely low distortion has to be heard to be disbelieved Only then will you begin to understand how close we have come to reality

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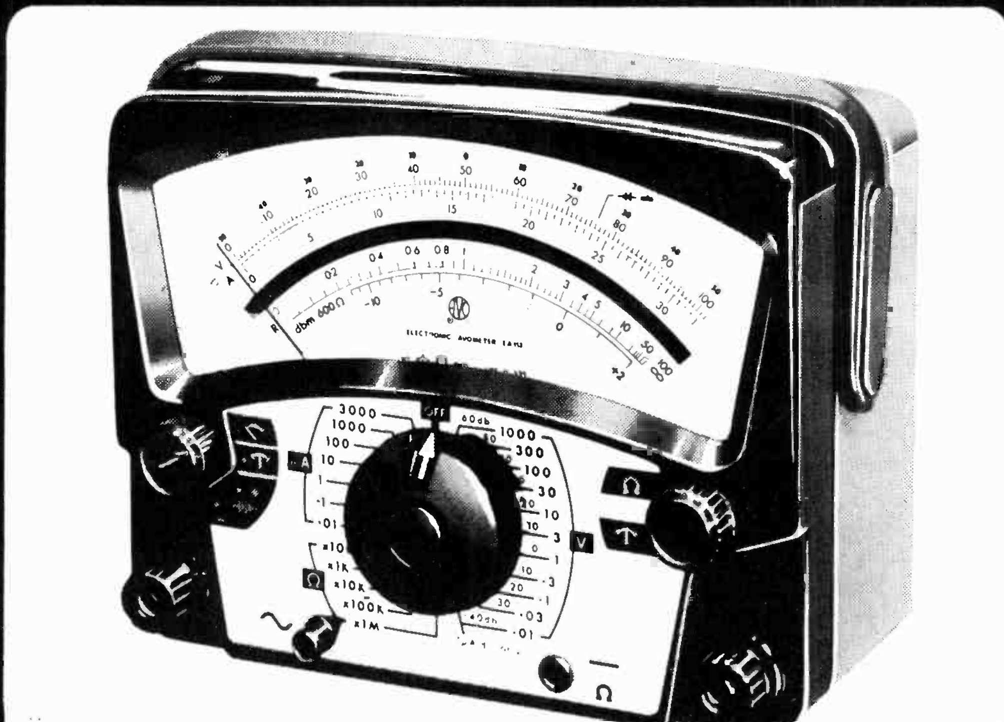
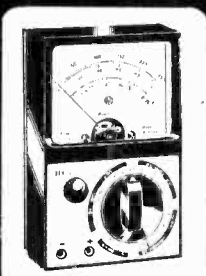
The AVO EA113 steps forward from the AVOMETER range to take a well deserved bow.

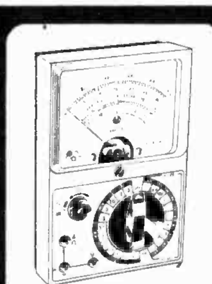


EA113



72

8 Mk 5



EM 272

DA 114

The AVOMETER range for Electronics.

EA113 does everything a major multimeter will do, but it does it with a high input impedance of 1MΩ/V (dc voltage ranges), a 100kHz capability, centre zero facility, single switch range selection, overload protection and other refinements, all for a UK Trade Price of well under £95. EA113 is, of course, an Electronic multimeter.

The range of measurement and accuracy are outstanding too. Voltage from 100μV to 1kV (±1.25%): Current from 0.01μA to 3A (±1.25%): Resitance from 1Ω to 100MΩ.

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Choose your next multimeter from the British-built AVOMETER range and ring your Distributor for price and delivery.

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THORN Thorn Measurement Control and Automation Division

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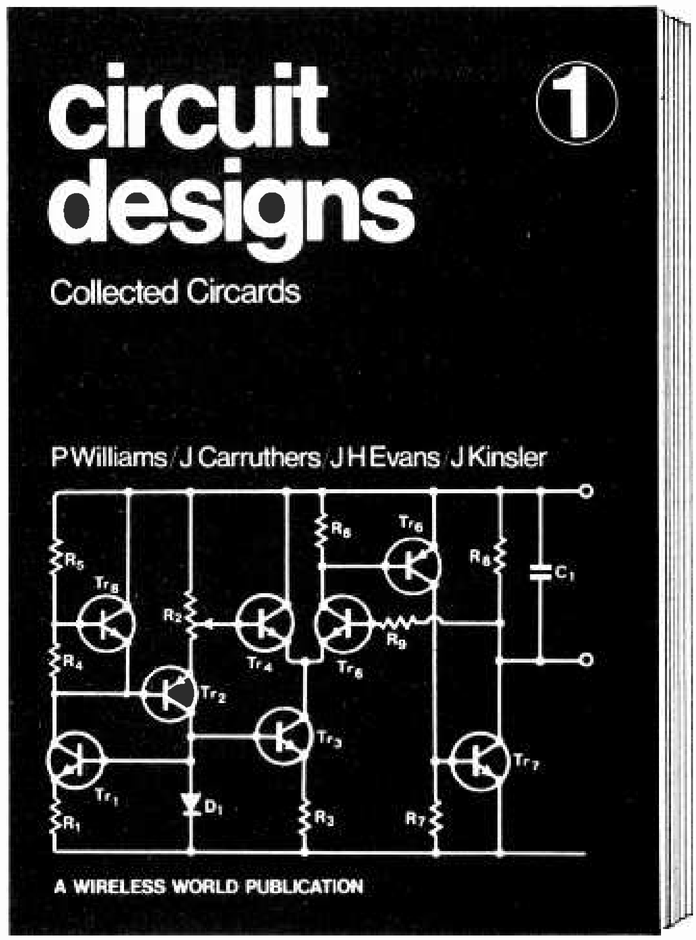
Here's a book of very special appeal to all concerned with designing, using or understanding electronic circuits. It comprises information previously included in the first ten sets of Wireless World's highly successful Circards – regularly published cards giving *selected* and *tested* circuits, descriptions of circuit operation, component values and ranges, circuit limitations, modifications, performance data and graphs. Each of the ten sets – including additional circuits – in this magazine size hard cover book has been updated where necessary, and is preceded by an explanatory introduction. Circuit designs (1) is the first collection of its kind.



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Please send me . . . . copy/copies of Circuit Designs – Number 1 at £10.40 each inclusive. I enclose remittance value £. . . . . . .(cheques payable to IPC Business Press Ltd.)

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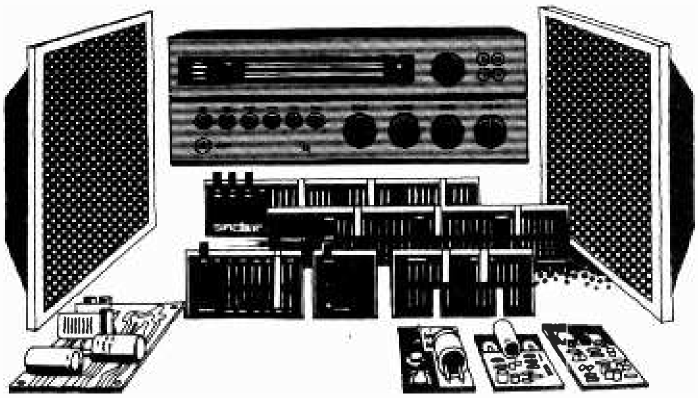
Sinclair hi-fi



The watts...

The Sinclair range of hi-fi products. Three different ways of achieving hi-fi excellence – whatever area of hi-fi you're interested in.

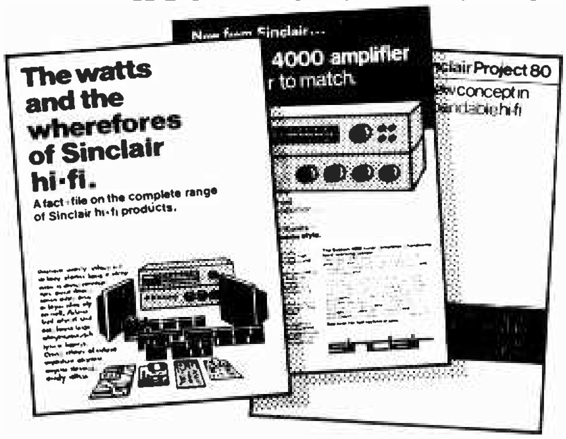
And the Sinclair range fact-file gives you the full run-down on all of them.

On Project 80 – the build-as-you-please hi-fi module system.

On IC20 – the revolutionary integrated circuit amplifier kit.

And System 4000 – the luxury hi-fi amplifier and matching tuner.

and the wherefores.



The Sinclair range fact-file shows you the whole story. Technical specifications... complete descriptions... big, clear pictures... and test reports by impartial hi-fi journals.

A real bundle of goodies.

Send for Sinclair's range fact-file – now!

See if the answer's here – the information on the component you've been looking for.

Simply cut the coupon and send it to the no-stamp-needed FREEPOST address below.

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St Ives (0480) 64646

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WW/8/HF

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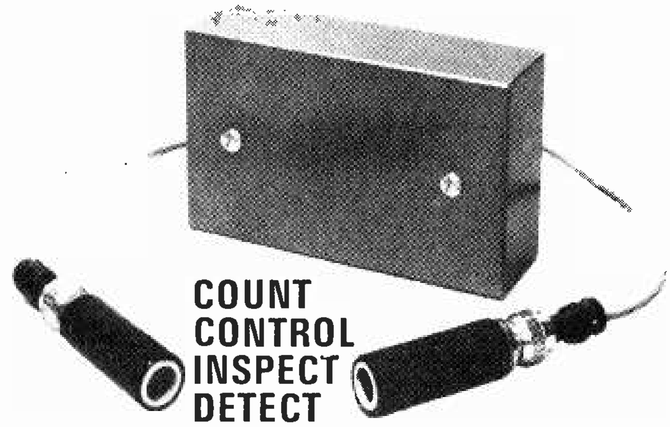

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A low cost, rugged and reliable photo-electric relay/counter supplied complete with optical heads.

Supply: 110, 240, 440V a.c. mains

Output: Model PR has 2 sets C/O relay contacts, 250V a.c. 6A
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Controls: Sensitivity, make or break beam, time delay

Lamp: 6V, 2W M.B.C. Operates up to 3 metres

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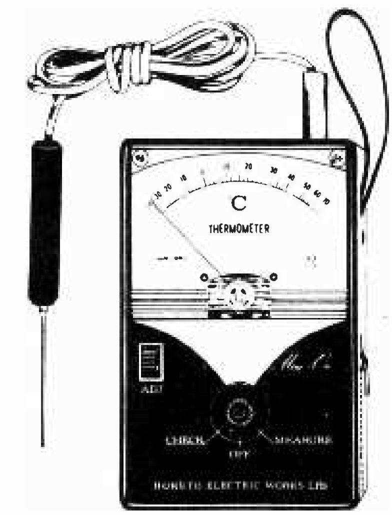

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A Thermometer designed to operate as an Electronic Test Meter. Will measure temperature of Air, Metals, Liquids, Machinery, etc., etc. Just plug-in the Probe, and read the temperature on the large open scale meter. Supplied in zippered vinyl case with transparent front and carrying loop. Probe, and internal 1½ volt standard size battery. **Model "Mini-On 1" measures from – 40°C to + 70°C, price £17.50 Model "Mini-On Hi" measures from + 100°C to + 500°C, price £20.00** (V.A.T. EXTRA)

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WW—043 FOR FURTHER DETAILS

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TYPE D12/400S

A wide selection of types are available to drive practically any equipment within the power rating.

A random selection of types:

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C12/30S	12v DC	115/230v 30watts Sine wave	£40.00
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Please send for literature WW675 All prices + VAT

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digital arithmetic tutor

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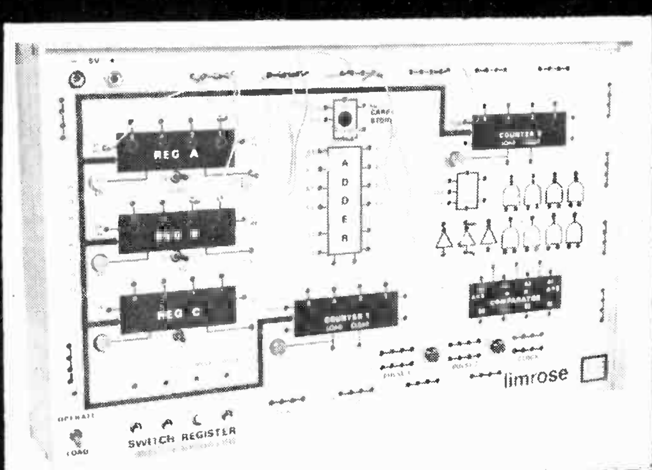
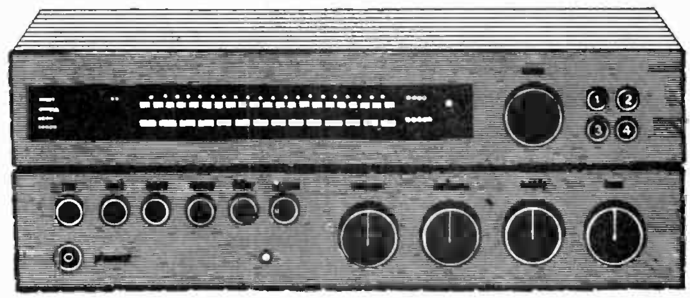


For more information, please contact :

limrose electronics ltd.
241-243 Manchester Road, Northwich, CW9 7NE
Tel. 0606 41696 and 0606 41697.

WW—023 FOR FURTHER DETAILS

Sinclair System 4000



The watts...

Black, beautiful, and incredibly good value. Sinclair's two self-contained hi-fi units – in one handsome, elegant style.

A 17 watts per channel amplifier and a matching FM tuner.

The amplifier offers 17 W RMS per channel output... 0.05% total harmonic distortion... and a price tag of around £50.

The System 4000 tuner completes a handsome, hard-working system.

Engineered and designed to accompany the System 4000 stereo amplifier, the FM tuner matches it in specification and design – and at around £40 completes a system of outstanding value.

and the wherefores.

Get the full technical specifications...

See what impartial hi-fi journals thought of its performance...

And read up on the rest of the Sinclair range...

It's all in the Sinclair hi-fi range fact-file.

Send for Sinclair's fact-file now!

See if the answer's here – the information on the component you've been looking for.

Simply cut the coupon and send it to the no-stamp-needed FREEPOST address below.

We'll send you the Sinclair fact-file – giving you all you need to know about System 4000, and the rest of the Sinclair hi-fi range.

Plus information about a few extras you're sure to find rather interesting.

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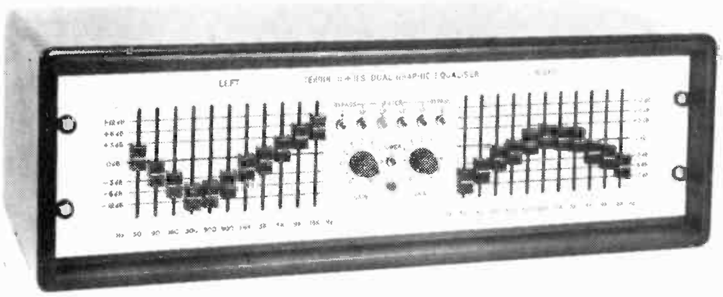
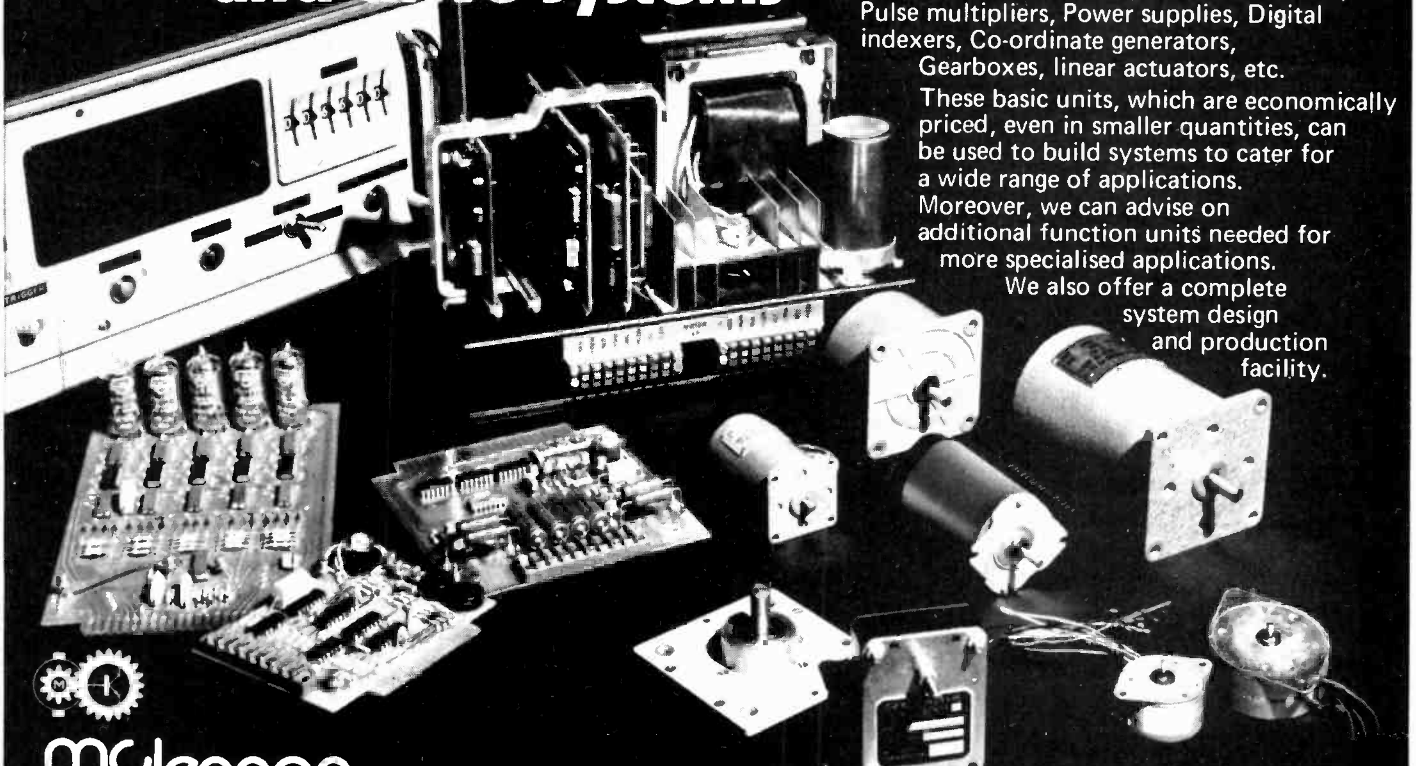
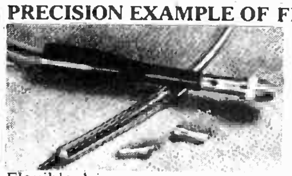
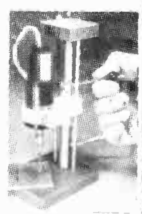
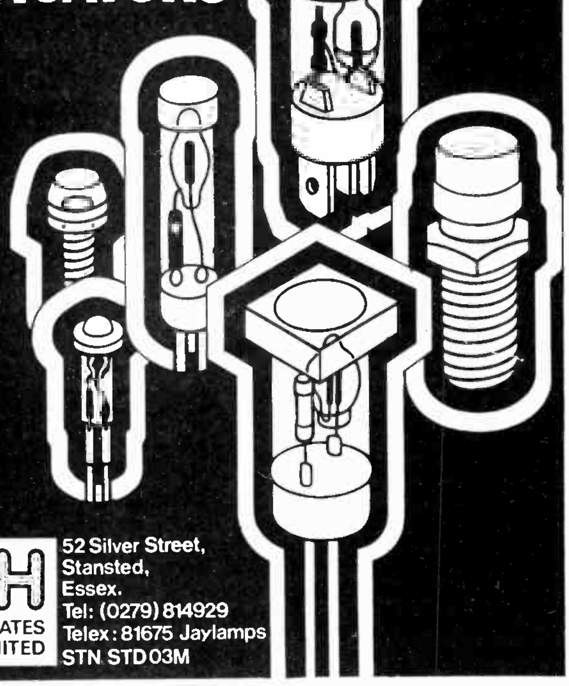


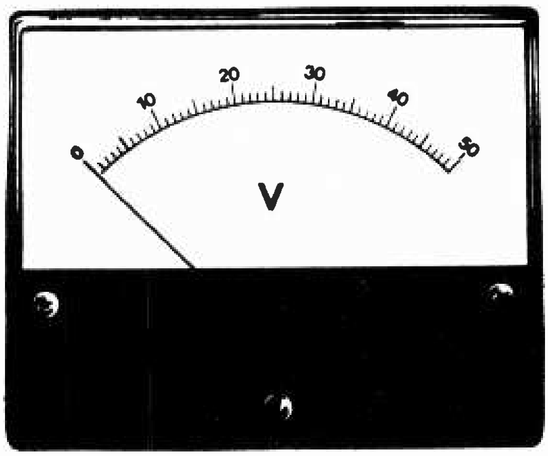








METER PROBLEMS?



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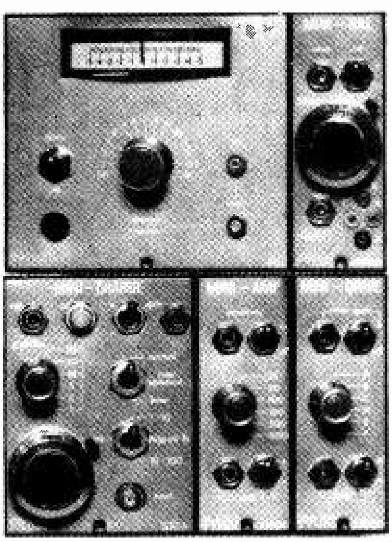
AMPLIFIERS and SYSTEMS



reliable high performance & practical controls. individually powered modules—mains or dc option single cases and up to 17 modules in standard 19" crates small size—low weight—realistic prices.

FYLDE **Fylde Electronic Laboratories Limited.**

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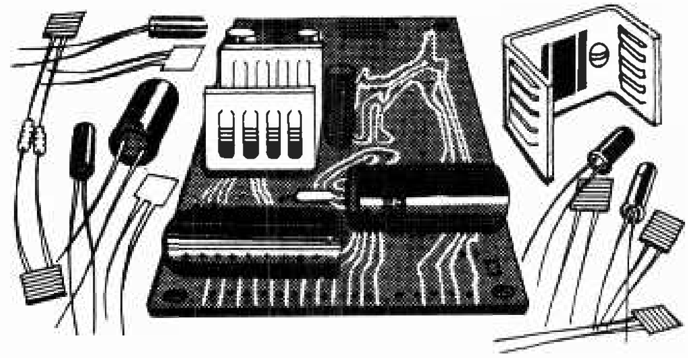
Sinclair IC20



The watts...

The Sinclair IC20 is a revolutionary new 20 watts stereo amplifier kit.

It incorporates state-of-the-art integrated circuits – two monolithic silicon chips each containing the equivalent of over 20 transistors! These deliver 10 W per channel into 4 Ω speakers.

And the IC20 has integral short-circuit protection and thermal cut-out – it's virtually indestructible. Use it for converting your mono record player to stereo... for upgrading your existing stereo... or for improving your car radio/tape player.

Its cost? Only £7.95 + VAT!

and the wherefores.

Get the full technical specifications...

See what impartial hi-fi journals thought of its performance...

And read up on the rest of the Sinclair hi-fi range...

It's all in the Sinclair hi-fi range fact-file.

Send for Sinclair's fact-file now!

See if the answer's here – the information on the component you've been looking for.

Simply cut the coupon and send it to the no-stamp-needed FREEPOST address below.

We'll send you the Sinclair fact-file – giving you all you need to know about IC20, and the rest of the Sinclair hi-fi range.

Plus information about a few extras you're sure to find rather interesting.

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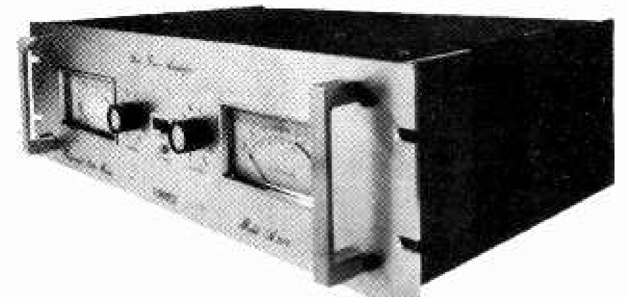
STEREO POWER AMPLIFIERS



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A range of professional stereo power amplifiers designed and manufactured to a very high standard

The A Series (Professional Studio Monitor) amplifiers feature dual power supplies to maintain full RMS power on both channels.

The B Series (Professional) amplifiers feature single power supplies suitable for most music applications.

		STANDARD	WITH VU's
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ROGERS

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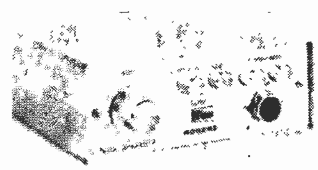
A comprehensive, versatile range of test equipment primarily designed for the measurement of high quality audio equipment but with additional applications in the electronics industry in general. The equipment is of particular interest to the professional audio engineer, recording studios, broadcasting authorities and educational establishments.

DM344A Distortion Factor Meter. Designed to make accurate and rapid measurements of total harmonic distortion generated within high quality audio amplifiers, recording and transmission equipment. **Selling Price: c/w Bench Case £175.00 + VAT.**

S324 Low Distortion Oscillator. Generates a pure sine wave and has been designed as a general purpose low distortion signal source. The primary application, used in conjunction with the DM344A, is the measurement of total harmonic distortion. **Selling Price: c/w Bench Case £80.00 + VAT.**

AM324 AF Millivoltmeter. Designed for voltage measurements in the audio and low RF ranges and principally for measuring low level signals in high impedance circuits. **Selling Price: c/w Bench Case £75.00 + VAT.**

PS1A. Regulated Mains Power Supply. **Selling Price: £18.50 + VAT.**



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*The new Rank WOW & FLUTTER Meter Type 1742

Fully transistorised
for high reliability

Versatile
Meets in every respect all current specifications for measurement of Wow, Flutter and Drift on Optical and Magnetic sound recording/reproduction equipment using film, tape or disc

High accuracy
with crystal controlled oscillator

Simple to use
accepts wide range of input signals with no manual tuning or adjustment

Two models available:
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CCIR 409-2 Specifications
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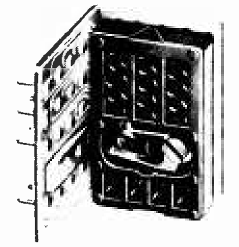
Switching problems? Rely on Zettler.

Producing 30 basic types of relay and 15.000 variants with regard to contact stacks, terminals, energizing current and contact material, Zettler is among the largest manufacturers of electro-mechanical components.

Our product range comprises:
Low profile (flatform) · Timing · Miniature · Low contact capacity · Hermetically sealed · Stepping · Mains switching · Latching Contact stacks · Solenoids



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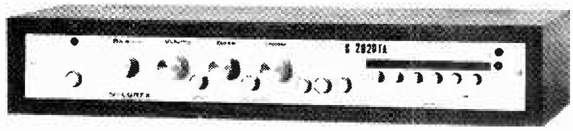
A member of the worldwide ZETTLER electrical engineering group, est. 1877

Please look us up at the International Fire Exhibition, London, 28 July-1 August, 1975. Stand No. 1, Grand Hall, Olympia.

WW—004 FOR FURTHER DETAILS

S-2020TA STEREO TUNER/AMPLIFIER KIT

NEW PRODUCT

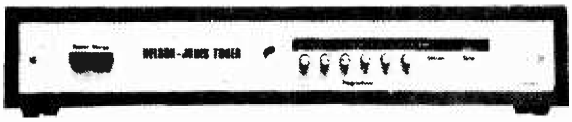


SOLID MAHOGANY CABINET

A high-quality push-button FM Varicap Stereo Tuner combined with a 20W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier: Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc), THD less than 0.1% at 20W into 8 ohms. All sockets, fuses, etc, are PC mounted for ease of assembly. Tuner section: uses Mullard LP1186 module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88–104MHz. 30dB mono S/N @ 1.8μV.THD typ. 0.4%.

PRICE: £47.95 + 99p p&p + VAT.



NELSON-JONES STEREO FM TUNER

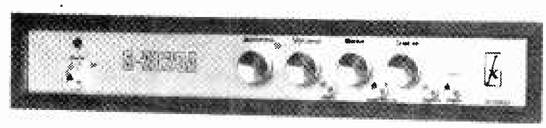
A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.

Brief Spec. Tuning range 88–104MHz. 20dB mono quieting @ 0.75μV. Image rejection—70dB. IF rejection—85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

PRICE: Mono £25.46 + 85p p&p + VAT;
With Portus-Haywood Decoder £31.96 + 85p p&p + VAT;
With ICPL Decoder £29.73 + 85p p&p + VAT.

NEW PRODUCT

S-2020A AMPLIFIER KIT



Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring.

Typ. Spec. 20 + 20W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc). Toroidal mains transformer.

PRICE: £29.95 + 99p p&p + VAT.

STEREO MODULE TUNER

A low-cost Stereo Tuner based on the Mullard LP1186 RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC. Variable INTERSTATION MUTE. PLL stereo decoder IC.

Typ. Spec. Sens. 30dB S/N mono @ 1.8μV. Tuning range 88–104MHz. LED sig. strength indicator. LED Stereo indicator. THD typically 0.4%.

PRICE: Stereo £26.32 + 85p p&p + VAT. Mono £22.40 + 85p p&p + VAT.

ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS.

SUB ASSEMBLIES

BASIC NELSON-JONES TUNER

Supplied as a printed circuit board with all components and screening box to build a varicap tuner module. Performance spec as above for complete N-J Tuner. For suitable stereo decoders see below. (Illustrated without screening box.)

PRICE: £12.88 + 25p p&p + VAT.

BASIC MODULE TUNER

Supplied as a printed circuit board with all components and screened Mullard LP1186, to build a mono or stereo tuner module. Performance spec as above for Stereo Module Tuner complete kit.

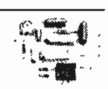
PRICE: Mono £11.11 + 25p p&p + VAT; Stereo £13.89 + 25p p&p + VAT.

PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER

Mk II version of this design (WW Sept. 1970). The lowest distortion phase-locked stereo decoder kit available (Typ. 0.05% @ N-J Tuner O/P level). Separation 40dB up to 15KHz.
Complete kit comprises PCB and all components, inc. stereo LED.

PRICE: £7.68 + 25p p&p + VAT.

PHASE-LOCKED IC DECODER



Integrated circuit phase-locked stereo decoder based on the MC1310. THD typically 0.3%. Separation 40dB @ 1KHz.

PRICE: £4.27 + 20p p&p + VAT.

PUSH-BUTTON UNIT

The six-position push-button unit used in our tuners and tuner/amp. Each track has the required diode law for stability of tuning. There are approx. 40 turns on each button and there are six separate moving pointers. An AFC disable switch is incorporated with each button. The unit is finished in black with red pointers.

PRICE: £3.00 + 20p p&p + VAT.

Please send SAE for complete lists and specifications.

INTEGREX LIMITED, Portwood Industrial Estate, Church Gresley, Burton-on-Trent, Staffs, DE11 9PT. Tel. Swadlincote (0283 87) 5432. Telex 377106.

WW—076 FOR FURTHER DETAILS

Measure airflow accurately for only £67·00

The AVM500 gives accurate and immediate metering of airflow. The standard scale is between 0 and 30 metres/second (70mph). Other calibrations can be supplied at cost.

Airflow is measured by a constant temperature bridge, supported on a lightweight probe, which is connected by cable to the meter. Operation is by battery. The AVM500 is therefore extremely quick and easy to move and instal. A recording instrument is available.

Please send details of your AVM500. I am interested in wind measurement for ....

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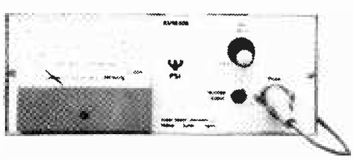
Address ....



WW4

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120 watts RMS into 4 ohms

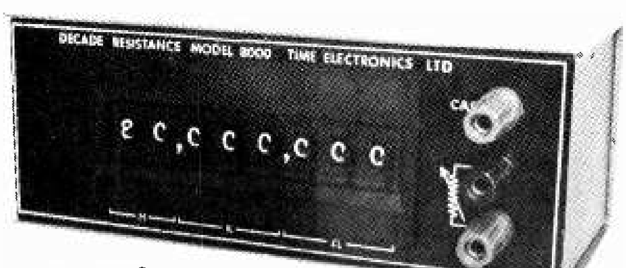
For full details on our range of mixers, amplifiers and light control units, contact:

ICELECTRICS LTD

15 ALBERT ROAD, ALDERSHOT
HANTS. TEL: 0252 28514

WW—083 FOR FURTHER DETAILS

8 DECADE RESISTANCE BOX



- ★ 1Ω-100MΩ ★ 0.1% Accuracy
- ★ Colour coded digits, Ω yellow, KΩ white, MΩ red

TIME ELECTRONICS LTD.
Botany Industrial Estate Tonbridge, Kent
Tel. Tonbridge (07322) 5993 (3 lines)

WW—036 FOR FURTHER DETAILS

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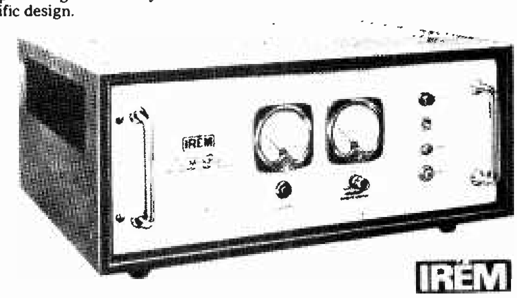

IREM

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CT 5001	40 Pin 12 Dig 4 Funct. Chain up Fix Dec Cal.	£ 1.49	3/3.95
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7403	0.11	7443	0.75	7489	1.50	74158	0.70
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7405	0.13	7445	0.70	7491	0.71	74162	0.85
7406	0.24	7446	0.85	7492	0.39	74163	0.85
7407	0.24	7447	0.75	7493	0.39	74164	0.25
7408	0.12	7448	0.69	7494	0.42	74165	1.25
7409	0.12	7450	0.11	7495	0.51	74166	1.15
7410	0.11	7451	0.12	7496	0.55	74170	1.65
7411	0.16	7453	0.12	74100	1.25	74175	0.85
7413	0.26	7454	0.12	74107	0.25	74180	0.85
7416	0.25	7460	0.11	74121	0.25	74181	2.95
7417	0.25	7470	0.25	74122	0.35	74182	0.85
7420	0.11	7472	0.21	74123	0.49	74192	0.90
7426	0.22	7473	0.26	74145	0.85	74193	0.90
7430	0.11	7474	0.26	74150	0.75	74194	0.95
7432	0.22	7475	0.37	74151	0.57	74195	0.80
7437	0.24	7476	0.26	74153	0.59	74198	1.70
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74H00	£ 0.16	74H20	£ 0.16	74H52	£ 0.16	74H72	£ 0.26
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74H08	0.16	74H30	0.16	74H60	0.16		
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4007	0.29	4020	1.15	4050	0.48	4082	0.29
4008	1.30	4021	1.10	4066	0.75	4528	0.85
4009	0.49	4023	0.21	4068	0.29	4585	1.25
4010	0.49	4024	0.85	4069	0.29		
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930	£ 0.10	936	£ 0.10	944	£ 0.10	962	£ 0.10
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LM300	TO99	£ 0.45	340U	TO92	£ 1.25	739	A DIP	£ 0.65
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305	TO99	0.60	555	V DIP	0.45	5556 (1456)	V DIP	0.65
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	TO99	0.90	562	B DIP	2.55	75450	V DIP	0.45
309K	TO3	1.45	565	A DIP	1.45	75451	V DIP	0.45
311	V DIP	0.90	566	V DIP	1.50	75452	V DIP	0.45
320K	TO 3 NEG		567	V DIP	1.60	75453	V DIP	0.45
	5.2,12,15	1.25	709	A DIP	0.22	75454	V DIP	0.45
324	A DIP	1.07	710	A DIP	0.25			
340K	TO3	2.10	711	A DIP	0.30			
	12V 1 AMP		723	A DIP	0.38			

V = Mini Dip A = 146 Dip B = 166 Dip

Data sheets supplied on request. Add .20 ea. excepted as noted.

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1101	256 Bit Ram Mos	£ 1.95
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MIN ORDER £ 2.5

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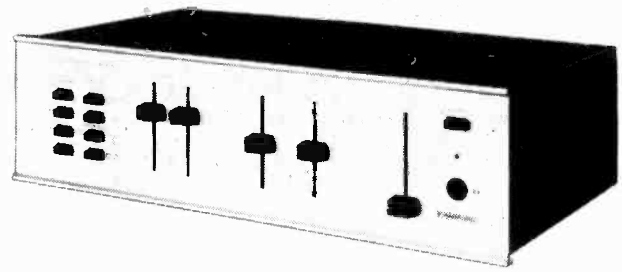
RADFORD HD250

High Definition Stereo Amplifier



A new standard for sound reproduction in the home! We believe that no other amplifier in the world can match the overall specification of the HD250.

Rated power output: 50 watts av. continuous per channel into any impedance from 4 to 8 ohms, both channels driven.

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Distortion, preamplifier: Virtually zero (cannot be identified or measured as it is below inherent circuit noise.)

Distortion, power amplifier: Typically 0.006% at 25 watts, less than 0.02% at rated output (Typically 0.01% at 1 Khz)

Hum and noise: Disc,—83dBV measured flat with noise band width 23 Khz (ref 5mV); —88dBV "A" weighted (ref. 5mv)

Line —85 dBV measured flat (ref 100v)
—88d BV "A" weighted (ref 100v)

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Dept. WW

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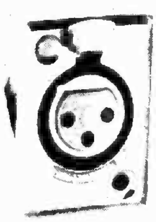

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Broadcast pattern jackfields, jackcords, plugs and jacks.

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WW—028 FOR FURTHER DETAILS

STEREO IC DECODER

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

MOTOROLA MC1310P EX STOCK DELIVERY

SPECIFICATION

Separation: 40dB 50Hz-15kHz
Distortion: 0.3%
I/P level: 560mV rms
O/P level: 485mV rms per channel
Input impedance: 50kΩ
Power requirements: 8-14V at 16mA
Will drive up to 75mA stereo 'on' lamp or LED.

KIT COMPRISES FIBREGLASS PCB
(Roller tinned), Resistors, I.C., Capacitors, Preset Potm. & Comprehensive Instructions

ONLY £3.98

WHY PAY MORE? post free

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Suitable as stereo 'on' indicator for above
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GREEN 59p

MC1310P only £2.15 plus p.p. 10p

NOTE

As the supplier of the first MC1310P decoder kit, of which we have sold literally thousands, our customers can benefit from our wide experience.

V.A.T.

Please add V.A.T. to all prices

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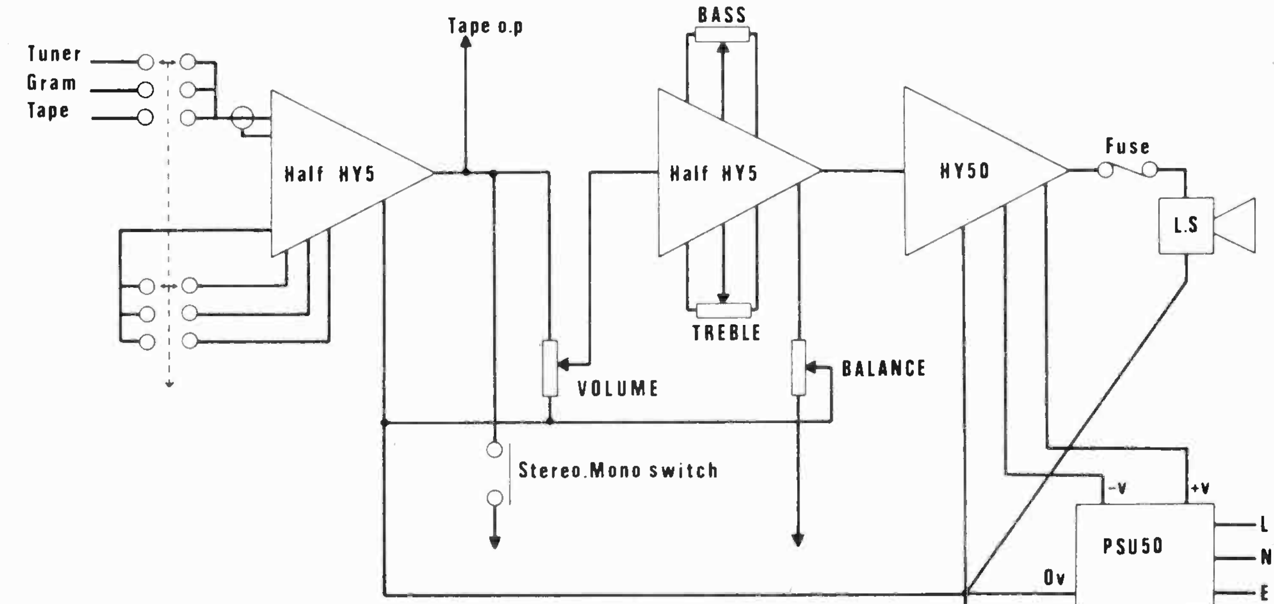
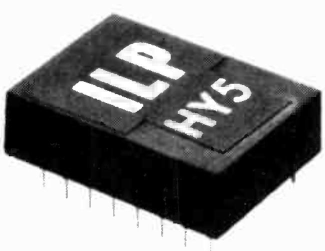
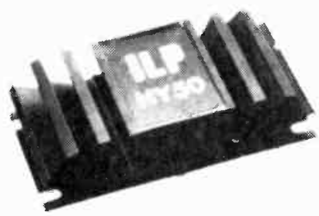
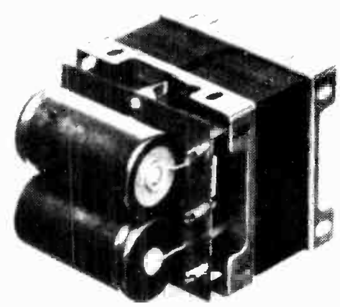


Mono electrical circuit diagram with interconnections for stereo shown







The HY5 is a complete mono hybrid preamplifier, ideally suited for both mono and stereo applications. Internally the device consists of two high quality amplifiers the first contains frequency equalisation and gain correction, while the second caters for tone control and balance.

TECHNICAL SPECIFICATION

Inputs

Magnetic Pick-up	3mV.RIAA
Ceramic Pick-up	30mV
Microphone	10mV
Tuner	100mV
Auxiliary	3-100mV
Input impedance	47kΩ at 1kHz

Outputs

Tape	100mV
Main output	0db (0.775 volts RMS)

Active Tone Controls

Treble	±12db at 10kHz
Bass	±12db at 100Hz

Distortion	0.05% at 1kHz
Signal/Noise Ratio	68db
Overload Capability	40db on most sensitive input
Supply Voltage	±16–25 volts.

PRICE £4.75 + £1.19 V.A.T. P & P free.

The HY50 is a complete solid state hybrid Hi-Fi amplifier incorporating its own high conductivity heatsink hermetically sealed in black epoxy resin. Only five connections are provided: Input, output, power lines and earth.

TECHNICAL SPECIFICATION

Output Power 25 watts RMS into 8Ω
Load Impedance 4–16Ω
Input Sensitivity 0db (0.775 volts RMS)
Input Impedance 47kΩ
Distortion Less than 0.1% at 25 watts typically 0.05%
Signal/Noise Ratio Better than 75db
Frequency Response 10Hz–50kHz ±3db
Supply Voltage ±25 volts
Size 105 × 50 × 25 mm.

PRICE £6.20 + £1.55 V.A.T. P & P free

The PSU50 incorporated a specially designed transformer and can be used for either mono or stereo systems.

TECHNICAL SPECIFICATIONS

Output voltage	50 volts (25–0–25)
Input voltage	210–240 volts
Size	L.70, D.90, H.60 mm.

PRICE £6.25 + £1.56 V.A.T. P & P free

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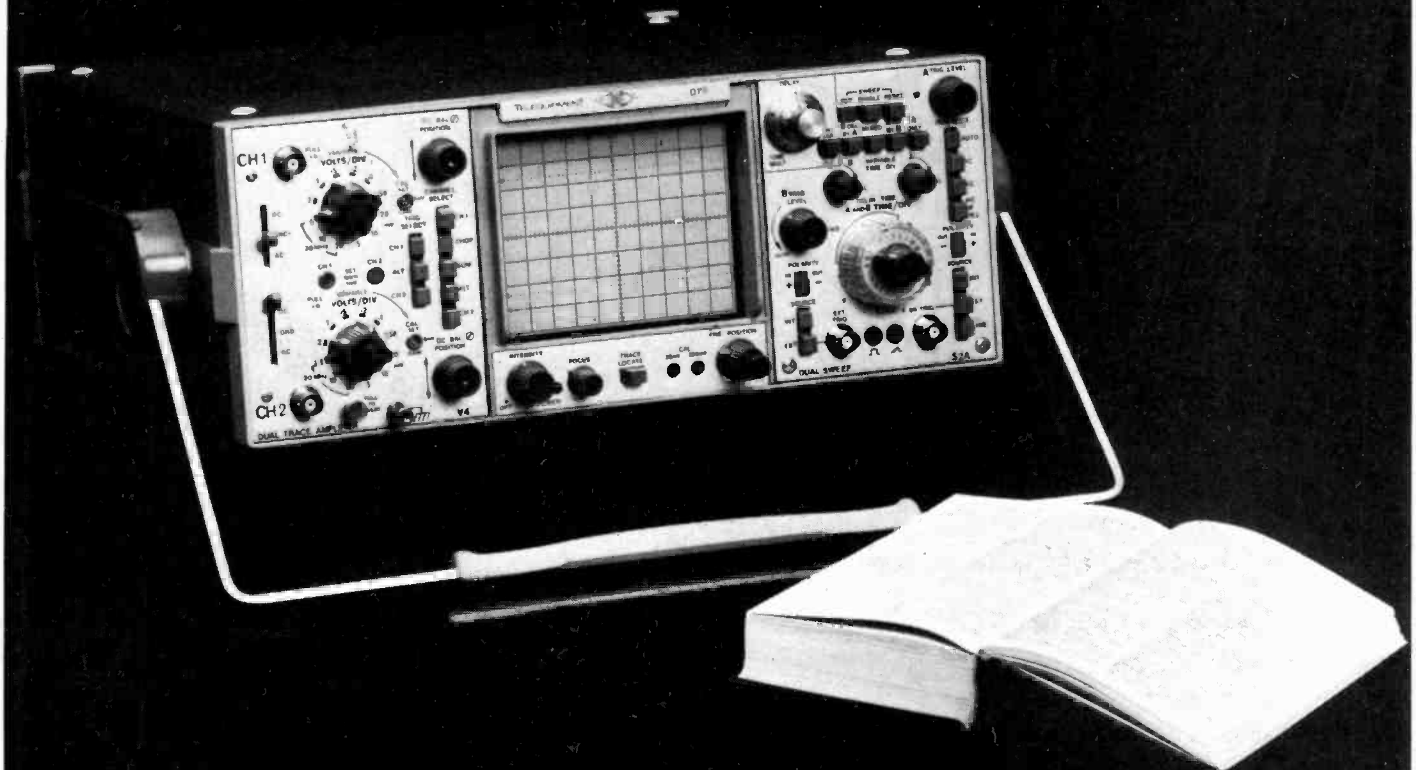

in one word

value

'Value' is an overworked and underrated word. But still the most effective way to describe Telequipment's D75 50MHz Dual Trace portable oscilloscope costing only £506.*

In more detail it is:

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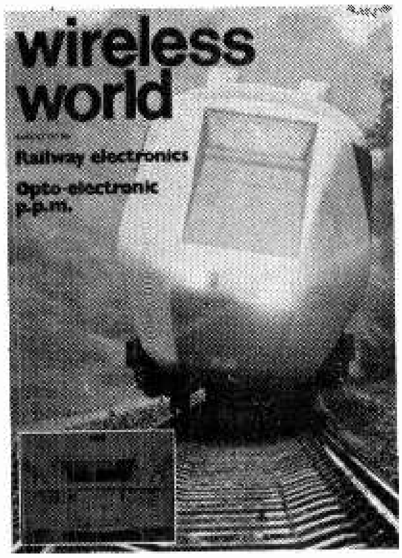

This month's front cover shows British Railways' advanced passenger train, symbolic of the achievements being made with the help of electronic systems — the subject of an article in this issue.

IN OUR NEXT ISSUE

Variable frequency oscillator. Phase-locked loop design uses discrete components and provides stability by using a low-frequency control oscillator

Radiating cables. An investigation of radiating properties for localized radio coverage in buildings and city streets.

Transmitter power amplifiers. Start of a series on the design of transmitter power amplifiers for h.f. and v.h.f. mobile radio.

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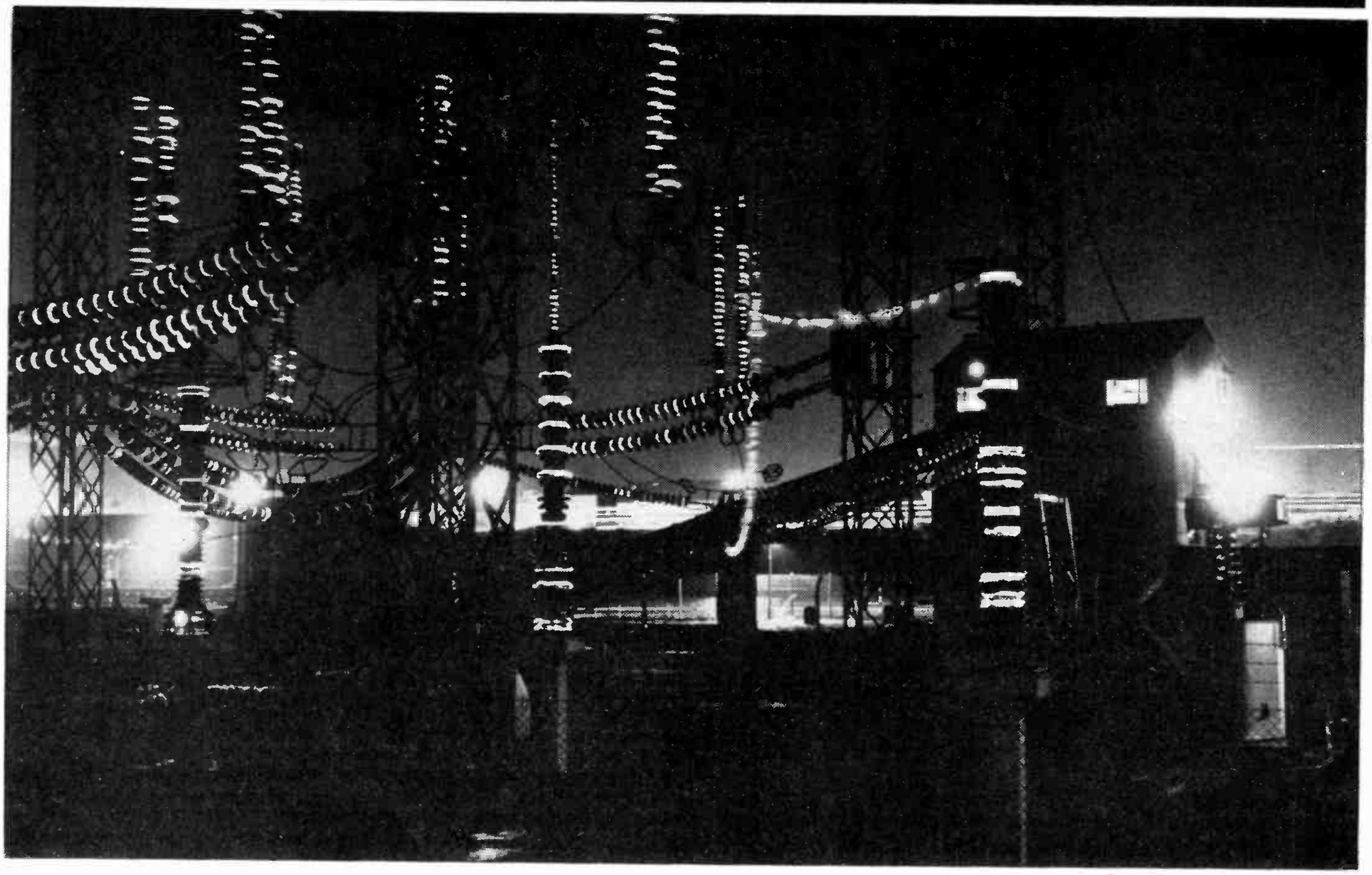

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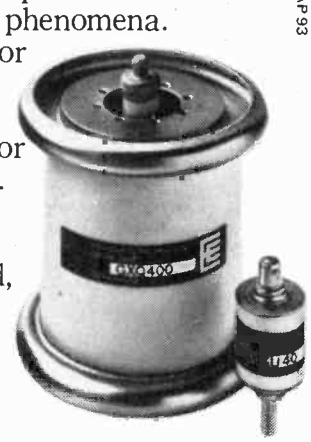

Right, GXQ400, a crowbar protection device and GXU40, for protection circuits in ground/air communications equipment.

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wireless world

Not always the spice of life

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Right from the start, the branch of technology engineers call electronics progressed faster than our powers of organization have been equipped to handle it. Every few years – and the intervals are getting smaller – some new possibility has emerged and been developed. In the last twenty years calculators, colour television, video tape recording, surround sound, various kinds of "convenience" audio tape mechanisms, noise reduction systems and others have either been invented or intensively developed.

Now workers in our kind of engineering have no lien on original thought. A high proportion of them have an interest in photography, and they may care to reflect on the number of "systems" that have evolved in recent years – 120 or 620 roll film, 35mm cassettes (half and full frame) 127, 126, 110 "instant" cartridges, Polaroid . . . and so on. But the point to bear in mind is that they are all still with us, because there is little trouble with incompatibility. One doesn't buy "programme material" – one makes one's own.

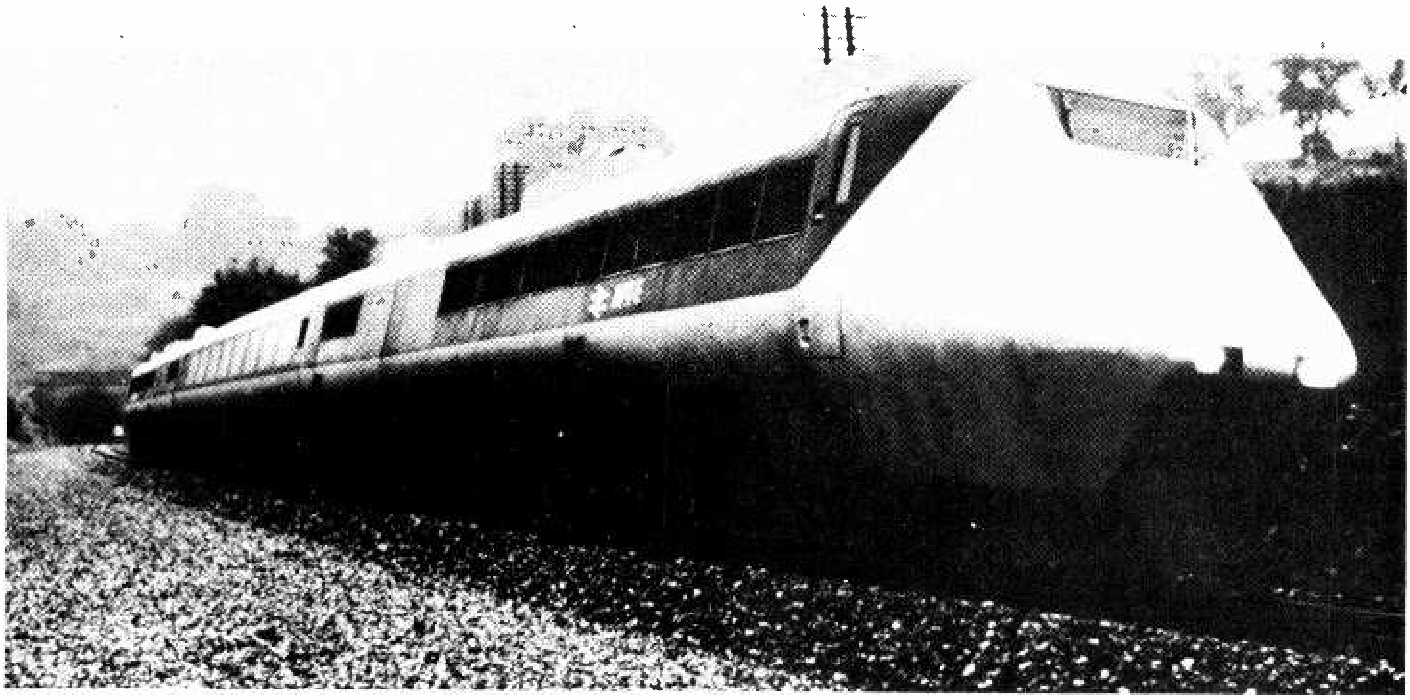
By way of contrast, it seems unlikely that losers in the surround-sound battle will still be with us in 1985, or that there will be more than one noise-reduction system available, or that the domestic video recorder people will have more than one or two kinds of machine to offer. That is inevitable, and sensible. But what happens to all the buyers of current quad equipment or domestic video? Well, they will have to write off their £500 or so "investment" and fork out again. It's very good for business.

There is no halting change, and in spite of the cynics, change – at least in engineering circles – can often be equated with progress. But would it not be a better idea to try to reach some agreement on standards *before* rushing into bulk manufacture? Because, done the other way round, it is to some extent unavoidable that the eventual agreement will be biased towards the system backed by the most lavish PR campaign – not, in our experience, an infallible guide to engineering excellence.

A polished performance in a similar situation was the choice of colour television system for Europe twelve years ago. Thorough investigations were carried out by the EBU and broadcasting authorities and, although in the end some countries agreed to differ, all the arguing was done and a choice made before the confusion and not after. People had not been encouraged to lay out several hundred pounds on the wrong type of receiver and the only complication now is the standards conversion between countries, which is no problem to the viewer.

The diversification of video recording machines and the clutter of surround-sound audio equipment is an affront. In an area where the non-technical consumer is in a poor position to make a choice, he should not be bewildered by a welter of nearly, but not quite, equivalent ways of achieving his aim. Manufacturers should take warning from a correspondent on the West Coast of America, who reports that a tour of dealers revealed hardly any with stocks of surround-sound hardware. When questioned, the dealers said that the confusion in standards has stopped the public buying and that many of the demonstrators which were built when surround-sound was first produced are now being dismantled.

Computers, communication and high speed railways



On September 15, 1830 in the reign of King William IV, the history of railway signalling commenced when the Liverpool to Manchester railway was opened by the Duke of Wellington — a soldier turned politician. The signalling system consisted of railway policemen stationed a mile apart along the track, who indicated to the driver by disciplined hand signals on a time-interval basis whether the line was considered to be clear or obstructed. By night red or white lamps were used. In 1834 the first fixed signal was erected.

From then onwards there has been a steady development in railway signal engineering. It has proceeded from two-aspect to three-aspect time interval and from two-aspect to four-aspect space interval; from flags to semaphore signals; and from upper quadrant signals to multiple-aspect colour lights. Speeds have increased from the 30 m.p.h. of the Liverpool & Manchester Railway to the present day high speed trains where moves towards a 500km per hour train are already evident.

British Railways' 240 km per hour electric advanced passenger train (APT) with its unique body-tilting mechanism, is undergoing main-line trials. The French Societe de l'Aerotrain has designed a 180km per hour electrically linear-motor driven air supported hover-train. They also have the "Orleans" air cushion vehicle capable of 280km per hour. The German Federal Government is completing a test centre at Donauriad as part of its planning for a "desirable transportation system of the future". Krauss-Maffei has already demonstrated a magnetically - supported vehicle, designed for a maximum 320km per hour and its Transrapid system, as it is called, is moving into a new phase with test vehicles reaching 500km per hour on the Donauriad track.

This article describes how the railways have been making progress in utilization of electronic systems which are now becoming more and more necessary for economy, efficiency and safety as traffic volume and speeds increase. Control and signalling for high speed trains, centralized signal-box operation, a modernized communications system and computer control for the goods fleet are all examined with an eye to the future to determine the benefits that accrue from developments in electronics.

by W. E. Anderton
Assistant Editor, *Wireless World*

The U.S. Government has allocated massive funds for high speed train research and several corporations are using the Colorado test facility for operational testing of high speed trains with air-cushion or magnetic suspension and utilizing linear propulsion. In 1973 the U.S. signed an agreement with the Soviet Union to co-operate in the field of high speed transport. The Russians have a test facility at Kiev, where linear-motored monorail cars and rolling stock are on trial, as well as air-cushion or magnetic suspension. Japanese National Railways is also experimenting with magnetic levitation and linear motors for suspension and propulsion for its second Tokaido Shinkansen line which will be needed in 1980. Its Tokaido one is already the envy of the world and has been described as the finest operating in any country.

High speed running can be achieved only with suitably designed electrical signalling systems. It has been found, however, that high average speeds on routes with many converging and diverging junctions, carrying mixed traffic, is very difficult to achieve by simply replacing mechanical signalling with electrical equipment controlled from the original signal boxes. The speed of trains and the limited view of overall operations given to each operator provides a disjointed control system and can result in very rapid build-up of delays when mishaps occur. The solution in this country has been found in centralizing control in large signal boxes having very wide areas of track under their control. Operators in these signal boxes are provided with the most modern facilities: control consoles and indicating diagrams depicting each route, track circuit, signal, switch point etc, with convenient means of setting routes; comprehensive train-describer systems which continuously display on the indicating diagram the head-codes of all trains in their correct geographical location; automatic train-identity recording printers etc; teleprinter links to adjacent signal boxes and Traffic Control offices; extensive telephone installations for communications with other signal boxes, Traffic Control Centres, station staff, shunters, train crews etc.

Typical of these new boxes, the work at Feltham represents a further step in the Southern Region's programme of using modern signalling techniques to control large sections of line from a single signal box. Forty-five boxes were replaced when Feltham came into operation at the end of last year and it now controls 351 colour light signals and 112 points in 70 miles of track in the Feltham area. The Feltham signal box is one of the thirteen which will eventually control the whole of British Rail's Southern Region.

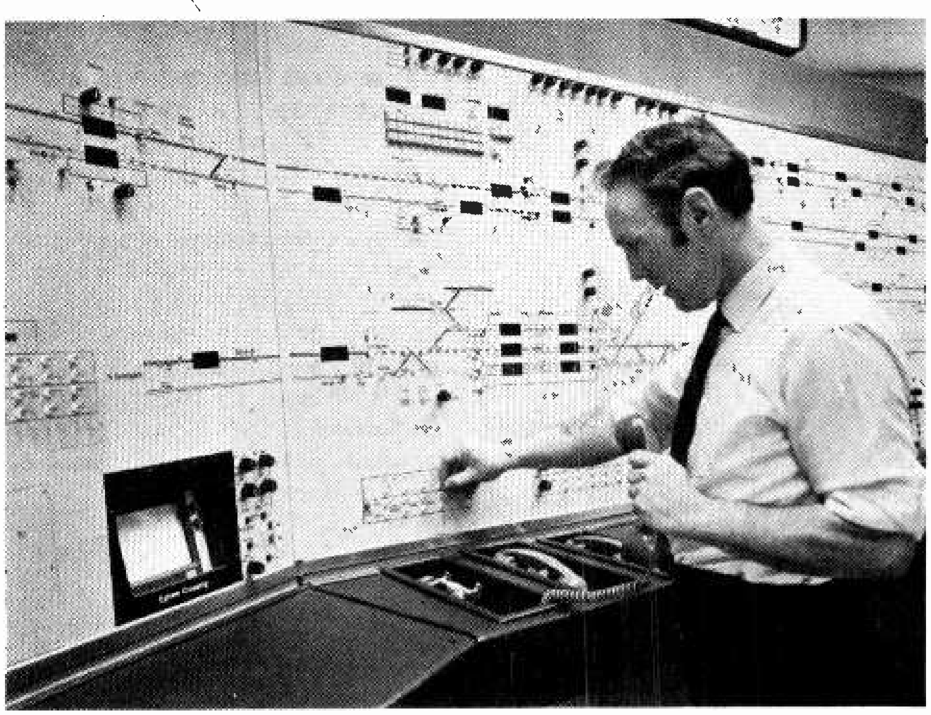
The control room houses a five section vertical control panel of the mosaic type. The panel depicts the track layout in a diagrammatic form. Level crossing, signal and points push-button switches and lamp indicators in the line of track provide white and red lights along the track showing "route set" and track "occupied" respectively. The routes are set by the signalman using an entrance/exit operating system. Two push-button switches are operated in a sequential manner and set a route from signal to signal.

The signalling console also houses closed-circuit television monitors, used to observe the road traffic over each crossing. Remote monitoring using this system is used up to distances of 21 miles. Each control panel has a diagram showing a section of the tracks controlled from the box, with push-buttons to operate the points and signals. Trains passing along the lines are shown on the diagram by red lights, while miniature cathode-ray tubes identify each train by a code number. A computer is also used to summarize and record data being continuously fed into the signal box, which is a two-level building, the lower floor containing signalling, train-description and telecommunications equipment rooms together with workshops and stores for the maintenance of that equipment. The upper floor houses the control panel and amenities for the signalmen, traffic regulators and maintenance staff located in the signal box. Information on trains entering or leaving the signalling control area is exchanged automatically between the Feltham and adjacent signal boxes using the telecommunication cable transmission system and is transmitted to the dual computer system situated at Feltham, which controls the operation of a four-digit display on small c.r.ts mounted in the signalling control panel. Progress of the trains is checked with the signal equipment and the descriptions are transferred automatically along the line of route, advance warning of a train's progress being transmitted to adjacent signal boxes. Synchronized station clocks, public address and train departure indicators are being provided on the stations within the control area, the latter two services being controlled from the train describer equipment.

Co-ordination of traffic movements is carried out by the Regulator who sits behind the operators and has a complete view of the whole of the control and indication panel while advance warning of train movements is provided for him on the teleprinter machines on his desk.

From this initial outline of the complexity of British Railways control and signalling systems it becomes clear that the telecommunication system must be wide in its scope of operational practices from providing a general telephone service for administration and control to facilities for data transmission for computer systems. This should enable railway management to achieve a competitive and efficient service for its customers.

Interior of Feltham signal box with a close up view showing one of the five track control panels.



Telecommunications

To appreciate the span of the operation in the U.K.[1] it is necessary to delve again into the recent history of railway communication. At the time of nationalization, British Rail inherited four separate telephone systems. These had all been developed independently to provide communication within each railway company, thus offering little scope for expansion into an integrated system. Financial limitations during the early years of nationalization also hampered overall development.

In the middle sixties, the Railways Board began to realize the need for efficient communication and a careful study was made into the various aspects of setting up a satisfactory and economic system that would provide all the facilities required for a modern business organization. In 1969 the Board gave authority for work to proceed in establishing a railway-owned and maintained telecommunications network. The provision of this network is known within the railway organization as the National Telecommunications Plan (NTP). The principal object of the plan is in providing an automatic extension-to-extension trunk-dialling telephone network between all business centres on the railway, as well as a good base for data-transmission services.

The nationwide small-diameter coaxial trunk cable routes consist of surface concrete troughing. The major part of the grid provides for either two or four tubes with a sufficient number of quadded conductors included as may be required for other purposes, the whole comprising a composite cable of the requisite size. The coaxial tubes are engineered to the relevant Post Office specified standard for the particular type of cable. They provide a bandwidth of 4MHz per pair of tubes or 960 high-quality audio circuits, giving a transmission performance to CCITT standards. Consideration is in hand to convert some of the line systems to 12MHz to provide for the ever increasing demand for circuit needs.

To enable compensation to be provided for attenuation loss, transistorized repeaters are inserted in the cable every 4000m and they are housed in buried metal boxes. The repeaters are power fed from the terminal stations and main repeater stations, the power feeding points being a maximum of about 70km apart. Speech channels have an effective bandwidth of 300-3,400Hz, outband signalling provided at a frequency of 3825Hz. The cables are sheathed with lead, aluminium or plastic to suit the particular conditions. They are also gas pressurized to provide additional security.

It is particularly important to reduce impulsive noise to a minimum to avoid any increase in transmission error rate. The methods employed to reduce any induced voltages to the limits specified by the CCITT include the use of special steel-tape armouring, which acts as an electromagnetic screen, in addition to a

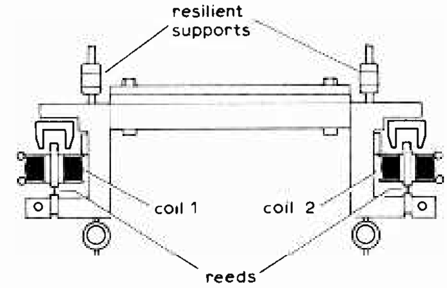


Fig. 1. Arrangement of the tuned double reed unit.

high-conductivity screening sheath of aluminium and the use of booster transformers and return conductors associated with the traction-supply path. The use of pulse code modulation is becoming widespread to provide high-grade circuits over local cables.

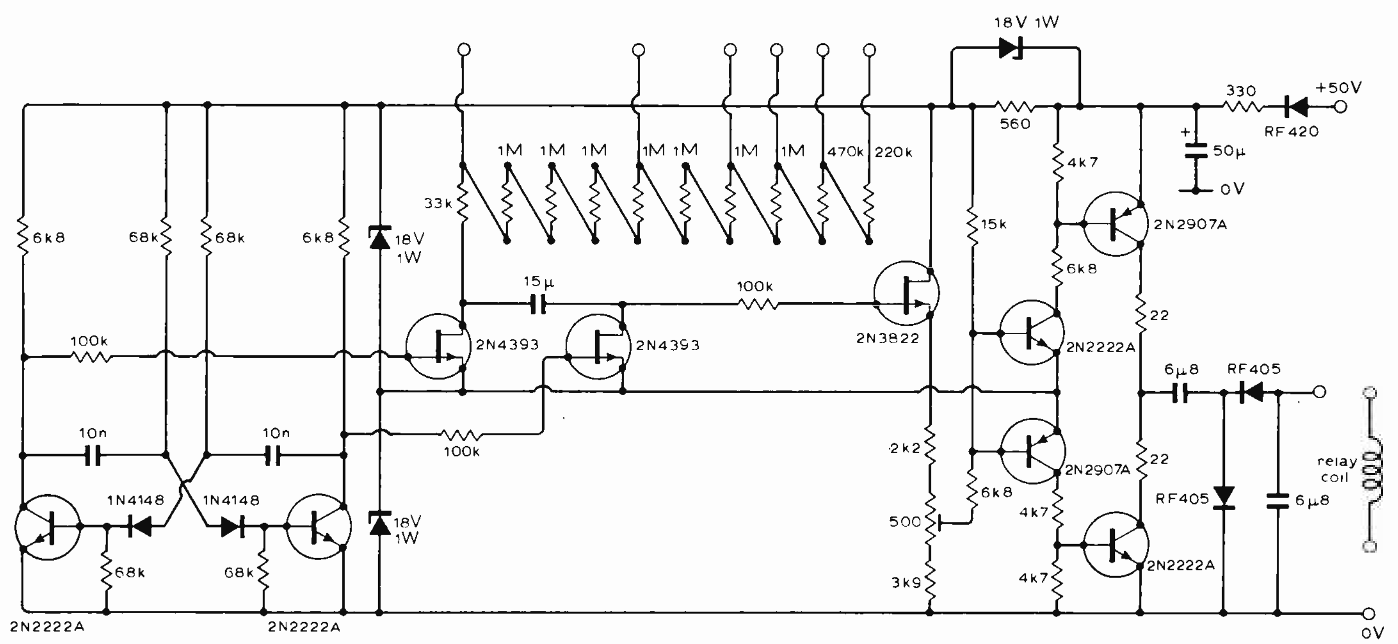
Time division multiplex systems are used only for the transmission of information that cannot affect the safety of trains.[2] Although it is technically possible to design t.d.m. systems that operate on a fail-safe principle, such systems are not economical in cost or efficient in utilization of the carrier-channel bandwidth. An alternative form of multiplexing is the well-known frequency-division method. In this method, a number of generators of frequencies $f_1 \ldots . f_n$ may be connected to a line and at distant points; receivers of $f_1 \ldots . f_n$ may also be connected to the line. The transmission of any of the available frequencies will operate the appropriate receiver. The principle is widely used where on/off data is to be transmitted. The method is not attractive when large quantities of data have to be transmitted between two points; it is most useful where the individual transmitters or receivers are required at different points, for instance along the track.

Fig. 2. Basic circuit developed by ML Engineering of a fail safe solid state timer. The timer, which is accurate to better than 5% and will provide up to four minute delays in two second intervals, is protected by ML patents.

If the components that determine the operating frequencies of the generator and receiver filter can be guaranteed not to deviate from their normal frequency for any reason whatsoever during the life of the equipment, it is possible to design an f.d.m. system of the necessary high standard of integrity. The remaining problems are concerned with the exclusion of all other sources of interference in the operating frequency band of the system, and a circuit design that cannot result in self oscillation and which continuously proves the correct functioning of all components.

The device chosen for frequency determination in both transmitter and receiver filters is a tuned metal rod that operates on the same principle as a tuning fork. These "reeds" are made of alloys that give them highly stable characteristics. Each reed is about 38mm long and 3mm diameter. A narrow neck is formed near one end, the precise size of which determines the resonant frequency of the reed. Each reed is clamped at the end nearest the neck, with the other end free to move between the poles of a permanent magnet. The reed passes through the centre of a coil and excitation of the coil at the resonant frequency of the reed causes the reed to vibrate, or conversely, vibration of the reed will produce an electrical output at the resonant frequency at the terminals.

In both transmitters and receivers, these reed assemblies are employed in pairs (see Fig 1). Each reed and clamp is mechanically coupled to the clamp of the other of the pair. To use these reeds as receiver filters, the coil of one reed is connected to line and the coil of the



other to an amplifier with a transformer/rectifier output driving a safety relay. Both reeds are tuned to the same frequency; when an electrical signal of this frequency appears on the line, the first reed vibrates causing the second to vibrate in sympathy and produce an output on the coil that will be amplified and rectified causing the relay to operate. Consider now the effect of a signal on the line that is just outside the passband of the filter or perhaps a shock to the first coil which overstresses it to the extent of changing the natural frequency of its reed. In both instances, owing to the inefficiency of mechanical coupling, the second reed will not vibrate and the filter will become inoperative.

The passband of these reed filters is between 0.65 and 0.9Hz. The frequency range of the whole system is from approximately 390 to 890Hz. To eliminate the possibility of false operation by induced signals from neighbouring power systems, channel frequencies in the bands covered by the odd harmonics of the supply frequency are not used for safety functions. This still leaves 51 available channels for full safety circuits and the remainder are available for non safety circuits such as indications. Transmitters and receivers can be arranged to transmit in either direction on one pair of wires, giving a full duplex system. Maintenance of reed equipment is simple and consists of interchanging plug-in units. Failure rates of channels are approximately 1.2% per 1000 hours.

Computers in control

The object of the Total Operations Processing System (TOPS) which started operation in 1973 is to increase the efficiency of handling of the British Rail goods fleet which will be reduced to 175,000 wagons by 1976 while the freight tonnage is estimated to increase from the present 200 million tons to 220 million tons.

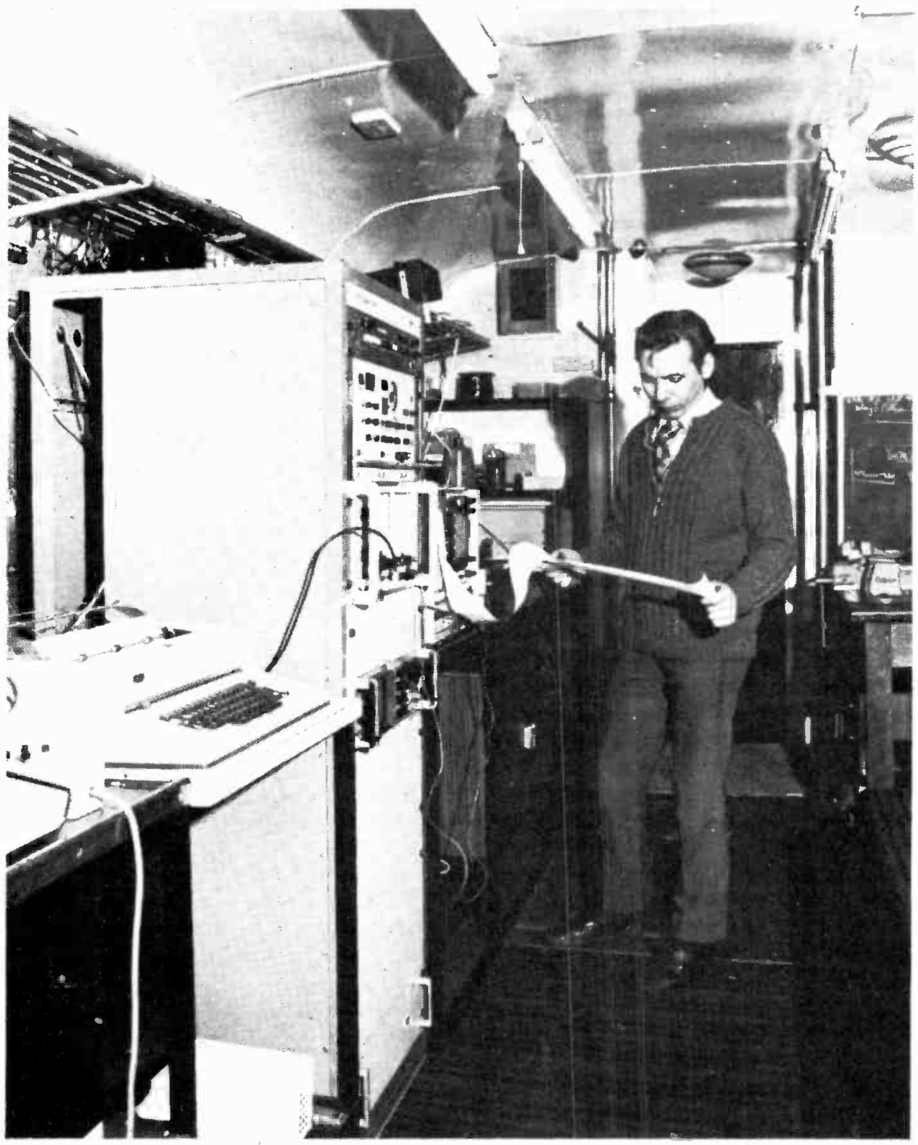
International Aeradio's contribution to the programme involved the manufacture and installation of a comprehensive set of data signal processing, switching and monitoring equipment which is situated between dual IBM 370/165 computers installed close to the BR headquarters at Marylebone and remote data terminals which are located at the numerous freight terminals and area headquarters. The complete data communications network (which utilizes the national telecommunications network) is controlled from a monitoring console and enables controllers to monitor the performance of each of the low-speed and medium-speed data paths.

Where circuit degradation occurs, the system enables data path re-routing to be carried out both within the main control centre and at the remote terminals.

The central processing unit requires

British Rail's mobile radio laboratory, test coach Iris, which has been equipped by the Research & Development Division to carry out radio system survey work anywhere on the network. Its first task was to evaluate the performance of a possible system of track-to-train communication which overcomes the loss of signal problems experienced with normal radio links, particularly in tunnels and cuttings.

View of the data processing equipment inside test coach Iris (see text).



to receive messages at the data transfer rate of 188,000 characters per second in a parallel mode. It therefore demands a large number of high-speed bursts of information over a short-distance, wide-band channel. In contrast, the field data terminals operate at a relatively slow speed, 134.5 baud, in a series mode over narrow-band long-distance links. To ensure a steady interchange of data, a series of communication multiplexers are connected between the links and the computer. The multiplexers have a multichannel input with the capability of interconnecting a number of low- and medium-speed circuits with a main wideband output to the computer.

Transmission over the long-line system is frequency division multiplex, the voice frequency signal conversion to binary code being achieved by using modem data sets situated at the ends of the line circuits. The low speed modems are frequency stockable to enable up to eight data channels per audio line to be realized. In addition, facilities are provided at remote transmission centres to combine local data links into their allocated frequency slot in the audio band line.

TOPS is just one of two or three major systems for which there are opportunities for further development with respect to computer control in automatic route setting and train regulation.[3] Another major new project, the production planning system, will be less obvious to the public as it concerns the succession of activities between the specification by the Passenger and Freight Marketing departments of the train services to be provided and the publication of the timetables, working instructions, locomotive programmes, station platform arrangements and the hundred and one other documents necessary for the day to day running of the railway. The application of computers to this process requires a whole series of interlinked systems and the main stages will be as follows: allocation of track capacity; allocation of locomotives; allocation of train crews; and preparation of documents. In the allocation of track capacity, as an example, the computer will calculate the fastest available path within the speed restrictions imposed by the track, the nature of the train and the movements of other trains, and will display this on a v.d.u. screen or graph plotter. The timetabler will then decide whether any train should be switched to an alternative track or held at a signal to allow another to pass and sends a decision message to the computer.

The introduction of a national seat reservation system, heavily reliant on computer processing and information storage is a must for the smooth and efficient operation of high density, high speed passenger services in the future. British Rail seem slow to make progress in this field, but the problems are largely political rather than technical.

The essential reservation system requirements designed to meet future conditions are for equipment and procedures to handle high volumes of information and a capability for providing passengers' requirements quickly up to the latest time practicable prior to train departure. The system would not only provide the best possible customer service, but at times when demand for seats exceeds supply, would ensure that only the requisite number of reservation tickets is issued for a particular service, thus providing the essential measure of control necessary.

A computer reservation system can fulfil the basic requirements of making reservations quickly and once the customer's requirement is established at any sales point equipped with a computer terminal, issue of a reservation ticket can be effected virtually instantaneously.

The design of the proposed computer system will consist of computers at the central site, holding files of fares and inventory information, connected by telecommunication links for data transmission with computer terminals located at sales outlets. Equipment at sales points, mainly BR stations, will consist of: a keyboard, for entering details of the reservation required; a

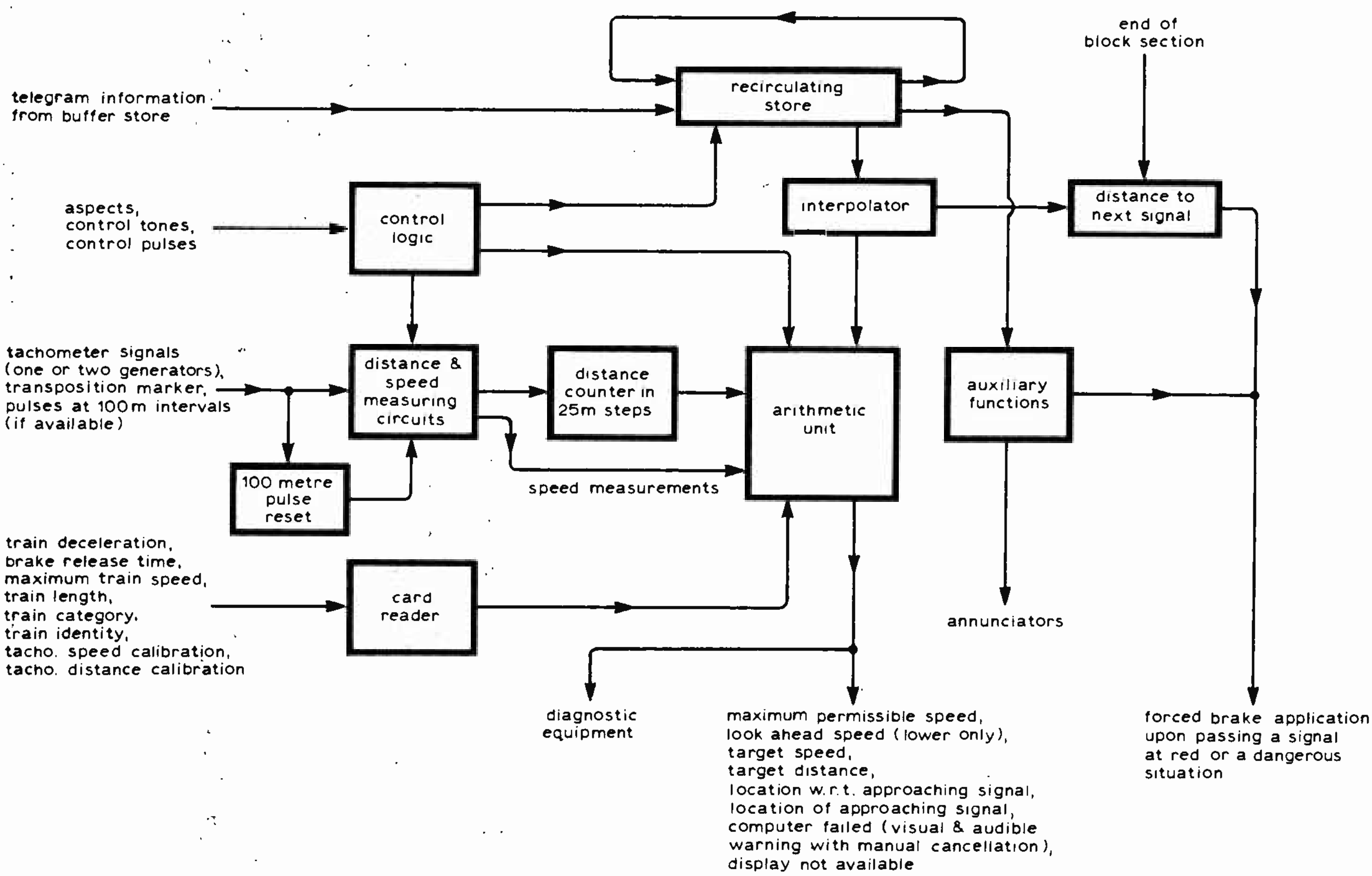


Fig. 3. Main processor for train-borne equipment in a possible speed supervisory system. The maximum safe speed is calculated from track conditions and the driver warned if he exceeds it. If the warning should be ignored the train will automatically be brought to rest.

ticket printer; and a visual display unit, which provides information to the operator.

Leaky feeders

A possible system of track-to-train communication which overcomes the loss of signal problems experienced with normal radio links, particularly in tunnels and cuttings, is under examination by BR's Research and Development Division. Several leaky coaxial cable types, each with a different braid pattern, are being tested for optimum efficiency at operating frequencies of 46, 86, 138 and 460MHz. For the tests, a 1W signal is fed into a cable strapped to the wall of a tunnel along a stretch of test track. Signals are analyzed by a mobile laboratory, known as test coach Iris, which has been equipped to carry out radio system survey work anywhere on the network.

The sampling rate of an analogue to digital converter which accepts the received signal on board Iris is dependent on wheel-velocity so that the reception bandwidth and accuracy of information received is known and constant. A point worth noting here is that radiation from a leaky feeder is not literally through the holes or imperfections in the outer braid. These imperfections, however, do cause an imbalance in the signal current flowing in inner and outer conductors. The result is therefore a radiated signal. Both data and speech communications can be handled and a single cable can serve a number of parallel tracks.

Two parameters are used to specify the performance of a cable: the longitudinal attenuation per unit length of a cable; and the coupling loss between the cable and antenna. For a complete definition of coupling loss,[4] the arrangement of the cable, and the mobile antenna and its type, together with the distance between the two must be defined, cable attenuation in dBs being approximately proportional to the square root of frequency. For minimum attenuation and hence minimum fixed station equipment per unit length of cable the frequency should be as low as possible. Coupling loss varies with frequency; increasing by about 10 to 20dB from 40 to 500MHz. From this it can be seen that optimum frequencies are in the low v.h.f. region. Frequencies below 30MHz are not really practical except in completely underground systems. Naturally propagated radio signals follow an inverse square law, where a 6dB or four times power increase gives a doubling in distance. Cable systems follow an inverse logarithmic law and a 6dB power increase will give a range increase of only 100 to 300m. Power is therefore not as important a factor as with conventional radio systems. Work has been sponsored partly by the International Union of Railways (European members each contribute to different aspects of research, BR's involvement being with leaky feeder communications) and help has been received from the Coal Board on repeater development.

Another aspect (sic) of work by BR's Research and Development Division at Derby is for a new four-aspect signalling system which could be flexible enough to provide major advances in the field of automatic high-speed train control.

The communication system consists of short stretches of an inductive loop laid between the rails and is based on the tuning-fork tone generation that has been described. The loops at present carry 160mA but this is being reduced to 60mA (remember that a traction rail can carry more than 10,000A).

The driver is supplied with visual information on the particular aspect which he is approaching and must acknowledge by pressing the appropriately lit, appropriately coloured button, otherwise the brakes are automatically applied. A separate colour display in the cab also confirms the aspect after a signal has been passed.

One major problem encountered during development was in deciding whether or not received information was valid or not, depending in which direction the train was travelling. This was overcome by an elegant application of the Poynting vector principle – polarity of the vectors between magnetic and electric fields (which is sensed) depends on the relative position of the power supply.

New signalling developments

An even more advanced system under development can supply the driver with maximum speed information and also any approaching speed restrictions. Failure to comply with speed restrictions, after a short time delay, results in the brakes being automatically applied and the driving system shut down. Another system for collecting trackside information and feeding this to the train driver is by means of transponders fastened to the sleepers. As the train passes over a transponder, it sends an inductive signal to the device which absorbs some of the energy and uses it to "talk" to the train by sending back a coded message. This message can identify the train's exact location and contain other information such as the existence of any speed restrictions which might be coming up. Each transponder requires no maintenance as it uses no internal or external power supply.

Test Coach Mercury has recently been hitching a ride on Inter-City express trains to test such a system between London and Birmingham. Signals at a frequency of 150kHz are transmitted from the coach's underfloor aerial about 18 inches above ground towards the transponders. On receipt of the signal, the transponder uses some of the received energy to generate a 24V d.c. supply to power the solid-state circuitry which generates a coded 75kHz signal which is transmitted back to the train. The code is in the form of binary coded decimal numbers. These numbers are built into the transponder at manufacture and with the availability of 80 bits for coding, the number of combinations is high.

It will be possible to use stored speed supervision information on the train which would be read from store as the train progressed on route. In order to ensure that the store was keeping step with the actual running of the train, uniquely identified transponders would act as position markers. Readings from them being checked against the same information from the store. Speed information would only be displayed to the driver on direct correlation.

Fail safe

Behind all developments and operations to do with railway transport whether mechanical, electrical, organizational or whatever, there is one overriding philosophy, the prime requirement of fail-safe operation.[5] The change in conditions that has occurred with the abolition of so many of the manual and mechanical features and their substitution by automatic electrical or electronic systems is now rapidly approaching the point where little responsibility can be counted upon from the human element and the machine must be capable of accepting full responsibility for safety.

A definition of the term fail safe that has been offered is "a design quality of mechanical and electrical signalling equipment and of the system within which it is used, that under failure conditions will provide safety for traffic." The major contribution made by electronic developments in communications, signalling and computer control, apart from economic control of a system that is making more and more operational demands, is in the reduction of failure-rate within the bounds of the fail safe philosophy and thus providing for Britain a system that can be run with efficiency and safety.

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2. Barker, P. J. "Train control and signalling methods," *GEC Journal of Science and Technology*, Vol. 39, No. 2, 1972, pp.70-75.
3. Bowick, D. M. "Computer Systems Impact on Railways," *The Chartered Institute of Transport Journal*, Jan. 1975, pp.179-185.
4. Cree, D. J. "Railway Radio Communication using Radiating Coaxial Cables," paper delivered at the Intex International Conference, Liege, Belgium, April 1974.
5. Hadaway, H. W. "Fail Safe," paper read at the Institution of Railway Signal Engineers, Feb. 9, 1967.

New domestic equipment

A report on innovations in and around the domestic electronics trade shows, 1975

It's bigger, better, brighter and, most importantly, more expensive – seemed to be the theme of this year's trade shows. The underlying reason for these superlatives lies in the surprising range of technical innovation demonstrated in new television sets, radios and hi-fi equipment on display.

Television

The most noticeable trend in television sets was the tendency towards period cabinets, of which examples were shown by most of the large European manufacturers, the increasing use of precision in-line tubes (p.i.l.), and a large number of remote control devices. In addition, at least four manufacturers showed examples of service aids which could be directly connected with a TV chassis, and which would show on a panel marked with block diagrams of the set circuit whether correct voltage conditions were obtained at the relevant points around the circuit. These service aids were being offered by Körting Transmare, Loewe Opta, Grundig and AEG Telefunken.

The Grundig model Color 6022 television set is a new 26in version with rather unusual facilities. The only control externally visible is the on/off button. All remaining controls are relegated to a remote unit carrying buttons for the selection of up to 12 channels – colour, contrast, brightness, volume, sound mute and a stand-by position. The last-mentioned allows the suppression of both picture and sound, leaving mains connected to the set ready for instant turn-on when the stand-by button is once again operated.

New from ITT, is the feathertouch de luxe model 103, using the standard CVC 9 chassis, and the touch-control unit developed for the other three Feathertouch models. The model 103 has a 26in tube, and is housed inside a teak cabinet with a tambour door.

Precision in-line tubes featured large in Körting's new 20in model which uses a chassis standardised for all three units. An additional feature provided in the 20in p.i.l. TV set, is sockets for headphones and a connexion for external video cassette recorder.

The models AEG Telefunken introduced at their show, included a 22in, 90° hybrid table model, the PALcolor 634, and a 110°, 26in tube model, the PALcolor 743. The latter includes touch tuning up for to eight selected stations, of which the eighth station can be used alternatively for an input from a video recorder. A wired remote control unit can also be connected via a rear mounted panel socket. Two models, the PAL 783 and the 884, provide for remote control using an ultrasonic control unit and, again, an additional socket for video recorder is available on both of these sets.

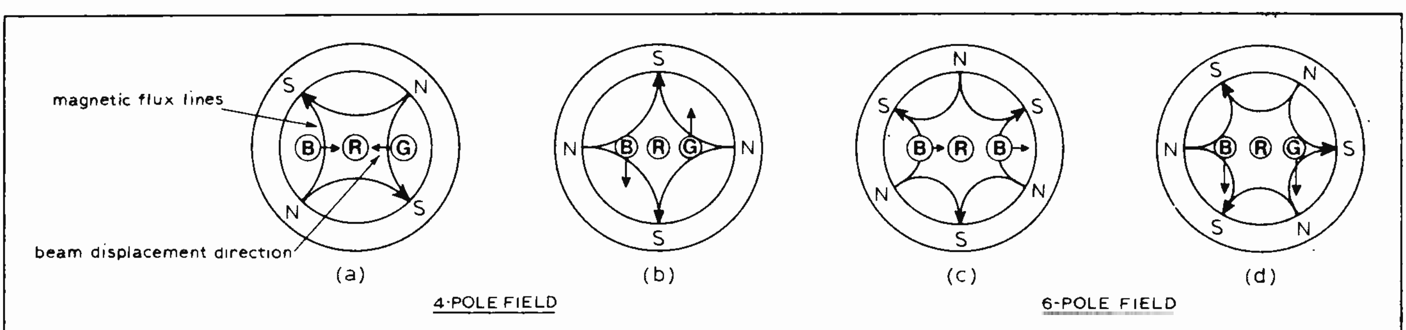
Philips appear to have gone in a very similar direction to AEG Telefunken and Körting, and have introduced a new 26in 110° colour television set, the model 585. This unit also offers touch tuning, and remote control for channel selection. A preview was also offered of the Teletext decoder forming part of a 26in colour television set, and featuring page selection by thumb-wheel numerical switches. Regrettably, this set did not appear to be functioning well at the time and so no assessment of quality of the decoder could be made.

The display of products put on by Pye, included a new colour television receiver with 26in 110° tube. In addition, two new television sets, the CT236 and the CT232, also utilised 110° tubes. The CT236 employed a high-speed warm-up tube, said to give a picture within seconds of switching on. In a separate exhibit the Pye Labgear TV-aerial equipment was displayed, including the CM7000 series of head-end amplifiers. These amplifiers are principally designed for use with wideband cable television systems, the CM7000/HE model being a high level, head-end amplifier for v.h.f./u.h.f. and providing separate gain-controllable inputs on all bands. A second amplifier, the CM7006/WR, is a double outlet repeater amplifier, again for use with wideband systems operating within the frequency range 40MHz to 860MHz.

Of all the innovations in television receivers shown at the trade shows, the precision in-line, slot-mask tube was the most obvious. Until now, few models have been shown or marketed here in the UK using this type of tube. Originally developed by RCA in America and reported in *Wireless World* in 1972, the precision in-line tube has been taken up by such companies as Thorn and Mullard, with other manufacturers adopting the design in Europe and Japan.

The principal features of the precision in-line tube reside in the mask which is

Fig. 1. Fields produced by the convergence-magnet rings, used on the newly-adopted p.i.l. tubes, showing beam movement with ring rotation.



an arrangement of vertical slots instead of the conventional dot shadow mask arrangement used widely until now. In addition, the electron gun is arranged as a horizontal array in a 29mm neck. Finally, deflection is achieved by a precision toroid static deflection yoke, in which the coils are mechanically wound, to permit individual placement of each wire into an accurate position. The yoke is permanently locked on to the tube during the manufacturing process, the position being precisely determined by automatic adjustment devices. The design of yoke and the adjustment technique adopted during the manufacturing process ensure that purity and convergence are optimized for each individual tube. Final adjustment of static convergence and purity is achieved with the use of several ring magnets located on the neck of the tube. These ring magnets are constructed in the form of four plastics rings containing individual barium ferrite magnets. This substance has the unusual property of having a permeability close to 1, a valuable feature in view of the potential interaction with the yoke field, which is in close proximity. Two of the rings produce a four-pole field as shown in Fig. 1, the other two producing a six-pole field. The location and geometry of the field is shown in relationship to the three electron guns and also demonstrates the direction in which the beams are moved with rotation of the magnets.

A major advantage to be obtained from this form of combined tube assembly and yoke is that no convergence adjustment need be made on tube replacement, since all this has been factory preset. Replacement of the tube is simple and consists of removing the tube socket and e.h.t. anode connector, disconnecting the wiring to the scanning yoke and degaussing coil and also the chassis connexions to the metal degaussing assembly. The tube can then be removed and the plastic tie wraps which attach the degaussing assembly to the ring band can be cut to release it. A replacement tube can be refitted into the degaussing assembly and the entire assembly replaced into the set quickly and simply, thus making the servicing operation cheap and rapid.

Audio and radio products

Almost all manufacturers having a foothold in the hi-fi field, and also making radio and television products, were showing additions to their range of audio and radio equipment. In some instances it was obvious that the trend was towards considerably higher priced ranges, this being justified by the buoyance of the more expensive end of the market. Typical among such manufacturers was Sony, who introduced several extremely expensive products called the Super Hi-Fi Range. Almost every one of these products has some technological innovation. For example, a direct drive turntable model ES4750

Fig. 2. New loudspeaker from Technics has been designed to provide as linear phase response as possible (see text).

had a cabinet made of reclaimed plastics material with the curious description of SBMC (Sony Bulk Moulding Compound).

Somewhat cryptically, the product brochure describes SBMC as a material combining toughness with a lightweight and attractive appearance and suggests that it is already known that the substance is remarkable free of resonance associated with wood and alloy constructions found in conventional turntables. It was evident however, that in turntable design, Sony have been particularly anxious to overcome some of the mechanical feedback difficulties which have been a problem with turntables in the past.

In the model PS4750 turntable, the disc is supported by a series of flexible circular rubber pads with a cup shaped cross-section providing a highly compliant damped suspension for the disc. The companion model direct drive turntable, the PS6750, uses a liquid-filled turntable mat with the same objective in mind. An explanation offered for this level of sophistication, by a visiting Japanese engineer from Sony was that the disc itself can vibrate in resonant models, when excited by the stylus tracing high level modulation in the recorded grooves.

A further trend towards the use of unusual materials was evidenced in the tone-arm of the PS6750 turntable, which was also made from SBMC and said to have properties which reduced low frequency howl round. It was obvious from an examination of the arm design that some considerable reduction in effective mass had been achieved from the use of this material. Just how the arm relates in terms of performance to the best of European arms can only be judged on closer examination. However, the Japanese have long been aware of the preference for certain arms manufactured in Great Britain, and have been occupied in a serious study of the design of suitable new arms, capable of realising a good performance with the very high-compliance cartridges available today.

During the course of the trade show it was discovered that two other manufacturers, Pioneer and Technics, are also marketing similar carbon fibre arms in Japan.

Carbon fibre formed the basis of one of the design changes in the cones and domes of the drive units of two new loudspeakers from Sony, the SS5050 and the SS8150 units. Here carbon fibre is mixed with a normal paper pulp producing a random stiffening web of threads in the pulp when the cone is shaped in the normal vacuum forming process. Despite the obvious technical achievement that was represented in these two loudspeakers, perhaps the most remarkable aspect was the price of the larger of the two units, the SS8150, which was optimistically quoted at "approximately £1,500 per pair"!

In the same price bracket was a new professional tape recorder, the TC 800-2, priced at £1,200. This machine has unusually large programme meters switchable to v.u., p.p.m. or p.p.m. hold characteristics. The input and output attenuators are step calibrated, but perhaps the most noticeable feature of all, signifying a new development in reel-to-reel tape, the bias and equalisation switching provides for ferrichrome tape.

In explanation, ferrichrome tape is of a dual layer construction, in which the first layer coated on the base foil, consists of conventional ferric oxide formulation, followed by a thin surface layer of chromium dioxide. This type of tape technology was introduced in 1973 by Sony in Japan, as a cassette tape.

Other technical developments

Linear phase loudspeakers, or perhaps more correctly minimum phase loudspeakers, made some of the more important news at the trade shows, as far as high fidelity reproduction was concerned. Earlier this year proposals for linear phase loudspeakers had been made by Bang and Olufsen and it is now understood that these are to be released in the autumn of this year. The Bang and Olufsen units are of a relatively modest size and externally bear some similarities to other speakers on the market, inasmuch as the cabinet is of fairly conventional appearance and rests on a metal stand some 18in or so high. However, there the resemblance to other loudspeakers ends, since removal of the front cover reveals an angled panel similar to that used by Bang and Olufsen in their earlier wall mounted loudspeakers.

Both the front and back panels of the B&O Uni-phase loudspeakers are plastics moulded. The crossover network has been briefly described in our earlier report on the AES 50th Convention in London.

These loudspeakers were not displayed at the trade show, in fact there was little news forthcoming of them. However, shortly after the shows, telephone conversations with B&O revealed their intention to release the Uni-phase loudspeakers in the near future.

The linear phase loudspeakers that did make an appearance at the shows were from Technics by Matsushita and distributed by National Panasonic (UK) Ltd. These units are considerably more unusual in their appearance than those being offered by Bang and Olufsen, and are illustrated in the accompanying photograph. Little is known about how Technics achieved the minimum phase characteristics in their loudspeaker since not only is it a three unit system whereas the B&O is a four unit system but also, B&O have patent applications pending on the "filler driver" principle of obtaining phase-linearity in a loudspeaker crossover, with high rates of roll off in the base and tweeter units.

It is therefore suspected that a simple 6dB per octave crossover unit is being used by Technics, although this would be quite surprising since it is somewhat of a reversion to techniques used by manufacturers 15-20 years ago! Nevertheless, this type of crossover is capable of giving a minimum phase performance, provided that the drive units themselves also meet this requirement. However, using such a low rate of roll off requires drive units capable of providing a performance over a far greater extension of frequencies than is normally encountered in modern drive units. Undoubtedly the Technics drive units are of a very high standard, and comments made by those who have heard the loudspeakers suggest that Technics have achieved a very high standard.

As yet, little is known about the importance of phase linearity in loudspeakers and for this reason *Wireless World* plans to publish an article on the subject written by the engineers involved in the development of the Babg and Olufsen product.

In conclusion, mention should be made of at least one or two of the cassette recorders seen in the Hitachi display and that of Johnsons of Hendon, marketing the Aiwa brand. The former is an interesting design, since it provides a three head function with only two head units. The normal record/replay head is replaced by a single unit containing two heads, a separate record head with its own gap and alongside, in the same can, is the replay head with its own gap.

The advantages to be gained from this form of construction, are that optimum gap proportions can be obtained for the two functions, instead of resorting to the compromise found in conventional two head recorders. Details have not yet been released about the structure of the head itself, which must have presented quite a considerable design problem to the Hitachi engineers.

Mention should also be made of a new head introduced into a cassette recorder by JVC. This is a Sendust type and said to have performance superior to that of its ferrite counterpart. The Aiwa cassette recorders were of interest not only because of their performance, or the fact that they have offered machines which also follow the fashion for front loading techniques, but because the method of loading and unloading revealed rather interesting features in the way the cassette is handled.

One of the two cassette recorders, mounted in a music centre, required that the cassette be posted vertically down into the front lid of the machine. The lid would then be pushed forward to close and locate the cassette. At the termination of the recording, when the eject button was pressed the lid, instead of flying open depositing the cassette in one's lap, lowered gently under the influence of an oil damping arrangement and the cassette slowly rose an inch or so out of the holder.

There were several other interesting features about this product, but regrettably lack of space permits only a mention of their other front loading cassette recorder which, when the cassette is placed in the front lip of the cassette holder, "gobbles" it up mechanically, and lowers it gently on to the transport platform. Ejection of the cassette reverses the procedure.

B.L.

Literature Received

CATALOGUES

The complete 1975 list of publications and "book-kits" by the prolific Tab Books organisation is available free from Tab Books, Blue Ridge Summit, Pensylvania, U.S.A WW401

The new Guest Distribution catalogue is now available, which covers passive components, electromechanical products, semiconductors, tools and production equipment. Guest Electronic Distribution Ltd, Redlands, Coulsdon, Surrey, CR3 2HT WW402

PASSIVE DEVICES

A large range of transformers — power, audio, pulse, etc. — is described in a publication issued by Tridem Transformers and Electronics Ltd, Mill Stream Industrial Estate, Unit No. 8, 156A Christchurch Road, Ringwood, Hants, BH24 3SD. WW403

Five leaflets from Astralux describe the company's ranges of reed relays, plugs, sockets and jacks, with complete functional and dimensional information. Astralux Dynamics Ltd, Brightlingsea, Colchester, Essex CO7 0SW WW404

EQUIPMENT

Bosch have published a new catalogue, containing full descriptions of their Blaupunkt range of car radios, cassette and cartridge record/playback units and accessories. Publicity Manager, Bosch Ltd, P.O. Box 166, Rhodes Way, Watford, WD2 4LB WW405

A leaflet describing the Pitman Model 235 Isotope Localization Monitor (a scintillation detector and ratemeter for medical use) is available on application to Pitman Instruments, Jessamy Road, Weybridge, Surrey, KT13 8LE WW406

A full range of transducers and instrumentation for the audio band of frequencies is described in the 1975 B & K Short Catalogue, now obtainable from B & K Laboratories, Cross Lances Road, Hounslow, TW3 2AE WW407

We have received a leaflet describing the ERSA VAC 40 vacuum de-soldering tool and portable vacuum pump, which is said to be useful for either small or large holes in printed-circuit boards. Greenwood Electronics, Portman Road, Reading RG3 1NE WW408

The solid-state motor controller, Type 721, for use with d.c. shunt motors of up to ¼ h.p. is described in a leaflet now obtainable from Solid State Controls Ltd, Brunel Road, Acton, London W3 ..... WW409

A leaflet from Moore Reed is now available, describing the range of permanent-magnet d.c. servomotors, with their performance curves. Moore Reed & Co Ltd, Walworth, Andover, Hants, SP10 5AB WW410

We have received a brochure on the range of studio colour picture monitors made by the Belgian BARCO company. Monitors and brochures can be obtained from Crow of Reading, P.O. Box 36, Reading, RG1 2NB WW411

GENERAL

A 12-page edition of the IBA Transmitter Pocket Guide, which contains details of 246 u.h.f. stations (existing and future), 47 v.h.f. stations and 39 independent local radio transmitters. Free from Engineering Information Service, Independent Broadcasting Authority, 70 Brompton Road, London, SW3 1EY WW412

Peak-reading audio level indicator

An instrument using l.e.d. opto-electronic display devices

by S. F. Bywaters, B.Sc. and J. E. West

The instrument to be described is arranged with rise and fall times comparable to the BBC peak programme meter and to display the signal level logarithmically, so that it may be calibrated in decibels. It was considered that an opto-electronic level display offers advantages over the conventional programme meter; for example in ease of observation, an incremental column of light was thought preferable to a moving spot.

Detected peak signal levels undergo a logarithmic voltage-to-time conversion and digital circuitry is employed to process and display the resultant time function as an incremented column of light-emitting diodes. Although there is a significant amount of digital circuitry, the logic functions performed are simple and this, combined with the simplicity of the means used to obtain an accurate logarithmic display, helps to make the unit competitive in component cost to, for example, the Nelson-Jones i.c. peak programme meter[1].

Modular construction is employed, the circuit being divided into three sections: input detectors and logarithmic convertor; digital decoding and display logic; and the system clock. This makes the system suitable for multi-channel use (the clock being common to all channels). A block diagram, Fig. 1, illustrates this.

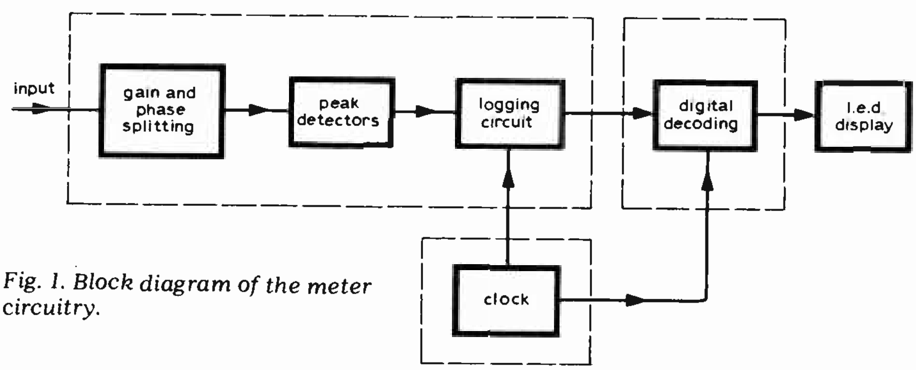


Fig. 1. Block diagram of the meter circuitry.

Amplification and detection

The CA 3051 (dual differential amplifier shown in Fig. 2) performs the functions of input amplification and phase-splitting. Only one of the amplifiers is needed for this, so the other may be used in a similar manner for a second channel. Bias for both amplifiers is derived from the internal diode string. Positive and negative peak detection is accomplished by taking the two phase outputs from the CA 3051 to two 748 operational amplifiers (IC_2 and IC_3) and then to BCY 31 transistors (Tr_1 and Tr_2) whose emitters are joined together and to the inverting inputs of the op-amps (see Fig. 3). The 748 amplifiers used with a 10pF compensating capacitor have a higher slewing rate than the more common 741 and thus an improved h.f. performance. The use of the transistor BCY 31 obviates the need for rectifying diodes, as the transistors combine current gain and rectification. These alloy junction transistors were chosen because they have a sufficiently high reverse V_{BE} rating to withstand the voltages encountered in this circuit arrangement. Since they are p-n-p types, the rectified voltage becomes more negative as the signal input level increases, so that charge is taken *from* C_8, and high current pulses do not flow in the supply lines. The signal rise time constant (actually the capacitor discharge time constant) is 2.2ms, produced by R_{10} and C_8. The signal decay time constant, given by C_8 being charged *up* to the 10-volt sub-rail by R_{11}, is chosen to be one second.

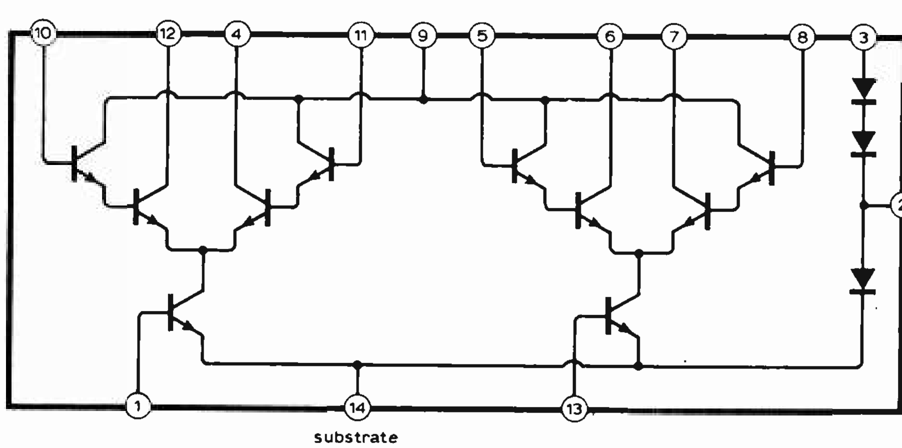
Logarithmic conversion

The process used for linear to logarithmic conversion makes use of the exponential function representing the resistive discharge of a capacitor. This may be expressed as:

$$V_t = V_0\, e^{-\frac{t-t_0}{CR}} \quad (1)$$

where V_t is the voltage existing across

Fig. 2. Schematic diagram and pin connections for the CA3051.



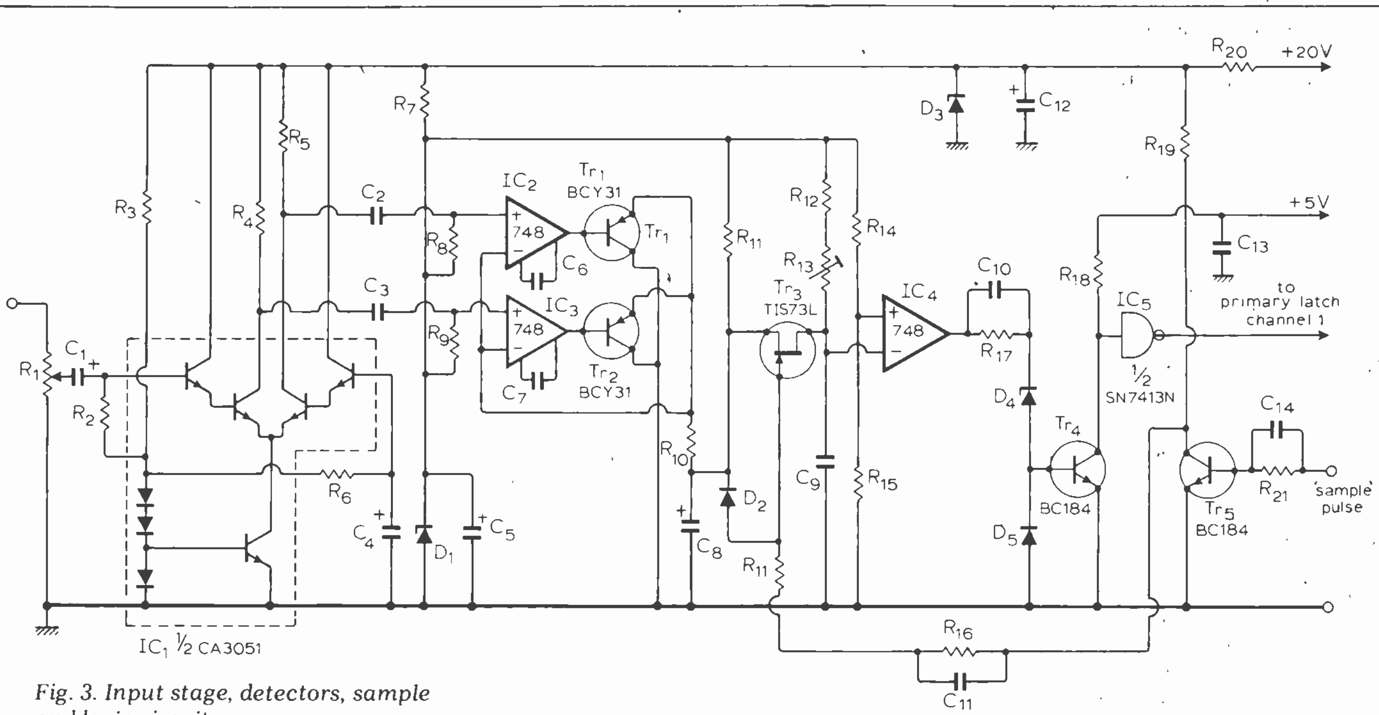


Fig. 3. Input stage, detectors, sample and logic circuit.

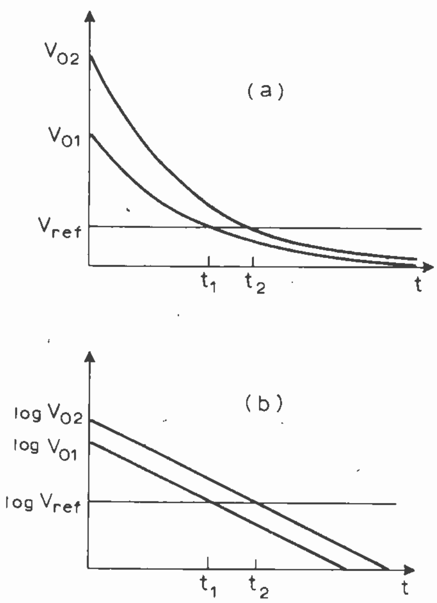


Fig. 4. Capacitor discharge (see text).

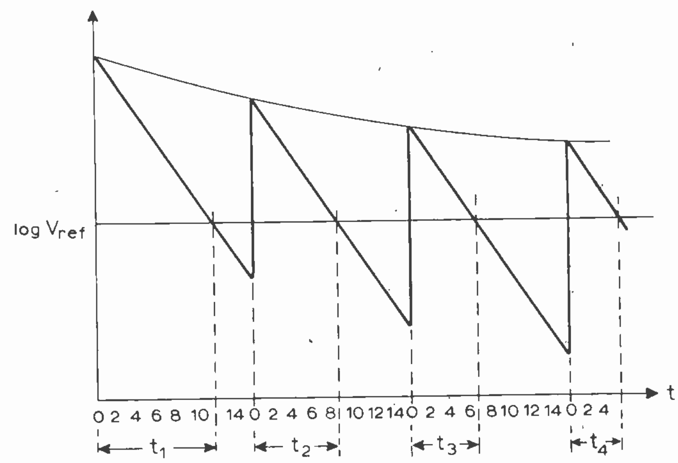
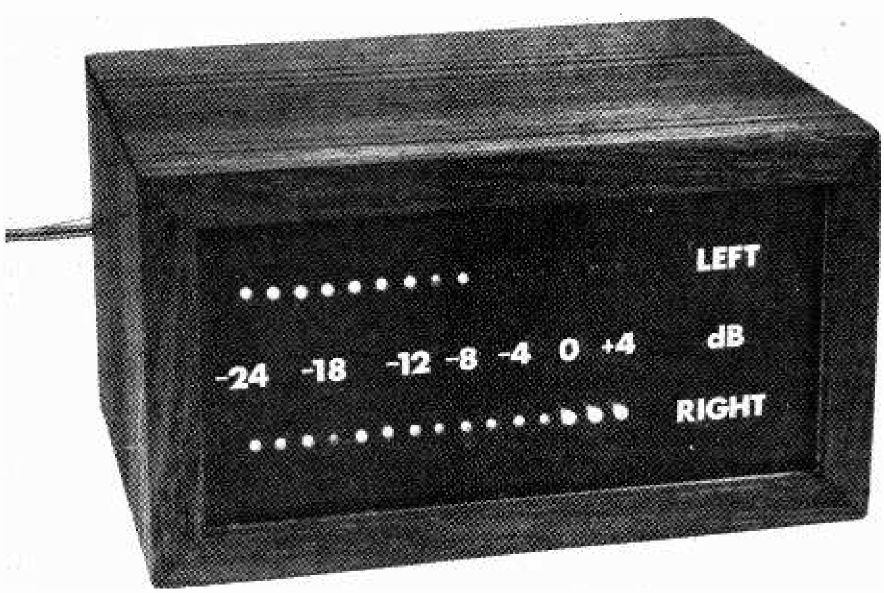


Fig. 5. Sample and decay of a varying voltage.



Prototype, enclosed in a wooden sleeve, with a clear Perspex front panel, on which calibration markings are made, and a smoked Perspex inner panel through which the l.e.ds are mounted.

the capacitor at time t, measured from t_0, at which time the voltage was V_0. If C is in farads, V in volts, and R in ohms, then t will be in seconds. Now if $x=e^y$, then $y=\log_e x$.

Similarly, from (1)

$$-\frac{t-t_0}{CR}=\log_e\frac{V_t}{V_0}$$

$$\text{or } \frac{t-t_0}{CR}=\log_e\frac{V_0}{V_t}$$

Now if we arrange that C and R are constant, we have

$$t-t_0 \propto \log_e\frac{V_0}{V_t}$$

If we make $V_t=V_{ref}$, a fixed reference voltage, and vary V_0, then the time interval $t-t_0$ is proportional to the logarithm (to base e) of the ratio of V_0 to V_{ref} and, since the decibel scale is also logarithmic, by a suitable choice of C and R it is possible to arrange for fixed increments of $t-t_0$ to represent precise increments (in decibels) of V_0.

Fig. 4(a) shows the normal exponential decay curves for a resistor and capacitor combination for two arbitrary values of V_0: V_{01} and V_{02}. Fig. 4(b) shows the same exponential decays, but with the logarithm of V_0 plotted on the ordinate.

In a practical system we may arrange for a sample of a varying voltage to decay to a voltage V_{ref}, measuring the time taken to do so by means of a digital counter. A four-bit binary counter will measure sixteen time increments, as shown in Fig. 5. It can be seen that if the sampling rate is sufficiently high, the time intervals, t_1, t_2, t_3, t_4 etc, will follow the envelope of the varying voltage. (As sample acquisition takes a finite time, one of the sixteen time increments will have to be used for this function, and for generating other control pulses required.).

In the detector circuits the rectified voltage has a rise time of 2.2 ms and a decay time of one second. A sampling rate of 2kHz was thought suitable for a visual display, which for a four-bit counter defines the clock rate as 32kHz. A 30dB range was chosen which, using fifteen time increments (sixteen minus one for sampling and control pulses) yields a resolution of 2dB for each clock period (1/32ms). A 2dB decrease corresponds to a voltage 0.7943 of its original value, hence

$$e^{-\frac{t}{T}}=0.7943$$

where $T=CR$, the capacitance-resistance product to achieve the exponential decay, and $t_r=1/32$ ms, from which we obtain

$$T=0.136\text{ms}.$$

If C is chosen to be 4.7nF, then R is nominally 28.9 kilohms (components C_9 and R_{12} + R_{13} in Fig. 3). A trimming resistor, R_{13} is provided to facilitate precise calibration.

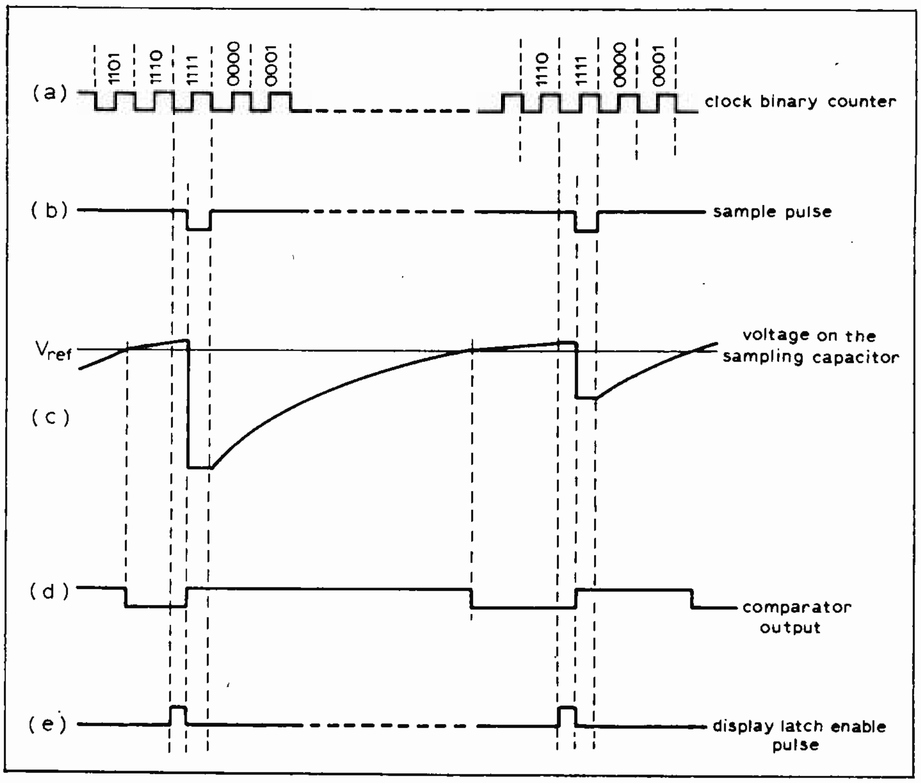


Fig. 6. Timing sequence (see text).

The f.e.t. Tr_3 is used as the sampling gate, being driven by Tr_5 which performs the necessary level conversion from t.t.l. to drive the f.e.t. gate sufficiently negative to cut it off between sampling pulses. For the transistor type used, TIS 73L, the gate-source cut-off voltage can be between -4 and -10V.

A 748 operational amplifier (IC_4) is used open-loop as a voltage comparator. Voltage V_{ref} is established on its non-inverting input by R_{14} and R_{15}, yielding approximately −120mV with respect to the +10 volt sub-rail (bearing in mind that the peak-detected input voltage grows more negative with increasing input level). Transistor Tr_4 converts the comparator output swing to t.t.l.-compatible levels and drives a Schmitt NAND gate (1/2 × SN7413). Thus a t.t.l. level transition is obtained when the decaying voltage on C_9 passes through the value V_{ref}.

At this point it might be useful to investigate the timing sequence of the system (Fig. 6). We have an input voltage which is being continuously detected and then periodically sampled, a binary time-count being produced proportional to the logarithm of the ratio of the peak input voltage to a reference voltage. The sampling pulse is produced at a fixed moment in the measuring cycle (i.e. sixteen clock cycles) but the comparator level changes at a time in this cycle dependent on the input voltage. We require to store this time information and arrange for it to be displayed for a fixed time in each measuring cycle, so that the l.e.d. illumination time, and hence their apparent brightness, is independent of the input voltage.

Digital display logic

The level transition from comparator IC_4 is used to hold in a "primary" latch (SN7475) the binary count at the transition instant (see Fig. 7). This time count is transferred to the "display" latch (SN7475) during the last clock period of each measuring cycle, and the output of this latch is decoded to one of sixteen outputs by an SN74154 four line to sixteen line decoder. The 0000 time count, decoded to output 0, corresponds to the detected voltage V_0 being less than V_{ref} and is not displayed. The SN74154 produces a "low" output for the decoded count and, using SN7407 buffer drivers, a "low" voltage is required to illuminate the diodes, so to generate a column of light instead of a spot we need the logic function:

$$X_r=X_r.\,X_{r+1}.\,X_{r+2}.\,---\,.\,X_n$$

where Y_r is the input to an SN7407 driver, X_r is the corresponding SN74154 output and X_n is the SN74154 output corresponding to the highest binary count. This logic function is effected by means of SN7408 AND gates. By varying the common anode voltage to the diodes their brightness may be adjusted. If this facility is not required and the diode current is less than sixteen milliamps, the SN7407 drivers may be omitted, and the diodes driven directly from the SN7408 outputs.

Clock and control generator

The clock generator is shown in Fig. 8. The oscillator (1/4 × SN74132) operates at about 32kHz, the binary time count

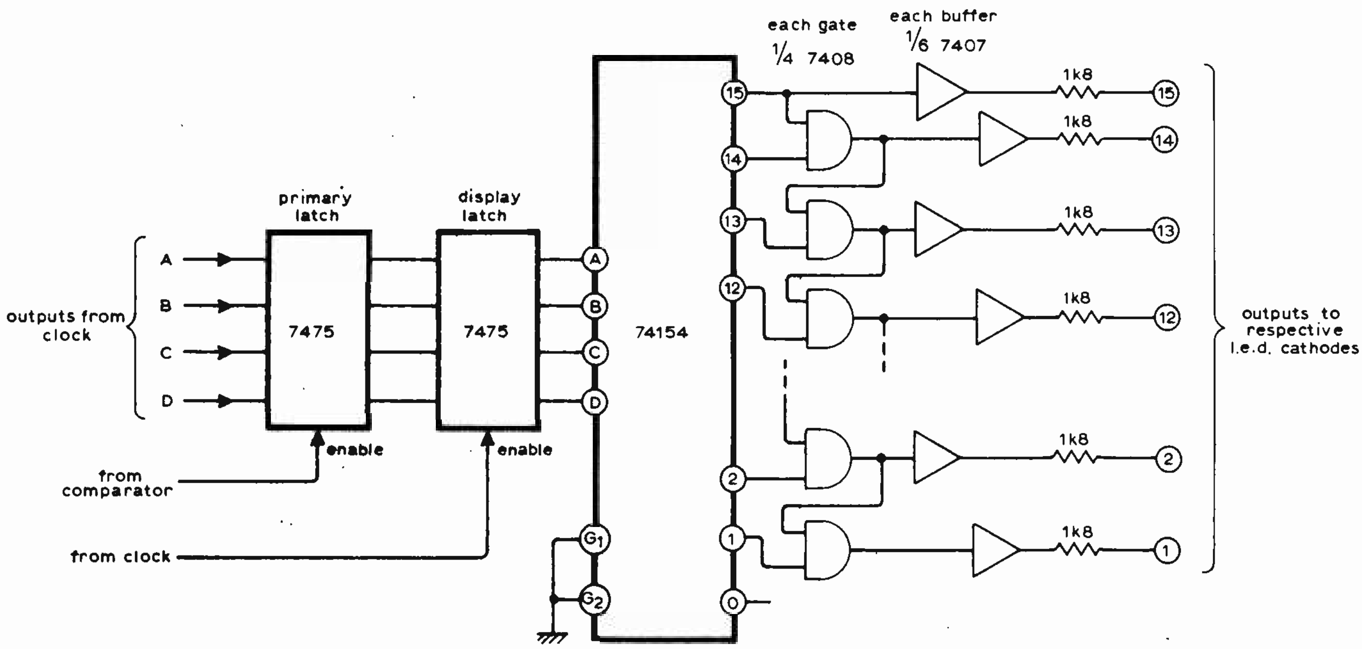
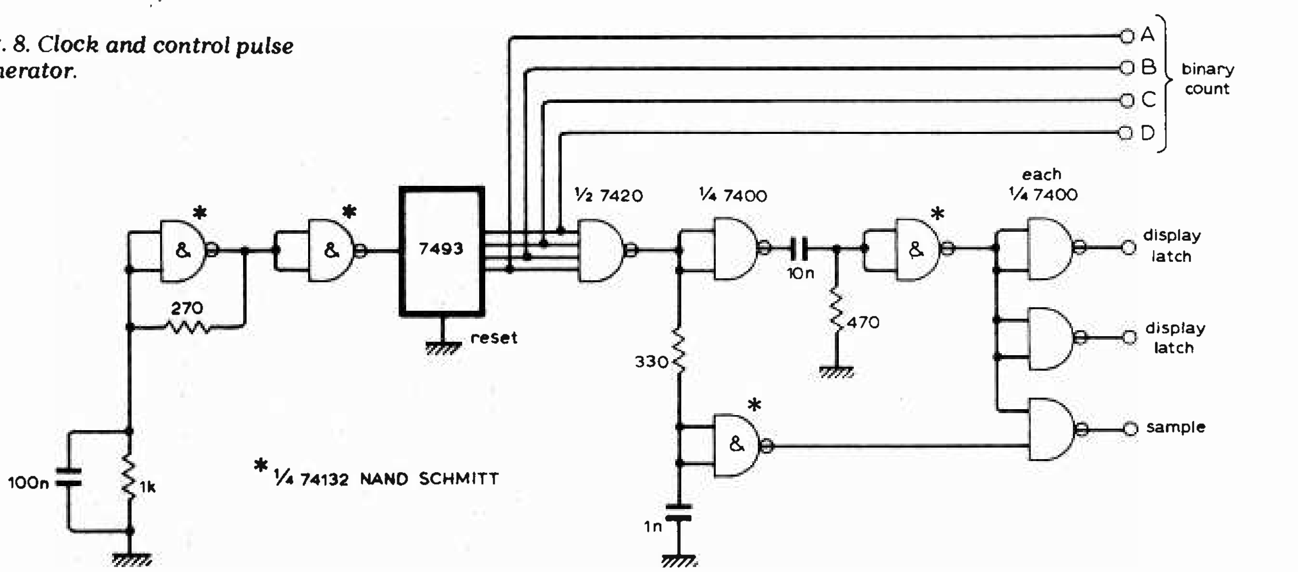


Fig. 7. Digital decoder circuit.

Fig. 8. Clock and control pulse generator.



being produced by the SN7493 four-bit counter. The sample and display pulses are produced by the logic gates, with small time constants introduced to avoid spikes caused by propagation delays.

Setting up

To adjust the 2dB increments, it is convenient to apply a signal, setting the level so that one of the lower light-emitting diodes is just illuminated, and then increase the signal level by 20dB, adjusting VR_2 until a diode 20dB higher up the column is just illuminated. It may be necessary to repeat the procedure since the two adjustments are interdependent.

Overall sensitivity is adjusted by means of the input potentiometer R_1. Maximum sensitivity is less than 100mV for a fully lit column of diodes. The l.e.d. brightness may be varied by the selection of series resistance and also by the voltage applied. In the prototypes, 560-ohm resistors were used with a fixed 5-volt supply and 1.8 kilohm with a variable three- to ten-volt supply. Provided that the anode voltage remains reasonably constant with change of load, altering this voltage will vary the brightness of all the diodes together. A circuit suitable for varying the brightness is shown in Fig. 9.

Construction

The prototype was constructed as a two-channel system on glass-fibre printed circuit boards. Three boards were used: input stage, detection, sample and log. conversion for two channels; clock and control pulse generator; display logic (2 required, one for each channel).

The light-emitting diodes used were type TIL 209, which produce a red, diffused light. Although a switching type f.e.t. is to be preferred in the

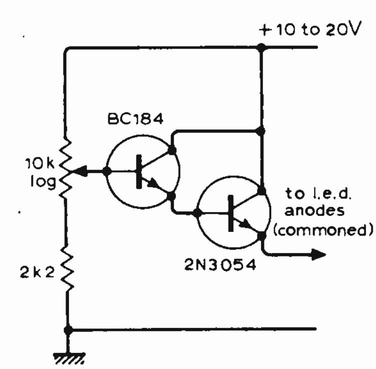
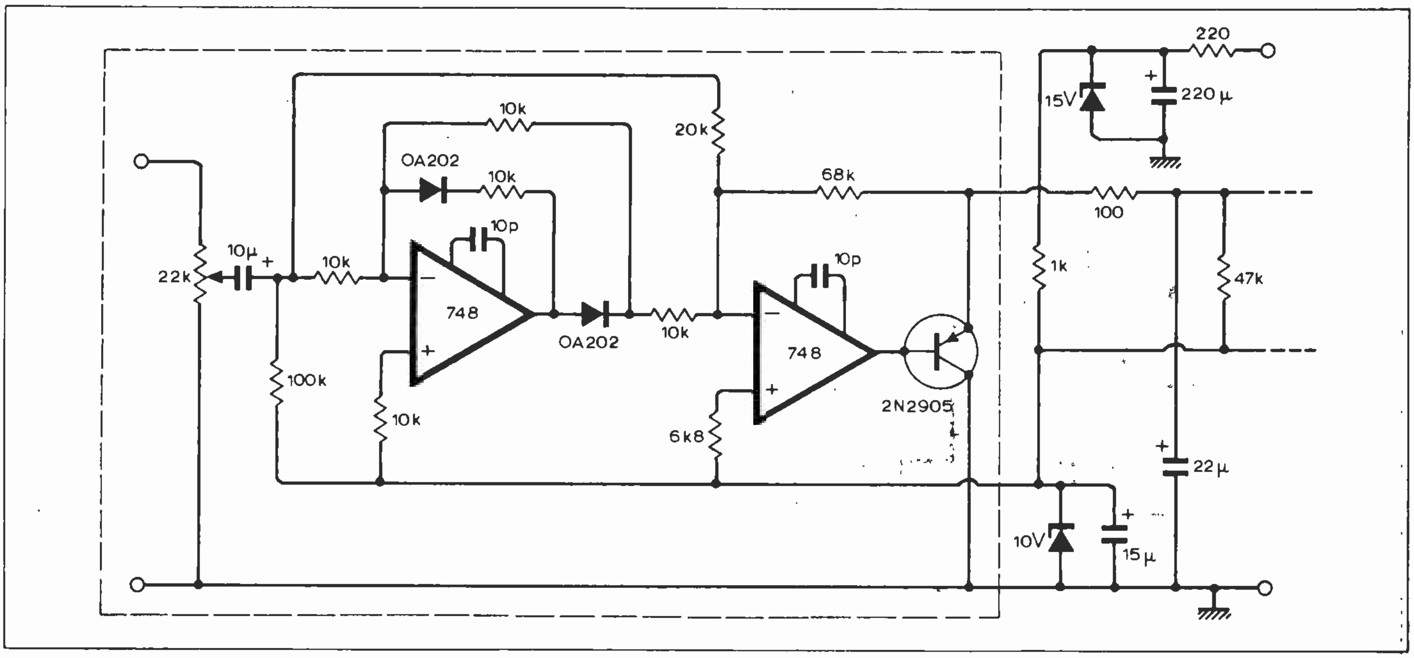
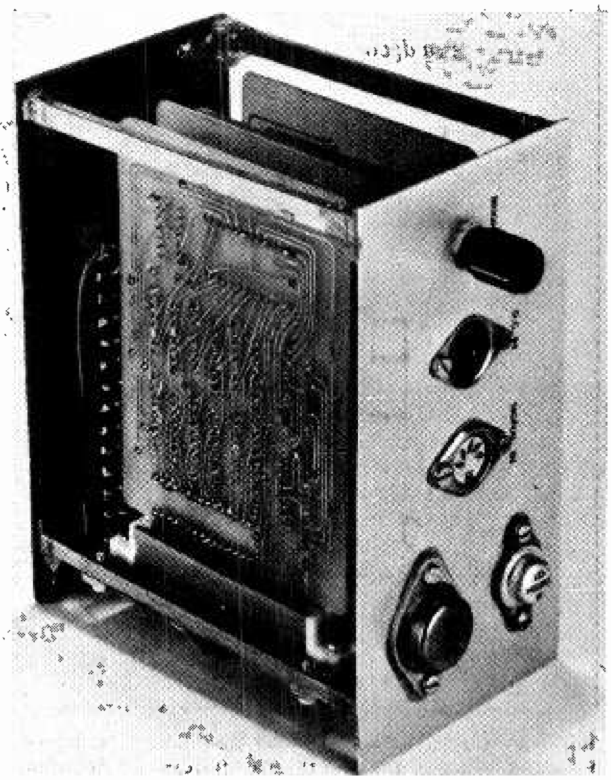


Fig. 9. Circuit to vary the l.e.d. brightness.



sampling circuit, a Texas TIS 73L being used in the prototype, it is thought that an n-channel general-purpose f.e.t. (e.g. 2N 3819) could be used, although sampling errors may be introduced, which will become serious when transistors with a high drain-source "on" resistance are used. Wherever digital circuitry is used in conjunction with analogue circuitry, care must be taken to ensure that switching spikes are not injected into the analogue system. A possible source of trouble in this circuit was found to be the output of IC_4 (Fig. 3), which is used as a comparator and produces fast voltage transitions of almost 15 volts at a repetition rate of almost 2kHz. It should be ensured that the audio input is kept away from such potentially troublesome areas. In extreme cases of interference, where the fault cannot be traced to careless grounding arrangements, an input buffer amplifier may be helpful.

Fig. 10. Alternative lower sensitivity input circuit shown within dotted lines (see appendix). The remainder of the circuit is as before in Fig. 3.



Rear view of the p.p.m. The circuitry is mounted on three main p.c. boards.

Acknowledgement

The authors would like to express their appreciation for the use of facilities in the Department of Phonetics and Linguistics at University College London.

Reference

1. L. Nelson-Jones, "An I.C. Peak Programme Meter, *Wireless World*, November 1972, p.515.

Appendix

An alternative input circuit, useful when the high sensitivity of the present unit is not required (e.g. for line level signals at about 0dBm), is shown in Fig. 10. It employs the well-known full-wave precision rectifier circuit, with a discrete transistor included in the second amplifier feedback loop to increase the current-sinking capability. This configuration replaces all the input circuitry in Fig. 3 up to the 100ΩμF 22μF integrating time constant

PEAK-READING INDICATOR

Components list

(For digital decoder component values see Fig. 7. For clock and control pulse generator components, see Fig. 8.) The l.e.ds for levels -24dB to -2dB (see prototype photograph) are red Texas TIL209 type and for levels 0dB to +4dB are yellow Xciton XC209Y.

Resistors — R

1	100k lin	13	20k preset
2	100k	14	120
3	3.9k	15	10k
4, 5	5.6k	16	1M
6	100k	17	15k
7	1k	18	1k
8, 9	100k	19	10k
10	100	20	220
11	100k	21	1k
12	22k		

Capacitors — C

1	1μ/16V	9	4.7n
2, 3	220n	10	10n
4	1μ/16V	11	1n
5	15μ/25V	12	220μ/25V
6, 7	10p	13	10n
8	22μ/16V	14	1n

Transistors — Tr

1, 2	BCY31
3	TIS73L
4, 5	BC184

Diodes — D

1	BZY88 (10V)	4	BZY88 (4.7V)
2	OA202	5	OA202
3	BZY88 (15V)		

Integrated circuits — IC

1	CA3051
2, 3, 4	748
5	SN7413N

Television — solid-state and digital

Highlights from the 9th international TV symposium at Montreux

He wore as a kind of badge of office a solid-state image sensing panel attached to his tie. It was a charge-coupled device. His office was to look after an experimental tubeless colour television camera, using three such c.c.ds, on the RCA stand at the recent Montreux international television symposium. The camera gave very passable colour pictures on a monitor, though not of broadcasting quality. The badge of office seemed to symbolize a great deal of the new technology presented at this combined conference and exhibition. Large-scale integrated circuits and devices such as the c.c.d. have brought in a whole new era of solid-state electronics and digital information processing to television broadcasting. The analogue signal as we used to know it seems to be lost in a welter of quanta, digits and logic, but all to the good, so we are told.

To return to the c.c.d. solid-state image sensor, it has some important advantages over the conventional camera tube – no image lag, no "blooming" (enabling the camera to handle bright reflections from the scene without causing "tailing" or picture smear), perfect geometry, small size, low power consumption, ruggedness and long life. The main disadvantage at the moment is poor resolution, owing to the limited number of sensing elements that can be fabricated on a panel. The RCA device, for example, has 512 x 320 (about 164,000) elements. However, also at the symposium M. F. Tompsett of Bell Labs described their latest c.c.d. image sensor which has about 235,000 elements and is claimed to have a resolution "compatible with commercial broadcast TV use" (It wasn't demonstrated so we couldn't judge for ourselves.) This silicon device measures 20mm x 16mm – the imaging area being designed to be equivalent in size to the scanned area of a standard 1-inch camera tube – and has 496 interlaced scan lines with 475 horizontal picture elements. It has been used in an experimental camera measuring 6in x 2½in x 2½in to demonstrate the feasibility of high-resolution video-telephone systems.

The BBC Research Department has been doing some investigations into these solid-state image sensors and the head of the Department, P. Rainger, presented a paper by J. R. Sanders which surveyed their possibilities. Apart from the problem of poor resolution, he mentioned that they suffer from blemishes, poor background (dark-current irregularities) and high cost. Also, the quantum efficiency of the devices – potentially above 50% over the visible spectrum – falls to only 5% at the blue end of the spectrum (450nm wavelength). This is because the light has to pass through the electrode structure and blue light in particular suffers considerable attenuation before it reaches the silicon substrate in which the minority charge carriers are generated. One possible way round this problem is to make the substrate very thin so that the optical image can be formed directly on the rear face of the substrate.

The following table adapted from Mr Sanders' paper lists the devices that have so far been made:

Table 1 — Imaging arrays

	elements	type	available
Bell Labs	475 x 496	c.c.d.	no
	220 x 256	c.c.d.	no
RCA	320 x 512	c.c.d.	yes
Fairchild	190 x 244	c.c.d.	no
	100 x 100	c.c.d.	yes
GEC (UK)	100 x 100	c.c.d.	no
	32 x 32	c.c.d.	yes
GE (USA)	188 x 244	c.c.d.	yes
Integrated Photomatrix	64 x 64	photodiode	yes
Reticon	50 x 50	photodiode	yes

In his article in the June 1975 issue J. Dwyer gave an outline of the general properties and advantages of digital techniques in broadcasting. As far as television is concerned one of the major applications of digital processing is to achieve accurate timing conversions and corrections to the signal. At Montreux, for example, probably the biggest and most advanced digital system was the IBA's standards conversion equipment DICE (Digital Intercontinental Conversion Equipment), which converts 525-line NTSC colour pictures into 625-line PAL or SECAM colour pictures and also operates in the reverse direction. It was shown on the Marconi stand because this company are now manufacturing and marketing it under licence from the IBA. The system has been described in detail before. The basic idea is, of course, to take signals on one television standard, quantize and store them in digital form and then read them out of the store at a rate appropriate to the required output standard. The difference between the numbers of input and output television lines is taken care of by information interpolation techniques, extending over five lines. Digital storage is based on m.o.s. shift registers. Spatial filters of novel design are used to remove interlace between successive input fields to achieve movement interpolation, to separate luminance from chrominance components and vice versa, and to demodulate the chrominance information into I and Q components.

In a lecture on DICE, J. B. Sewter of the IBA said that it was in effect a very high speed computer making 600 million additions per second – and with input and output data rates of 85.6 and 86.4 Mbit/s respectively into and out of its 2.4 Mbit store, he thought it was possibly the fastest computer in the world.

A type of timing adjustment that is needed in a great many broadcasting situations is to improve the timebase stability of signals from the smaller and cheaper helical-scan video tape recorders. This enables these machines to be used as sources which meet the full broadcasting timebase stability requirements. In the digital timebase corrector, again the principle is to digitize the signal information from the v.t.r., store it in a digital store, remove the v.t.r. sync pulses, then to read out the stored video information at a rate determined by new reference sync pulses fed in from the broadcasting system. Also fed in from the broadcasting system is a colour subcarrier of correct frequency and phase, and this is used in the machine to obtain luminance of correct timing and chrominance of correct hue.

Typical of the latest digital timebase correctors was one shown by the fairly new British firm Quantel Ltd (see Fig. 1). This is produced in two versions, one for 525-line NTSC or monochrome helical-scan v.t.r.s and one for 625-line PAL, SECAM or monochrome v.t.rs. The first includes a line-by-line velocity compensator to convert high-frequency timebase errors, and also a one-line "drop-out compensator" which reinserts the correct luminance and the correct chrominance hue. In the PAL/SECAM version a two-line "drop-out compensator" ensures that correctly-phased (PAL) and correct colour axis (PAL and SECAM) colour signals are reinserted. In both versions the differential gain is 3% and differential phase 3° ; the range of correction is ±1 line; while the corrected timebase stability is ±4ns in a mode of operation locked to the colour burst or ±25ns in a mode locked to the horizontal sync pulses. The machine will automatically "clean up" incorrect field edits done on a simple v.t.r. — for example when the editing results in two even fields occurring in sequence on the tape.

Many of the digital processing systems applied to television signals sample the incoming analogue signal at a rate of three times the colour subcarrier signal, in order to quantize it as part of the analogue-to-digital conversion process. This frequency (13 MHz for the PAL system), which is in excess of the theoretically required Nyquist rate of twice the highest frequency being handled, has become accepted as a sort of standard. However, one speaker at the symposium, J. Lowry (the Canadian who "cleaned up" the Apollo 16 and 17 television pictures from the moon) strongly recommended the use of four times the subcarrier frequency. He claimed that this provides a higher signal/noise ratio (more than 2dB better than for $3 \times f_{sc}$) a wider and flatter frequency response, improved differential gain (less than 2%) and differential phase (less than 2°), and allows precise locking on to the I and Q signals and simple separation of chrominance and luminance. Mr Lowry described one of his own products, a timebase corrector from Digital Video Laboratories Inc, based on these principles. This uses 8-bit digitizing of the analogue video signal and has the wide range of correction of six television lines. One comment from a British speaker was that this four-times subcarrier sampling technique might well be advantageous for preserving the information in the new components recently added to the UK television signal for the Teletext transmissions.

When television signals are digitized, say into p.c.m. form, they do of course require channels of large information capacity or bandwidth. Within the digital processors themselves, or for short distance transmission, this is not much of a problem; but if digitized television signals are to be sent across the country by p.c.m. transmission systems, along with other services, the large amount of channel capacity they occupy in bits/second could be regarded – at least by people who don't like television — as somewhat wasteful. A certain amount of attention, therefore, is being paid to how to reduce the bit rate without impairing the picture quality. One technique is to go the opposite way to Mr Lowry and actually reduce the sampling rate to less than the theoretically required $2 \times f_{sc}$ – this is known as sub-Nyquist sampling. Theoretically it shouldn't work, but it does. Another way of reducing the bit rate is to use in place of p.c.m. a system of coding called differential p.c.m. (or d.p.c.m.) The principle of this is to take advantage of any redundancy in the picture information and only send bits when the picture signal changes (hence "differential").

The Institut für Rundfunktechnik at Munich has been doing some research along these lines, and Dr N. Mayer of the IRT presented some results of his studies into economical digital coding methods. The various methods he has tried and compared are: conventional p.c.m. for composite colour signals; conventional p.c.m. for composite b.f.l. signals; differential p.c.m. with sampling frequencies of three times and twice the colour subcarrier frequency; and differential p.c.m. on the separate colour components R—Y, B—Y and Y, with and without sub-Nyquist sampling. Some of the results are shown in Table 2. It has been assumed that in practical television systems there would be several coding processes in tandem, so the experiments were conducted with three codecs (coder-decoders) in tandem. Note that, as would be expected, conventional p.c.m. results in the highest bit rate, of 106 Mbit/s, while the lowest bit rate is given by d.p.c.m. with Nyquist sampling. Dr Mayer found that signal degradation due to multiple coding and decoding is very dependent on the coding system used.

The recording of video signals is still basically an analogue process, though at the last IBC in London we heard details of the BBC's digital v.t.r. (see November 1974 issue). For the moment in video recording the centre of the stage seems to be taken by the video disc, and several of these were described and/or demonstrated at Montreux – the Philips VLP, the Telefunken-Decca TeD, the RCA Selectavision disc, Herr Rabe's magnetic disc, the Thomson-CSF videodisque, and – a new one to us – the Robert Bosch optical video disc. The excuse for describing this new Bosch development in a report largely devoted to digital techniques is that, like some of the others, it uses a kind of pulse modulation to impress the video signal information on the disc. An important feature of the development is that, unlike most of the video disc systems, which are playback-only for the user, it allows you to do your own

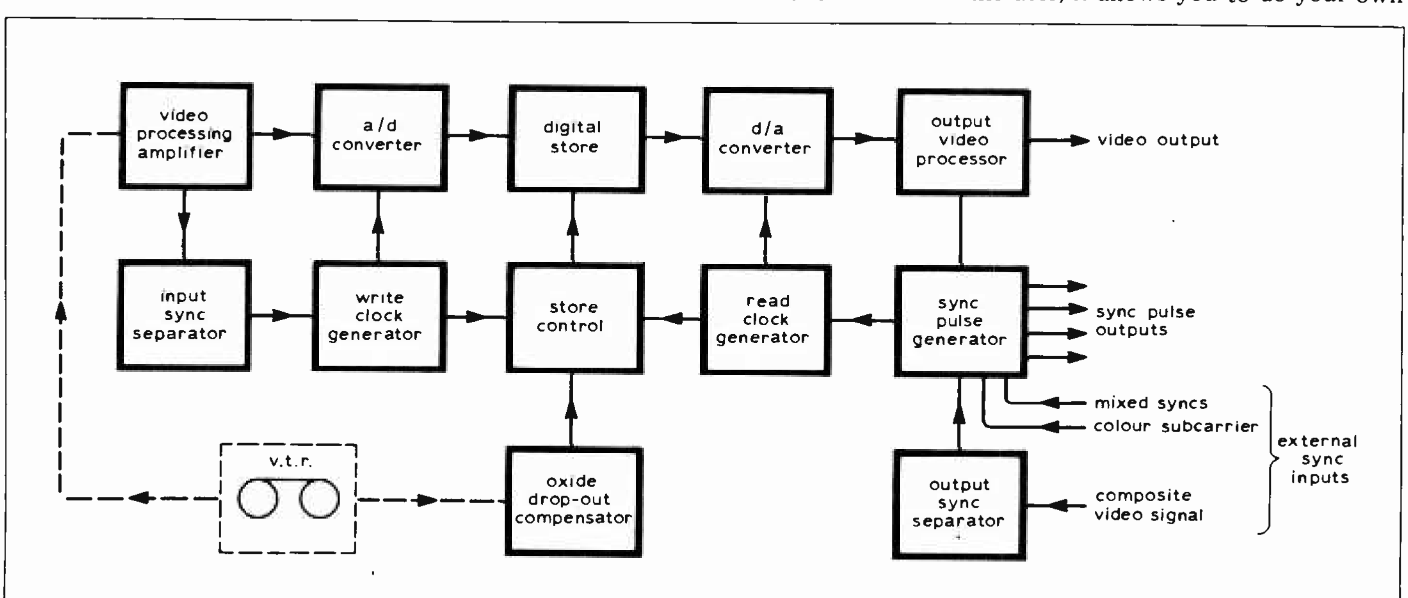


Fig. 1. Digital timebase corrector shown by Quantel, for allowing small helical-scan v.t.rs to be used as picture sources for the broadcasting system.

Table 2 — digital coding methods for colour TV signals

Coding method and sampling rate	Comb filter	Low-pass filter	Mixing	Suitable for colour TV system	Sensitivity to bit errors	Bit rate without error correction
p.c.m. composite signal 3 × f_{sc}	0	3	yes	NTSC PAL SECAM	less than d.p.c.m.	106 Mbit/s 8 bit/picture element
p.c.m. b.f.l. composite signal	1	3	yes	NTSC PAL SECAM	less than d.p.c.m.	60 Mbit/s 8 bit/picture element
d.p.c.m. composite signal 3 × f_{sc}	0	3	no	NTSC PAL	more than p.c.m.	60 Mbit/s 5 bit/picture element
d.p.c.m. composite signal 2 × f_{sc}	2	3	no	PAL	more than p.c.m.	53 Mbit/s 6 bit/picture element
d.p.c.m. colour signal components U,V,Y	3 0 for Y 3.5 MHz	3	no	NTSC PAL SECAM	more than p.c.m.	70 Mbit/s 5 bit/picture element
d.p.c.m. components U,V,Y sub-Nyquist	6 0 for Y 3.5 MHz	3	no	NTSC PAL SECAM	more than p.c.m.	56 Mbit/s 5 bit/picture element

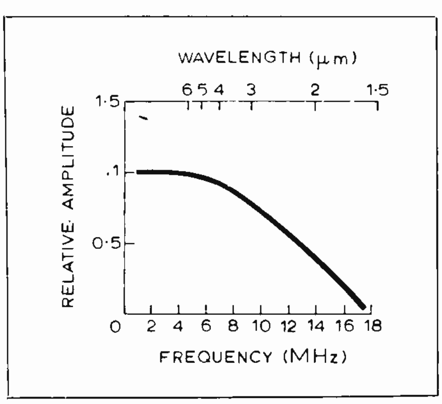
recording. However, the recording is done by a 200mW laser, which is a rather dangerous and expensive device to have around the home, and in fact the recording system is basically intended for professional use.

The Bosch disc, about 10 inches in diameter, is made of transparent Plexiglass, on which is evaporated a thin amorphous metallic layer, actually a bismuth-selenium compound. The metallic layer is less than 0.1μm thick (about 600 Å). This is rotated at 50 rev/s in front of the 200mW argon laser, the beam of which is focussed on the metallic layer and, as a result of pulsing, the laser makes a series of small holes in it by evaporating the metal as the disc rotates. The laser moves radially across the disc and thus forms a spiral track of holes in the metallic layer over the whole of the recording surface. Writing speed is 30m/s. The holes in the layer are "rounded slots" or "elongated circles," spaced approximately 2.5μm apart along the track and about the same distance apart between adjacent track lines. The video signal, including PAL colour information, and the sound signal on a carrier are added and used to produce a frequency-modulated signal. This f.m. signal modulates the beam of the argon laser, by means of an electro-optical modulator, and the beam, as explained, is focussed on to the surface of the disc. Constant spacing between the disc and the focussing objective lens is maintained by an air cushion. The frequency modulation of the laser beam becomes transformed into wavelength modulation on the record, in the form of the series of holes already described.

For playback, an unmodulated laser beam (of lower power than the recording laser) is focussed on the track and maintained in position by a servo system using a 20kHz "dither." The light is either transmitted through the holes or reflected from the metal between them, but in either case is modulated by the moving holes and is picked up by a photo-diode and so converted back to the original f.m. signal.

The available playing time depends on the smallest usable wavelength, the track separation, the disc diameter, the maximum frequency to be recorded and the rotational speed of the disc. At 50 rev/s playing times between 10 and 20 minutes are possible. The frequency response of the system is extremely good as can be seen from the amplitude/frequency characteristic Fig. 2. The falling response with higher frequency is the result of the recorded wavelength approaching the diameter of the playback light spot, which has a natural limit determined by the light wavelength used. There is no fixed value for the smallest usable wavelength but this depends on the noise, which rises with the reduction of the signal. A player for the Bosch disc was demonstrated in the exhibition and the pictures and test patterns reproduced on a monitor were of excellent quality. 5 MHz bars in a test pattern were resolved quite clearly. Obviously the extreme thinness of the metallic layer and the sharply defined holes are major factors contributing to the high quality of the pictures.

Fig. 2. Amplitude/frequency response of the Bosch optical video disc recording system. Note the almost flat response up to about 6MHz. The wavelength figures refer to the wavelength of the recorded signals on the disc.



According to H. Düker, who gave a paper on the Bosch video disc, several machines are under development: a single-head playback-only type; a two-head type in which both heads work simultaneously, one recording and the other playing back; and a double-disc machine in which simultaneously both discs could be recording, both playing back, or one recording and the other playing back.

Colour systems line up: Now that we in the UK have become settled with the PAL colour television system for some years we tend to forget about the other systems which contended in the great "systems battle" of about 15 years ago. But, of course, NTSC and SECAM are still going strong in other countries, and here is a reminder of the situation:

NTSC: USA, Japan, Canada, Mexico

PAL (Already transmitting): UK, W. Germany, Belgium, Denmark, Finland, Ireland, Yugoslavia, Netherlands, Norway, Austria, Sweden, Switzerland, Brazil, Zanziba/Tanzania, Hong Kong, Thailand, Bahrein, Kuwait. (Opted): Iceland, Australia, New Zealand, South Africa, Indonesia, Malaysia, Singapore, Pakistan, Abu Dhabi, Dubai, Oman, Katar.

SECAM (Already transmitting): France, Monaco, USSR, E. Germany, Czechoslovakia, Lebanon. (Opted): Poland, Bulgaria, Hungary, Iraq, Iran, Saudia Arabia, Zaire, Egypt, Tunisia, Cuba, Haiti, Ivory Coast, Luxembourg, Morocco.

Italy and China are among the countries which have not yet decided which colour system to adopt.

Letters to the Editor

MUSIC WITHOUT MOVEMENT

Regarding the article "Digital techniques in recording and broadcasting" by Mr J. Dwyer in the June issue, it is interesting to realize that, by using currently available computer stores, it is already perfectly feasible to make a hi fi audio recorder to play for an hour or more with no moving parts whatsoever!

Furthermore, such a recorder would have instant replay from any part of the recording and erasure of any part to the limits of one byte.

It is a fair guess that such a recorder does at this moment exist! I wonder how long it will be before reel-to-reel, cassettes and cartridges using tape are as dead as the dodo?
Ronald G. Young,
Peacehaven,
Sussex.

THE BLATTNERPHONE

I was most interested to see in your April issue a photograph of the actual Blattnerphone machine that I came to know and fear at Savoy Hill in 1931. Basil Lane quite rightly refers to the dangerous operating propensities of this machine, and as one of those who had to volunteer to handle the beast I can speak from some experience.

Apart from the motor on/off switch there were no braking facilities of any kind and the only way a whirling spool could be slowed down was to grasp the spool and hope to avoid a dangerously sharp end of tape. Nice judgement together with some courage was required to avoid a loop of tape occurring between the two drums. Failure in this endeavour usually resulted in the tape crashing down on the driving capstan with consequent breakage.

Tape was joined by soldering with a blow-lamp heated iron and careful chamfering sometimes ensured that heads were not demolished by the joins.

Editing was not then attempted but spare pieces of tape had to be carefully conserved and this involved coiling the tape in one's hand like a clock spring. It was as well not to be disturbed in this task as accidental release of the coiled tape resulted in it exploding into a rather beautiful sphere with which one could do nothing because the ends disappeared into the interior.

Rewinding facilities did not exist and spools had to be changed over to achieve this, and an incident when a talk by Sir Oliver Lodge was reproduced backwards resulted in the quick establishment of a routine of rewinding immediately after recording.

Much useful work was done with this machine and I find it interesting to consider that my present-day cassette recorder utilises many of the principles of the early system and it is, at the same time, by no means lethal.
Gwilym Dann,
Chipstead,
Surrey.

DIGITAL FREQUENCY SYNTHESIS

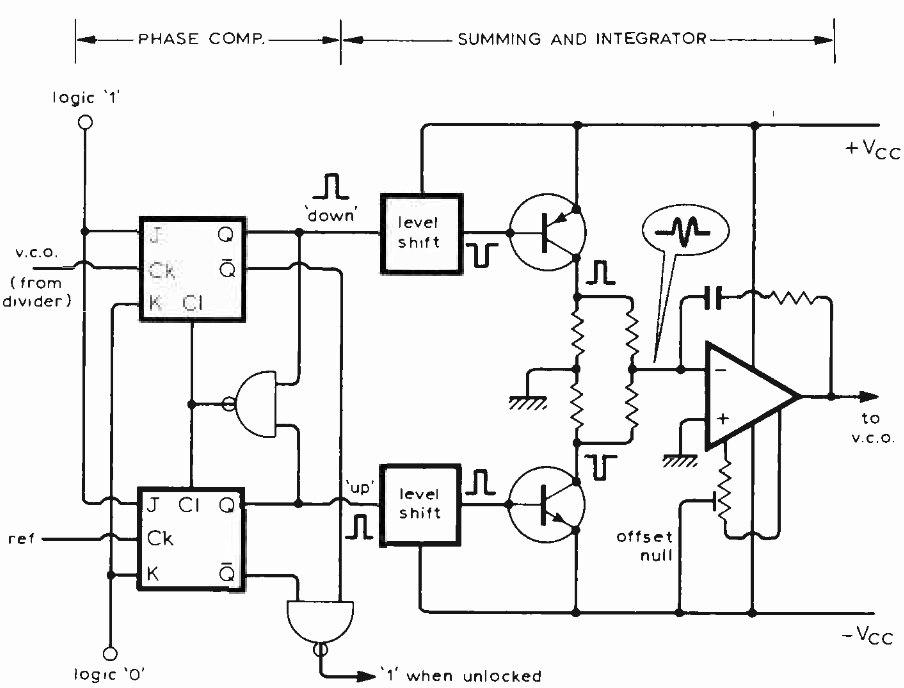
The article by Ayre and Woodward in the May issue "Digital frequency-synthesis — a new approach" draws attention to the advantages of reduction of the low-frequency energy content of the output of the phase-comparator in a phase-lock synthesizer system using a low comparison frequency. Readers may be interested in my own realisation of the infinite pull-in comparator which is equivalent to the circuit of Fig. 9 and rather simpler.

The negative edges of the v.c.o. pulses and the reference pulses clock each of the two JK flip flops. Whichever pulse arrives first sets the appropriate flip flop, and subsequently a pulse arriving at the other flip flop will cause both flip flops to be reset. Thus an output is present at one or other of the flip flops for the duration of time that one pulse is ahead of the other. These two outputs correspond to the "go up" and "go down" outputs of Fig. 9. If the two frequencies are different, the higher one will always arrive first after the first cycle, thus ensuring that the v.c.o. will move towards the correct frequency.

I show also the manner in which the "up" and "down" pulses were summed in a synthesizer I built to synthesize 144-146 MHz in 25 kHz steps in an amateur radio mobile transceiver. The "up" and "down" pulses pull the input to the integrator either up or down via transistors tied to either supply line. Since these transistors only conduct during a correction pulse, and in the locked state these pulses are very short indeed, noise on the supply lines has virtually no effect on the v.c.o. jitter. This arrangement also allows the op-amp offset adjustment to be set so that the first pair of reference-frequency sidebands can be nulled completely. When this happens, the v.c.o. and "ref" pulses are arriving at the two flip flops at precisely the same time, and so the two Q outputs are both identical short pulses equal to the reset propagation delay, and these two short pulses cancel out in the summing stage. Higher order sidebands, which are the result of differences in the pulse shapes of the "up" and "down" pulses, can be easily removed by the loop filter. The NAND gate on the $\bar{Q}$ outputs of the flip flops provides an output when the system is not locked, and this can be used to inhibit the output of the v.c.o. while channel changing.
J. P. Martinez, G3PLX,
Gosport,
Hants.

Mr Ayre replies:

The circuit put forward by Mr Martinez is similar to the basis of the system used in our article and is exactly right for the



application stated, i.e. to cover a narrow band in fairly large steps.

Our application was to cover a very wide frequency range with a much greater resolution and a very low level of unwanted frequency modulation. To this end, it was necessary to have two modes of phase locking: the coarse control, similar to the one offered by Mr Martinez, and a fine one in which the level of modulating signal is reduced to a mimimum.

Some other problems that our system was designed to overcome were the extended time to achieve lock when a comparison frequency of 100Hz was used, and the tendency to lock onto harmonics. We also found that with such a low comparison frequency the drift rate of the integrator was critical. This led to the use of our f.e.t. gating circuit which has the effect of isolating the integrator between correction pulses. For the radio amateur application this is unnecessary, the offset null adjustment being adequate.

I hope that these comments are adequate explanation of the difference in complexity between our system and that put forward by Mr Martinez.

NOVEL CLASS B AMPLIFIER?

It would seem that the letter "A novel class B output?" in the April issue has been aptly titled. Although the amplifier will have a quiescent current of 15mA, it will reproduce signals in class AB, with a variable duty cycle.

To see why, assume that, starting with no input, the amplifier is fed sine waves of constant amplitude. Initially, Tr_6 will conduct for approximately 50% of each cycle, during which Tr_7 is shut off; for most of the remaining 50% Tr_5 and Tr_6 are switched off, with Tr_7 conducting 15mA. The capacitor at the collector of Tr_7 will charge and the bias current increases. A steady state will be reached when Tr_6 has approximately a 95% duty cycle.

If presented with music, or any other signal of fluctuating level, the duty cycle will vary, being near class B when a loud passage follows silence, and entering class A as the level decreases.

Tanj Bennett,
Churchill College,
Cambridge.

CONTROLLING STAGE LIGHTING

We recently constructed a six-way, 2.5-kW solid state dimmer board for a local theatre. We learned a number of things about such projects, and thought your readers might be interested.

1. In general, triacs look attractive for high-power dimmers, but are not as suitable as a pair of back-to-back s.c.rs. There are two reasons for this. First, triacs are inherently a low frequency device – above 60Hz they may have difficulty commutating off at the end of an a.c. cycle.

This problem is compounded when incandescent lamps are the load. At low conduction angles, the resistance of the loop filament is low, and there are very large pulses of current just before the voltage passes through zero. When s.c.rs are used, each s.c.r. has a whole half cycle to commutate off.

Secondly, the problem of cooling the triac is made more difficult by the fact that all the heat is generated at one point; using two s.c.rs means that there are two hot spots which may be physically separated. This enables the use of thinner cooling fins.

2. Initially, we attempted to use a mastering system with small lamps and photoresistive cells. It was our idea to put a photoresistive cell in series with each dimmer variable resistor. A small lamp would shine on the photoresistive cell, and six of these lamps (one for each dimmer) would be connected to the master. (This scheme was suggested in two different sources which shall remain nameless to protect the guilty.)

For a number of reasons this mastering arrangement was unsatisfactory. For one thing, all the cells had different characteristics which had to be trimmed out. For another, the combination of small incandescent lamp with photoresistive cell produced an incredibly nonlinear response. For a third, the response time was in the order of 1½ seconds from the initiation of a blackout to its completion.

Finally, the characteristics of the cells tended to drift with time and temperature, requiring endless trimming sessions.

We scrapped this optoelectronic arrangement and replaced it with an all-electronic circuit which, while containing many more parts, has proven completely satisfactory.

3. The radio frequency chokes were constructed by winding 14 a.w.g. wire on ⅜ in. dia. × 7 in. long ferrite rod. Because only about half the surface area of the wire is exposed to air, the coils overheated and had to be rewound with 10 a.w.g. wire. The chokes were a considerable source of noise because the magnetic field causes the choke to shrink and expand at twice line frequency.

Fortunately, we have located a supplier who will manufacture C-core chokes which are relatively quiet, and we intend to use these in the future.

4. Because of the inrush current that occurs when an incandescent lamp is connected to the line, power switches must be substantially derated. In other words, a switch rated for 30 amps a.c. will not handle a 30-amp lamp. A derating factor of at least ten is advisable. Since this was not practical, master switches were connected to de-energize the thyristor firing circuit.

5. The protection of the thristors is a particularly difficult problem. One has to choose a combination of circuit breaker and fuse that will protect the thyristor under short circuit conditions, and this means choosing a fuse that will vaporize faster than the thyristor. Unfortunately (as we found out) one cannot assume that a 25-amp fuse will protect a 25-amp or even a 40-amp thyristor. The "I^2t" rating of the fuse must be less than that of the thyristor. Motorola and General Electric both publish application notes on this subject. Ordinary (thermal) circuit breakers are far too slow to protect thyristors; magnetic circuit breakers must be used.

The most suitable form of protection is probably electronic; we intend to experiment in this area.

In conclusion, then, the building of a high-power dimmer board is not as simple as it might appear at first. To avoid some problems, it may be wise to attempt to build a number of low-power dimmers rather than a few monsters.

Peter D. Hiscocks,
Ryerson Polytechnical Institute,
Toronto, Canada.

MULTI-RATE VAT

I wonder how much longer the average amateur will tolerate the folly of the new multi-rate VAT. Since we now are expected to pay 25% VAT on electronic components — regardless of what they *are* used for, but rather for what they *might* be used in — the extra work and additional burden for the retailer has become a farce. I was told over the 'phone the other day that if I bought the parts for an electronic clock individually, it would be subject to 25% rate, but if I bought the whole thing as a kit it would only be 8% since a clock does not come under the category of either hi-fi or television. Customs & Excise, as usual, have been enjoying the fog — they can't tell the difference between an i.c. unit and a semiconductor. The retailer is therefore supposed to ask the customer whether the wire he wants is for household wiring (at 8%) or for connecting his speakers (at 25%).

Might I suggest that if we write to M.P.s and the Chancellor we suggest that electronic components are all rated at 8%, and the finished goods such as television sets and radios are rated at 25%. That way we can still afford to enjoy ourselves!

John C. Nuttall,
Worthing,
Sussex.

An analysis of the VAT situation was given in the July issue, p.303. – Ed.

News of the Month

Stockholm's buses computerized

A computerized traffic control system for city buses is to be developed and manufactured for the Greater Stockholm Passenger Transport Company. The system allows the progress of each bus to be followed on a display screen in a traffic control room. Traffic controllers will know the exact location of each vehicle at any given moment, together with how many passengers are on board and this data will be automatically transmitted from the buses to a central computer. The new system will generate a great deal of data valuable for traffic planning and will also help to improve service to passengers. An instantaneous view of the current traffic situation means that fresh buses can be put into service as and when needed.

The order initially applies to 65 buses on five inner-city routes, though the computer to be used has a capacity for 500 buses. It is due to come into operation in 1977 and if results are satisfactory it will be extended.

TV landmark disappears

At the end of May, work began on dismantling an historic landmark in the story of television broadcasting. The 200-ft steel aerial tower which has dominated the Hayes, Middlesex, skyline above EMI's Central Research Laboratories is to disappear. It was from here that the test pictures for the world's first regular high-definition television service were broadcast in 1935, establishing the 405-line standard which was to remain in force until 1961. At this time the Baird system of television was strongly favoured and representations had been made to the BBC to adopt this system for public service, although the feasibility of high-definition 50Hz, 405-line transmission had been demonstrated by EMI in 1931 in a presentation to the Optical and Physical Society. An advisory committee was therefore set up under the chairmanship of Lord Selsdon to investigate the various methods available before advising the BBC on which to adopt.

Originally, experimental transmissions from Hayes used an aerial mounted on the roof of the research building. To increase the area of broadcast coverage, it was decided to erect the 200-ft tower which was completed in 1936. Reception stations were established up to 40 miles distant from Hayes and the Selsdon Committee were invited to inspect the system to determine its viability for public service, compared with the Baird system. Subsequently, the BBC was recommended to transmit both the Baird system and the high-definition system on alternate weeks for an experimental period from an aerial at Alexandra Palace modelled on that at Hayes, and a photograph of this aerial was transmitted by the BBC to introduce the early news programme. The BBC's experimental broadcasts began in November 1936 and by early 1937 the high-definition system developed at Hayes was adopted.

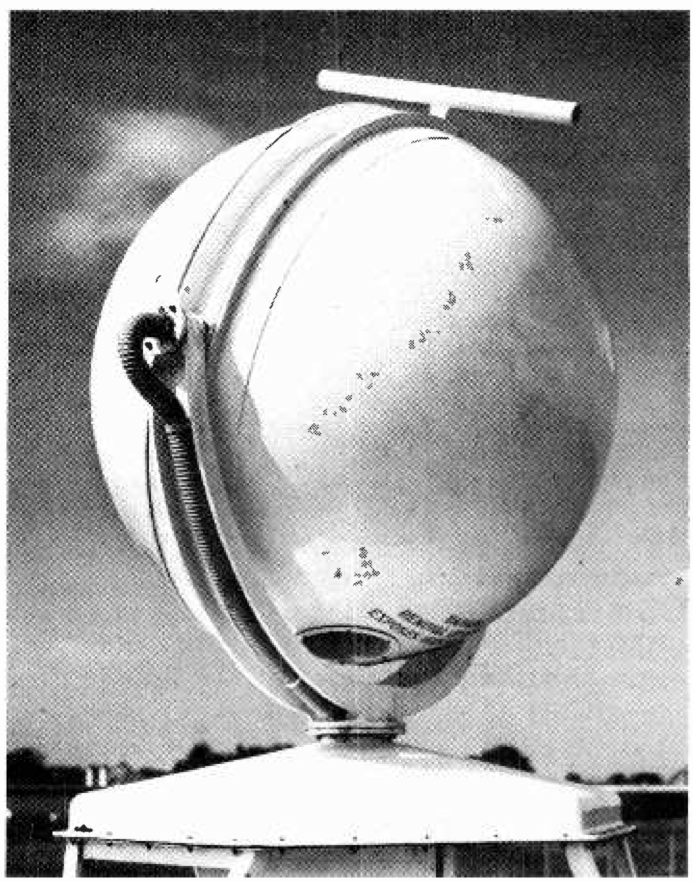
Live stereo from Japan

The first intercontinental stereo relay to the UK took place on May 24th when BBC Radio 3 carried the final concert of the tour of Japan by the BBC Symphony Orchestra live via satellite from Tokyo. This stereo relay was made possible by the co-operation of the Japanese Broadcasting Authority (NHK), the British Post Office and the Internal and Overseas Telecommunications Agencies in Japan (NTT and KDD).

From Tokyo the stereo signals were carried to the Japanese satellite earth station at Yamaguchi near the southern tip of Honshu island and thence to the Intelsat IV satellite which is in geostationary orbit about 35,000km above the Indian Ocean. From the satellite the signals were beamed to the British Post Office earth station at Goonhilly, Cornwall, from which they were routed to the International Sound Programme Centre at Faraday Exchange in London and thence to Broadcasting House. The programme signals were distributed by the BBC's p.c.m. system to the Radio 3 transmitter network. Reception was reported to be excellent, even better than expected.

Large-area liquid crystal display

An experimental model of a liquid crystal display which measures 0.4 × 0.5m has recently been developed and is capable of a selective display of 600 alphanumeric or Japanese "Kana" characters – the system is the result of joint research carried out since 1972 by Hitachi, Dai Nippon Toryo Co and the Asahi Glass Company, of Japan.



Two hemispherical radomes house the antenna, transmitter and receiver for the 3cm type WF3 windfinding radar manufactured by Plessey Radar.

Liquid crystal is an organic compound having fluidity and optical anisotropy and whose transparency changes with the application of a voltage potential. Development of a large area display had been held up by the long time lag between the applied voltage and the change in transparency. The research group overcame this problem by employing what they call a "dynamic scattering mode" and also by improving the liquid crystal material, method of panel fabrication and driving technique. In the scattering mode, the panel indicates characters by a whitening of the liquid crystal material when a voltage is applied. Possible fields for application of this large area display include computer terminals and information displays at airports and railway stations. Before commercial production becomes possible it will be necessary to apply further research on simplifying production processes as well as on the use of l.s.i. in the driving circuit.

Tower Bridge won't fall down

To ensure that the new electro-hydraulic control systems function efficiently while Tower Bridge in the City of London is undergoing modernization, pressure transducers are being connected into each of the main hydraulic loops. Reliability has always been a key feature of Tower Bridge. An Act of Parliament states that rivercraft must always have access to the upper reaches of the River Thames. Since 1894, the two famous road spans, each weighing more than 1,000 tons have been raised and lowered by duplicated, steam powered, water hydraulic systems. In recent years these have become costly to operate and maintain and so new drive machinery with electrohydraulic controls is being installed.

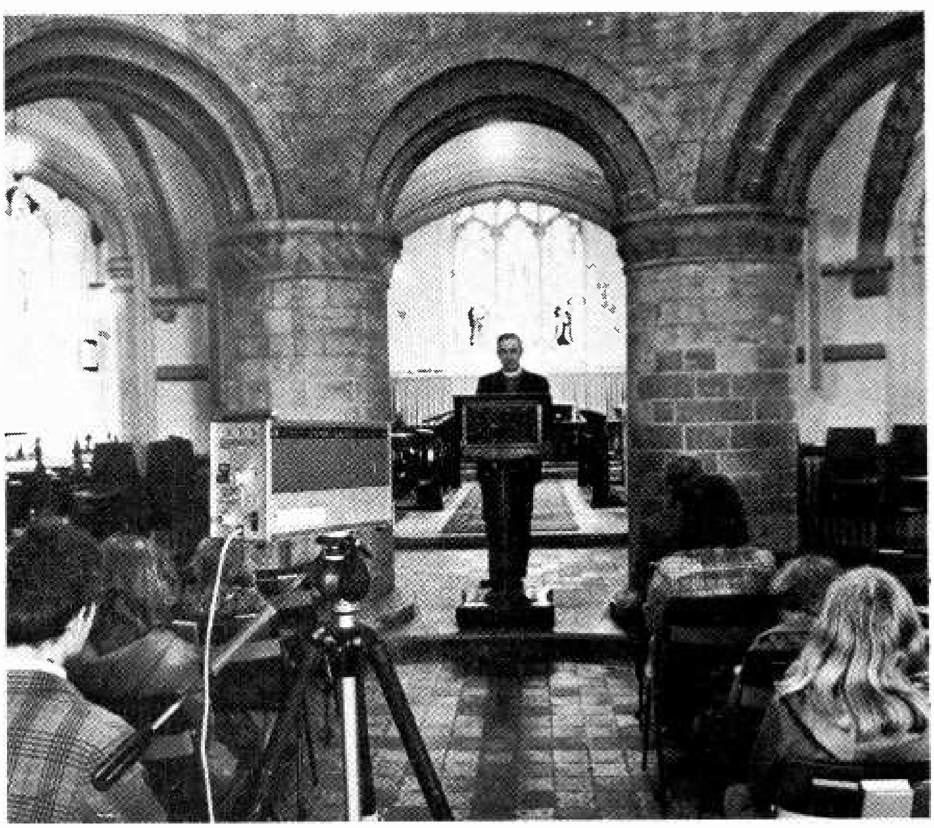
In each of the four machinery rooms there will be duplicated main drive units. Signals from pressure transducers mounted in each of the drive unit's main hydraulic loop will be fed to a central control centre where one man will be able to continuously minitor the condition of the system.

Ship simulator innovations

A ship simulator suitable for the training of bridge teams including ship's officers, pilots and helmsmen has been ordered by the UK Department of Industry. The simulator is capable of providing anti-collision, navigation, pilotage and ship handling exercises for ships between 500 and 500,000 tonnes with the vessel responding correctly to wheel and throttle. The effects of tidal stream and depth of water under keel can also be taken into account. The manoeuvering behaviour of the vessel is governed by a computer mathematical model developed jointly by the National Physical Laboratory Ship Division and by Decca. Incorporated are wheelhouse with a bridge control console including wheel and autopilot, engine throttle, anti-collision radar, ship's telephone, radio communications, warning annunciators and chart table.

A bridge window is also provided through which can be seen the bows of the ship and lights of navigation markers and of other ships. Up to 16 lights can be shown at one time, for example eight buoys and two other ships. Engine and propeller noises and vibration are generated, varying correctly with engine revolutions. The simulator may be programmed for real or artificial exercise areas, which can be changed in a few minutes by inserting different magnetic tape cassettes. Each exercise is automatically recorded on a track plot for subsequent analysis, together with recordings of r.p.m., ship speed, rudder angle, rate of turn, drift angle and heading.

"And verily I say unto you, that if Parliament shalt have radio then so shalt we have TV." This is what happened at the Holy Sepulchre Church, Cambridge where an overflow of the student congregation had to be accommodated in the church hall across the road. The service is conveyed by a closed circuit TV link combined with a sound system.



Trading boom at LECS

The 24th international London Electronic Component Show which closed at Olympia on May 16 defied the prophets of gloom and doom. Nearly 20,000 people including visitors from 61 different countries attended the show and though the overall figure is down on the 1973 LECS, trading and business conducted during the four-day event exceeded both expectation and previous records.

Sixty Years Ago

In August 1915, the "Questions and answers" column invited readers to send questions on technical and general problems that arose during the course of their work. A Mr C.J.M. of Upminster wrote to ask whether wireless telegraphists must transmit with the right hand. He said that at present he can transmit 20 words/min with his left hand, but only 15 with his right. *Wireless World* replied – "We would strongly advise C.J.M., and any other students who have acquired the habit (very nasty) of sending with their left hand, to confine their practice to the right hand until they are able to send at a good commercial speed. Ability to send with the left hand is an accomplishment of some value when the possessor is already expert with his right hand, for on occasions where a considerable amount of traffic is being handled a change from one hand to the other may come as a welcome relief. Normally, however, all wireless work is done with the right hand, and the apparatus is arranged on the operating table in such a way that left-hand working is most inconvenient.

Well now we all know!

Consumer electronics in the U.S.A.

Chicago consumer electronics show — June 1975

The impression of this annual show is that it is a far more commercial operation than those experienced in this country, with an undercurrent of hard selling and much less emphasis on technical innovations or ideas. Such is the effectiveness of the jet age that there were few surprises at this show, a large number of the significant audio products having appeared somehow at the Festival du Son in Paris three months before.

British companies were very much in evidence, largely due to the efforts of the Federation of British Audio and the co-operation of the Department of Trade and Industry. The F.B.A. had taken a large stand in the centre of the hall and a dozen companies were represented there. Whilst the F.B.A. did everything it set out to do, it seemed sad that the exhibit stand itself was so dull. It should have cost little more to compete with the visual impact of many of the adjacent exhibitors, and with products of this quality there is nothing to be shy about. Quad had a static display and were showing the new 405 "current dumping" power amplifier at a nearby hotel. Also represented were Decca Special Products, Jordan Watts, showing their full range transducer, KEF, Gale, Richard Allan, Celestion, Harrison, Neal, Lamb Laboratories, Linn Products and Keith Monks Audio.

New loudspeakers

KEF were showing for the first time a new bookshelf reference standard loudspeaker, the KEF 103, rated at 80W programme. A very interesting feature of this two-way system is the adjustable front panel in which the square section of the baffle holding the two drive units can be detached and relocated in any of four orientations so that optimum stereo can be obtained with either system in any position.

The engineers at Kenwood seem to have been burning a lot of midnight oil developing techniques and materials for loudspeaker design. It is very interesting that when most of their competitors are choosing to make tweeter diaphragms from beryllium or Mylar, Kenwood have chosen to make these domes from a pulp of the sweet daphne tree, faced with titanium foil. This, it is claimed, gives the perfect piston motion. Such a tweeter is incorporated in the Model 7 loudspeaker system which also uses a 4⅛in mid-range unit with a daphne-pulp dome and a 14in base driver whose cone is made from Douglas fir pulp and stainless steel wool, a combination said to reduce cone flexing distortion! These features, along with a copper cap on the bass unit pole piece to reduce eddy distortion, iron-cored cross-over inductors, metallized-film capacitors and a five-laminate lumber-cored cabinet construction, leave one to suppose that a great deal of care has been taken and we look forward to hearing this system.

Headphone and tweeter systems from Pioneer, based on their development of piezo-electric-treated Mylar (so-called high-polymer film) were on display. This very thin plastic material is metallized on both sides and changes its dimensions in response to a voltage applied across the film. In both the headphone and tweeter the contraction of the film is turned into useful radiating movements by pre-stretching the film over plastics foam in a full or part-full cylinder. Being nearly a pure capacitance this tweeter will handle high apparent powers and is very efficient in terms of output/volts applied.

Electrovoice were introducing their Interface A, which is a carefully engineered a.b.r. system with the a.b.r. mass-loaded and significantly larger than the bass driver. Careful dimensioning has allowed one of the more exotic alignments to be attained when used with an active equalizer supplied. This equalizer boosts the low frequency output of the amplifier by 6dB in the region of 35 Hz and allows a response to 32 Hz from a 25-litre enclosure with average sensitivity.

Amplifier ruling

The Federal Trade Commission introduced a ruling on claims made about power amplifiers, which became law in February of this year. One aspect of this ruling is that any power amplifier must be able to meet its specification after being pre-conditioned by a continuous sine wave drive at 30% output (both channels) at 1kHz in an ambient of 25°C for one hour, followed by five minutes at full rated power. Of course 30% output is very near the lowest efficiency of a Class B amplifier and they get very hot. An immediate result seems to be that a lot of familiar amplifiers from many manufacturers, SAE, Crown, Phase-Linear, BGW, etc, have grown blowers.

One development which is attempting to get round this is a pulse-width-modulated (Class D) switching amplifier from Infinity Sound Systems which is rated at 250W per channel at less than 0.1% distortion. Switching rate is 500kHz and the power supply is converted to 25kHz, so efficiency is very high and heat dissipation low. The unit is quite small, measuring 17in by 11in by only 3in high. The matching preamplifier features a playback only noise reduction system using a noise-signal cross-correlation circuit.

This amplifier had a very large amount of heatsinking, roughly what would be expected for a Class B unit of the same size; however as it was obviously protected by thermal switches and claimed to run cool, it may be temperature sensitive. Probably Infinity haven't finished designing p.w.m. amplifiers yet, and this looks promising.

High power amplifiers were very much in evidence and there is a wide choice in the 250 to 500 watt range. The ESS 500A is a typical example. It is rated at 250 watts per channel at less than 0.1% distortion, with hum and noise better than 102dB below rated output. Protection circuits are quite complex and they include thermal dissipation reduction and speaker protection. Of course there are many larger amplifiers, and companies such as Crown, BGW and Cerwin-Vega all make units that can put out 2000 watts or more. Only one amplifier was seen using the new f.e.t. output transistors: this was the Yamaha B-1 and it was rated at 180 watts per channel. This company had one of the most elaborate preamplifiers at the show and the features included all-f.e.t. circuitry, dual reading VU meters, six-position phono impedance matching and a built-in signal generator giving a choice of four frequencies plus pink noise. The Lux company had an interesting preamp too, and its double cascode transistor input stage could handle 400 mV with a nominal phono sensitivity of 2mV. It also boasted a Class A push-pull output stage, mid-range tone controls, and a choice of bass and treble turnover frequencies.

A low noise pre-amplifier from Burwen features active cartridge termination – this is to give lower noise, claimed to be 77dB below 2.5 mV. Also newly out was the Burwen extender equalizer EQ 3200 which is a well thought out programme equalizer with carefully chosen band filters below 150 Hz and above 3kHz to allow maximum equalization of room emphasis. The noise-curative dynamic noise filter DNF 1201 by the same company was demonstrated and was very effective on noisy programme: this machine was a consumer version of the Burwen system of fast-response, low-pass-filter noise reduction and sells for about £100.

Tape recorders

There were many new tape recorders on show. The frequency response of a new Sony open-reel machine was only 2dB down at 47kHz so it will soon be possible for enthusiasts to tape their CD-4 records. Naturally, this machine is not cheap but improvements tend to find their way into less expensive equipment sooner or later. In any case, one of the reasons for the extended high frequency response is the use of the hybrid Ferri-chrome tape, now obtainable in open-reels. But TDK have just announced a new tape using a fine-grain ferric oxide and cobalt ion formulation which, they say, is superior to both chrome and Ferri-chrome. And so it goes: one can only hope that ths tape battle will not lead to a proliferation of equalizing controls. Already the majority of the new cassette decks have provision for low-noise, CrO_2 and Ferri-chrome. Nearly all have built-in Dolby systems (one, a Sony model costs only $150) and the more expensive models have monitoring facilities, variable speed control and all kinds of gadgets. Several use extended range VU meters, in other words a semi-logarithmic scale which permits readings down to –40dB, a most useful feature.

Two interesting cassette recorders caught the eye. The Yamaha TC800GL, with an attractive appearance by Mario Bellini, offers all the usual facilities and, in addition, a memory rewind and a + 3% speed control for fine tuning of pitch. The other is a front-loading machine from JVC, the CD1960, featuring the automatic noise-reduction system and the new sendust alloy heads developed by JVC. JVC say this is a third-generation head material which offers at least twice the maximum flux density possible with Permalloy and the hardness of ferrite. It is also much more elastic than ferrite and so does not tend to chip or crack in the way that ferrites do.

A very interesting development in tuners from Kenwood is the Model 700T. It combines a 1.8 μV IHF sensitivity, distortion less than 0.2% and 100 dB image rejection, a synthesized local oscillator with a linear scale pointer display of frequency — probably the first chink in the digital armour. After all, there is no reason for having to use digital frequency readout just because it can now be done; in fact, the analogue display is often much more useful and acceptable. The synthesizer system locks in 200 kHz steps in accordance with the f.m. channel spacings, giving high "resettability" and long-term stability of 0.00024% to a tuner of conventional operation. The same tuner has a pulse-noise blanking system and a good a.m. section.

Statistics show that over 6,000,000 Citizens Band radios are now in use in the USA and that one car out of 33 is so equipped! Apparently lorry drivers are enthusiastic users but anyone or almost anyone can get a FCC licence. There are 23 channels in the allotted 27 MHz band and the cheaper hand-held models are very suitable for campers, hikers and boating people. If the output is less than 100mW no licence is required. So there was a great variety of CB radios on show and most of the companies concerned also make scanning receivers for the police bands. The majority use crystals but some of the more expensive use a digital frequency synthesizer. An example is the Optiscan which employs an optically scanned card to offer a selection of up to 16,000 scanned frequencies in the 30MHz to 510MHz bands.

More than 40 companies showed calculators ranging in price from $10 to print-out units costing $200 or more. A year ago it was said in jest that we would soon have $10 calculators but one might ask what would one get for that money? Well, the Novus 600 offers a 6-digit, 4-function facility with automatic add, subtract, multiply and divide with a 2-place decimal setting. Commodore has a new model with algebraic logic, seven-digits and floating decimal at $9.95. Alco make a similar model, now available on the U.K. market. It measures 7½ inches square by 1 inch deep, with a cutout for a handle in one corner. The fancy plastic case is decorated with Schoolteacher Mickey Mouse and the model is called Mickey Math – what else? Litronix had a new model which features a floating decimal, square, percent, reciprocal and automatic constant with full accumulating memory. After 15 minutes it shuts itself off, and it costs $29.95. Another model, the 2270, performs five statistical functions: arithmetic mean, variance, standard deviation, sum of x and sum of x^2 with square root and full accumulating memory, all for $39.95.

Quadraphonic sound does not seem to generate the excitement it did a year or two ago. In a way it has come of age, and it is accepted as viable medium with many advantages over stereo for those who want to pay the price. A special Quad-a-Rama combined demonstration affair was always well attended and there were a great number of quadraphonic receivers to be seen. Onkyo are still the only makers of a model with automatic CD-4 to matrix switching, which was surprising as this seems such a logical (sorry!) thing to do. The standard practice is to provide decoding for both CD-4 and SQ, with Sansui and one or two others giving a choice of QS as well. There must be well over 500 f.m. stations now broadcasting matrix records and many are equipped with Sansui QS or CBS-Sony SQ encoders. Dealers' estimates of their quadraphonic sales vary from 5% all the way up to 50%. In general, those who take the trouble to demonstrate, and demonstrate properly, get a high percentage of sales.

There were countless watches available, all in the same sort of format as a conventional mechanical watch, the basic differences being concerned with finish and the choice of l.e.d. or liquid crystal displays. It would seem to be a precarious time for all concerned in watches, particularly if prices take a dive in the way that calculators have over the past year. The l.e.d. watches all have a switch to activate the display for a short time, hence saving the battery: it seems a pity that one needs two hands to tell the time on these (no pun intended).

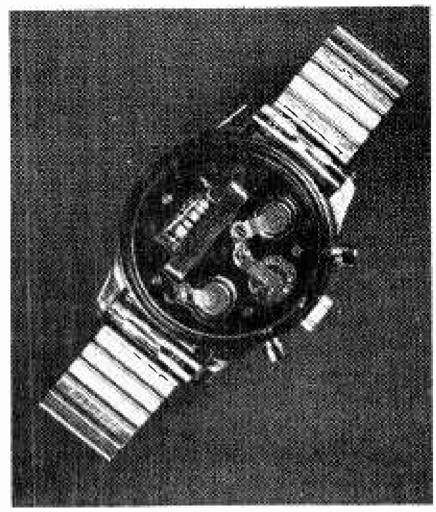
Television set sales are down 30% in 1975 so far but audio components are up 10%. Food for thought here. . . Projected TV sales for 1975 vary between 7 and 7½ million sets compared with 9½ million in 1973. Mortek were demonstrating a three-dimensional TV receiver, using a closed circuit camera. The viewing distance was quite critical, being about plus and minus one inch, but it was stressed that the model was a prototype and that the optimum distance of 18 inches from the tube would be suitable for medical and industrial applications.

This report was compiled from contributions by G. W. Tillet and J. R. Stuart.

Digital wristwatch

2—Construction

by D. D. Clegg



As mentioned in the introduction to this article, this watch was designed around a specific empty wristwatch case, Type 155-72. This case was chosen because it is fitted with two push buttons, which would have been difficult to engineer on a plain case and, although its diameter is not greater than most gent's watches, it is much deeper. Supplied with the case is a brass ring which forms the main framework of the module, which is assembled as a "sandwich" of three thin printed circuit boards with cut-outs for the components so that much of their depth is taken up in the p.c. boards.

The module is divided into two sub-units, connected by three flying leads. The front sub-unit comprises the display and the main logic i.c. assembled into the brass ring, while the rear part contains the complete oscillator circuit and the three mercury batteries. The batteries are held in place by a perspex block (the battery block) and the battery connexion clips are kept clear of the back of the case by a perspex spacer (the rear spacer block).

Printed circuit boards

The printed circuit boards are shown in Fig. 10. These boards will be supplied by the manufacturer on a single piece of 1/32in, 1oz copper, epoxy glass material and are undrilled and uncut to keep the price down. The cost of tooling-up to produce small quantities of completed boards to the required accuracy would certainly double, and more than likely triple the total cost of a set of boards.

The boards should be cut out oversize with a small saw and then filed to the exact size with a fine jeweller's file. They should be cut to just inside the copper delineating circle. The printed circuit boards are gold plated and great care should be exercised during filing so as not to scratch the surface. This is particularly important on the display board. If necessary during the filing process the surface can be protected by a layer of self adhesive tape. The cut-outs can then be filed out until the copper, shorting the component contact pads, is removed. This should be checked with an ohm-meter because even a very small whisker of copper left across two pads will cause incorrect operation of the watch and can prove very difficult to trace after assembly. It is important also to check that the components will fit into the cut-outs provided for them. Again, this is particularly important on the display board, where not only the size should be checked, but also the orientation of the display. Once the watch is assembled, if the display is mounted at even quite a small angle to the horizontal, it will be very noticeable.

All of the components are mounted on the copper sides of the printed circuit boards; their location can be seen in Fig. 9. The only holes drilled in the boards are the screw holes (lettered A to E in Fig. 10) and the two arcs of holes at the periphery of the display and main logic boards.

The main logic and display boards are mounted back-to-back (plain sides together) to form a double-sided board, the through connexions being made by short pieces of wire through these two arcs of holes.

Before assembling these two boards together, check that they are the correct way round, i.e. the switch cut-outs on the two boards are at the

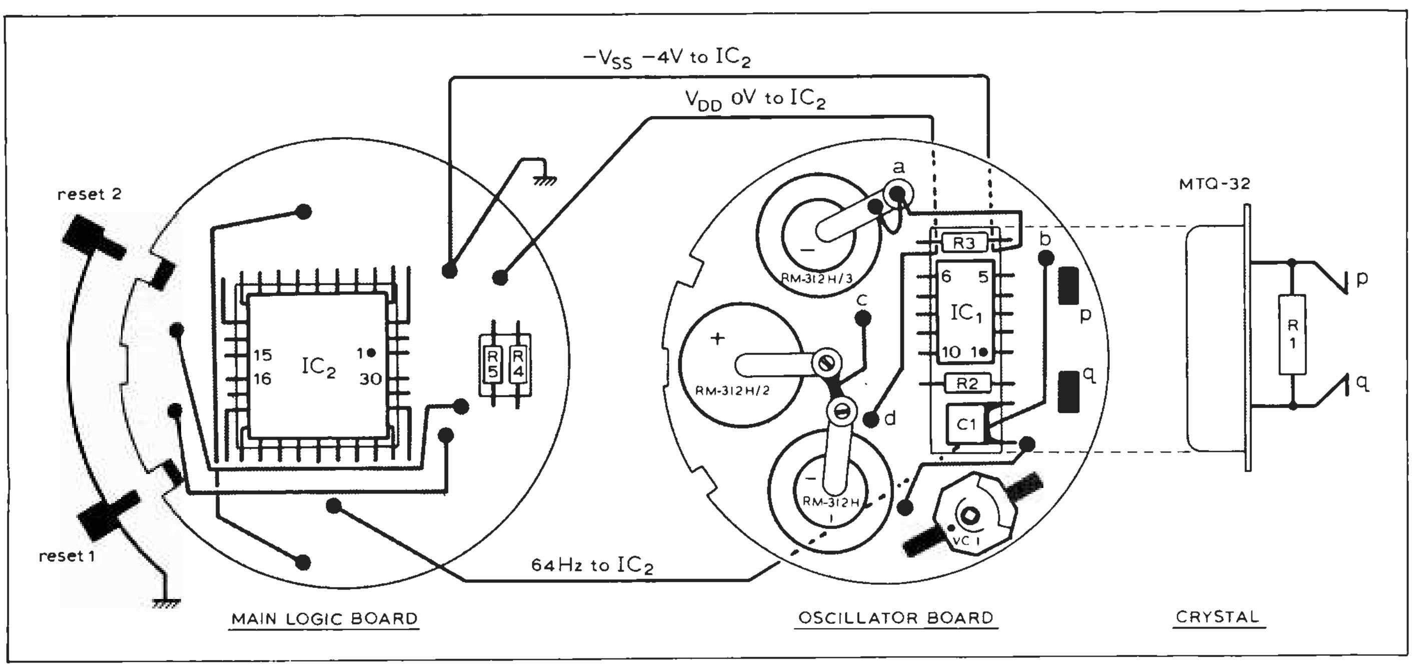
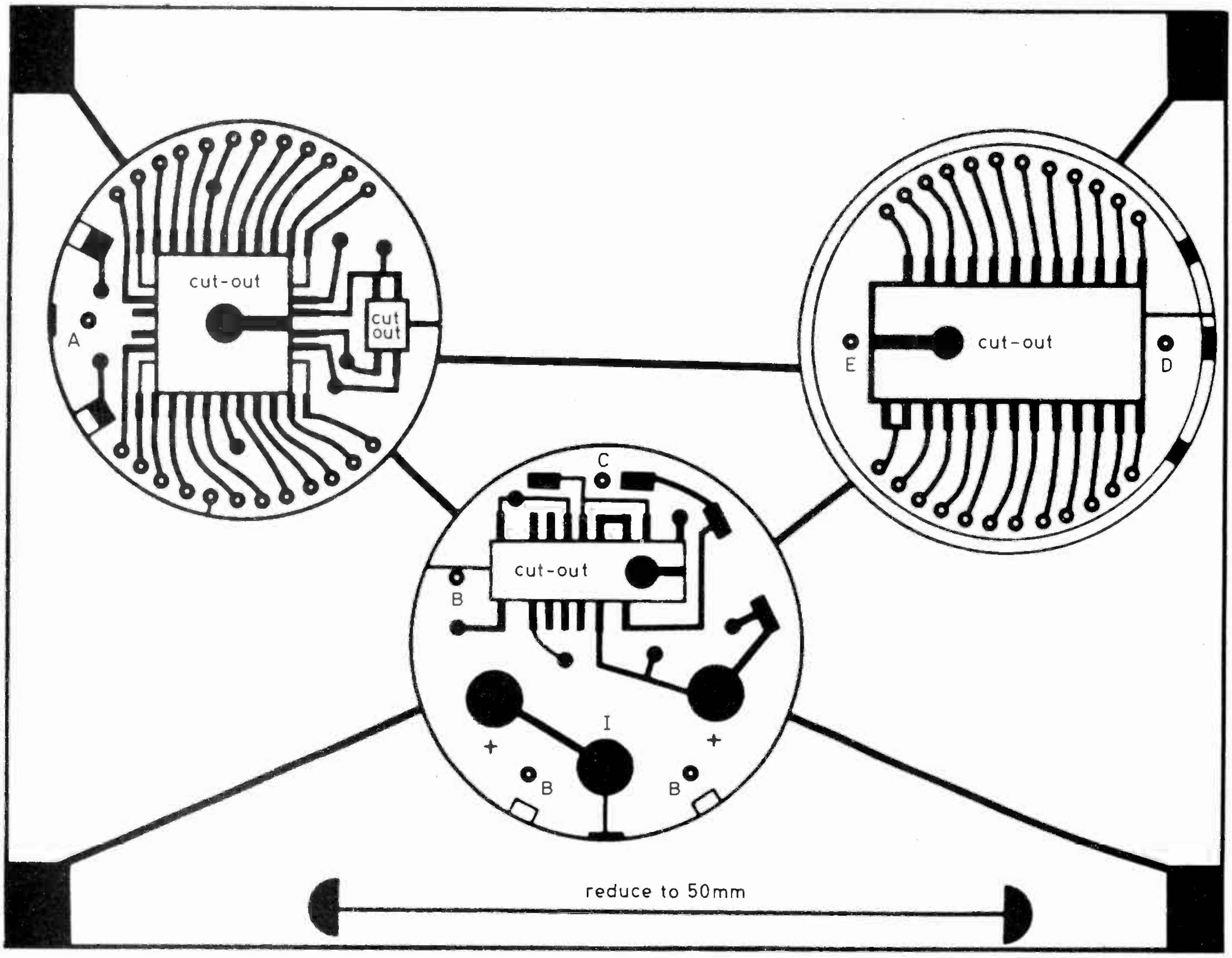


Fig. 9. Logic and oscillator board wiring. The crystal and R_1 are mounted above R_3, IC_1, R_2 and C_1 as shown.



same side. To start with, wire only two of these connexions, one at the top and one at the bottom, allowing the two boards to be accurately aligned before the others are wired. They should be wired with thin, tinned copper wire of about 34 or 36 s.w.g. The wire should be bent over on both sides of the board(s) and soldered with only the absolute minimum of solder. The solder must not protrude more than 0.5mm above the surface of the boards; if necessary file these connexions to reduce these solder spots to this height.

Component fabrication

If the specified case is purchased, then it will be supplied with a brass ring. Its dimensions should agree pretty well with those given in Fig. 12A although the height and width of the switch clearance cut-outs may need to be increased. Holes "J" will not be present and should be drilled with a 0.58mm drill (number 74) and tapped 16BA. They are then countersunk slightly to suit the 16BA screws used (see Fig. 13). If the specified case is not purchased then the brass ring can quite easily be fabricated from two 0.5mm thick strips of brass, soldered together so that the joins do not coincide.

Fig. 12G shows the faceplate and Figs. 12B, C and D give details of the battery clips, contact bridge and the switch contacts. In the author's prototype the faceplate was made from a piece of printed circuit board, bright nickel plated, which had the author's name etched in it. The faceplate described here is very much cheaper and any decoration can be stencilled on or added with Letraset.

When assembling the faceplate, the tapped blocks should be drilled and tapped before being glued to the faceplate proper. To prevent glue from blocking the holes they should be filled with wax or plasticine. Before the glue sets it should be checked that the holes "K" line up with the holes "D" and "E" in the display board.

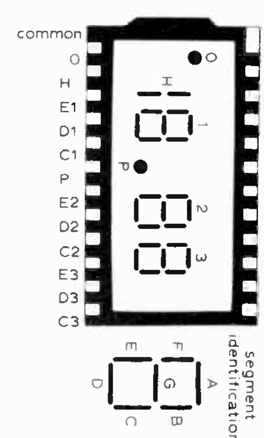
The battery clips, contact bridge and switch contacts are made from 0.125mm thick beryllium copper, gold plated. The author "rescued" some contacts from an old relay to make these components in the prototype.

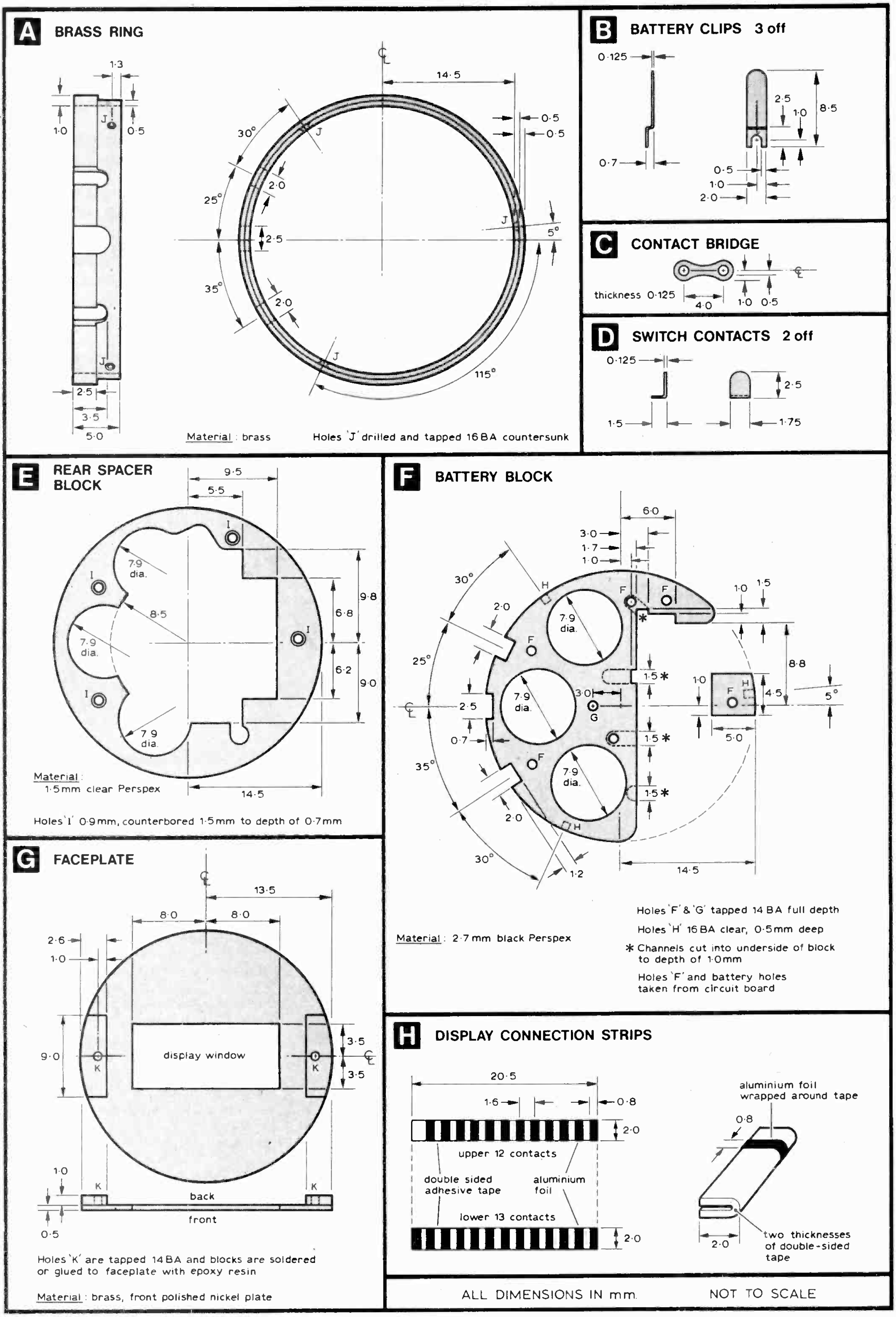
Fig. 12F shows the battery block which can be made from an offcut of ⅛in (3.175mm) black perspex and reduced to the required thickness of 2.7mm with abrasive paper. The best way to start making this component is to file out a 29mm diameter disc. The positions of the tapped holes "F" can

Fig. 10. The three p.c. boards as supplied. Holes on the arc of connexions are 0.5mm, countersunk on plain side. Hole A is 1.5mm; holes B are 0.9mm and C is drilled 0.9mm, counterbored 1.5mm to a depth of 0.3mm on plain side.

Fig. 12. Mechanical information.

Fig. 11. Display connexions.




A BRASS RING
Material : brass
Holes 'J' drilled and tapped 16BA countersunk
B BATTERY CLIPS 3 off
C CONTACT BRIDGE
thickness 0·125
D SWITCH CONTACTS 2 off
E REAR SPACER BLOCK
7·9 dia.
Material : 1·5mm clear Perspex
Holes 'I' 0·9mm, counterbored 1·5mm to depth of 0·7mm
F BATTERY BLOCK
7·9 dia.
Material : 2·7mm black Perspex
Holes 'F' & 'G' tapped 14 BA full depth
Holes 'H' 16BA clear, 0·5mm deep
* Channels cut into underside of block to depth of 1·0mm
Holes 'F' and battery holes taken from circuit board
G FACEPLATE
display window
back
front
Holes 'K' are tapped 14BA and blocks are soldered or glued to faceplate with epoxy resin
Material : brass, front polished nickel plate
H DISPLAY CONNECTION STRIPS
upper 12 contacts
double sided adhesive tape
aluminium foil
lower 13 contacts
aluminium foil wrapped around tape
two thicknesses of double-sided tape
ALL DIMENSIONS IN mm
NOT TO SCALE

then be marked through from the oscillator board. The correct size to drill these holes for tapping 14BA is 0.7mm, the nearest numbered drill size being No. 70. The battery holes should be drilled out undersize and filed to the 7.9mm diameter required. Do not take this measurement from an actual cell, since the manufacturer's data gives the diameter of these cells as being between 7.6 and 7.87mm, and if the hole were cut undersize later cells might not fit.

Although the material specified for the battery block is black perspex, constructors may find that the use of transparent perspex enables the positions of the various holes to be determined more easily.

Holes "H" should not be drilled until final assembly of the module, when their positions can be accurately determined by inserting the rear sub-unit into the brass ring of the front sub-unit, and marking their positions through holes "J". Fig. 12E shows the rear spacer block. The material specified for this component is clear perspex; the author used red transparent perspex in the prototype, although almost any plastic material is suitable.

Assembly

The first stage in the assembly of the module has already been described; this was the construction of the double-sided display/main logic board which is part of the front sub-unit. The next stage is to glue the brass ring to this assembly with epoxy resin adhesive. The outer diameter of the brass ring is the same as that of the display board (31mm), while its inner diameter is the same as that of the main logic board (29mm). The brass ring fits over the main logic board so that it rests on the plain side of the display board with the main logic board inside. Take care to use no more adhesive than is required, and check that the ring is accurately aligned with the boards before it sets. Once the glue has cured, remove any excess from around the outside with a fine file and check that it fits into the watch case. Fig. 14 is an exploded view of the front sub-unit.

At this stage it is advisable to assemble the three main components of the rear sub-unit (Fig. 15) and check that it fits into the front unit.

Fig. 13 gives details of the various screws required in the watch; the best way to obtain these is to buy a 20 gram box of assorted wristwatch screws from a watchmaker's suppliers, and sort out what is required. Alternatively constructors could ask their local watchmaker to help them obtain these. Once the mechanical work has been checked, the electronic components can be fitted. A word of caution here, however; the integrated circuits are c.m.o.s. devices and can be destroyed by quite small static charges picked up through incorrect handling. These devices will be supplied in plastic carriers and wrapped in conductive foam: leave them in this until you are ready to install them. Because of the possibility of damaging the i.cs due to static, the assembly of the module from this point onwards should be carried out on an earthed conductive surface, for example a sheet of aluminium kitchen foil. All the components and tools should lie on this earthed surface and a small soldering iron with an earthed bit must be used. The author would advise constructors to obtain some 26s.w.g. solder to assemble this watch as the more popular 22s.w.g. will be found to be rather too thick.

The component leads should be cut to a length of between 1.5 and 2mm. Before soldering the components on the oscillator board, check that the component leads are not so long as to prevent the battery block from mounting flat on the board.

Fig. 9 shows the positions of the components on the two boards. It also shows the wired links on the main logic board and the flying leads connecting the two sub-units together. These wired connexions should be made with a flexible p.v.c. covered wire with an overall diameter of not more than 0.5mm (e.g. pickup connecting wire). The three leads from the rear sub-unit to the front sub-unit should not be more than 25mm long. The −4V connexion to the frame (Fig. 9) is soldered to the inside of the brass ring as close to the surface of the main logic board as possible. One lead of the trimmer capacitor, VC1, is marked with a coloured dot; this indicates the "earthy" end of the capacitor (connected to the rotor) and must be connected to V_{DD}.

The switch contacts are mounted on the main logic board; there should be a gap of between 0.5 and 0.75mm between the inside of the brass ring and the contact.

When fitting the integrated circuits take great care that they are mounted the correct way round; mistakes here can be very difficult to correct, particularly with IC_2. The tops of both i.cs are the sides which are printed with the type number: pin 1 of IC_1 is marked by a small dot; pin 1 of IC_2 is the end lead whose "elbow" is T-shaped.

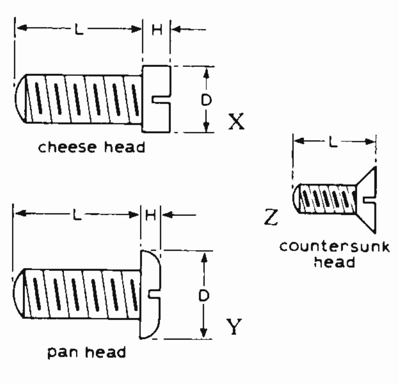
After soldering the main components to the oscillator board, fit the battery block before the crystal and feedback resistor R_1. Coat the underside and the ends of the crystal with a thin layer of silicone rubber; this will hold it in place and reduces the chance of shock damage if the watch is knocked or dropped. The rear sub-unit can then be completed by fitting the battery clips, contact bridge and finally the rear spacer block (see Fig. 16). resistor R_4 should be omitted from the main logic board until the faceplate has been fitted, as one of the fixing screws is underneath it.

Display

The liquid-crystal display consists of two glass plates separated by a thin layer of the liquid crystal material: the inner surfaces of these glass plates are coated with a thin layer of transparent, conductive indium oxide in the required pattern, which can just be seen if the display is viewed almost parallel to its surface. The connexions to the display Fig. 11 are provided by continuing the indium oxide conductors to the edge of the upper plate. Liquid-crystal displays of the watch variety are difficult to connect: they cannot be soldered as can most other components, and the invisibility of the connexions does not help! Many manufacturers overcome this problems by using conductive adhesives, although for the home constructor this is inadvisable: the adhesives themselves are very, very expensive and the display would be difficult to replace when this is required.

As a result of the difficulties experienced in connecting watch displays

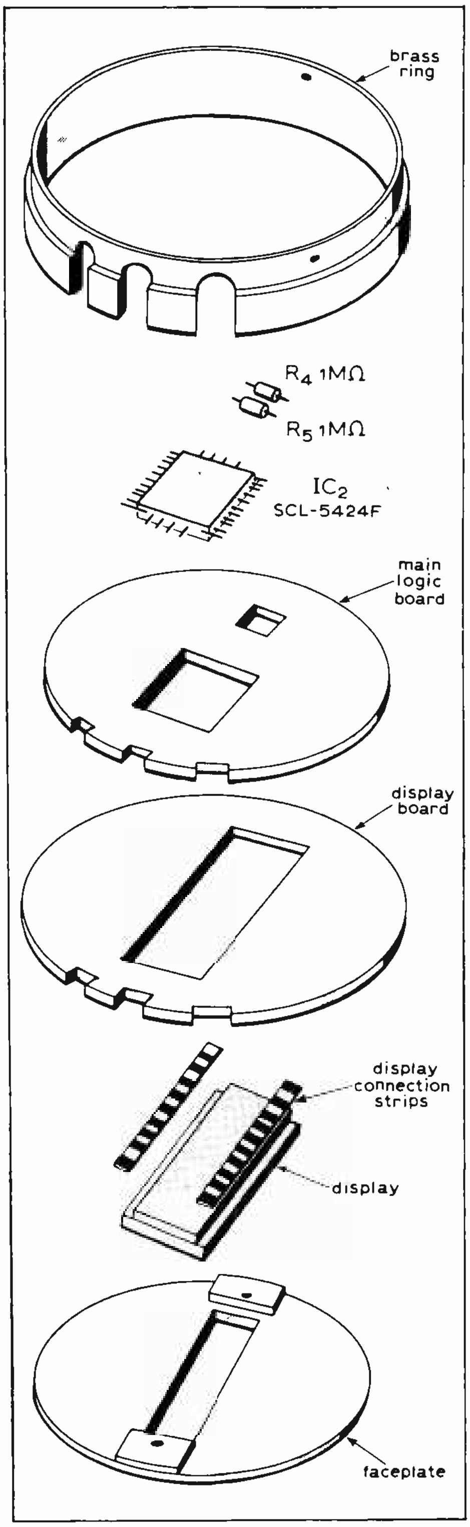
Fig. 13. Screws used in the watch.



	No USED	BA SIZE	HEAD TYPE	L mm	D mm	H mm	USE
1	3	14	Y	1.8	2 0	0 3	secure battery block to oscillator board through holes 'B'.
2	1	14	X	1 5	1.4	0 3	secures small piece of battery block to oscillator board through hole 'C'
3	4	14	X	2 0	1 4	0.6	secure rear spacer block to battery block through holes 'I'.
4	3	14	Y	1 5	2.0	0.3	secure battery clips to battery block
5	1	14	X	1 5	1 4	0.5	secures faceplate through hole 'D' Hole 'A' clears the head of this screw
6	1	14	X	1 2	1 4	0.3	
7	3	16	Z	1 5	—	—	secure rear sub-unit to front sub-unit through holes 'J' thus forming complete module.

and to overcome similar problems, a number of connector manufacturers have designed some very ingenious systems. One such system, by Amp Inc., consists of an elastomer rod with metallized bands around its circumference at the required contact pitch. These rods are held between the display connector edges and the printed circuit board by adhesive tape. All of these connector systems are quite new and the author received data on them only after designing the watch (and part way through construction of the prototype). The Amp system described above is for a surface mounting display and is not suitable for this watch.

Fig. 14. The front part of the watch in exploded form.



The display connexion method to be described may appear to owe much to a certain Heath Robinson, but it is quite cheap and, if it is carefully and accurately made, it will be reliable.

Figure 12H shows the "construction" of the display connexion strips, which are made by laying 0.8mm wide strips of aluminium foil at intervals of 1.6mm across two thicknesses of self-adhesive tape, at least one of which must be double-sided. The author advises constructors to adopt the following formula:– lower layer of tape – Sellotape double-sided; top layer of tape – Scotch magic transparent tape, with the foil stuck on with its bright side outwards. This "sandwich" is then folded over so that the inner surfaces (those without foil) stick together. The strip thus formed is cut to the required size. These connexion strips can then be fitted accurately to the display board and pressed down; the display should then be aligned on top by viewing it almost parallel to its surface so that the contact pads can be seen. It should then be pressed down to hold it in position while the faceplate is fitted. The faceplate fixing screws should be tightened only until the display starts to compress the connexion strips, take great care not to screw them too tight.

Once the display and faceplate have been fitted, resistor R_4 can be soldered onto the main logic board and the rear sub-unit fitted into the front sub-unit. Make sure that the flying leads lie side by side and not on top of each other, and that the oscillator board sits directly in contact with the top of IC_2. The positions of holes "H" can now be determined by marking through holes "J" in the brass ring, and drilling them with a 0.7mm drill. After fitting the two sub-units together, the module is complete.

Testing

Before applying power to the module it should be given an overall visual check, just to make sure that there are no, possibly expensive, errors. The rear sub-unit is tested by itself to start with, by disconnecting the three connexions to the main logic board and connecting the 64Hz output to an oscilloscope ($R_{in} \geqslant 10M\Omega$, $C_{in} \leqslant 10pF$) using the $-V_{ss}$ (−4V) connexion as the common. (The 'scope is effectively across R_3.)

The three batteries can now be inserted (see Figs. 9 & 15) starting with cell number 1. The negative connexion of this cell should be replaced by a microammeter connected with very short leads. The 'scope should show a 64Hz waveform consisting of 15μs pulses of approximately 4volts amplitude at intervals of 15.6ms. The current indicated on the meter should not be over 5μA; it will typically be about 2μA.

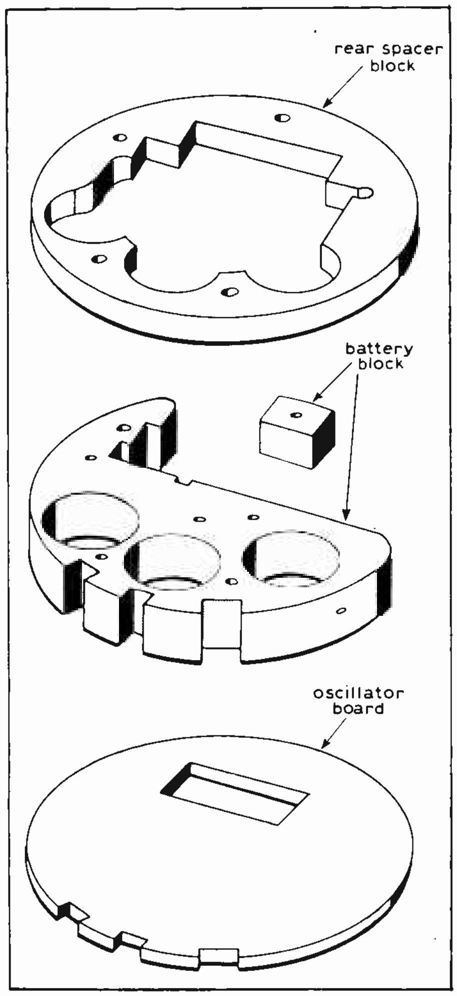


Fig. 15. The rear sub-unit.

If the current is much lower, and the output is present, then there is no cause for concern; if, however, the output is absent then the oscillator is faulty and all the components should be carefully checked. If, on the other hand, the current is much above the specified 5μA, then there may also be a fault. Check that this is not caused by excessive output loading due to the 'scope.

Once the oscillator has been successfully tested, remove the batteries, re-assemble the module and re-insert them, starting as before with cell number 1. Check that the current is not more than 0.3μA more than the oscillator takes by itself.

The display point should now be flashing at a 1Hz rate, and the display will show a "random" time; there may also be some segments missing from some of the digits. This is caused by a combination of the counters powering up in non-valid states and incomplete decoding of the outputs; it is nothing to worry about at this stage. If all appears to be well, the operation of the reset controls can now be tested. This can be accomplished by connecting the switch contacts to the brass ring with short pieces of wire. The SCL-5424-AF integrated circuit does not have switch anti-bounce circuitry on the reset inputs and operation of these controls

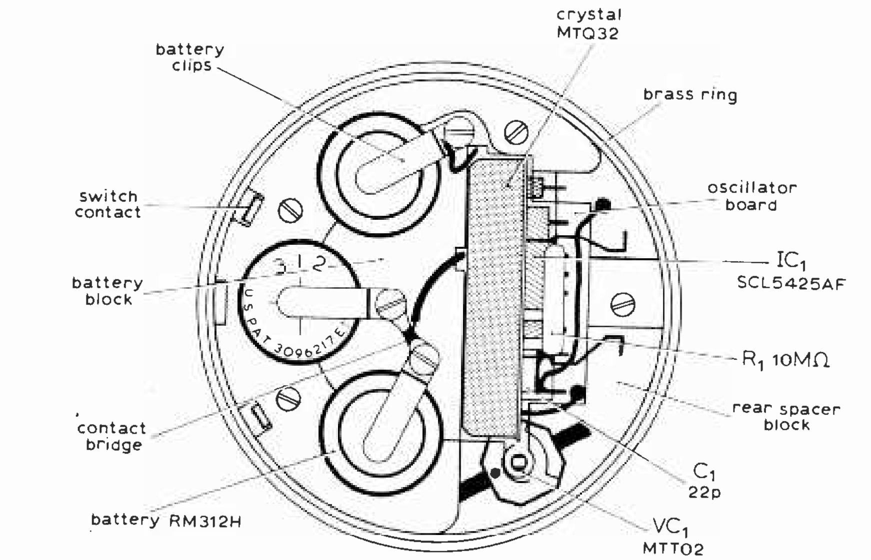


Fig. 16. View of the completed module.

may sometimes cause the minutes or hours to advance several counts at one time.

Finishing touches

Before inserting the module into the case, the screws securing the push-buttons should be removed and their heads should be highly polished. Also the case is supplied with a winding knob which should be fixed in position by means of a suitable screw. The crinkle spring supplied with the case is discarded and the inside of the case back is lined with a piece of thin insulating material, backed by a thin piece of plastic foam to keep the module in position if this is required. The final appearance of the completed watch is improved if the edge of the faceplate and any visible parts of the display board are painted matt black.

Oscillator adjustment

A frequency counter will be found useful in adjusting the oscillator to the exact frequency of 32.768kHz. This must be done with the module in the open case because variation in stray capacitance would cause a slight frequency shift. The frequency counter should be connected to the unused 256Hz output of IC_1. Alternatively a tuned amplifier (tuned to 32.768kHz) can be used to pick up the very small amount of radiation from the module. This is a technique that is used by a number of watch manufacturers. The trimmer VC_1 should be adjusted with a plastic trimming tool having a 0.75mm square end. If a frequency counter is not available, then the watch can be adjusted by trial and error, although it may take several weeks to arrive at an acceptable degree of accuracy.

Parts list

R_1.....10MΩ Mullard CR25. Electro-value.
R_2.....330kΩ 0.125 watt carbon composition. Doram.
R_3.....100kΩ 0.125 watt composition. Doram.
R_4.....1MΩ 0.125 watt carbon composition. Doram.
R_5.....1MΩ 0.125 watt carbon domposition. Doram.
C_1.....22pF Mullard C333 series. R.S. Components. (Min. Cer. Cap.)
IC_1.....SCL-5425-AF Trans-World Scientific Ltd, Short St, High Wycombe, Bucks.
IC_2.....SCL-5424-AF Trans-World.
X_1.....MTQ-32-12 Motorola.
VC_1.....MTT-02 Motorola.

Both Motorola components from Pambry Electronics Ltd, 45 High St, Burnham, Bucks.

Case.....155-72 Gleave & Co, 111 St John Street, Clerkenwell, London EC1V 4JA.

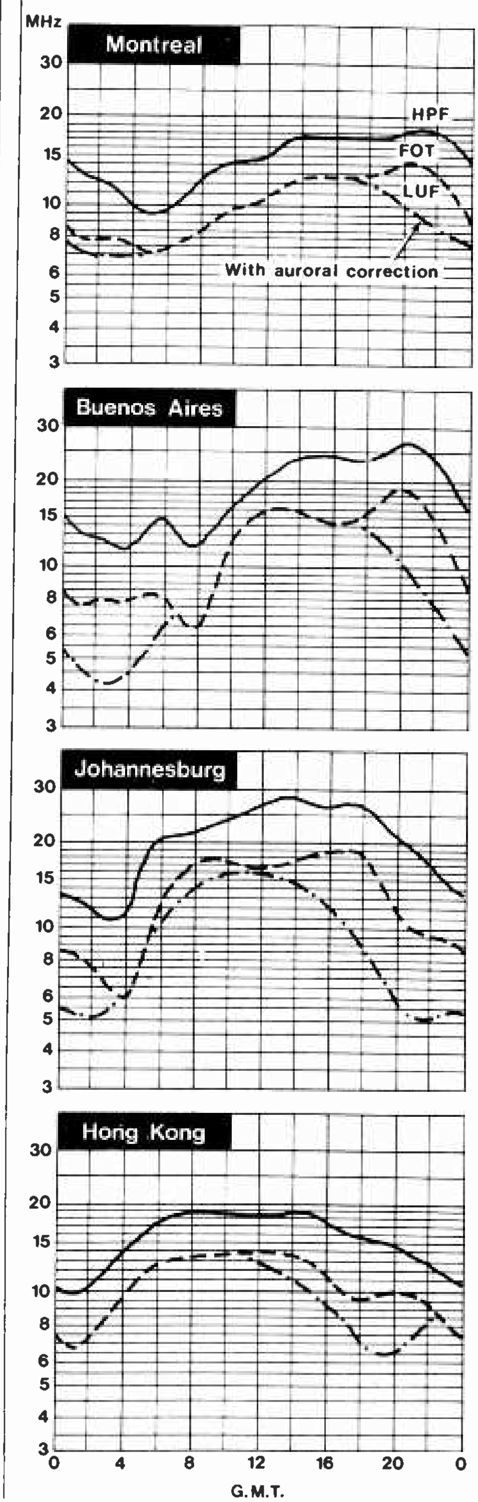
Printed circuit boards: Photoetch Ltd, 9 Lower Queen Street, Penzance, Cornwall TR18 4DF.

Display: Type LC-201135-0000: Brown Boveri and Company, Albany House, 41 High Street, Brentford, Middlesex TW8 0BH.

HF predictions

The recurrence pattern of magnetic activity which was expected to break up in the spring and reform about now has in fact remained clearly defined throughout recent months. This has resulted in day to day variation of conditions greater than that normal for time of year with tendency for poor days to be dominant.

Solar activity is now very low. Minimum order index values have been observed since March so a new sunspot cycle can confidently be expected soon.



Reference and regulator circuits

Background to the topics of sets 23 & 24 of Circards

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

Paisley College of Technology

Reference circuits — see set 23 for tested circuits

Some semiconductor devices have highly non-linear characteristics, in which the non-linearity is well-defined with predictable and small dependence on temperature. If a region of the characteristic is found for which the slope resistance is either very much greater than or very much less than the static resistance then the device can be used as a current or voltage reference respectively.

In Fig. 1 (a) there is an extended region over which the voltage varies little for large changes in current. Fig. 1 shows the dual characteristic with current being maintained constant against changes in bias voltage. The most commonly used device belonging to the former category is the zener diode, the reverse characteristic having a sharp breakdown region. There are two physical mechanisms that can control the reverse conduction of a p-n junction: zener breakdown and avalanche breakdown.

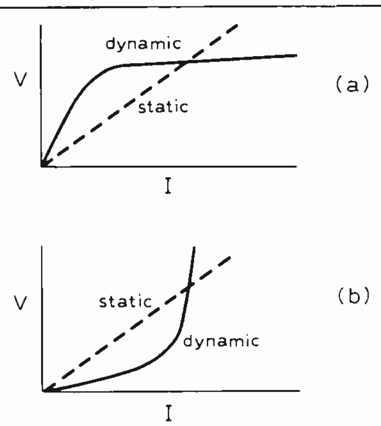


Fig. 1

Zener breakdown is a field effect which dominates for heavily-doped narrow junctions, where even small p.ds of three or four volts can provide a sufficiently intense field for the direct production of hole-electron pairs. The observed characteristics are that the current increases steadily as the operating region is approached, with a rounded knee, and with a temperature drift of about -2mVK^{-1}. To a first order the slope resistance of such diodes is inverse to the quiescent current.

At higher p.ds, which can only exist with more lightly doped broader junctions where the zener effect is unable to limit the voltage, thermally generated holes and electrons are accelerated by the field. If the p.d. is large enough some will gain sufficient kinetic energy before colliding with other atoms, to produce further hole-electron pairs by collision. These in turn may generate further pairs and at a particular voltage there is a very sharp increase in current. Below breakdown the current is negligible, while above it the slope resistance is low. The voltage changes with temperature by less than $+0.1\%\ \text{K}^{-1}$.

There is an intermediate doping level resulting in breakdown voltages between five and seven volts where both processes contribute significantly to the total current. The proportion is dependent both on the junction and on the current level, but it is possible for diodes between 5.5 and 6.5V to have negligible drift with temperature if biased correctly (lower currents for the higher voltage devices). An identical breakdown occurs in the base-emitter region of a transistor, and planar silicon transistors can be used as low-current zener diodes with good slope resistance. Breakdown voltage for the base-emitter junction is typically 6 to 10V, varying little for a given device. (Breakdown diodes are commonly described as zener diodes regardless of which physical process dominates.)

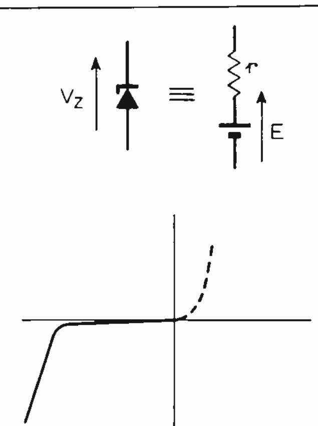


Fig. 2

A simplified equivalent circuit for such a diode if biased into the low slope region is shown in Fig. 2. It consists of a constant e.m.f. in series with a small resistance. The resistance is assumed constant i.e. the characteristic is approximated to by the 'piecewise linear' graph shown. A circuit for a simple zener diode regulator is shown in

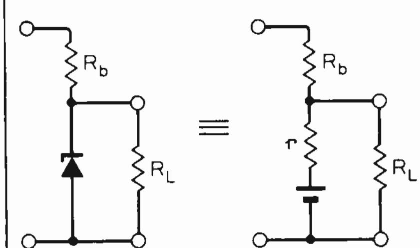


Fig. 3

Fig. 3. For changes in the supply voltage, load current etc the constant e.m.f. may be suppressed e.g. for an input voltage change ΔV_S, the output voltage changes by

$$\left(\frac{\dfrac{rR_L}{r+R_L}}{Rb+\dfrac{rR_L}{r+R_L}}\right)\Delta V_S$$

Since $r \ll R_L$ and $r \ll R_b$ are reasonable assumptions for a correctly designed circuit, the result simplifies to $\Delta V_o/\Delta V_S \approx r/R_b$. Similarly the output resistance is $\approx r$.

Where the diode is used simply to produce a stable reference voltage, the load current can usually be arranged to be negligible, or at least reasonably constant. This leaves only supply voltage and temperature variations to be dealt with, though for high-stability designs ageing of the device may be equally important in bringing long-term drift. The two problems require different solutions.

The effect of supply voltage is determined by the circuit design, while temperature effects can be minimized by choosing the right diode. In some cases the reference diode may have one or more forward-biased diodes added in series. By selecting as the reverse-biased diode, one with a breakdown voltage $>7V$, its positive drift can be balanced against the negative drift of the forward-biased diode(s). In the circuits of Figs 4 to 7 the single zener diode could be replaced with any such combination.

Though the diode has a low slope resistance its voltage stability will be ideal if fed from a constant current (Fig 4). A practical way of realizing this is to use a transistor with a fixed base-potential and large emitter resistor. Any variation in supply voltage causes only a small variation in the transistor current and hence a still smaller change in the output voltage. An extension of the method, the ring-of-two reference (Fig. 5) has two zener diodes each controlling the constancy of current fed to the other. In this and other related circuits the variation in output voltage due to supply charges can be reduced to a few tens of microvolts – generally far lower than the variation due to temperature changes.

Most i.c. voltage reference/regulator circuits are based on similar principles while exploiting the matched-characteristics of adjacent transistors as in Fig. 6. The transistors Tr_1 and Tr_2 comprise a current mirror forcing the zener diode current to equal the current in R_E, which in turn is closely defined by the zener voltage. Both circuits contain a positive feedback loop, clamped by the zener, but they are essentially bistable in nature i.e. all devices could remain non-conducting indefinitely. To inhibit this condition the resistor R_S (which can be very much greater than R_E) provides a starting current without significantly impairing the regulation.

Where the reference voltage is of an inconvenient value then a voltage amplifier may be added as in Fig. 7. Further advantages accrue from this approach. The current drawn from the diode is reduced to negligible proportions; the output current capability is increased without forcing the zener to operate at a high current; the output impedance is very low because of the shunt-derived negative feedback; the diode can be biased either from a separate supply, or from the amplifier output provided it is sufficiently greater than the zener voltage. This last method is of the same nature as those adopted in the circuits of Figs 5 and 6 viz that the zener voltage indirectly controls its own bias current. The stability can be extremely high, but the non-conducting state can also occur and may require a separate starting circuit.

Although zener diodes are the most common voltage reference units, they can be replaced by any element conforming to Fig. 2). Examples include forward-biased silicon diodes, assymetric voltage dependent resistors (down to 1V), forward and reverse biased

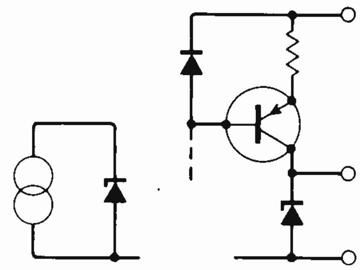


Fig. 4

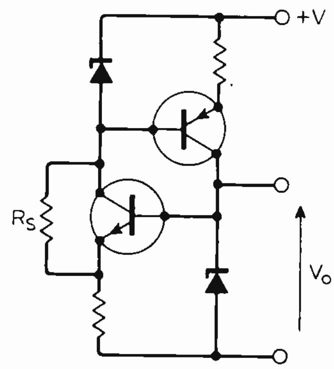


Fig. 5

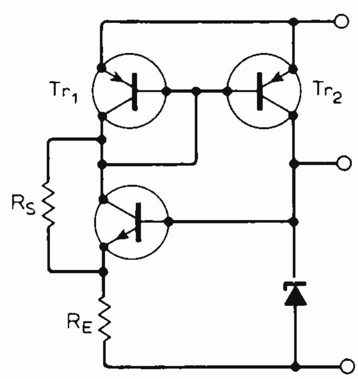


Fig. 6

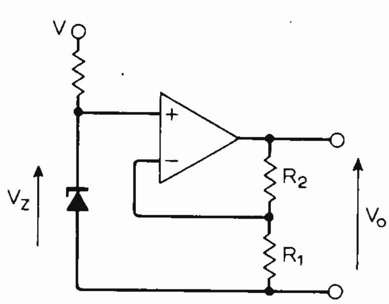


Fig. 7

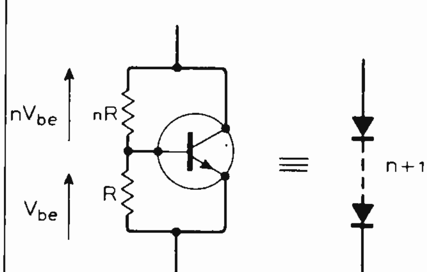


Fig. 8

junctions of transistors. A useful circuit where high stability can be sacrificed in exchange for flexibility is the amplified diode circuit of Fig. 8. If a transistor is biased by a potential divider between collector and emitter then under certain constraints, the terminal p.d. approximates to that of $(n+1)$ diodes in series. The current in the potential divider must be much greater than the transistor base current, but not much in excess of the collector current. Note that n need not be an integer and that by replacing the base-collector resistor with a variable control, we have a simple variable zener diode. The temperature drift is relatively large, about $+0.3\%K^{-1}$, but an overall stability of a few percent is readily achievable under laboratory conditions.

A completely different principle is embodied in the circuit of Fig. 9. While the V_{be} of a transistor falls as the temperature rises, ΔV_{be} between two identical transistors operated at differ-

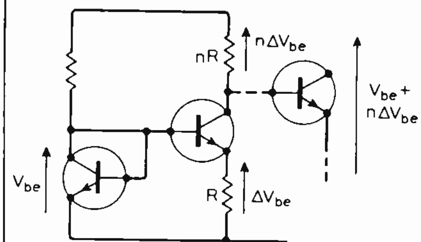


Fig. 9

ent currents has a positive coefficient. The circuit, a much simplified form of that used in recent i.c. regulators, has a terminal p.d. of $V_{be}+n\,\Delta V_{be}$. A study of the transistor equations shows that this sum equals the energy-band gap of silicon at the point where the temperature drifts cancel. This voltage is about 1.23V and is scaled up by suitable amplifying circuits where required. The forward characteristics of devices can reasonly be expected to offer better long-term stabilities than in the breakdown region, and this principle is well-established in i.c. reference circuits of the highest ouality.

Voltage regulators — see set 24 for tested circuits

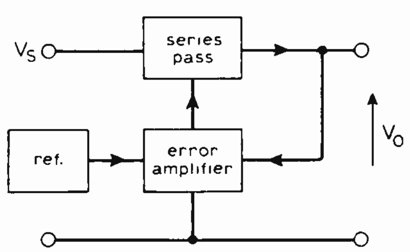
The regulator is divided into the reference section and a d.c. power amplifier. These both require supply voltages; the convenience of having a single supply may outweigh the improved stability that can be obtained. The output current can cause the amplifier supply to vary: the source impedance including increased ripple if it is a rectified a.c. supply. Because the current required by the reference circuit is low and constant, it is easier to avoid any serious ripple/regulation effects. It is essential that the d.c. amplifier have (a) an accurately defined voltage gain, (b) a low output resistance, (c) a sufficiently high output current/voltage capability, (d) a temperature drift that is either low or of the appropriate sign and magnitude to compensate for any drift in the reference section.

A simple configuration that meets these requirements in principle is shown in Fig. 10. The amplifier can be a standard operational amplifier if the output current is not much in excess of 10mA, and single-ended supply operation is permissible in many cases. The method is extended in Fig. 11 to the provision of output voltages that differ from the reference voltage. The output voltage is of opposite polarity to the reference voltage requiring a separate negative supply. The op-amp can be replaced by any circuit meeting conditions (a) to (d) above. Before turning to detailed study of possible configurations it is important to consider an alternative viewpoint.

A discrete component circuit that has all elements of a practical regulator is given in card 3. Three transistors comprise a voltage amplifier of gain (R_4/R_5+1) with high input- and low output-impedance (alternatively Tr_1, Tr_2 are the error amplifier and Tr_3 the series-pass transistor).

A serious problem arises in all regulators with emitter-follower outputs. The minimum input-output differential includes the V_{be} of Tr_3 plus the voltage-drop across R_2. This figure is markedly increased when Tr_3 is replaced by compound transistors for greater output current capability. This property has serious implications for the maximum efficiency of which the circuit is capable, and also for the maximum dissipation the output stage may be called on to tolerate.

A control engineer would interpret the regulator as a control system and partition it differently. For example many regulator diagrams show the output transistors not as part of a d.c. amplifier but as a separate series-pass circuit. The remainder of the amplifier is then shown, see diagram, as an error-detecting section, comparing the output or a portion thereof with a reference signal – the difference is amplified in control the series block. The approach is not only valid, it may well be more acceptable to many users. Treating the error amplifier plus the series-pass section as a single unit, with internal feedback defining its characteristics, allows easier interchange between voltage regulators, d.c. amplifiers etc.



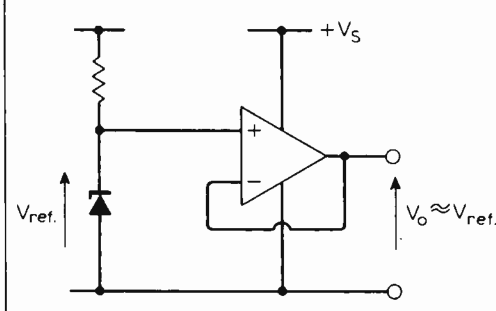


Fig. 10

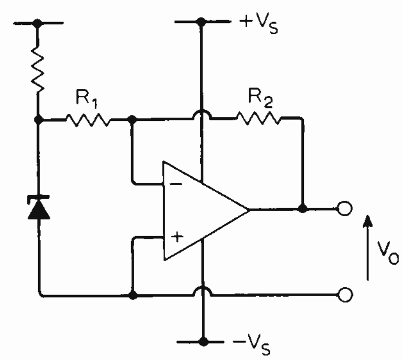


Fig. 11

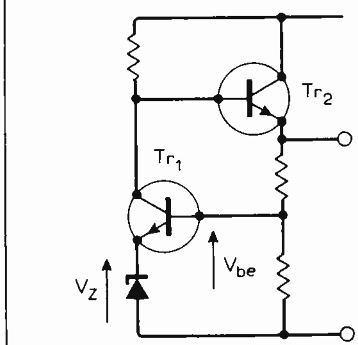


Fig. 12

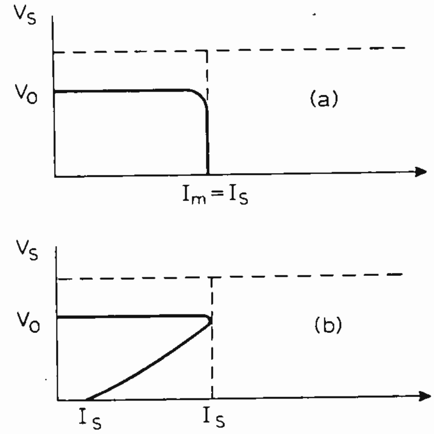


Fig. 13

A possible solution is to replace Tr_3 by a common-emitter p-n-p transistor, driving its base from the collector of Tr_1 to restore the feedback condition (Tr_3 would then be providing an additional inversion). A simplified form of the circuit for which this is not possible is shown in Fig. 12) The effective reference voltage in this circuit is $(V_z + V_{be})$ and for best temperature stability, V_z would be chosen to have a drift of $+2mV\ K^{-1}$ to cancel the negative V_{be} drift. This circuit is the basis of a large number of commercial regulators, though the functional similarity may be hard to recognize amongst the welter of extra functions such as current limiting variable output voltage etc.

Although the basic form can be designed for output currents of 100mA+, any further increase forces the base current of Tr_2 too high – normally Tr_1 collector current has to be at least as great as the base current of Tr_2. It may not be convenient for the zener current to exceed about 10mA since the regulation is impaired. To keep the zener/error amplifier current low, it is sufficient to replace the output stage by a pair of transistors connected to give increased current gain.

A major problem in the design of voltage regulators is to protect against load resistances falling below specified levels, and the size and cost of transistors, heatsinks and power supplies is dictated by the occasional fault condition rather than by the ratings into any intended value of load. For this reason the technique described as foldback or re-entrant current limiting was devised. The resulting characteristic is shown in Fig. 13(b), with the current falling back to a short-circuit value close to zero as the short-circuit condition is approached. The technique involves a current-limit reference voltage which depends on the output voltage. As soon as the current-limit circuit is activated the output voltage begins to fall simultaneously reducing the current as shown.

Topics in set 23 of Circards

Monolithic reference
Simple current reference
Compensated circuits
μA to mA and mV to V calibrator
Low temperature coefficient voltage reference
Bipolar references
Variable reference diodes
Williams ring-of-two reference
Zener diode characteristics
Non-zener device characteristics

Topics in set 24

Zener diode shunt regulator
Simple transistor regulators
Feedback series regulators
Bipolar/c.m.o.s. op-amp regulator
Dual-polarity regulator
Monolithic regulators — 1 & 2
Self-regulating d.c. converter
Switching regulator
Regulator using current-differencing amplifiers

See July issue, page 322, for details of how to order.

World of Amateur Radio

200-mile microwave contacts

The steady increase in microwave operation — and the rising standard of results — is reflected in the recent success of the Barry Radio Society Microwave Group who, operating as GW4BRS/P, made a 200-mile non-line-of-sight contact on 10 GHz with the Scottish station of G. Burt, GM30XX/P. The Welsh group were at Porthgain (national grid reference SM 814 327) at 100 ft above sea level and the Scottish station at Auchenmalg Bay (NX 236 517) only 20 ft above sea level. Good contact, with some 20 dB in hand, was established by super-refraction propagation within a minute of switching on the equipment and without the help of a talkback link on any other band. Contact was also made with GM3DXJ/P and GM8HEY/P. The Barry group included GW4AMV, GW3PPF and G8FGD, and was using a 10mW Gunn diode generator through a circulator to an SIM2 mixer with 40673 mosfet pre-amplifier to a broadcast receiver used as a 106 MHz i.f. amplifier/discriminator. The aerial was a 2ft 6in diameter dish. The equipment at GM30XX uses an X-band Gunn diode in the dual role of transmitter and self-oscillating mixer.

Warsaw and v.h.f.

The recent IARU region 1 meetings in Warsaw agreed to recommend a number of changes to the voluntary band-planning of the 144 and 430 MHz bands and also to seek for Region 1 countries an amateur allocation between 220 and 225 MHz (currently part of the aeronautical allocation). The c.w. calling frequencies are to be 144.05 and 432.05 MHz s.s.b. calling 144.30 MHz (upper limit for s.s.b. 144.50 MHz) and 432.30 MHz, random meteor-scatter s.s.b. 144.20 MHz, slow-scan TV calling frequency 144.5 MHz. The recommended speed for radio teleprinting is to be 45.45 bauds (although British amateurs would probably have preferred 50 bauds) and a.f.s.k. standard tones for r.t.t.y. are to be 1275 Hz space, 1445 Hz mark (for 170 Hz shift) or 2125 Hz mark (for 850 Hz shift).

Proposals were also put forward for a German-developed reduced bandwidth amateur television standard (s.a.t.v.) requiring about 1 MHz bandwidth and with the sound transmitted by means of narrow-band frequency modulation of the vision carrier. For normal amateur TV the use of vestigial sideband techniques and a vision frequency of 439.25 MHz is recommended.

Whose finger on the rule book?

One of the long-established facts of European amateur operation is that many of the most vital operating practices are established as voluntary agreements rather than imposed by the licensing authorities. Most amateurs accept and fully endorse these recommendations but are alert to any suggestion that anyone — whether a national society or an international union — has the right to issue instructions or impose penalties for non-observance. Looking through the generally very sensible proposals adopted at Warsaw, I notice a touch of Big Brother in a series of detailed "instructions and recommendations" concerning operation through the Oscar satellites, the report stating that "National Societies will supervise the implementation of these recommendations and take action as considered appropriate with persistent offenders". The right, for example, of the R.S.G.B. to endorse such an attitude is hardly strengthened by the disclosure in the report that roughly 50 per cent of British amateurs are regrettably not members of the national society. Can we make the suggestion that societies can make only recommendations, not issue instructions, even on behalf of AMSAT?

FCC Docket 20282

Discussion of the FCC proposals (Docket 20282) for the restructuring of the American amateur radio service continues unabated with an A.R.R.L. survey of members' opinions bringing in no less than 56,000 replies. Generally the new proposals seem to be fairly widely supported although some of the detailed suggestions are not proving popular.

The suggestion has been put forward in *Ham Radio* that power limits, to be readily enforceable, should be specified in the form of maximum heater or filament power (eg 200 watts for thoriated tungsten filaments or 60 watts for indirectly-heated oxide cathodes). But where would this leave the semiconductor man now that all-transistor transmitters of over 1 kW rating are being developed for commercial operation?

Bill Orr, W6SAI, in CQ believes that the restructuring is an attempt by FCC to restore growth to the amateur movement in the United States but does not tackle what he sees as the prime reason why it has slowed down. This he believes is Citizen's Band operation which, with no examinations, siphons off potential amateur operators but often results in their soon losing interest in radio communication. He urges the dropping of the American Morse code test to 10 wpm (it is currently 13 wpm) but adds "don't eliminate it as this opens the door to amateur radio to the 'Purple Phantom' and 'Ozark Charlie' operators".

A G-line pioneer

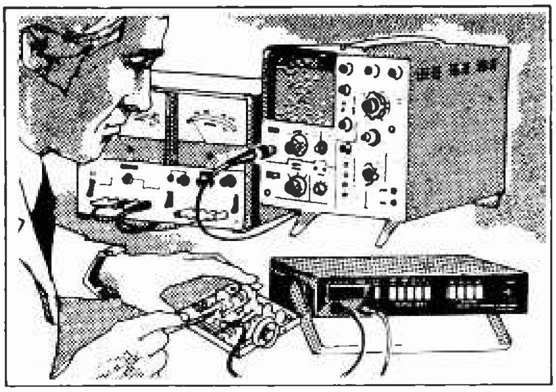
David Corfield, G5CD, who has died after several years of ill-health was first licensed in 1926 and operated from Beeston and then for many years in the London area. Throughout his long career as a valve applications and technical liaison engineer with STC and Thorn-AEI he was extremely active in pioneering amateur u.h.f. and f.m. transmission and, as a Council member of the Royal Television Society, played a leading role in setting up one of the first amateur television stations at what was then the Norwood Technical College in South London in the 'fifties. He served on the R.S.G.B. technical committee from 1935 to 1971 and was one of the group of amateurs who prepared the first British amateur radio handbook in the 'thirties. I vividly remember an R.S.G.B. lecture he gave at the I.E.E. during which he publicly demonstrated, possibly for the first time in the U.K., the Goubau single-wire transmission line ("G-line") system by successfully lighting a small bulb at the back of the lecture theatre via a single-wire feeder strung across the theatre. Altogether he served on more than 16 technical and industry committees.

In brief

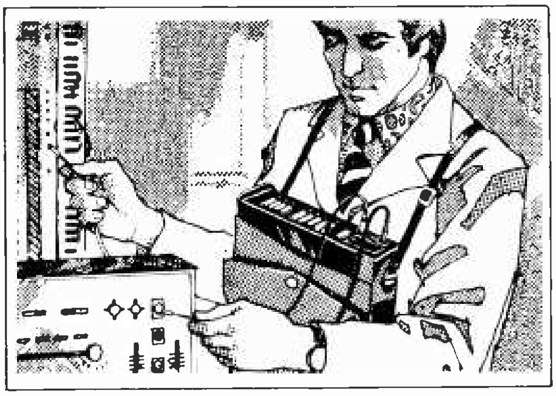
Class A licences in the sequence G4EAA are now being issued with Class B licences now well into the G8KAA sequence. . . . The R.S.G.B. newsbulletins (GB2RS) are now being radiated in north-west England from Knutsford on 3.6 MHz at 11.15 a.m. and from Stockport on 144.5 MHz at 10.45 a.m. . . . Bob Green, G3APH and formerly SU1KG is anxious to hear from any of those who operated in Egypt in the 'twenties and 'thirties (9 Hopgrove Lane North, Malton Road, York) . . . The fourth Midlands 'National Amateur Radio Exhibition' is being held at the Granby Halls, Leicester on October 30, 31 and November 1 (trade enquiries to Tom Darn, G3FGY, Sandham Lodge, 1 Sandham Lane, Ripley, Derbyshire DE5 3HE). . . . The R.S.G.B. mobile rally at Woburn will be held this year on August 3. Other August rallies include Bromsgrove Mobile Picnic on August 10 at Avoncroft Building Museum; Derby Society rally at Rykneld School, Bedford Street, Derby on August 18.

PAT HAWKER, G3VA

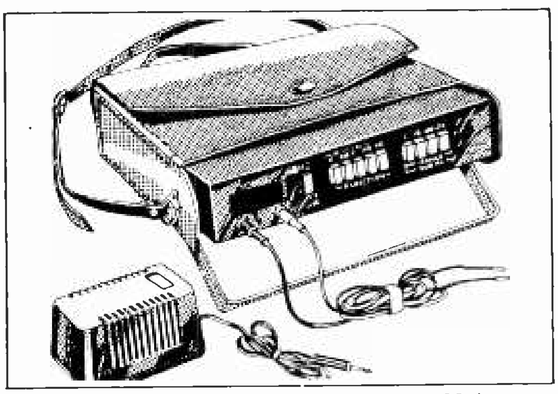
The Sinclair DM2 Multimeter: full technical story



Use it in your laboratory. The DM2 sits rigidly on its combined carrying handle/stand.



Use it on the move. Keep the DM2 in its carrying case – it's always ready for use.



All you need to use the DM2 ... anywhere. Mains adaptor ... carrying case ... multimeter ... you're ready for quick, efficient metering – whatever the situation.

DC Volts

Range	Accuracy	Input Impedance	Resolution
1 V	0·3% ± 1 Digit	> 100 MΩ	1 mV
10 V	0·5% ± 1 „	10 MΩ	10 mV
100 V	0·5% ± 1 „	10 MΩ	100 mV
1000 V	0·5% ± 1 „	10 MΩ	1 V

Maximum overload – 350 V on 1 V range
1000 V on all other ranges.

AC Volts

Range	Accuracy	Input Impedance	Frequency Range
1 V	1·0% ± 2 Digits	10 MΩ/40 pF	20 Hz–3 KHz
10 V	1·0% ± 2 „	10 MΩ/40 pF	20 Hz–3 KHz
100 V	2·0% ± 2 „	10 MΩ/40 pF	20 Hz–3 KHz
1000 V	2·0% ± 2 „	10 MΩ/40 pF	20 Hz–1 KHz

Maximum overload – 300 V on 1 V range
500 V on all other ranges.

DC Current

Range	Accuracy	Input Impedance	Resolution
100 μA	2·0% ± 1 Digit	10 KΩ	100 nA
1 mA	0·8% ± 1 „	1 KΩ	1 μA
10 mA	0·8% ± 1 „	100 Ω	10 μA
100 mA	0·8% ± 1 „	10 Ω	100 μA
1000 mA	2·0% ± 1 „	1 Ω	1 mA

Maximum overload – 1A (fused).

AC Current

Range	Accuracy	Frequency Range
1 mA	1·5% ± 2 Digits	20 Hz–1 KHz
10 mA	1·5% ± 2 „	20 Hz–1 KHz
100 mA	1·5% ± 2 „	20 Hz–1 KHz
1000 mA	2·0% ± 2 „	20 Hz–1 KHz

Maximum overload – 1A (fused).

Resistance

Range	Accuracy	Measuring Current
1 KΩ	1·0% ± 1 Digit	1 mA
10 KΩ	1·0% ± 1 „	100 μA
100 KΩ	1·0% ± 1 „	10 μA
1000 KΩ	1·0% ± 1 „	1 μA
10 MΩ	2·0% ± 1 „	100 nA

Overload protection – 50 mA (fused).

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WW/8/75

A 50MHz oscilloscope

4—construction and test

by C. M. J. Little, B.A.

Department of Electronics, Southampton University

The overall size of the oscilloscope is 11in wide, 13in high and 16in long. The front and back panels are made from ⅛in aluminium joined by five steel bars, each of ½in square cross section. One bar is placed at each corner of the panels and the fifth at the centre of the bottom edge of the panels. This gives a very rigid frame. 16 s.w.g. aluminium panels are bolted on to the longitudinal rods in order to divide the chassis into separate compartments. A sketch of the layout is given in Fig. 17. Aluminium angle would be a better alternative to the steel rods as it is much easier to cut and drill. I recommend the constructor to make a good job of the mechanical work as it greatly improves the appearance and durability of the finished instrument. The prototype was not made very carefully in this respect and as a result the Y plug in does not fit correctly, and is difficult to remove and replace.

Three pairs of matched f.e.t.s are used in the instrument. These should be matched in V_{GS} at about 500μA drain current, as shown in Fig. 18. Matching of V_{GS} to within 0.2V will be satisfactory.

Testing completed boards for the first time is tricky, as a mistake can destroy transistors very easily. This especially applies to emitter followers when a short is present between the emitter and earth. If a Variac is available, use it to increase the mains voltage very slowly, checking voltage levels all the time, in order to try and locate faults before any damage is done. When making measurements or adjustments with the instrument switched on, be very careful to avoid slips of the screwdriver. My worst disaster was a momentary short between the +115V rail and the +18V rail. This blew about 8 transistors and the 709 in the e.h.t. generator!

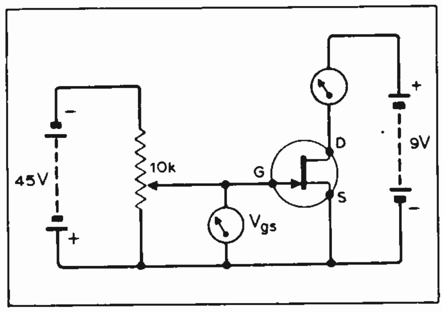


Fig. 18. Method of matching f.e.t. gate-source voltages at 500μA drain current.

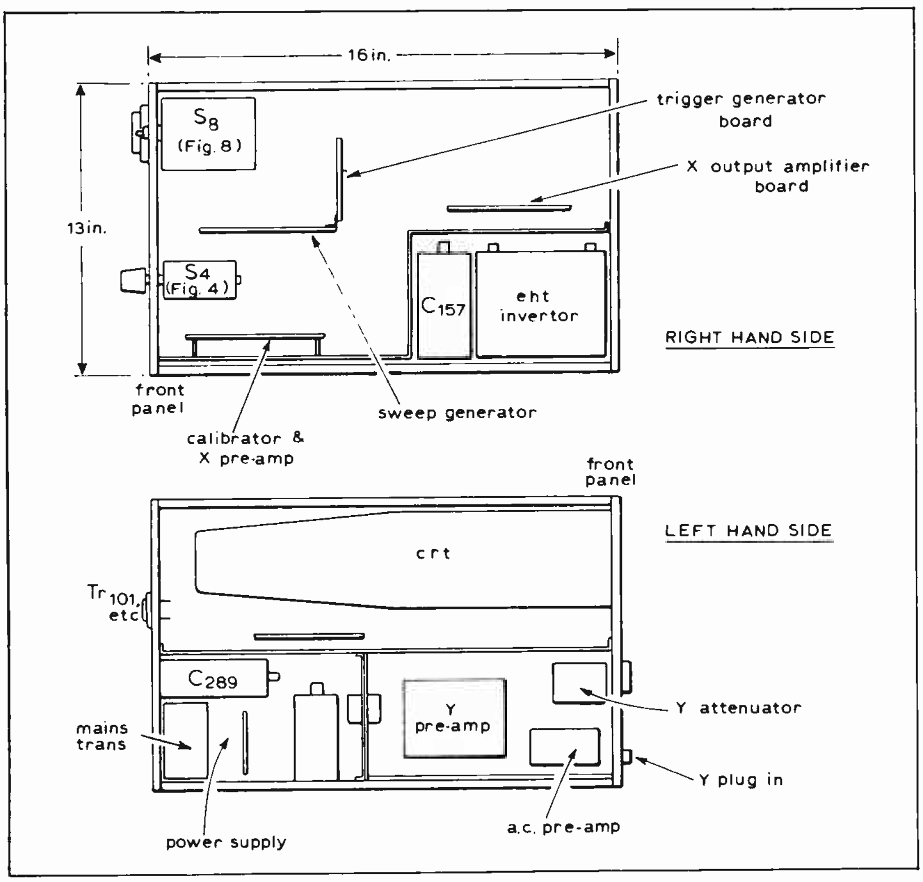


Fig. 17. The layout of units in the author's instrument. A vertical panel divides the oscilloscope into two halves. Power supplies and Y amplifier are separated by aluminium screens.

Power supply

The mains transformer used is a 1A type made by Osmabet Ltd. It has a tapped secondary giving 40, 50, 60, 80, 90, 100 and 110 volts. The final winding from 100 to 110 volts is not needed and is removed to allow room for the 6.3V isolated heater winding. The transformer is dismantled and the final winding on the secondary is removed, the number of turns being carefully counted. A new winding is added to give 6.3V, which will have 0.63 times the number of turns that were removed. This winding must be insulated to at least 1kV and it is more convenient to use p.v.c. insulated wire instead of enamelled.

The reader may have noticed the curious choice of reservoir and smoothing capacitors. The exact value of these is not important, and may be any value above 1000μF. If it is difficult to obtain 150V working capacitors for C_{289}, C_{156} and C_{157} use two capacitors of double the value in series, and include voltage equalizing resistors of about 33kΩ (Fig. 19).

The construction of the power supply is not critical, and any layout may be used. Tr_{101}, Tr_{102}, and Tr_{105} should be mounted on heatsinks, the back panel being used in the prototype.

The only testing procedure needed is to check all the voltages and to adjust R_{286} for exactly 18V at the emitter of Tr_{105}. Check the heater voltage with the tube connected and adjust if more than 10% out.

E.h.t. generator

The e.h.t. transformer, T_2, must be wound by the constructor as no commercial component is available. I used an LA13 core, which was obtained surplus, and was the largest pot core I could find, for the greater the winding area, the easier it is to wind the high voltage secondary. The core of the LA13 measures 1¾in in diameter and 1¾in in total height. A core such as the LA4, with a size of 1½in diameter by ⅞in height would probably be satisfactory. The oscillator circuit is not at all critical and will work with almost any transformer.

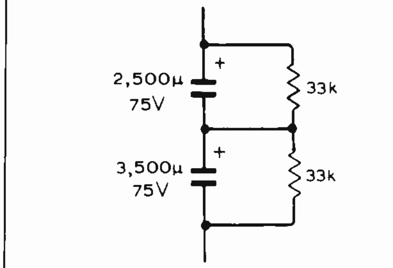


Fig. 19. The simulation of 150V capacitors by lower-voltage types. Resistors equalize voltages.

The high voltage winding should be wound first, with a layer of p.v.c. insulating tape between each layer. The layers should be wound neatly, and a gap of between 1/16in and ⅛in left between the end of each layer and the flange of the bobbin, as contact between adjacent layers will certainly result in flashovers. 34 s.w.g. enamelled wire is used for the secondary, but if space is limited thinner wire may be used. The primary is wound with 22 s.w.g. p.v.c. insulated wire.

L_7 is uncritical, and winding details are given in the parts list. The e.h.t. smoothing capacitors C_{126}, C_{128} and C_{129} may be difficult to find in the values specified. Any values from about 2,500pF to 0.01μF may be used. Diodes D_{63} to D_{66} should ideally be the ceramic encapsulated e.h.t. diodes specified, but these are expensive, about £3 each. An

Parts list

Power supply

R
10W 280, 281
¼W 10% 282, 283
¼W 5% 285, 287
½W 5% 289, 284
5W 10% 288
¼W preset 286

C
150V elec. 289, 156, 157
75V elec. 151, 152
60V elec. 153, 154
15V elec. 150
160V, 10% poly. 155

D
200V, 1A silicon 92-97
50V, 1A silicon 90, 91
51V 5W Zener 98, 99
5.6V, 400mW Zener 100
11V, 400mW Zener 101, 102

Tr
2N 3055, etc. 101, 102, 105
BC 182, 107, 108, etc. 103
BC 107 104
Mains transformer Osmabet OMT/5 (modified). Osmabet Ltd., 46 Kenilworth Road, Edgware.
2A fuse
2-pole mains switch

E.h.t. generator

R
¼W 5% all but 232 (½W 5%) and 222 (preset)

D
IN 914, etc. 61, 62
DA_{63-66} can be either IN2379 or IN2378 encap. silicon, or can be ITT selenium types K83/90D, K8/50 or K8/45. ITT Electronic Services, Edinburgh Way, Harlow.

C
1.5kV poly. or paper 126, 128, 129
3kV disc ceramic 125, 127
10% polyester 122, 123, 124, 121

Tr
BFY50 80
BFY50 with h.sink 82, 83

IC_1 709 or 741 minus R_{224} and C_{121}
L_7 1.5mH, R_{dc} 10Ω 100T 24g on LA4 core. Uncritical
T_2 LA13 core P. 10T+10T 22g p.v.c.
S. 900T 38g enam.

C.r.t. circuit

R
½W 5% 263, 265, 266, 269, 274, 267
¼W 5% 260, 261, 262, 271
2W 5% 264
¼W preset 272, 273
carbon variable 268, 270
WW variable 275

D
IN914 80
80V, 400mW Zener 81
OA200, etc. 82

C
160V polyester 140,141

Tr
BFX85, BF257 100
L_8 Twist coil
C.r.t. Brimar D13-47GH/26. Base B12F. Thorn-AEI Ltd, P.O. Box 17, Enfield Middlesex.
Mumetal shield from Telcon Metals Ltd, Manor Royal, Crawley, Sussex. Hart Electronics, Ltd, Penylan Mill, Oswestry hold supplies of shields.

Y output amplifier

R
¼W 5% 3, 6, 13, 14, 15
¼W solid carbon 4, 5, 7, 8, 9, 10
¼W 10% 1
2W 5% 11, 12
¼w preset 2, 16
ferrite beads L_1, L_2 (Doram)
L_3, L_4 12T 28g on ¼in former with core

C
50V ceramic 1-6
airspaced trimmer 7

Tr
TIS 52, BSX20 2, 5, 6
BC107, etc. 1
2N 3866 with h.sink 3, 4

Y preamplifier

R
¼W 10% 20, 40
¼W solid carbon 21, 49, 50
¼W 5% 25, 26, 29, 34, 27, 31, 24, 35, 36, 37, 39, 41, 42, 43, 45, 47, 22
½W 5% 33
carbon preset ¼W 28, 30, 32, 23, 46
WW or carbon variable 38, 44

C
50V ceramic 10, 12-14, 16-18
400V ceramic 11
polyester 15

Tr
MPF111, 112 or 105 matched 10, 15
TIS 52, BSX20 11, 13
BC 107

D_1, D_2 BAX13 (low capacitance)
IC_1 μA 733 (ITT Electronic Services) or LM 733C
S_1 single-pole on/off
L_5, L_6 ferrite beads (Doram)
RL_1 single-pole reed-relay —12V (Doram)

Y attenuator

R
all ⅛W sub-miniature 1% selected

C
ceramic tubular trimmers 30-32, 34, 35, 37, 38, 40, 41, 43, 44, 46, 47, 49, 50, 53
ceramic 10% 33, 36, 39, 42, 45, 48, 51, 25

A.C.×100 preamplifier and Y input

R
metal oxide 2% 51-53
¼W 5% 59, 54, 55, 61, 58, 57
¼W 10% solid carbon 60
¼W preset 56

C
400V polyester 20
Ceramic or silver mica 21
6V elec. 23, 24
25V elec. 22
160V polyester 25

alternative, which will be satisfactory but less reliable, are the selenium stick rectifiers specified in the parts list.

The construction of the e.h.t. inverter is not critical with the exception of the high voltage components. These should be mounted with adequate insulation and spacing, remembering that the insulation breakdown voltage of air is about 10kV/cm.

I found it convenient to make the circuit in a screened box measuring about 5×5×4in. The circuit should be screened to avoid interference with the rest of the oscilloscope.

The inverter part of the circuit should be tested before the feedback loop is connected. Disconnect the base lead of Tr_{80} and C_{123} from R_{225} and connect to the slider of a 5kΩ potentiometer across the 18V supply. Connect a 470kΩ 2W resistor between −1kV and earth, and monitor with a voltmeter. If possible connect an ammeter in the 12V supply line. Increase the voltage on Tr_{80} base. The output voltage should be smoothly adjustable from zero to −1.5kV. Do not exceed 1.5kV. Any jumps in voltage or flashovers should be investigated before connecting the feedback loop. If the frequency is too low, resulting in an annoying whistle, turns may be removed from the primary and secondary of T_2, keeping the ratio constant. Do not try and lower the frequency by adding capacitance in the primary circuit as this usually results in parasitic oscillation. Finally reconnect Tr_{80} and C_{123} to R_{225} and set the −1kV rail to the correct voltage by adjusting R_{222}. Check the +3kV rail which should be between +2.5kV and +3.5kV.

C.r.t. and blanking

The twist coil, L_8, is wound directly on the glass of the c.r.t. About 1500 turns of any convenient gauge wire are necessary, commencing the winding 9 centimetres from the screen and finishing it less than 17.5cm from the screen. Flexible wire leads should be glued to the glass and brought out through the square hole in the Mumetal shield.

Normal carbon potentiometers are used for R_{268} and R_{270}, mounted directly on the front panel. No trouble has (yet) occurred with insulation breakdown, although it would be better to use the type with plastic spindles, mounted on an insulated bracket. The blanking amplifier is built on a small piece of Veroboard which is mounted near the tube base.

When these circuits have been built,

Tr
MPF111, 112, 105 — 20
BC107 etc. — 21
BC212 etc. — 22
S_2 3-pole 3-way (Doram)
S_3 2-pole 12-way (Doram)

X output amplifier

R
¼W 5% — 82, 86, 84, 88, 89, 91, 92, 94-97
¼W 10% — 81, 85, 98, 102, 100, 87
5W 5% — 99, 101
¼W preset — 93, 90, 83
carbon or WW variable — 80

D
IN 914 — 10, 11, 16-19
12V 400mW Zener — 12-15

C
polyester — 60, 61
ceramic — 62, 64
200V ceramic — 65
silver-mica — 63

Tr
BC107, 108 etc. — 30
BC212, 213 — 31-33
BC107 — 34, 35
BF257 with heat sink — 36, 37 (no substitutes)
RL_2 single-pole, sub-min. reed relay —12V (Doram)

Horizontal switching

R
¼W 10% — 110, 111, 117, 118
¼W 5% — 112, 114, 119
½W 2% metal oxide — 115, 116, 120, 22, 121
¼W preset — 113

C
400V ceramic — 70
polyester or ceramic — 72
compression trimmers — 71

Tr
MPF111 etc, matched — 40, 41
BC212, BC213 — 42
D_{20}, D_{21} — IN914
S_4 2-pole, 6-way rotary. Separate sections for $S_{4(a)}$ and $S_{4(b)}$

S_5 3-pole, 3-way rotary.

Sweep generator

R
½W 5% — 134, 140, 161, 162, 152
¼W preset — 150
WW variable — 145, 160 (pref. 10-turns)
all other ¼W 5%

D
IN914 — 30, 33, 34, 36, 37, 39, 40
400mW Zener — 31, 35, 41
BAX 13 — 32
OA200, IN914 — 38

S_6 1-pole on/off
S_7 push-button, momentary
90V neon

C
160V polyester or ceramic — 83, 84, 87, 81
polyester or ceramic — 80,82,86
1% silver mica — 85

Tr
BC107 — 50-53, 55, 57, 58, 60, 61
MPF111, etc. — 54
BFY50 (heatsink) — 56
C407 — 59

Sweep timing switch

R
metal oxide 5% ¼W — 173-182
— 170-172, 183, 188, 185, 186
¼W preset — 187
WW or carbon variable — 184

C
Compression trimmer — 98, 100, 102, 104
1% silver mica — 96, 97, 99, 101, 103, 105
1% polyester — 94, 95
5% polyester — 90-93
10% polyester — 106
S_8 4-section, 4-pole, 23- (or 24)-way. Diamond H Controls Ltd, Vulcan Road North, Norwich.

Tr_{70} BC212 etc

Trigger generator

R
WW or carbon variable — 203
¼W preset — 206, 207
all others ¼W 5%

C
ceramic — 110, 111, 113-115, 117-120
25V elec. — 112
10% polyester — 116
D_{50} 4.7mA tunnel diode (sub-min.) Type IN3717. J. Birkett, 25 The Strait, Lincoln.
D_{51} HP 2811 Schottky barrier from Hewlett-Packard Ltd diode or BAX13.

Tr
MPF111 etc. — 71, 74
TIS52, BSX20 — 72, 73
MPS3640, 2N4126, BCY70 — 75
S_9 2-pole, 6-way
S_{10} 2-pole, 2-way
L_7 30T 28g on ¼in former. No core.
T_1 Ferrite bead. Pri. 2T, sec. 4 turns 34g.

Calibrator

R
metal oxide 1% ¼W — 250-257
¼W 5% — 240, 246, 245, 247
metal oxide 2% — 242, 243, 249
¼W high-quality preset — 241, 244
¼W 10-turn preset — 248

D
IN914 — 71, 73, 74
5.6V 400mW Zener — 70, 72

C
5% polyester — 130,131

Tr
BC182 etc. 90-92

Errata

A resistor, designated C_{18}, 0.01µF, 50V ceramic, should be connected from Tr_{15} drain to zero volts.
The resistor between Tr_{21} emitter and Tr_{22} collector is R_{61} (47kΩ5%, ¼W).
The resistor on Tr_{36} base is R_{102} and is 100Ω, ¼W, 10%.

one should be able to obtain a focused spot on the screen. The X and Y plates may be left unconnected, but the input to the blanking amplifier, point A, should be connected to +18V. Take *great care* not to burn the phosphor as a single spot may be made very bright. R_{267} may be adjusted if the focus control does not have sufficient range.

Y amplifier

Both the Y output amplifier and the Y preamplifier must be built on double-sided printed circuit boards, with the upper copper side used as a ground plane. Instability is almost certain to occur if any other method of construction is used. The output amplifier is built on a board measuring 3in×4½in, and the preamplifier on one measuring 3½in×4in. All earth connexions are made to the ground plane, and this facilitates board layout.

With reference to the preamplifier board, he ground plane should be extended under IC_1 to provide screening between its input and output leads. The reed relay RL_1 is mounted under the board as close as possible to R_{46} and pin 9 of IC_1. The components associated with the shift controls R_{38} and R_{44} are mounted on the two controls, but apart from these all the components are mounted on the board.

The connexions to the plug-in Y preamplifier from the main unit are made via a plug and socket. An 8-way Jones connector was used in the prototype but proved to have too great a stray capacitance to be used for the two signal leads. These were therefore made via sub-min. Harwin plugs. These plugs and sockets were not suitable for chassis mounting so it is not possible to remove the plug-in unit without taking the case off the main unit. This undesirable situation can be avoided by using a more modern plug and socket, similar to that used in commercial instruments. Unfortunately I cannot specify a particular type, as I have not yet modified the prototype.

The ×100 a.c. preamplifier is built on a small piece of Veroboard, and is mounted near S_1 and the input socket. It

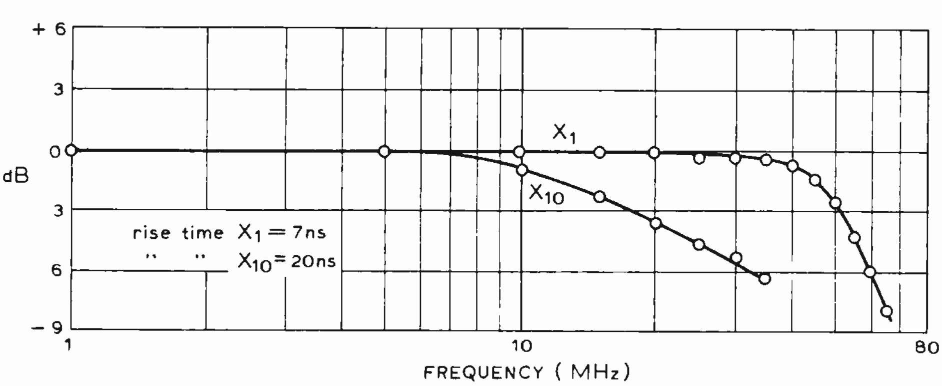


Fig. 21. Frequency/amplitude response of the Y amplifier. The effect of using the higher gain of the input amplifier is evident.

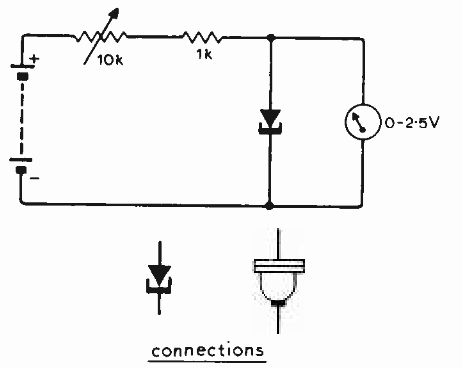


Fig. 20. Testing the tunnel diode, D_{50} in Fig. 9 (shown incorrectly as a Zener diode).

should be screened from the main board. The input connector should be a 50Ω BNC type.

The attenuator has turned out to be the least successful of all the sections that make up the Y amplifier. From about the 5V/cm to the 50V/cm positions the attenuator degrades the pulse shape at high frequencies (see photographs). This is thought to be due to inductive effects in the large capacitors that shunt the lower arms of the resistive dividers (C_{45}, C_{48}, C_{51}, C_{54}). The cure is probably to reduce the shunting time constant in these sections, i.e. to make C_{44}, C_{47}, C_{50} and C_{53} smaller, perhaps about 3pF each. C_{45}, etc, may then be made smaller as well, raising the frequency of any resonance effects to outside the passband. In any event, all the components including the resistors should be as small as possible. The method of construction used is as follows: A piece of double sided printed circuit board about 3in square is mounted between the two wafers of S_3, completely screening one from the other. The components are mounted as near the switch as possible, with all earth connexions going to the copper board; the resistor and trimmer joining the 2 poles in each wafer, C_{35} and R_{64} for example, pass through holes in the screen. The side nearer to the front panel should be the input side of the attenuator. Thick wire should be used to interconnect the earth connexion on the input socket, the attenuator screen, and the main board earth plane.

The complete setting up procedure for the Y amplifier will now be given, although it is not possible to make some of the adjustments until the timebase is working.

Switch to 100mV/cm, gain ×1, d.c. coupled, and short the input. Set the shift controls to their centre positions, R_{28} to its mid position, and adjust R_{32} to centralize the spot. Set the voltage at Tr_1 emitter (Fig. 1) to exactly +14V with R_2. Set the voltage at pin 1 of IC_1 to 7.5V with R_{23} (Fig. 2), keeping the spot central. Check that the voltage at pin 2 is also 7.5V. Now apply a suitable input voltage and adjust R_{30} for a sensitivity of exactly 100mV/cm. Switch the gain to ×10 and adjust R_{46} for a sensitivity of 10mV/cm. Finally switch to ACX100 and adjust R_{56} (Fig. 3) for a sensitivity of 100μV/cm.

The high frequency adjustments can only be made using a pulse generator with a rise time of less than 5ns. This should be terminated at the input socket with the correct lead. Display a square wave at about 5MHz. Set C_7 (Fig. 1) to minimum capacitance and R_{16} to maximum resistance. Adjust L_3 and L_4 for an optimum pulse shape without overshoot, keeping the two inductors at the same value. Now C_7 and R_{16} can be adjusted to decrease the rise time as much as possible. The photograph shows that I managed to achieve. These adjustments should be made at the 100mV/cm gain setting.

The attenuator is adjusted in the usual way with a 1kHz square wave. The input capacitance can be standardized using either a capacitance meter, or a ÷10 probe.

Sweep generator, triggering and X amplifier

It may be difficult to obtain the 24-way switch for the timebase speed selector. A possible supplier has been given in the parts list, or the surplus shops may be tried. An alternative circuit uses a 9-pole 4-way switch to select the decades, and a 3-pole 3-way switch to provide multipliers of ×1, ×2 and ×5. This arrangement will work equally well, but is less convenient to use.

The diode recommended for D_{51} in Fig. 9 is a Schottky barrier diode, as the combined low forward voltage and very high speed provides an optimum suppression of the unwanted positive pulses on the secondary of T_1. A gold bonded germanium diode or a high speed silicon diode may be substituted. The effect of inadequate suppression of the positive pulses is that the ramp is ended by the trigger pulses, resulting in a slightly shorter sweep length. The effect is obvious when the fine speed control is rotated, as the right hand end of the trace will move in discrete steps.

The tunnel diode, D_{50}, may be any component with a 4.7mA peak current. The faster switching sub-miniature axial package is preferred.

Tunnel diodes may be tested using

the circuit of Fig. 20. As the current is varied the voltage will switch between about 200mV and 700mV. Take care not to let the current exceed about 10mA and also do not overheat the diode when soldering. Tunnel diodes are very easily destroyed.

The sweep generator may be built on veroboard as the layout is not critical. The trigger circuit, Fig. 9, is built on a small printed circuit board which is mounted on the sweep generator board and at right angles to it. This is to ensure that the leads to both primary and secondary of T_1 are short. The X amplifier, Fig. 5, is once again built on a double sided p.c. board with a ground plane, as the first few versions, built on Veroboard, showed instability.

The adjustment and calibration of the

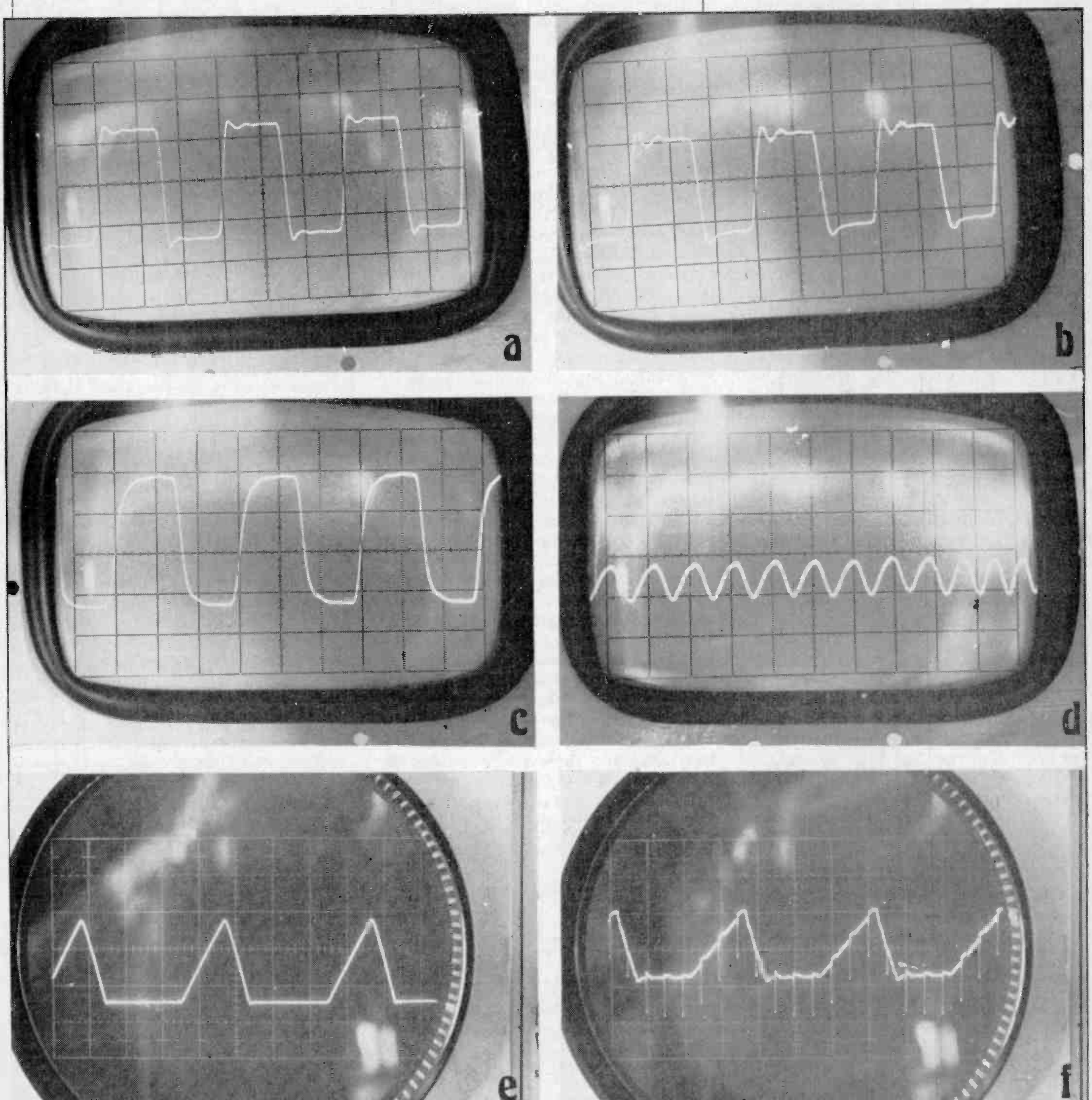


Fig. 22 (a) shows the amplifier transient response. 5MHz square wave with generator rise time of 5ns. Y amplifier sensitivity 100mV/cm. Time scale 50ns/cm. Settings at (b) are as at (a) but with sensitivity of Y amplifier 5V/cm. Note the waveform degradation caused by the attenuator.

The same waveform is shown at (c) but Y amplifier sensitivity 10mV/cm.

A 100MHz sine wave is shown at (d). Y amplifier 100mV/cm, time scale 10ns/cm. Note that the non-linearity is caused by the X amplifier when used with ×5 expansion. Also note that stable displays can be obtained well beyond the Y amplifier bandwidth.

Photograph (e) shows the time base waveform at a speed of 50ns/cm, displayed on Tektronix oscilloscope. This is the waveform at point D (Fig. 7).

The photograph at (f) shows the waveform at the base of Tr_{50} (Fig. 7) when the timebase is being triggered by a 1MHz waveform. The timebase speed is 500ns/cm, and the waveform shows the sharp negative trigger pulses, and the well suppressed positive pulses (see text).

X amplifier and time base circuits can only be finally completed when the circuits in Fig. 6 have been built.

Switch S_5 (Fig. 6) to 'X AMP' and S_4 (Fig. 6) to 100mV/cm. Short the external X input. Adjust the X shift to centralize the spot and set the mean X plate voltage to +50V with R_{83} (Fig. 5). Now switch back to 'TB × 1' and display an input at about 1kHz. Adjust the fine speed control until 1 cycle of the 1kHz waveform occupies 1cm on the X axis. Now switch back to 'TB × 1' and display (Fig. 5) for an expansion of exactly 5. Switch back to 'X AMP', apply an input, and adjust the sensitivity of the X amplifier to 100mV/cm with R_{93} (Fig. 5). The sweep length may now be set to a suitable value with R_{160} (Fig. 7). I suggest 10.5cm. R_{187} (Fig. 8), the sweep speed calibration, should be adjusted on the 1ms/cm range, with R_{184} in the 'calibrated' position. The trimmers on the speed selector switch can now be adjusted until all the timebase ranges are accurate. It should be possible to obtain an accuracy of ±2% over all the sweep speeds if the timing components have been selected to 1% tolerance. R_{113} (Fig. 6) is set so that the undeflected spot is in the centre of the screen when S_5 is switch from 'TB' to 'X AMP'. R_{150} (Fig. 7) is adjusted so that the single sweep facility works correctly. If it is set to too low a value, the sweep will free run in the 'single sweep' position of S_6; if it is set to too high a value, S_7 will be unable to reset the sweep.

The trigger generator must now be set up. Apply a noise free 1kHz sine wave with an amplitude of about 4cm on the screen. Set S_9 (Fig. 9) to 'AC' and adjust the trigger level control for a triggered sweep. Back off the stability control as far as possible without losing the display. A stable single display should now be obtained, without any multi-triggering. Adjust R_{207} until multi-triggering just does not occur, and check over the entire range of the trigger level control. Now reduce the amplitude of the input signal, continuously adjusting the level control, until the minimum signal that will generate a trigger has been obtained. This should be less than 0.3cm peak-to-peak. The adjustment of R_{207} is a compromise between avoidance of multi-triggering and trigger sensitivity.

R_{206} is adjusted so that triggering occurs at the same position on the waveform when the slope switch S_{10} is changed over. The adjustment should be made initially on a large amplitude waveform and then checked for smaller and smaller amplitudes until the minimum is reached. The adjustment of R_{206} and R_{207} will interact slightly.

With the exception of the X attenuator compensation, this completes the adjustment and calibration of the timebase circuits.

Note. C_{63} (Fig. 5) can be adjusted if the high frequency compensation of the X amplifier is incorrect. This can be checked by examining the retrace waveform of the sweep on the 50ns/cm range (disconnect the retrace blanking). There should be no overshoot of the flyback and the flyback time should be as short as possible. A photograph of the 50ns/cm sweep waveform (as seen on another oscilloscope, and measured at point D (Fig. 7)) is provided for reference. Do not try and examine the waveform at the collectors of Tr_{36} and Tr_{37} (Fig. 5) using another oscilloscope as any extra capacitance here will affect the adjustment of C_{63}.

Amplitude calibrator Fig. 13

The easiest way of setting up this circuit is as follows: Short the base of Tr_{91} to earth to inhibit the operation of the astable. Now measure the voltage at the 1V terminal using a digital voltmeter of 0.1% accuracy, and adjust R_{248} for 1V d.c. Check the other outputs and if necessary readjust R_{248} until all outputs are within ±1%. Remove the short on Tr_{91} and connect a frequency meter to the 5V output, leaving the digital voltmeter connected to the 1V output. Now adjust R_{241} and R_{244} until the frequency is 1kHz, and the digital voltmeter reads 0.5V. This ensures that the mark-space ratio is exactly 0.5.

VAT rates — details

The following list of components details certain items on which specific agreement has been reached between HM Customs & Excise and the Electronic Components Board, and is extracted *verbatim* from a recent press release.

"The Electronic Components Board and Customs and Excise have agreed upon the following recommendations to traders:

1. Product categories to be charged at 25 per cent VAT

(a) TV cathode ray tubes.
(b) TV tuners including tuners featuring touch button controls and/or remote control units.
(c) TV delay lines.
(d) TV, radio and audio loudspeakers (except loudspeakers suitable only for public address purposes).
(e) TV and radio wound assemblies (deflection coils, colour correction coils, line output transformers, switched mode inductors, wound aerial rods, r.f. and i.f. wound assemblies).
(f) All receiving valves for domestic use.
(g) All voltage multipliers for domestic use (triplers, etc).
(h) Modules for domestic appliances.
(i) Consumer modules for TV, radio and audio equipment.
(j) Linear integrated circuits suitable for use in TV, radio and audio equipment.
(k) Discrete semiconductors:
  i) Transistors, triacs and thyristors, plastic encapsulated and less than 3 amps rating.
  ii) Power transistors for TV deflection applications.
  iii) All plastic diodes of less than 1 amp rating, excepting 2(f).
  iv) All zener diodes of power rating less than 3 watts.
  v) Rectifiers of a kind suitable for use in low voltage battery charger equipment having a current rating of less than 5 amps.
(l) Capacitors (excluding those types indicated in 2(m).)
(m) Resistors (excluding those types indicated in 2(n).)
(n) Switches having a rating of less than 5 amps and user controls (variable resistors, etc) of less than 2 watts max. dissipation of a kind suitable for use in TV, radio and audio equipment.

2. Product categories to be charged at 8 per cent VAT

(a) Professional assemblies.
(b) Storage systems.
(c) Matrix stacks.
(d) Industrial assemblies (norbit logic elements, etc).
(e) Automobile assemblies (excluding those products used for in-car entertainment equipment — radio, stereo, etc).
(f) Microwave products (tube, solid state or passive networks).
(g) Professional deflection assemblies.
(h) All professional tubes.
(i) Infra red devices.
(j) Integrated circuits (excluding items indicated in 1(j).)
(k) Ferrites and wound ferrites (excluding items indicated in 1(e).)
(l) All discrete semiconductors (excluding those items indicated in 1(k).)
(m) Capacitors:
  i) Paper capacitors of greater than 0.5 microfarad and/or metal cased.
  ii) Sintered tantalum capacitors of greater than 300 microfarad and/or metal cased.
  iii) Film capacitors meeting IEC specification 68.2 or equivalent (21 day humidity rating) and/or metal cased.
  iv) Electrolytic capacitors meeting IEC specification 103 Type I — 85°C or equivalent specification or operating in excess of 200V a.c.
  v) Mica capacitors.
  vi) Vacuum and pressure gas capacitors.
(n) Resistors:
  i) Metal film with a stability better than 1 per cent over 1000 hours.
  ii) Wirewound resistors (except main ballast resistors of a kind suitable for use in TV, radio or audio equipment).
(o) Edge connectors and connectors for more than 8 ways.
(p) Electro mechanical components — excluding switches having a rating of less than 5 amps and users controls (variable resistors, etc) of less than 2 watts max. dissipation of a kind suitable for use in TV, radio and audio equipment.
(q) Magnets.
(r) Printed circuits for the assemblies described in items 2(a), 2(d) and 2(e).

It is recognised that there may be some individual products to which the application of these definitions is not entirely straightforward. If a firm finds one of its products is described above as chargeable at 25% but, in its view, the product is not suitable for use as a part of goods within the Higher Rate Schedule, it may report the facts to the Electronic Components Board which will if necessary take the matter up with Customs and Excise, when an individual ruling will be given. The recommendations above will, in any case, be kept under review in the light of experience."

Electronic circuit calculations simplified

3 — Capacitive circuits

by S. W. Amos, B.Sc., M.I.E.E.

Parts 1 and 2 of this series were devoted to calculations of resistance values. This article is concerned with calculations of capacitance values and shows that these are similar in many instances to those of resistance: indeed many of the formulae are identical.

Tuning circuit. Fig. 1 shows a form of tuning circuit commonly used in the oscillator section of medium- and long-wave receivers. It is of interest because it contains an example of two capacitors in parallel (the variable tuning capacitor C_1 with the preset trimming capacitor C_2) and of capacitors in series (the padding capacitor C_3 with the C_1C_2 combination).

Suppose we wish to know the value of the effective tuning capacitance (i.e. the capacitance across the inductor L) when the tuning capacitor C_1 is at its maximum and minimum values. We will assume that C_1 has a maximum capacitance of 500pF and a minimum of 25pF, that C_2 has a maximum capacitance of 50pF and that C_3 is 630pF.

We will begin by calculating the parallel capacitance of C_1 and C_2. The effective capacitance C_{eff} of two capacitors C_1 and C_2 connected in parallel (Fig. 2) is the arithmetic sum of the individual capacitance values thus:

$$C_{eff}=C_1+C_2$$

(This rule also applies to *resistors connected in series*). When both capacitors are at their maximum $C_1=500$pF and $C_2=50$pF, making the total capacitance 550pF. C_1 is 25pF at its minimum and if C_2 is still 50pF, the total capacitance is 75pF. Thus the effect of C_2 is to treble the minimum value of C_1 but to add only 10% to the maximum. The effect on the maximum value of C_1 is an illustration of a general rule that when a large capacitor is connected in parallel with a small one, the effective capacitance is slightly greater than the larger. Since the trimmer contributes two-thirds of the effective minimum of C_1 but hardly affects the maximum it follows that the trimmer has a marked effect on the tuning at the high-frequency end of the band but has negligible effect on the tuning at the other end. Trimmer capacitors should therefore be adjusted at the high-frequency end of the band.

Let us now consider the effect of the series capacitor C_3. In general the effective capacitance C_{eff} of two capacitors C_3 and C_4 connected in series (Fig. 3) is given by the expression:

$$C_{eff}=\frac{C_3C_4}{C_3+C_4}$$

$$=\frac{\text{product of individual capacitances}}{\text{sum of individual capacitances}}$$

(This expression also applies to *resistors in parallel*). In our numerical example C_3 is 630pF and C_4 consists of C_1 and C_2 in parallel and we know that C_4 has a maximum value of 550pF and a minimum of 75pF. When C_1 is at maximum we have:

$$C_{eff}=\frac{C_3C_4}{C_3+C_4}=\frac{630\times550}{630+550}\text{pF}$$

$$=294\text{pF}$$

When C_1 is at minimum:

$$C_{eff}=\frac{C_3C_4}{C_3+C_4}=\frac{75\times630}{75+630}\text{pF}$$

$$=67\text{pF}$$

The padder has thus nearly halved the effective maximum tuning capacitance but has reduced the minimum by about 10%. The effect on the minimum value is an example of a general rule that when a large capacitor is connected in series with a small one, the effective capacitance is slightly less than the smaller. Since the padder reduces the maximum capacitance considerably but hardly affects the minimum, it follows that it has a great effect on the tuning at the low-frequency end of the band but has negligible effect at the other end. The value of the padder should therefore be chosen to give the required tuning range at the low-frequency end of the band.

The ratio of maximum to minimum capacitance across L is 294 to 67pF i.e. 4.38 : 1. This is a useful ratio to know because from it we can easily calculate the tuning range of the receiver. The ratio of maximum to minimum frequency (or maximum to minimum wavelength) of an LC circuit is equal to the square root of the capacitance ratio – in our example 2.1 : 1 approximately. The frequency range could therefore be

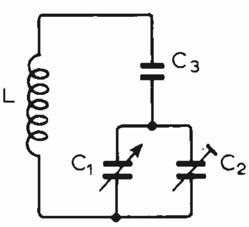


Fig. 1. Tuning circuit providing examples of capacitors connected in parallel and in series.

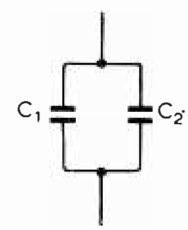


Fig. 2. Two capacitors connected in parallel.

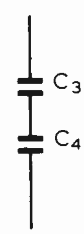


Fig. 3. Two capacitors connected in series.

from 1MHz to 2.1MHz which, for an intermediate frequency of 465kHz, corresponds to a tuning range of 535kHz to 1.635MHz, the medium waveband.

The rules quoted in Part 2 for calculating the effective value of two resistors connected in parallel apply equally to two capacitors connected in series. For example to calculate the capacitance C_1 needed to be connected in series with a given capacitance C_2 to give a required capacitance C_{eff} we can use the expression:

$$C_1=\frac{C_2C_{\text{eff}}}{C_2-C_{\text{eff}}}$$

$$=\frac{\text{product of original and effective capacitances}}{\text{difference of original and effective capacitances}}$$

For example the series capacitance required to reduce 820pF to 330pF is given by

$$C_1=\frac{\text{product}}{\text{difference}}=\frac{820\times330}{820-330}\text{pF}$$
$$=550\text{pF approximately.}$$

If two equal capacitors are connected in series, the effective capacitance is half that of each capacitor. If we connect in series with a capacitor another of double its value, the effective capacitance of the combination is two-thirds that of the original capacitor. In general if we connect in series with a capacitor another of n times its capacitance, the effective capacitance of the combination is $n/(n+1)$ that of the original.

If we express the reduction in capacitance as a percentage we can use a rule similar to that for resistors in parallel, e.g. to reduce the effective capacitance by 1% the series capacitor should have 100 times the capacitance of the original and for a 5% reduction the series component should be approximately 20 times the original. In general the series capacitance for a p% reduction in capacitance should be $(100-p)/p$ times the original which, for small percentages, is approximately $100/p$ as in the two numerical examples quoted above.

As a numerical example suppose a medium-wave receiver is found to have a waverange extending to 500kHz and that the minimum frequency is required to be 520kHz. The correction could, of course, be achieved by adjustment of the inductance followed by a trimmer adjustment at the high-frequency end of the band. Suppose, however, that the inductor must not be altered and that the correction must be achieved by connecting a capacitor in series with the tuning capacitor. Such a capacitor will not significantly affect the tuning at the high-frequency end as already explained. What value of series capacitance is required? The frequency correction is approximately 4% and this requires a capacitance correction of double this, i.e. 8%*. From the rule just quoted the series capacitor should be (100−8)/8, i.e. 11.5 times the maximum tuning capacitance. If the tuning capacitance has a maximum value of 350pF, the required series capacitor is 11.5×350pF which is approximately 4000pF.

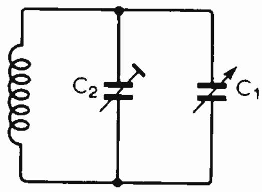


Fig. 4. Long-wave signal-frequency tuning circuit.

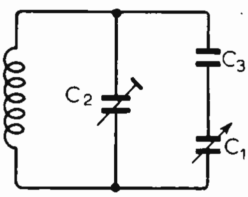


Fig. 5. Bandspread short-wave oscillator tuning circuit.

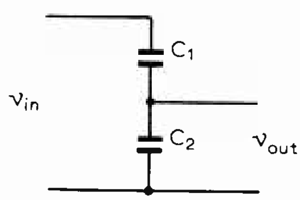


Fig. 6. Capacitive voltage divider.

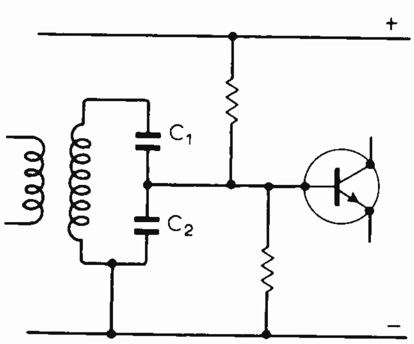


Fig. 7. Use of a capacitive divider to feed a bipolar transistor in an i.f. amplifier.

* Small alterations in capacitance are best expressed as percentages and for small percentages the resulting frequency change is *half* that of the capacitance change, e.g. a 4% change in capacitance gives a 2% change in resonance frequency. Large alterations in capacitance are best expressed as the ratio of the maximum to the minimum capacitance and here the resulting ratio of maximum to minimum resonance frequency is the *square root* of the capacitance ratio, e.g. a 9 : 1 capacitance ratio gives a 3 : 1 resonance frequency ratio.

Long-wave signal-frequency tuning circuit. As a numerical example consider the long-wave signal-frequency tuning circuit illustrated in Fig. 4. It is required to tune over the range 800 to 2,000 metres (150 to 375 kHz) and the tuning capacitor C_1 has a maximum capacitance of 350pF. What should be the capacitance of the trimmer C_2?

The ratio of maximum to minimum frequency is 375 to 150, i.e. 2.5 : 1. The ratio of maximum to minimum effective capacitance must hence be $2.5^2 : 1$ that is 6.25 : 1. If we neglect the minimum capacitance of C_1 and take C_2 as the minimum capacitance of the circuit, the maximum capacitance is (C_1+C_2) and we have the simple relationship

$$C_1+C_2=6.25C_2$$

which gives C_2 as 67pF approximately. The minimum capacitance of C_1 will, of course, contribute something towards this and C_2 could well be made a preset component of 70pF maximum capacitance which can be adjusted to resonance at 375kHz with C_1 at minimum.

Bandspread short-wave oscillator tuning circuit. Sometimes it is required to limit the tuning of a receiver to a small frequency range. For example it may be desired to cover the 49-metre band (5.95 to 6.2 MHz) in one sweep of the tuning capacitor. Such bandspread tuning greatly eases the difficulty of accurately tuning short-wave signals. The tuning is determined by the oscillator section of the receiver and for the standard intermediate frequency of 465kHz its frequency range is from 6.415 to 6.665 MHz. The centre frequency is 6.54MHz and the total tuning range (250kHz) is 3.8% of this. The total effective change in tuning capacitance must therefore be double this, i.e. 7.6% of the average (midband) capacitance. If we decide that the midband capacitance shall be 50pF, then the effective capacitance range must be from 48.1 to 51.9pF. The problem is to devise a tuning system to give such a range.

The required change in capacitance (3.8pF) could possibly be obtained from a small variable capacitor but a more general solution is to use a series combination of a fixed capacitor (C_3 in Fig. 5) and a variable capacitor C_1, the balance of fixed capacitance being provided by a parallel capacitor C_2. Suppose we choose for C_1 a capacitor with a maximum capacitance of 10pF and a minimum of 2pF. What value of C_3 will give a 3.8pF change in capacitance as C_1 is swung from minimum to maximum? To obtain an approximate answer we can assume that C_3 will be large compared with the minimum value of C_1 so that the effective

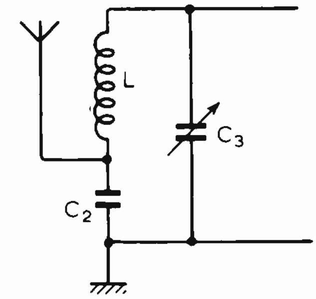


Fig. 8. Shunt capacitance aerial-coupling circuit.

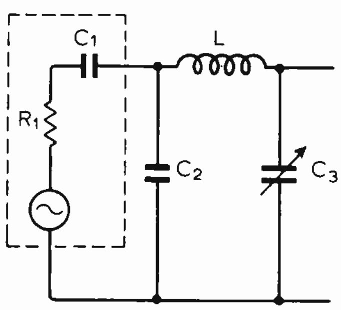


Fig. 9. The previous diagram when the aerial is replaced by an equivalent generator.

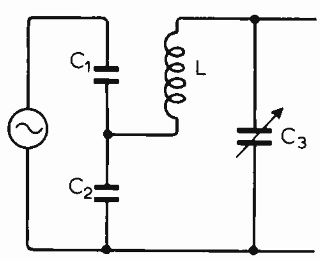


Fig. 10. The previous diagram simplified by the omission of R_1.

minimum capacitance of the combination is also 2pF. (In fact the minimum capacitance will necessarily be slightly less than 2pF so that the frequency coverage will be slightly greater than calculated.) The maximum capacitance of the combination is required to be 5.8pF and this enables us to calculate C_3 immediately from the relationship:

$$C_3 = \frac{\text{product of original and effective capacitance}}{\text{difference of original and effective capacitance}}$$

$$= \frac{10 \times 5.8}{10 - 5.8}\text{pF}$$

$$= 14\text{pF}$$

Finally we must determine the value of C_2. The midband capacitance of the C_1C_3 combination is approximately 4pF and to give a total midband capacitance of 50pF, as assumed initially, C_2 must be 46pF. To allow for stray capacitance, including the self-capacitance of the tuning inductor, it would be wise to make C_2 preset and to adjust it to give the required frequency range as C_1 is varied.

Capacitance divider. Two capacitors in series can be used as a voltage divider in much the same way as two resistors in series. The relationship between v_{in} and v_{out} (Fig. 6) is given by:

$$\frac{v_{out}}{v_{in}} = \frac{C_1}{C_1 + C_2}$$

(This should be compared with the corresponding expression $R_2/(R_1 + R_2)$ for the resistive potential divider.)

An example of an application of a capacitive divider is illustrated in Fig. 7. It is normal practice to derive the input signal for a bipolar transistor i.f. amplifying stage from a tapping (inductive or capacitive) on the preceding i.f. transformer. There are two main reasons for the use of such a tapping:
(a) it enables the effective damping of the tuned circuit by the transistor input resistance to be adjusted to obtain a desired Q value and hence the required shape of i.f. passband response.
(b) it limits the voltage gain of the transistor and this may be necessary to ensure stability particularly if no neutralisation or unilateralisation is used.

As a numerical example suppose that these design considerations dictate a capacitive divider step-down ratio of 8 : 1 and that the effective tuning capacitance should be 200pF What capacitor values should be used? To obtain the required effective tuning capacitance we have the relationship:

$$\frac{C_1C_2}{C_1 + C_2} = 200\text{pF}$$

From the voltage step-down requirement:

$$\frac{C_1}{C_1 + C_2} = \frac{1}{8}$$

Division of the first equation by the second gives us immediately that

$$C_2 = 1600\text{pF}$$

It is then probably quicker to obtain the value of C_1 by the product/difference relationship thus:

$$C_1 = \frac{\text{product of original and effective capacitances}}{\text{difference of original and effective capacitances}}$$

$$= \frac{1600 \times 200}{1600 - 200}\text{pF}$$

$$= 230\text{pF approximately.}$$

Shunt-capacitance aerial-coupling circuit. A less-obvious application of a capacitive divider occurs in the shunt-capacitance aerial-coupling circuit illustrated in Fig. 8. This is a very simple method of coupling an external aerial to a tuning circuit and is useful when the aerial is at some distance from the receiver and is coupled to it by a coaxial cable: the capacitance of the cable simply adds to the value of the coupling capacitance C_2.

To analyse the performance of this circuit we must replace the aerial by an equivalent generator, and for a vertical rod or wire likely to be used for medium-wave or long-wave reception the equivalent generator need consist simply of a voltage source in series with a resistance R_1 and a capacitance C_1 as shown in Fig.9. R_1 is commonly around 40 ohms which is negligible compared with the reactance of C_1 and it is therefore permissible to omit R_1 leaving the circuit in the form shown in Fig. 10. The circuit now consists of a capacitive potential divider C_1C_2 and its voltage output is magnified Q times by the resonant circuit LC_3. Thus we can say immediately that the voltage gain from the voltage induced in the aerial to that developed across C_3 is given by:

$$\text{voltage gain of shunt-capacitance aerial-coupling circuit} = \frac{QC_1}{C_1 + C_2}$$

Normally C_1 is small compared with C_2 and this can thus be simplified to:

$$\text{voltage gain of shunt-capacitance aerial-coupling circuit} = \frac{QC_1}{C_2}$$

This expression contains no term in frequency nor does it include C_3, this illustrating a good feature of the aerial-coupling circuit, namely that the voltage gain is independent of frequency. The value of the gain depends on Q and C_1 (which are fixed) and on C_2 which should be small to give high gain. Unfortunately there is a lower limit to the value of C_2 which can be used as illustrated in the following numerical example.

Suppose it is desired to cover the medium waveband (525 to 1605 kHz) and that C_3 has a maximum capacitance of 350pF and a minimum of 20pF. As shown earlier in this article C_2 has little effect on the minimum effective tuning capacitance but it does reduce the maximum and this reduction determines the minimum acceptable value of C_2. The ratio of maximum to minimum frequency in the medium waveband is 3.05 : 1 and thus the maximum to minimum effective tuning capacitance ratio must be 3.05^2 : 1, i.e. 9.35 : 1. Let the total minimum capacitance be 35pF (this includes an allowance of 15pF for the trimmer). Then the maximum effective capacitance should be 9.35 × 35, i.e. 327pF. The maximum capacitance of C_3 is in fact 365pF (i.e. 350pF plus 15pF for the trimmer). From these two figures we can calculate the value of C_2 from the expression:

$$C_2 = \frac{\text{product of original and effective capacitances}}{\text{difference of original and effective capacitances}}$$

$$= \frac{365 \times 327}{365 - 327}$$

$$= 3140\text{pF}$$

If we take the aerial capacitance as 200pF and the Q value of the tuning inductor as 100, the voltage gain is given by:

$$\text{voltage gain} = \frac{QC_1}{C_2}$$

$$= \frac{100 \times 200}{3140}$$

$$= 6.4 \text{ approximately.}$$

This is a low value but it is constant over the band: moreover there is very little damping of the tuned circuit LC_3.

Series-capacitance aerial-coupling circuit. Another aerial-coupling circuit which can similarly be treated as an example of a capacitive divider is the series-capacitance circuit shown in Fig. 11. As before we can replace the aerial by a series RC circuit and the resistance can be neglected leaving the equivalent circuit in the form shown in Fig. 12. As we shall see C_4 is in practice only a few pF, small compared with the aerial capacitance C_1. The effective capacitance of C_1 and C_4 in series is thus nearly equal to C_4, and C_1 can thus be omitted. The circuit then reduces to the simple form shown in Fig. 13. In this C_4 and C_3 form a capacitive divider, the output of which is magnified Q times by the tuned circuit LC_3. Thus the voltage gain, from voltage induced in the aerial to the voltage developed across C_3 is given by:

$$\text{voltage gain of series-capacitance aerial-coupling circuit} = \frac{QC_4}{C_3 + C_4}$$

Normally C_4 is small compared with C_3 and this can thus be simplified to:

$$\text{voltage gain of series-capacitance aerial-coupling circuit} = \frac{QC_4}{C_3}$$

Now Q is fixed for a given tuning inductor. C_4 is also fixed and its value can be determined as shown below. C_3 is the tuning capacitor and its capacitance varies over a ratio of more than 9 : 1 to span the medium waveband. It follows that the voltage gain of the aerial-coupling circuit similarly varies over a range of more than 9 : 1, being a maximum at the high-frequency end where C_3 is a minimum. Another important point is that C_4 is in parallel with C_3 and its value is therefore limited if, for example, the full extent of the medium waveband is to be covered.

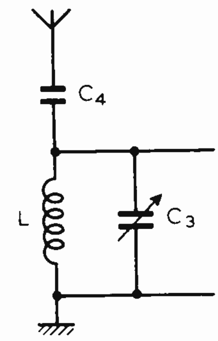


Fig. 11. Series-capacitance aerial coupling circuit.

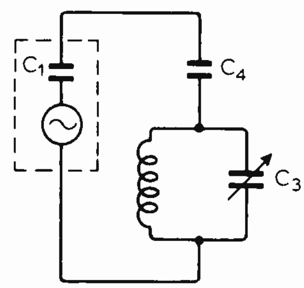


Fig. 12. Series-capacitance aerial-coupling circuit with the aerial replaced by an equivalent generator.

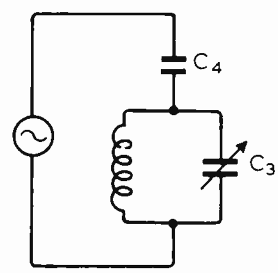


Fig. 13. As explained in the text, C_1 can be omitted, leaving the equivalent circuit for series-capacitance aerial coupling in this form.

As a numerical example consider the medium waveband (525 to 1605 kHz). As already shown this requires a variation in effective tuning capacitance of 9.35:1. If the tuning capacitor has a maximum capacitance of 350pF and a minimum of 20pF, then the maximum capacitance which can be placed in parallel with the tuning capacitor, while still permitting the whole of the waveband to be covered, is given by C in the equation:

$$9.35(C + 20) = C + 350$$

which gives

$$C = 20\text{pF approximately.}$$

Thus the trimmer and aerial coupling capacitor (effectively in parallel) must not exceed 20pF. An allowance of, say, 10pF must be made for the trimmer to allow alignment of the tuned circuit with others in the receiver and thus C_4 is limited to a maximum of about 10pF.

To estimate the value of voltage gain obtainable suppose the Q of the inductor is 100. If C_4 is 10pF we have, for the low-frequency end of the band, where the tuning capacitor has a maximum value of 360pF:

$$\text{voltage gain} = \frac{100 \times 10}{360}$$

$$= 2.8$$

a very low value. At the high-frequency end of the band the tuning capacitance is 30pF (minimum plus trimmer) and the voltage gain is given by:

$$\text{voltage gain} = \frac{100 \times 10}{30}$$

$$= 33$$

more than ten times the low-frequency gain, thus illustrating the wide variation mentioned above.

(Next article: RC combinations)

Teletext

We plan to publish in the near future a short series of articles on the Teletext television information system, culminating in a design for a decoder for use with domestic receivers. The decoder to be described will provide for full Teletext facilities, including colour, upper and lower-case characters, flashing indication and separate detection of news flashes and sub-titles. It will also contain provision for the display of time-selected Type C pages. Cost will be around £85. Teletext is a unified version of the BBC's CEEFAX system (*Wireless World*, May 1973, p.222) and the ORACLE system developed by the IBA (July 1973 issue, p.314). Test transmissions were started by the BBC in September 1974 on BBC1, while a group of independent television companies (London Weekend, ITN and Thames) will be starting them in July 1975. The Teletext broadcasting standard was outlined in News of the Month, November 1974 issue.

Circuit Ideas

Continuous dividing of two pulse rates

The following circuit you can use as a ratio ratemeter whose output signal is proportional to N_1/N_2 where N_1 and N_2 are average rates of the applied input pulse trains. The circuit is very simple and consists of two main parts: a logical circuit and an integrator. The logical circuit converts two input trains into one train whose pulse rate is equal to N_1, while the width of its pulses is given by the time intervals between two neighbouring pulses of train N_2. It is evident that, under certain conditions, at the output of the integrator the d.c. signal will be proportional both to the pulse rate of first train (N_1) and to the pulse interspaces in the second train (the interspaces are equal to $1/N_2$), i.e., it is proportional to the value $k\ N_1/N_2$ where constant k is given by the integrator.

The circuit diagram is shown in Fig. 1(a) and waveform responses in important circuit points are illustrated at (b). From the function of the proposed circuit it follows that such a ratio ratemeter works satisfactorily as long as in every time interval, defined as a gap between two successive pulses N_1, there appear at least two pulses N_2. For regularly distributed input pulses it is sufficient to satisfy the following condition: $2N_1 < N_2$. As far as random pulse trains are concerned the condition should be fulfilled to a greater extent. Naturally, in a practical application it is dependent chiefly upon the distribution of processing pulse trains. Measurements have shown that with regularly distributed pulses the achieved accuracy is better than 1% while for statistical pulses (Poisson distribution and $5N_1 < N_2$) the accuracy of the resulting ratio is approximately 2%.

The logical part of the ratio ratemeter can be designed with digital i.cs in general use. Fig. 1(a) shows that to do this it is sufficient to use only one integrated system containing two J-K flip flops. Another example of logic part design is shown in Fig. 2. Any integrated version of operational amplifier can be used in the integrator.

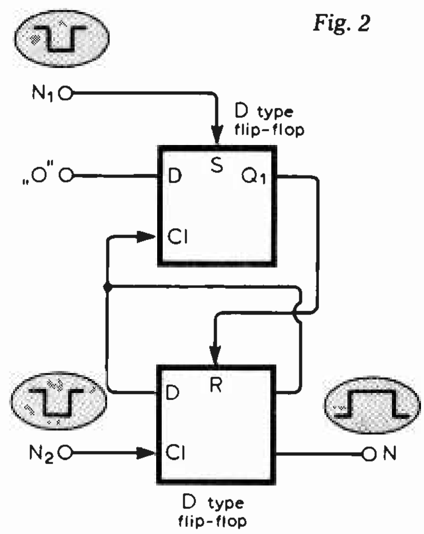


Fig. 2

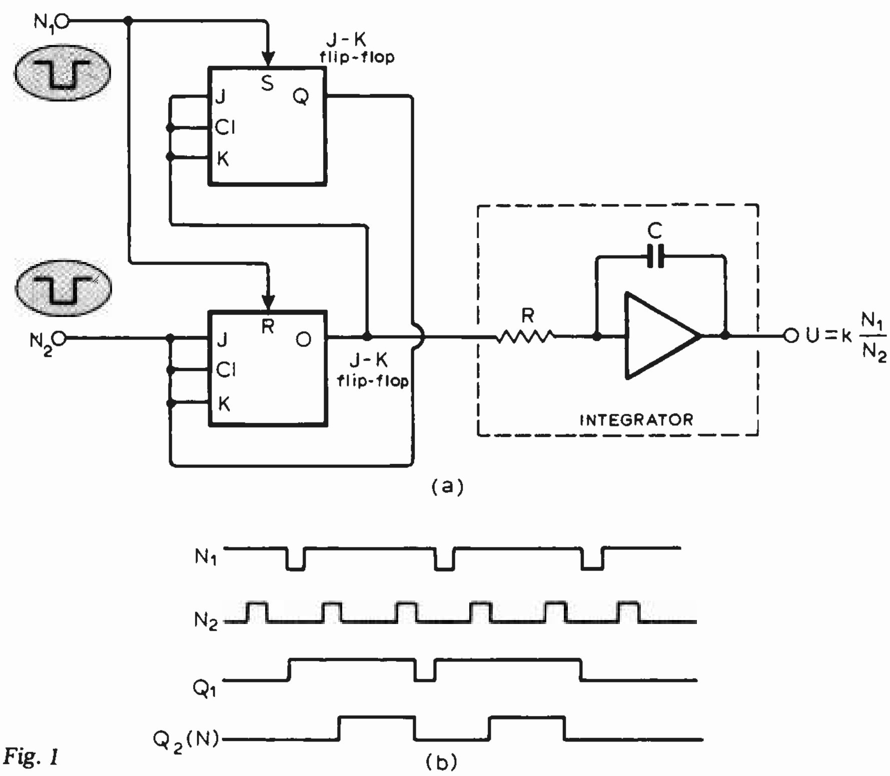
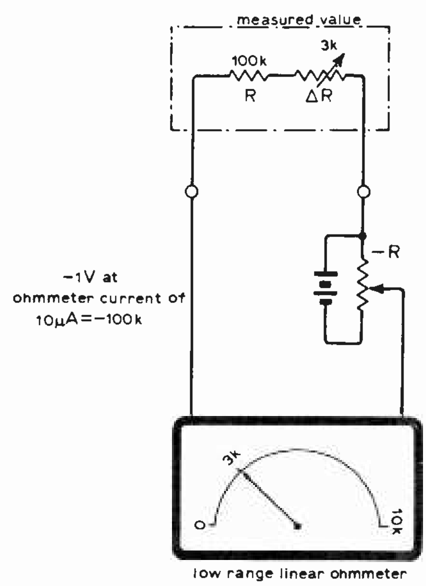


Fig. 1

J. Sabol,
Radiation Centre,
University of Birmingham

Cancellation by negative resistance provides alternative to Wheatstone bridge

When a small resistance variation must be measured in the presence of a large fixed resistance, the Wheatstone bridge technique is usually used. A better way, which eliminates balancing and/or output voltage signals which are a non-linear function of resistance change, is the use of a linear ohmmeter and negative resistance cancellation of the high fixed resistance value. A linear ohmmeter produces a constant current at its terminals; this allows the use of a potential as a negative resistance because the fixed current holds the Q-point of the battery or source of potential at some constant negative resistance value. Then the ohmmeter may be used on a low range (on which it would be pegged without the bucking voltage) to show the small resistance value change.



In the example shown, a battery and low-resistance potentiometer is used as a variable voltage source to produce the negative resistance value to cancel 100 kΩ of the unknown's total value; allowing the variation value of 3 kΩ to be read on the 10 kΩ range of the linear ohmmeter.

The linear ohmmeter may be any commercial instrument, such as the digital instruments available with resistance measuring ranges.

David R. Schaller,
Milwaukee,
Wisconsin

New Products

Rotary slider

A fader control, model, RS100, combines the linear slide action of existing devices with the circular resistive track of a conventional potentiometer. The unit consists of a sealed "pot" at each end of the control. A belt system is incorporated around the two "pots" which are moved by linearly moving the belt with the attached slide knob. Robins/Fairchild, 75 Austin Boulevard, Commack, N.Y. 11725, U.S.A.
WW 301 for further details

V.h.f. receiver

A recent addition to the Eddystone range of receivers is the 1990R/1 which covers the 25 to 235MHz band. Another version, the 1990R/2, offers an extended frequency range to 500 MHz. Both types will receive a.m., f.m., c.w. and pulse transmissions and are suitable for mobile communications, monitoring or laboratory use with facilities to operate from a standard mains supply or a 12V d.c. negative earth supply. Eddystone Radio Ltd, Eddystone Works, Alvechurch Road, Birmingham B31 3PP.
WW 313 for further details

Miniature p.c.b. sockets

A range of miniature sockets for vertical mounting in p.c.b. holes of 0.40in diameter is rated at 5A, 1800V d.c. The sockets are silver plated and have a p.t.f.e. insulating cover in eleven colours. Oxley Developments Co. Ltd, Ulverston, Cumbria.
WW 309 for further details

Autoranging d.v.m.

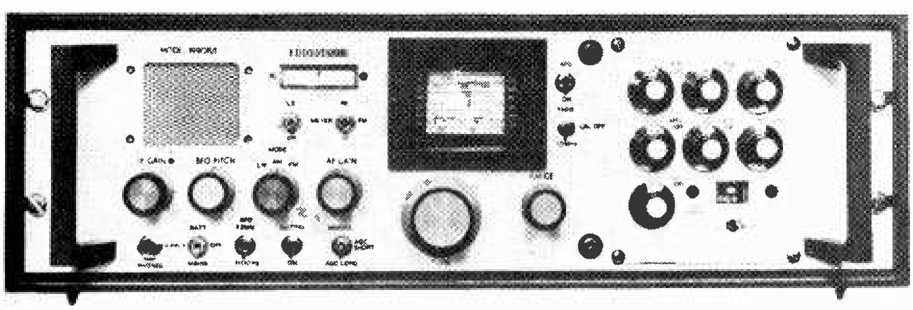
A recent addition to the B & K range of electronic voltmeters is the model 2427. This is a general purpose instrument for measurement of + peak, — peak, maximum peak, true r.m.s. and average value of signals with complex waveforms, and also d.c. values. An automatic mode selects the correct range according to the input level and the measured value may be indicated in mV, V or dB on a four-digit, seven-segment display. Frequency range of the 2427 is from 0.5Hz to 500kHz and the voltage range is from 10mV to 300V a.c., and from 100mV to 300V d.c. Decibel ranges are from —80 to +50dB ref. 1V, from +40 to +170dB ref. 1μV, and from —80 to +52dBm ref. 0.775V. B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middlesex.
WW 305 for further details

Tuner frequency-display

The AY-5-8100 is a 4½-digit frequency counter designed specifically for the hi-fi tuner market. The 28-lead m.o.s. microcircuit consists of a counter capable of accepting a 350kHz input and displaying the output on a fluorescent display. The three-stage frequency divider divides the input signal by ten, ten and eight to provide coverage of the medium, short and v.h.f. wavebands. In this way frequencies up to 2,999MHz, 29.995MHz and 299.95MHz can be displayed. General Instrument Microelectronics Ltd, 57-61 Mortimer Street, London W1N 7TD.
WW 311 for further details

Digital panel meters

A range of Swiss-made d.p.ms that have 1500V isolation between analogue input and digital output and interface directly with computer systems has been introduced by A D Products. The 1999-count panel meter with 16mm l.e.d. read-out, is in two display formats, 3½-digit



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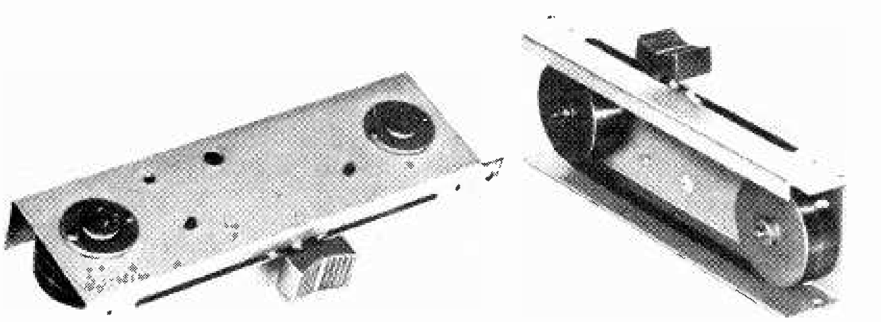

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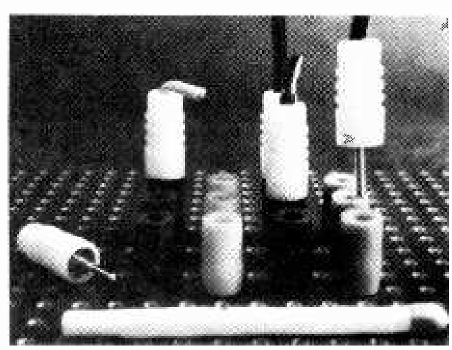


WW309

decimal or 3-digit hexadecimal and is housed in a 48 × 96mm DIN 43700 standard case. Standard features are: greater than 1000MΩ input resistance, input filter, reading rate of three per second, five ranges of direct voltage up to 1,000V and eight ranges of direct current up to 2A. Basic accuracy is 0.05% f.s. ±1 digit. Dimensions are 96W × 48H × 120D mm. Amplicon Electronics Ltd, 9 Lion Mews, Hove, Sussex BN3 5RA.
WW 323 for further details

Digital multimeter

The Simpson 360 digital multimeter offers a 3½-digit l.e.d. display, 29 ranges of measurement and an analogue output signal for interfacing to chart recorders. The meter will measure alternating and direct current up to 10A direct voltage up to 1100V, alternating voltage up to 600V, and resistance up to 19.99MΩ. The 360 measures 182×137×95mm and weighs about 2kg. Bach-Simpson (UK) Ltd, Trenant Industrial Estate, Wadebridge, Cornwall PL27 6HD.
WW316 for further details

Digital impedance meter

General Radio have announced the 1685 digital impedance meter. This instrument automatically measures *R*, *L* and *C* and has go/no-go limits for *D* and *Q*. Values for *C* and *L* are made at either 120Hz or 1kHz to offer an accuracy to within 0.5% and 0.1% respectively. General Radio Co. (U.K.) Ltd, Bourne End, Bucks.
WW 300 for further details

High-frequency breadboard

A range of self-adhering, tinned-copper strips and solder pads with plastic substrates, known as Lo-pads, is suitable for high-frequency breadboards. The pads, which are thin and flexible, may be cut with scissors and positioned to cross over each other. When this system is used in conjunction with a mini-mount system (from the same manufacturer) four impedance levels are obtained — ground, r.f. ground, matched impedance, and high impedance. Wainwright Instruments & Co, D-8031 Oberlating-Seefeld, Aubachstrasse 25, Germany.
WW 306 for further details

Flat-cable clips

A flat-cable clip manufactured from nylon is available in three sizes and will accommodate cables from 1 to 3in wide which are stacked up to 5¼in high. The base of the clip can be screw mounted or glued and the design of the device permits the removal of cable and re-use of the clip. Panduit Ltd, Sittingbourne Industrial Park, Unit 22a Crown Quay Lane, Sittingbourne, Kent.
WW 303 for further details

L.e.d. bar display

A 10-bar line array from ITT provides a linear display which may be extended to any length in multiples of 10 bars. The device uses a light pipe construction with GaAsP diodes presented in a 10-pin d.i.l. package. ITT Components Group Europe, Electron Device Division, Brixham Road, Paignton, Devon.
WW318 for further details

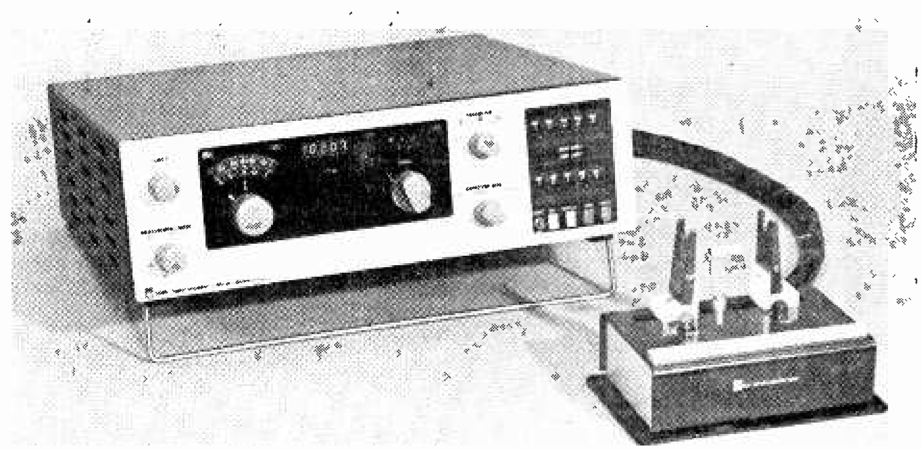
Signal conditioner

The SE994 is a six-channel system that will condition the signal from any transducer that accepts a bridge supply voltage from 5 to 15V d.c. Single, half or full-bridge configurations are accommodated and zero balance, gain set, internal/external calibration are also provided. A 1V full scale output is produced, from a minimum 10mV input, which is compatible with magnetic tape recorders, data loggers or meter units. SE Labs (EMI) Ltd, North Feltham Trading Estate, Feltham, Middlesex.
WW 308 for further details

Field tester for computer terminals

Identified as Field Datameter model DTM1000, Weir Instruments have introduced a diagnostic test set which combines a comprehensive pulse measuring system and a digital multimeter in a portable unit designed specifically


WW316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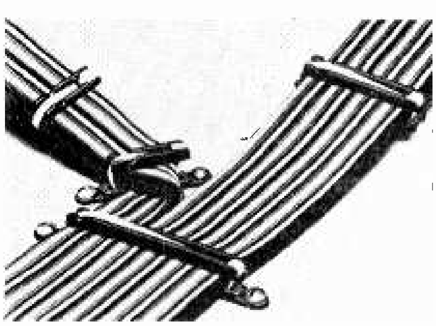
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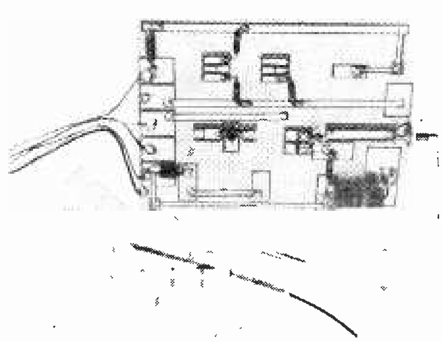
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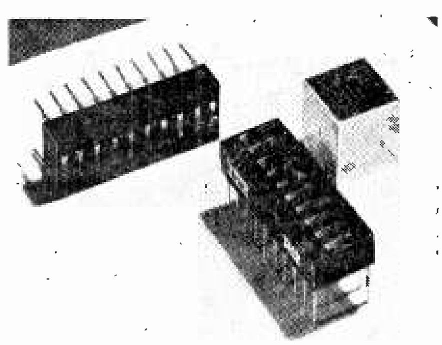
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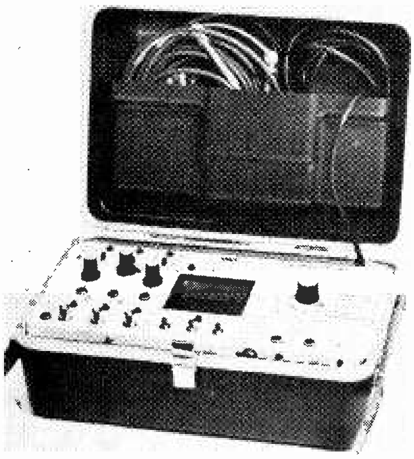

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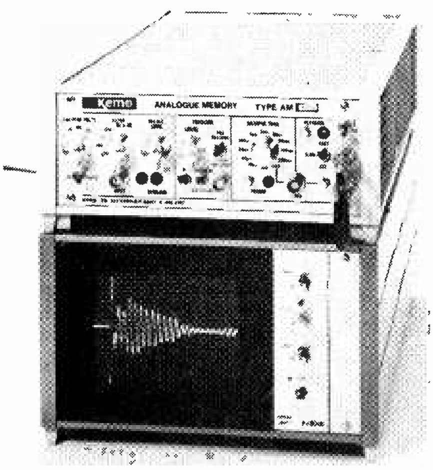

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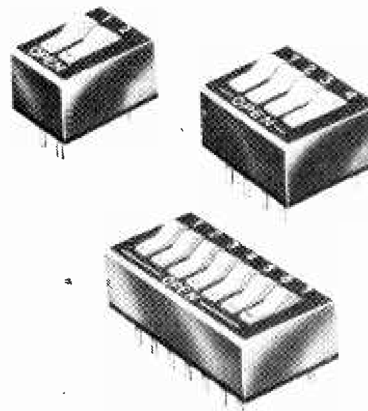


WW312

for use with Burroughs Intelligent Terminals and a wide range of computer peripheral equipment. The single unit effectively replaces a kit of test instruments including an oscilloscope, a pulse count meter, a frequency counter and a digital voltmeter. In addition to the normal functions of frequency measurement, pulse width timing and two-line time-interval measurement, the unit can be switched to indicate the coincidence (or overlap) time of two pulses applied to separate inputs, the duty cycle of a pulse waveform as a percentage of a total waveform period, the pulse count between external "start" and "stop" signals on either a one-shot or automatically up dated repeat basis. The digital multimeter section indicates d.c. voltage from 100μV to 1kV, a.c. voltages from 1mV to 500V and resistance over the range 0.1Ω to 9MΩ. All pulse and multimeter measurement results are indicated on a five-digit l.e.d. display with autoranging on frequency and multimeter functions. Weir Instrumentation Ltd, Durban Road, Bognor Regis, Sussex.
WW315 for further details

Wireless microphone

Beyer have introduced a wireless microphone system called the transistophone. This consists of a pocket transmitter, TS160, or a microphone transmitter, SM1600 (see photograph) and a receiver — NE160. All the units are crystal stabilised and operate in the 140 to 180MHz band. Beyer Dynamic (GB) Ltd, 1 Clair Road, Haywards Heath, Sussex.
WW 302 for further details

Analogue memory

The type AM1024 analogue memory is a digital store organized as 1024 × 9-bit words. Eight of the bits are used to retain converted analogue data, the remaining channel is available for synchronization, timing or control functions in a system. The memory is provided with crystal-controlled sampling increments between 3μs and 300ms. Two fixed playback speeds are offered which are compatible with a c.r.o. or an X-Y plotter. Kemo Ltd, 9-12 Goodwood Parade, Elmers End, Beckenham, Kent BR3 3QZ.
WW 307 for further details

Pc.b. rocker switches

The 76 series of d.i.l. printed circuit board rocker switches comprises nine sizes with between two and ten independent single contact switching positions. The moulded devices have a minimum height above the board of 7.75mm and can be supplied with a transparent protective cover. Highland Electronics Ltd, 33-41 Dallington Street, London EC1V OBD.
WW 312 for further details

Video equaliser

The 2503 video equaliser is designed for the PAL and SECAM colour systems. The unit will detect and continuously correct distortion in the six parameters of a video signal that are most noticeable to a viewer; overall signal level, 2T pulse amplitude, 2T pulse shape, bar tilt, chroma amplitude and chroma delay. Basically the unit receives a test signal incorporated in the transmitted picture signal. This is compared with stored reference voltages and any differences are corrected. Matthey Printed Products Ltd, William Clowes Street, Burslem, Stoke-on-Trent ST6 3AT.
WW 304 for further details

Rotation monitor

The type RM15 shaft-rotation monitor will provide an alarm or control signal when the speed of a rotating shaft reaches a preset level. The monitor accepts a signal from a sensor such as a magnetic transducer used in conjunction with a toothed wheel to give a train of pulses whose frequency is proportional to the rotational speed of the shaft. Gould Advance, Controls & Calculator Division, Raynham Road, Bishop's Stortford, Herts.
WW317 for further details

Electronic watch modules

Three electronic watch modules incorporating l.e.d. displays are available to volume users from National Semiconductors. Model WM01 is a complete, calibrated and warranted watch module that displays hours, minutes and seconds. Models WM02 (12 hour) and WM03 (24 hour) are similar to the WM01 but they also display date of the month on command. National Semiconductor, The Precinct, Broxbourne, Herts EN10 7HY.
WW 314 for further details

Comb generator

Scientific Research Corporation has developed a small comb generator which covers the 4 to 8GHz band. Comb spacing of the device is 100MHz with an output power of −25dBm ±10dB and an r.f. input of 100MHz at 0dBm. The generator, which operates in a temperature range from −55 to +71° C, measures 1.17 × 0.67 × 0.49in, and is available from REL Equipment and Components Ltd, Croft House, Bancroft, Hitchin, Herts SG5 1BU.
WW 310 for further details

Solid state held over until next month

Products seen at LECS

London Electronic Components Show, May 1975

Miniature relays

The 270/280 series of miniature mercury-wetted reed relays are for low-level switching applications. The mercury wetting of the relay contacts eliminates electrical contact "bounce" and gives a stable contact resistance (initial contact rating 0.05Ω maximum). The devices are suitable for interfacing with low-level logic equipment, while the power ratings enable them to be used for switching inductive loads. Ratings for the Form A types in the series are: breakdown 1.2kV d.c. minimum; switching 200V, 1mA and 28V, 1A (1kV d.c. and 2A d.c. maximum); d.c. contact rating 50W maximum. The corresponding figures for the Form C types are: breakdown 1kV d.c. minimum; switching 200V, 1mA and 28V, 1A (200V d.c. and 1A d.c. maximum); d.c. contact rating 14W maximum. Astralux Dynamics Ltd, Brightlingsea, Colchester, Essex CO7 0SW.
WW 327 for further details

Attenuator for cable television

A variable attenuator designed for cable television distribution systems and manufactured by Egen Electric provides a maximum attenuation range of 20dB, while maintaining a constant 75Ω input/output impedance and ensuring maximum power transfer. Insertion loss is less than 0.5dB and operating frequency range covers v.h.f. and u.h.f. bands between 40 and 860MHz. Egen Electric Ltd, Charfleet Industrial Estate, Canvey Island, Essex SS8 0PG.
WW 326 for further details

Time delay relay

A miniature time delay relay by Magnetic Devices Ltd gives a delay of up to 66 seconds, adjusted by fine and coarse potentiometers. Contact rating is 6A at 250V a.c. or 30V d.c. The plug-in relay is designed to operate from 12, 24, or 36V d.c. Magnetic Devices Ltd, Exning Road, Newmarket, Suffolk.
WW 334 for further details

Storage scope

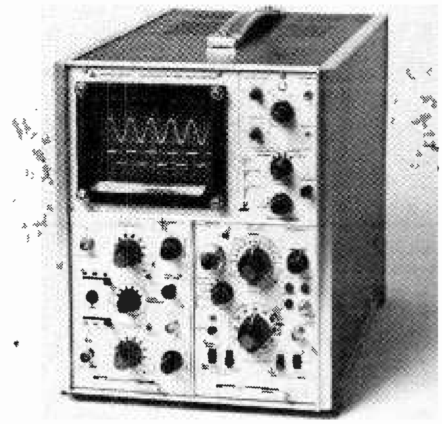
An improved version of the OS2200 storage oscilloscope from Gould Advance, the OS2200A, offers more comprehensive storage facilities at a lower cost than earlier models in the range. The incorporation of a stored brightness control improves the storage time, with low-brightness traces stored for up to approximately 30min, a times-three improvement over previous models, while a hold facility allows traces to be retained for a period of several days even when the instrument is switched off. The instrument is available in two versions: high bandwidth (10mV at 25MHz) and high gain differential with a sensitivity of 50μV/cm at 2MHz. Both versions use a wide-range timebase incorporating trigger delay and single-shot facilities. The OS2200A measures 25 × 29 × 44.5cm and costs £751 plus VAT with the wide-bandwidth Y amplifier and £816 with the high-gain differential Y amplifier. Gould Advance, Instrument Division, Roebuck Road, Bishop's Stortford, Herts.
WW324 for further details

Dry battery

Latest addition to the range of Sonnenschein Dryfit batteries is a 12V, 12Ah battery capable of supplying loads up to 100A. It measures 186 × 81 × 168mm and weighs approximately 5.25kg. The unit may be stored, charged and discharged in any position as the electrolyte is jellified and each cell is sealed with a one way safety valve which resets after gas has been released. F.W.O. Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ.
WW322 for further details

Contactless switches

Three kinds of contactless switches made by RAFI (Raimund Finsterhölzl) of Germany and imported by Cole Electronics use hall-effect devices. They are encoded thumbwheel switches, microswitches, and push-button/toggle switches. The plunger in these last-mentioned kinds of switch moves a permanent magnet with respect to a hall-effect chip. The hall voltage produced by the magnetic field is amplified and fed to a Schmitt trigger circuit. Two transistors with open collectors provide antiphase outputs. These bounce-free switches are claimed to be long life and relatively free from vibration and atmospheric effects. In the three-decade thumbwheel switches, operation of the selector alters the positions of pin-shaped magnets in relation to four hall i.cs. Cole Electronics Ltd, Church Road, Croydon CR0 1SG.
WW 331 for further details



WW324

WW322

Carbon on ceramic potentiometers

Series K10 and K15 potentiometers are high stability carbon preset controls with a performance closer to that of cermet types. The carbon track is deposited onto a ceramic substrate to give better heat dissipation. Temperature coefficient is within ± 5 parts in 10^4 per deg C. Measuring 10mm wide for the K10 and 15mm wide for the K15, they have a power rating of 0.5W and 1W respectively at 55°C (both derating to zero at 90°C) Available in the range 100 to 5MΩ, with a tolerance of either ± 20% or ± 10%. AB Electronic Components Ltd, Abercynon, Mid Glamorgan CF45 4SF. **WW 330 for further details.**

Polystyrene capacitors

New capacitors from Pye TMC Components Ltd feature a newly-developed plastics casing — called polystramethylene terephthalate — having excellent self-extinguishing properties. These extended-foil polystyrene capacitors are available in the range 1nf to 160nF at 63V d.c. and 1nf to 82nF at 125V d.c. Pye TMC Components Ltd, Graham Bell House, Roper Road, Canterbury, Kent.
WW 333 for further details.

Real and Imaginary

by "Vector"

NOONDAY UPON THE MARKET-PLACE

Greetings, fellow Europeans!

By the time you read this, the tumult and the shouting will have died and the captains and the kings, although still with us, will have found something else to pontificate about. But, as I write, the Common Market referendum is just over and a bemused electorate has decided that, if they can't beat 'em, they may as well join 'em. A decision which, I'm sure, will be welcomed by all thinking gnomes (on both sides of the Channel) who see in it a golden opportunity to make a fast buck, and which will, equally certainly, be damned to all eternity by those who don't.

As I've said, by the time this issue is in your hands, the topic of whether to or not will be as dead as the dodo. We're in, and the topicality now lies in what's likely to happen to us now we are in (by 'us' I mean the electronics industry in particular).

Unfortunately, in one sense, we can't consider electronics in isolation. Every industry is interdependent on every other and all of them in the long run depend on the prosperity of the individual. To ensure that we've got to sell a bit more than we buy in. So what have we got to sell that could possibly interest our new kith and kin over on the mainland? Agricultural produce? We can't even begin to feed ourselves and anyway there's nothing we can grow that they can't. Motor cars? Can you honestly see British Leyland giving Fiat, Renault or Mercedes-Benz any sleepless nights when, regardless of tariffs, the Japanese are already munching steadily away at the home market?

So what about electronics? Those of us who are long enough in the tooth may recall those far-off days when the BBC and (then) ITA were affluent enough to be pressured into lumbering themselves with a dual-standard service. One of the main platforms of support for the adoption of the 625-line standards was that it would enable British domestic receiver manufacturers to sell their wares on the Continent; this in bland disregard of the fact that, in the field of sound radio, where no significant difference in standards existed, British exports to the Continent had never exceeded 0.1% of the total exported. Since we went to 625 lines has anyone noticed fleets of cargo boats, loaded to the gunwales with British television sets, heading for the EEC countries?

Conversely, of course, you'd have to trudge many a weary mile before you found a French or Italian receiver on offer in British shops. The tariff barriers on either side have kept the member countries into relatively watertight compartments; a bad thing, one can argue. Yes, maybe; but for whom? Surely for the country with the most push and go, raring to go but thwarted by the sheer economics of the thing.

Can we, in this country, honestly see ourselves in that role? Aren't we, as a nation, too prone to imagine ourselves back in the days when a large proportion of the globe was coloured pink and we possessed ready-made markets by right of conquest? Don't we still have an inner conviction that the rest of the world acknowledges that if it's British it's best? Will we ever come to terms with some hard facts of life? For instance, that we're a grossly overpopulated little island, heavily over industrialised and with an inadequate supply of raw materials from internal sources. And, above all, that we're the poor relations of the EEC with a reputation for tea-breaks, an appalling incidence of industrial disputes and God's gift to all customers who have the foresight to insert a hefty penalty clause in their contracts against late delivery (and they all do).

So what do we do? Commit national hara-kiri? Of course not. We've got to count our blessings, tighten our belts and set our house in order, to get three clichés out of the way in one go. We might well make a start by returning to war-time food rationing, but making sure this time that it was enforced equally in the luxury hotels and Acacia Avenue. In industry we should be prepared to work longer hours, provided that comparable sacrifices were made up to Board level. In many industries, and certainly in electronics, there is a gross wastage and duplication of effort; too many departments which originated in all good faith as controls to promote efficiency and which have since blossomed into empires in their own right, parasitic on the works floor. (What is the point of saving money if the control systems which effect it cost ten times as much as they save?) the gospel of expansion for expansion's sake must be abandoned and the creed that mergers and economy are natural bed-fellows abandoned. There are a thousand-and-one ways in which the electronics industry might be streamlined to produce a highly competitive product without sacrifice of quality; all of them demand considerable positive effort; many involve a superficial loss of status in individuals and some are downright obnoxious. But to go on in the pious belief that somehow things will, of their own accord, take a turn for the better, is but to place the point of the sacrificial sword on the national belly-button.

Financially and in material possessions the Germans and the French have a far better time of it than we do. Don't begrudge them; don't envy them. They've earned it and they're going on earning it. Labour productivity in these countries makes us inept by comparison; return on capital is four times better in Germany than we can manage and strikes by comparison are almost non-existent. The adage that hard work never killed anybody is borne out by a better life-expectancy in both countries than we possess. In fact just about the only way in which we have the edge over them is in the possession of more television sets and more telephones — and there's a moral there if only I could think of it.

Something drastic has to be done before the tariff barriers fall. Even now there are a fair proportion of Continental cars on our roads and, on our own works floors, German machine tools and such equipments as photo-plotting machines are well in evidence (I've even seen them in factories where they actually make them themselves!).

Test and research engineers need no introduction to Rohde and Schwarz equipment which carries a cachet similar to Rolls-Royce. For many years this German firm has been selling their equipment in a modest way in Britain and the USA, with the price-tag as a deterrent to all but a relative few. Now I see that in the States R and S have changed tactics. Instead of manufacturing in the Fatherland, paying expensive shipping charges and import duties, they've come to an agreement with an American firm to manufacture their products over there, using American components. As a consequence the price has dropped to less than one-half and even in some instances to one-third. The firm is already selling to the Federal Aviation Administration, which, for starters, is pretty cheeky. One imagines that threat is not lost upon Hewlett-Packard and Tektronix, neither should it be on the British manufacturers of top-quality testgear.

In terms of capital goods (broadcasting transmitters, communications systems, radar systems and so on) Britain can scarcely expect to achieve massive orders from the Common Market countries, which, for the most part, have large electronics interests covering these areas. Our markets are, as they always have been, further afield. But so, too, are theirs and we're going to have to fight tooth and claw to keep them.

TRANSISTORS

Type	Price (£)	Type	Price (£)	Type	Price (£)	Type	Price (£)
AC107	0.35	BC119	0.29	BD115	0.65	BF273	0.16
AC117	0.24	BC125	0.22	BD123	0.98	BF336	0.35
AC126	0.25	BC126	0.20	BD124	0.80	BF337	0.35
AC127	0.25	BC132	0.15	BD130Y	1.42	BF458	0.60
AC128	0.25	BC134	0.20	BD131	0.45	BF459	0.63
AC141	0.26	BC135	0.19	BD132	0.50	BF596	0.70
AC141K	0.27	BC136	0.20	BD135	0.40	BF597	0.15
AC142K	0.19	BC137	0.20	BD136	0.46	BFR39	0.24
AC153K	0.28	BC138	0.20	BD137	0.48	BFR41	0.30
AC154	0.20	BC142	0.30	BD138	0.50	BFR61	0.30
AC176	0.25	BC143	0.35	BD139	0.55	BFR79	0.24
AC178	0.27	BC147B	0.13	BD140	0.62	BFT43	0.55
AC179	0.27	BC148	0.12	BD144	2.19	BFW10	0.55
AC187	0.25	BC149	0.14	BD145	0.75	BFW11	0.55
AC187K	0.26	BC149B	0.15	BD163	0.67	BFW16A	1.70
AC188	0.25	BC152	0.25	BD183	0.56	BFW30	1.38
AC188K	0.26	BC153	0.20	BD234	0.75	BFW59	0.19
AC 193K	0.30	BC154	0.20	BD519	0.76	BFW60	0.20
AC194K	0.32	BC157	0.15	BD520	0.76	BFW90	0.28
ACY28	0.25	BC158	0.13	BDX18	1.45	BFX16	2.55
ACY39	0.68	BC159	0.15	BDX32	2.55	BFX29	0.30
AD140	0.50	BC161	0.48	BDY16A	0.38	BFX30	0.35
AD 142	0.52	BC167B	0.15	BDY18	1.78	BFX84	0.25
AD143	0.51	BC168B	0.13	BDY20	0.99	BFX85	0.26
AD149	0.48	BC169C	0.13	BF115	0.20	BFX86	0.26
AD161	0.48	BC170	0.15	BF117	0.45	BFX87	0.28
AD162	0.48	BC171A	0.15	BF120	0.55	BFX88	0.24
AF114	0.25	BC172	0.14	BF121	0.25	BFY18	0.53
AF115	0.25	BC173	0.20	BF123	0.28	BFY40	0.40
AF116	0.25	BC176	0.22	BF125	0.25	BFY41	0.43
AF117	0.20	BC177	0.20	BF127	0.30	BFY50	0.25
AF118	0.50	BC178	0.22	BF158	0.25	BFY51	0.23
AF121	0.32	BC178B	0.22	BF159	0.27	BFY52	0.23
AF124	0.25	BC179	0.20	BF160	0.22	BFY57	0.32
AF125	0.25	BC179B	0.21	BF161	0.45	BFY64	0.42
AF126	0.25	BC182L	0.11	BF162	0.45	BFY72	0.31
AF127	0.25	BC183	0.11	BF163	0.45	BFY90	0.70
AF139	0.35	BC183K	0.12	BF167	0.25	BLY15A	0.79
AF147	0.35	BC183L	0.11	BF173	0.25	BPX25	1.90
AF149	0.45	BC184L	0.13	BF177	0.30	BPX29	1.70
AF178	0.55	BC186	0.25	BF178	0.33	BPX52	1.90
AF179	0.60	BC187	0.27	BF179	0.33	BRC4443	0.68
AF180	0.55	BC208	0.12	BF180	0.35	BRY39	0.47
AF181	0.50	BC212L	0.12	BF181	0.33	BRY56	0.40
AF186	0.40	BC213L	0.15	BF182	0.44	BR101	0.47
AF239	0.40	BC214L	0.15	BF183	0.44	BSW64	0.38
AF279	0.84	BC238	0.12	BF184	0.26	BSX19	0.13
AL100	1.10	BC261A	0.28	BF185	0.26	BSX20	0.19
AL102	1.10	BC262A	0.18	BF194	0.15	BSX76	0.15
AL103	1.10	BC263B	0.25	BF195	0.15	BSX82	0.52
AL113	0.95	BC267	0.16	BF196	0.15	BSY19	0.52
AU103	2.10	BC268C	0.14	BF197	0.17	BSY41	0.22
AU110	1.90	BC294	0.37	BF198	0.20	BSY52	0.45
AU113	2.40	BC300	0.60	BF199	0.25	BSY54	0.50
BC107	0.12	BC301	0.35	BF200	0.35	BSY56	0.80
BC107B	0.40	BC303	0.60	BF218	0.35	BSY65	0.15
BC108	0.12	BC307B	0.12	BF222	1.08	BSY78	0.40
BC108A	0.12	BC308A	0.10	BF224J	0.15	BSY91	0.28
BC108B	0.13	BC309	0.15	BF240	0.20	BT106	1.24
BC108C	0.14	BC323	0.68	BF241	0.22	BT116	1.20
BC109	0.13	BC377	0.22	BF244	0.18	BU105/02	1.95
BC109C	0.14	BC441	1.10	BF254	0.45	BU108	3.25
BC113	0.13	BC461	1.58	BF255	0.45	BU126	2.99
BC114	0.20	BCY42	0.16	BF256	0.45	BU204	1.98
BC115	0.20	BCY71	0.22	BF257	0.49	BU205	1.98
BC116	0.20	BCY87	4.65	BF258	0.66	BU207	3.00
BC117	0.20	BCY88	2.42	BF259	0.93	BU208	3.15
				BF262	0.70	BU209	2.55
				BF263	0.70	BUY77	2.50

Type	Price (£)	Type	Price (£)	Type	Price (£)
C106F	0.43	ZTX310	0.10	2N3790	4.15
C111E	0.56	2XT313	0.12	2N3794	0.20
CRS1/40	0.75	ZTX500	0.17	2N3819	0.35
CRS3/40	0.95	ZTX502	0.17	2N3820	0.49
D40N1	0.45	ZTX504	0.42	2N3823	1.45
E1222	0.55	ZTX602	0.24	2N3866	1.70
E5024	0.20	2N525	0.86	2N3877	0.25
ME6001	0.16	2N696	0.23	2N3904	0.16
ME6002	0.17	2N697	0.15	2N3905	0.18
ME8001	0.18	2N706	0.12	2N3906	0.15
MJE340	0.68	2N706A	0.15	2N4032	0.43
MJE341	0.72	2N708	0.35	2N4036	0.52
MJE370	0.65	2N744	0.30	2N4046	0.35
MJE520	0.85	2N914	0.19	2N4058	0.17
MJE521	0.95	2N918	0.30	2N4123	0.13
MJE2955	1.20	2N918	0.42	2N4124	0.15
MJE3000	1.85	2N930	0.35	2N4126	0.20
MJE3055	0.74	2N1304	0.21	2N4236	1.90
MM721	0.70	2N1305	0.21	2N4248	0.12
MPF102	0.40	2N1306	0.31	2N4284	0.19
MPSA05	0.47	2N1307	0.22	2N4286	0.19
MPSA55	0.50	2N1308	0.26	2N4288	0.13
MPS6566	0.21	2N1309	0.36	2N4289	0.20
MPSU05	0.66	2N1613	0.34	2N4290	0.14
MPSU06	0.76	2N1711	0.45	2N4291	0.18
MPSU55	1.26	2N1890	0.45	2N4292	0.20
MPSU56	1.26	2N1893	0.48	2N4871	0.24
OC26	0.38	2N2102	0.51	2N4902	1.30
OC28	0.65	2N2217	0.36	2N5042	1.05
OC35	0.59	2N2218	0.60	2N5060	0.32
OC36	0.64	2N2219	0.50	2N5061	0.35
OC42	0.55	2N2221A	0.41	2N5064	0.45
OC44	0.25	2N2222A	0.50	2N5087	0.32
OC45	0.32	2N2369A	0.42	2N5294	0.35
OC70	0.32	2N2401	0.60	2N5296	0.57
OC71	0.32	2N2484	0.41	2N5298	0.58
OC72	0.32	2N2570	0.18	2N5322	0.85
OC73	0.51	2N2646	0.53	2N5449	1.90
OC75	0.25	2N2712	0.12	2N5457	0.30
OC81	0.53	2N2904	0.22	2N5458	0.35
OC81D	0.57	2N2904A	0.26	2N5494	0.85
OC139	0.76	2N2905	0.26	2N5496	1.05
OC140	0.80	2N2905A	0.28	2N6027	0.65
OC170	0.25	2N2926G	0.13	2N6178	0.71
OC171	0.30	2N2926Y	0.12	2N6180	0.92
OCP71	0.92	2N29260	0.12	2SC643A	1.36
ON188	2.19	2N3019	0.75	2SC1172Y	2.80
ON236A	0.65	2N3053	0.21	3N140	1.21
ORP12	0.55	2N3054	0.55	40250	0.60
R2008B	2.05	2N3055	0.60	40327	0.67
R2010B	2.95	2N3133	0.54	40361	0.48
TAG3/400	1.54	2N3134	0.60	40362	0.50
TIC44	0.29	2N3232	1.32	40429	0.80
TIC46	0.44	2N3235	1.10	40439	2.67
TIC47	0.58	2N3254	0.28	AC128/AC176	0.52
TIP29A	0.49	2N3323	0.48	AC141K/AC142K	0.56
TIP30A	0.58	2N3391A	0.23	AC187/AC188	0.60
TIP31A	0.65	2N3702	0.13	AC187K/AC188K	0.61
TIP32A	0.67	2N3703	0.15	AC193K/AC194K	0.71
TIP33A	0.99	2N3704	0.15	AD161/AD162	0.95
TIP34A	1.73	2N3705	0.11	BC142/BC143	0.70
TIP41A	0.80	2N3706	0.10		
TIP42A	0.91	2N3707	0.13		
TIS43	0.30	2N3715	2.30		
TIS73	1.36	2N3724	0.72		
ZTX109	0.12	2N3739	1.18		
ZTX300	0.16	2N3771	1.70		
ZTX304	0.22	2N3772	1.90		
		2N3773	2.90		

DIODES

Type	Price (£)
AA113	0.15
AA119	0.09
AA129	0.20
AA143	0.10
AAZ13	0.30
AAZ17	0.12
BA100	0.15
BA102	0.25
BA110U	0.30
BA115	0.12
BA141	0.17
BA145	0.17
BA148	0.17
BA154	0.13
BA155	0.16
BA156	0.15
BA157	0.25
BAX13	0.06
BAX16	0.07
BAY72	0.11
BB105B	0.52
BB110B	0.45
BR100	0.50
BY100	0.15
BY103	0.22
BY126	0.16
BY127	0.17
BY133	0.23
BY140	1.40
BY164	0.55
BY176	1.68
BY179	0.70
BY206	0.31
BYX10	0.15
OA47	0.07
OA81	0.12
OA90	0.08
OA91	0.07
OA95	0.07
OA200	0.10
OA202	0.10
OA210	0.29
IN914	0.07
IN916	0.10
IN4001	0.05
IN4002	0.06
IN4003	0.07
IN4004	0.08
IN4005	0.09
IN4006	0.11
IN4007	0.14
IN4148	0.05
IN4448	0.10
IN5400	0.15
IN5401	0.17
IN5402	0.20
IN5403	0.22
IN5404	0.25
IN5404	0.27
IN5406	0.30
IN5407	0.34

ZENERS

400mW	
3-33V	0.12
1W	
3 3 100V	0.18

THYRISTORS, TRIACS AND TRIACS WITH TRIGGER

IF VRM	50V	100V	200V	400V	600V
3A	—/—/—	—/28/30	—/34/36	—/50/52	—/66/70
4A	26/—/—	30/—/—	38/—/—	60/—/—	75/—/—
6A	29/—/—	33/44/46	42/56/58	68/80/84	80/100/105
8A	32/—/—	38/50/52	47/64/61	75/92/97	90/114/120
10A	36/—/—	42/60/63	51/74/78	84/104/109	100/128/13
16A	—/—/—	—/82/90	—/88/95	—/132/140	

Notes: All prices are in pence per unit First price in each group is thyristor, second is triac, third is triac with trigger. Encapsulation depends on current rating and device type. Connection data supplied with each device. Quantity enquiries welcomed.

INTEGRATED CIRCUITS

Type	Price (£)	Type	Price (£)
CA3045	1.40	TAA630Q	4.18
CA3046	0.70	TAA630S	4.18
CA3065	1.90	TAA700	4.18
MC1307P	1.19	TAA840	2.02
MC1310P	2.94	TAA861A	0.49
MC1327PQ	1.01	TAD100	2.66
MC1330P	0.76	TBA120S	0.99
MC1351P	0.75	TBA240A	2.97
MC1352P	0.82	TBA480Q	1.90
MC1358PQ	1.85	TBA500	1.99
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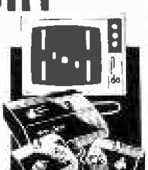

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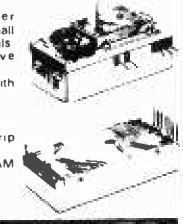

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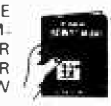

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AC178	0.25	BD131)	MP	OC22	0.50	2N2924	0.18
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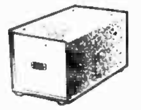
CASED TRANSFORMERS



Housed in smart resin coated steel cases with 3 core power cable and outlet socket, fused primary winding. Isolation types are fitted with 3-pin outlet sockets and are available with 110 volt or 240 volt output (Please state). Auto types are fitted with 2-pin flat style sockets up to 500 VA. 3-pin sockets from 750 to 3000 VA. See Auto and Isolation sections for prices. Plugs extra.

SAFETY ISOLATING

Prim. 120/240V Sec 120/240V Centre Tap with screen

VA (WATTS)	REF No.	PRICE Cased £	PRICE Plugs 2 Pin + 1 Earth £	PRICE Open £	Post £
60	149	8.35	0.88	4.37	0.56
100	150	9.15	0.88	4.90	0.64
200	151	11.45	0.88	8.14	0.80
250	152	12.90	0.88	9.80	0.88
350	153	15.50	0.88	11.88	0.95
500	154	17.25	0.88	13.62	1.13
750	155	27.10	1.10	20.59	O.A.
1000	156	35.40	1.10	29.15	O.A.
1500	157	42.00	1.10	33.37	O.A.
2000	158	49.75	2.64	37.10	O.A.
3000	159	73.15	2.64	58.55	O.A.

MINIATURE & EQUIPMENT

Primary 240V with Screen

VOLTS Sec. 1	VOLTS Sec. 2	MILLIAMPS Sec. 1	MILLIAMPS Sec. 2	TYPE No.	PRICE £	Post £
3-0-3	–	200	–	238	1.50	0.25
0-6	0-6	500	500	234	1.38	0.25
0-6	0-6	1000	1000	212	1.90	0.47
9-0-9	–	100	–	13	1.40	0.25
0-9	0-9	330	330	235	1.50	0.25
0-8-9	0-8-9	500	500	207	1.93	0.34
0-8-9	0-8-9	1000	1000	208	2.75	0.47
15-0-15	–	40	–	240	1.35	0.25
0-15	0-15	200	200	236	1.38	0.25
20-0-20		30	–	241	1.35	0.25
0-20	0-20	150	150	237	1.38	0.25
0-15-20	0-15-20	500	500	205	2.73	0.56
0-20	0-20	300	300	214	1.93	0.47
0-20	–	3500	No Screen	1116	3.30	0.64
20-12-0	–	700	–	221	2.20	0.47
12-20		(D.C.)				
0-15-20	0-15-20	1000	1000	206	3.50	0.56
0-15-27	0-15-27	500	500	203	3.00	0.56
0-15-27	0-15-27	1000	1000	204	3.85	0.56

12 and 24 VOLTS PRIMARY 200-240 Volts

12V	24V	TYPE No.	PRICE £	Post £
0.3	0.15	242	1.58	0.34
0.5	0.25	111	1.38	0.34
1	0.5	213	1.74	0.47
2	1	71	2.30	0.47
4	2	18	2.96	0.56
6	3	70	4.18	0.56
8	4	108	4.56	0.64
10	5	72	5.20	0.72
12	6	116	5.51	0.72
16	8	17	7.00	0.80
20	10	115	10.42	0.88
30	15	187	13.25	1.01
40	20	232	14.85	O.A.
60	30	226	16.83	O.A.

30 VOLTS

PRIMARY 200/240V
SECONDARY 12, 15, 20, 24, 30V

AMPS	Ref. No.	Price £	Post £
0.5	112	1.90	0.47
1	79	2.40	0.56
2	3	3.50	0.56
3	20	4.50	0.64
4	21	5.15	0.72
5	51	6.40	0.72
6	117	7.16	0.88
8	88	9.55	0.95
10	89	9.67	0.95

50 VOLTS

PRIMARY 200/240V
SECONDARY 19, 25, 33, 40, 50V

AMPS	Ref.	Price	Post
0.5	102	2.58	0.47
1	103	3.48	0.56
2	104	5.03	0.64
3	105	5.81	0.72
4	106	7.58	0.88
6	107	12.30	0.95
8	118	13.20	1.13
10	119	17.02	O.A.

60 VOLTS

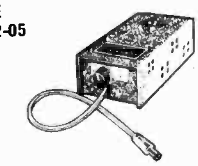
PRIMARY 200/240V
SECONDARY 24, 30, 48, 60V

AMPS	Ref.	Price	Post
0.5	124	2.30	0.56
1	126	3.41	0.56
2	127	5.09	0.72
3	125	7.52	0.80
4	123	8.75	0.95
5	40	9.75	0.95
6	120	11.20	1.01
8	121	15.00	1.19
10	122	18.20	O.A.
12	189	18.50	O.A.

BRIDGE RECTIFIERS

	Price
ONE AMP	
50 P.I.V.	0.20
100 P.I.V.	0.20
200 P.I.V.	0.28
600 P.I.V.	0.30
FOUR AMP	
100 P.I.V.	0.55
200 P.I.V.	0.59
400 P.I.V.	0.65
600 P.I.V.	0.75
TWO AMP	
50 P.I.V.	0.35
100 P.I.V.	0.40
200 P.I.V.	0.45
400 P.I.V.	0.50
SIX AMP	
50 P.I.V.	0.65
100 P.I.V.	0.70
200 P.I.V.	0.08
400 P.I.V.	0.90

POWER UNIT TYPE CC12-05



Output switched 3, 4.5, 6, 7.5, 9 and 12 Volts at 500 mA D.C. Operates from 240 V mains, suitable for Radios, Tape Recorders, Record Players, etc. Size 7.5 × 5.0 × 14.0 cm. Price £3.95 Post 25p.

AUTO TRANSFORMERS

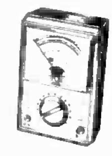
VA (Watts)	Ref No	PRICE Cased	PRICE Plugs 2 & 3 pin £	PRICE Open £	Post £
Tapped at 115, 220, 240 Volts					
20	113	3.85	0.20	1.71	0.47
Tapped at 115, 200, 220, 240 Volts					
150	4	6.38	0.20	4.12	0.56
200	65	7.04	0.20	4.95	0.64
300	66	8.00	0.20	5.81	0.72
500	67	10.99	0.20	8.85	0.88
750	83	13.82	0.85	10.80	0.95
1000	84	17.27	0.85	13.68	1.13
1500	93	21.87	0.85	18.31	O.A.
2000	95	33.11	1.60	24.25	O.A.
3000	73	47.94	2.10	35.10	O.A.

NEW! 2" AND 4" PANEL METERS

2" Movement	I.R. Ohms	4" Movement	I.R. Ohms
SIZE: 60mm Wide × 45mm High × 40mm Deep.		SIZE: 110mm Wide × 82mm High × 43mm Deep.	
0-50 micro A.	1250	0-50 micro A	1400
0-100 micro A.	580	0-100 micro A	730
0-500 Micro A.	170	0-500 micro A	200
0-1 mA	170	0-1 mA	200
0-5 mA	170	0-5mA	200
0-10mA	6	0-10 mA	6
0-50 mA	0.5	0-50 mA	0.5
0-100 mA	0.5	0-100 mA	0.5
0-500 mA	0.5	0-500 mA	0.5
0-1 AMP	0.5	0-1 AMP	0.5
0-2 AMP	0.5	0-2 AMP	0.5
0-25 Volt	15K	0-25 Volt	15K
0-50 Volt	50K	0-50 Volt	50K
0-300 Volt	300K	0-300 Volt	300K
"g" Meter	170	"g" Meter	200
VU Meter	9250	VU Meter	5250

VU Meters are complete with detectors. Modern wide view. Price 2" £3.20 Post 10p. Price 4" £4.00 Post 10. Lamps 60p per set.

C1000 MULTI-METER



Compact General Purpose Mini Multimeter
Input Resistance 1000 ohms per volt
Ranges AC Volts 0-15 50 250 1000 Volts
DC Volts 0-10 50 250 1000 Volts
DC Current 0-1 mA 0-100 mA
Resistance 0-150K ohms
Size 60 × 24 × 90 mm
Complete with Batteries, Test Prods, Instructions

Special price **£3.30** Post 25p

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also available ¼ watt at 70°CE 12 range 10Ω—1MΩ. 5% tol above 470KΩ 10% tol at **95p** per 100.

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6mm dia., 12mm length leads length approx. 20mm. Recommended ballast resistor 150K ohms for 240 Volt operation. Price. Packet of 10 for **60p**. Postage 15p.

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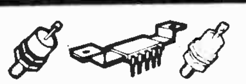

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TRIACS

1.6AMP PLASTIC TO5

NAS0161 W	100v	.27
NAS0161X	100v	.26
NAS0162W	200v	.30
NAS0162X	200v	.28
NAS0164W	400v	.40
NAS0164X	400v	.38
NAS0166W	600v	.55
NAS0166X	600v	.52

6AMP ISOLATED TAB

NAS0651W	100v	.46
NAS0651X	100v	.44
NAS0652W	200v	.58
NAS0652X	200v	.56
NAS0654W	400v	.84
NAS0654X	400v	.80
NAS0656W	600v	1.05
NAS0656X	600v	1.00

10AMP ISOLATED TAB

NAS1001W	100v	.63
NAS1001X	100v	.60
NAS1002W	200v	.78
NAS1002X	200v	.74
NAS1004W	400v	1.09
NAS 1004X	400v	1.04
NAS1006W	600v	1.34
NAS1006X	600v	1.28

3AMP "CLIPPED TAB"

NAS0301W	100v	.30
NAS0301X	100v	.28
NAS0302W	200v	.36
NAS0302X	200v	.34
NAS0304W	400v	.52
NAS0304X	400v	.50
NAS0306W	600v	.70
NAS0306X	600v	.66

8.5AMP ISOLATED TAB

NAS0851W	100v	.52
NAS0851X	100v	.50
NAS0852W	200v	.67
NAS0852X	200v	.64
NAS0854W	400v	.97
NAS0854X	400v	.92
NAS0856W	600v	1.20
NAS0856X	600v	1.14

16AMP ISOLATED METAL

NAS1601W	100v	.90
NAS1601X	100v	.82
NAS1602W	200v	.95
NAS1602X	200v	.88
NAS1604W	400v	1.40
NAS1604X	400v	1.32
NAS1606W	600v	1.85
NAS1606X	600v	1.75

Devices with Internal Trigger have "W" suffix. "X" denotes Standard Triac.

THYRISTORS

1.6AMP MIN. TO5

NAS006P	50PIV	.25
NAS006Q	100PIV	.28
NAS006R	200PIV	.31
NAS006S	400PIV	.40
~~NAS006T~~	600PIV	.52

4AMP ISOLATED TAB

NAS106P	50PIV	.26
NAS106Q	100PIV	.30
NAS106PR	200PIV	.36
NAS106S	400PIV	.56

6AMP ISOLATED TAB

NAS206P	50PIV	.37
NAS206Q	100PIV	.42
NAS206R	200PIV	.50
NAS206S	400PIV	.77

8AMP ISOLATED TAB

NAS306P	50PIV	.41
NAS306Q	100PIV	.47
NAS306R	200PIV	.59
NAS306S	400PIV	.85

16AMP ISOLATED TAB

NAS806P	50PIV	.50
NAS806Q	100PIV	.58
NAS806R	200PIV	.73
NAS806S	400PIV	1.15

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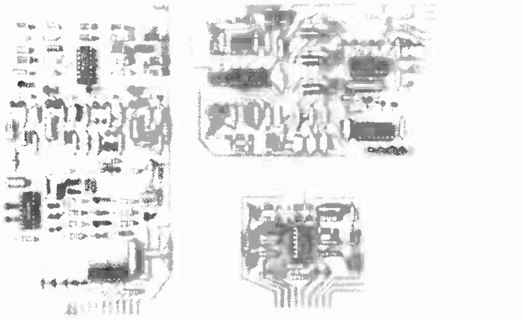

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Feed 2 channels (200–1000mV as obtainable from most pre amplifiers) into your choice of any of our 3 decoders and take 4 channels out with no overall signal level reduction. On the logic enhanced decoders Volume, Front Back, LF–RF, LB–RB and Dimension controls can all be implemented by simple single gang potentiometers—no need for exotic 4 gang units!
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M1 Basic matrix decoder with fixed 10-40 blend. 10 Resistors 14 Capacitors 1 Integrated Circuit Printed Circuit Board **£6 54**
L1 Full logic controlled decoder with wave matching and front back logic for enhanced channel separation using three specially designed Integrated Circuits. 24 Resistors 42 Capacitors 3 Integrated Circuits Printed Circuit Board. **£19 80**
L2 More advanced full logic decoder with variable blend, extended frequency response, increased front back separation. 43 Resistors 44 Capacitors 3 Integrated Circuits 9 Transistors 6 Diodes Printed Circuit Board **£28-20**
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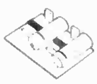
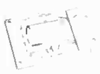
POWER AMPS



SS103
Compact I.C. amp. 3 watts R.M.S. Single channel (mono) On P.C.B. size 3½"x2". Needs 6-22V supply **£1.75**

SS103-3
Stereo version of above. (Two I.Cs.) **£3.25**



NEW! SS105 Mk. 2
A compact all-purpose power amp. Can be run from 12V car battery. Size 3½"x2". Useful 5w output (mono) into 3Ω using 13.5V. Excellent value. **£2.25**

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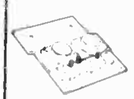
Similar in size to SS105 but will give 10w output into 4Ω using 24V (mono). Two in stereo give first-class results, suitable for many domestic applications. **£2.75**



SS140
Beautifully designed. Will give up to 40w R.M.S. into 4Ω. Excellent S.N.R. and transient response. Fine for P.A., disco use, etc. Operates from 45V DC. Two in bridge formation will give 80w R.M.S. into 8Ω. **£3.60**

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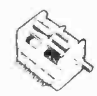
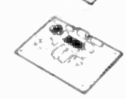
FM Tuners



SS201
Front End assembly. Ganged tuning with well engineered slow-motion geared drive in robust housing. A.F.C. facility. Requires 7-10V. Excellent sensitivity. 88-108mHz. **£6.25**

SS202
I.F. Stage (with I.C.). Designed to use with SS201 uses I.C. Carefully checked before despatch. For 9-16V. **£5.25**



SS203
Stereo Decoder. Designed essentially for use with SS201 and SS202, this excellent decoder can also make a stereo tuner of almost any single channel FM tuner. Supplied ready aligned. A.L.E.D. can easily be fitted. 9-16V. **£5.62**

SAVE £5 ON THE S/S TUNER
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- **TP5** 20 Transistors, PNP Germanium, Red Spot A.F.
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- **TP7** 1 2N174 150w 80Vce Power Transistor, with mounting assembly
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- **TP29** 8 power diodes 400V, 1.25A Silicon FST 3/4

UT SELECTION
- **UT1** 50 PNP's Germanium, AF & RF.
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- **UT4** 100 Silicon diodes, min. glass, similar to IN914, IN916
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PLASTIC POWER TRANSISTORS

40 WATT SILICON

Type	Polarity	Gain	VCE	Price
40N1	NPN	15	15	20p
40N2	NPN	40	40	30p
40P1	PNP	15	15	20p
40P2	PNP	40	40	30p

90 WATT SILICON

Type	Polarity	Gain	VCE	Price
90N1	NPN	15	15	25p
90N2	NPN	40	40	35p
90P1	PNP	15	15	25p
90P2	PNP	40	40	35p

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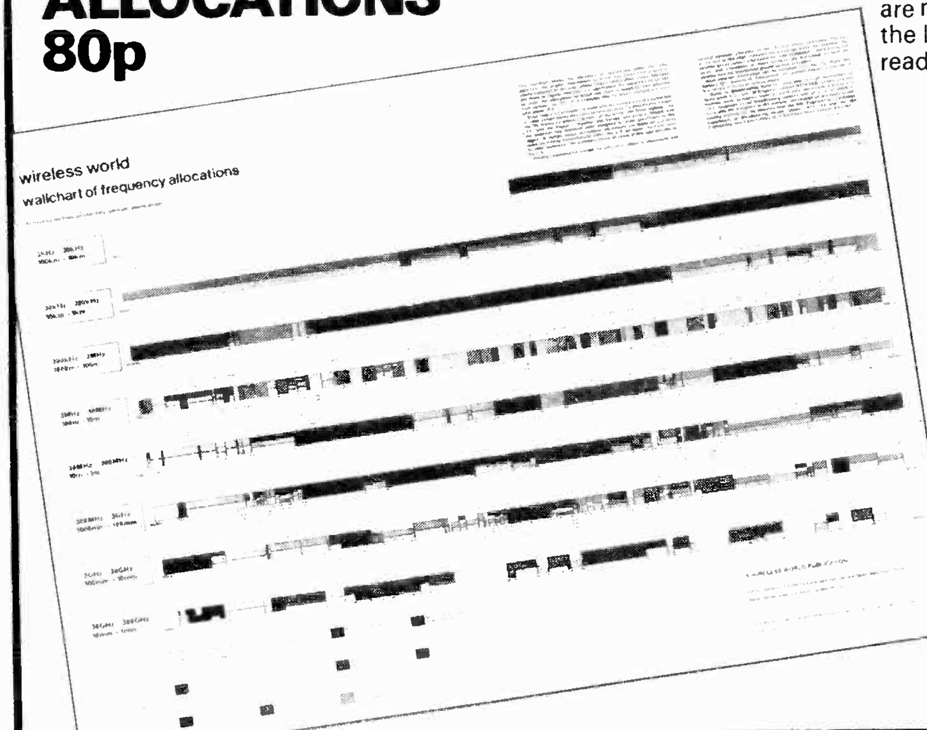
Wireless World FULL COLOUR WALLCHART OF FREQUENCY ALLOCATIONS 80p



The wallchart shows the allocation of frequencies within the radio spectrum ranging from 3 kHz to 300 GHz and is scaled on eight logarithmic bands contriving 15 main categories of transmissions which are identified by colours. All the important spot frequencies and 'special interest' frequencies are marked. The information is taken from the ITU and has been condensed into easily read chart form. Measures 2′ 11″ × 1′ 11″.

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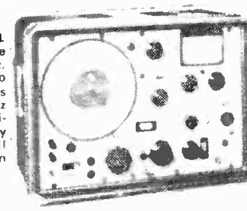

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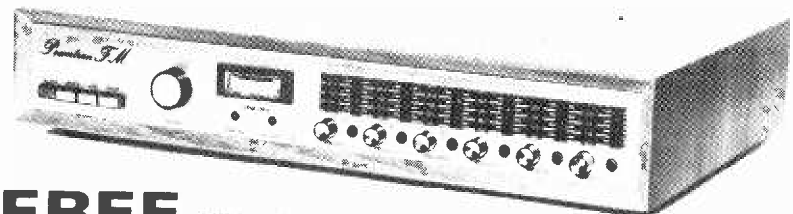

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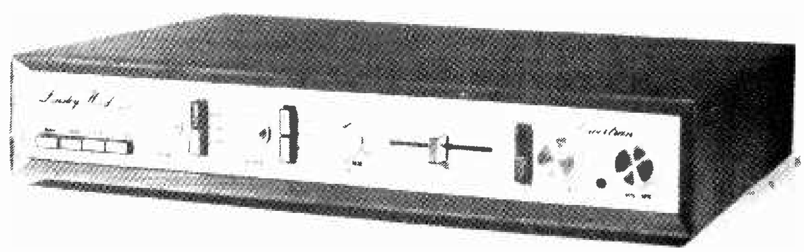
DESIGNER APPROVED KIT

In Hi-Fi News there was published by Mr Linsley-Hood a series of four articles (November 1972–February 1973) and a subsequent follow-up article (April 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The power amplifier is complemented by a pre amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

Hi-Fi News Linsley-Hood 75W/Channel Amplifier Mk III Version (modifications as per Hi Fi News April 1974)



Full circuit description in handbook (pack 15—price 30p)

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8	Set of potentiometers (including mains switch)	£2 05
9	Set of 4 push button switches rotary mode switch	£3 70
10	Toroidal transformer complete with magnetic screen housing primary 0 117 234 V secondaries 33 0 33 V 25 0 25 V	£9 15
11	Fibreglass printed circuit board for power supply	£0 65
12	Set of resistors capacitors secondary fuses semicon ductors for power supply	£3 50
13	Set of miscellaneous parts including DIN skts mains input skt fuse holder inter connecting cable control knobs	£4 25
14	Set of metalwork parts including silk screen printed fascia panel and all brackets fixing parts etc	£6 30
15	Handbook	£0 30
16	Teak cabinet	£7 35
	2 each of packs 1 7 inclusive are required for complete stereo system	
	Total cost of individually purchased packs	£69 75

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SPECTRUM ANALYSER TYPE MW.69S (Decca): Further details on request. **£200.**

MARCONI DUAL TRACE UNIT TM-6456: £30. Post 60p.

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 — 40-400 pulses per sec. Pulse Width — 0.5-10 microsecs. Timing — Undelayed or delayed from 3-300 microsecs from external or internal pulse. Output — 1 milliwatt max., 0 to —127 dB variable. Output Impedance — 50O. Price: **£120** each + £2 carr.

H.V. TRANSFORMER: 8000/8000. Output 300mA. rms. Size: 12in. x 12in. x 36in. 230V input. **£40.** Carr. £4.

FIREPROOF TELEPHONES: £25.00 each, carr. £1.50.

POWER UNIT: 110/230 volts a.c. input. 28 volts d.c. at 40 amps output. **£30.00** each, carr. £3.00.

SMOOTHING UNIT (for the above): **£10.00** each, carr. £2.00.

X-BAND MODULATOR CALIBRATOR TYPE MC-4420-X: Mnfr. James Scott. **£125** each.Carr. £1.

HP-766D DUAL DIRECTIONAL COUPLER: 940-1975MHz. **£35** each, 75 post.

BACKWARD WAVE OSCILLATOR TYPE SE-125: 6.3 heater, 105V Anode. 7.9mA. Mnfr. Watkins & Johnson. **£85** each. Carr. £1.

TEKTRONIX TIME MARK GENERATOR TYPE 180-S1: 5, 10, 50 MHz. **£65.** Carr. £2.

TRANSISTOR ANALYSER TA 1001 (K.&N. Electronics Ltd): **£95.** Carr. £3.

CHRONOTON MODEL 25E: 0.4-10 seconds in seven ranges. **£50.** Carr. £1.

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. Imternal 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 29in. x 12¼in. x 10in. Secondhand condition. **£32.50** each. Carr. £2.50.

ROTARY INVERTERS: TYPE PE.218E — input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1Ph. P.F.9. **£20.00** each. Carr. £2.50.

FREQUENCY METER BC-221: 125-20,000 Kc/s complete with original calibration charts. Checked out, working order **£20** + £1.50 carr. Unused as new condition complete with headset, spare valves. charts. **£35** + £2.00 carr.

ALL U.K. ORDERS SUBJECT TD VALUE ADDED TAX. THIS MUST BE ADDED TD THE TDTAL PRICE (including post or carriage)

If wishing to call at stores, please telephone for appointment

W. MILLS

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191 LONDON ROAD · ROMFORD ESSEX
ROMFORD 44473 **RM7 9DD**

E.H.T. POWERUNIT. 110/240v 50Hz giving 5Kv at 50 m/a. METERED OUTPUT **£18.50.** P P. £1 50.

COPPER LAMINATE P.C. BOARD
8½ x 6 x 1/16 inch, 3 for **75p.** P P 25p
10 x 4 x 1/16 inch, 5 for **75p.** P.P 25p
10½ x 5½ x 1/16 inch, 3 for **75p.** P P. 25p
10 x 8½ x 1/16 inch, 3 for **£1.** P P 25p
17 x 9½ x 1/16 inch, 2 for **£1.20.** P P 25p

PRECISION A.C. MILLIVOLTMETER (SOLARTRON) 1.5mv to 15v., 60dB to 20dB. 9 ranges. Excellent condition. **£24.** P.P. £2.

TELEPHONE DIALS (new) **£1.** P.P 15p
EXTENSION TELEPHONES (Type 706). Various colours. **£3.95.** P P. 75p
RATCHET RELAYS (310 ohm). Various types **£1.20.** P P 20p
UNISELECTORS (New) 25 way. 12 Bank (Non bridging). 68 ohms. **£6.50.** P.P. 50p
1,000 TYPE KEY SWITCHES. Single 2 x 4 c/o Locking **50p.** P P 10p Bank of 4—2 x 4 c/o each switch (one biased). **£1.20.** P P. 15p

OVERLOAD CUT-OUTS. Panel mounting (1¾ x 1¼ x ½in.). 800 M/A/1.8 amp.-10 amp. **45p.** P P 5p.

ALL PRICES INCLUDE V.A.T. EXCEPT WHERE SURCHARGE IS INDICATED

QUADROPHONIC DECODER MODULE. C.B.S./S.Q. Type, using I C. MC 1312P. With slight modification direct substitute for P.E. "RONDO" Board. Complete with Data. **£4** each.
15% VAT Surcharge

S.T.C. CRYSTAL FILTERS (10.7 Mhz). **15% V.A.T. Surcharge**
445-LQU-901A (50 Khz spacing). **£3.** P.P. 20p.
445-LQU-901B (25 Khz spacing). **£4.** P.P. 20p

V.H.F./U.H.F. POWER TRANSISTORS (Type BLY38). 3 watt output at 100-500 Mhz, **£2.25.** P.P. 10p.

15% V.A.T.
HIGH CAPACITY ELECTROLYTICS
1,000μf/100v (4 x 1⅜in) **60p.** P P. 20p 1.400μf/200v (4¼ x 2in) **£1.** P P 20p 2,200μf/100v (4 x 1¾in) **90p.** P P. 20p 2,500μf/100v (4 x 2in) **90p.** P P 20p. 4.000 + 3,000μf/70v (4½ x 2in) **75p.** P P. 20p 10,000μf/25v (4½ x 1½in) **75p.** P P 20p 25,000μf/40v (4¾ x 2½in) **£1.** P P 20p

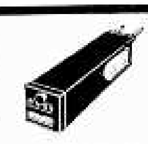
H.D. ALARM BELLS. 6in. Dome. 6/8v. D C. **£2.75.** P P 97p.

MULTICORE CABLE. 6-core (6 colours) 14/0076 Screened P.V.C **22p** per yard. 100 yards at **£16.50.** P P 2p a yard. 7-core (7 colours) 7/22mm. Screened P V C **22p** per yard. 100 yards **£16.50.** P.P 2p per yard 30-core (15 colours) **25p** per yard. 100 yards **£20.** P P 2p per yard

RIBBON CABLE (8 colours) 10m **£1.65.** P.P 20p 100m. 8-core 7/ mm Bonded side by side **£11.50.** P P £1

WE REGRET THAT ALL ORDERS VALUE UNDER £5 MUST BE ACCOMPANIED BY THE REMITTANCE.

HIGH-SPEED MAGNETIC COUNTERS. 4 digit (non reset) 24v or 48v (state which). 4 x 1 x 1in **65p.** P P 15p



5 digit (non reset) 24v **£1.15.** P P 15p

3 digit 12v (Rotary Reset) 2¼ x 1¾ x 1¼in. **£1.30.** P P 15p 6 digit (Reset) 240v. A C **£3.50.** P.P 25p

RELAYS. SIEMANS/VARLEY. PLUG-IN. Complete with transparent dust cover and base 2 pole c/o **45p;** 6-make contact **50p;** 4-pole c/o contact **60p** each. P.P. 10p each 6-12-24-48v types in stock.

MINIATURE REED RELAYS (3/6v). 1 make (30 x 8mm) **20p;** 2 make (32 x 12mm) **30p.**

12v. 2 c/o 5 amp. H.D. RELAY, 65p. P P. 15p

240v. A.C. RELAY (PLUG-IN TYPE). 3 c/o 10 amp. contact with base **85p.** P.P 25p

10 TURN POTENTIOMETERS (M.P.C.) 10 K ohm. 0.5% Lin 38mm x 22mm. 14mm Standard Spindle. **£2.** P.P. 15p. (Dials **50p** each)

GARRARD PLINTH & COVER. For 'Zero-100' etc beautifully finished in brushed aluminium and black with hinged smoke/grey perspex lid. **£9.75** P.P. £1

24v. A.C. RELAY (PLUG-IN). 3 pole c/o **75p.** P.P. 15p. 2-pole change over **55p.** P P 15p

BULK COMPONENTS OFFER. Resistors/Capacitors, 600 new components **£2.50.** P P. 35p. Trial order 100pcs. **60p.** P P 20p. **15% V.A.T.**

REGULATED POWER SUPPLY. Input 110/240v., output 9v D.C 1½ amp., 12v. D C. 500 m/a. **£4.75.** P P 75p

MINIATURE "ELAPSED TIME" INDICATORS. (0-5000 hours) 45 x 8mm. **75p.**

TRANSFORMERS

ADVANCE TRANSFORMERS "VOLSTAT". Input 242v A.C
C.V.50. 38v at 1 amp; 25v at 100 m/a, 75v. at 200 m/a **£2.50.** P.P 65p.
C.V.75. 25v at 2½ amp. **£3.** P.P. 75p.
C.V.100. 50v at 2 amp.; 50v. at 100 m/a **£3.75.** P.P. 75p
C.V.250. 25v. at 8 amp; 75v. at ½ amp. **£6.50.** P P £1.50
C.V.500. 45v. at 3 amp, 35v. at 2 amp. **£10.** P.P £1 75

H.T. TRANSFORMER. Prim 110/240v. Sec 400v. 100 m/a. **£2.50.** P P. 65p.

L.T. TRANSFORMER "TOROIDAL". Prim 240v. Sec 30v at ½ amp: Size 3 in dia. thick **£1.65.** P P. 20p

L.T. TRANSFORMER. Prim 240v Sec 27-0-27 at 800 m/a 7 5 amp **£2.25.** P P. 50p.

L.T. TRANSFORMER. Prim 110/240v. Sec. 0/24/40v 1½ amp. (Shrouded) **£1.95.** P.P 50p.

L.T. TRANSFORMER. Prim. 200/250v Sec 20/40/60v at 2 amp. (Shrouded) **£3.** P.P. 50p.

L.T. TRANSFORMER (H.D.). Prim. 200/250v Sec 18v at 27 amp ; 40v. at 9 8 amp.; 40v at 3 6 amp ; 52v. at 1 amp; 25v at 3.7 amp **£17.50.** P.P. £2.50

L.T. TRANSFORMER. Prim. 240v Sec 16-0-16v at 2 amp **£2.** P P 50p.

L.T. TRANSFORMER PRIM. 120-0-120v Sec. 12v. at 1 amp. **70p.** P.P. 20p

L.T. TRANSFORMER PRIM. 240v Sec. 18v 1 amp. **£1.** P P 20p.

POWER UNIT (TRANSFORMER/RECTIFIER). Prim. 240v. output 17½v (unsmoothed) at 1 amp. **£1.85.** P.P 45p.

L.T. TRANSFORMER ("C" CORE). 200/240v Secs. 1-3-8-9-v All at 1 5 amp. 50v at 1 amp **£2.50.** P.P 50p

L.T. TRANSFORMER ("C" CORE). 200/240v. Secs. 1-3-9-27v All at 4 amp **£4.** P.P 50p.

L.T. TRANSFORMER ("C" CORE). 200/240v. Secs. 1-3-9-27v All at 10 amp **£7.50.** P P. £1.50.

L.T. TRANSFORMER ("C" CORE). 200/240v Secs 1-3-9-20v All at 4 amp **£5.50.** P P 75p.

L.T. TRANSFORMER ("C" CORE). 120/120v. Secs. 1-3-9-9v. All at 10 amp. **£6.50.** P P. 75p.

L.T. TRANSFORMER ("C" CORE). 110/240v. Secs. 1-3-9v 10 amp. 35v. 1a..50v 750 M/A. **£6.50.** P.P. 75p.

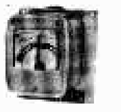
HIGH POWER BATTERY MOTOR

12v operated, strong enough to power a motor mower, go-cart or similar. Speed easily variable. These motors can also be used as a brake for any rotating machine, simply by coupling the spindle to the machine and short-circuiting the windings by a variable resistance, price £2.50 + post and V.A.T. 74p. *DITTO* but 6/12v even more powerful as it's larger and is series wound. £3.50 + 85p post and V.A.T.

FIRE ALRM SWITCHES

in cast iron case with break glass panel. These are red and engraved "Fire break glass"; they have hinged lid and second safety switch for testing purposes. Limited quantity, £1.75 each + post and VAT 46p.

HIGHLY SENSITIVE MOVING COIL RELAY



panel mounting with glass window, this measures approx. 5½" x 4" x 5", triggering current can be varied from a fraction of a milliamp to 5 milliamps by removing the front and adjusting the setting level. Price £8 each + post and VAT 95p.

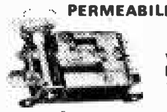
DC HIGH CURRENT PANEL METERS

3½" wound wide angle 240° movement meters, flush mounting fitted with external shunts, made by Crompton Parkinson brand new, still in maker's cartons. These are a real bargain at £5.50 each. Reasonable quantities available in the following ranges:
0-10 amps, 0-20 amps, 0-30 amps, 0-40 amps, 0-50 amps. Post and VAT 80p each.

EDGE MOUNTING MOVING COIL METER

Size 2¾" x 1" by Weston, 100 μA movement scaled DB, unused still in original maker's cartons. £2.50 each + post and VAT 50p.

PERMEABILITY TUNERS



M.W. two stage ideal for use with ZN414 or similar circuit. Price 15p each + post and VAT 15p.

OVEN THERMOSTAT

Made by the famous Diamond H Company, this has a sensor joined by a capilliary to a variable control and when fitted with a knob is ideal for many ovens or processes. 50p each + post and VAT 15p.

AUDIO AMPLIFIER

Part of the famous Reditune background music system, secondhand, but believed in good order. However, no guarantee; we are selling for spares value only. These are 6 valve amplifiers, the output valves are 2 x EL 84 in push/pull, complete with mains transformer, rectifier and ample smoothing equipment. The mains transformer alone, today, would cost at least £4. Size is 9½" x 5½" x 4½". Price only £2.00 + postage and VAT £1.50.

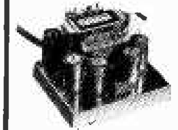
BREAK-DOWN UNIT

Contains hundreds of useful parts some of which are as follows — 66 silicon doides equivalent OA 91. 68 resistors, mostly ½ watt 5% covering a wide range of values. 4 x .1 mfd 400v infd condensers. 15 x .01 mfd 100v condensers. 2 RF chokes. 8 x B9 valve holders. 1 x 4H choke. 1 x 115v transformer. 1 boxed unit containing 4 delay lines also tag panels, trimmer condensers, suppressors, etc., on a useful chassis sized approx. 9" x 5" x 7". Only 75p (the 66 diodes would cost at least 10 times this amount). This is a snip not to be missed. Post and VAT 75p.

GPO PUSH BUTTON DIALLING UNIT

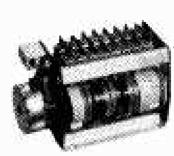
Will take the place of the normal rotating dial, has 10 numbered keys, so suitable for other digital systems. A desk mounting unit with rubber feet, this is a very intricate and expensive piece of apparatus. New and unused — our price only £9 each + £1.36 post and VAT.

24v POWER PACK



Normal mains input with a thermal safety device, 800 mA output, 4000 mfd of smoothing and full wave rectification, completely enclosed in plastic box and with flex for mains and terminal block for output. Price £1.75 + £1 post and VAT.

8-SWITCH DISCO LAMP CONTROLLER



Mains motor driving a drum with adjustable trips operating 8 changeover 10 amp switches, so a total of 40K watts of lighting can be controlled enabling an unlimited variety of effects to be achieved and changed with the minimum of effort. This is a real snip at £7.50 + £1.15 post and VAT.

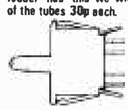
TERMS: Where order is under £5 please add 30p surcharge to offset packing expenses.

J. BULL (ELECTRICAL) LTD.
(Dept. W.W.)
103 TAMWORTH ROAD, CROYDON CRO 1XX

NEW ITEMS THIS MONTH

AC mains operated relay with single changeover 10 amp contacts, open type single screw fixing through the base. **50p** each.
Battery condition testers. This is another item which has been out of stock temporarily but we are pleased to say, in stock again Price now **£3.50.**
AM/FM tuning condenser as fitted to many Japanese and Hong Kong portables, this has two main tuning sections and four trimmers, approx size 1" × 1" × 1" **60p** each
Battery charger kit comprising 2 amp transformer, 2 amp full wave rectifier and 2 amp meter suitable for charging 6v or 12v. Special bargain price **£1.50** the kit + 30p post
MacDonald record auto-changer with cueing arm and ceramic stereo cartridge. This is a very superior auto-changer and one we can thoroughly recommend. Limited quantity, special price **£7.35** + £1 post and insurance. Plinth and cover (the plinth has to be modified very slightly) available, price **£4.95** + £1 post, or if you buy both together you can get a discount of £1.

Instrument case measures 18" × 12" × 12". This is a very well-made case built on an angled framework, has rounded corners and edges. Into this framework fit the 8 panels All panels are louvred for ventilation, side panels are also fitted with handles, the bottom panel has 4 rubber feet. These instrument cases would probably cost around £15 each. We have approx. 100, not new but in very good condition and offer them at **£3** each.
Laboratory volt meter, BS1. This is the conventional square case, size 7" × 7" × 3½" with a leather carrying handle and rubber feet for horizontal and vertical standing. The meter is intended for horizontal use on the bench and has a mirrored scale. Hefty terminals along the top select the 3 ranges 0–150v, 0–300v and 0–600v DC. Price **£6** + £1 post and insurance.
Laboratory amp meter, companion instrument to the above, but to read 0–20 amps 50 cycles. **£5** + £1 post and insurance.
Soil heating transformer, 4v, 5v or 6v output, very heavy duty secondary rated at 250 amps, price **£20** + carriage £2 first 100 miles then £1 per 100 miles extra.
7 watt stereo/mono amplifier with usual switching and controls, in attractive teak style case. **£9.**
3 core lead, 7' 6" long, ribbed, virtually non-kinkable 23/36 conductors, so OK for 8 amps. Price **10p** each
0–1 mA meter 2¼" square, flush mounting, English make ex equipment but perfect. **£1.75.**
0–100 microamp meter, as the above, but **£2.25.**
Solenoid 4–6v, size approx 1" × 1" × 0.4" thick, twin coils give excellent pull. Mounted in frame but easily removable from this frame, fitted with lever giving approx 0.4" push or pull Price **30p** each
Cold cathode tube Swiss made "Elasta" type No. ER 12A We have no technical information on this tube and if any reader has this we will be obliged for any information. Price of the tubes **30p** each.



Push switch, double pole changeover contacts rated at 10 amps 250 volts made by the American Honeywell Co. A very reliable and robust switch with plenty of applications Oblong plastic body, snap fitting into a hole size 1⅓" × ⅓" Offered at only a fraction of its proper price, namely **20p** each.
Ditto but single pole changeover, fits into a hole size 1" × ⅓". Price **15p** each.
(**Note:** the two switches above do not require a knob as they have a polished and tapered plunger.)
Ditto, but dished knob. **10p** extra with knob.

W.&B. MACFARLANE

126 UXBRIDGE ROAD, HANWELL, LONDON W7 3SL
Where p.p. not advised add 10p per £ handling and post (in UK).
Cash with order.
Personal callers welcome. Open Mon.-Wed. 9.30-5.00. Fri.-Sat. 9.30-5.00.
Free Car Park adj. **PRICES SHOWN ARE EXCLUSIVE OF VAT.**

TRANSISTORS AND DIODES (25%)

Type	
BSY29 (SNPN)	17p
BD107 (SNPN)	65p
2N711B/2G106 (SPNP)	45p
2N985 (GPNP)	£1.00
2N1304 (GPNP)	17p
2N1309 (GPNP)	32p
2N1046 (GPNP)	£2.60
2N1146A (GPNP)	50p
2N1557 (G)	55p
2N2080 (G)	£1.20
2N2082 (G)	£1.20
2N2405 (SNPN)	57p
2N3054 (SNPN)	45p
2N3055 (SNPN)	47p
2N3375 (SNPN)	£3.60
2N4427 (SNPN)	55p
2N5322 (SNPN)	55p

ASZ18/OC26 25p, OC35 **45p**, DC42 **45p**, OC71 **12p**, CV7006/OC72 **20p**, OC75 **25p**, OC83 **28p**, GET110/NKT303 **25p**, OC702 **10p**, OA10 **25p**, RAS508AF **25p**, RAS310AF **25p**, STC Wire End 400PIV1A 4 for **50p**, IN3193 **13p**, IN3194 **14p**, IN3255 **20p**.

RCA PHOTOMULTIPLIER (8%)
C31005B Caesium and Antimony Cathode Spectral Response Designation RCA 107 or S-11 Incl P/P **£38.00.**

THYRISTORS (8%)

GE2N1774 200v 5a.	£1.20
CR1-021C 20v. 1a.	25p
CR10-101B 100v 10a	£1.00
CR10-021 10a	£1.00
CR10-40B 10a	£1.00
CR10-051 10a	£1.00
CR10-017 10a	£1.00
BTX 92 1200R 16a 1200v	£2.85

INTEGRATED CIRCUITS (8%)

MC353G Half Adder	£2.20
MC356G 3 inp OR/NOR GATE	£1.60
MC358AG AC coupled J-k Flipflop	£5.50
MC365G Line Driver	£5.50
CA3020 Wideband Pow. Amp	£1.00
CA3021 Low power video	£1.30
CA3028A RF 1F Amp.	£1.00
CA3038A Operational Amp	£2.30
CA3035 Pos Volt Regulator	£1.35
CA3085 Pos. Volt Regulator	90p
CD4035AE 4-stage Serial Register	£2.00
CD4017 AE Decade Counter Divider	£4.00
CD4047AD Monostable Astable Multivibrator	£4.00

RECTIFIER STACKS (8%)
GEX541B1P2 .. **£6.88** GEX541HP3F **£6.00**
GEX54181P1 **£3.50** SX751N1B1P1F **£6.00**
GEX541N81P1F **£6.00**

WESTINGHOUSE (8%)
Westinghouse 3ph bridge rectifier assy type U5028/10 input 35v rms output DC 47v 480 amps, naturally air cooled Inc carr **£56.00**
Type G2 5066 input 38v rms output 47.5v DC 54 amps 30°C, naturally air cooled Inc carr **£25.00**

SWITCHES (8%)
Edward High Vacuum "Speedivac" model VSK1B range 25-760 torr contact ratings 250v 5a volume 4 2 cu cm max working pressure 15lb/sq in gauge net weight 17 ozs. **£6.50**
Belling Delay hand reset L415 **£1.25**
Stackpole min rocker 125v. 10a 250v 5a **25p**
Tippalite Rocker 12v **65p**

CIRCUIT BREAKERS 250v AC each **£1.35** (8%)

AMP	TRIP	TYPE
20	D	Westingh 550
40	—	Securex 5000
70	Inst.	Westingh 550
70	4	Heinemann (60c.) AM12
80	Inst	Westingh 550
80	—	Securex 5000
90	Inst.	Westingh 550
100	—	Securex 5000
200	—	ETA Magnetic

DIGITAL COUNTERS (8%)
Veeder Root Mech. Reset 4 dig. **55p**

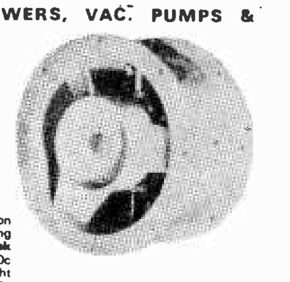
STABILIZED POWER SUPPLIES (8%)
Gresham Lion GX60/10a—60v 10 amp set to 30v **£65.00** incl carriage
Lambda CC28v—Inp 205-265v. output 28v. dc/±5% 3 4 amp **£38.50** incl. p. & p.
Power Elect. Inp 240v outputs 20v 6 5a.10v 3.4 amp + 10v. 300ma **£38.50** inc carriage

RELAYS (8%)
Varley ITT Min. 700Ω 20v **50p**
Magnetic Dev. Type 596E **£2.00**

CONNECTORS (8%)
McMurdo Red Range. Plug RP24 **56p**
McMurdo Red Range. SKT RS32 **90p**
Eng. Elect. Edge. 36 way 0.2 inch pair **£1.00**
Sylvania Edge. 48 way 0 125 inch pair **40p**
Amphenol MS3106B-36-10 **£4.50**
Continental microminiature 28 1080IN26 **£1.30**

CAPACITORS (25%)
Daly Electrolytic 9000μF 25v **60p** p/p 15p; 500μF 50v **35p** p/p 10p; TCC 16μF + 16μF + 8μF 450v **75p** p/p 15p; CCL 50μF + 50μF 275v **45p** p/p 10p; CCL Suppressor Unit Type SU103/1 comprising capacitor Diode and Resistor **45p** p/p 10p. Dubilier Metalised Paper type 426 100μF 150v **60p** p/p 25p. RIC 1 8μF 440va.c **40p** p/p 10p.

FANS (25%), CENTRIFUGAL BLOWERS, VAC. PUMPS & MOTORS (8%)



Airmax Type M1/Y3954 (3 blades) Cast Aluminium alloy impeller & casing (corresponds to current type 3965 7½") 230v. 1ph 50c 2900rpm Class "A" insulation 425 cfm free air weight 9½lbs. incl p.p. **£23.00**

Woods Aerofoil short casing type S Ref HS895/4/66 Cap. 2.5fiF. Non-reverse 220/240v 1ph 50c 0.19a 2700rpm. 6" cast alum. impeller 4 blades width casing 2⅝" total 5¼" weight 5¼lbs incl. p p **£13.00.** Aerofoil Code 7.5 280K 200/250v. 1.0a 1 ph 50c 2700rpm 550cfm free air. 7½" impeller 14 blades incl. p p. **£16.00.**

Service Electric Hi-Velocity Fans, suitable for Gas combustion Systems. Steam exhausting Pneumatic conveying. Cooling Electronic equipment, Air blast for Oil burners. **Secomak** Model 365 (corresponds to 575) Airblast Fan. 440v 3ph 50c 0-75hp 2850rpm. continuous 160cfm 12 in w.g. nett weight 44lb. price incl. carr. **£47.00. Secomak** model 350 250v 1ph 50c 0.166hp. 2800rpm continuous 50cfm 2 in w.g net weight 34lbs. price incl. carr **£33.00.** (8%)

Air Controls type VBL4 200/250v 1ph 50c 110cfm free air weight 7½lbs Price incl p.p. **£16.50.**

Type VBL5 200/250v 1ph 50c 172cfm free air. Weight 10¼lbs. price incl. p.p. **£19.50.**

William Allday Alcosa rotary vane oil free Single Stage Vacuum Pump Model HSPOB 8 HG Rpm 1420. E.E.3 phase induction motor 1/3hp cont 220/250v. 380/440v. Class E ins incl carr **£29.00.**

Alcosa blower FAD 3-8cfm at 5psi. Rpm 1420. Motor EE 3ph 50c ¼hp 1400rpm. incl. carr. **£29.00.**

Gast MFG. Vacuum pump 0522-P702-R26X Motor 110/120v a.c 1ph 60c 1725rpm Class E 10 cu ft to 10in Mercury in 2 mins maintains vacuum 635mm Mercury. Or as compressor 10psi in. or 15psi cont. incl. carr. **£29.00.**

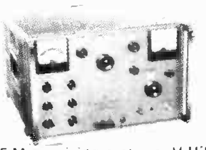
3 phase 2HP motor 60/50c.. 1800/1500 RPM. 208/220/440v **£25.00** incl. Carriage

Cat. 2026391 Potter Instruments flange mounting capstan motor. 0.2HP cont. 110v DC 4 amp **£27.50** inc. carr.

ELECTRONIC BROKERS

SIGNAL SOURCES

FM AM SIGNAL GENERATOR TYPE 202H



This superb generator in grade one condition. F.M., A.M., C.W. & pulse coverage 54 to 216MHz. Used to testing and calibration of F.M. receiving systems, V.H.F., T.V., Mobile and general Communications. Freq. range 54-216MHz ÷ 2 Bands. R.F. stability 0.01%. R.F. output 0.1 µV-0.2V. V.S.W.R. 1.2. Signal to noise ratio 50dB below 10KHz. Dimensions 16¾" x 10¼" x 18⅜"

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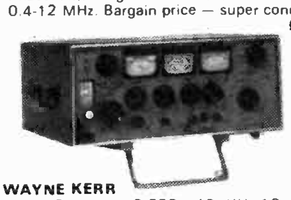
ADVANCE
Audio Signal Generator HIB 15Hz-50 KHz, 200µV-20Vm± 2dB. Sine Wave & Square Wave **£65**
Audio Signal Generator JIB 15Hz-50KHz 0.2V-25V **£65**
VHF Square Wave Generator SG21 9KHz-100MHz. Max O/p 2V **£35**
Signal Generator D1 **£39**

AIRMEC
Signal Generator 702 30Hz-30KHz in 3 bands **£60**
Signal Generator 701 **£60**
H.F. Signal Generator 201 30KHz-30MHz in 7 Bands. Int.Xtal calibrator o/p level variable 1µV-1.1V 75 ohms impedance Int. Mod. at 1KHz. Ext. Mod 30Hz-10KHz **£75-£115**

GENERAL RADIO
Unit Oscillator 1218-A P.O.A.
Unit Oscillator. General Radio Type 1209C. Freq. 250-920 MHz. Accuracy 1% Drift 0.2%. Output into 50 ohms = 150 MW with PSU 1201 — CQ18 as illustrated **£215**

HEWLETT PACKARD
U.H.F. Signal Generator 614A 900-2100MHz 1% Accuracy. Output 0.1uV-0.2V into 50 ohms. Modulation: CWInt. or EXT. FM & Pulse
S.H.F. Signal Generator 618C 3.8-7.6GHz ± 1% 50 ohms **£550**
Signal Generator 608B 10-400MHz 0.1µV-0.8V **£195**
Signal Generator 612A 450MHz-1230MHz Internal & Ext. A.M. 50 ohms **£495**
Audio Oscillator Type 201C. 20 Hz-20 KHz 0-40 dB in 10 dB steps. Distortion less than 0.5%. Also 200 CD & 200B **£95**

MARCONI INTS.
Oscillator TF1247 20-300MHz (Suitable for use with Marconi TF 1245 & 1245A "Q" Meters) **£135**
FM/AM Signal Generator TF 995A/3S. 1.5 Mhz-220 MHz. 2µ V-200mV. Superb condition **£385**
U.H.F. Signal Generator TF 1060/2. 450-1200 MHz. 0.15µV-447mV. Sine and pulse mod. facilities **£420**
U.H.F. & S.H.F. Signal Generator TF 1058. 1600-4000 MHz. 0.1µV-445mV **£295**
Phase/AM Signal Generator TF 2003. 0.4-12 MHz. Bargain price — super condition **£150**



WAYNE KERR
Video Oscillator. 0.22D. 10 KHz-10 MHz **£150**
A.F. Oscillator S121. 10 Hz-120 KHz **£45**

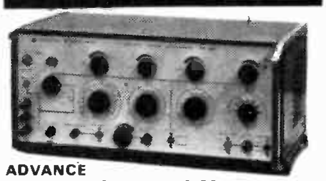
BRUEL & KJAER
Portable Sound Level and Vibration Meter 2203 and Octave Filter Set 1613 **£275**

SWEEP GENERATORS

HEWLETT PACKARD
Sweep Oscillator 692D 2-4GHz **£495**
Sweep Oscillator 693B 4-8GHz **£495**

JERROLD
Sweep Signal Generator 900B Centre Freqs. 500KHz-1200MHz Sweep widths narrow as 10KHz to 400MHz wide 50 ohms P.O.A.

PULSE GENERATORS

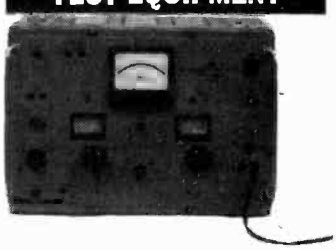


ADVANCE
Double Pulse Generator PG.56
Pulse Amplitude 0.1V-10V. Sq. wave 0-10V. Rise Time 10nsec. (typically) **£87.50**
Pulse Generator PG.55 P.O.A.
Modular Pulse Generator Advance Type PG.52. System of 5 Signal generating & Processing units. Repetition freqs. up to 20MHz & Output pulses to 20V (50 ohms) Rise & Fall times 5nsec. Its versatility enables the production of complex pulse & ramp waveforms not obtainable from conventional pulse generators **£250**

MARCONI
Double Pulse Generator TF.1400/S. Min. type CT.434. c/w TM 6600 Sec. Pulse gen. Plug In. 10Hz-100KHz. 100nsec-100µsec. Negative pulses up to 200V E.M.F., +VE pulses up to 60V E.M.F. & Simultaneous +VE &—VE pulses up to 20V E.M.F. P.O.A.

SOLARTRON
Precision Pulse Generator G.O.1377. 100V single or double pulses. 0.2 amp paraphase outputs. Simultaneous +VE & —VE outputs. Square wave to 5MHz 10nsec. Rise time. Pulse repetition freq. — 10Hz-1MHz. Pulse duration 0.1µsec-100msec **£125**
Pulse Generator OPS. 100C P.O.A.

TELEPHONE TEST EQUIPMENT



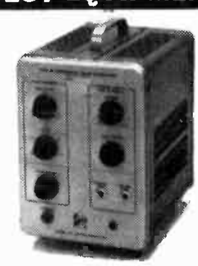
Siemens Level Meter 3D 335 10KHz-17MHz. Complete system by Siemens. Comprising: 3W.518 Level Oscillator. 3D. 335 Level Meter. 3W.933 Sweep Attachment. 3D 346 Screen Level Tracing Receiver P.O.A.
Siemens Level Meter 3D 332. 0.3-1200KHz. Level Oscillator 3W.29. 0.3-1200KHz P.O.A.

S.T.C.
Octave Filter 74143A. 37.5-12,800Hz For analysing noise and interference on comms. systems, particularly useful with 74142 psophometer P.O.A.
Selective level Measuring Set 74184B 60-1364KHz P.O.A.
Measuring Set 74831A P.O.A.

A.T.&E.
Telegraph Distortion Measuring Set. Various types: 5BV, 5BV3, 6BV, 6A P.O.A.

MURPHY RADIO
Receiver VHF field strength RX.506 & interference measuring set c/w Power Unit P.O.A.

OSCILLOSCOPE TEST EQUIPMENT



TEKTRONIX
Pulse Generator Type III. 0.5µsec risetime. Amplitude ± 5V. 30 to 250 nsec. difference between trigger and output pulses **£60**
Time Mark Generator 180A **£85**
Pulse Generator 109. 0.25 nsec. Risetime 0-55V Calibrated variable amplitude. Impedance 50 ohms **£35**
Pre-Trigger Pulse Generator III **£60**

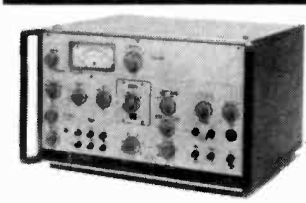
RESISTANCE & DECADE BOXES

MARCONI
Decade Potentiometer TF.221 **£40**
Variable Air Condenser Muirhead Type 11-B 1250pF Max. P.O.A.
AC-DC Converter Type AC-DC. For use with Precision "R" Boxes **£90**

NEGRETTI & ZAMBRA
Quick Reading Potentiometer **£55**
Tinsley Vernier Potentiometer Type 3126B. A precision equipment as used in laboratories and measurement standards areas **£125**

DORAN
Whetstone Bridge Type 1401 **£45**
Whetstone Bridge Type 3557 **£45**

T.V. TEST EQUIPMENT



Wandel & Golterman VZM.2. Distortion measuring set for phase & amplitude mod. For multichannel FM Radio Systems up to 12MHz Base bands **£400**

MARCONI
Sine Squared Pulse & Bar Generator TF.2905/B **£225**

GRESHAM LION
Waveform Generator 625 lines. Sine squared. Pulse & Bar P.O.A.
Waveform Generator 625 lines staircase P.O.A.

WANDEL & GOLTERMAN
Measuring Set VZM 1 **£495**
Generator & Receiver. VZM.83 **£275**

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Numeric Tube B 5853 0-9 Digit 1.4" height Brand New **£1.00**

Also Alpha Numeric Nixie Tube B.7971. Displays alphabet & 0-9 numerals **99p**

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G.E.C. Type F **£2.50**
Graseby Insts. Type 821 12G-0-12G **£25**
Sperry Type 212502-0100 P.O.A.
Sperry Type 214202-0100 P.O.A.
Langham Thompson LA.2 **£25**
Types up to 100G. Choppers —
Ericcson N.29B34Hz **£4**
Elliott Synchroverter G.1280 **£4**
Elliot Synchroverter 95908 **£4**

MODULATORS
S.E. Labs SE.441/2 **£45**
S.E. Labs SE.501/2 **£45**
Osc. amp. demod. SE. Labs. Type SE 62/12. 4000 p.s.i. **£85**

TRANSDUCERS
S.E. Labs SE.150T ±2.5 p.s.i. **£35**
S.E. Labs SE.153/A7481 15 p.s.i. **£35**
S.E. Labs SE.250/A5962 1000 p.s.i. **£25**
S.E. Labs SE.150B 50 p.s.i. **£35**
S.E. Labs SE.105 1000 p.s.i. **£25**
S.E. Labs SE.165 4000 p.s.i. **£25**

TEMPERATURE INDICATORS
Made by Ether. Models with Temp. Ranges, 0-600°C. 0-800°C & 0-1000°C **£25-£50**

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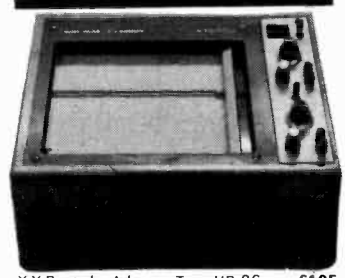
3 turn and 5 turn available, 10 turn 3600 Rotation

5 ohms	Beckman	Type A	£3.00
50 ohms	Bourns	35005-2-500	£1.00
100 ohms	Relcon	05-B10	£1.00
300 ohms	Beckman	7216	£2.50
500 ohms	Beckman	A	£2.50
500 ohms	Colvern	2501/264	£3.00
500 ohms	Colvern	2402/13	£3.00
500 ohms	Colvern	2501/9	£3.00
500 ohms	Relcon	07-10	£2.50
1K	Beckman	as 690	£3.00

X-Y & U/V RECORDERS



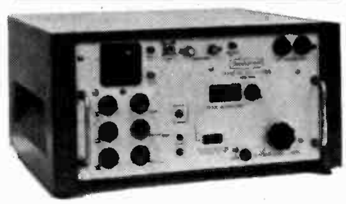
X-Y Recorder Advance Type HR.96 **£195**
ADVANCE
X-Y Recorder HR.92/1 **£150**
BELL & HOWELL
U.V. Recorder 5/127. without Galvo's **£225**
BRYANS
X-Y Recorder 20021 **£195**
ELECTRONIC ASSOCIATES
Vari-Plotter **£145**
SE3006 UV P.O.A.

INSULATION TESTERS

EVERSHED & VIGNOLES
Circuit Tester Ohmeter 0-3 ohms 0-39 ohms **£18**
Circuit Tester Ohmeter 0-1000 ohms. 100-200 kohms **£18**
Megger Series + II 250V **£12**
Megger Series III Mk. 3 250V **£20**
Megger 250V **£20**
Megger 500V **£37**
Battery Megger 500V **£37**

PYE
Insulation Tester 10B 500V **£25**

MISCELLANEOUS



Transfer Oscillator Type 7580HBy Beckman. DC-15GHz with counter. 7.5MHz-15GHz without counter. Sensitivity 100mV (R.M.S.) **£350**

MARCONI
Distortion Factor Meter TF.142F. Fundamental Freq. Range 100Hz-8KHz. Dist. measurement ranges 0-5% & 0-50% **£60**
Portable Receiver Tester TF.888/3. 70KHz-70MHz. Xtal check 500KHz & 5MHz. 1KHz A.F. Oscillator. A.F. Power 10mW. 100mW & 1W **£69**
Carrier Deviation Meter TF.791C. Carrier Freq. range 4-250MHz. Freq. dev. ranges 0 to ± 5KHz. 0 to ± 25KHz. 0 to ± 75KHz & 0 to ± 125KHz. Input impedance 50 ohms **£75**
Wave Analyser TF.455E **£95**
Noise Generator TF 1301. 200-1700 MHz **£60**

ADVANCE
Recorder Calibrator HC.20 **£20**
Printer PR 1 Intended for use with almost any kind of counter. 7 digit display, 2" wide paper print-out **£55**

B.P.L.
Megohmeter RM.160. For insulation resistance up to 400 million M ohms **£35**
"Q" Meter T1 **£75**

AIRMEC
Modulation Meter 210 **£75**
Modulation Meter 210A **£135**

EDDYSTONE
Receiver 770R/1 **£285**

HEWLETT PACKARD
Microwave Link Analyser 3701/02/03 **£2000**

MUIRHEAD
Facsimile Transmitter Receiver Type 900. Easily convertible to receive weather pictures from satellite systems **£850**

SAVAGE
Amplifier Mark II Star Model 1KM2Z. 1 KW output. Freq. 50-10 KHz. Good condition **£1650**

WAYNE KERR
Video Noise Level Meter M.131 **£75**

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AC127	25p	BC186	27p	BFY44	50p
AC128	25p	BC212	12p	BFY50	25p
AC176	25p	BC212L	14p	BFY51	25p
AC187	27p	BC213	12p	BFY51	25p
AC188	27p	BC213L	12p	BFY52	25p
ACY17	25p	BC214	14p	BFY53	25p
ACY18	25p	BC214L	15p	BFY90	65p
ACY19	25p	BC238	15p	BSV45B	65p
ACY20	25p	BC239	15p	BSV68	40p
ACY21	25p	BC300	30p	BSW63	65p
AD140	60p	BC301	30p	BSW68	80p
AD142	60p	BC302	30p	BSX21	25p
AD161	45p	BC303	40p	BY127	20p
AD162	45p	BCY31	55p	BY164	65p
AF114	25p	BCY32	95p	IS100	15p
AF115	25p	BCY33	60p	IS103	15p
AF116	25p	BCY34	65p	MJ340	50p
AF117	25p	BCY38	65p	MJ481	95p
AF118	50p	BCY39	95p	MJ2801	£1.25
AF124	30p	BCY55	£1.50	MJ2901	£1.95
AF239	60p	BCY70	20p	MJE340	50p
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BC109	14p	BD135	50p	MPF102	45p
BC109c	16p	BD136	50p	MPF103	
BC113	13p	BD139	75p	(2N5457)	35p
BC114	13p	BD140	87p	MPF104	
BC115	15p	BD153	80p	(2N5458)	35p
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BC149	12p	BF178	35p	OA91	10p
BC149c	14p	BF180	35p	OA200	10p
BC157	14p	BF194	16p	OA202	10p
BC158	14p	BF105	16p	OA210	35p
BC159	15p	BF196	16p	OA211	35p
BC167	14p	BF197	16p	OC16	90p
BC168	15p	BF200	35p	OC19	85p
BC169	14p	BF224	18p	OC22	55p
BC169c	15p	BF244	18p	OC26	65p
BC172	13p	BF245	45p	OC28	60p
BC182	12p	BF259	55p	OC35	60p
BC182L	12p	BFX29	30p	OC36	65p
BC183	12p	BFX34	30p	OC42	40p

OC44	20p	IN4001	8p	2N2904	25p	2N4058	14p
OC45	25p	IN4002	9p	2N2905	30p	2N4059	14p
OC70	15p	IN4003	9p	2N2906	25p	2N4060	12p
OC71	30p	IN4004	10p	2N2907	25p	2N4061	12p
OC72	20p	IN4005	12p	2N2926	13p	2N4062	12p
OC75	25p	IN4006	14p	2N3053	25p	2N4126	18p
OC76	25p	IN4007	16p	2N3055	50p	2N4286	25p
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OC139	30p	2N706	12p	2N3643	30p	2N4291	32p
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OC171	30p	2N708	15p	2N3703	12p	2N4444	£1.00
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TIP30	55p	2N1303	30p	3N3708	14p	2N5191	96p
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TIP32A	69p	2N1305	30p	3N3771	£1.50	2N5194	£1.10
TIP33A	£1.00	2N1306	30p	2N3772	1.60	2N5195	£1.40
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TIP42A	85p	2N1613	30p	2N3820	55p	2N5457	35p
TIP42A	85p	2N1711	30p	2N3823	70p	2N5458	35p
TIP29B	54p	2N1890	60p	2N3866	85p	2N5459	40p
TIP30B	60p	2N2146	15p	2N3904	22p	2N5485	55p
TIP31B	65p	2N2147	90p	2N3905	25p	2N5490	55p
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TIP33B	£1.06	2N2217	25p	2N4014	80p	2N5777	40p
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TIP33C	£1.20						
TIP34C	£1.80						
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ZTX300	15p						
ZTX500	16p						
ZTX501	20p						
ZTX504	50p						
ZTX531	30p						
XTX550	25p						
IN659	8p						
IN914	8p						
IN916	8p						

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LM380	2 watt Audio Amp. 14 pin DIL	90p
LM381	Stereo Pre-amplifier 14 pin DIL	160p
MC1307	Stereo Preamp 14 PIN DIL	120p
MC1310	Coiless Stereo Decoder 14 PIN DIL	200p
MC1312	4 channel SQ Decoder 14 PIN DIL	220p
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NE536	FET Op Amp TO99	250p
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NE565	PLL 14 PIN DIL	325p
NE566	PLL Function Generator 8 PIN DIL	200p
NE567	PLL Tone Decoder 8 PIN DIL	250p
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TBA800	5 Watt Audio Amp	90p
TBA810	7 Watt Audio Amp	100p
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ZN414	TRF Radio Receiver TO18	110p
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3A400V	Stud	75p
7A100V	TO5+HS	80p
7A400V	TO5+HS	84p
12A400V	Plastic	140p
16A100V	Plastic	160p
16A400V	Plastic	180p

OTHER

BT106 1A/700V	Stud	140p
C106D 3A/400V	Plastic	45p
MCR101 0.5A/15V	TO-92	25p
2N3525 5A/400V	TO-66	91p
2N4444 8A/600V	Plastic	185p
2N5060 0.8A/30V	TO-92	34p
2N5062 0.8A/100V	TO-92	45p
2N5064 0.8A/200V	TO-92	48p

TRIACS

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3 Amp	85p	99p	120p
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10 Amp	109p	154p	165p
15 Amp	145p	180p	220p

OTHER

40430	99p
40486	99p
40669	95p
BR100 DIAC	21p

TRANSISTORS

AC126	11p	BF167	23p	OC72	11p	2N3706	10p
AC127	11p	BF170	23p	OC73	50p	2N3707	11p
AC128	11p	BF173	25p	OC74	30p	2N3708/9	9p
AC141	18p	BF177	26p	OC81	12p	2N3771	170p
AC142	18p	BF178	28p	OC82	12p	2N3772	180p
AC176	11p	BF179	33p	OC83	20p	2N3773	220p
AC187	12p	BF180	33p	OC84	18p	2N3866	70p
AC188	11p	BF181	33p	TIP41A	65p	2N3903/4	15p
AD149	43p	BF182	33p	TIP42A	70p	2N3905/6	15p
AD161	36p	BF184	22p	TIP2955	70p	2N4058	15p
AD162	36p	BF185	22p	ZTX300	13p	2N4059	10p
AF114	13p	BF194	10p	ZTX500	15p	2N4060	13p
AF115	13p	BF195	10p	2N697	13p	2N4289	20p
AF116	13p	BF196	14p	2N698	30p	2N4347	130p
AF117	13p	BF197	15p	2N706	12p	2N4348	160p
AF118	50p	BF200	32p	2N708	18p	40360	40p
AF121	33p	BF257	32p	2N918	40p	40361	43p
AF124	30p	BFR39	30p	2N929	20p	40362	45p
AF125	30p	BFR40	30p	2N930	18p	40409	55p
AF126	30p	BFR79	30p	2N1131	18p	40410	55p
AF127	30p	BFR80	30p	2N1132	18p	40411	225p
AF139	33p	BFX29	30p	2N1302/3	17p	40594	75p
AF181	45p	BFX30	30p	2N1304/5	21p	40595	85p
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AF239	38p	BFX85	25p	2N1308/9	28p		
BC107	9p	BFX86	25p	2N1613	20p		
BC108	9p	BFX87	20p	2N1711	20p		
BC109	10p	BFX88	24p	2N1893	30p		
BC115	20p	BFY50	16p	2N2218	21p		
BC147	7p	BFY51	16p	2N2219	20p		
BC148	7p	BFY52	15p	2N2220	19p		
BC149C	8p	BRY39	34p	2N2221	20p		
BC157	10p	BSX19	16p	2N2222	20p		
BC158	8p	BSX20	16p	2N2369	14p		
BC159	9p	BSX21	22p	2N2484	30p		
BC169C	12p	MJE340	45p	2N2904	20p		
BC177	18p	MJE370	72p	2N2905	20p		
BC178	17p	MJE520	68p	2N2906	20p		
BC179	18p	MJE521	80p	2N2926RB	7p		
BC182	10p	MJE2955	99p	2N2926O	8p		
BC183	10p	MJE3055	65p	2N2926YG	9p		
BC184	11p	MPSA12	50p	2N3053	18p		
BC187	30p	MPSA06	30p	2N3054	40p		
BC212	11p	MPSA56	32p	2N3055	50p		
BC212	11p	MPSU06	62p	2N3441	80p		
BC213	10p	MPSU56	78p	2N3442	140p		
BC214	14p	OC26	40p	2N3702/3	11p		
BCY70	18p	OC28	55p	2N3704/5	11p		
BCY71	22p	OC35	48p				
BD123	100p	OC36	56p				
BD124	65p	OC41	15p				
BD131	40p	OC42	15p				
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BF115	22p	OC71	11p				

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CV3986, CV3988, CV3991, CV3998, CV4001, CV4002, CV4003, CV4004, CV4005, CV4006, CV4007, CV4008, CV4009, CV4010, CV4011, CV4012, CV4013, CV4014, CV4015, CV4016, CV4017, CV4018, CV4019, CV4020, CV4022, CV4023, CV4024, CV4025, CV4028, CV4033, CV4035, CV4038, CV4039, CV4040, CV4056, CV4059, CV4060, CV4062, CV4063, CV4064, CV4079, CV4501, CV4502, CV4503, CV4504, CV4507, CV4508, CV5060, CV6004, CV6008, CV6045, DA30, DA41, DA42, DA100, DET22, E55L, E80CC, E80FC, E80F, E80L, E80T, E81CC, E81L, E82CC, E83CC, E83F, E88CC, E90CC, E90L, E91H, E92CC, E180CC, EA50, EA52, EA76, ECC35, ECF804, EF50

EF54, EF55, EF804, EFP60, EL91, EN30, EN31, EN32, EN91, ESU74, ESU76, ESU77, F6057, F6060, F6061, F6063, FX219, FX225, FX227, G1/371K, G120/1B, G150/2B, G180/2M, G240/2D, G400/1K, GN4, GT1C, GTR120W, GTR150MS, GU18, GU20/21, GU50, GXU1, KT66, KT67, KT88, M8079, M8080, M8081, M8082, M8083, M8091, M8096, M8097, M8098, M8100, M8136, M8137, M8140, M8141, M8142, M8144, M8149, M8157, M8161, M8162, M8163, M8167, M8179, M8190, M8196, M8204, M8212, M8214, M8223, M8224, M8225, M8232, M8237, M8245, ME1400, ME1401, OA2, OA3, OA4G, OB2, OB3

OD3, OG3, OZ4, OZ4A, PT15, QA2400, QA2403, QA2404, QA2406, QA2407, QB3/300, QB3-5-750, QB4-1100, QF41, QF45, QQV02-6, QQV03-10, QQV03-20, QQV03-20A, QQV04-15, QQV06-40, QQV06-40A, QS70/20, QS75/20, QS75/40, QS75/60, QS83/3, QS92/10, QS95/10, QS105/45, QS150/40, QS150/45, QS150/80, QS1200, QS1202, QS1203, QS1205, QU37, QV03-12, QV04-7, QV05-25, QV06-20, QY3-125A, QY4-250A, QY4-400A, R10, R17, R18, S11E12, S130, S130P, STV280/40, STV280/80, SU41, SU42, TD03-10, TT15, TT21, TTR31MR, TZ40, U17, U19, U27, VLS631, Z300T, Z759, Z803U

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AA119	0.7
AAZ13	0.12
AAZ15	0.10
AC107	0.51
AC126	0.25
AC127	0.25
AC128	0.15
AC176	0.25
AC187	0.21
AC188	0.20
ACY21	0.22
ACY39	0.78
AD140	0.50
AD149	0.50
AD161	0.44
AD162	0.44
AF115	0.25
AF116	0.25
AF117	0.24
AF186	0.48
AF239	0.44
ASY27	0.33
ASY28	0.25
BA102	0.25
BA115	0.10
BC107	0.14
BC108	0.13
BC109	0.14
BC113	0.15
BC117	0.21
BC143	0.30
BC147	0.10
BC148	0.8
BC169C	0.15
BC182	0.12
BC182L	0.12
BC184L	0.13
BCY32	0.85
BCY33	0.38
BCY34	0.45
BCY70	0.18
BCY71	0.22
BCY72	0.15
BCZ11	0.65
BD121	1.00
BD124	0.65
BD131	0.42
BD132	0.50
BF115	0.20
BF167	0.25
BF173	0.28
BF179	0.33
BF180	0.36
BF181	0.35
BF194	0.10
BF195	0.13
BF197	0.15
BF200	0.32
BFS61	0.25
BFS98	0.25
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BFX88	0.24
BFY50	0.21
BFY51	0.20
BFY52	0.20
BY100	0.27
BY126	0.14
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BZX61 series	0.20
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CRS1 05	0.35
CRS1 40	0.50
CRS3 05	0.40
CRS3 40	0.65
MJE340	0.47
MJE370	0.68
MJE520	0.63
MJE2955	1.27
MJE3055	0.77
MPF102	0.40
MPF103	0.36
MPF104	0.35
MPF105	0.36
NKT404	0.66
OA5	0.72
OA10	0.40
OA79	0.10
OA81	0.18
OA91	0.7
OA200	0.08
OA202	0.06
OC16	1.00
OC20	2.00
OC23	1.35
OC25	0.40
OC28	0.66
OC35	0.55
OC36	0.60
OC42	0.40
OC44	0.20
OC45	0.20
OC71	0.18
OC72	0.28
OC76	0.30
OC77	0.54
OC81	0.29
OC81D	0.28
OC81Z	0.45
OC83	0.27
OC140	1.14
OC170	0.30
OC171	0.30
OC200	0.54
OC201	0.90
OC202	0.90
OC203	0.55
OCP71	1.20
ORP12	0.60
ORP60	0.55
TIC44	0.29
TIC226D	1.50
TIL209	0.20
ZTX107	0.12
ZTX108	0.8
ZTX300	0.13
ZTX301	0.14
ZTX302	0.18
ZTX304	0.24
ZTX500	0.13
ZTX501	0.15
ZTX503	0.16
ZTX531	0.25
ZTX550	0.18
IN914	0.06
IN4001	0.06
IN4002	0.7
IN4003	0.8
IN4004	0.8
IN4005	0.10
IN4006	0.12
IN4007	0.12
IN4009	0.06
IN4148	0.06
IS131	0.13
IS921	0.07
IS2033	0.20
IS2051A	0.20
IS2100A	0.20
IS3010	0.25
2N696	0.15
2N697	0.16
2N706	0.12
2N706A	0.12
2N1131	0.25
2N1132	0.24
2N1302	0.18
2N1303	0.18
2N1304	0.28
2N1305	0.22
2N1306	0.28
2N1307	0.28
2N1308	0.28
2N1309	0.30
2N1613	0.21
2N1614	0.45
2N2147	0.78
2N2160	0.78
2N2369A	0.16
2N2646	0.50
2N2904	0.20
2N2904A	0.25
2N2905	0.32
2N2905A	0.25
2N2906	0.20
2N2926	0.12
2N3053	0.18
2N3055	0.45
2N3525	0.91
2N3614	0.65
2N3615	0.65
2N3702	0.11
2N3703	0.12
2N3704	0.14
2N3705	0.15
2N3706	0.11
2N3707	0.13
2N3708	0.07
2N3709	0.10
2N3710	0.11
2N3711	0.11
2N3819	0.38
2N3820	0.50
2N3823	0.50
2N3903	0.15
2N3904	0.20
2N3905	0.25
2N3906	0.25
2N4058	0.15
2N4059	0.10
2N4060	0.13
2N4061	0.13
2N4062	0.14
2N4289	0.30
3N141	0.81
40360	0.40
40361	0.45
40362	0.40
40430	0.85
SN7400	0.16
SN7401	0.16
SN7402	0.16
SN7403	0.16
SN7404	0.26
SN7405	0.22
SN7406	0.42
SN7407	0.42
SN7408	0.28
SN7409	0.28
SN7410	0.16
SN7411	0.25
SN7412	0.30
SN7413	0.36
SN7416	0.36
SN7417	0.36
SN7420	0.16
SN7422	0.25
SN7423	0.37
SN7425	0.37
SN7427	0.37
SN7428	0.40
SN7430	0.16
SN7432	0.37
SN7433	0.37
SN7437	0.37
SN7438	0.37
SN7440	0.22
SN7441AN	0.92
SN7442	0.79
SN7445	0.16
SN7451	0.16
SN7453	0.16
SN7454	0.16
SN7460	0.16
SN7470	0.36
SN7472	0.38
SN7473	0.41
SN7474	0.42
SN7475	0.59
SN7476	0.45
SN7480	0.60
SN7482	0.87
SN7483	1.10
SN7484	1.00
SN7486	0.47
SN7490	0.55
SN7491AN	1.00
SN7492	0.70
SN7493	0.70
SN7494	0.80
SN7495	0.80
SN7496	0.95
SN7497	3.87
SN74100	1.89
SN74107	0.45
SN74110	0.58
SN74111	0.86
SN74118	0.90
SN74119	1.68
SN74121	0.50
SN74122	0.70
SN74123	1.00
SN74141	0.90
SN74145	1.26
SN74150	1.75
SN74151	1.00
SN74154	2.00
SN74155	1.00
SN74156	1.00
SN74157	0.95
SN74170	2.52
SN74174	1.57
SN74175	1.10
SN74176	1.26
SN74190	2.00
SN74191	2.00
SN74192	2.00
SN74193	2.00
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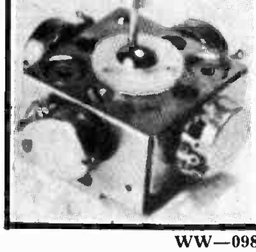

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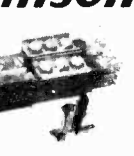

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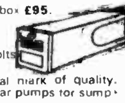

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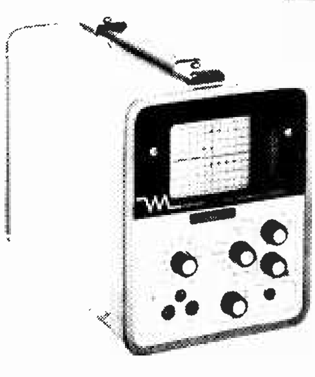

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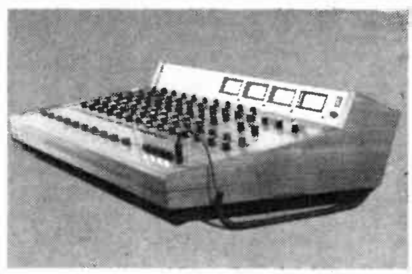

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Natural Environment Research Council

British Antarctic Survey

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2 All Saints Passage
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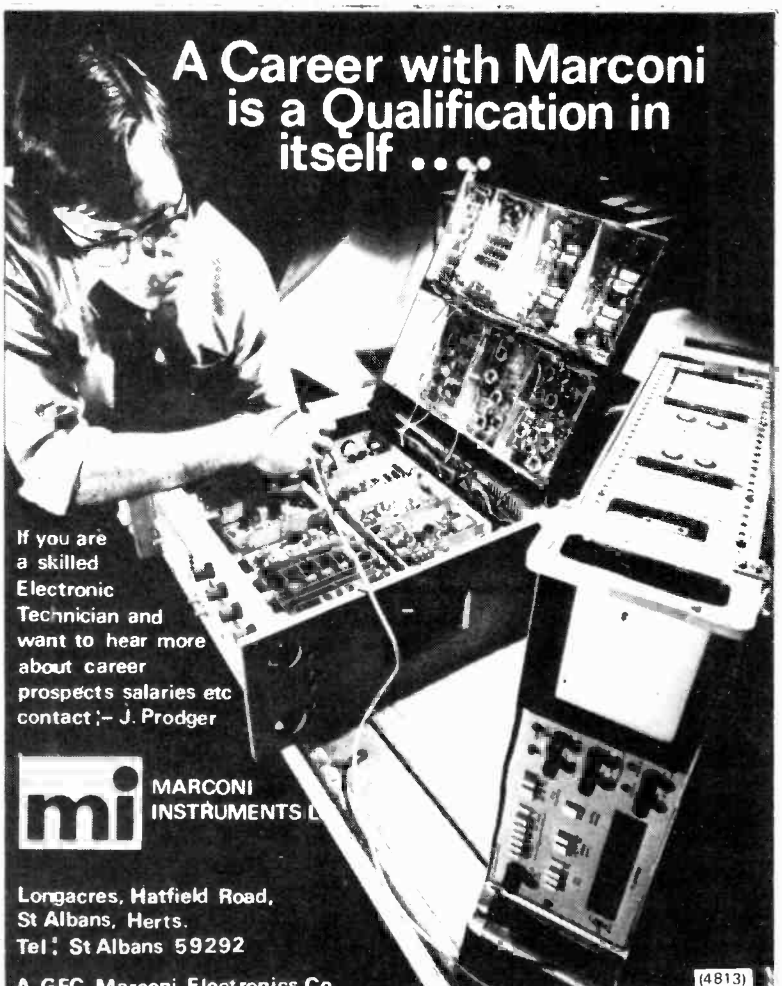

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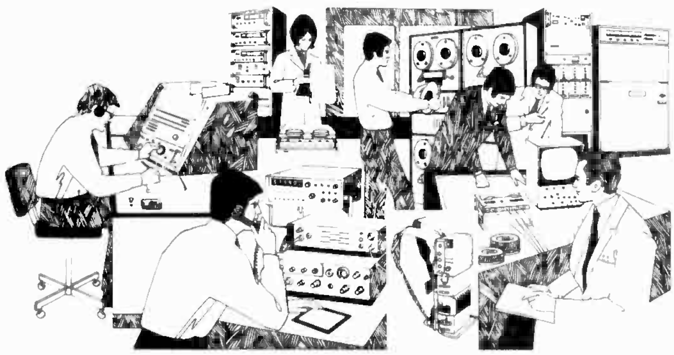
(4810)

Professional Engineers



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Cheltenham, Glos GL52 5AJ
Telephone Cheltenham 21491 Ext 2270

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British Antarctic Survey

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Write, giving full details, to **The Director**
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Join the Post Office Maritime Service. We have openings for Radio Operators at several of our coastal stations.

The work is just as interesting, just as rewarding as aboard ship, but you get home to see your wife and family more often. You need a United Kingdom General or First Class Certificate in Radiocommunications, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting pay for a man of 25 or over is £2,905 with further annual increases after that. Though we're happy to take people from 19 up.

In addition to your basic salary, you'll get an average allowance of £700 a year for shift duties and there are opportunities for overtime.

Other benefits include a good pension scheme, sick pay and prospects of promotion to Senior Management.

For more information, write to: ETE Maritime Radio Services Division (R/B/7), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London, EC1A 1AR

Post Office Telecommunications

Her Majesty's Government Communications Centre

HANSLOPE PARK, MILTON KEYNES MK19 7BH

has vacancies in the following fields of R & D work:

(a) **VHF/UHF COMMUNICATIONS**
(b) **COMMUNICATION FIELD TRIALS**
(c) **ACOUSTICS**
(d) **MICROWAVES**
(e) **GENERAL CIRCUIT DESIGN — ANALOGUE, DIGITAL**
(f) **STATISTICS/OPERATIONAL ANALYSIS/SYSTEMS ANALYSIS**

Most posts will be at Hanslope Park but some, in particular (f), will be in London. Posts in London carry a London allowance of £410 per annum in addition to the salaries quoted below.

Candidates for post (f) should be experienced scientists-/engineers who have specialised later in one of the required fields. An ability to deal with non-technical people is essential.

Appointments will be made within the grades of Higher Scientific Officer except for (d) and (f) where appointments may also be made within the Senior Scientific Officer grade. The appointments will be established within Government Service with a non-contributory pension scheme.

Higher Scientific Officer

Applicants should be under 30 years of age but this requirement may be waived if special qualifications or experience can be offered. They should have one of the following qualifications:

(a) A degree in a scientific or engineering subject.
(b) Degree-standard membership of a Professional Institution.
(c) A Higher National Certificate or Higher National Diploma in a scientific or engineering subject.
(d) A qualification equivalent to (c) above.

In addition the following relevant experience is required:

(a) Applicants with 1st or 2nd class honours degrees — at least two years' post-graduate experience.
(b) Applicants with other qualifications — at least five years' post qualifications experience.

Salary Scale: £3254 - £4454 with entry point dependent upon experience beyond the minimum required.

Senior Scientific Officer

Applicants should be at least 25 and under 32 years of age, although the upper age limit may be waived if experience of special value can be offered.

Applicants should have obtained a 1st or 2nd class honours degree and have had a minimum of four years' appropriate post-graduate experience.

Salary Scale: £4185-£5778. Entry will normally be at the minimum of the scale but applicants with experience of special value may be entered above the minimum

Applications, stating the field of work and the grade required, should be made to:

Administration Officer
HM GOVERNMENT COMMUNICATIONS CENTRE
Hanslope Park
Hanslope
MILTON KEYNES MK19 7BH

4743

Senior Technical Officer

There is a vacancy for a Senior Technical Officer in the Telecommunications Maintenance Section of British Airways Group Management Services. He reports to the Superintendent of Telecommunications Maintenance and is responsible for the organisation of a staff of 20. This team provides a full maintenance service for a wide range of equipment including data-systems, CCTV, CRT display devices, also audio and general telecommunications systems. His responsibilities include the provision of technical training for staff, the development of specialised test equipment and the maintenance of repair standards. He has frequent liaison with other engineering sections and the user departments.

Applicants should have at least 5 years' experience in the repair or design and development of Telecommunications equipment, with responsibility for the control of staff. He should be qualified to at least HNC or an equivalent level in an electronics or telecommunications subject, and a higher standard would be an advantage.

The post is based at Heathrow Airport and carries a starting salary of £3,841 including London Weighting. Other benefits include an excellent contributory pension scheme, a first class sports and social club and opportunities for concessional holiday air travel worldwide.

Applications, including details of age and experience, quoting reference 480/WW/MA, should be addressed to:

Manager, Selection Services, British Airways, P.O. Box 10
Heathrow Airport, London, Hounslow, TW6 2JA

British airways

(4818)

Natural Environment Research Council

British Antarctic Survey

WIRELESS OPERATOR MECHANICS required for expedition to spend approximately 30 months in Antarctica.

Applicants must be single and aged 22-30 and should have experience of maintaining and operating SSB transmitters and receivers. Teleprinter experience desirable.

Salary from £2,060 per annum depending on qualifications and experience. Low income tax, polar clothing and messing free.

If you are interested in seeing a largely unknown, remote and fascinating part of the world, please write to:
The Establishment Officer
British Antarctic Survey
2 All Saints Passage
CAMBRIDGE CB2 3LS
Tel: Cambridge (0223) 61188

4783

Top Recording Studio
requires

EXPERIENCED MAINTENANCE ENGINEER

Please reply in writing to:
Miss L. Packham
8-10 Basing Street, London, W11

(4794)

waltham forest college

RADIO & TELEVISION TECHNICIAN

Salary Scale T.3 £2,736 to £3,030 p.a. inclusive of London Weighting

To be responsible for servicing, maintenance and repairs to colour and monochrome television receivers, radios, closed circuit television, and electronic test equipment.

You will be required to prepare laboratory and workshop apparatus for class use, and to construct and test prototype equipment. Candidates should hold the City & Guilds Radio and Television Servicing Certificate and have appropriate experience. You will be required to order equipment and stores, and maintain stock control. Ability to instruct in operation of equipment would be an advantage. Housing accommodation is available in approved cases.

Application forms from the Personnel Officer, Town Hall, Forest Road, London E17 4JF (Tel: 01-527 5544, ext. 332).

Closing date: 28th July, 1975. Ref: Q.056.

(4792)

UNIVERSITY OF SURREY

Salary Scale: Technician 4 £2247-£2628 p.a.

Applications are invited for the position of

TECHNICIAN

in the Electronics Workshop of the Physics Department. The successful candidate will work with a small team, under the general direction of a Chief Technician, who are involved with the design, construction, modification and servicing of a wide range of electronic equipment.

Several years' relevant experience together with a minimum qualification of ONC or equivalent will be necessary.

Application forms available from the Assistant Secretary (Personnel), University of Surrey, Guildford, Surrey GU2 5XH.

(4784)

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U.K. Company invites applications from interested parties for the Australian Agency for a wide range of Mobile and Static Telescopic Lattice Towers, manufactured in the U.K.

Substantial markets have been developed in major countries of the world and the potential for the Australian Continent is regarded as unlimited in the fields of Radio Communications and Flood Lighting.

It would be most desirable that the proposed agency be negotiated with the principal of an existing business with established connections (by virtue of existing selling agencies of other products) within either or both of the fields of Commercial/Amateur Radio/Contractors Plant.

An open area of approx. 2,000 square feet would be required to unload containers and store tower sections. Longest piece 7 metres, heaviest piece 180 kgs.

See this journal for Product Advert.

Please write, giving full relevant history and interest in proposal to:

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Walsall, WS8 7EX
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(4795)

Telecomms Engineer-technicians

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So the men we send to work on those contracts must be good — qualified to ONC or HNC standard and experienced enough in the following areas to handle responsibility with confidence.

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VHF and UHF, ground-to-air R/T and HF equipment using SSB, ISB, FSK techniques.

Airfield Navaids

ILS, CRDF, VOR, DME, NDB, and ATC tower equipment.

Marine Electronics

radar, R/T, ship TV, autopilot gyro and navigational equipment.

Salaries are high by UK standards — up to around £4,500. And with free accommodation and no local income tax, anyone working for us abroad keeps what he earns.

Find out more about these world-wide opportunities with IAL by writing to or phoning John Nisbet, Technical Recruitment Officer, International Aeradio Limited, Aeradio House, Hayes Road, Southall, Middlesex. Tel. 01-571 0678.

IAL

4793

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Applicants must be in possession of a high standard of knowledge in sophisticated Hi-Fi products and be capable of complimenting the work of an enthusiastic experienced team of audio engineers.

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(4821)

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An expanding Electronics Company specialising in the

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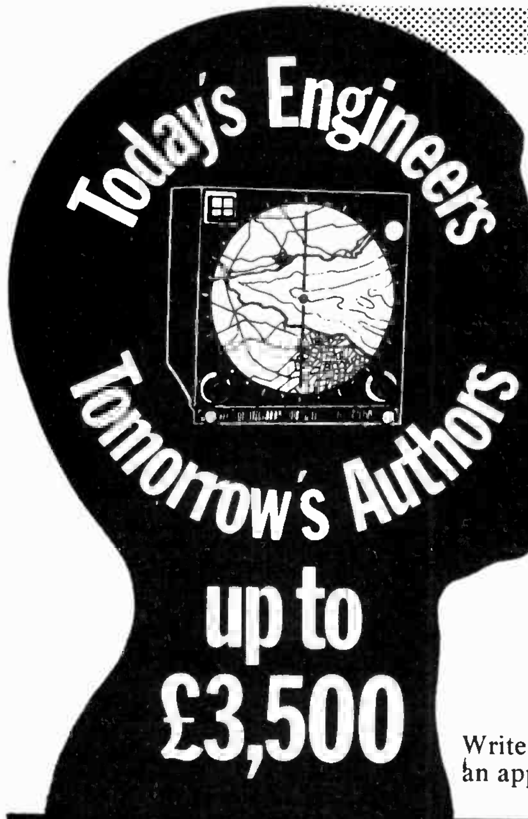
Quantel is the only British Company delivering digital television systems. Broadcast quality digital timebase correctors from the Quantel range are currently in use throughout the world with helical scan video tape recorders.

The company provides first-class opportunities for career development in modern, well-equipped laboratories situated in the centre of Newbury.

Please apply in writing to: **The Personnel Officer**
Quantel Limited
18 West Mills
NEWBURY, Berkshire

4803



Ferranti in Edinburgh are noted as pioneers and producers of sophisticated avionic systems. Understandably, such equipment demands high quality publications. And this is where you as an engineer come in.

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Write or telephone for an application form to: Edward Atkinson Staff Appointments Officer
Ferranti Ltd., Ferry Road, Edinburgh.
Tel: 031-332 2411 Ext. 172 (4820

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CROWN AGENTS

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The Royal Swaziland Police Force require Senior Technical Officers to undertake either a) Field Maintenance or b) Installation and commissioning of the Police communications equipment and to control the apprentice workshops, the technical stores and the second line servicing.

Both posts include on-the-job training of small groups of technician trainees.

Candidates, preferably under 30 years of age MUST have had relevant apprenticeship **or** Armed Services Training as an electronic/radio technician with several years subsequent experience with VHF/UHF systems including transmitters and associated equipment to third line service standard.

Salary in the scale £3,300 to £4,410 p.a. which includes an allowance, normally tax free, of £1,068 or £1,884 according to marital status. A gratuity of 25% basic salary is payable.

Other benefits include free passages, government housing at moderate rental, children's holiday visit passages. An interest-free car loan of £900 and an appointment grant of £300 may be payable.

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Ministry of Overseas Development.

For further particulars you should apply, giving brief details of experience to

CROWN AGENTS, M Division, 4 Millbank, London SWIP 3JD, quoting reference MK/WF.

(4819

PRODUCTION ENGINEER

For responsible work on small batch production and testing of electronic instruments. HNC or equivalent qualifications preferred with experience of electronic equipment manufacturing and testing methods.

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To assist the manager of a department which manufacture, tests, and services a range of important recorders. Experience of electronics and electro-mechanical instruments essential.

We offer an attractive salary related to qualifications and experience. Sickness benefits, profit sharing scheme and pension scheme. Three weeks' annual holiday increasing with employment time.

Apply to:

Mr. R. Johnston (Production Engineer)
Mr. D. W. Saunders (Test Engineer)
Environmental Equipments Limited
Eastheath Avenue, Wokingham, RG11 2PP, Berks. Tel. Wokingham 784922 (4824)

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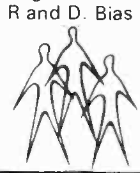
Applications are always invited from Engineers with a background of test and R and D. Bias to Avionics useful.



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London, NW1
Tel: 388 1609

(4830)

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Intelligent practical young school leavers offered opportunities to train ultimately as Public address and sound recording Engineers, Day release scheme, must be of smart appearance and live with parents in Central London area. Write or telephone for interview to:—

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Tel. 01-499 1231 (4832

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Telephone: Reading (0734) 55341

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BC107, 108, 109		11	10.5	10
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DIL Sockets	8 pin	12	11	10
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7413	36	34	33
7420	18	17	16
7430	18	17	16
7442	77	73	70
7447	99	94	89
7473	42	40	38
7474	38	36	34
7476	42	40	38
7486	33	31	29
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7492	60	57	54
7493	60	57	54
74121	48	46	44
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4012	24		22
4013	66		60
4015	175		158
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The duties are concerned with the commissioning, diagnosis of faults, and rectification of electronic equipment associated with liquid flow measuring devices, mainly on readout and control.

Permanent staff position with a Company car, four weeks' holiday after one year of service, contributory pension scheme, etc.

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AVERY

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4688

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CCTV and Audio Visual Aids Technician (Grade 5) with special responsibility for Television Studio and equipment. At least 6 years' experience in electronics. TV Studio experience desirable. HNC, HND, Advanced City & Guilds or equivalent. Some evening work. Salary £2,850-£3,306 (incl. London Weighting). For more details apply to the Vice Principal, Morley College, 61 Westminster Bridge Road, London SE1 7HT. (4815

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Join the National Air Traffic Services of the Civil Aviation Authority as a Radio Techician and you have the prospect of a steadily developing career in a demanding and ever expanding field.

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You should be 19 or over, with at *least one year's practical experience in telecommunications.*
Preference will be given to those having ONC or qualifications in Telecommunications.

Once appointed and trained, you will be doing varied and vital work on some of the world's most advanced equipment including computers, radar and data extraction, automatic landing systems, communications and closed circuit television.

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Name . . . .

Address . . . .

. . . .(WW)

NATS

National Air Traffic Services (4836)

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(4765)

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AT LAST WE HAVE A STOCK OF THE TRIMMERS YOU'VE ALL BEEN ASKING FOR!
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25-WAY ISEP PLUGS AND SOCKETS, 40p set. (1 plug + 1 skt). Plugs and sockets sold separately at **25p** each.
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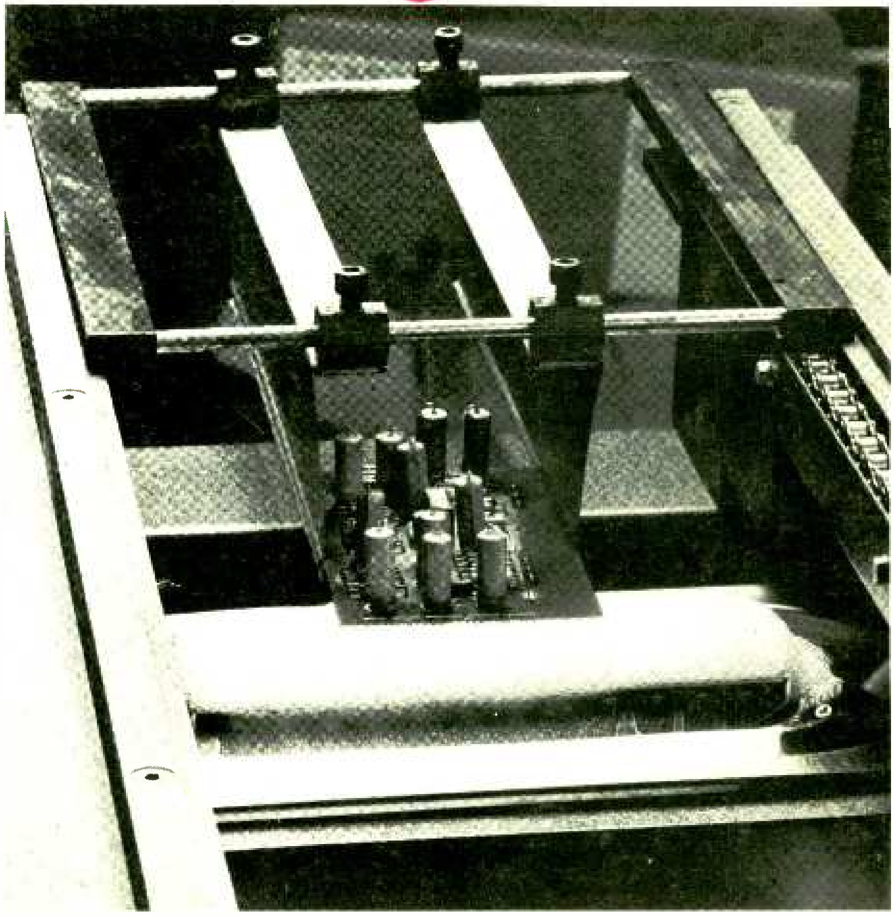

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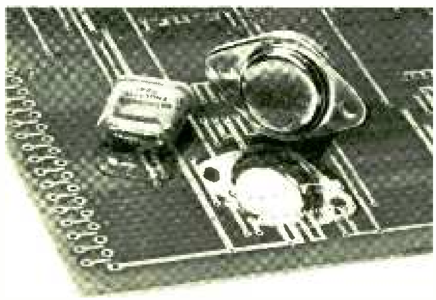

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