wireless world

OCTOBER 1982 80p

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V.d.us

Modular preamplifier

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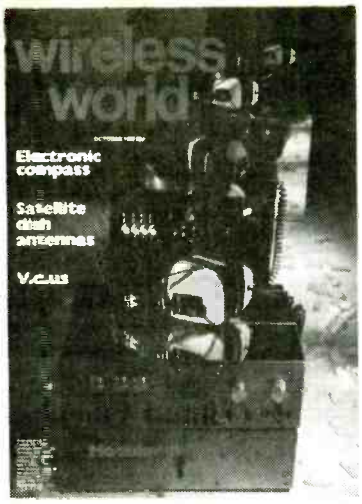

Front cover is John Linsley Hood's new preamplifier, shown on the power amplifier featured in June, July and August: Photograph by Alan McFaden and Alan Kerr.

NEXT MONTH

Two-metre transceiver. Six-mode design with microprocessor control for mobile use. Nine frequency memories are committed by push buttons.

Robin Howes explores the theme that many thoughtful people in responsible positions are concerned about the way industrial societies are going in a two part article on engineers and social responsibility.

Instead of trying to ignore Planck's quantum hypothesis suppose we afford it more than lip service; what then? Dr Murray continues Heretics Guide to Physics by discussing the new situations that would arise.

J. H. Buijs analyses reproduction of binaural recordings via loudspeakers and gives a circuit that also improves headphone reproduction of stereo programmes.

Current issue price 80p, back issues (if available) £1, at Retail and Trade Counter, Units 1 & 2, Bankside Industrial Centre, Hopton Street, London SE1. Available on microfilm; please contact editor.
By post, current issue £1.23, back issues (if available) £1.80, order and payments to EEP General Sales Dept., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.
Editorial & Advertising offices: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.
Telephones: Editorial 01-661 3500. Advertising 01-661 3130.
Telegrams/Telex: 892084 BISPRS G.
Subscription rates: 1 year £14 UK and £17 outside UK.
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Distribution: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Telephone 01-661 3500.
Subsciptions: Oakfield House, Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone: 0444 59188. Please notify a change of address.
USA: $39 surface mail, $98.30 airmail. US subscriptions from IPC B.P., Subscriptions Office, 205 E.42nd Street, NY 10017.
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ELECTRONICS
BROADCASTING
AUDIO
OCTOBER 1982

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COMMUNICATIONS
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Vol 88 No 1561

CX80 COLOUR MATRIX PRINTER

New low price
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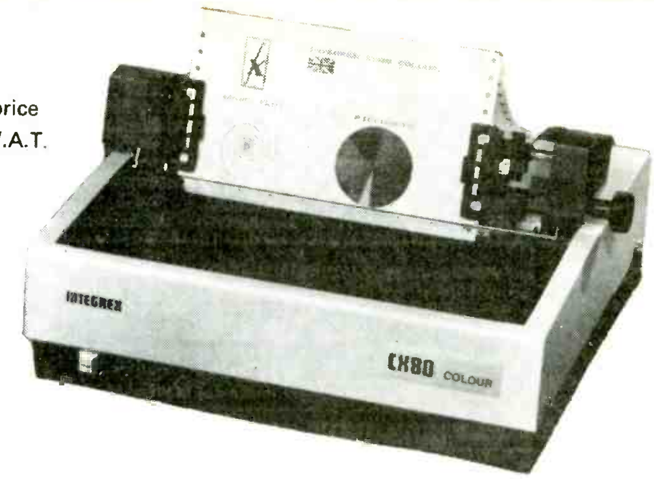

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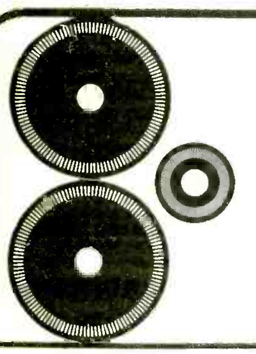

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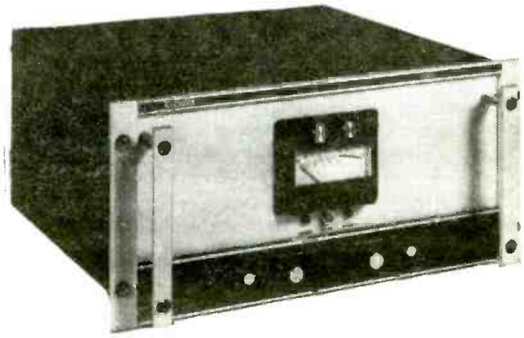

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WW10/82

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SWITCHES

TOGGLE 2A 250V	
SPST	33p
DPDT	44p

SUB-MIN TOGGLE

SPST on/off	54p
SPDT c/over	60p
SPDT centre off	85p
SPDT biased both ways	105p
DPDT 6 tags	75p
DPDT centre off	88p
DPDT biased both ways	145p
DPDT 3 positions on/on/on	185p
3-pole 2 way	205p

SLIDE 250V

DPDT 1A	14p
DPDT 1A c/off	15p
DPDT 1/2A	13p

PUSHBUTTON 6A with 10mm Button

SPDT latching	99p
DPDT latching	145p
SPDT moment	99p
DPDT moment	145p
Mini Non Locking	
Push to Make	15p
Push to Break	25p

DIL SWITCHES (SPST) 4 way 70p; 6 way 85p; 8 way 90p; 10 way 145p. (SPDT) 4 way 190p.

ROTARY SWITCHES (Adjustable Stop type) 1 pole/2 to 12 way; 2p/2 to 6 way; 3 pole/2 to 4 way; 4p/2 to 3 way 45p

ROTARY: Mains DP 250V 4 Amp on/off 56p

ROTARY: (Mak-a-switch) Make a multiway switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers (max. 6 pole/12 way - DP switch). Mechanism only 90p

WAFERS: (make before break) to fit the above switch mechanism. 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way, 6p/2 way 56p
Mains DP 4A Switch to fit 45p
Spacers 4p. Screen 6p

ROCKER 5A/250V SPST	28p
ROCKER 10A/250V SPDT	38p
ROCKER 10A/250V DPDT c/off	95p
ROCKER 10A/250V DPST with neon	85p

THUMBWHEEL Mini front mounting

Decade Switch Module	220p
B.C.D. Switch Module	275p
Mounting Cheeks (per pair)	75p

VEROBOARD 0.1in

	clad	plain
2½ × 3¼	80p	65p
2½ × 5	91p	—
3¾ × 3¾	91p	—
3¾ × 5	105p	87p
3¾ × 17	360p	232p
4¾ × 17	470p	—
Pkt of 100 pins		50p
Spot face cutter		135p
Pin insertion tool		178p

VQ Board	175
DIP Board	385
Vero Strip	144

PROTO DECs

Veroblock	375p
S-Dec	350p
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Bimboard 1	575p
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2×5 way	90p	99p	85p	65p
2×8 way	130p	150p	110p	78p
2×10 way	145p	166p	125p	90p
2×13 way	175p	200p	150p	110p
2×17 way	205p	236p	169p	135p
2×20 way	220p	250p	190p	150p
2×25 way	235p	270p	200p	175p
2×30 way	—	—	230p	220p

EURO CONNECTORS

	Female Socket Strt Pins	Female Socket Angle Pins	Male Plug Strt Pins	Male Plug Angle Pins
DIN41617 31way	180p	—	—	185p
DIN41612 2×32 A+B	300p	345p	235p	295p
DIN41612 2×32 A+C	350p	355p	250p	350p
DIN41612 3×32 A+B+C	375p	380p	260p	370p

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0-100μA
0-500μA
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0-5mA
0-10mA
0-50mA
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DPCO
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PIEZO TRANSDUCERS Type PB-2720 55p

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Standard 6MHz	280p
Wideband 8MHz	425p

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6 × 12	150p	195p	

DIL SOCKETS

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8pin	8p	25p
14pin	10p	35p
16pin	10p	42p
18pin	16p	52p
20pin	22p	60p
22pin	25p	70p
24pin	25p	70p
28pin	28p	80p
40pin	30p	99p

EDGE CONNECTORS

	.1	.156
2×15 way	—	140p
2×18 way	180p	145p
2×22 way	199p	200p
2×23 way	210p	—
2×25 way	225p	220p
2×28 way	210p	—
2×30 way	245p	—
2×36 way	295p	—
2×40 way	315p	—
2×43 way	395p	—
2×75 way	550p	—

RIBBON CABLE

	price per foot Grey	Color
10 way	12p	22p
16 way	18p	32p
20 way	25p	40p
24 way	35p	50p
34 way	48p	60p
40 way	55p	75p
50 way	65p	90p
64 way	85p	110p

DIL PLUG (Headers)

	Solder	IDC
14 pin	44p	99p
16 pin	49p	105p
24 pin	88p	178p
40 pin	250p	255p

ZIF DIL SOCKETS

24 pin	575p
28 pin	820
40 pin	975p

CRYSTALS

32.768KHz	100
100KHz	235
200KHz	268
455KH	370
1MHz	275
1.008M	275
1.28MHz	392
1.6MHz	395
1.8NHz	395
1.8432M	200
2.0MHz	225
2.4576M	200
3.278M	150
3.5794M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.80MHz	200
4.194304M	200
4.433619M	100
5.0MHz	160
5.185MHz	300
5.24288M	390
140	
6.144MHz	150
6.5536MHz	225
150	
7.168MHz	250
7.68MHz	200
8.0MHz	150
395	
8.86723M	175
9.00MHz	150
10.0MHz	175
10.24MHz	200
10.7	150
12.0MHz	175
300	
14.31814M	170
16.0MHz	200
18.0MHz	180
18.432M	150
200	
19.968MHz	150
24.0MHz	170
325	
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12 inches	198p	215p	315p	490p
24 inches	210p	235p	345p	540p
36 inches	230p	250p	375p	595p
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Single ended	160p	200p	260p	300p
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Angle Pins	160p	210p	250p	355p
W/Wrap Pins	120p	130p	195p	295p
Sockets				
Solder lugs	110p	160p	210p	350p
Angled Pins	165p	215p	290p	440p
W/Wrap Pins	150p	180p	240p	420p
Covers	100p	95p	100p	110p

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pcb mounting. Miniature, Split Bobbin
3VA: 2x6V-0.25A; 2x9V-0.15A; 2x12V-0.12A; 2x15V-0.1A 200p
6VA: 2x6V-0.5A; 2x9V-0.3A; 2x12V-0.25A; 2x15V-0.2A 270p

Standard Split Bobbin type.
6VA: 2x6V-0.5A; 2x9V-0.4A; 2x12V-0.3A; 2x15V-0.25A 220p
12VA: 2x4.5V-1.3A; 2x6V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A 295p (35p p&p)
24VA: 2x6V-1.5A; 2x9V-1.2A; 2x12V-1A; 2x15V-0.8A; 2x20V-0.6A 330p (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-1A; 2x30V-0.8A 465p (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x25V-2A; 2x30V-1.5A; 2x50V-1A 920p (75p p&p charge to be added over and above our normal postal charge)

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1A	T03	Metal case			
5V	7805	145p		7905	220p
12V	7812	145p		7912	220p
15V	7815	145p		7915	220p
18V	7818	145p			
1A	T0220	Plastic casing			
5V	7805	40p		7905	45p
12V	7812	40p		7908	60p
15V	7815	40p		7912	45p
18V	7818	40p		7915	45p
24V	7824	40p		7918	45p
				7924	60p
100mA	TO92	Plastic casing			
5V	78L05	30p		79L05	60p
6V	78L62	30p			—
8V	78L82	30p			—
12V	78L12	30p		79L12	60p
15V	78L15	30p		79L15	60p

CA3085	95p
LM300H	170p
LM304H	170p
LM305H	140p
LM309K	135p
LM317K	350p
LM317KP	99p
LM317H	280p
LM323K	500p
LM325N	240p
LM326N	240p
LM337	175p
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78HG + 5V to + 25V 5A	599p
79HG-2.25V to 24V 5A	785p

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4000	10	4075	15	4539	110
4001	10	4076	46	4541	140
4002	12	4077	18	4543	80
4006	50	4078	18	4549	375
4007	15	4081	16	4553	245
4008	48	4082	16	4554	190
4009	24	4085	50	4555	35
4010	24	4086	52	4556	35
4011	11	4909	125	4557	320
4012	16	4093	26	4558	120
4013	25	4094	120	4560	160
4014	50	4095	75	4561	104
4015	50	4096	70	4562	495
4016	20	4097	290	4566	165
4017	38	4098	75	4568	250
4018	45	4099	110	4569	175
4019	25	4160	95	4572	30
4020	50	4161	99	4580	460
4021	50	4162	99	4581	250
4022	50	4163	99	4582	99
4023	16	4174	99	4583	99
4024	32	4175	105	4584	48
4025	16	4194	105	4585	99
4026	80	4408	790	4597	330
4027	24	4409	790	4598	290
4028	50	4410	725	4599	290
4029	60	4411	675	40085	90
4030	30	4412	775	40097	45
4031	125	4415	480	40098	193
4032	30	4419	280	40100	215
4033	125	4422	770	40101	130
4034	140	4433	770	40102	140
4035	66	4435	850	40103	175
4036	275	4440	999	40104	95
4037	110	4450	350	40105	110
4038	110	4451	350	40106	46
4039	290	4490	350	40107	60
4040	50	4500	675	40108	450
4041	60	4501	28	40109	100
4042	45	4502	60	40110	300
4043	50	4503	40	40114	240
4044	50	4504	75	40161	194
4045	105	4506	35	40163	65
4046	65	4507	35	40174	65
4047	50	4508	130	40175	75
4048	40	4510	45	40181	220
4049	25	4511	45	40182	90
4050	25	4512	50	40192	90
4051	45	4513	199	40193	68
4052	60	4514	115	40194	90
4053	50	4515	115	40195	72
4054	85	4516	55	40244	195
4055	85	4517	275	40245	195
4056	85	4518	40	40257	195
4057	1915	4519	30	40373	240
4059	480	4520	50	40374	245
4060	60	4521	110		
4061	2295	4522	125		
4062	995	4526	70		
4063	85	4527	65		
4066	30	4528	70		
4067	245	4529	150		
4068	16	4530	90		
4069	16	4531	130		
4070	15	4532	70		
4071	15	4534	456		
4072	15	4536	275		
4073	15	4538	90		

OPTO

LS400C	255
OCP71	120
ORP12	86
ORP61	85
2N5777	45
BPX25	195
270	
295	

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LEDs with Clips	
TIL209 Red	11
TIL211 Grn	14
TIL212 Yel.	14
TIL220 .2" Red	12
.2" Green, Yellow or Amber	14
0.2" Bi colour Red/Green	65
Green/Yellow	78
0.2" Tri colour Red/Green/Yellow	85
Hi Brightness Red	59
LED 2" red	55
Square LEDs, Red, Green, Yellow	30
Rectangle Stackable LEDs	
Red, Green or Yell	18
Triangular LEOs	
Red	18
Green or yellow	22
LD271 Infra Red	46
SFH205 Detector	118
TIL32 Infra Red	58
TIL78 Detector	60
TIL38	45
TIL100	80
BARGRAPH Red 10 segments	225
ISOLATORS	
IL74	55
ILD74	99
ILQ74	185
TIL111/2/4	90
TIL117	125
4N33 Photo Darlington	135
7 Segment Displays	
TIL307	675
TIL312 .3" CA	105
TIL313 .3" CC	105
TIL321 .5" CA	115
TIL322 .5" CC	115
DL704 .3" CC	99
DL707 .3" CA	99
FND357 Red	120
FND500	115
.3" Green CA	150
.6" Green CA	215
.3" + 1 Red CA	150
.3" + 1 Green CA	150
DVM176	1885
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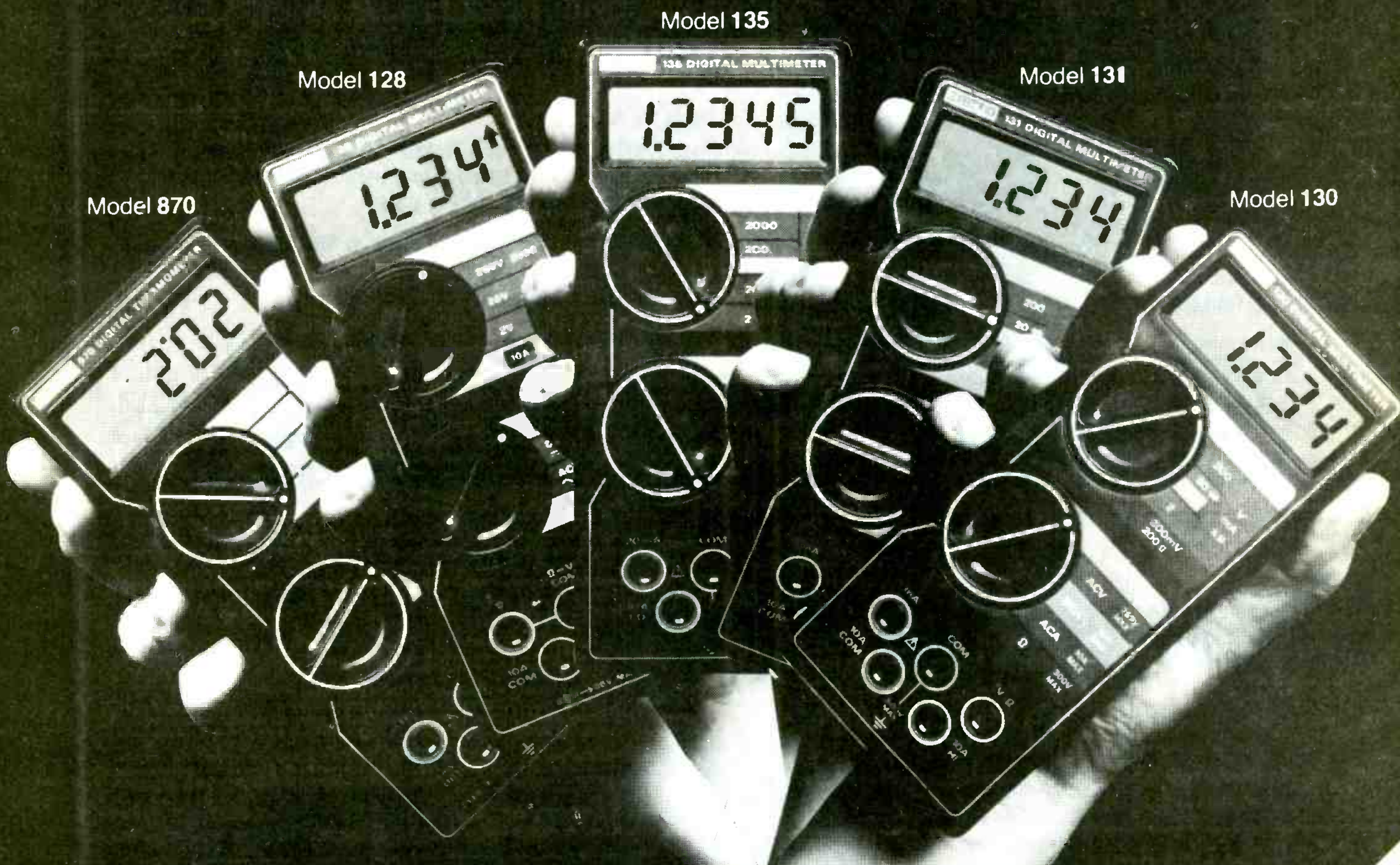
HANDSOME!

First there was the 130. A handheld D.M.M. which still sets the standards our competitors strive to match.

Next came the 131. The introduction of the 135 saw 4½ digits on a handheld D.M.M. for the very first time.

And that same commitment to innovation has resulted in the latest additions to the range. The Keithley 128 D.M.M. with audio-tone and 870 Digital Thermometer with centigrade and fahrenheit readout.

The result is an unrivalled selection of handheld measuring devices. Each specification carefully matched to a given need. With performance that looks pretty good on paper. And even better in the field!



Model 870 ● 0.025% accuracy ● Centigrade and fahrenheit readout ● Measures up to 1370°C ● 0.1° resolution up to 200°C

Model 128 ● Audio-tone with adjustable threshold ● 25 ranges: 5 functions ● 10 amp span

Model 135 ● 0.05% accuracy ● Full overload protection ● ACU bandwidth to 20 KHz

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Model 130 ● 25 ranges: 5 functions ● 10 amp span ● 0.5% accuracy

All models are guaranteed accurate for one year. And built to the high standards of quality expected of the Keithley name.
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Telex 847047
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WW – 083 FOR FURTHER DETAILS

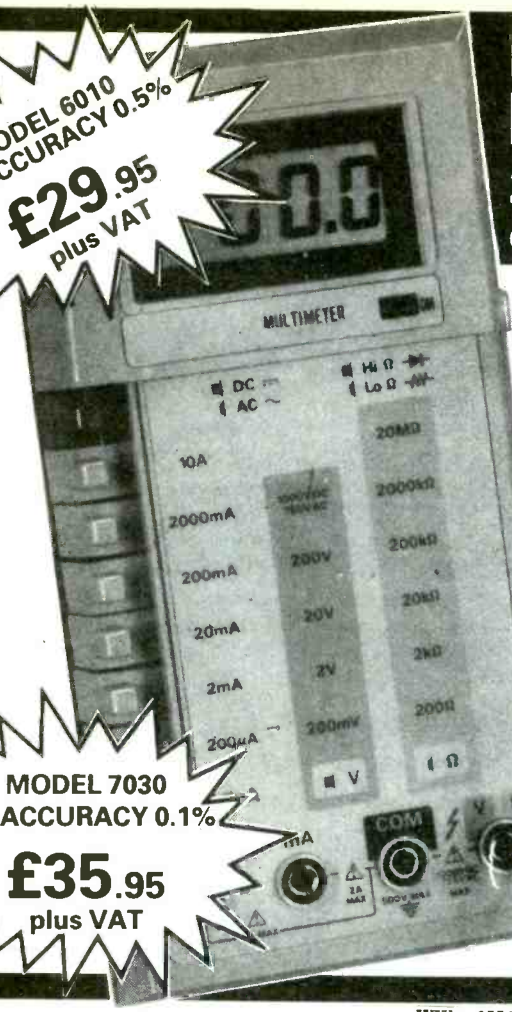
I would like to know more about your Handheld Units.
Please send me details on ☐ D.M.M.'s ☐ 870 Thermometer

Name ______
Company ______
Address ______
Position ______
Telephone ______

WW/10/82

Introducing two new hand-held digital multimeters

28 Ranges, each with full overload protection



MODEL 6010
DC ACCURACY 0.5%
£29.95
plus VAT

MODEL 7030
DC ACCURACY 0.1%
£35.95
plus VAT

10 amp AC/DC

SPECIFICATION 6010 & 7030

BATTERY: Single 9v dry cell. BATTERY LIFE: 200 hours. DIMENSIONS: 170 x 89 x 38mm. WEIGHT: 400g inc. battery. MODE SELECT: Push button. AC DC CURRENT: 200μA to 10A. AC VOLTAGE: 200mV to 750V. DC VOLTAGE: 200mV to 1000V. RESISTANCE: 200Ω to 20MΩ. INPUT IMPEDANCE: 10MΩ. DISPLAY: 3½ Digit 13mm LCD. O/LOAD PROTECTION: All ranges.

OTHER FEATURES:

Auto polarity, auto zero, battery-low indicator, ABS plastic case with tilt stand, battery and test leads included, optional carrying case.

Please add 15% to your order for VAT. Postage and packing is free of charge.
Trade prices available on application.

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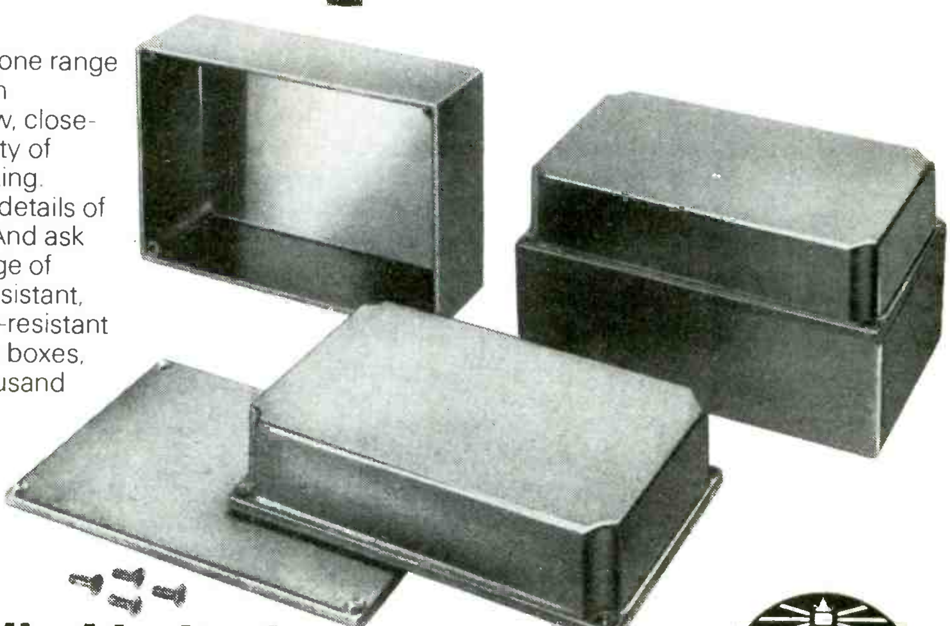
Double Top

This new addition to the Eddystone range of diecast boxes is supplied with interchangeable deep or shallow, close-fitting flanged lids giving flexibility of application with minimum stocking.

Please write or telephone for details of the new, versatile 10758P box. And ask about the whole Eddystone range of strong, lightweight, corrosion-resistant, diecast aluminium boxes, water-resistant boxes and moulded ABS plastic boxes, in a range of sizes to meet a thousand applications.



STOP PRESS!

The flexibility of deep/shallow and base lids has now been extended to a number of standard sizes.

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Telephone: 021-475 2231 Telex: 337081
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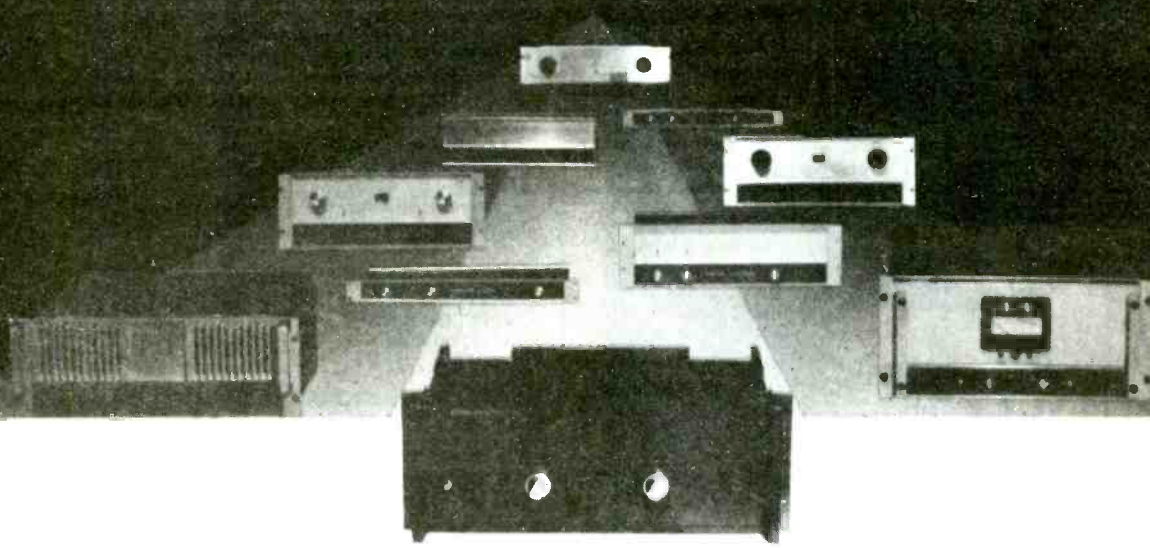
The Professional Choice



amcron

Since the introduction of the DC300 in 1967, AMCRON amplifiers have been used worldwide — wherever there has been a need for a rugged and reliable amplifier. Their reputation amongst professional users, throughout industry, has made the name of AMCRON synonymous with power amplification. For power you can depend on - choose AMCRON, the professional choice.

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TELEPHONE: 01-853 5295
TELEX: 923393 LASER G

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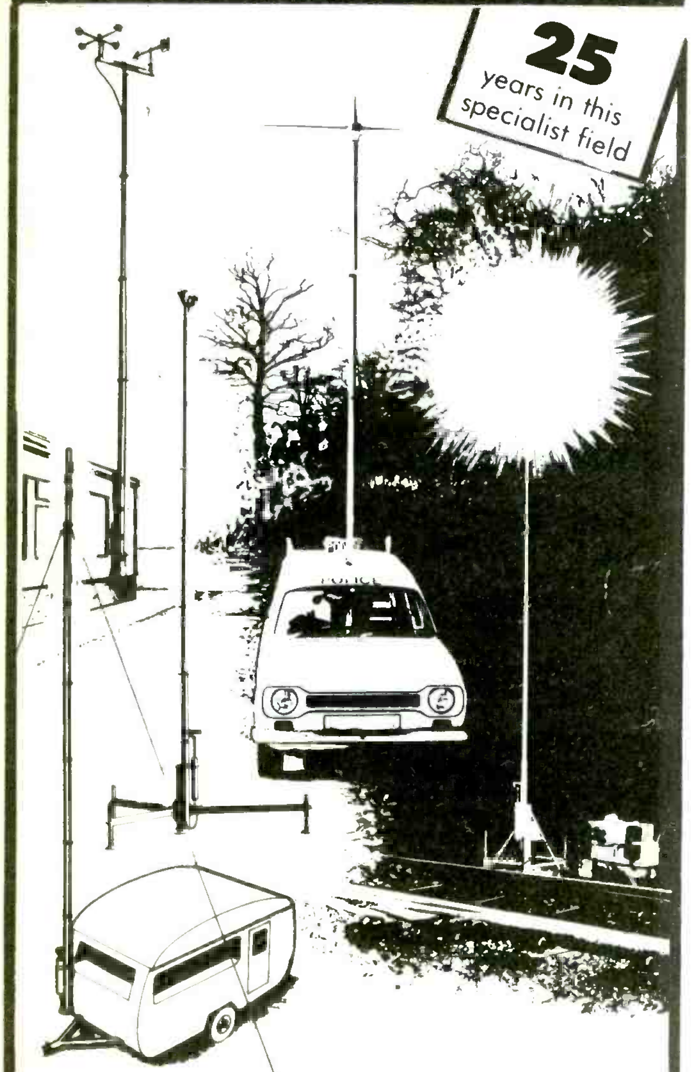
The lightweight mast with 101 applications



The smoothly operated QTM Mast comes fitted with handpump or can be vehicle mounted with 'Power Pack' for extension and retraction. Available in a range of heights up to 15 metres, the QTM mast can provide the ideal answer for:

- Mobile Radio Telephone
- Police Mobile HQ (UHF)
- Field Telecommunications
- Floodlighting
- Anemometer and Wind Measurement
- Environmental - gas sampling collector
- High level photography
- Meteorology
- And a host of other uses

CLARK MASTS

Find out more about the QTM series by writing or phoning:-

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England PO33 3PA
Tel: Isle of Wight (0983) 63691
Telex 86686

EUROPE
GENK TECHNICAL PRODUCTS N.V.(W.W.)
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Telefoon 011-380831
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EV88 – A low-cost evaluation system for the 8088 microprocessor

EV88 is a single board microcomputer that is ideal for evaluating the 8088 8-bit/16-bit microprocessor. EV88 can also be used as a powerful controller, and, with a suitable cross-assembler running on a standard microcomputer, and an EPROM programmer, for low-cost development of 8088-based systems.

EV88 is supplied fully assembled and tested, with comprehensive documentation, and a copy of The 8086 Book, by Rector and Alexy. All you need is a 5V 1A power supply and a terminal or a suitable microcomputer.

★ 8088 microprocessor in minimum mode (software compatible with the 8086 16-bit microprocessor).
★ Comprehensive monitor in 2K EPROM.
★ 2K CMOS RAM.
★ Cassette interface.
★ 24 lines of I/O.
★ Eight levels of interrupt.
★ RS-232 compatible serial interface (300 baud to 9600 baud).
★ Three-channel counter/timer.
★ Buffered data, address and control lines.
★ Double Eurocard.
★ On-board expansion to 16K EPROM/RAM (sockets provided).
★ Breadboarding area.
★ All bus signals available on 64-way DIN 41612 connector.
★ Single 5V supply.
★ Price £300 plus VAT. Includes delivery.

8088/8086 design service available (software and hardware).

LFH Associates Ltd.
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Stony Stratford
Milton Keynes
(0908) 564271

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GREENWELD
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Type	100+	1k+
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133	.04	.02
BA130	.04	.02
155	.04	
BYX94	.06	.04
BY127	.07	.06
BY196	.07	
BY197	.07	
BY198	.08	
CG50H	.03	.01
DK14	.04	.02
FA2001	.05	
FA2008	.05	
HG5085	.04	
OAZ201	.04	
OAZ206	.04	
SXG31	.04	
SX632	.04	.03
SX753	.40	
IN446	.04	
458	.04	
459	.04	
627	.04	
643	.04	
3062	.05	
3890	.35	
4001	.03	.02
4002	.03	.02
4003	.032	.022
4005	.04	.027
4006	.044	.030
4007	.048	.032
4148	.02	.013
4149	.03	.018
4447	.03	.018
4448	.03	
4154	.03	.018
4742A	.06	.045
5243B	.06	
5279	.05	
5402	.08	
5403	.09	
5404	.10	.085
5405	.11	
5406	.12	
IS101	.05	
410	.10	
423	.25	
921	.05	.032
IS4020A	.07	.05
5056A	.07	
25G10	.97	

BRIDGES

	100+
WO1	.15
WO2	.16
WO4	.17
WO6	.19
SO2	.19
SO4	.22
SO6	.28
PW005	.39
15A100V	1.20
12A200V	.65
B80C600	.14

CMOS

Type	100+
4001B	.12
4007A	.10
4011B	.12
4012B	.12
4012UB	.12
4013A	.20
4013B	.20
4014B	.40
4015B	.40
4016A	.22
4016B	.25
4017A	.29
4022A	.40
4023C	.12
4023A	.12
4025A	.12
4027B	.26
4028B	.40
4029A	.42
4035CP	.50
4040	.42
4042	.47
4049B	.20
4049A	.17
4051B	.42
4052B	.42
4060B	.60
4060A	.60
4069B	.12
4078B	.18
4085A	.40
4086	.40
4503B	.30
4511B	.42
4518B	.39
4520B	.39
4528B	.42
4582	.60
40014	.32
74C00	.18

TTL

Type	100+
7400	.08
7401	.08
7405	.09
7408	.10
7409	.10
7410	.10
7413	.15
7417	.18
7420	.10
7426	.20
7427	.20
7430	.08
7437	.19
7440	.11
7442	.30
7445	.30
7447	.32
7450	.10
7454	.10
7460	.10
7472	.18
7473	.20
7474	.15
7483	.40
7485	.45
7490	.20
7491	.36
7493	.18
7496	.39
74107	.16
74109	.28
74121	.22
74123	.25
74150	.45
74151	.30
74155	.28
74179	.65
74180	.45
74181	.80
74182	.50
74190	.40
74194	.50
74366	.40

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Tant Beads: 2.2/16 .04; 10/35 .16.
ITT PMT POLYESTERS: .01/400 02; .22/100 .023; .33/100 .025; .47/100 .028; .68/100 .04; 1/100 .055.

400mW Zeners, 5%: All E24 values from 2V4 to 36V and 75V at .035; 1k (mixed 100s) .029.
1.3W 5% Zeners: 3V6 3V9 4V3 7V5 11V 12V 13V 16V 18V 30V 56V 75V 110V 180V at .06. 1k (mixed 100s) 045.

TRANSISTORS

AC 127	.16	BD132	.26
AC128	.16	BD246	.30
AD161/2	.45	BD433	.28
BC107	.08	BD695A	.45
BC108C	08	BD696A	.45
BC109C	.09	BF173	.16
BC182B	.05	BF181	.18
BC182L	.05	BF195	06
BC183	.05	BF258	.20
BC183L	.05	BFY50	.17
BC184	.05	BFY51	.15
BC212B	.05	BFY52	.15
BC213	.05	BRY46	.17
BC214B	.05	BU206	.70
BC214L	.05	BU208	.92
BC308B	.05	OC35	.70
BC327	.06	PBC108	.05
BC328	.06	TIP31A	.21
BC338	.06	TIP32A	.21
BC547	.05	TIP41C	.32
BC548	.05	2N1132	.16
BC549	.05	2N2222	.10
BC557	.05	2N2369	.12
BC558	.05	2N2646	.40
BC559	.05	2N2926R	.05
BCY70	.12	2N3053	.16
BCY71	.12	2N3055	.30
BCY72	.12	2N3702-10	.05
BD131	26		

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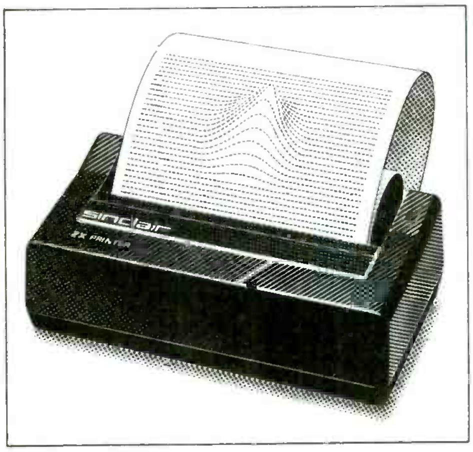
um

The ZX Printer – available now

Designed exclusively for use with the Sinclair ZX range of computers, the printer offers ZX Spectrum owners the full ASCII character set – including lower-case characters and high-resolution graphics.

A special feature is COPY which prints out exactly what is on the whole TV screen without the need for further instructions. Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your ZX Spectrum. A roll of paper (65ft long and 4in wide) is supplied, along with full instructions. Further supplies of paper are available in packs of five rolls.



The ZX Microdrive – coming soon

The new Microdrives, designed especially for the ZX Spectrum, are set to change the face of personal computing.

Each Microdrive is capable of holding up to 100K bytes using a single interchangeable microfloppy.

The transfer rate is 16K bytes per second, with average access time of 3.5 seconds. And you'll be able to connect up to 8 ZX Microdrives to your ZX Spectrum.

All the BASIC commands required for the Microdrives are included on the Spectrum.

A remarkable breakthrough at a remarkable price. The Microdrives are available later this year, for around £50.

RS232/network interface board

This interface, available later this year, will enable you to connect your ZX Spectrum to a whole host of printers, terminals and other computers.

The potential is enormous. And the astonishingly low price of only £20 is possible only because the operating systems are already designed into the ROM.

ZX Spectrum

Available only by mail order and only from

sinclair

Sinclair Research Ltd,
Stanhope Road, Camberley,
Surrey, GU15 3PS.
Tel: Camberley (0276) 685311.

How to order your ZX Spectrum

BY PHONE – Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day. BY FREEPOST – use the no-stamp needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option, of course. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research, FREEPOST, Camberley, Surrey, GU15 3BR. **Order**

Qty	Item	Code	Item Price £	Total £
	Sinclair ZX Spectrum – 16K RAM version	100	125.00	
	Sinclair ZX Spectrum – 48K RAM version	101	175.00	
	Sinclair ZX Printer	27	59.95	
	Printer paper (pack of 5 rolls)	16	11.95	
	Postage and packing: orders under £100	28	2.95	
	orders over £100	29	4.95	
			Total £	

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Name: Mr/Mrs/Miss

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WRW 810

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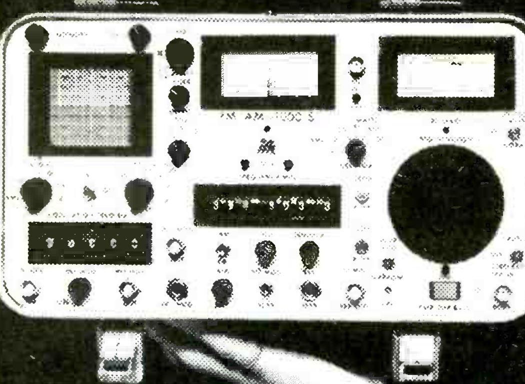
Testing... Testing... Testing...



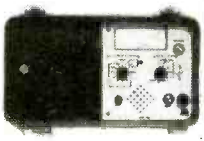
anywhere!

FM/AM 1000s with Spectrum Analyser—we call it the SUPER—S

A portable communications service monitor from IFR, light enough to carry anywhere and good enough for most two-way radio system tests.
The FM/AM 1000s can do the work of a spectrum analyser, oscilloscope, tone generator, deviation meter, modulation meter, signal generator, wattmeter, voltmeter, frequency error meter—and up to five service engineers who could be doing something else!

A PRACTICAL TOP UP! MM-100 MULTI-METER

Simply replaces the protective lid of the FM/AM 1000s. It includes a modified probe. PB-114, and a built in speaker unit with independent volume control for audible response to signal measurement. This practical 'top up' will perform the following functions.



Sinad: Measurements for 1 kHz tone ($\pm$ 20 Hz)
Distortion: To 30%
DC Volts: Up to 300 volts and up to 800 volts when the X10 probe is used
AC Volts: 600 VRMS maximum for frequencies between 25 Hz and 25 kHz
Ohms: Using the modified probe, part number PB-114, Ohms can be measured on scales X1 to X10 K
% AM Measured on the RF signal applied to the FM/AM-1000 unit

OPTIONAL ACCESSORIES

A choice of R.F. power attenuators and protective carrying cases.

For further information contact Mike Taylor

Hunting

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Middlesex UB7 0LL
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E180CC	4.20		13.80*	UCC85	0.70	6C6	0.55	13D3	0.70		
E180F	7.70	MH4	2.50	UCF80	1.30	6CH6	8.20	13D5	0.90		
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EB91	0.60	OA2	0.70	UF41	1.35	6D6	0.70	19G3	11.50	P800 IR	
EBC33	1.15	OB2	0.80	UF80	0.95	6F6	1.60	19G6	6.50	P800 IB	
EBC90	0.90	PABC80	0.80	UF85	0.95	6F6GB	1.10	19H5	39.55	XQ1020R	
EBF80	0.60	PC85	0.75	UL84	0.95	6F7	2.80	20D1	0.80	XQ1020B	
EBF83	0.60	PC86	0.85	UM80	0.90	6F8G	0.85	20F2	0.85		
EBF89	0.80	PC88	0.90	UM84	0.70	6F12	1.50	20E1	1.30		
EC52	0.65	PC97	1.25	UY82	0.70	6F14	1.15	20P1	0.65	SPECIAL V	
EC91	4.40	PC900	0.90	UY85	0.85	6F15	1.30	20P3	0.75	4CX 1000A	
EC92	0.85	PCC84	0.50	VR105/30	1.25	6F17	3.20	20P4	1.25	4CX 5000A	
ECC81	0.65	PCC89	0.85	VR150/30	1.35	6F23	0.75	20P5	1.35	BM 25L	
ECC82	0.60	PCC189	0.85	X66	0.95	6F24	1.75	25L6GT	0.95	BW 153	
ECC83	0.65	PCF80	0.80	X61M	1.70	6F33	10.50	25Z4G	0.75	DM 25LB	
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ECF80	0.85	PCF800	0.50	Z803U	16.00	6J5	2.30	30FL14	2.15	BR 189	
ECF82	0.65	PCF801	1.75	Z900T	2.45	6J5GT	0.90	30L15	1.10	BR 179	
ECF801	1.05	PCF802	0.70	1A3	0.85	6J6	0.65	30L17	1.10	CV6131	
ECH34	2.25	PCF806	1.20	1L4	0.50	6J6W	0.90	30P12	1.15	GMU 2	
ECH35	1.70	PCF808	1.45	1R5	0.80	6JE6C	2.95	30PL13	1.25	TY4-500	
	2.10*	PCH200	1.35	1S4	0.45	6JS6C	2.95	30PL14	2.45	BK485/5552A	
ECH42	1.20	PCL81	0.75	1S5	0.45	6K7	0.80	35L6GT	1.40	MIL 5948/1754	
ECH81	0.70	PCL82	0.95	1T4	0.45	6KD6	3.35	35W4	0.80		
ECH84	0.80	PCL84	0.90	1U4	0.80	6L6M	2.80	35Z4GT	0.80		
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EF39	1.25	PL81	0.85	3A4	0.70	6LD20	0.70	80	1.70	SN7408N	0.18
EF80	0.65	PL82	0.70	3AT2	2.40	6KG6A	2.70	85A2	1.40	SN7445P	0.85
EF83	1.75	PL83	0.60	3D6	0.50	6Q7G	1.30		2.55*	SN74453P	1.10
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EF812	0.75	PY80	0.70	5U4G	0.75	6V6GT	0.95	954	0.60	cX4	0.95
EFL200	1.85	PY81/800	0.85	5V4G	0.75	6X4	0.95	955	1.20	SN76013N	1.80
EH90	0.85	PY82	0.65	5Y3GT	0.95	6X4WA	2.10	956	0.60	SN76003N	1.60
EL32	1.10	PY83	0.80	5Z3	1.50	6X5GT	0.65	957	1.05	SN76033N	1.35
EL34	1.80	PY88	0.60	5Z4G	0.75	6Y6G	0.90	1625	1.80	MC6800P	5.80
	2.90*	PY500A	2.10	5Z4GT	1.05	6Z4	0.70	1629	1.85	MC68B00P	
EL81	2.45	PY809	6.45	6/30L2	0.90	7B7	1.75	2051	2.90		6.40
EL82	0.70	PY801	0.80	6AB7	0.70	8BN8	2.95	5763	4.20	MC14511BA	
EL84	0.80	QQV03/10	7.50	6AC7	1.15	9D2	0.70	5842	7.50		2.20
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EL90	1.00		21.50	6AH6	1.15	10C2	0.85	5933	6.90	MM6300-1J	
EL91	4.20	QQV03-25A		6AK5	0.65	10F18	0.70	6057	2.20		3.80
EL95	0.80		36.50	6AK8	0.60	10P13	1.50	6060	1.95	MCM6810AP	
EL504	1.70	QQV06/40A		6AL5	0.60	11E2	19.50	6064	2.30		3.40
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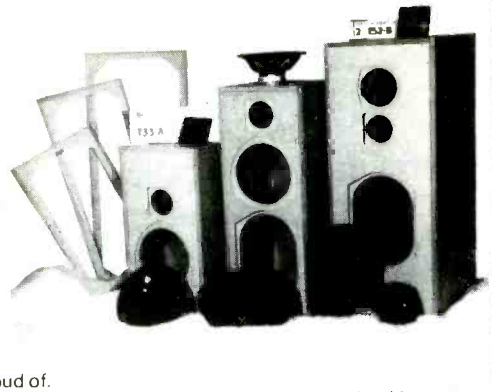

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The editing and emulation facilities, video output and serial/parallel input/output provided as standard make the EP4000 very flexible to allow its use in three main modes:

- As a stand alone unit for editing and duplicating EPROMs.
- As a slave programmer used in conjunction with a software development system or microcomputer.
- As a real time EPROM emulator for program debugging and development (standard access time of the emulator is 300ns).

Data can be loaded into the 4k x 8 static RAM from a pre-programmed EPROM, the keypad, the serial or parallel ports and an audio cassette. Keypad editing allows for data entry, shift, move, delete, store, match and scroll, and a 1k x 8 RAM allows temporary block storage. A video output for memory map display, as well as the built-in 8 digit hex display allows full use of the editing facilities to be made.

Items pictured are: ● EP4000 Emulator Programmer – £545 + £12 delivery; ● BSC buffered simulator cable – £39; ● MESA 4 multi EPROM simulator cable – £98; ● 2732A Programming adaptor – £39; ● 2764 Programming adaptor – £64; ● 2564 Programming adaptor – £64; ● BP4 (TEXAS) Bipolar PROM Programming module – £190

Also available (not shown): ● VM10 Video monitor – £99; ● UV141 EPROM Eraser with timer – £78; ● GP100A 80 column Printer – £225; ● PI100 interface for EP4000 to GP100A – £65.

VAT should be added to all prices

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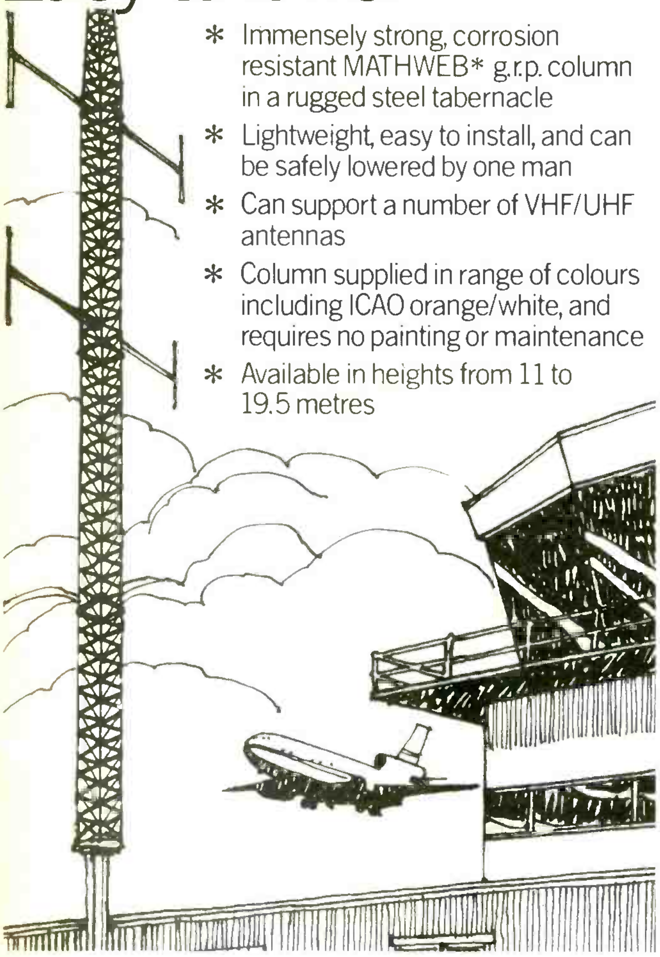

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For more information talk to Chris Pettitt, Marketing Manager, Antenna Systems Division.

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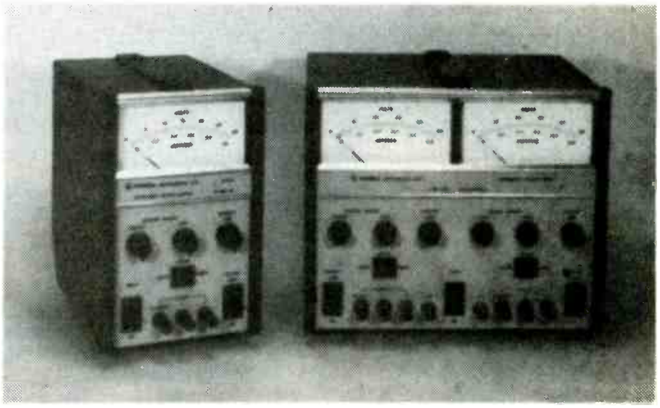

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L12-10C*	0-12V, 10A
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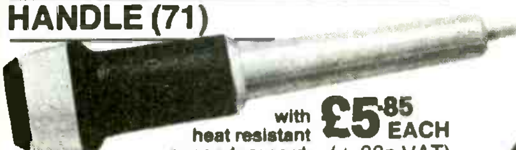

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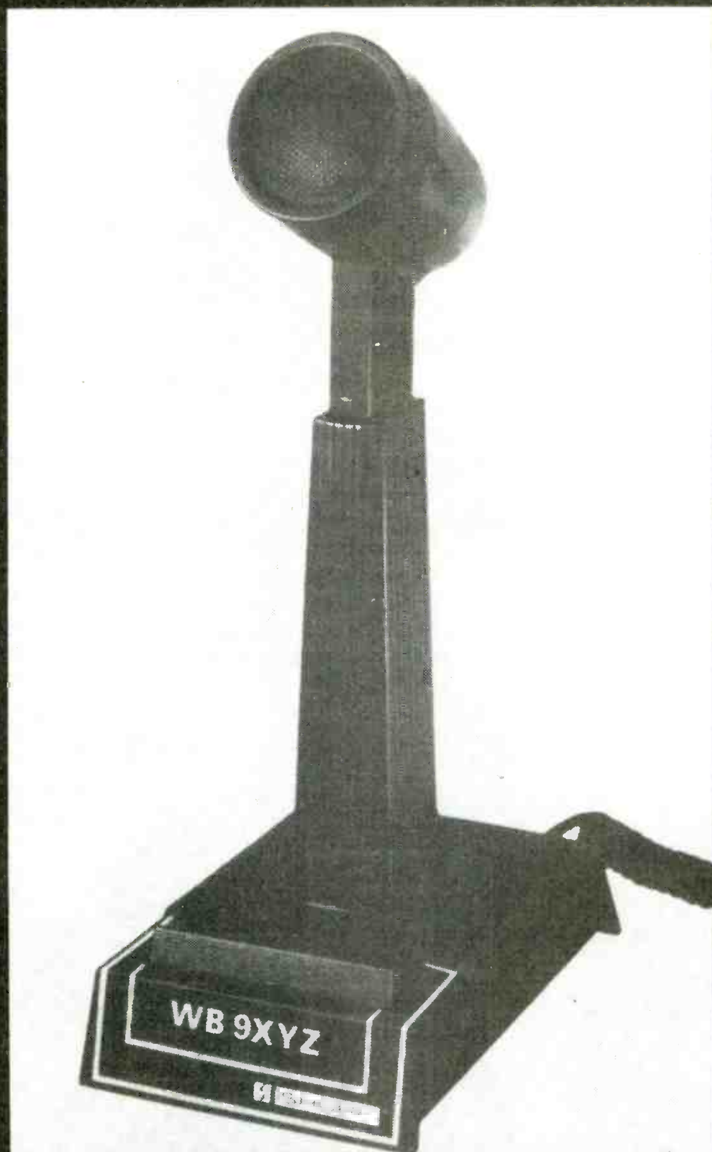

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Vision of the future

Viewed dispassionately, broadcasting information between fixed points on the earth seems to be a nonsense – a little like throwing a bowlful of sugar in the air in the expectation that some of it will fall into one's cup of coffee.

The UK is about to take the step of laying broad-band cables (optical-fibre and copper coax.) to provide more television, radio and interactive information services in the home, at a cost of several thousand million pounds. This use of cable is greatly to be applauded – not necessarily because yet more television will be provided, but because it at least makes possible the eventual use of the radio spectrum at v.h.f. and u.h.f. up to 1GHz for communication between mobile stations, which cannot use alternative means.

But there is some doubt, at least, that cable, used in the way recommended by the Information Technology Advisory Panel, is the best way of going about it. Thirty channels, twenty of them for entertainment, are proposed for the main network of optical fibre, but a reversion to copper in the form of coaxial cable for each group of users will reduce the bandwidth to around 35MHz – say four tv channels and interactive information for banking, shopping, alarms, etc.

There seems little need to institute a new programme of cable laying to provide not much more in the way of facilities than already exists, particularly when the new Telecom digital telephone network will be able to handle the two-way information – teletex, and the rest – quite adequately. If there is a real need for tens of channels of television – a need felt by viewers, not that experienced by those hoping to see the first Lord Thomson of Fleet's remarks about commercial television revived – then a direct-broadcasting satellite is the answer.

Given a commercial incentive, it seems more than likely that small dish aerials and down-converters could be manufactured at a reasonable cost, and the compromise solution, microwave distribution of satellite broadcasts, would possibly be somewhat cheaper.

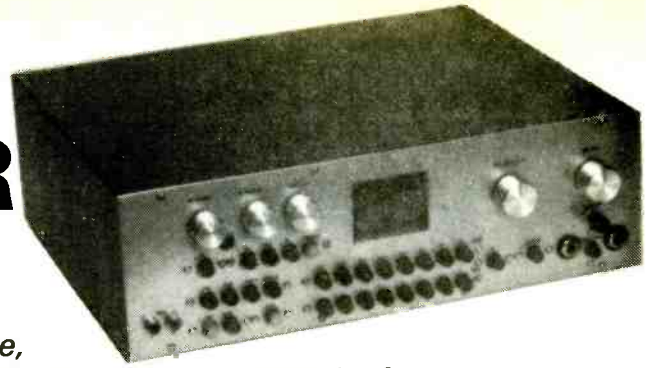
British Telecom are, after all, in the business of cables, and have been since the telephone; they would therefore seem to be the best people to instal, and supervise any system of communications using cable as a medium. The BBC and IBA have unrivalled reputations in the production of programmes and in the technical business of broadcasting. Who better, then, to continue to do so?.

The 'nonsense' of broadcasting may not, therefore, be quite as nonsensical as it seems, so long as it can be kept well away from those users who need radio communication for other than entertainment purposes – the real users of radio.

The rush of information technology to the head evidently being experienced by the government could, if not regulated by wise counsel, undo the years of effort by broadcasters to provide superbly well-engineered and programmed services. There is no need for national cable television: its popularity in the US is only in part due to the proliferation of channels it affords. US television suffers from two handicaps vis-à-vis its UK counterpart – its use of the NTSC standard and its infestation with 'sponsorship'. NTSC does not take kindly to the kind of terrain US cities provide – phase errors more or less ignored by PAL create chaos in NTSC – and the kind of programmes Americans receive from broadcast transmissions are not of the highest quality in the first place. And yet only about a third of US homes are connected to a cable. In the UK there would be even less point in taking cable signals, where almost everyone can receive good signals and reasonably good programmes.

Why the need for haste? It seems unlikely that the increased export market for programmes and services anticipated by Kenneth Baker at Communications '82 would materialize, and a sudden Cabinet fascination with IT is not a good reason for impetuous change in the name of progress.

MODULAR PREAMPLIFIER



A matching unit to the 80-100W power amplifier described in the June, July and August issues of Wireless World. Each circuit in the design is separate, and can be included or omitted, as desired, or switched in and out from the front panel. The design includes a noise blanker and image-width control

by J. L. Linsley Hood

In the July 1969 issue of *Wireless World*, and in a subsequent postscript in December 1970, I described a 'Modular preamplifier' which I had built to drive a Williamson (valve-operated) audio power amplifier (subsequently replaced by a pair of 10 watt, class 'A' transistor-operated power amps).

This preamplifier was of modular form almost by accident, in that it was intended to fit, with the minimum of inconvenience, into odd corners within the massive antique oak 'radiogram' cabinet which currently housed the Williamson power amplifer, the turntable, a home-made communications receiver, and the existing valve preamplifier – together with a short exponential-horn loudspeaker unit! To remove the valve preamplifier was too difficult a task, since it was integral with the demodulator and i.f. stages of the radio receiver, so its replacements would have to fit in where they could. This necessitated the assembly of the pre-amp. circuit from a series of modules having a low output impedance and a high input impedance, so that they could be interconnected as required by lengths of screened cable without the need to worry about any audible degradation of frequency response.

In the event, it became clear that a modular design of this type had many attractions for potential constructors, in that they could use those bits which fitted their needs, and ignore those for which they had no requirement. The attractiveness of this approach has remained with me, and was very much in my mind when I considered what type of signal conditioning stages I should use to precede the 80-100 watt power amplifier, if these were to be of interest to anyone other than myself.

However, much has changed since 1969, and it was apparent that in the fiercely competitive and highly demanding world of 'Hi-fi' of the 1980s, much more was necessary than the types of circuit block which were merely a large improvement on a rather off-colour 1950 d.i.y. hotchpotch. I have, therefore, tried to take a new look at what could or should be provided in the way of signal amplification and conditioning prior to the main power amplifier stage, and to put together circuits which would meet these requirements with the greatest economy in circuit design consistent with the type of performance now expected from such equipment.

The task of the circuit designer in this field has been enormously assisted by the availability of low-noise, low-distortion integrated circuit operational amplifiers of the Texas Instruments 'TL071-TL072' series, and its equivalents such as the NS 'LF351-LF353'.* Under proper conditions of use, these can give a total harmonic distortion, over the whole effective audio bandwidth, of the order of 0.01% at 10 volts r.m.s. output, and with an effective input noise resistance of the order of 2000 ohms or less. This makes it a

* An article by J.L.L.H. on these integrated circuits appeared in *WW*, September, 1982.

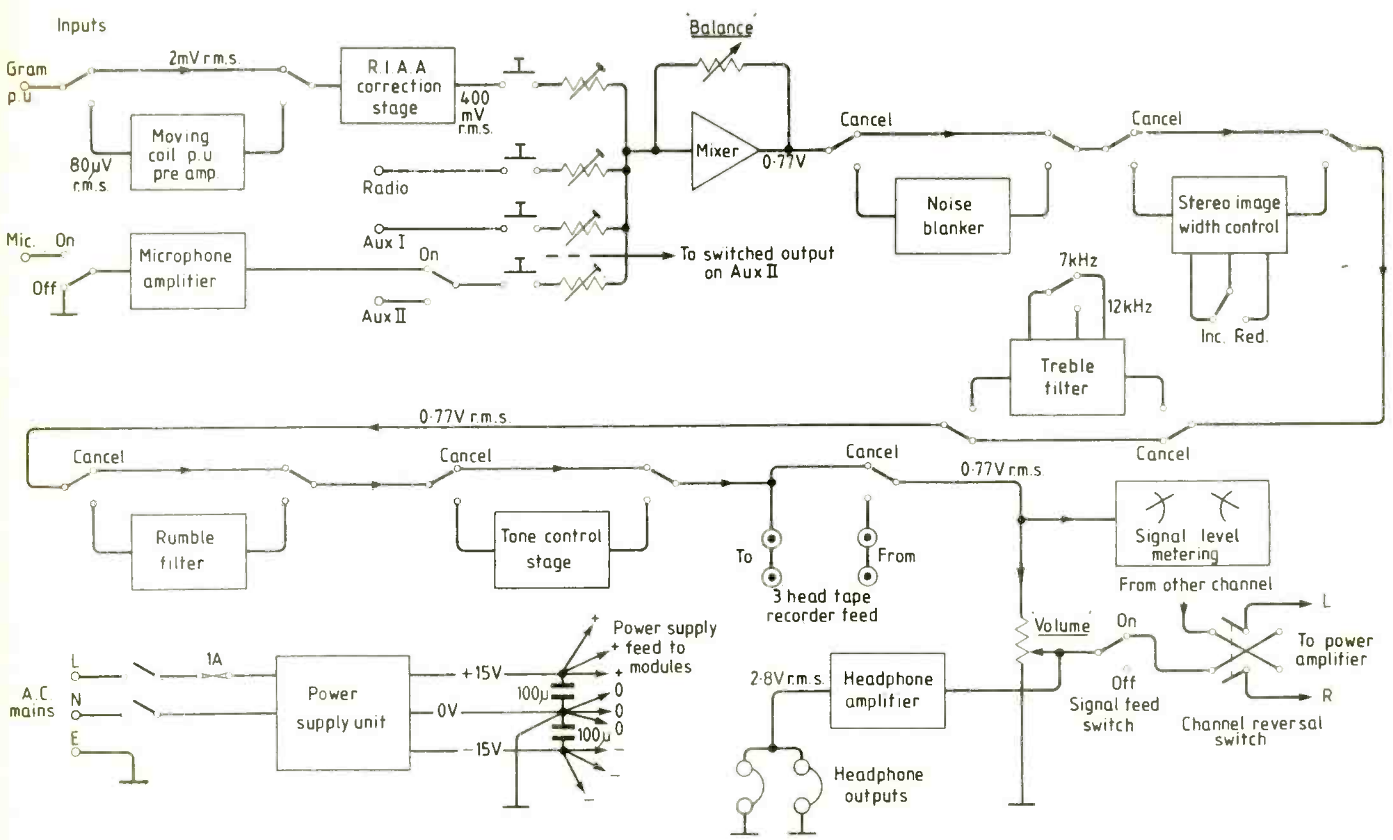


Fig. 1. *Layout of modules in preamplifier assembly, shown in the mode adopted for normal input from a good quality record.*

sensible proposition to envisage the pre-amplifier modules operating at the 0dB level (referred to 0.774V r.m.s. in 600Ω), employing this type of op. amp. gain block, to give both an adequate overload margin and a negligible contribution to total circuit noise and distortion. (The gain characteristics of the power amplifier unit were chosen to give maximum output at 0.774 V r.m.s. input).

I should, perhaps, explain at this point that my decision to use conventional 'audio-oriented' operational amplifiers, rather than the many, often equally good, special-purpose 'consumer' circuit blocks which are readily available, is due mainly to inward doubts on my part as to whether such consumer i.cs, with their special circuit applications and their unique package and pin configurations, have an adequate guarantee of availability. Certainly some of these introduced during the 1970s have long since vanished, while the 8-pin dil or T099-based 741 and its successors have gone from strength to strength, as process or technology improvements have been incorporated into 741 pin-compatible designs – such as the TL071!

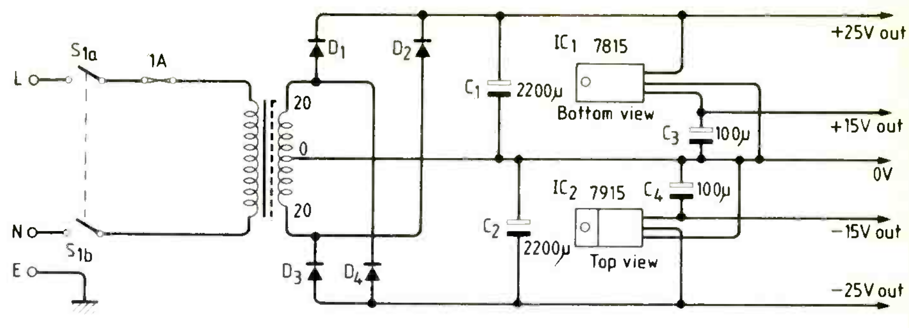


Fig. 2. *Circuit diagram of power supply. Toroidal transformer from RS Components.*

Basic design philosophy

The intention of the design is to handle the signal, at all stages after the input-signal amplification, at a low impedance – say 600 ohms – and a peak signal level not greatly in excess of 0.774 V r.m.s. through a series of optional, unity-gain, non-inverting conditioning modules (there is one exception to this, to which I shall refer later). They can be included or omitted as required without design problems, or indeed – as in the case of the prototype – included physically but omitted or selected by means of a switch. This allows the signal handling chain to have as few elements in its sequence as is necessary, while allowing the inclusion of other stages as and when these are thought to be useful. The modules I have included in this design are: a microphone amplifier; a low-noise, low-impedance head-amplifier intended specifically for use with moving-coil pick-ups; a two-stage 'series-shunt' RIAA-characteristic pick-up input amplifier; and a four-input, virtual-earth mixer stage. The output signal level from this stage is at a nominal 0.774V, 600 ohms impedance, and the subsequent stages operate at this level. These are: a noise-blanker stage to minimize the annoying intrusion of 'clicks' due to scratches on records; a stereo 'image-width' control stage; a two-frequency, variable-slope treble filter; an eight-octave ±3dB additive lift or cut tone-control stage; a rumble filter having a steep cut (approximately −22dB/octave) below 30Hz; and a signal strength display meter.

For convenience in the use of the pre-amplifier when recording on to tape from the microphone inputs, I have also included a separate, twin-output headphone amplifier, in parallel with the switchable output to the main amplifier. This allows the preamplifier to be used on its own as a very high quality system for private headphone listening.

These stages are all based, where practicable, on the use of dual fet-input, low-noise operational amplifiers (TL072 or equivalent) operated from ±15V d.c. supply lines, which are derived from a conventional bridge-rectifier power supply via a pair of positive and negative output integrated-circuit voltage stabilizers (7815/7915 series). This gives a signal line which normally resides within 15mV of the 0V centre-line potential, and eliminates clicks when stages are switched in or out of circuit.

I have shown the layout of the prototype preamplifier, in block diagram form, in Fig. 1, though I expect that most potential users would wish to employ a simpler combination of these component modules.

With this last thought in mind, I have described the modules, not in the sequence in which they have been listed above, but in their order of practical importance from the point of view of the user wishing to build the simplest of the possible useful combinations.

Power supply unit (Fig. 2)

This is of simple and conventional form, using a small, 10VA 20-0-20 volt p.c.b.-mounted toroidal transformer, a bridge connected rectifier, and a pair of integrated-circuit voltage regulators giving a smooth, reasonably ripple-free pair of 15V supply lines. In addition, a pair of less well smoothed 25V lines are provided for the headphone amplifier circuit, to avoid the possible intrusion of undesirable high-current signal components into the voltage supply lines used to power the early, small signal, stages.

Although small toroidal transformers are substantially more expensive than their 'E' and 'I' cored counterparts, the very low external magnetic field associated with these toroids make it very much easier to incorporate a power supply on to the pre-amp. chassis, without hum problems. Even so, care should be exercised in the disposition of the wiring associated with the inputs to the microphone amp., the RIAA stage, and, particularly, with regard to the moving-coil head amplifier. All in all, I think the extra cost of the toroidal transformer is amply justified.

Mixer stage (Fig. 3)

Although most normal usage of any pre-amplifier will not require any form of signal mixing, nevertheless some form of input amplification and impedance transformation will be needed for most likely external input sources if it is intended to handle the signal through the remaining stages of the preamp. at 0.77V r.m.s. and a nominal 600 ohms line impedance. Nothing will be lost, therefore,

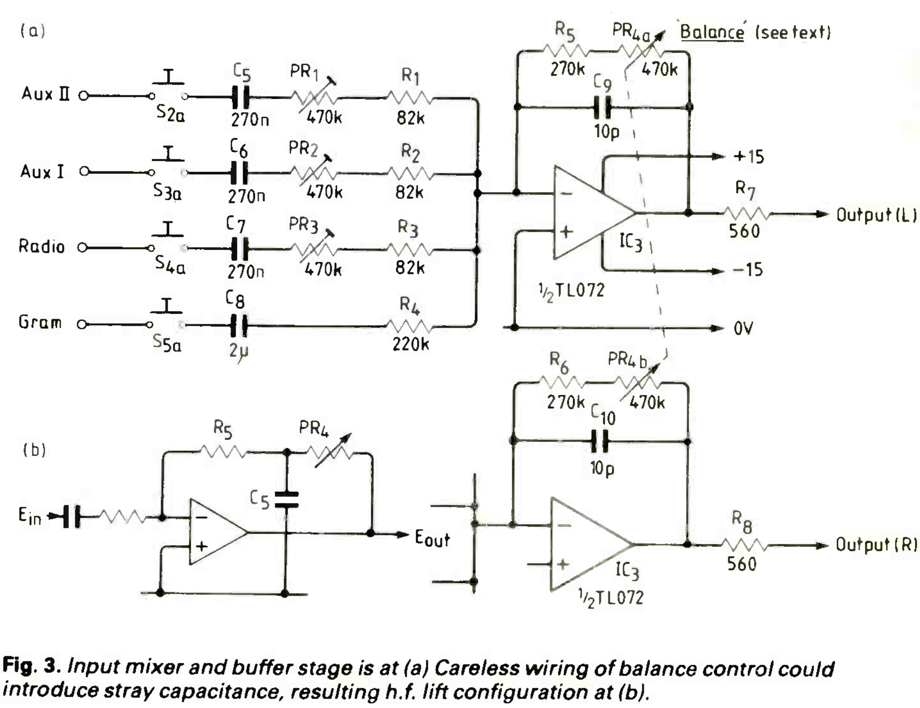


Fig. 3. *Input mixer and buffer stage is at (a) Careless wiring of balance control could introduce stray capacitance, resulting h.f. lift configuration at (b).*

in economy or simplicity, if the input buffer amplifier is arranged as a 'virtual-earth' mixer stage, which can operate equally well with a single or with multiple inputs.

A minor inconvenience does arise, however, in this context, due to what I think of as the absurd DIN convention for signal outputs from such things as radio receivers and tape recorders. This stipulates an output operating effectively as a constant-current source, giving an output voltage of 1mV for each 1kΩ of load resistance. This cannot give a decent signal to noise ratio at load impedances much less than some 100kΩ, and at this value or above, care must be taken to avoid electrostatically induced 50Hz ripple. The need to cater for inputs of this type has forced the adoption in this circuit of component resistor values which are much higher than I would otherwise have preferred. If the user intends only to use the circuit with signal sources having output impedances of 10kΩ or lower, all of the resistor values in the circuit can be reduced, with advantage, by a factor of 10, which will much reduce 'hum' pick-up and similar problems. If this is done, however, the capacitor values, with the exception of C_9 and C_{10} should be proportionally increased.

Only one channel is fully drawn in Fig. 3(a): the other channel is identical with the exception of the connexions to the 'balance' potentiometers ($PR_{4(a)}$ and $PR_{4(b)}$) which are reversed, so that one half will increase in value as the other is reduced. One point should be noted, however, in wiring this potentiometer – screened cable should only be used for this as a last resort, if the siting of the mixer circuit board makes it essential, since the effect of stray capacitance will be to form the circuit shown in Fig 3(b), which operates as an h.f. 'lift' configuration. The purpose of the small capacitors (C_9 and C_{10}), of 5-10pF value, is to preclude possible instability due to this type of stray capacitance. An ideal embodiment of this circuit would be to enclose it within a small metal box, within which the balance pot. could be fixed, and short, unscreened leads used in its wiring.

On setting up, the input potentiometers (and the gain pots within the RIAA stage) should be set so that the signal levels on all the inputs peak at about the 1V level (0dB+3dB).

Series-shunt RIAA equalizing stage (Fig. 6)

Few aspects of audio engineering have generated so much debate as that concerned with the niceties of the frequency response correction required for the reproduction of RIAA-standard gramophone recordings. This debate is, I think, fully justified since so many of the circuit configurations employed to achieve this aim, even when apparently quite well designed, can be shown by mathematical analysis, when all the appropriate circuit parameters are included, to perform relatively badly.

The basic RIAA replay specification stipulates the response curve generated by three time constants – 3180, 318 and 75 microseconds. This leads to the well-known curve shown in Fig. 4(a) in which the 3dB break points occur at 50.05Hz, 500.5Hz and 2122.1Hz, and in which the response at 21.221kHz and the l.f. asymptote below 20Hz are respectively −20dB and +20dB with respect to 1kHz. Part of the performance shortcomings of even well-known and prestigious commercial units stem from the almost universal adoption of the equalization circuit arrangement shown in Fig. 5(c), which employs series-connected feedback. This is done because it allows a lower apparent input noise component when measured under input short circuit conditions, although this advantage is lessened when measured with pick-up cartridge inductance in circuit. The snag with the arrangement of 5(c) is that it has a gain characteristic which tends to unity at high frequencies, as shown in Fig. 4(b), which gives a transient response to the system which is significantly different from that ideally required, and this difference is, in my experience, quite audible.

The possible configurations which can be used to provide the RIAA characteristic compensation are shown in Fig. 5. An almost perfect approach to the required curve is possible with the passive network of (a) and the shunt feedback system of (b). The difficulty in the case of (a) is that some form of input buffer amplifier stage is necessary, and this will work under non-ideal conditions of high signal inputs at high frequencies, leading to problems of overload margins. For this reason it is seldom employed commercially. The somewhat less good overall noise figure associated with the circuit arrangement of (b) has also ensured its neglect in commercial designs, even though it has the merits of simplicity and accuracy of frequency and transient response. The inherent unity gain at h.f. characteristic of (c) presents the circuit designer with a problem, in that the unwanted h.f. break-point depends on the feedback factor. If a low closed-loop gain is used, to allow a high measure of n.f.b. in the interests of circuit linearity and constancy of input impedance, the upper break point will occur at a lower, and more instrusive, part of the frequency spectrum. On the other hand, a high closed-loop gain may not offer adequate circuit performance.

A solution to this dilemma may be found in the addition of a supplementary CR time-constant, as shown in (d), to straighten out the unwanted h.f. break-point due to the amplifier reverting to

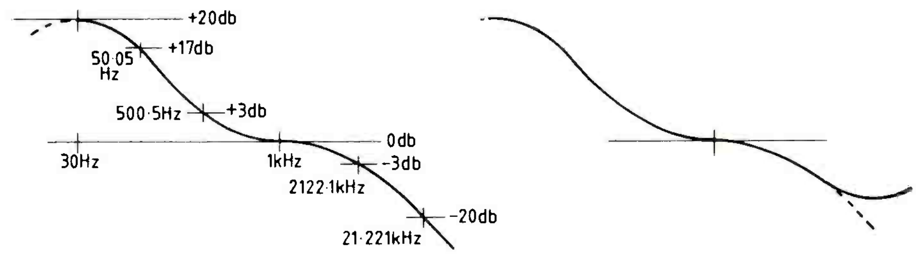


Fig. 4. *RIAA recommended equalization characteristic (a). Curve at (b) shows response of series-feedback circuit seen at Fig. 5 (c).*

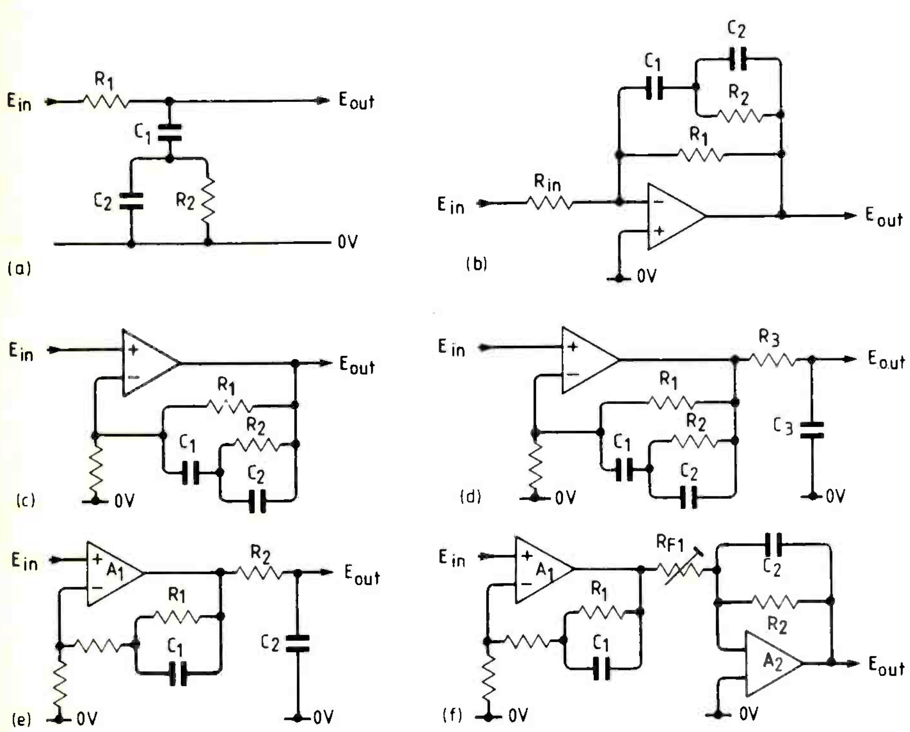


Fig. 5. *Possible RIAA correction circuit arrangements: passive circuit (a); shunt feedback (b); series feedback (c); series feedback with h.f. correction RC; series plus passive network; series/shunt feedback.*

Table 1
Gain of RIAA stage as a function of signal frequency

F_{in}(Hz)	Gain (dB)	
10	60.33	due to input coupling capacitor and feedback d.c. blocking capacitor (C_{11} and C_{114})
20	61.25	
30	60.64	
50	58.95	
100	55.05	
200	50.06	
500.5	44.47	
1k	41.63	
2122.1	38.81	
3k	36.89	
5k	33.41	
10k	27.89	
21.221k	21.67	

Note. The recent amendment to the RIAA recommended curve below 30Hz is intended to take recognition of unwanted v.l.f. components of signal output and is redundant where ancillary rumble filtering is available.

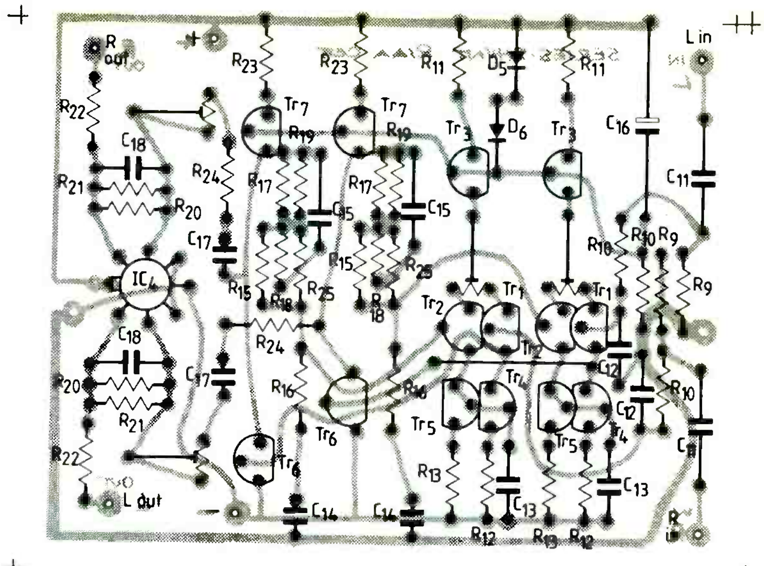


Fig. 7. *Printed-board pattern and component layout for RIAA stage.*

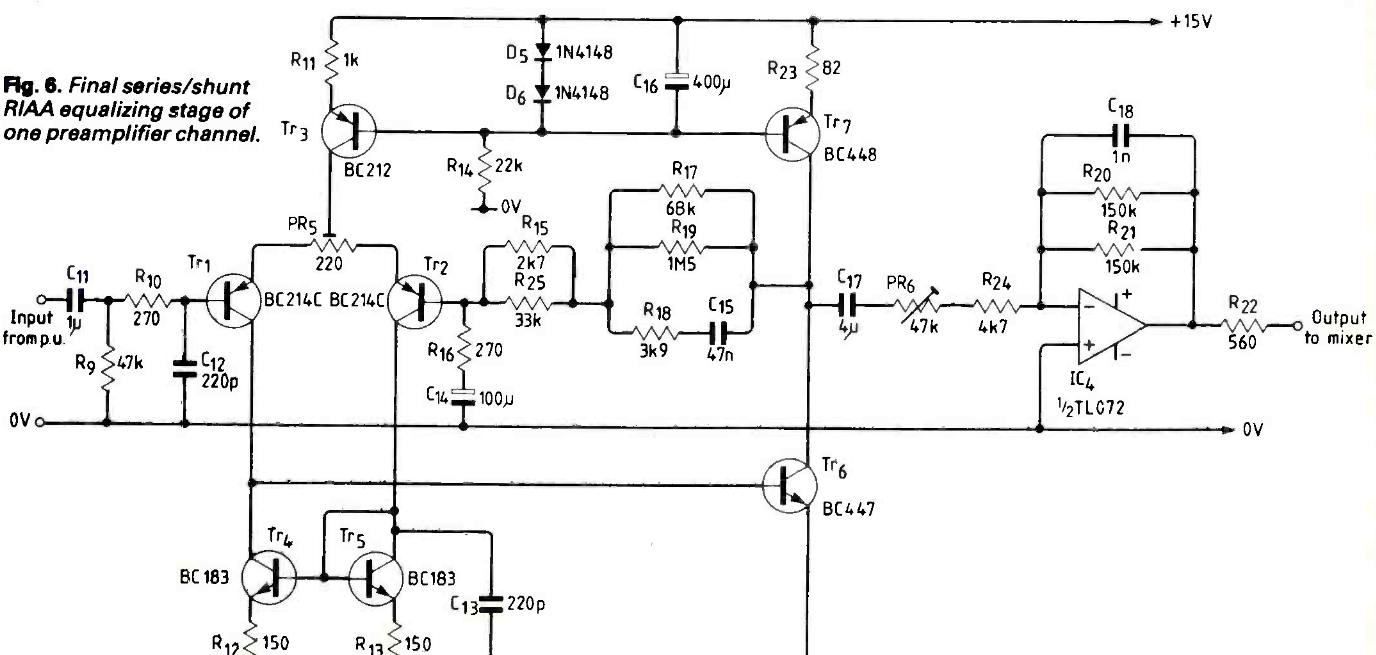
unity gain. This, however, leaves the query as to why, if a passive h.f. integrating time-constant is to be employed at all, this should not have the 75μs characteristic called for by the RIAA specification, leading to the system of (e), which has been used for some years by one or two of the more thoughtful manufacturers. This can have an almost ideal frequency and transient response, and its only snag is that the inherent attenuation of the output integration network requires that the output of the amplifier A_1 must be fairly large at h.f., which lessens the possible overload margins of the system.

This difficulty can be removed if the passive integration network is replaced by an active stage, as shown in (f), which results in a very satisfactory solution to the various conflicting requirements of this stage, and, in view of the ready availability of high quality i.cs, having a satisfactorily low noise component at the signal levels associated with this second stage, does not substantially increase the cost of the system in comparison with that of (e). Moreover, the independence of the overall performance, apart from gain, of the circuit in respect of the value of R_{f1} allows this to be used to set the overall RIAA stage gain. In view of these many advantages I have used this 'series-shunt', two-stage configuration as the RIAA input stage in this design. Because the target noise resistance, referred to the input, was 500 ohms, which is lower than can be obtained from currently available i.c. operational amplifiers, I have used a discrete component design for the input stage. The circuit of this is shown in Fig. 6.

This is of conventional form, employing an input long-tailed pair of low-noise p-n-p transistors (Tr_1, Tr_2) driving a current-mirror load (Tr_4, Tr_5). Transistors Tr_3 and Tr_7 are constant-current sources for the input long-tailed pair and the output class A amplifier stage (Tr_6). The RC network C_{14}, C_{15}, R_{15}, R_{16}, R_{17}, R_{18}, R_{19} and R_{25} provides the required frequency response adjustment for the 10Hz-1kHz part of the RIAA curve, while the network C_{18}, R_{20} and R_{21} gives the necessary 75μs de-emphasis to generate that part of the curve from 1kHz upwards.

The input integration network R_{10} and C_{12} lessens the possibility of radio signal breakthrough, and the potentiometer PR_5 allows the output signal voltage to be adjusted to a level adequately close to 0V, if it is desired to operate the amplifier in a completely direct-coupled mode to minimize v.l.f. phase-shifts. The calculated frequency response of the RIAA stage, for all the component values shown, is given in Table 1. In this the l.f. open-loop gains of the two amplifier stages are assumed to be 100,000 (which is close to

Fig. 6. *Final series/shunt RIAA equalizing stage of one preamplifier channel.*



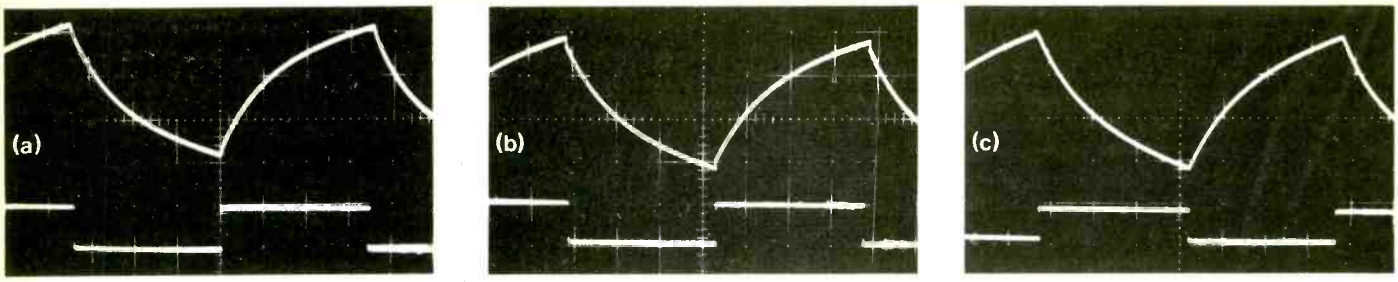


Fig. 8. *Response of equalizing circuits to square-wave input. Passive circuit of Fig. 5(a) produces curve (a); curve (b) is output of system when conventional series-feedback equalizer is used; series/shunt circuit chosen and shown in Fig. 6 produces trace at (c).*

Table 2 Performance of RIAA stage

Maximum output voltage swing	10V r.m.s.
Distortion at 10V r.m.s. and 1kHz	0.01%
Distortion at 10V r.m.s. and 20kHz	0.018%
Current consumption (two channels)	17mA
Distortion at 0.774V r.m.s. and 1kHz	0.003%
Input noise resistance	450 ohms

(Measured with first stage only, and with feedback network adjusted to give a flat response gain of 100×. Input s/c, measurement bandwidth 250kHz, temperature 20°C.)

Mains hum components (50 and 100Hz) −100dB ref. 0.774V when fed from recommended power supply.

the expected value), and a value of 10kΩ is assumed for the total value of PR_6+R_{24} – this will only affect the gain, not the frequency response. The conformity of the frequency response to the RIAA standard, using preferred-value resistors and capacitors, is within 0.2dB over this frequency range. In view of likely component tolerances it does not seem profitable to aim for a closer fit than this. The other performance characteristics of the circuit are listed in Table 2.

Since the layout of the circuit may be critical to its performance, I am showing the p.c.b. layout employed in the prototype in Fig. 7. Measurements on the performance of this showed agreement with the calculated results within the 0.5dB level of confidence in the accuracy of test instruments and signal sources.

To illustrate the differences in the transient response given by the various possible types of RIAA equalizing stage, Fig. 8 shows the output given by the system when it is driven by an input 1kHz square wave. That of a passive RC equalizing network is shown at (a), that from a conventional series-feedback system with an upper gain asymptote of 25kHz at (b), and that from the series-shunt feedback system adopted in Fig. 6 in that of (c). This is very similar in shape to that given by the passive network.

Overload margin

An important design characteristic in any input stage, where this precedes any signal level control, is its ability to avoid input overloads. Typical moving-magnet and variable-reluctance cartridges have output signal levels in the range 0.5-2mV/cm/s recorded velocity. The highest modulation levels capable of being traced by the best of modern cartridges are of the order of 40cm/s, but, in general, the maximum groove velocities will be a good bit less than this. These very high modulation levels also only occur at frequencies in excess of 1kHz – since at lower frequencies there would be a substantial risk of groove breakthrough. The first stage gain at 1kHz is 28.58dB (26.85×) which would give a worst possible output voltage of 2.15V at the collector of Tr_6. The clipping level at this point is 10.2V r.m.s., which gives an adequate margin for overload avoidance. The gain of the second stage can be made as low as necessary by adjustment to PR_6. The 47kΩ value suggested is likely to cover all practical cartridge requirements.

Practical preamplifier system

Although the complete preamplifier, in its prototype form, contains more modules than this, a very satisfactory performance will be given, under most normal conditions, by the relatively simple system built up from the units described above, comprising the RIAA input stage, the mixer module, and the ±15 volt d.c. power supply unit, with the power amplifier stage fed directly from a 10kΩ log. dual-gang pot connected to the output of the mixer module, as shown in Fig. 1. Indeed, for the bulk of my own listening, this is all I leave switched into circuit.

The remaining modules and some constructional notes will be given in the following parts of this article. WW

THE ETHER – AN ASSESSMENT

Does the ether exist? Dr Aspden shows that Oliver Heaviside's insight could have pre-empted Einstein's success with the General Theory of Relativity and encouraged investigations into the properties of the ether.

by H. Aspden*

Ph.D., B.Sc., F.I.E.E.

Though relativity has very little bearing upon the practical problems of radio transmission, it does preclude belief in the ether and wave propagation as contemplated by Maxwell, leaving us with no tangible alternative. Until we have a better understanding of the vacuum medium and the way in which it regulates electromagnetic wave motion, it is likely that Einstein's ideas will be questioned.

Essex, writing about relativity and time signals (*Wireless World*, October 1978), and Wellard, writing about the work of James Clerk Maxwell (*Wireless World*, March and May, 1981), both evoke this controversy.

In fact, special relativity, which dates from 1905, has very dubious support, because alternative explanation of $E = Mc^2$ and mass increase with speed is available from textbooks on classical electromagnetism[1]. Besides, the transmutation of mass and energy, the basis of $E = Mc^2$, was recognized by Jeans, writing in 1904, one year before Einstein introduced his theory[2]. How, then, can we have confidence in relativity, when Essen demonstrates so convincingly the absurdity of expecting time to pass at a different rate when perceived by different observers in relative motion?

Einstein's theory really depends, for its acceptance, principally upon the success of the later 1916 General Theory of Relativity, which brought a slight modification to Newton's Law of Gravitation. The successive elliptical orbits of the planet Mercury were known to have a progressive advance, part of which was anomalous, as judged from Newton's Law. Einstein's Law gave the right answer and relativity was thereby acclaimed.

Einstein made no reference to an earlier paper by Gerber[3], entitled 'The Space and Time Propagation of Gravitation'. It appeared in 1898, eighteen years before Einstein wrote on the subject, and gave precisely the same formula for the advance of Mercury's perihelion as that presented by Einstein. Gerber's paper explained how the anomalous perihelion motion of the planet could be explained by recognizing that gravitation propagated at the speed of light. When Einstein's paper appeared in *Ann. d. Phys.* in 1916, a colleague of Gerber arranged for the publication of an updated version of Gerber's work in the 1917 issue of this same journal. However, Gerber, then deceased, was unable to defend his theory against attack. It was in error; the direct propagation of gravitational action between sun and planet at the speed of light only gives a partial account of the anomaly.

Meanwhile, as we may read from the opening passage of Leon Brillouin's book 'Relativity Reexamined'[4], Heaviside, in 1893, had pointed out that 'to form any notion at all of the flux of gravitational energy, we must first localize the energy'. If this is taken to heart, it leads us to recognize that the flow of gravitational energy is not directly along the line between sun and planet, but is, of necessity, via a longer route. The energy must flow from one of these bodies to the surrounding field and then from the field to the other body. This modifies the resulting retardation of gravitational action and affects the perihelion motion accordingly. The result, as the author[5] has shown, is in exact accord with that originally predicted by Gerber. Einstein's Law of Gravitation, the only significant consequence of his general relativity theory, can be deduced by a simple classical analysis, which exploits the intuitive remark of Oliver Heaviside dating from 1893.

This, in itself, does not prove that Einstein's theory is wrong. We do, however, have viable alternative theory which is quite simple, and one must wait for the experimental evidence to direct us on the right course. This evidence is likely to come from measurements evidencing the properties of the ether. Already, in 1980, we have the experimental data of Graham and Lahoz[6] showing that the ether can assert a force, and supporting Maxwell. Burrows (Letter to the Editor, *Wireless World*, October 1981) asserts that this is a one-off measurement needing verification. It is nevertheless backed by the discovery that the Earth's cosmic motion through space at a speed of some 400 km/s can be detected by measuring anisotropy in the intensity of the 3K background radiation. (See article entitled 'The Cosmic Background Radiation and the New Aether Drift' in *Scientific American*, May 1978). Furthermore, as we shall see below, it is supported by other evidence on electromagnetic-wave propagation suggesting that the Earth's West-East motion due to its rotation can be directly measured as a linear velocity by optical techniques.

On such a course, the ether is destined for reacceptance and Einstein's theory may have to yield ground. There is, therefore, purpose in reassessing the ether and its properties, and in this quest we will again be mindful of Heaviside. It is to his great credit that he discovered how to design a telegraph line capable of propagating signals without distortion. The inductive and capacitative properties of a telegraph line cause the speed of propagation to depend upon frequency. By appropriate matching of these properties, as well as resistance and leakance, the attenuated signal can propagate without distortion. Now, electromagnetic waves propagate through the ether without distortion and, though the ether is not subject to resistance and leakance, it does have inductance and capacitance, because there are magnetic fields and electric fields in the vacuum.

Nature, anticipating Heaviside's contribution to telegraphic communication, has provided that extra something in the ether to secure distortionless signal propagation. This becomes an important clue in our quest to understand more about the ether.

According to its dictionary definition, 'ether' is 'a medium, not matter, that has been assumed to fill all space and transmit electromagnetic waves'. With such definition, the 'ether' remains valid terminology. The problem which some scientists have in accepting the existence of the ether arises from a further assumption that the ether cannot adapt to its environment and so must regulate the constancy of the speed of light in a universal frame of reference. When motion of the Earth about the sun could not be detected by speed of light measurements in the laboratory frame, the very existence of the ether came under challenge. Yet what logic is there in saying that A is believed to have property B, but we cannot detect property B, so A does not exist? Surely, the only valid conclusion is that A may still exist but it appears not to have property B.

Why bother? We have Maxwell's equations and we have relativity. The latter tells us not to expect to detect anything at all except according to physical laws which adapt to the reference frame of an observer. Without an observer, whether real or hypothetical, there can, in

*IBM United Kingdom Ltd.

relativity, be no definitive physical phenomena. Hence we are supposed to live in a somewhat abstract world and are encouraged not to seek to understand the universal and uniform nature of whatever it is that permeates the vacuum and regulates electromagnetic wave propagation.

I have good reason for believing that a great deal of opportunity is being missed in scientific and technological research by accepting doctrinaire theory and not keeping an open mind on this ether question. For example, it is to the credit of those engaged in precision measurement in fundamental physics that some constants can now be determined to a few parts in 10^{12}. Such precision defies imagination if related to the measurement tasks we undertake domestically or in industry. Yet, what is really fascinating is that Nature is actually able to regulate physical quantities universally and hold them stable to such accuracy, notwithstanding environmental fluctuations, wherever we look in the universe. This surely suggests a fundamental mechanisma and a reference or control medium, having a universal metric binding all matter together as part of a common system. To me, this is the primary role of the so-called ether, with the light propagation characteristic assuming secondary importance.

By postulating an electric but neutral medium of the simplest possible kind and analyzing its structure, as if it were a kind of invisible and elusive crystal extending throughout space, the author[7], in collaboration with Dr Eagles of the National Standards Laboratory in Australia, has found it possible to deduce fundamental constants (notably $\alpha = 2\pi e^2/hc$) to the measured accuracy of less than one part per million. It is this that has committed me to a course of scientific enquiry founded upon a positive belief in the ether rather than a passive acceptance of a rather sterile theory of relativity.

In the above expression, e is the electric charge of the electron, h is Planck's constant and c is the speed of light *in vacuo*. Hence the dependence of α upon the metric of the ether medium is very closely related to electomagnetic wave propagation, because $E = h\nu$, Planck's radiation law, signifies the energy of quanta propagated as electromagnetic disturbances at the speed of light and at frequency ν.

It is a relatively simple task to show that this structured vacuum medium can accommodate to the propagation properties of electromagnetic waves, and particularly on two basic counts. These are: (a) the fact that the speed of propagation is referred not to an absolute frame but to one which can adapt to the reference frame of an Earthly observer and (b) the equally important fact that light travelling in true vacuum suffers no dispersion resulting from its speed varying with frequency.

From the optical characteristics of ionic crystals it is known that there is dispersion, significant at frequencies in the vicinity of the natural resonant frequency of the crystal. One should than bear in mind that energy quanta of sufficient strength can induce the creation of electron-positron pairs in the vacuum. This suggests that the ether sets a critical frequency threshold ν_0 and so may have an electrical structure conforming with this resonant frequency. Thus, in proposing a kind of crystal structure for the vacuum medium and establishing, as I have[7], that it has a natural frequency ν_0 given by mc^2/h, the Compton frequency of the electron of mass m, one is led directly into the question of dispersion.

Before dealing with this, consider first the other problem. Michelson's experiments towards the end of the 19th century have shown that the Earth itself determines the local frame in which light has a speed c independent of direction. This is not in the least surprising if we admit the vacuum medium to be electrically-structured. Lorentz has shown that, according to classical electron theory, the speed of light in matter depends upon electron density and the oscillation period of such electrons in material media. Electron density does not depend upon rotation, nor is it a vector. Therefore, the speed of light (as opposed to its direction) should be unaffected by rotation. Hence, if there is any theoretical connexion or analogy between this situation in matter and what may govern the speed of light in vacuum, the expectation must be that, in the laboratory vacuum, the speed of light is referred to the Earth's inertial (non-rotating) frame. An experiment aimed at detecting the Earth's rotation using optical techniques referred to the vacuum should give a positive result.

Such an experiment was performed by Michelson in 1925, confirming the classical expectation from ether theory by sensing the Earth's rotation. Earlier, Sagnac had sensed the rotation of optical apparatus by speed of light measurement, a technique now applied in the ring-laser gyro. It is assumed that detection of speed of rotation accords with relativity, owing to parts of the rotating apparatus having motion relative to other parts. On the other hand, if such experiments permit comparison of the speed of light East-West versus West-East and afford a measure of linear speed difference, it is relativity that is in difficulty. With the advance of optical measurement techniques, it should soon be possible to resolve this question.

For translational motion with the Earth, the vacuum structure acquires a linear displacement. Clearly, any displacement of electric charge in the vacuum must be transitory and oscillatory, unless it is balanced by a matching counterflow or reverse displacement of some of the charge present. Otherwise there would be a steady build-up of charge and an ever-increasing electric field. One may, therefore, visualize the vacuum as having two charge structures capable of moving through one another in opposite directions. This is quite possible because there are no rigid bonds between the charges, just electric field interactions.

It is this dual structure for charge displacement that is the key. The primary structure moves forward with the Earth. The secondary structure moves through the primary structure in the reverse direction and, by analogy with an optical effect named after Fresnel, we expect this reverse flow to affect the speed of light through the primary structure. Fresnel's theory explains why the speed of light increases in proportion to $u(1-1/\mu^2)$, where u is the velocity of the disturbing medium and μ is the applicable refractive index. This can be deduced from electron theory, but it has been verified by experiments in which the speed of light through moving water is measured.

Applying this same theory to the vacuum itself, and recognizing the counter displacement, it is an easy matter to arrive at the result discovered experimentally by the Michelson-Morley observations.

Let there be N like charges, e, per unit volume within an electrical continuum of uniform but opposite charge density σ. Then:

$$Ne = \sigma \tag{1}$$

Let N_1 and N_2 denote the population

'Being a physicist, Nurse, he may be allergic to ether, but ask him if he wants our high-speed rejuvenation treatment. Oh, and the nearest Relativist to contact if it fails.

density in the primary structure and the secondary structure, respectively. Then:

$$N = N_1 + N_2 \qquad (2)$$

On electron theory, the propagation velocity is proportional to $(ne^2/m)^{1/2}$, where there are n charges e of mass m per unit volume, also having a resonant mode at frequency given by the angular velocity ω:

$$\omega^2 = 4\pi ne^2/m \qquad (3)$$

From the properties of matter, we know that the propagation velocity in a structured medium is given by $(P/\rho)^{1/2}$, where P is the pressure modulus of the medium and ρ its mass density.

These considerations guide us to the formula:

$$c_1 = (P/N_1m)^{1/2} \qquad (4)$$

for the speed of light c_1 set by the primary vacuum structure, where ρ becomes N_1m. P becomes the pressure or energy density modulus of this primary structure.

Let v denote the velocity of the primary structure and u the velocity of the secondary structure in reverse flow. The linear momentum of the vacuum has to be zero unless there is a steady build-up of electric field. Hence:

$$vN_1 + uN_2 = 0 \qquad (5)$$

Even in the absence of matter, the vacuum has a refractive index μ referenced on the primary structure and attributable to the disturbing effect of the secondary structure. This is simply:

$$\mu = c/c_1 \qquad (6)$$

The speed of light in the frame of reference set by (5), the rest frame, then becomes c, the value set by the combined effect of the primary and secondary vacuum structures, augmented by the Fresnel drag of $u(1-1/\mu^2)$ caused by the disturbance of the secondary structure.

From (4) and (6), μ^2 becomes proportional to N_1, with P constant, so that, from (2), μ^2 is $1-N_2/N$ and $1-1/\mu^2$ is $-N_2/N_1$. We then see from (5) that $1-1/\mu^2$ becomes simply v/u. Thus the Fresnel drag in the vacuum, which is $u(1-1/\mu^2)$, is the velocity v of the primary structure, proving, from simple classical electron theory, that the speed of light will be referenced on the vacuum structure moving with the Earth, as was found by Michelson.

We do not need to appeal to relativity for an explanation of this basic observation. The Michelson-Morley experiment verifies that Maxwell's electric displacement can be a dual and reciprocal phenomenon. Oscillations of the electrical structure of the vacuum can occur at the resonant frequency ν_0 with no reverse motion of the secondary structure or counter-displacement. However, we may expect light propagation at lower frequencies to involve counter-displacement and it is this that brings a new and important dimension to Maxwell's theory. With it comes a solution to the dispersion problem.

Note that the frequency of an electromagnetic wave has no meaning at a point in space and time. Frequency concerns rate of change and this information implies comparison of signal strengths at two points in time or two points in space. However, given dual displacement at a point in space, as we now have in the theory just presented, the frequency can be codified by the relative strengths of the two displacement parameters.

The frequency of the signal is, in fact, preserved in transit through the vacuum medium, because the medium propagates two electric displacement signals in anti-phase, and the relative amplitude of the signal strengths determines the frequency. As we shall now see, this involves the vacuum adjusting to the signal in transit to adopt a locally-tuned condition having the resonant frequency of the signal. The frequency ν_0 at which electron-position pair creation occurs is the limit frequency beyond which there is no counter-displacement. However, the interesting point is that there is no forced oscillation and so no dispersion characteristic in the vacuum, since the vacuum adapts to any frequency and exhibits the properties of a tuned LC system.

It is easily shown how the capacitance and inductance of unit volume of the vacuum can be evaluated. The capacitance per unit volume is $1/4\pi$ and the inductance per unit volume is frequency-dependent and proportional to ρ/σ^2, where $\rho = Nm$ and $\sigma = Ne$.

The presence of an electric field of strength V signifies imbalance between displacement and counter-displacement, represented by a displacement distance x, where x is $x_1 + x_2$, x_1 and x_2 being the respective displacements of the primary and secondary structures and x_2 being a negative quantity. The restoring force on charge e is then:

$$Ve = 4\pi\sigma ex \qquad (7)$$

The energy stored by this displacement is $2\pi\sigma ex^2$, owing to the linear force rate, and, in energy density terms, this becomes $2\pi\sigma^2x^2$, which, from (7), is $V^2/8\pi$, as expected. This is also $\frac{1}{2}CV^2$, where C is the capacitance per unit volume, and so C is $1/4\pi$.

Under dynamic conditions, we can equate the force given by (7) with mx_1 to find a resonant angular frequency ω. (7) becomes $4\pi\sigma ekx_1$, where kx_1 is x. Thus, from (1):

$$\omega^2 = 4\pi Ne^2k/m \qquad (8)$$

At the threshold angular frequency $2\pi\nu_0 = \omega_0$ and this applies for the zero counter-displacement condition for which $x = x_1$ and $k = 1$. Thus, since k is $1 + x_2/x_1$, $(\omega/\omega_0)^2$ becomes $1 + x_2/x_1$, showing how the frequency ω is codified by the ratio of the displacements. (x_2 is negative.)

The value of the inductance L per unit volume is readily found from (8), because ω^2 is 1/LC and C is $1/4\pi$. We find that L is $(\rho/\sigma^2)/k$.

Such analysis assures us that the vacuum medium does not forcibly respond to the dynamic frequency characteristics of a signal. It propagates the primary and secondary displacements and the local vacuum resonates at the optimum frequency set by these displacements. In this way the signal frequency is preserved over vast distances.

The dual electrical displacement suggested above greatly strengthens the basis on which one can develop a phenomenological ether theory supporting Maxwell's equations. More important, however, it opens the path for new avenues of research into the effects of energy absorption from electromagnetic waves and their mutual interference. Meanwhile, note that Einstein's $E = Mc^2$ law, the keystone of special relativity and his law of gravitation, the basis of his general relativity, have both succumbed to alternative explanation [5-8].

It is likely to be in the optical measurement field, involving speed of light tests in relation to Earth rotation, that we may see the determining experiments, crucial to relativity. The ether will surely survive. WW

The Author

Following electrical engineering studies at Manchester University and two years of graduate training in industry, Harold Aspden did Ph.D. research on magnetism at Trinity College, Cambridge. Shortly after embarking on a career in the patents profession, some 29 years ago, he had an idea on electromagnetic reaction which intrigued him and led to a firm belief in the need for an ether. Dr Aspden has had success in his chosen career, having directed IBM's European Patent Operations for the last 18 years, but his ambition is to achieve success in his private quest to bring the ether back into favour. The very substantial scientific potential which Dr Aspden sees in an ether revival is evident from his book 'Physics Unified', published in 1980.

References

1. H. A. Wilson, 'Modern Physics', 2nd., Blackie, 1946.
2. H. H. Jeans, *Nature*, *70*, 101 (1904.
3. P. Gerber, *Zeitschrift f. Math., u. Phys.*, *43*, 93 Z1898).
4. L. Brillouin, 'Relativity Reexamined', Academic Press, 1970.
5. H. Aspden, *J. Phys. A:* Math. Gen., *13*, 3649 (1980).
6. G. M. Graham and D. H. Lahoz, *Nature*, *285*, 154 (1980).
7. H. Aspden and D. M. Eagles, *Physics Letters*, *41A*, 423 (1972).
8. H. Aspden, *Int. Jour. Theor. Phys.*, *15*, 631 (1976).

Falklands electronics

The fierce media criticism of inconsistent censorship and the absence of any video link with the British Task Force in the South Atlantic (at least until the despatch of Gresham Lion digital slowscan tv equipment) has been followed by many revelations of the improvisations that were necessary to overcome operational problems and the absence of airborne early-warning radar.

The satellite-carried speech links made available to the reporters, but also presumably used for encrypted Service traffic, certainly provided reliable and reasonably good-quality communications (though this would not necessarily be the case against an enemy with more sophisticated jamming or anti-satellite systems). Nevertheless it has been alleged that there remains a serious e.m.c. problem that required radar to be turned off during satellite transmissions. It has also come as a surprise to find the extent to which missile countermeasures still depend on the use of vast amounts of "chaff" – the "window" technique of World War 2 – with *Aviation Week* reporting that Plessey Aerospace were working a 24-hour-day, 7-days-a-week producing the stuff. Chaff and helicopter decoys seem to have proved moderately effective in diverting some Exocet missiles away from their intended targets – though one that was deflected from an aircraft carrier promptly locked on to the ill-fated Atlantic Conveyor. There have been rumours of attempts to recover nuclear weapons from some sunken Royal Navy vessels, though it is equally possible that the work is aimed at recovering cryptographic or other sensitive material. Equally alarming are the reports that two Russian Cosmos ocean surveillance satellites launched during this period were carrying nuclear electric-generators for the radars and were similar to the nuclear-powered satellite that caused so much public concern when it came down over Northern Canada on January 24, 1978. If the Falklands have underlined anything it is that we live in an extremely dangerous world – to which advanced electronics and communications contribute. It can be claimed that the British electronics systems were used defensively as well as offensively, and mostly worked, though in some cases not without considerable last-minute improvisation.

Manpack satellite

The Special Air Service had its own communications links back to the UK as well as what was clearly a considerable number of clandestine infiltration links between the Task Force and the SAS reconnaissance and intelligence-gathering parties. There has been no public information given on whether these communications were effected via satellite or on h.f. or a mixture of both. But at least one British firm, Ferranti Electronics, has recently announced the development of a manpack portable satellite terminal "Mansat" that has a shallow-reflector aerial built into a rigid carrying module. It could, one imagines, be used for infiltration communications. This equipment, working on about 7.5 GHz, can provide a duplex telephony link and a 50 bit/sec telegraphy link using a standard QWERTY-type keyboard. It works from internal batteries, and GaAs field-effect transistors are used in both the receiver and transmitter chain. Microprocessors take care of message storage, encoding, display and alarm monitoring. It is claimed that the equipment can be positioned and in contact within two minutes. But I rather doubt if such equipment was used in the South Atlantic, and "old-fashioned" h.f. may have provided the intelligence.

Wideawake Ascension

Back in 1967 I was lucky enough to be one of a small party of journalists forming possibly the only press trip ever made to Ascension Island. It was at the time of the opening of the Cable and Wireless earth station built by Marconi on the island as part of the elaborate NASA Apollo communications system. The island, even then, was an amazing contrast between modern communications, missile tracking aerials, a BBC overseas relay station with four 250 kW transmitters and an old-style brass-instrumented telegraph cable station (this was before the South African telephone cable), giant turtles coming ashore to lay their eggs and millions of wideawake terns, all to a backdrop of a desolate, crater-pitted, near lunar landscape. Water was in short supply but whisky was 60p a bottle, gin 25p and the temporary residents paid no income tax! And though I recall well the computerized, air-conditioned NASA tracking station and the large futuristic "aerial farms" what really remains in the memory is the pleasant English farm at the top of Green Mountain where, on behalf of Cable and Wireless, a Somerset farm-manager looked after 2000 sheep, 300 pigs and 35 milking cows! The island has been a natural communications centre since the days when it was garrisoned by the Royal Navy and Royal Marines. Sadly, there are still the graves of young sailors put ashore with yellow fever in the nineteenth century. Landing a large Britannia aircraft at Wideawake Airport was quite an event for the island and one wonders how much it has all been changed by the furious burst of activity this year.

Whose light pipe?

British Telecom do not believe in hiding their light under a bushel or burying their talents in a napkin. Not only have they instituted a prestigious Martlesham Medal to give recognition to their own research engineers but they recently put out a 1500-word, seven-page press release to mark the second such award to Dr George Newns and Dr Keith Beales. This was for their development of the double crucible production process for optical fibres. I am all for giving medals to engineers and full credit to those whose work is seldom in the public eye. But BT's publicity boys do lay it on a bit thick. Was it really BT who, to quote the press release, "first took up the challenge (of optical fibres) and began devoting time and resources to the enormous problems of translating theory into practice"?

It is evident from the release that BT set up its research team for optical fibres during 1968. Yet I recall talking to Dr Kao at STL at Harlow, early that year. He showed me some of his continuing work on optical fibres which had obviously been started many months earlier. It was devoted to the very practical problem of producing low-attenuation glass. He was convinced this was possible and outlined to me the role optical fibres could play in telecommunications.

BT's press release also recalls that the first Martlesham Medal went last year to Dr Tommy Flowers "the man who invented Britain's and possibly the world's first computer . . . Collossus (sic)". Again Tom Flowers deserves the highest praise for his important pioneering work on the Bletchley Park cryptographic computers but it would have been nice if BT's publicity boys had included just a passing reference to Alan Mathison Turing – but then Turing owed his allegiance to GCCS and "C" of the Secret Service and not to the inventive British Post Office!

Stormy ionosphere

Solar storms, sudden ionospheric disturbances and blackouts, high levels of polar cap absorption and intense auroral conditions continued to dominate the h.f. scene in July. In fact July 12-18 witnessed one of the biggest proton flare events for many years. A blackout on h.f. on July 12 lasted four hours. While this resulted in generally poor h.f. conditions, v.h.f. operators were able to take advantage of the near-sensational auroral conditions which unusually extended as far south as the Mediterranean area. British and Irish stations, for example were able on 144 MHz to contact F6KAW/EA6 in Minorca.

Although it is possible to trace a link between solar storms and auroral conditions, there still remains no positive way of predicting "sporadic E" openings which are linked to wind shears in the upper atmosphere. However Jim Stewart, WA4MV1 has recently convirmed in a letter to *QST* the growing belief that a link can be shown between Sporadic E and certain types of severe weather, particularly severe thunderstorms. He notes that apart from heavy rain and turbulence, some thunderstorms appear to produce wind shears and large static-electric charges that play a significant part in the process. Examination of hundreds of weather maps and other data have convinced the American that there is very often a severe weather area roughly midway between stations linked by sporadic E propagation. Storm activity above 60,000ft could result in 144 MHz openings, whereas storms at around 40,000 ft tend to result in 50 MHz openings. While his results may apply primarily to the large land area of the United States, it is one of the few ideas so far advanced that could lead to prediction of Sporadic E openings.

AMATEUR RADIO

Amateur satellites

So far attempts by Stanford University, using a large dish aerial, to regain control of the British UoSAT OSCAR satellite, built by the team at the University of Surrey – appear to have failed. As reported earlier a "one-in-a-million" software error caused both beacon transmitters to be switched on simultaneously with consequent desensitizing of the on-board receivers. At the time of writing it is still hoped that control can be regained by a strong command signal but hopes are fading, and this experimental scientific satellite remains virtually out of action.

A low-orbit Russian amateur radio satellite "Iskra Two" which was ejected from the manned Salyut/Soyuz orbiting space station on May 17 re-entered the earth's atmosphere early in the morning of July 9. Although it carried an h.f. transponder this was activated only for a brief period.

Amsat-UK (94 Herongate Road, Wanstead Park, London E12 5EQ) has published a new edition of its useful 16-page booklet "Guide to Oscar Operating" providing the basic information needed by amateurs who wish to have a go at making contacts through Oscar satellites and background information and practical experiences since the first amateur satellite was launched in October 1961.

Here and there

I.A.R.U. statistics now put the total number of licensed amateurs at over 1.1-million of which about 200,000 are in Region 1 (Europe/ Africa), about 480,000 in Region 2 (North and South America) and about 470,000 in Region 3 (Asia and Oceania). Japan heads the table with around 450,000, U.S.A. 390,000, West Germany 42,000, U.S.S.R. and Argentina each 26,000. Then comes the U.K. with around 25,000 followed by Canada 21,000, Italy 17,000, Brazil 14,000 and Australia 13,000 though these figures may already be a little out-of-date.

A Dutch enthusiast, Ryn Muntjewerff is now known to have received 435 MHz amateur television pictures in November 1979 from F1AJD, Angouleme, France over a distance of about 1000 km, thought to be a record for this band. Among the journals and newsletters devoted entirely to amateur television are: *CQ-TV* of the British Amateur Television Club, *"A5 Amateur Television Magazine"* (USA monthly), *"The ATVer"* (Australia), *NBTV* (Narrow Bandwidth Television Association, UK) and *"Der TV Amateur"* (West Germany).

Aerial pioneers

Two names that have become almost part of the language of aerials – Beverage and Kraus – have recently been reflecting in the columns of *QST* on the continued value of designs put forward in 1922 and 1937 respectively. Harold Beverage, ex-W2BML first developed and described his very long but low aerials 60 years ago when working for RCA. He has revealed that after becoming interested in radio as early as 1912 he had two job offers on graduating from college: playing trombone at Loews Theatre for `2 per week or working for General Electric for $11.20 a week. Such was his enthusiasm for radio that he opted for G.E.! Apart from the still famous Beverage aerial, he was co-inventor with H. O. Pearson of the "diversity reception system" for combatting fading on h.f. Curiously the most complex diversity systems these days – quadruple diversity – are usually at much higher frequencies for troposcatter or long microwave links across sea paths.

Professor John Kraus, W8JK – for many years a leading figure among American radio astronomers – made his name initially when he adapted Dr George Brown's work on close-spaced medium-wave aerials in order to produce the first effective bi-directional rotary h.f. beams in 1937. This was a few months before another leading amateur, Van Roberts, similarly adapted Brown's work on close-spaced parasitic arrays to come up with the aerial that has made Yagi's name famous throughout the amateur radio world. John Kraus shows that a special attraction of the original W8JK-type of array is that it can work effectively over a continuous frequency range of more than 3 to 1 without traps or loading coils and with non-critical dimensions. The availability (so far in some countries only) of 18 and 24MHz bands makes the W8JK design particularly attractive and its may well be heading for a revival.

So far American amateurs have not been able to make use of any of the new h.f. bands (10, 18 and 24MHz) since the USA have not yet ratified the WARC 1979 agreements. Japanese amateurs were authorized to use the 10MHz band from April 1, 1982. Maximum power is 500 watts for stations having a frequency measuring instrument and 10 watts for those without!

Heavy guns

The American FCC have been firing some heavy guns recently in its efforts to stamp out abuses of the American radio regulations. A former Californian amateur indicted of operating a station without a licence and using obscene, indecent and profane language has been facing, if found guilty, a possible maximum sentence of 10 years imprisonment and a fine of up to $70,000. Another Californian lost his amateur licence after taking a licence examination on behalf of a candidate. The FCC has refused to renew the licence of a former amateur who two years ago was found to have deliberately jammed an amateur repeater. Unlicensed operators facing charges of putting out broadcast transmission on 7040kHz from Miami directed at Cuba have been referred to the U.S. Department of Justice with a request for criminal prosecution which could result in a $10,000 fine and/or a one year prison sentence.

In brief

A reminder that many local adult centres are starting RAE classes in the second half of September. In Beckenham, Kent the demand for morse classes in the London area has caused a switch from RAE classes to morse training . . . . Date of the Midlands v.h.f. convention has been changed to October 9 at The Polytechnic Wolverhampton. Reminder that Welsh Amateur Radio Convention is at Oakdale Community Centre, Blackwood, Gwent on September 26 . . . There are hopes that amateur radio activities may be permitted again soon in Poland. . . A "congress of radio amateurs connected with the railways" (FIRAC – Federation International Radio Amateur Cheminot) is to be held at Gunton Hall, Lowestoft from October 4 to 8 (details G. Sims, G4GNQ, 85 Surrey Street, Glossop, Derbyshire SK13 9AJ).

PAT HAWKER, G3VA

CIRCUIT IDEAS

Static b.c.d.-to-binary converter

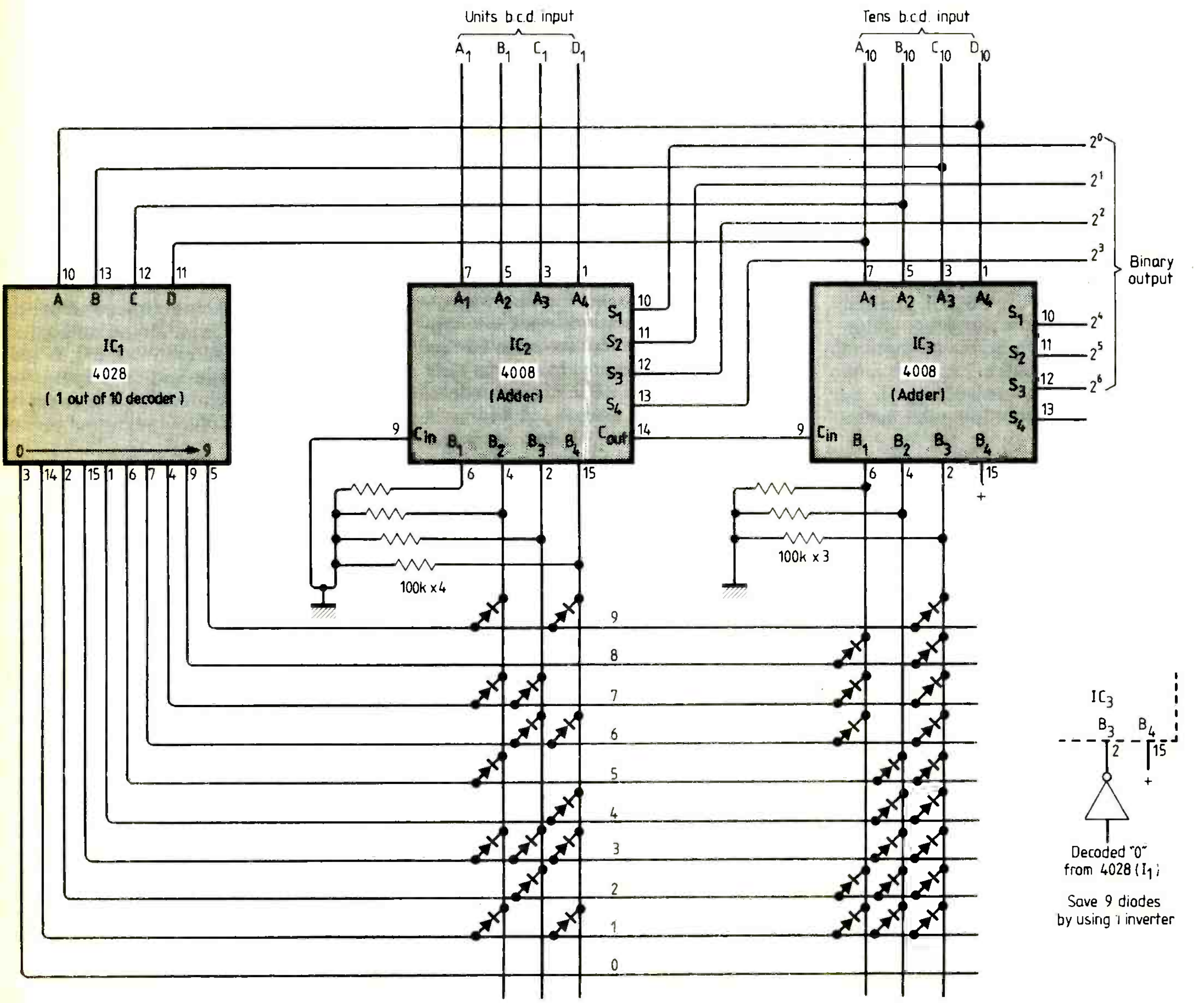
Converters such as those used in synthesizers, where a decimal channel number might have to be changed into binary form to drive a p.l.l., might be in the form of a relatively expensive and, perhaps inconvenient prom, or as binary and decimal up/down counters in parallel, which can give carry and synchronizing problems, or they may be made up using shift registers with correction networks like the 74184. The following is a static cmos converter on similar lines.

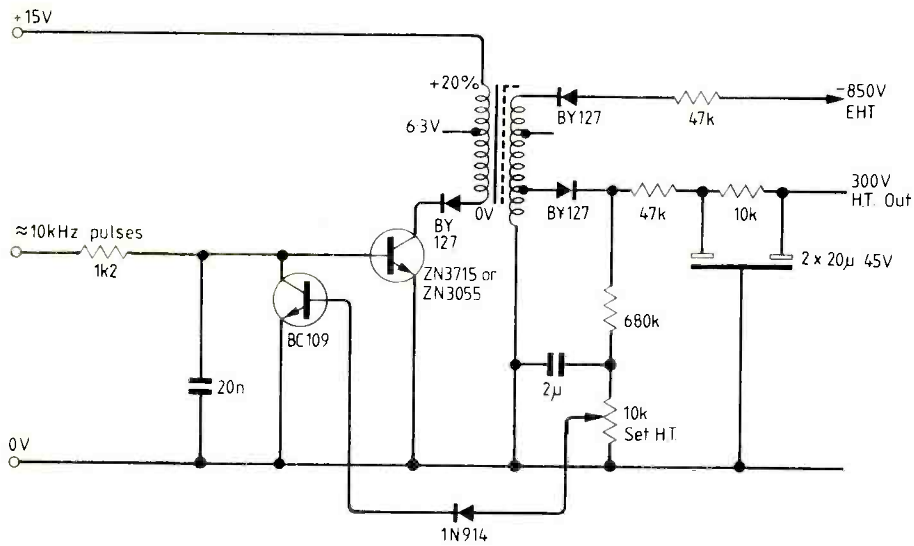
For digits zero to nine, both binary and b.c.d. forms are the same but the first decimal carry, at 10, leads to problems at the 'tens' A input, resulting in a binary 16 being interpreted. Therefore, six has to be subtracted to return the original value, 10. At the next carry, b.c.d. 20, binary 32 is interpreted, and must be corrected by subtracting twice 6, and so on for each successive decade. Here, rather than carrying out subtractions, two's complements implemented by diode matrices are added using two 4-bit full adders. A one-out-of-10 decoder chooses the correction value as represented in the table. B_4 of the second adder is not used, but should be tied to either rail. Nine of the 33 diodes may be replaced by the inverter as shown. Expansion of the circuit is possible.

Falko Kuhnke
Institut für Geophysik und Meteorologie
Braunschweig

Decoded output IC_1	Equiv. decimal range	Subtraction value	Added complement IC_3 (B_4) (128)	B_3 64	B_2 32	B_1 16	IC_2 B_4 8	B_3 4	B_2 2	B_1 1
0	0 – 9	%	X	L	L	L	L	L	L	L
1	10 – 19	5	X	H	H	H	H	L	H	L
2	20 – 29	11	X	H	H	H	L	H	L	L
3	30 – 39	17	X	H	H	L	H	H	H	L
4	40 – 49	23	X	H	H	L	H	L	L	L
5	50 – 59	29	X	H	H	L	L	L	H	L
6	60 – 69	35	X	H	L	H	H	H	L	L
7	70 – 79	41	X	H	L	H	L	H	H	L
8	80 – 89	47	X	H	L	H	L	L	L	L
9	90 – 99	53	X	H	L	L	H	L	H	L

X = don't care





Oscilloscope supply

Circuit shown provides around 850V at 75μA and 300V at 2mA from a 15V supply. Insulation of the output transformer (an RS196 224) is flash tested to 5kV but one could be specially wound using, say, a Mullard FX2243 or Siemens 631 N 27. The prototype was driven by a unijunction transistor oscillator and buffer circuit.

G. V. Whitney
Sale
Cheshire

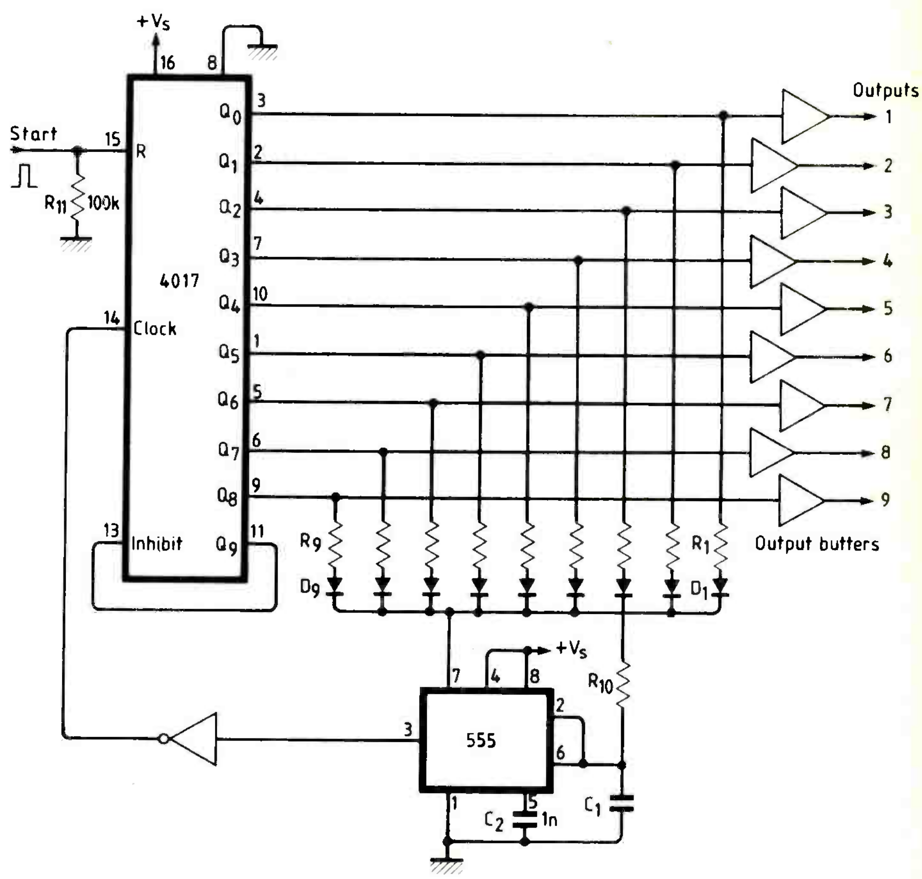
Minimum-parts sequencer

Combining a cmos decade counter with the 555 timer yields a simple yet versatile adjustable-delay sequencer. Buffered outputs 1 to 9 are activated in succession as the 4017 counter is clocked. Each output remains on for a duration proportional to the values of R_1 to R_9 respectively.

A momentary high level on the start input resets the counter, activates output 1 and starts charging C_1 through R_1, D_1 and R_{10}. As C_1 charges, the timer output goes high, causing a negative transition, due to the inverter, on the counter's clock input, which is ignored. When C_1 reaches 2/3 V_2, the timer output goes low, clocking the counter, enabling output 2, setting R_1 low while pulling R_2 high, and enabling another charge cycle on completion of discharge through R_{10}.

The sequence continues until the ninth count, when inhibit input (pin 13) is activated, preventing further clocking. Since all charging resistors are deactivated, the system remains inactive until start is pulsed. A more elegant approach would be to connect an extra inverter between the junction of the 9 and inhibit outputs of the counter and the reset (pin 4) input of the timer. Keep in mind that upon power-on or after the timer has been reset (low on pin 4), the first timing period will be approximately twice as long as the reset, due to the capacitor having to charge from ground instead of 1/3 V_s.

Many variations are possible. For example, repetitive sequences of up to 10 steps can be obtained by grounding the counter's inhibit input and connecting an extra resistor and diode to timer pin 7 from the counter's 9 output. A 4-bit binary counter feeding a 4-to-16 converter (e.g. cmos 14515) will provide up to 16 lines.



Pin 5 of the timer, shown de-coupled to ground through C_2, can be used as a modulation input to compress or expand all output times simultaneously, i.e. scale factor. Output buffers can be selected according to requirements or omitted entirely if driving other cmos logic.

Values of resistors R_1-R_{10} should be kept as large as possible to minimize loading of the cmos output stages during charging. If potentiometers are used to trim timing, R_{10} should be at least 4.7kΩ to minimize inrush current, should any pot be turned to zero resistance. The time delay caused by the combination of R_{10} and C_1 adds a constant to the time that each output remains high.

V. Labuc
Noranda Research Centre
Quebec

FAULT-FINDING IN MICROPROCESSOR-BASED SYSTEMS

The complexity of some systems aggravates the problem of fault location. Techniques include the use of special equipment and the ability of the processor to diagnose itself. The author discusses some of the available equipment and techniques.

by Stephen Day

During the last decade electronic systems have changed substantially in conception and complexity due to the introduction of microprocessors and their accompanying devices. Previously, such systems were designed using families of integrated circuit logic elements, the most complex of which would probably have been a four-bit synchronous updown counter. Fault finding in sequential random logic systems involved the use of logic diagrams annotated with waveforms and timing sequences, and required that the fault finder had a detailed understanding of the system operation. The equipment required would be a two-channel oscilloscope with various trigger and sweep facilities, and possibly a special test rig to provide signals to stimulate the printed circuit board, if it were being tested remote from its system. The time required to find a fault would depend largely on the skill of the test or service engineer. Equipment in service could be repaired quickly by module or PCB replacement, but ultimately, fault finding down to component level had to be undertaken in the manner described above.

Systems designed around microprocessors are conceptually different in that they are bus structured with data being transferred around the system in parallel. In general, input data is read and processed in the CPU to produce the output under the control of the system software. When debugging or fault finding on this type of system, many lines need to be monitored simultaneously and in synchronism with some derivative of the system clock. 'Glitches' and undefined levels on tri-state busses at other times are of no consequence.

Currently systems are being designed using the fourth generation of microprocessors with 20-bit address busses and 16-bit data busses. Clock rates are up to 11 MHz; and multiprocessor systems, with bus access time division multiplexed between processors under the control of a master, are being implemented as solutions to the demands of more processing power. All these advances in technology and system complexity aggravate the problems of fault location. To assist the designer and test technician in overcoming these problems various techniques can be used, some requiring special equipment and some utilising the power of the processor in self-diagnosis of faults. It is the purpose of this paper to discuss the current state of the art equipment and techniques and indicate how they are applicable to fault finding from design and development through assembly and test to in-field service.

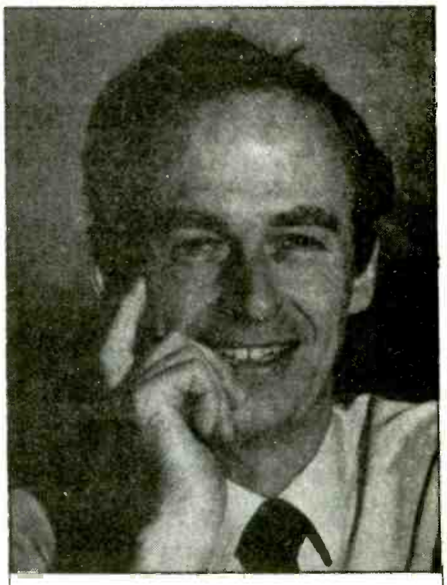
Logic analysers

The logic analyser was the first of a range of equipments designed specifically for data domain analysis and was initially produced as an instrument for use in the laboratory during the development phase of a microprocessor implementation project. Its appearance was similar to an oscilloscope but having multiline data probes. The data on each probe line could be sampled under control of a system clock which could be qualified typically to sample once every processor instruction cycle. The samples were stored in an internal memory with a capacity of up to 16x16-bit words, and the trigger word, from which sampling was initiated, was set up on a bank of switches.

More recently the ergonomics of logic analysers have been significantly improved and memory size has been increased up to 1000x20-bit words. The options available for setting up the equipment are displayed as a menu on the screen, with a cursor to indicate the next input required. The keyboard is used to enter the information to give the required operating sequence. Typical of the options for trigger selection are: clock source, edge polarity, trigger word, clock cycles delay, trigger start or end, block pattern recognition etc. Possible data display modes on the screen are:
(a) Table. A listing of the sampled data states in binary or to some other numerical base such as hexadecimal (Fig. 1a)
(b) Timing. Data is displayed across the screen as several channels showing the HI-LO activity (Fig. 1b).
(c) Graph. The horizontal axis represents analyser store addresses and the vertical axis the numerical value of the stored data (Fig 1c).
(d) Map. Each 16-bit sample is divided into its upper and lower 8-bit bytes. The values of these produce the vertical and horizontal deflection. (1d). The top left of the display is address 0000 and bottom right is FFFF. The map display will assume some unique pattern depending on the frequency of access of the various address lacations being accessed by the program being executed.

When monitoring the data on a microprocessor bus it is possible to reconvert the binary data back into its mnemonic assembly language from automatically and this feature, known as disassembly, has been built into some instruments. The analyser has a personality module according to the microprocessor in the system under development and the table display can then be a list of assembly language statements which are more readily interpreted for program debugging.

Remote access for initialisation and interrogation can also be provided by



The Author

Stephen Day, BSc, CEng. MIEE, graduated from Manchester University during his student/graduate apprenticeship with the UKAEA at Aldermaston. Later he moved to Godwin Warren Engineering as Senior Design Engineer. In 1974 he joined the IBA as a Senior Engineer and is at present working there as Project Leader for enhanced teletext.

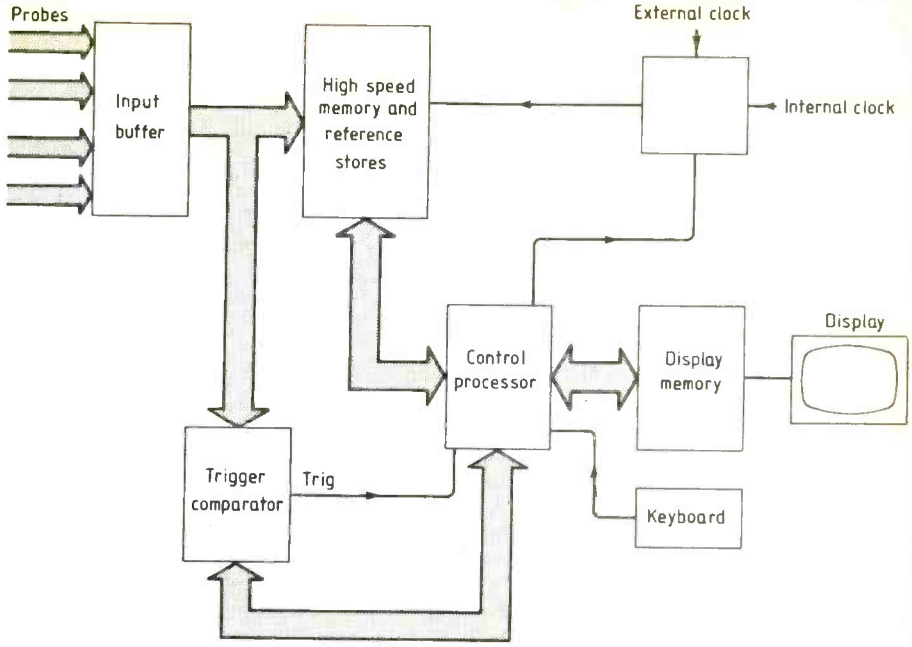
connection to an instrumentation bus.

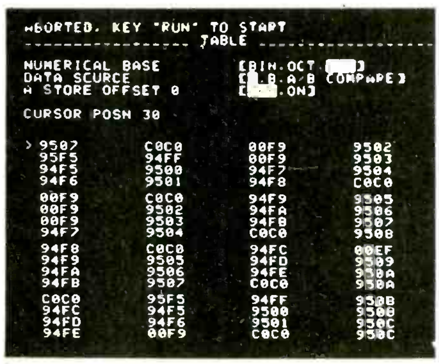
A further development of the logic state analyser is the logic timing analyser. This device samples the data input lines with a clock which is asynchronous with the system under test. In this way it is possible to trap random events or 'glitches' as small as 5 ns wide by using clock frequencies up to 20 MHz. The display is usually presented as a timing diagram. One particularly useful application for this type of instrument is in trapping intermittent faults. The technique is known as 'babysitting'. Having established what trigger condition to use, a set of normal data is sampled and transferred to the secondary or reference memory. The user can now leave the instrument to monitor the system under test and it will acquire new data each time the pre-selected trigger point is encountered. Any difference between the new data and the reference data will cause the analyser to stop sampling and indicate where the difference has occurred. On return the user can step through the logic timing diagram on the display and draw conclusions for futher investigation of the fault.

In circuit emulation (ICE)

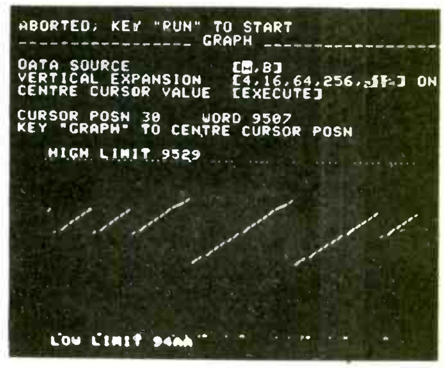
This is a technique for using a microprocessor development system to debug both hardware and software during the developmental phase of a project. Early microprocessor development systems were essentially for software development. They had the usual suite of routines for editing and assembling programs and it was possible to partially debug the software by limited execution within the development system. It was then necessary to commit the software to eprom in order to transfer it to the hardware of the system being developed. For further debugging use was made of a logic analyser to find out why programs operated incorrectly or whether the fault was in the hardware.

In-circuit emulation is created by additional hardware which allows the microprocessor in the target system to be emulated by a similar microprocessor in the development system. The ICE module connects to the target system by multi-way umbilical cable terminated with a plug which is inserted into the socket where the microprocessor would normally reside. In this way the resources of the development system are extended to the prototype in order to facilitate the hardware/software integration. Figure 2 shows a typical microprocessor development system with ICE. Resource allocation is extremely flexible in all modes of operation and will depend to some extent on the state of development of the prototype hardware. The development system mass storage medium, usually floppy disc, is used to store the target system software in both source and object form. Loading is quick and errors can be patched out in the object code to try modifications. These changes can then be incorporated in the source code and rapidly reassembled. Random access memory and i/o facilities of the development system can be used as though they are local memory and i/o of the prototype system even before this part of the hardware is built.

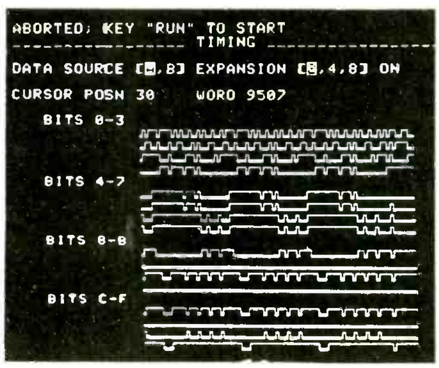




(a)



(b)



(c)

(d)

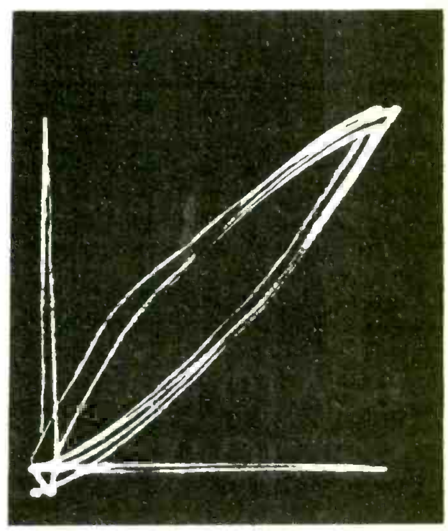


Fig. 1. Block diagram of a logic analyser. Its various modes of display are: a. a table; b. a timing chart; c. a graph; and d. a map (see text).

During emulation a breakpoint can be specified which can be conditional on a number of different factors such as memory read, memory write, instruction fetch or i/o operation at selected addresses. When the breakpoint has been encountered the internal registers of the processor and any memory locations can be interrogated and modified as necessary before restarting emulation. It is also possible to display the contents of the trace memory to check the instruction sequence before the breakpoint.

Another possible mode of operation is single stepping. In this way more detailed information can be acquired by the trace memory as the program is executed one instruction at a time.

Probably the most important advantage of ICE is the simple connection into the prototype system. One cable is all that is required with no need for circuit modifications or temporary jumpers. Early development and debugging of the software enables completion of the total system integration in the shortest possible timescale. Finally, the time consuming procedure of using eproms to transfer programs under development to the target system is eliminated.

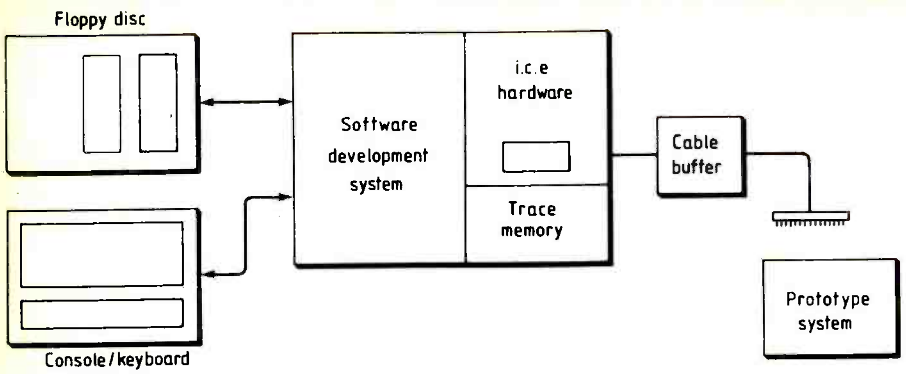


Fig. 2. In-circuit emulation system.

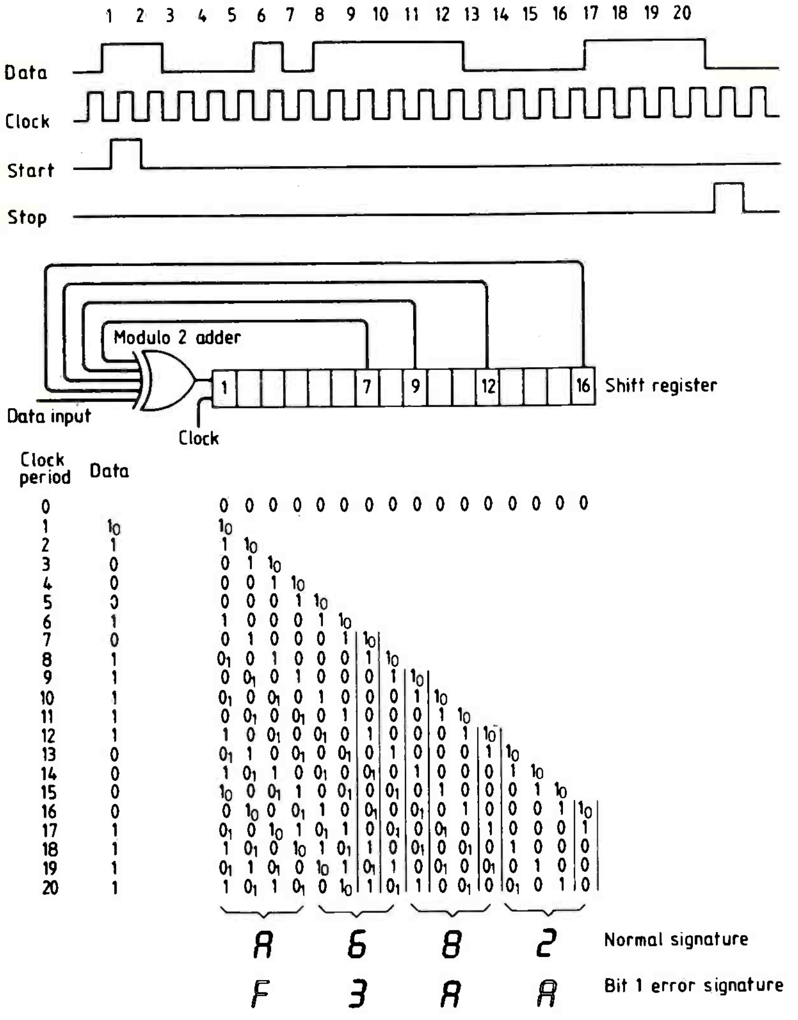


Fig. 3. Derivation of signature from data stream.

Signature analysis

If a piece of equipment is made to repetitively execute a certain sequence of instructions then it should be possible to identify correct operation by monitoring the changing logic levels at each node in the circuit. This would produce a mass of information which would be completely un-manageable in a test situation. In order to compress this information into a more useful form a technique known as signature analysis was developed by Hewlett Packard Ltd. The data appearing at a given node is sampled for a known period, between start and stop signals, by clocking it with the system clock into a feedback shift register. The residue at the end of the sampling period is a characteristic of the activity at that node.

Using a 16-bit shift register and arranging the feedback such that a maximal length sequence is produced will give 65 536 possible residual states. The parallel 16-bit output from the register is used to drive four hexadecimal displays and the resulting number is termed the 'signature' of that node. Errors in the data stream will normally cause a different signature to be displayed. It is possible to show[1] that all single bit errors will change the signature and that the probability of multiple bit errors being missed is less than 0.002%. This is far better than the performance of other techniques such as bit or transition counting.

An example of how a signature is derived is shown in Fig. 3. The data signal is gated with the four feedback bits in a gate which produces a logic one output only when the modulo two sum of the inputs is one. The clock is enabled during the window between the start and stop pulses and in this case samples the data 20 times. The chart shows how the bits propagate through the shift register and the resulting signature is A682. Superimposed on the chart is the result of introducing a single bit error in the first bit. The signature changes to F3AA. In a similar way it could be shown that the signature would be 8E92 for an error in bit 8 and 2682 for an error in the last bit. Thus it can be seen that a single bit error even in such a short sequence will produce quite a dramatic change in the readout from the signature analyser. In a practical situation the window period would be considerably more than 20 clock periods and can be more than 2^{16} (the cycle length of the register) if appropriate.

Signatures for a given circuit are not designed or calculated. What must be decided at the design stage is how start and stop signals can be produced and what hierarchy of tests is required to fully validate each node. This may involve the use of special test sockets to break feedback loops and isolate parts of the ciccuit under test. Finally, when the design is complete, the test routines are executed and the signatures at each node in the equipment are recorded. Documentation is completed by adding the singatures to the circuit diagram an example of which is shown in Fig. 4. The handbook should detail the sequence of tests and fixtures, switches or jumpers that are required.

After proving the operation of the system kernel a series of tests are run which sucessively introduce a larger percentage of the system until a signature fault is found. Faulty components can be located by backtracking until a device with a correct input signature but erroneous output signature is found.

Signature analysis is a very powerful service aid and is also useful for final assembly testing. The equipment is relatively inexpensive and the extra design work is minimal. Retrospective design into existing systems is also an attractive proposition.

Automatic test equipment (ATE)

This is the name given to usually large equipment sets which allow the user to test, thoroughly and quickly, complex circuit boards. They represent a considerable capital investment and are essentially fixed. Usually they can be justified only in a production situation with a high throughput although sometimes there is a case for them in a repair and maintenance department.

A typical ATE system is shown diagrammatically in Fig. 5. User communication with the system is via the console keyboard and v.d.u. Test routines are stored either on floppy or rigid discs. The processor controls setting up and running of the tests. It communicates with the unit under test (u.u.t) via the digital control unit and the high speed read/write memory. Connection to the u.u.t is made in a number of ways including via its edge connector, through a bed of nails fixture and through test clips and probes.

The usual test procedure involves the stimulation of the input nodes of the u.u.t with data in the form of arrays of sequential test patterns. The u.u.t is clocked at its normal operating speed and response data at all outputs and internal nodes is captured in the memory for comparison with the correct response pattern. Input sequences up to 4000 bits long are used and the output comparison is done either on a bit for bit basis or the response data is compressed into a signature for each node and then compared with stored signatures.

The imput test patterns are usually algorithmically generated by the test procedure in order to simulate some functional response. Another possibility is to use pseudo-random binary sequences as input data providing a more exhaustive though lengthy test. The correct response patterns are assessed either by emulation or heuristically. In the first case it is necessary for the ATE to have detailed circuit information of the u.u.t and also to store a library of device models so that the correct response can be calculated. Functional models of complex l.s.i devices such as microprocessors are therefore required. In the second case a known good unit is monitored through all the tests and the correct responses are learnt and stored for later use.

The result of this initial testing is that the unit is either good or faulty, and in the latter case there is no information concerning the possible fault location. A second series of diagnostic tests then has to be executed and these will involve the operator following a set of simple instructions displayed on the v.d.u. The operator is guided through the circuitry applying either current or voltage probes until a faulty component is found. A label is then printed which can be attached to the unit for return to assembly.

Thus an ATE system is very comprehensive in its ability to fault find large numbers of different circuits by having different bed of nails configurations and storing its programs and responses on disc.

It does suffer from the drawback that, although the operator requires little skill or training, it is necessary to program the system in some considerable detail for each new bosrd. Special high level languages have been developed to make programming easier, but there is no standard, and usually a skilled ATE programer is required.

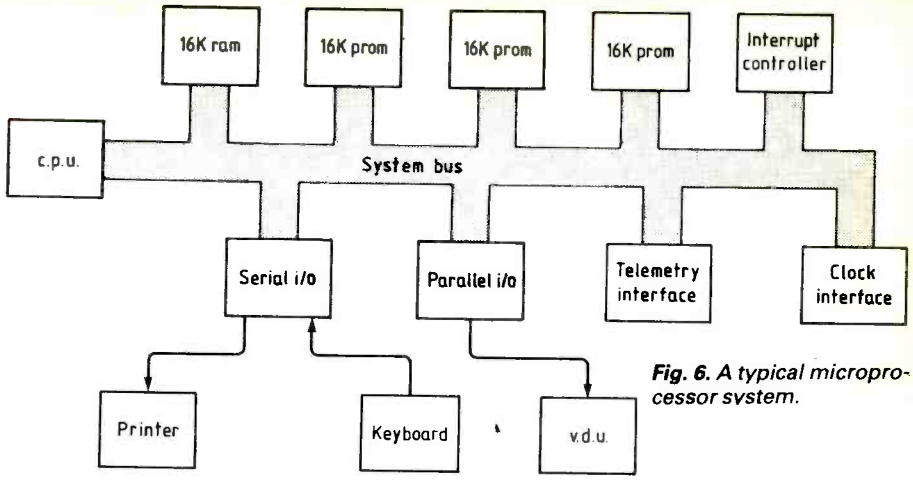


Fig. 6. A typical microprocessor system.

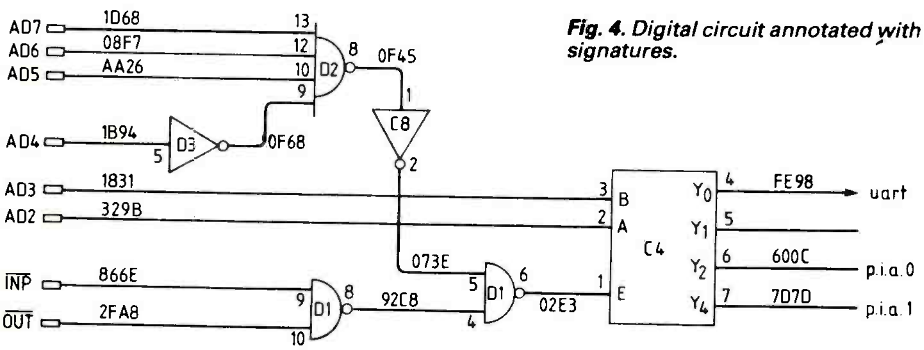
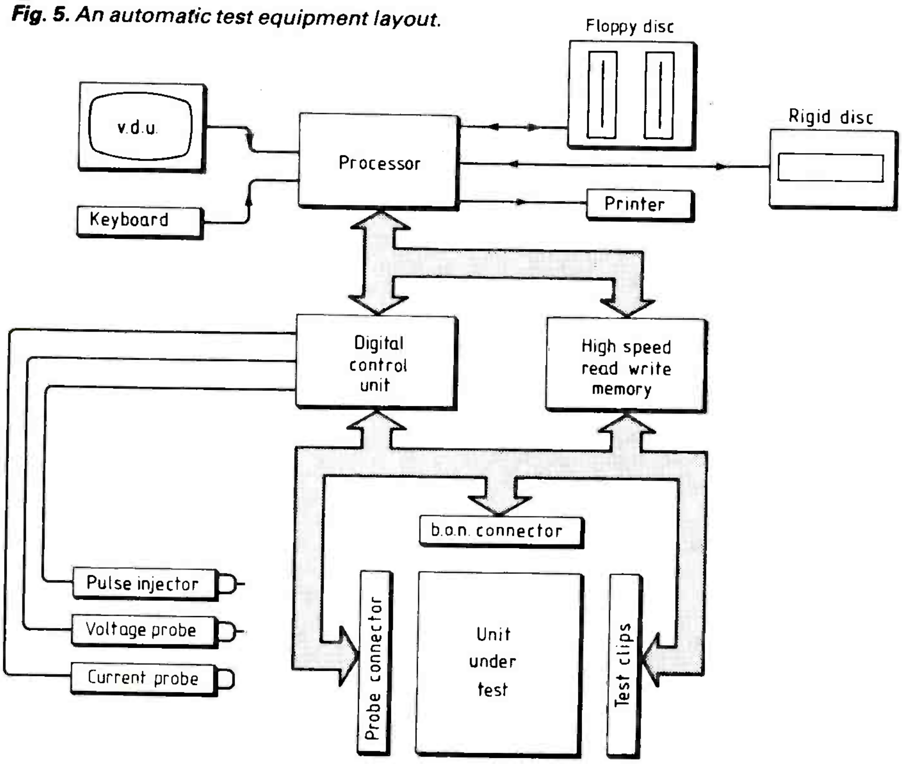


Fig. 4. Digital circuit annotated with signatures.

Fig. 5. An automatic test equipment layout.



Portable diagnostic test sets

A diagnostic tester designed to fault-find and validate a specific microprocessor system can sometimes prove to be a cost effective solution to provision of field service maintenance equipment. It is portable and versatile and is used to perform automatic functional tests on the equipment within its normal operating environment.

A typical microprocessor system is shown in Fig. 6. It comprises 10 printed circuit cards with connection to various peripherals. The tester has access to the system bus and the i/o sockets. One convenient form of implementation is therefore an extra circuit card which plugs into a spare socket in the system rack and connects to a hand held controller with an alphanumeric display. The components necessary for such a test set are shown in Fig. 7.

The test programs are stored in prom on the test card and the small ram is used as stack, display buffer and workspace, so that the main system ram need not be operational. The u.s.a.r.t with its clock divider chain producing clock rates for 110 and 1200 baud is used to test the serial links. One p.i.a controls the display and reads the keypad and the other is used to test the interrupt system and the parallel i/o. The most convenient address at which to locate the test routine will normally be zero so that system reset will initiate the test sequence. It will probably therefore be necessary to have a switch on the main system which will disable memory at overlapping addresses while the test routines are executing.

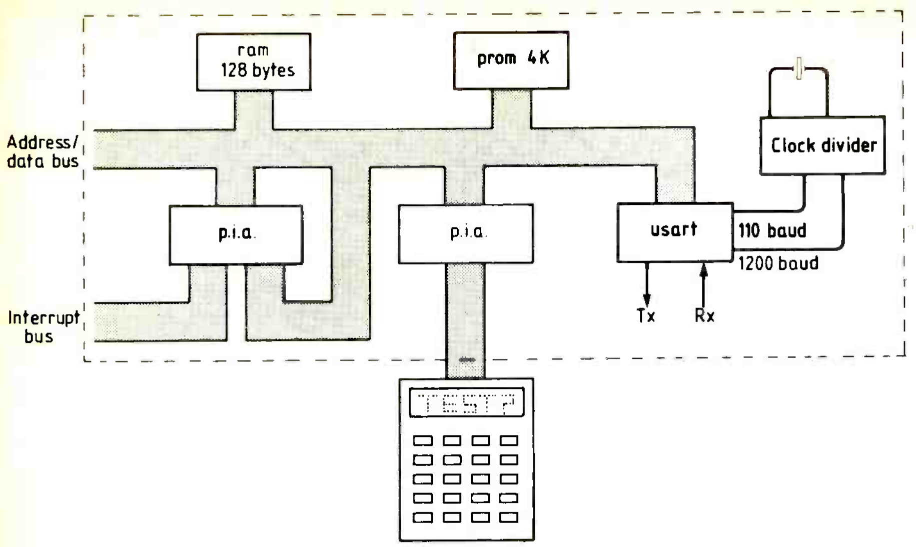


***Fig. 7.** A test set consisting of a p.c.b. and a control module.*

Fault finding follows a logical sequence of building up confidence in the operation of the system components. The c.p.u of the main system is used as the processor to execute the tests. The address and data busses and the c.p.u are confirmed as operational if the tester initialises correctly. Memory tests consist of write-read pattern checks on ram and checksum test on prom. The serial inputs are tested by lopping to the tester serial output. The serial outputs are looped to the tester serial input and known data sequences can be sent out to assist with fault finding at the peripherals. The tester displays diagnostics for each test to indicate success or mode of failure. In the case of proms and rams the actual faulty chip can be indicated. The fault, when located. can be rectified by changing a circuit card; or a series of lower level test can be executed in order to fault-find down to component level with the aid of scope and logic analyser.

In many systems validation routines are an integral part of the software and are run at initialisation. However, they cannot perform such comprehensive tests as this type of portable test set with interaction of a maintenance engineer. The operation of the tester is straightforward and requires minimum documentation. It is also readily acceptable as part of the maintenance engineer's kit.

Conclusions

Several techniques have been discussed in this paper which make fault analysis in the data domain a practical proposition. In a design and development laboratory, use is made of logic analysers and microprocessor development systems with in circuit emulation. In production and field maintenance the choice is less straightforward. ATE for assembly use appears to be the best technique for thorough testing but is costly both in initial equipment and in programming. Equipment for service use can be selected only when a maintenance philosophy has been evolved depending on the type of equipment, numbers in service, ability and availabilty of field personnel, acceptable down time etc.

Future developments will see the introduction of 32 and 64 bit microprocessor systems which will require even more sophisticated techniques for fault finding. Designs will become fault tolerant by the introduction of both chip and peripheral hardware redundancy. In the field there will be greater use of remote fault analysis. Faulty systems will be connected by telephone lines to central installations, the test routines being down loaded and results fed back for analysis.

There will therefore be a continuing trend towards improved system reliability by increasing MTBF and minimising down time on the occurrence of a fault. WW

References

1. Frohwerk, R. A. 'Signature analysis: a new digital field service method'. HP Journal, May 1977.

Reprinted from *IBA Technical Review*, No. 15, 1981.

BOOKS

Regulated Power Supplies, (3rd ed.),
by I. M. Gottleib
423 pp., paperback
Prentice-Hall International, £13.95. ISBN 0-672-21808-9
AN expansion of the earlier works, dealing in an extremely thorough manner with a subject which is not often treated in isolation. Practice, rather than theory is the approach, from a description of basic requirements to the implementation of linear and switching-type voltage and current regulators. The author not only provides an exceptionally detailed treatment of the subject, but does it in a literate manner.

Computing

Mastering Computer Programming
by P. E. Gosling
212 pages, hardback/paperback
MacMillan £8.95/£2.95
The title of this book is one result of its forming part of the Master series, but the author lays no claim to omnipotence. He has produced a very 'accessible' description of the processes involved in writing programs, with a useful chapter on errors and a piece on Fortran, Cobol and Pascal – Basic is used in the body of the book. The writing is direct and easy to read.

Microprocessor Development and Development Systems
Edited by Vincent Tseng
202 pages, hardback
Granada, £16.00
In the development of most applications using microprocessors, a 'development system' to aid programming and testing is of great benefit. The book, written by several authorities in the field, describes a number of such systems and their use and includes a chapter on emulators. There is also a section on managing without a d.s. The style is descriptive and 'readable'.

Microcomputer Design and Troubleshooting
by Eugene M. Zumchak
350 pages, paperback
Prentice-Hall, £12.55
A rather more down to earth treatment of the practicalities of design with micros than is usually found at this level. A home-built development system is described and further chapter headings include read/write timing, interfacing, hardware testing and software design.

Circuit Design Programs for the Apple II
by Howard M. Berlin
132 pages, plastic bound
Prentice-Hall, £11.15
One of the Blacksburg series, this is a set of Basic programs intended to take the labour out of circuit design calculations, graph plotting and signal analysis, including average and r.m.s. values and Fourier series. Equipment needed to use the programs is either an Apple II Plus or Apple II with Applesoft card. A minimum of 32K ram is required, 48K being preferable.

Amateur radio

Amateur Radio Equipment Fundamentals
by A. D. Helphick, K2BLA
248 pp., hardback
Prentice-Hall International, £14.20. ISBN 0-13-023655-1
The tradition of home-built amateur radio equipment has largely given way to the operation of commercial gear. In an attempt to offset this trend, Mr Helphick has provided a course of instructions in the basics of design and construction of transmitting and receiving equipment, and has included two chapters of designs for receivers, transmitters and a 100W linear amplifier.

ELECTRONIC COMPASS USING A FLUXGATE SENSOR

A device to fill the gap between the old-fashioned compass and expensive gyro-based navigation systems – an all-solid-state, high-resolution magnetic sensor.

by Neil Pollock

With the ready availability of micro-computers, simple dead reckoning navigation systems for boats and cars can be constructed, if suitable distance and direction inputs are available. A 'distance-travelled' signal can usually be obtained quite easily, but the provision of a digital magnetic heading is more difficult. It would be possible to arrange a servo pointer follower and angle digitizer attachment for a conventional moving magnet compass, but this would be mechanically complex and unattractive for amateur construction. An inherently digital solid-state compass is a much more elegant solution. A compass of this type would be valuable in any application where multiple output displays are needed, a computer readable output is required or where the sensor will be subject to high vibration or accelerations. In addition, the electronic nature of the sensor permits its location far from large metallic masses which can locally distort the field.

All solid-state compasses operate by sensing two or three resolutes of the horizontal component of the earth's magnetic field and then perform appropriate trigonometry with these resolutes to obtain the resultant magnetic flux direction. Using Hall-effect sensors, it is possible to produce very simple arrangements[1]. Unfortunately, during preliminary testing none of the low-cost, commercially available Hall-effect probes, including those with integral ferrite flux-concentrators, were found to have sufficient accuracy at magnetic field levels appropriate for compasses. Even when extra flux-concentrators formed by 2cm long Mumetal strips attached to each side of the sensor were added, increasing their output from microvolt to millivolt levels, the temperature drifts were of similar magnitude to the output produced by the earth's field. The disappointing results obtained with Hall-effect sensors forced the adoption of a fluxgate sensor with its inherently greater circuit complexity.

The theory of fluxgate magnetometers and compasses is beyond the scope of this paper and interested readers are referred to References 2 and 3. For a brief description of the principle of operation, see box.

An initial prototype of a fluxgate sensor used magnetic cores cut from Mumetal sheet, but an inconvenient post-fabrication annealing operation in a hydrogen atmosphere was required to obtain the desired magnetic properties. To overcome this difficulty, attention was directed to magnetometer designs which could be constructed using readily available commercial ferrite components.

Circuit

The arrangement finally chosen (based on a design intended for sounding rockets[4]), uses a 14mm diameter Philips ferrite toroid type number 4322-020-97140 (grey coating) or the equivalent uncoated toroid 4322-020-31390. Notes on adapting the design to use other toroid types are included later.

The circuit diagram and coil winding details are shown in Figs 2 and 3. The toroid is driven into saturation in alternate directions at about 10kHz by a magnetic multivibrator circuit of the type often used in inverters.

Windings P_1 and P_2 are the drive primaries while P_3 and P_4 provide the necessary feedback to maintain oscillation. The two secondary coils S_x and S_y are arranged so that in the absence of an applied external magnetic field they, at least in theory, experience no induced voltage. In practice, due to imperfections in the toroid and coils, voltage spikes are induced in the secondaries as the toroid goes into and out of saturation. These spikes have amplitudes varying from barely detectable to over one volt for different coil assemblies (Fig. 4).

When an external field is applied in the plane of the toroid some initial magnetization is induced in it. This initial magnetization results in one part of the toroid being driven into saturation before the part 180° away from it during one half of the oscillator cycle and the reverse situation occurring during the other half cycle. This non-symmetrical saturation of the core produces a flux unbalance and an induced voltage in the secondary windings. The magnitude of this induced voltage is closely proportional to the applied flux

Fluxgate magnetometers

There are very few means of measuring absolute values of magnetic fields. The most popular one is the Hall effect sensor, but most commercial units are designed for relatively high values of field.

The fluxgate configuration can measure very low field magnitudes by using the chopper-amplifier principle. Briefly, it is based on the fact that all parts of an uniformly excited toroidal magnetic circuit would be equally magnetized in the absence of external magnetic fields and therefore no voltage would be induced into a coil encompassing the whole magnetic circuit.

The introduction of external field in the plane of the toroid would result in a slight unbalance between the two halves of the magnetic circuit (see Fig. 1).

The flux at point A equals $\phi_A=\phi_0+\phi$, whereas point B, situated 180° away would correspond to a flux $\phi_B=\phi_0-\phi$. Where ϕ_0 is due to local toroid excitation and ϕ, to the external field.

Although the unbalance is very slight, it can be measured through one of its side effects: If we cyclically change the local excitation so as to switch the toroid between its two magnetic saturation points, we find that due to the unbalance, one half would be driven into saturation a short time before the opposite half and the toroid as a whole would, for a short period of time act as a small magnet. The net result is that a coil encompassing the complete magnetic circuit would pick up an induced voltage impulse, proportional to the external field.

By mounting two such coils perpendicularly to each other onto the same toroid, we can resolve any external field into its X and Y components in the toroid plane.

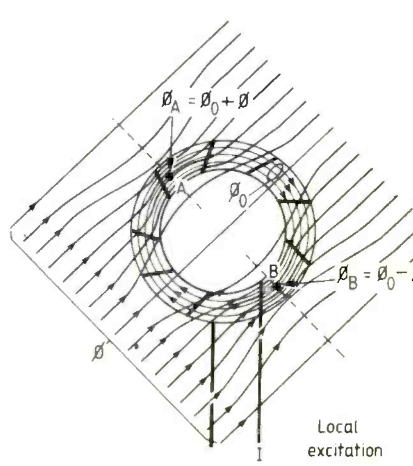


Fig. 1. Flux interference pattern.

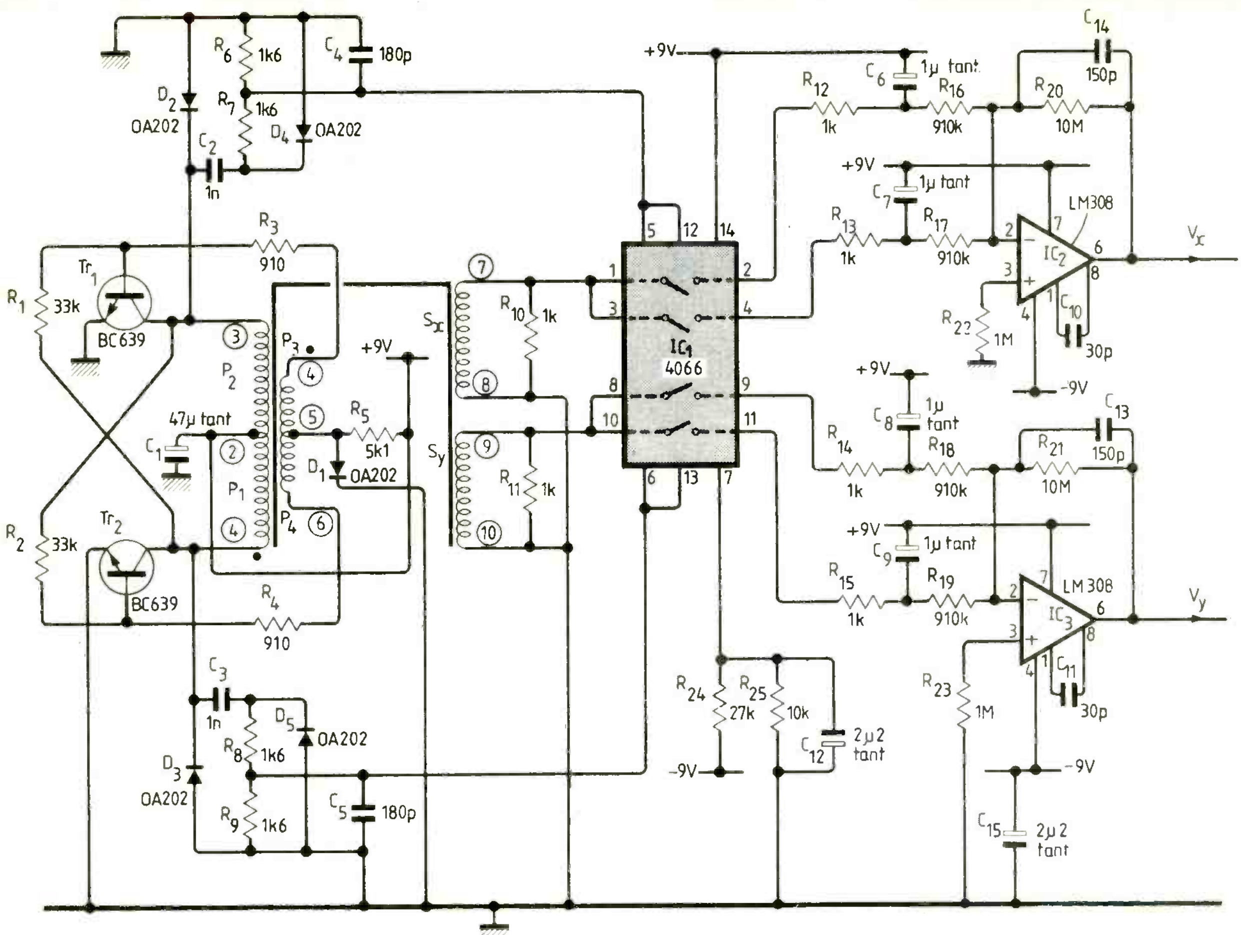


Fig. 2. Fluxgate sensor circuit diagram.

component perpendicular to the plane of the appropriate secondary coil. In practice, the effect of applying an external field is to change the amplitude of the pre-existing secondary voltage spikes. The amplitude of these spikes is also quite strongly temperature dependent. Figure 5 illustrates how the effect of an applied field is separated from the effect of temperature.

To perform the necessary arithmetic on spike amplitudes, a phase sensitive detector and summing amplifier is used for each secondary. The detector control signals (Fig. 6) are generated by differentiating, half wave rectifying and attenuating the primary drive voltages. The phase detector outputs are summed and the resulting mean voltages (outputs V_x and V_y) are proportional to the sine and cosine of the angle between the applied field and the plane of the S_x coil. In principle the compass output is simply the arctangent of the output voltage ratio. It is essential that the coil assembly and the associated electronics be located on the same circuit board because the zero offset is very sensitive to the relationship between the wires connecting the coil to the electronics.

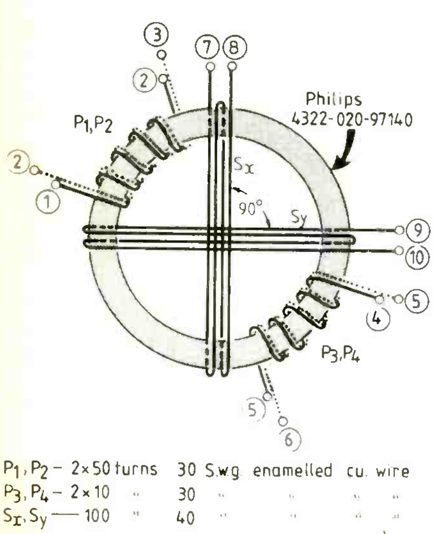


Fig. 3. Toroid windings.

Construction details

The coils are the heart of the device and, although they are relatively non-critical, an effort applied to winding them carefully and neatly will be well repaid. The primary drive windings P_1 and P_2 are wound on the toroid first and fill it about 1½ layers deep. These two coils are bifilar wound, that is they are wound with two wires side by side to produce two closely identical windings. The feedback windings P_3 and P_4 are bifilar wound on top of P_1 and P_2. The two secondary windings can either be wound on a tubular former with notches at 90° intervals, which fits around the pre-wound toroid (Fig. 7) or wound separately and then glued in place. If the latter method is adopted it is suggested that each secondary be wound around a 6mm by 16.5mm rectangle formed by four pins. On removal of the pins the preformed rectangular coil should be bound with another piece of coil wire (taking care not to create a shorted turn) so that is is bundled together. The two secondaries can then be placed around the toroid and secured with quick-setting epoxy glue. However the secondaries are wound, it is essential that they are a neat fit and closely coupled to the toroid. On completion of the windings the toroid assembly should be glued to the circuit board and the leads connected, being careful to observe the correct hand of the P_1, P_2, P_3 and P_4 windings. All windings should be securely glued to prevent any relative movement between them.

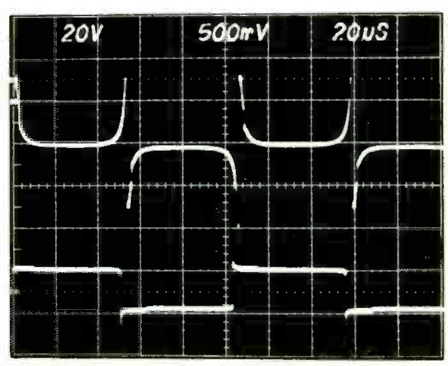


Fig. 4. Primary drive voltage (lower trace) and resulting secondary (S_X) voltage spikes (upper trace).

The remainder of the circuit is straightforward and a board layout and component positions are reproduced in Figs. 8 and 9. The use of metal-can transistors and integrated circuits should be avoided, since they could distort the applied magnetic field.

If it is desired to use a toroid other than the one specified, the following procedure is recommended. If necessary, change the number of turns on the primary windings, keeping the same ratio between drive and feedback windings, so that the operating frequency is in the range 5kHz to 50kHz. Change the value of C_2 and C_3 so that the phase sensitive detector control pulses are similar in length to the secondary spikes. Alter the value of R_{20} and R_{21} to obtain the desired overall sensitivity. Although they have not been tried, their specifications suggest that the following toroids could be used with only minor component value changes: Philips 4322-020-97060 (blue coating); Philips 4322-020-31390 (uncoated); Siemens B64290-K0045-X026 (coated); Siemens B64290-A0045-X026 (uncoated).

Performance

To facilitate calibration, the sensor board should be taped to a 360° plastic protractor which can be rotated inside a circle drawn on a piece of paper placed on a wooden table top. Care must be taken not to move any ferrous or magnetic objects near the compass sensor during calibration. The author experienced inconsistent results which were eventually traced to the effect of his metal belt buckle. A typical calibration chart is shown in Fig. 10. The V_x and V_y outputs are usually within ±1° of best fit sine curves with zero offsets in the range ±2volts. A peak-to-peak amplitude of about 1.2volts was produced by a horizontal flux density of 2.2×10^{-5} tesla (weber/m^2 – the value for Melbourne, Australia). Similar outputs should be obtained

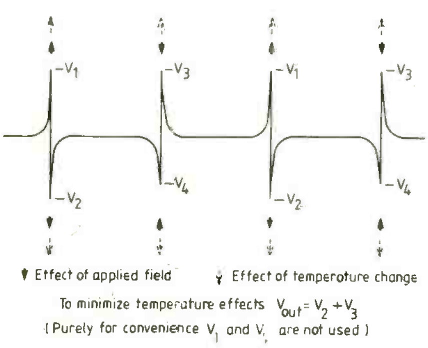


Fig. 5. Effects of temperature versus applied magnetic field on secondary waveform.

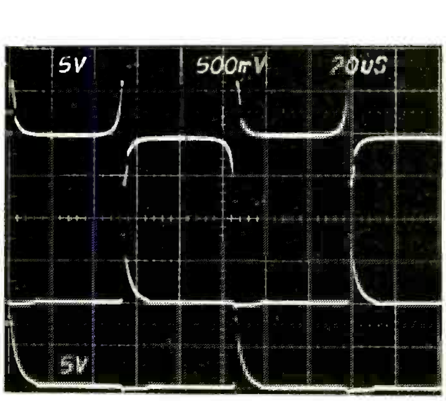


***Fig. 6.** Secondary output (S_X – IC1, pin 1 – upper trace) and phase sensitive detector's control signals: middle trace: IC_1, pin 5. lower trace: IC_1, pin 6*

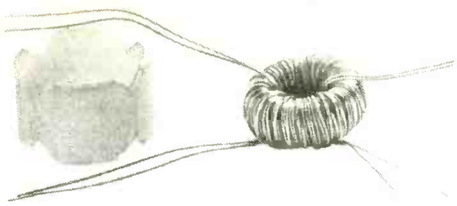


***Fig. 7.** Toroid with primary windings and former for secondaries.*

in Europe and the USA. In other parts of the world the horizontal flux density varies from zero at the magnetic poles to 4.13×10^{-5} tesla in the Bay of Bengal. If the sensor is not horizontal, total flux densities exceeding 6×10^{-5} tesla may be found. The sensor peak-to-peak output voltages are directly proportional to the field strength in the plane of the toroid. For carefully wound coils the phase angle between the two output voltages will be within a few degrees of the desired 90°. It is suggested that any departure from 90° is treated as a correction in the angle computation, but if desired the coils can be bent by trial and error prior to final glueing to produce the desired angle between them.

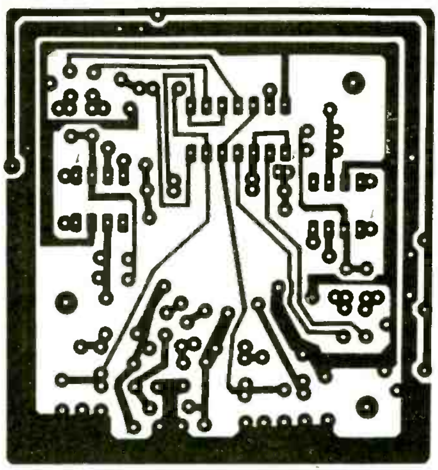


***Fig. 8.** Fluxgate sensor p.c.b. layout.*

The sensitivity of the sensor is quite strongly temperature dependent (about 5% per °C) but since both outputs are affected equally the indicated angle is unchanged. The zero offsets vary by about 10mV/°C and for operation in environments which are not temperature controlled, these changes would have to be corrected for, if maximum accuracy was required. The repeatability of the sensor calibration is excellent with no measurable change over a one month test period, and presumably for much longer periods since there is no obvious mechanism for long term drifts. The sensor is very sensitive to temperature gradients in the ferrite core and it is essential that it be protected from draughts. The sensor board draws 17mA from the +9volt supply and 2mA from the -9volt supply.

Installation

The sensor must be mounted in a horizontal attitude if accurate results are to be obtained. In a boat, where large attitude changes are often experienced, the sensor would have to be mounted on a set of gimbals. In a land vehicle subject to large accelerations but normally operating on an approximately level surface, it may be better to rigidly mount the sensor. If mounted near large ferrous objects or sources of magnetism, the sensor must be compensated as for a normal compass[3]. Fortunately with the freedom to remotely mount the sensor it is often possible to find a location where compensation is not required and the small residual errors can be treated as part of the calibration. If very long connecting leads are to be used between the sensor board and readout electronics, it may be necessary to include 1kΩ resistors in series with the V_x and V_y outputs to decouple the operational amplifiers from the cable capacitance.

Microprocessor readout system

In a microprocessor-based system the sensor outputs V_x and V_y would be multiplexed into an analog-to-digital

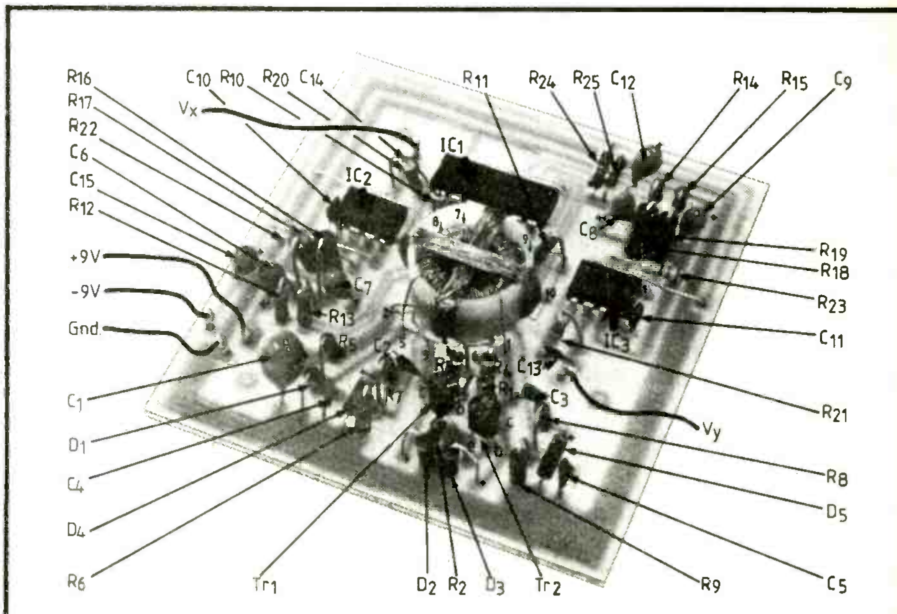


***Fig. 9.** Fluxgate sensor component positions.*

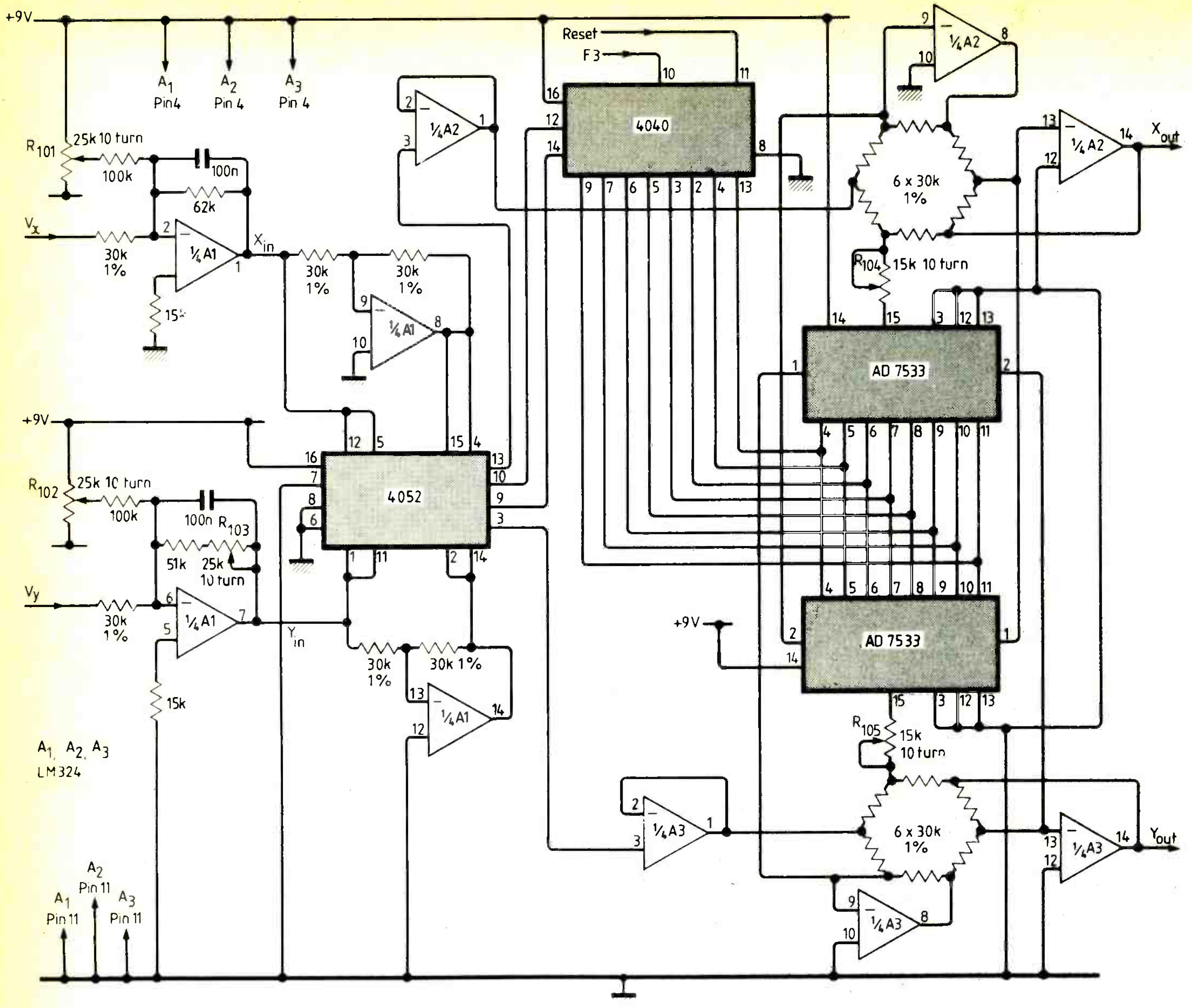


Fig. 12. Angle decoder: input circuitry and vector rotator.

converter with a useful resolution of at least 10 bits. An a. to d. converter like the Intersil ICL7109 would be the first choice in this application since it could be simply interfaced to most microprocessors using parallel or serial data transfer. When the digital values of V_x and V_y were read in, the ratio $R = (V_x - V_{xo})/(V_y - V_{yo})$ should be calculated, where V_{xo} and V_{yo} are the zero offsets which should be varied with the measured sensor temperature unless it is placed in a temperature-controlled enclosure. Using the value of R and the signs of $V_x - V_{xo}$ and $V_y - V_{yo}$ it would be possible to construct a look up table to give the heading angle with 1° resolution. The actual sensor will resolve heading changes of much less than 1° but when all sources of error are considered there is little point in aiming for greater overall resolution. Alternatively, if a dedicated arithmetic chip like the National Semiconductor MM57109 was available, it may be more efficient to take the arctangent of R and apply any necessary corrections to the computed heading later.

Hard-wired logic readout

In applications where a microprocessor is not available, it may be desired to have a dedicated hard wired readout system. A relatively simple, low cost, arrangement which was used during the development of the sensor is shown in block diagram form in Fig. 11. The operation of this system depends primarily on a vector rotator which has as inputs two analogue voltages X_{in} and Y_{in} which are taken as the X and Y components of an input vector and a digital angle θ (0 to 1024 for 0 to 360°). The outputs X_{out} and Y_{out} are the X and Y components of the input vector rotated through the angle θ. The heading angle is given by the value of θ which reduces the X output to zero (ie. the angle through

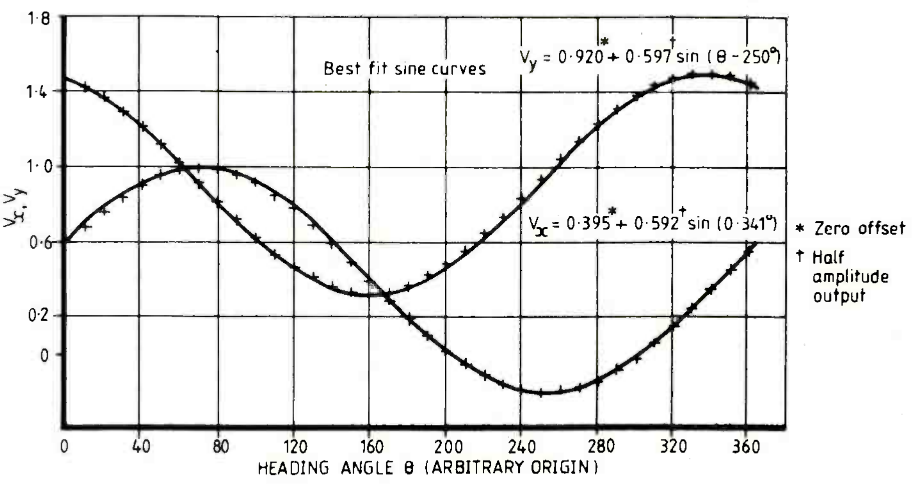


Fig. 10. Typical calibration chart.

which the input vector must be rotated, to align it with the system Y axis).

When a reading is initiated by the 2Hz update clock, the binary and b.c.d. counters start counting from zero. When X_{out} passes through zero in a negative going direction, a latch enable pulse is generated which gates the current b.c.d. counter contents into the display. The RS flip-flop is needed to ensure that only the first zero-crossing in each update clock cycle produces a latch-enable pulse. The 360/1024 ratio between F_2 and F_3 produces an output in degrees. Outputs in other units, eg. tenths of degrees or grads, could be produced simply by changing this ratio. For this system to work correctly, the X_{in} and Y_{in} inputs must have the same sensitivity and no offsets; this is achieved with a pair of offset and gain adjustment amplifiers.

The circuit which is designed around a simple vector rotator[5], using a pair of Analog Devices AD7533 low-cost multiplying digital to analog converters, is presented in Figs. 12 and 13. This circuit, which has an overall decoding accuracy of about ±1°, draws 15mA from the +9volt supply, 7mA from the −9volt supply and 170mA from the +5volt display supply.

The set up procedure, which consists of adjusting offsets, sensitivities and balance is as follows: with the sensor board not connected, adjust R_{101} and R_{102} to set X_{in} = 5volts and Y_{in} = 0. Remove the 4040

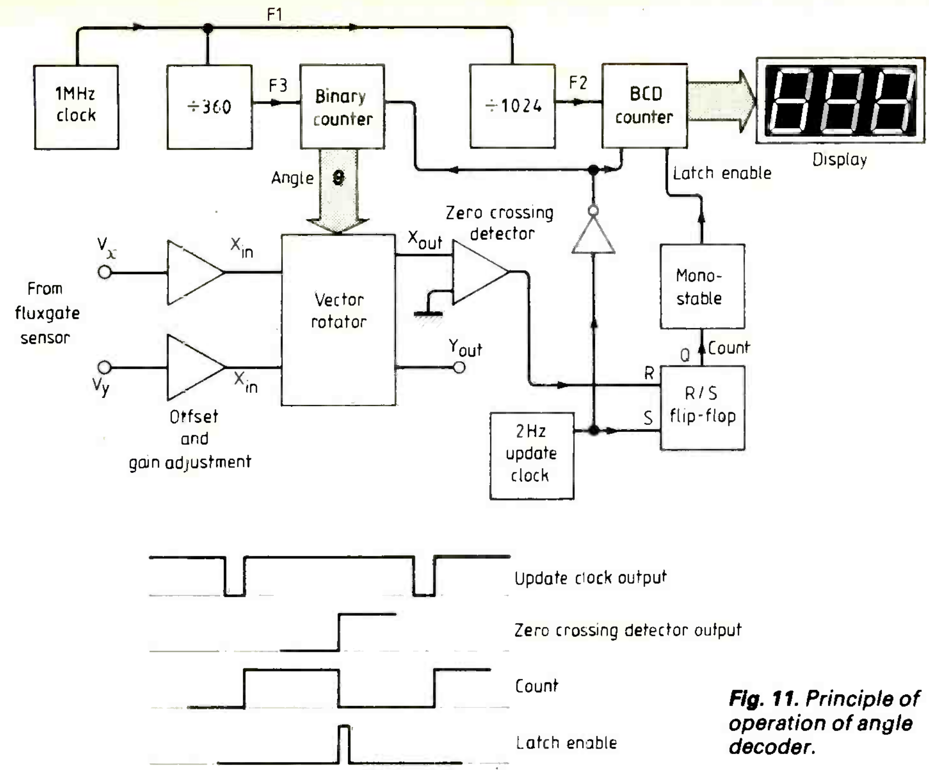
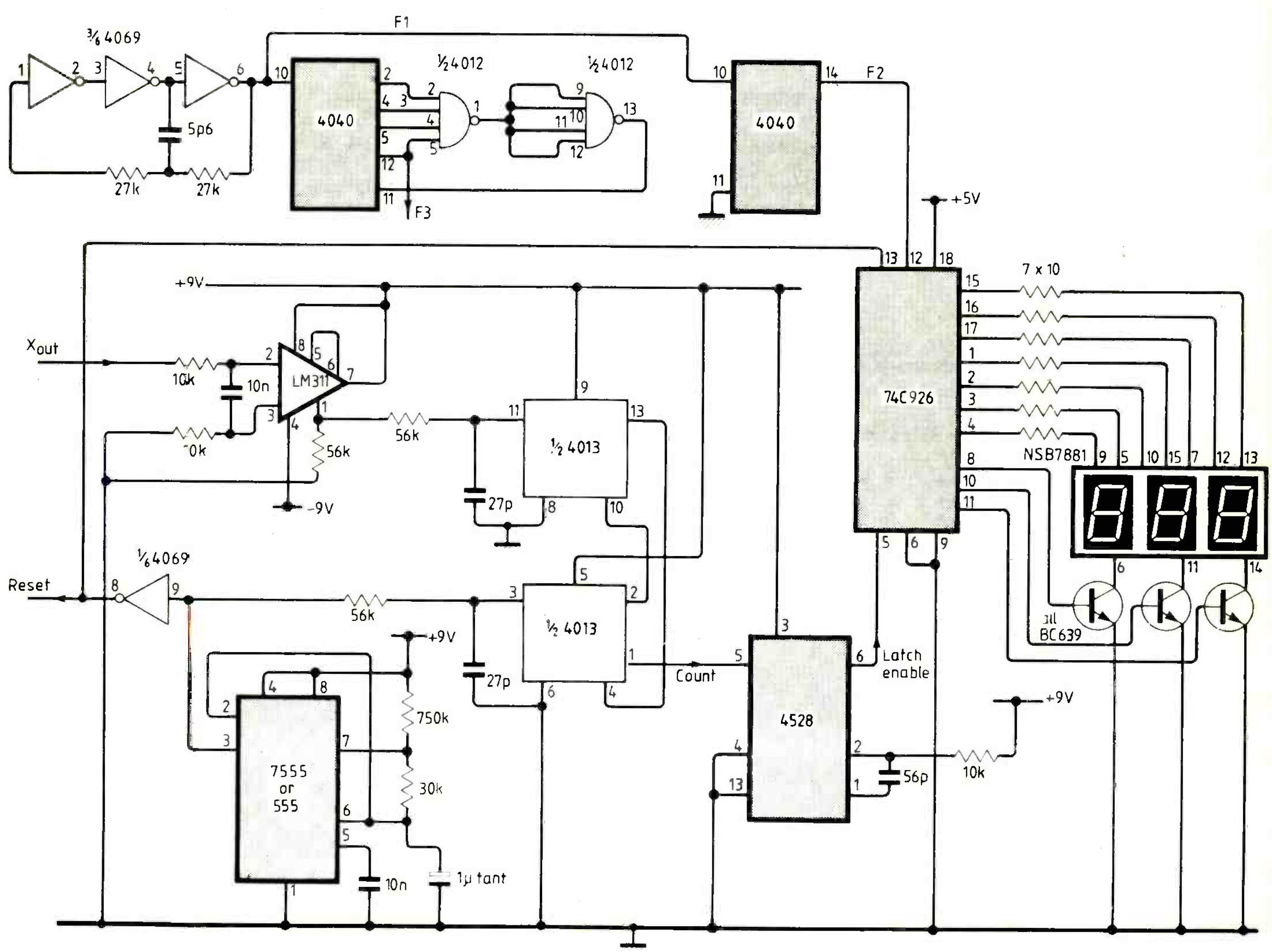


Fig. 11. Principle of operation of angle decoder.

Fig. 13. Angle decoder: control logic and display.



counter and ground its socket's pins 2-7, 9 and 12-14. Adjust R_{104} and R_{105} to set $X_{out} = -Y_{out} = 5/\sqrt{2} = 3.54$volts. Readjust R_{101} and R_{102} to obtain $X_{in} = 0$ and $Y_{in} = 5$volt. Check that $X_{out} \approx Y_{out} \approx 3.54$volts. This set up procedure for R_{104} and R_{105} is sufficiently accurate for most applications, but if maximum accuracy is needed an interative procedure[4] should be adopted. Replace the 4040 and connect the sensor board. While rotating the sensor board through 360° set R_{101} to remove the V_x zero offset so $X_{in,max} = -X_{in,min}$. Set R_{102} to remove the V_y zero offset so $Y_{in,max} = -Y_{in,min}$ and finally set R_{103} to equalize X and Y sensitivities so that $X_{in,max} = Y_{in,max}$. Since this circuit was developed primarily for bench testing, no compensation for changes in X and Y zero offsets with temperature is provided. An enthusiastic analog circuit designer could perform this compensation with thermistors in resistor networks around the input amplifiers.

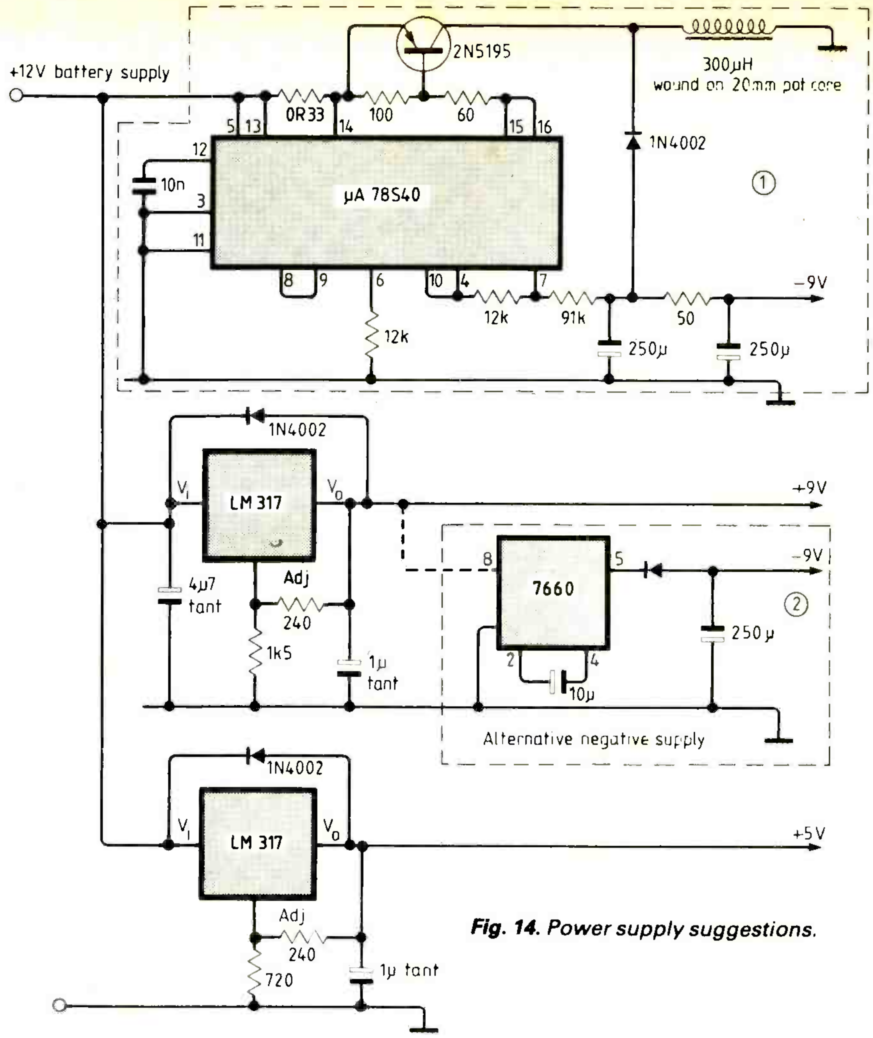


Fig. 14. Power supply suggestions.

Power supply

Since this system will normally be used in mobile applications, it is desirable that it should operate off a 12volt supply. A regulated power supply suitable for this purpose is shown in Fig. 14. Two alternative methods, (1) or (2) of generating the −9volt supply are shown. The Fairchild µA78S40 universal switching regulator was used for most of the development of this project. However quite recently the Intersil ICL7660 voltage converter became available and proved to have equal performance in this application with a considerably simpler circuit.

Magnetic compasses and the precautions required for their effective use are complex and it is strongly recommended that potential users read Ref. 3 and thoroughly check the accuracy of their own installation before relying on it in circumstances where life or property might be at risk. WW

References

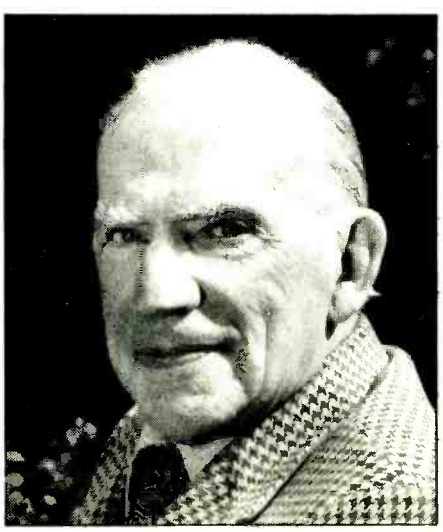
1. Steinbaugh, G. Hall Compass Points Digitally to Headings. Electronics, Dec. 18, 1980, pp. 112-114
2. Stuart, W. F. Earth's Field Magnetometry. Reports on Progress in Physics, Vol. 35, 1972, pp. 803-881
3. Hine, A. Magnetic Compasses and Magnetometers. Adam Hilger Ltd. London, 1968
4. Acuna, M. H. and Pellerin, C. J. A Miniature Two-Axis Fluxgate Magnetometer. IEEE Transactions on Geoscience Electronics, Vol. GE-7, No. 4, Oct. 1969, pp. 252-260.
5. Mayer, A. Low-Cost Co-ordinate Converter Rotates Vectors Easily. Electronics, Sept. 22, 1981, pp. 133-135

M. G. Scroggie – Fifty-nine years a *WW* author

There can be very few electronic engineers, from this country or abroad, to whom the nom de plume Cathode Ray is not part of their education. For nearly sixty years Marcus Scroggie has contributed articles on wireless and other manifestations of the mobile electron which have instructed, entertained and humiliated more readers than would probably care to admit to it.

His technique has often been to take a 'simple' circuit and concede that nothing could be easier. The next step in the process, to demonstrate that the apparent simplicity is a snare and a delusion, would possibly have reduced the number of engineers to a dangerous level had he not quickly moved on to show that, if approached in the proper manner, the circuit was unlikely to bite.

M. G. S. is not adverse to an argument, the most notable perhaps being the Affair of the Arrow, his contention being that to



put arrows on both ends of a vector/phasor was akin to not knowing whether the voltage is coming or going. He has also, on occasion, been a touch professorial with those who approach the Queen's English with evil intent. The editorial people in *WW* have long been terrified of writing 'd.c.' (meaning zero frequency) or phrases such as decoupling to earth' in case M. G. S. saw the piece and fired a broadside.

The first *WW* article under the name of Marcus Scroggie appeared in the issue for August 15, 1923 – a method of raising 800V for a valve transmitter, M. G. S. being also amateur operator 5JX. But the pieces which have contributed most to the stature of *WW* since the first article appeared in 1934 are the articles by Cathode Ray, for which tens of thousands of engineers have cause to thank him.

On his 81st birthday, we wish Marcus Scroggie well.

INTRODUCTION TO VDUs

A simple explanation for newcomers to computing of the characteristics of visual display units, their method of working and control, and a description of some integrated-circuit video-display controllers.

by Colin Carson

In the world of computers, the word 'monitor' has an unfortunate double meaning. A software monitor is a program, permanently resident in a computing system, which can be used to test peripherals or memory on that system and perform simple program debugging. An electronic monitor is almost a television set without the receiver and loudspeaker: essentially it is the tube, sometimes the power supply, and the electronics required to produce a picture. Instead of the aerial being the signal source, an unmodulated signal has to be provided – either composite video or direct drive. The former is a single line, whereas the latter is made up from three lines – a video line, horizontal sync. and vertical sync. lines.

Composite video

Figure 1 shows some sample video waveforms. In the composite video signal, the quiescent level is usually 0.3V, which corresponds to black level on the screen. Synchronizing pulses are superimposed on this black level, the short pulses forcing a horizontal retrace and the long ones vertical retraces. The majority of the time between horizontal sync. pulses can be used for the display, the remaining time from just before to just after the sync. pulses being the blanking period, during which the tube does a retrace. During blanking, the signal must not exceed the black level, or the retrace will be seen on the screen. The composite video signal rises to 1V, the 'white level' or brightest white on a white monochrome set: since the signal varies between 0.3V and 1V, the picture increases in intensity through levels of grey. The waveform shown would produce a bright white dot at the left-hand end of that scan line. A line impedance of 75 ohms is normally associated with composite video signals.

Direct drive

The direct-drive waveforms, also seen in Fig. 1, should produce the same visible results as the composite waveform shown above them. Direct-drive voltage levels are not as well defined as composite video – some monitors take signals from t.t.l. buffers, while others need 1V signals.

Direct drive has the advantage that all the drive signals are, normally, readily available from the circuitry generating the video signal; however, it is difficult to send these signals over long lengths of cable. This problem is avoided with composite video, which can be transmitted down metres of coaxial cable without much of a problem. Direct-drive signals can be converted to composite video with a handful of components, but the reverse procedure is not so easy. Generally, there are more direct-drive t.t.l. monitors on the market than the composite-video type and the price of the former is normally slightly lower.

Of course, a monitor is not essential: a low-resolution picture can easily be produced on a television set, by connecting a composite-video signal to a u.h.f. modulator. The modulated signal is fed down coaxial cable to the aerial socket on the television receiver, which is then tuned to the new signal on a spare channel.

Bandwidth

The picture is made up from discrete dots, which merge together when viewed from a distance. Only a finite number of dots can be fitted into the display time available and this number is limited by the bandwidth of the monitor or television. If a monitor possesses a bandwidth of 10MHz (1/f = 100ns), then the minimum width of a dot must at least be equal to 1/f and preferably double – that is 100 to 200ns. If this constraint is not met, then the monitor will be unable faithfully to interpret the video waveform. Having decided upon a dot width, its inverse is termed the dot-clock frequency and is usually the highest frequency needed in a system. When incorporating a video display into a system it is always desirable to generate dot-clock, processor clock and band rate from dividers driven from a single crystal oscillator – although this is not always possible.

Suppose a dot clock frequency of 10MHz is used with a monitor having a horizontal scan rate of 15.625kHz (64 microseconds) with 48 microseconds of that allowed for display, then it would be possible to display x dots on each horizontal scan line, where x equals the available time (48) divided by the dot width (0.1) – that is 480 dots.

A domestic television set has a bandwidth of between 4 and 8 MHz, whereas monitors commonly have bandwidths up to 20MHz, some up to 65MHz.

Horizontal scan rates

The television standard of 15.625kHz has the disadvantage that, to much of the population, it is audible. There is a growing trend to increase this frequency so that it cannot be heard, 18 to 20kHz being common. Obviously, as this frequency increases, so does the bandwidth necessary to display the required number of dots.

Vertical scan rate/refresh rate

In the UK, the vertical scan rate is nearly always 50Hz, although an increase of 5Hz or so can be useful for reducing screen flicker. As soon as a monitor is run at anything but 50Hz, care must be taken to avoid hum loops.

Knowing the vertical and horizontal scan frequencies, the maximum number of horizontal scan lines can be calculated. A frequency of 50Hz corresponds to 20 milliseconds between vertical sync. pulses, of which one millisecond might be needed for vertical blanking. The remaining 19 mil-

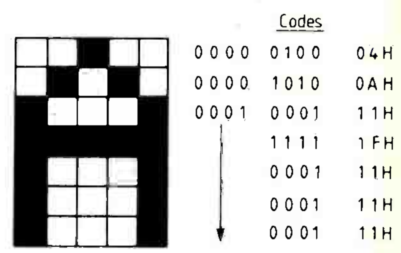


Fig. 2. *Capital A formed in a 7 × 5 matrix, with matrix patterns obtained from character generator and hex. equivalents.*

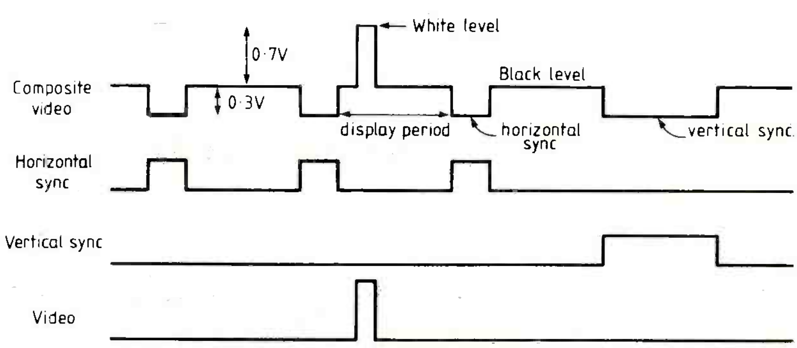


Fig. 1. *Video waveforms. Top is composite-video signal, while other three waveforms, fed separately, form the direct drive.*

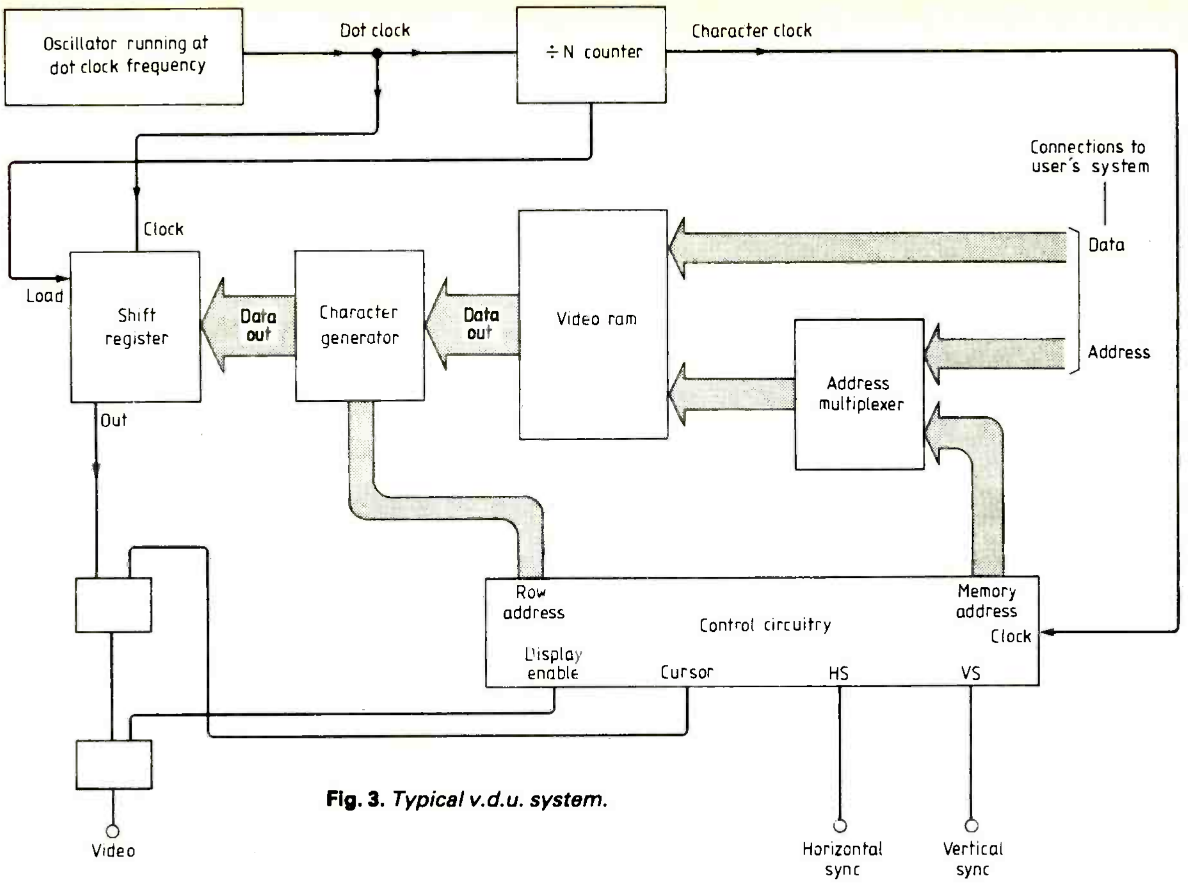


Fig. 3. *Typical v.d.u. system.*

liseconds is available for horizontal scan lines, the number of which is calculated by dividing this period by the horizontal scan time, i.e. 19000/64 = 296 scan lines.

Characters

A character can be displayed on the screen by illuminating specific dots within a small matrix, 5 × 7 and 7 × 9 being common matrix sizes. Figure 2 shows an upper case 'A' formed in a 5 × 7 matrix, which is adequate for low-bandwidth applications. Larger matrices improve character resolution, provided the monitor has sufficient bandwidth. With a 5 × 7 matrix, an inter-character spacing of one dot is acceptable, so a scan line supporting 480 dots could handle 480/(5 + 1) – i.e. 80 characters horizontally.

The matrix patterns for each character displayable by a video system are stored in a prom or rom character generator and make up what is known as the character set. Each pattern has to be coded into binary, using a 1 where the matrix is to be illuminated and 0 elsewhere. Each horizontal bit pattern in Fig. 2 is converted to a byte and stored, scan line by scan line, in the character generator, which is often a prom, so that the character set can be changed at will.

If 296 horizontal scan lines are available, and a 5 × 7 matrix is being used with three scan lines free between each row of characters, then 29 rows of characters could be fitted onto that screen. This would not be very readable and would not allow for lower-case letters with descenders such as 'g' or 'y'. They are accommodated by increasing the depth of the matrix or by raising them into the matrix, which can be strange visibly.

The character clock indicates the rate that characters appear on the screen. If dot clock is 100MHz and each character is 5+1 dots wide, then the character clock rate is 10/(5 + 1) = 1.67MHz.

Cursor

The cursor is a block or bar of light, often flashing, which moves around the screen indicating the position where the next character is to appear. As the screen is filled with text, so the cursor moves along covering each line in turn: carriage return sends the cursor to the start of the next line down. When the cursor reaches the end of the bottom line on the screen, it is common for the text to scroll, which means that each line of text moves up the screen one line and the top line disappears.

Video ram

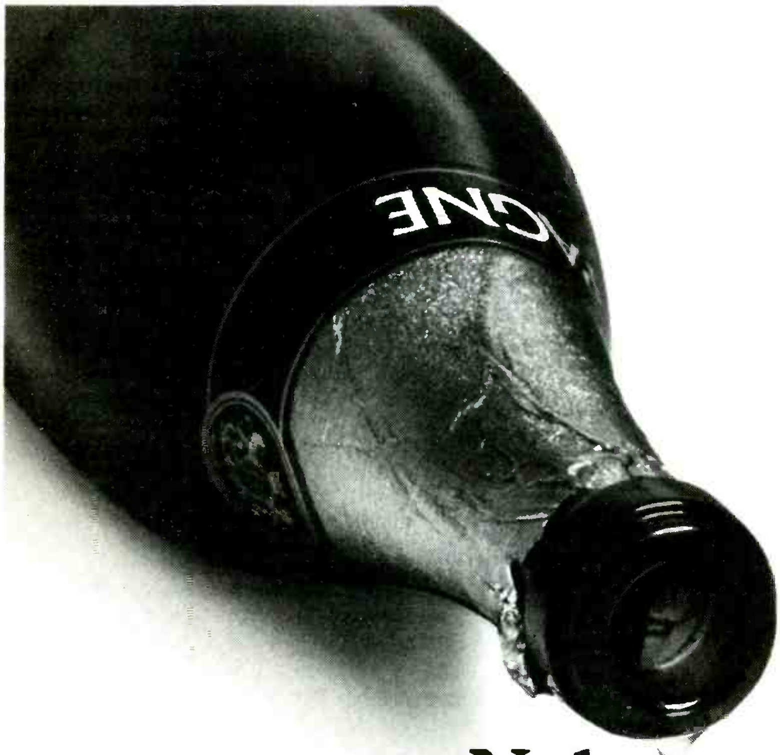
Figure 3 shows a typical, minimum visual-display system.

Screen information is stored in an area of ram known as video ram: in older designs, this ram often has separate data input and output pins. Each byte in the video ram corresponds to a position on the screen; for example, a screen having 16 rows of characters with 64 characters in each row requires 16 × 64, i.e. 1024 contiguous bytes of video ram. The first byte corresponds to the first character on the first row, the second to the second character on the first row . . . the 65th byte to the first character on the second row and so on until the 1024th byte which corresponds to the last character in the last row.

A code has to be stored in each location to define what character will appear at the allocated position on the screen. This code is usually an ASCII seven-bit code; the character generator is coded similarly. As the video ram is likely to be eight bits wide, and the ASCII code only seven, the spare bit can be used for other purposes.

The video ram is accessible by both the video control circuitry and the user's system – the latter may well want to read the video ram as well as write to it. Exactly how the circuitry arbitrates between the two interested parties is a matter for some care. In Fig. 3 a multiplexer is fitted to the address lines feeding the video ram so that they can be switched between the user's system and the video control circuitry, which issues a series of 64 sequential video ram addresses. At the top of the screen, the first address issued is 000H, as this corresponds to the first byte on the first row, the next 001H and so on up to 03FH. Suppose that 41H is stored in location 000H; shortly after the issue of that address by the control circuitry, 41H appears data output pins and this code is presented at the input of the character generator. The control circuitry also issues a row address for the character generator, which increments for each scan line of the character. The display-enable line is active except during blanking and the cursor line at the time it is present on the screen.

Continued next month



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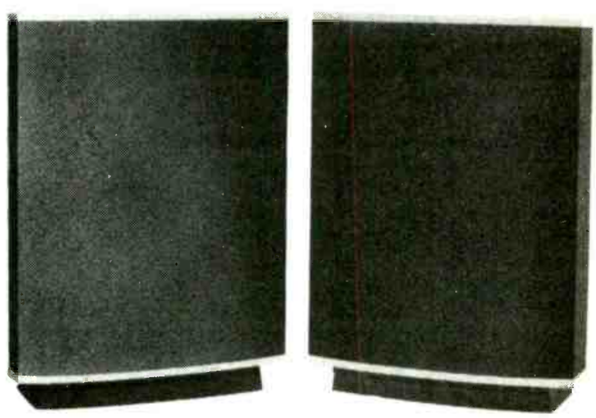

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AUDIO OSCILLATOR WITH TONE BURST

An audio signal generator, providing both sine and square outputs from 10Hz to 250kHz. Switch-controlled logic circuitry provides a variable mark/space-ratio tone burst, and the output can be switched to include a RIAA network

by J. T. Tiernan,
F.S.E.RT.

This article describes the design and construction of a signal generator capable of producing both sine and square waves in the range 10Hz-250kHz. Comprehensive tone-burst generation facilities are also provided. The oscillator section is a conventional Wien-bridge configuration, using an RA53 thermistor for amplitude stabilization; and for those who have no requirement for tone burst facilities, the oscillator, associated attenuator, and output amplifier may be used as the basis for a good general-purpose sinewave generator. The sine-wave distortion has not been measured, but the distortion figure for this type of circuit is usually claimed to be 0.5 - 1.0% over the 20Hz - 20kHz range. Also included in the oscillator section is an octave switching arrangement (very convenient for checking filter slope rates) and an RIAA pre-emphasis network, which may be used for testing the performance of magnetic pickup preamplifier inputs.

Circuit description

The oscillator, shown in Fig. 1 employs a Wien-bridge network to determine frequency and the oft-used R53 thermistor stabilizes the oscillator output at about 1V r.m.s. It is the simplest (and most reliable) form of stabilization, its main drawback being a relatively long thermal time constant which gives rise to some output-amplitude bounce on changing frequency.

Variation of R_A/R_B and/or C_A/C_B control output frequency: R_1 and R_6 set the maximum frequency for a given value of C; minimum frequency is determined by the maximum value of R_A/R_B (plus, of course, R_1 and R_6). In practice, the value of C_2 also affects the lowest frequency that can be obtained – the larger the value of C_2 the lower you can go.

A CA3140 op-amp is used as the active element in the oscillator, with R_7 included to help it sink current to the 0V line. Without R_7, there is noticable clipping of negative half cycles of the output sinewave. A 741 may be substituted directly for the 3140, but the 741's poor slew-rate performance will limit the upper frequency obtained to around 50kHz.

Frequency determination. Many signal generators have frequency bands spanning the 15-200 range; but that is not always convenient, and this design works in bands of 10-150 via the secection of CA_{1-4} and CB_{1-4} (Fig. 2). An additional and useful feature is provided by capacitors CA_{11-44} and CB_{11-44} in conjunction with S_7, operation of which effectively halves the value of the selected capacitors and causes the output frequency to be exactly doubled. It allows for quick and convenient checking of filter roll-off slopes.

The bandwidth of a given effect is usually proportional to its centre frequency, and this implies that it would be appropriate to give more dial space to the lower frequencies in order to keep bandwidth vs frequency in proper perspective. Many commercial signal generators for serious audio work give approximately equal space on the dial scale for each octave of frequency covered, and the (nearly) ideal component for R_A/R_B is a dual square-law potentiometer. Such components are available but, besides the expense, they are wirewound, rather large, and not well suited to high-frequency operation. However, shunting the active section of a log-potentiometer, as shown in Fig. 2 (R_{32} and R_{33} across R_A and R_B) produces a very acceptable result. Frequency calibration holds good up to about 50kHz, but above that there is a gradual divergence leading to a −15% error at the maximum output frequency.

The output from the oscillator at points E and F of Fig. 1, is about 1*V* r.m.s. and is fed to the tone-burst section (to be eventually returned to point G for output conditioning). Those who wish to make use of the oscillator section only may link points E and G directly.

Attenuator. Resistors $R_{8,9,10}$, in conjunction with S_2 and P_1, form a simple decade attenuator. The decade divisions are not exact owing to the finite input impedance (47k) of the output amplifier. The attenuator is placed before the amplifier in order to realise minimum output impedance, and hence maximum drive capability at the output terminal. If 600 ohm output impedance is required it can be achieved by bridging points M and N with a 600 ohm resistor.

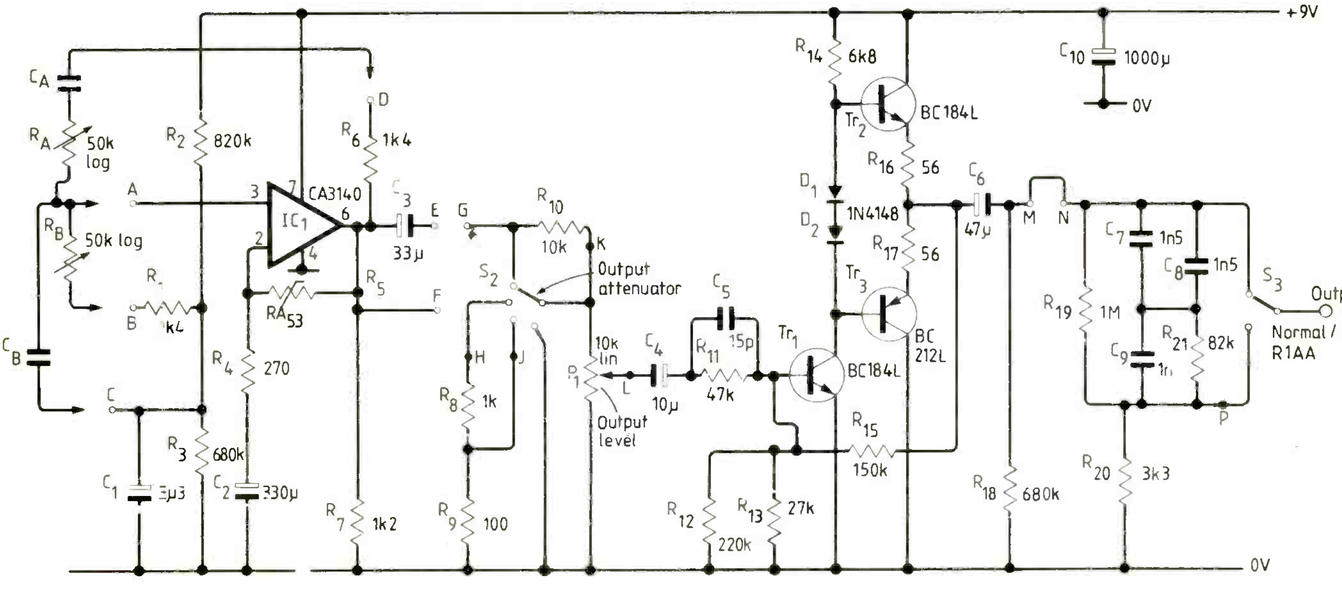


Fig. 1. Wien-bridge oscillator circuit with output amplifier. Frequency determining network shown in Fig. 2.

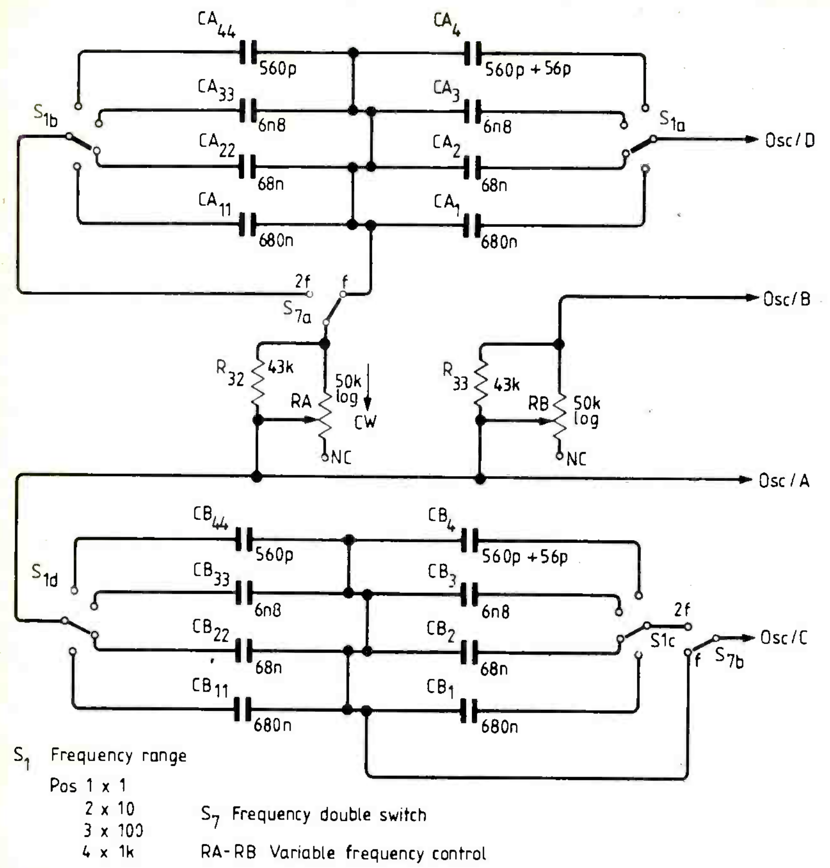


Fig. 2. Components shown as C_A, R_A, etc in Fig. 1. Frequency is switched in decade steps and S_7 doubles frequency.

Output section. The output amplifier is a simple class B design with a gain of about 2.5, and it is capable of driving output loads as low as 10 ohm (but at reduced output, about 300mV maximum). There are no discernible crossover effects and its performance is far superior to that which could be obtained by using, say, another 3140 op-amp. The d.c. levels have been chosen to allow operation down to +7.5V supply voltage (the lowest value at which the battery supply can be considered usable) at which the amplifier will deliver 2V r.m.s. before the onset of clipping. This approach restricts the maximum potential output which could be realised for supply voltages above 7.5V, but it should prove adequate for most test applications. With the amplifier gain value chosen it will always be possible to provide slight overdrive at the maximum settings of S_2 and P_1; and the short circuit output current is limited to 50mA r.m.s. with $R_{16}=R_{17}$ = 56ohms. Output rise and fall times (square-wave input with C_{12} = 18pF) are symmetrical and surprisingly good for so simple a design.

The final bit of output circuitry is a passive RIAA pre-emphasis network, accurate to within 1dB, and useful for carrying out equalization checks on magnetic pickup preamplifiers. The attenuation factor of the network measures 31dB, and output impedance 3k3 ohms, at 1kHz.

Tone burst generator

The ability to generate short but precisely defined bursts of signal is a very useful attribute for a piece of audio test equipment; audio systems can be fed with test inputs which approximate to the real-life situation, and the following applications spring immediately to mind:

- amplifier peak power determination;
- visual inspection of amplifier transient behaviour;
- measurement of noise reduction circuitry performance; (attack/release times and frequency sensitivity)
- loudspeaker tone burst testing.

In the circuit to be described, c.m.o.s. logic i.cs are used to generate the tone-burst control signals. The design uses four i.cs, and tone-burst timing is controlled by the outputs of a single 12 bit counter, clocked at the oscillator signal frequency. An oscilloscope pre-trigger is produced one half cycle before the start of a tone burst.

Logic description. The circuit diagrams for the control logic are given at Figs 4 and 5, but to aid understanding, an equivalent-function logic version, with associated waveforms, is given at Fig. 3. (The waveforms assume selection of the Q_1 and Q_2 outputs – points G and H – from the counter, to set the number of cycles in the burst and the total sequence period respectively.)

Referring to Fig. 3; the counter is running constantly, clocked via a squaring amplifier and Schmitt trigger (note that the counter advances on the negative transition of the clock signal). Every time

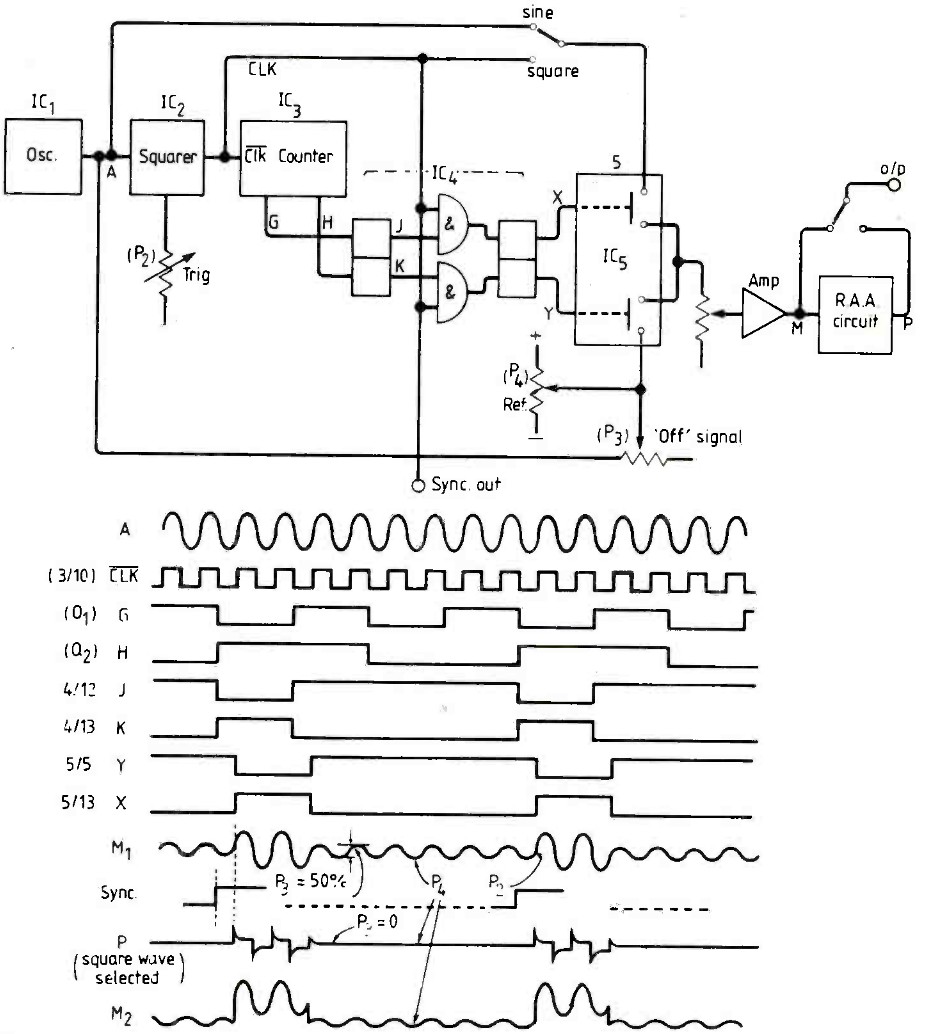
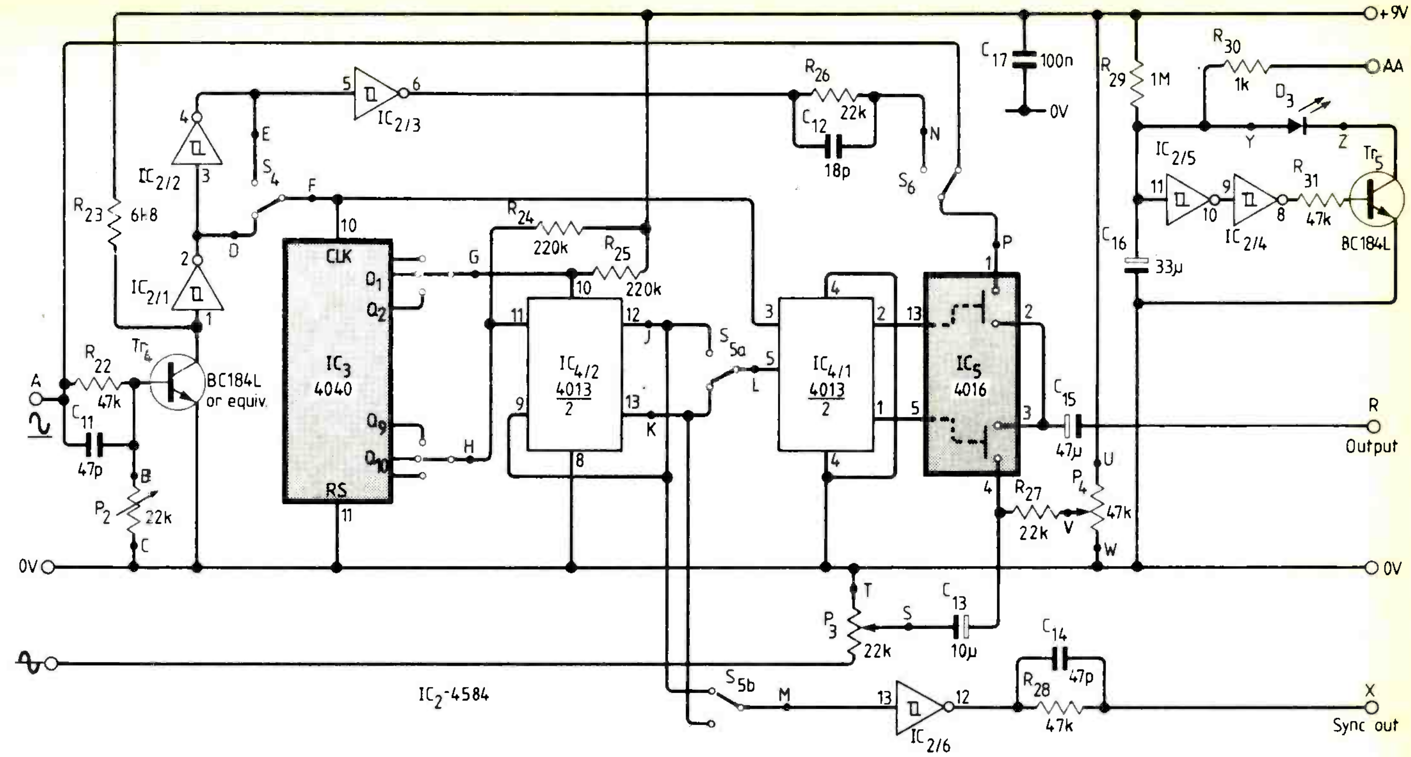


Fig. 3. Basic circuit of tone-burst switching, with waveforms.



G goes positive it will either set or maintain toggle output J at logic 1. Each positive transition of H will reverse the status of the first toggle, but reset will occur as soon as there is a positive transition at G.

Since the counter advances on the negative clock transition, the states of J and K will not be transferred to X and Y until half a cycle after they (J and K) have changed: this system ensures there will be no odd triggering effects due to counter propogation delays, but it will provide a convenient (and necessary, for some 'scopes) sync. waveform half a cycle before the analogue gate IC_5 is opened for a tone-burst transmission. During the X 'on' period, the upper gate of IC_5 transmits the input signal to the output attenuator: during the Y 'on' period it will pass whatever is present at the input of the lower gate, which is a d.c. level set by P_4 (usually to the centre level of the signal waveform on the upper gate) on which may be superimposed the input sine wave from point A, at an amplitude determined by the setting of P_3. The trigger control, P_2, sets the mark/space ratio of the Schmitt-derived square wave, and hence either (a) the duty cycle of the output waveform (square-wave output selected) or (b) the point on the sine wave at which the tone burst starts. Waveforms M_1, M_2 and P give some idea of the effects of P_2, P_3, and P_4. Note that the waveform lettering is correct in relation to Figs 4 and 5 except those noted arbitrarily as X and Y at the inputs to the analogue gates.

Fig. 4. *Tone-burst gating. Inputs from circuit of Fig. 1. (E and F) and output to G in Fig. 1.*

Taking the real-world circuits and dealing first with Fig. 4, Tr_4 takes the input sinewave, plus a 4.5V d.c. level, from point F in the oscillator section and raises it to a level suitable for operating the Schmitt trigger $IC_{2/1}$. Variation of P_2 allows variation of the m/s ratio of the resulting square wave between 0 and 100%. The Schmitt circuits invert the input waveform, and thus S_4 will select a clock-pulse train which may be either in phase or 180° displaced from the input sinewave. The setting of S_4 (INVERT) determines the polarity of the output tone burst, i.e. 'n' cycles, starting with a positive half cycle, or 'n' cycles starting negative. A third Schmitt, $IC_2/_3$, is used to invert and buffer the square wave for input to the analogue gate, and R_{26}/C_{12} attenuate it to approximately the same pk-pk amplitude as the sinewave (but only at V_{supply} = 9V; the square wave amplitude will vary according to the actual supply voltage).

The square wave at point F clocks the counter to produce division ratios 2, 4, 8, 16 . . . 2048, 4096 at the Q_0 . . . Q_{11} terminals, and the selected Q points are fed to the 'set direct' and clock inputs of $IC_{4/2}$ (a D-type flip-flop with the D input on pin 9) – refer back to Fig. 3 for the waveforms. Either the J or K output may be selected to feed the D input of $IC_{4/1}$, and the position of S_5 determines the tone-burst /space relationship of the output sequence. For $G=Q_2$, $H=Q_7$, S_5=K, the output will consist of sequences of eight cycles of signal followed by 248 (=256-8) cycles of 'space'. With S_5 = J and Qs unchanged, the output sequence will be reversed to 248 cycles of signal and eight cycles of 'space'.

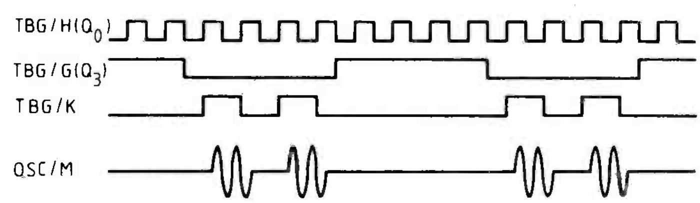


Fig. 6. *Setting S_8 in Fig. 5. to "PATTERN" produces this type of output.*

For constant sine or square-wave output (S_6) the Q selection switches (Fig. 5) are all set to 'off' (J = 1 via R_{25}) and $S_{5(a)}$ is set to select K (REVERSE).

The sync. output is taken from either J or K via $S_{5(b)}$ and buffered out via $IC_{2/6}$

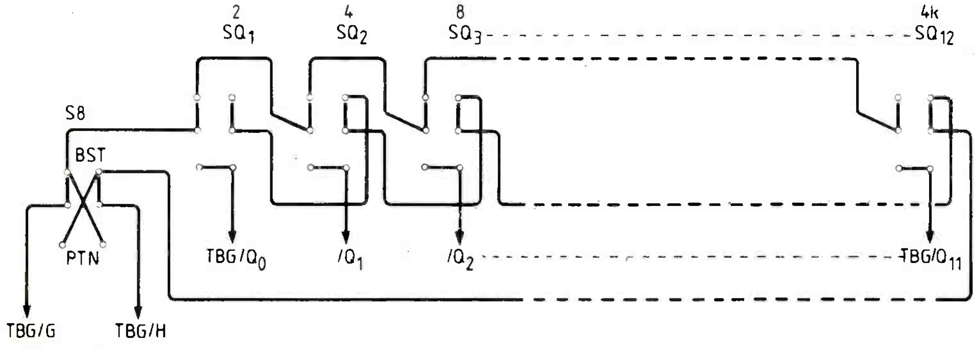


Fig. 5. *Switching for tone-burst gating. Circuit connects to G and H in Fig. 4.*

and R_{28}/C_{14}. In practice, point M can be connected directly to point L; $S_{5(b)}$ is only required if your oscilloscope 'prefers' triggering from a particular polarity waveform when $S_{5(b)}$ can be wired accordingly.

Q switching (Fig. 5). It is appropriate to look at the counter switching arrangements at this point rather than going immediately to the circuitry around $IC_{2/4}$ and $IC_{2/5}$. There are 12 Q switches, one for each of the counter outputs $Q_0 - Q_{11}$, and the interconnexions are such that, regardless of the total number of switches in the 'on' position, only the outer two are effective and feeding Q signals to S_8. With S_8 in the BURST position, the generated control signals are as depicted in Fig. 3. The time period contribution of an 'effective' Q switch depends on whether it is the first (feeding G) or the last (feeding H); the last switch sets the overall sequence time period in accordance with the normal binary weighting of its Q input, i.e. $Q_o = 2$, $Q_2 = 4$, $Q_2 = 8$ etc. The first switch sets the burst-time period within the overall sequence at a value equal to half its binary weighting ($Q_0=1$, $Q_1=2$, etc). Waveforms G, H, J make the relationship clear.

When S_8 is in the PATTERN position, the situation is rather different and the operation cannot be seen from the simple representation at Fig. 3. The waveforms given in Fig. 6 show what happens when $G=Q_3$ and $H=Q_0$. When, say, $G=Q_6$ and $H=Q_2$, the output will consist of 128 cycle sequence periods, within which there will be four bursts of eight cycles spaced at eight-cycle intervals. This option may have no useful application, but the result is too pretty to ignore, and it is the only option which can produce 1:1 mark-space ratio in tone-burst mode.

Turning now to the last two elements of IC_2 ($IC_{2/4}$ and $IC_{2/5}$); these are used to form a 'battery saver' circuit feeding a front panel led 'on' indicator (D_3). With the component values specified, C_{16} charges (via R_{29}) and discharges (Tr_5 and D_3) on a three-second cycle, causing the led to flash appropriately. But with the led buried in a plastic bung for panel mounting, and in a well-lit room, the effect is, frankly, disappointing; the led needs to be reasonably openly mounted, and angled upwards, for it to be worthwhile.

The resistor R_{30} and terminal AA are provided to give constant led operation when the generator is fed from an external supply (see Fig. 7); but if a rise to 16mA on battery operation can be tolerated, terminal AA may be connected permanently to the +9V supply line.

Finally, in this description of the tone-burst logic, a couple of points about the nature of the input to terminal A should be mentioned. In order to exercise smooth control of the m/s ratio fo the square wave out of $IC_{2/1}$, the input circuitry for Tr_4 has been designed to accept a sinewave input of about 1Vr.m.s. with a d.c. component of about +4.5V. It is also worth mentioning that shunting P_2 (22k) with a 33k resistor gives smoother control than the potentiometer on its own. The signal inputs to the analogue gates (IC_5) must not go outside the limits bounded by the power supply feeds to the i.c. Slight overdrive will result in clipping of the output and severe overdrive may cause permanent damage to the device. The output from Point F on the oscillator fulfils both the above, and if anyone wishes to make up the tone-burst logic only, to be driven from a generator with an earth-referred output, a coupling network similar to that at Fig. 8 must be used for coupling to point A (TBG/A) in the tone-burst logic.

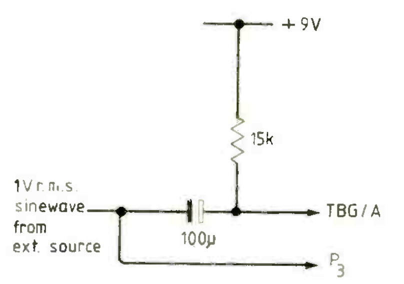
continued on page 86

Specification

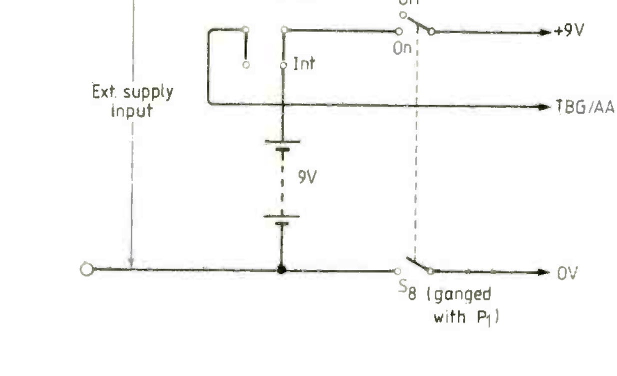
All measurements taken with battery supply, V=9.5V

Frequency range	10Hz-250kHz in four overlapping bands. 10-150 nominal band scale plus octave multiplier.
Output waveforms	1. continuous sine wave 2. continuous square wave with variable m/s ratio and symmetrical rise/fall times: to 70% 60ns; to 90% 250ns; at 7V pk-pk output and 10kΩ load. 3. Sine-wave burst: any binary figure (1,2,4,8 etc) between 1 and 2048 cycles within an overall timing sequence selectable between 2 and 4096 cycles. 4. Square-wave burst, as for 3. 5. Either 3 or 4, but with variable-amplitude sine-wave, interposed between the main burst signals. 6. Group burst patterns 7. All the above but with RIAA pre-emphasis.
Maximum output signal (1KHz sine wave)	R_L=10kΩ 2.5Vr.m.s. R_L=600Ω 2.25Vr.m.s. (+9dBm) R_L=100Ω 1.5Vr.m.s. R_L=10Ω 300mVr.m.s.
Amplitude/frequency stability	+0.5 -1.0dB, 10Hz-250kHz (ref. 1kHz, 2V r.m.s.)
*Square wave amplitude	Variable up to 7V pk-pk
Short-circuit output current	Limited at 50mA r.m.s.
Supply requirement	7.5-9.5V at 10mA (internal batteries) or 7.5-12V at 12-20mA (ext. supply)

*set approximately equal to sine wave pk-pk output (with 9V supply)



▲ *Fig. 8. Circuit to allow the use of the tone-burst generator alone.*



◄ *Fig. 7. Power supplies. See text for recommendations.*

LETTERS

TAPE VOICES

It is now more than eleven years ago that Konstantin Raudive's book, "Breakthrough" announced the discovery of the tape-voice phenomenon to the English speaking world. The publication started what at that time was expected to become the greater challenge in the field of parapsychology and electronics.

Wireless World also carried a detailed review of the book "which I strongly commend to your attention" (Vector, June 1971), and the comment that "the problem cries out for investigation". For the sake of truth, it must be admitted that some interesting investigations indeed was carried out, and the results of some very convincing tests (by Pye, Belling-Lee, and others) were published. Also, a lot of articles, radio and television programmes dealt with the matter. But after a short time, the interest decreased, and today (to my best knowledge) all research is done outside Britain.

Can it really be true that British engineers and technicians (I mean, of course, real technicians and not modern black-box manipulators with digitalized brains) have completely given up this, "the greatest challenge"? I can't believe that this should be the case.

Anyhow, if there is somebody working on the technical aspects of this matter, I should be very glad to hear of it.

Peter Stein
3400 Hilleroed
Denmark

LM 109

In Appendix 1 of the interesting article "LM 109 three-terminal voltage regular" (March 1982), J. L. Linsley Hood sounded hardly convincing when he neglected the last two terms of equation (1), as these are strongly temperature-dependent. I would like to propose a simpler, but more credible solution.

The voltage across a forward-biased emitter junction in silicon is approximately 0.6V and decreases by 2mV per degree Centigrade. Therefore $V_{BE}=0.6$ and $\partial V_{BE}/\partial T=-0.002$. On the other hand,

$$V_{BE}=\frac{kT}{q}\ln\left(1+\frac{I_E-\alpha_I I_C}{I_{EO}}\right)$$

where α_I is the inverted common-base current gain. As I_E and I_C are much greater than the leakage current I_{EO} and α_I is in the order of 0.5, it is reasonable to assume that

$$\frac{I_E-\alpha_I I_C}{I_{EO}}\gg 1$$

$$V_{BE}\approx\frac{kT}{q}\ln\left(\frac{I_E-\alpha_I I_C}{I_{EO}}\right)$$

Imposing the condition $I_{C1}=10I_{C2}$ for two identical transistors at the same temperature,

$$\frac{I_{E1}}{I_{E2}}=\frac{I_{C1}}{I_{C2}}=\frac{I_{E1}-\alpha_I I_{C1}}{I_{E2}-\alpha_I I_{C2}}=10$$

$$\Delta V_{BE}=\frac{kT}{q}\ln\left(\frac{I_{C1}}{I_{C2}}\right)$$

which is equation (3) in the article.

$$\frac{\partial}{\partial T}\Delta V_{BE}=\frac{k}{q}\ln\left(\frac{I_{C1}}{I_{C2}}\right)=\frac{\Delta V_{BE}}{T}$$

The reference voltage should be independent from temperature:

$$V_{out}=V_{BE}+\delta\Delta V_{BE}$$

$$\frac{\partial}{\partial T}V_{out}=\frac{\partial V_{BE}}{\partial T}+\delta\frac{a\Delta V_{BE}}{\partial T}$$

$$=-0.002+\frac{a\Delta V_{BE}}{T}=0$$

$\delta\Delta V_{BE}=0.002T=0.6$ volts for $T=300°K$.

Finally,

$$V_{out}=V_{BE}+a\Delta V_{BE}=0.6+0.6=1.2V,$$

which is the "band-gap" potential for silicon.

W. Falcone,
Department of Pharmacology
Leeds University.

CALCULATING V.S.W.R.

I have stumbled upon a quick method of calculating v.s.w.r. when the reflection coefficient is known and vice versa, which may be of interest to *Wireless World* readers. This method is especially helpful for use with a scientific pocket calculator. The theory behind this method is as follows:

$$\text{v.s.w.r.}(s)=\frac{1+|r|}{1-|r|}$$

where r is the reflection coefficient. This function has a minimum value of 1 when $|r|=0$, and a maximum value of infinity where $|r|=1$.

A function with identical properties is tan $(45°+|x|)$ which is 1 for $|x|=0$ and infinity for $|x|=45°$. Expanding,

$$\tan\,(45°+|x|)=\frac{\tan\,45°+\tan|x|}{1-\tan\,45°\,\tan|x|}=\frac{1+\tan|x|}{1-\tan|x|}$$

This leads to the conclusion that if

$$s=\tan\,(45°+|x|,\ |x|=\tan^{-1}|r|$$

$$\therefore\tan^{-1}s=45°\tan^{-1}|r|$$

The method of calculating $|r|$ from s is therefore to convert s into an angle by taking the inverse or arc tan on the calculator, subtract 45° and then take the tan of the difference.

A. Marshall
Teddington
Middlesex.

DOUBLE-BLIND LISTENING TESTS

IT would seem that the double-blind listening test (d.b.l.t.) method has been primarily concerned with measurement oriented methodology. Little, if any, consideration has been given to the hearing processes and the listening behaviour involved in the design of the test method. I believe there is reasonable cause to doubt the results of this test method.

The A-B d.b.l.t. is conducted in conditions which do not represent the situation in which we normally experience reproduced music. Perhaps a test that more closely parallels conditions in which audiophiles say they've heard differences would be a step in the right direction. Those conditions include but, are not limited to: aural familiarity with the equipment; aural familiarity with the room; and both of the above achieved through listening periods of an extended length of time.

Consequently, for a valid listening test, the person doing the test needs to be very familiar with the system; all of its components together in the partiuclar room in which the test is being conducted. This would probably be the home system of the person doing the test. A d.b.l.t. which ignores the normal listening conditions should be suspect.

Differences seem most noticeable (after long familiarity with one unit) the first few moments after a change is made. After changing to the unit on which one heard a difference, the longer one is exposed to only this new unit the less one is struck by the difference between the two. Long term listening periods (familiarity) are necessary to hear differences that are most noticeable when initially changed to another unit.

Shortening the listening period (as d.b.l.t. are now conducted) does not seem to lead to the same degree of noticeable difference. It seems that as we shorten the listening period between units the more alike they tend to sound. Carried to extreme, if we switched between the two units under test very rapidly there would be no percieved difference at all. We hear a composite of the two. Such qualities as imaging and related sound field perceptions require careful long term listening. In many cases only long term listening comparisons will clearly reveal a difference between the two and what that difference is.

Audophiles spend many hours listening to music via their own systems and develop a high degree of sensitivity with those particular systems. In many cases the equipment used compliments their perceptual biases, which increases the person's enjoyment and sensitivity to certain interests. Equipment changes are more likely to be noticeable in this environment, and it is in just this kind of environment that many audiophiles say that they hear differences.

The process of subjecting an individual, or worse, a panel of listeners, to only an evening of d.b.l.t. in an unfamiliar acoustical environment, with unfamiliar equipment and adding a randomizing procedure to the testing, results in just what one would expect – insensitivity and aural confusion. Such testing to date has been rather like an experiment where we design instrumentation to measure very accurately certain parameters but we don't understand the experiment and therefore gather accurate garbage.

No method exists that can "prove" either the existence or non-existence of a given perceptual phenomenon. Thus the astute audiophile will note the claims and counter-claims and the conditions that produced them, and will attempt for himself to hear (or not hear) what was claimed. He would be better served to listen for himself rather than accept others' biases and perceptions or the results of d.b.l.ts. As long as there continues to be an interest in listening tests, inquiry into the nature and behaviour of the listening and hearing processes must be sought, understood and appropriately incorporated.

Richard N. Marsh
Livermore
California, USA.

LETTERS

TELETEXT DECODER

Mr Alan Pemberton's letter on p.49 of February 1982 *WW* points out why the original erase page circuitry does not work correctly with interleaved magazines, as currently used on 'Oracle'.

Unfortunately, I found that the circuit he suggested, while working fine on Oracle, caused the loss of the first 4 rows of Ceefax pages (following the header) on my decoder. In his modified circuit, when 77,1 is high, the negative strobe pulses from 71,3 pass through 77,6 and clock IC_{78} on their positive going back edges. When 77,1 is low, 78,11 is held low regardless of 71,3.

However, as 71,3 is normally high, IC_{78} will also be clocked when 71,5 goes high, and I suspect that I was encountering unwanted loading of IC_{78} at this point.

The modification can be simplified by leaving the feed to 78,12 unchanged from the original design, while And gating 71,3 with Q (78,8) instead of 71,5; so that once IC_{78} is set, the clock is disabled until the bistable is cleared by the next field sync. on pin 13.

As my decoder uses the whole of IC_{77} for other purposes, the And gating was achieved by inserting a *germanium* diode between 71,3 and 78,11 (cathode to 71,3); and adding a second one from 78,11 to 78,8 (cathode to 78,8).

For the correct operation of the decoder with interleaved magazines, it is essential to break the link from 5,9 to 21,1; and to carry out the modifications described on p.60 of February 1977 *WW*, which check the magazine number of every row.

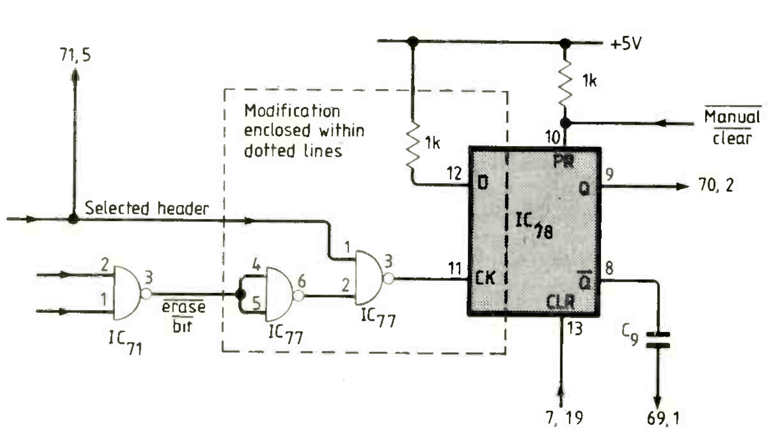
J. H. Hinton
Cambridge

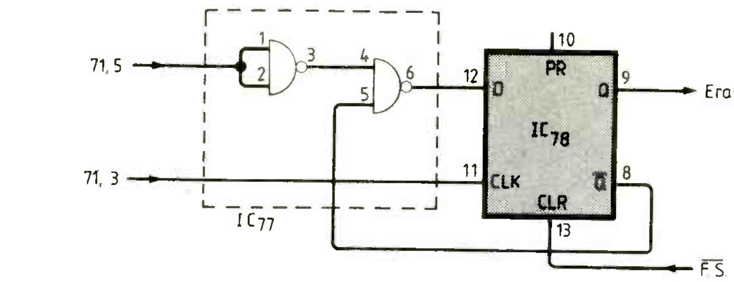
I have received details from Humphrey Hinton of his own modification, and now see the reason for the odd behaviour of my modification in his decoder. An earlier obscure modification of my own had resulted in IC_{78} being clocked by positive-going pulses, and not negative-going as in the original design.

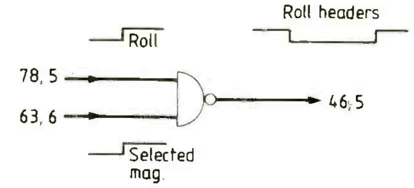
A simple re-arrangement of the gates of IC_{77} will ensure that 'standard' decoders will function correctly on both Oracle and Ceefax.

I thank Mr. Hinton for bringing this to my attention and apologise to constructors who have tried the modification without success.

Alan Pemberton
Sheffield







I was pleased to see in the Letter Column (*WW* February 1982) that an interest on the *WW* Teletext decoder still prevails. I was encouraged by Mr. Pemberton's letter to modify the clear page detection circuit enabling the decoder to work with interleaved magazines. Alas, I could not get it to work satisfactorily so I reconfigured the two spare gates as shown below.

This works upon the simple strategy that once a clear page bit has been correctly detected by 78(8), it can only be reset by the frame sync. pulses one field later, thus producing the required clear page action.

A few simple modifications which avid teletext followers may find useful are: –

i) Reduce value of C_{16} in the analogue board from 4n7 to a value closer to 470 pF, particularly if "missing rows" are experienced. This increases the attack rate of the peak detector such that during the framing code the slice level changes by less than 5%.

ii) A spare Nand gate (e.g. 49 (4,5,6)) may be used to display rolling headers only from the selected magazine, in order to prevent the ITV/ITN characters twinkling during "roll headers".

iii) Of greater annoyance than (ii) are the flashing time digits on Oracle, due to a difference (at present) between magazine 200 and all other magazines. With a difference of one or two seconds, the time display gives the illusion of an incorrectly adjusted decoder, whilst greater differences are simply confusing. The cure is straight forward, 62(10) is taken from 80(4), but the time is only updated from the selected magazine, which, for example, leads to an update every 16 seconds on Ceefax 700 magazine.

iv) If the ram disable pulse is used from IC_{318}(11) the page clearing function will not clear those locations where the selected page or time information is displayed. This can result in the header row changing colour during page/time selection due to the random bits stored in the rams at these locations. This can be overcome if IC_{309}(9) is taken from 78(9) which then ensures that Hamming bits are erased following roll or switch on.

Ken Drew
Nottingham

THE DEATH OF ELECTRIC CURRENT

Oh dear! Ivor Catt's latest letter (August) identifies him as a prime candidate for compulsory reading of Dr Scott Murray's series of articles. Then, at least, he might not confuse theories.

Classical electromagnetism, as developed by Maxwell in the 1860's, makes no appeal to the existence of the electron. For the case of a wave guided by a pair of wires, the wires determine the boundary conditions to the solution of the equations. Electrostatic theory requires that electric flux lines terminate on charges, but this is not always so for the electromagnetic wave. In any case, the classical theory of electric conduction imposes no limit on the speed of charges in the conductors – that comes from relativity theory.

So, Mr Catt is muddling models, which brings me back to the original point. Electric current and electromagnetic waves are only mechanistic models of processes which are beyond our comprehension – what Dr Scott Murray calls miracles. Hence, to say that a model does not exist is meaningless. If Mr Catt chooses not to like the electric current model that is his privilege, but it does not seriously devalue the usefulness of the model, which is judged by criteria other than credibility or personal preference.

Incidentally, M. G. Wellard may wish to note that the speed of light in water (refractive index ~ 1.33) is considerably less than that in vacuum. Cerenkov radiation is the electromagnetic equivalent of Concorde's sonic boom. Its existence (which is a fact) does not conflict with relativity. Perhaps Mr Wellard will apologize to Cerenkov.

R. T. Lamb
British Telecom
Milton Keynes

If Mr Catt's difficulties with electromagnetism are summarised by the example he gives at the end of his letter of August 82 then perhaps he can be helped.

As a pulse travels along the line the charge that terminates the electric field lines is provided by a current I. This consists of mobile electrons of charge e and if there are n such electrons per unit length of the line their velocity is v=I/ne. Suppose that I=1A and the conductors are copper wires of 1 mm^2 cross section then, ignoring the skin effect V is about 10^{21} per cm. Thus with $e=1.6.10^{-19}$C we have $V=6.10^{-3}$ cm s^{-1} or 2.10^{-13} the velocity of light. The skin effect, for a pulse of 1 ns risetime might raise V to 2 cm s^{-1} and, if the conductor is perfect and the electronic motion is solely limited by inertia V might even be as high as 100 cm s^{-1}, so that the electrons actually have to acquire a kinetic energy of $2.5.10^{-12}$ eV from the field.

F. N. H. Robinson
Clarendon Laboratory
Oxford

I write in response to Mr Ivor Catt's request in his letter on "The Death of Electric Current" (*W.W.* Aug. 1982).

The contradiction claimed by Mr Catt stems from his assumption that the apparent velocity with which charge moves along a conductor is the same as the velocity of individual electrons. It is well known from the free electron model of metals (see for example Solid State Physics: Second Edition: C. Kittel, Wiley 1956) that this is not the case. The current density, J (A/m), is given by NeV_D, where N is the number of electrons per cu. metre, e the electronic charge and V_D the drift velocity of the electrons. The drift velocity is the directed velocity component resulting from an electric field and superimposed on the thermal velocities of the electrons. The drift velocity is much less than the thermal velocity except in electric fields of very high values. The current density may be interpreted as qv, where q is the charge per unit length of conductor to sustain the electric flux of the TEM wave and v is the velocity with which the wave moves. Hence,

$$vq = NeV_D$$

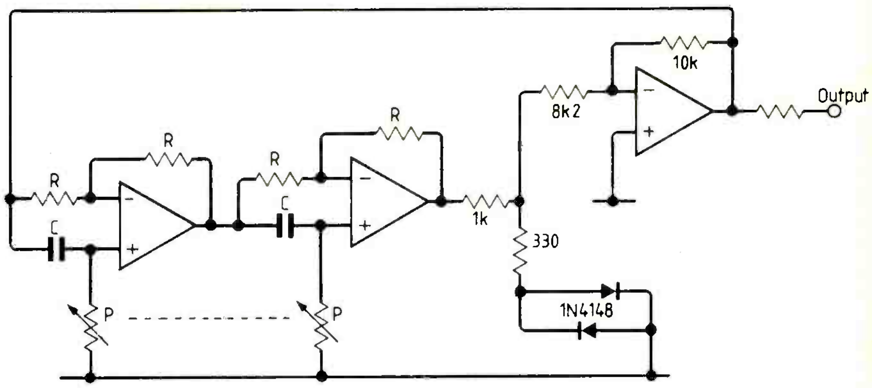
and $V_D/v = q/Ne$ will be a small ratio in typical conductors. The statement that "such electrons would have to travel at the speed of light in a vacuum" is thus wrong.

Dr J. Brown, C.B.E.
Technical Director
Marconi Electronic Devices Ltd

PHASE-SHIFTING OSCILLATOR

I read with great interest the February article by Roger Rosens on a phase shifting oscillator as I developed a similar oscillator recently. A feature of this type of oscillator is that amplitude stabilization can be much simpler than usual, and the circuit exhibits no amplitude bounce as the frequency is changed. As it is necessary only to limit the amplitude of oscillation and not the loop gain – which is constant with frequency – it is not necessary to include a thermistor, and the circuit shown has been found satisfactory.

This circuit is used successfully in our new high performance portable mixers, the 2000 series, giving 60Hz to 16kHz in a single sweep, at a distortion of less than 0.8%, and I have had the circuit working correctly at up to 500kHz.



Finally, another feature of this circuit, as developed by my colleague Steve Dove, is that if the loop gain is kept below unity, the circuit functions as a good bandpass filter!

Mike Law
Alice (Stancoil Ltd)

LOW-DISTORTION WIEN OSCILLATOR

With reference to Mr Linsley Hood's "New way of using Wien network . . . . ," in the May issue, this 'way' was described in one of my originating British patents on RC oscillators about 35 years ago. An r.f. pentode amplifier was followed by a valve phase splitter and a filament lamp was used for amplitude stabilisation. Since then, this oscillator has been continuously updated by the use of bipolars, f.e.ts, and i.cs for the amplifier, and thermistors, f.e.ts, i.cs, and opto-electronics for the amplitude stabilizer. We still think that this is the best 'way' to use a Wien bridge and are grateful for Mr Linsley Hood's enthusiastic support. As he says, quite a lot of harmonic distortion is produced at the 'input' of semiconductors and op. amps and this is made worse when using the high driving impedances that we prefer for other reasons. Our measurements of distortion on TL 072 op. amps at output voltages of about 2V are far worse than those quoted for his oscillator and we have attributed this distortion mainly to a non-true class A output stage, perhaps wrongly. It is a pity that his curve of distortion against frequency is limited by hum, as it would be interesting to see whether the worsening at the lower frequencies was mainly due to the time constant of the thermistor or the increasing drive impedance.

As a 'two for the price of one,' the voltage-controlled, variable-reactance device shown in Circuit Ideas in the issue November 1980 was described in my British patent, through the NRDC, about 25 years ago. The main advantages over variable-capacitance diodes are better frequency linearity and larger frequency variation due mainly to the fact that variable positive and/or negative reactance can be applied to a tuned circuit. This system allows the use of wideband swept oscillators with reasonably flat amplitude responses. It is also particularly useful for modulating the frequency of crystal-controlled oscillators. We have considered the use of this system in variable-frequency filters and would be interested to know if our New Zealand friends have also considered this.

F. G. Clifford
Wynberg
South Africa

CARTRIDGE ALIGNMENT

The letter from Mr R. J. Gilson in our August issue contained an error in the second sentence of the second paragraph, which should read ". . . the angular error to vary with radius . . ." – Ed.

AMATEURS AND BAND 1

G. M. Pheasant (August, 1982, page 60) expressed the hope that radio amateurs would be permitted access to the 50 MHz band when the 405-line television transmitters are withdrawn from service.

The BBC acknowledges the valuable contributions by radio amateurs to the study of propagation and wishes to encourage such activities. The Home Office and the BBC have recently discussed a proposal that exceptional permission could be given to a strictly limited number of UK radio amateurs to operate outside broadcasting hours in the 50-52 MHz band.

The BBC has no plans to continue broadcasting in Bands I and III after the existing 405-line television services have been withdrawn. The future use of these bands is being urgently considered by the Independent Review of the Radio Spectrum from 30 MHz to 960 MHz.

P. A. Laven
Assistant Head
BBC Engineering Information Department

It will be a great shame if a small portion of Band 1 isn't allocated to radio amateurs when it becomes available. This is a unique and valuable section of the spectrum for experimentation.

I propose the section 48MHz-48.6MHz, giving 48 × 12.5kHz channels with the third harmonics falling in the amateur 2 metre band, and making them easily policed and identifiable. Any fourth harmonics would fall on the IBA's Ch.9 only. (As a tv technician in North Devon, I know only of *one customer* using this channel.)

With careful avoidance of specific local radio frequencies second harmonics shouldn't be any problem either.

These are my personal views and I welcome comment or letters of support.

John Stacey G8BXO
South Molton
Devon

LETTERS

MODERN PHYSICS

"Nobody ever became sunburnt as a result of exposure to a differential equation" remarks Dr Murray (The Electromagnetic Analogy, *Wireless World* August, 1982). No, but somebody may have avoided sunburn by taking note of the differential equations which describe the attenuation of ultra-violet radiation in its passage through the atmosphere and the reaction kinetics of the ozone layer. Seriously, though, there seems to be a basic misconception about the role of mathematics in physics, for its role is essentially *predictive* and in no way *explanatory*. One feeds whatever data may be available into a mathematical model and if the operation of the mathematics at least declares the input data to be mutually consistent and preferably also indicates a future state of the physical system which coincides with its actual evolution, then the mathematical model is regarded as a correct representation of the physical system.

A more fundamental and problematic question is whether every physical phenomenon can be "explained" by a mechanical analogy in which one can see a cause-and-effect relationship between the parts, of the type which occurs in the large-scale physical world and can be appreciated by our five senses. The answer appears to be negative, ever since the development of quantum mechanics, which has no parallel in ordinary large-scale mechanics. One has only to cite the application of particle/wave quality both to electrons and to photons; but worst of all, there is even doubt whether causation rules in the world of microphysics which is represented by quantum theory. At this point one has to admit that one cannot "understand" the behaviour of elementary particles in terms of mechanical models. But if one accepts the logic of mathematics, one can accept the logic of mathematical models.

D. A. Bell
Walkington
Beverley

By the end of the last century it was conceded that space contained no unique reference point.

In a book on mechanics, published in 1888, Oliver Lodge commented "No such thing as absolute rest is known, but it is convenient, in mechanics proper, to consider the earth as a body at rest". This is still the current practice and as a result we have some very funny physics and peculiar paradoxes. In his 1905 paper on moving bodies, Einstein reiterated that there is no absolute rest, adding that his theory would not require an absolutely stationary space or an ether. He then proceeded to invent his own 'stationary'. He suggested we call a set of co-ordinates the "stationary system" and then use them to define the position and movement of a point, employing rigid standards of measurement, a completely impossible task since a fictional reference point can only produce fictional position and velocity.

In fairness to Einstein it should be mentioned that every physics text extant uses the words 'the velocity of a material point' in a manner which requires whimsical decision. We are told, B has a velocity v with respect to A and so travels from B to B' a distance l, in time t, so that l=BB' = vt. By a simple change of mind it could be claimed with equal truth that A has a velocity v with respect to B and moves a distance l = AA'. This dilemma is not solved by introducing conjurers' props like co-ordinate systems or frames of reference, inertial or otherwise.

The solution is simple. In space with no absolute rest only the separation of material bodies and the change of separation with time, can be described. Individual velocity and distance travelled must remain permanently indeterminate.

Mention whould be made of Einstein's co-operative myopic observers, without whose help the theory would not have been possible. The one sitting on an imaginatively moving plank, claimed he saw a flashing lamp (A) screwed to the end of it; the other observer, riding on the declared stationary co-ordinates said he say the lamp fastened to the x axis of his system.

Einstein's science fiction was most successful from his point of view; it earned him notoriety and a better job. How relativity theory became required reading in our universities is something I cannot understand.

Edwin Hill
Stockton
Rugby

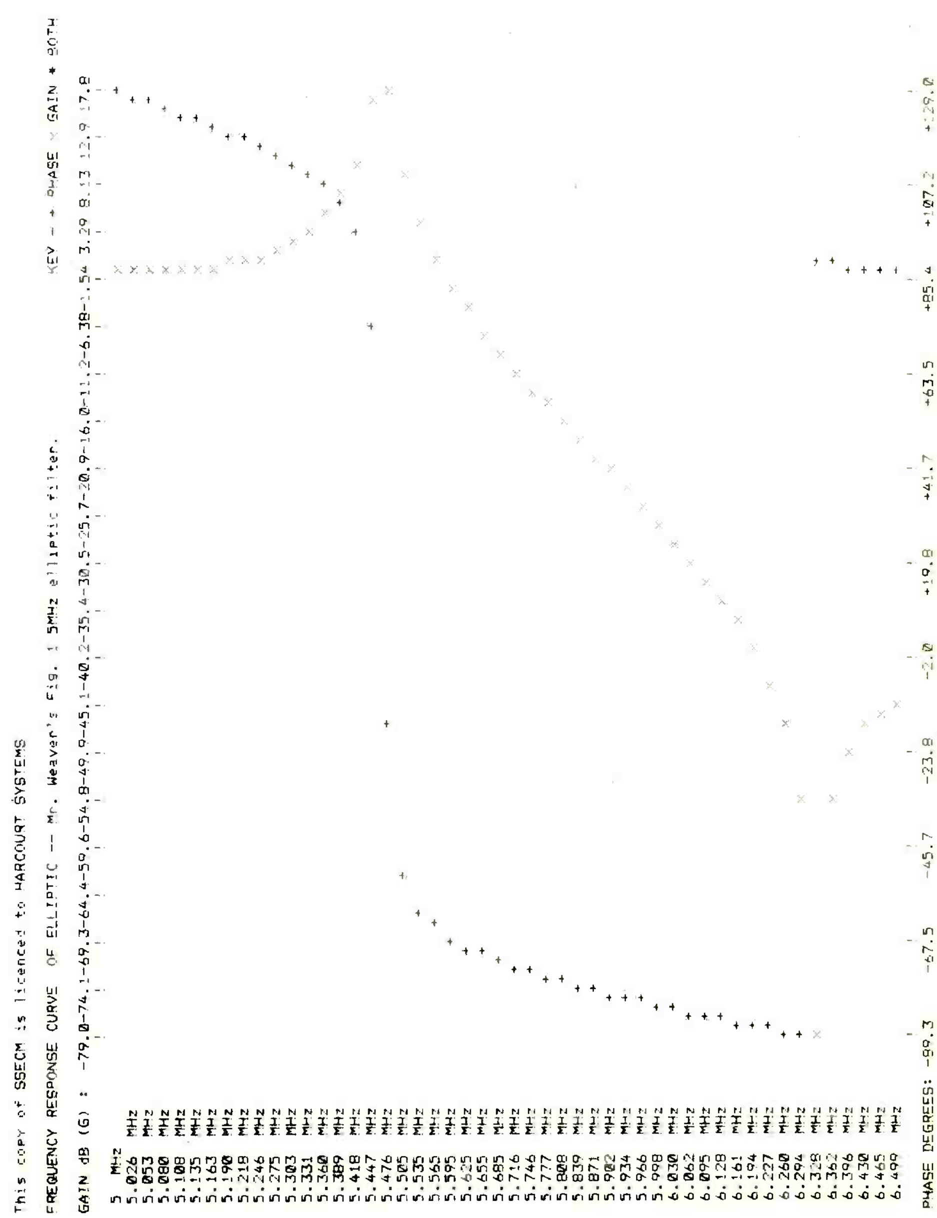
CIRCUIT MODELLING BY HOME COMPUTER

Further to my own article appearing alongside Mr Weaver's in the August issue I compared the technique of my article using Mr Weaver's examples.

I enclose the resulting graph. It is interesting to note that whereas Mr Weaver's technique takes 75 seconds for 15 points, the enclosed graph of his Fig. 1 took 20 seconds to calculate 50 points for the same circuit, and a further minute to print the graph. This shows the undoubted power of a compiler, although the ladder technique is inherently faster than the indefinite admittance matrix technique of my article.

The ladder technique is normally superior for passive networks, but for active networks the indefinite admittance technique is essential.

R. I. Harcourt
Orpington
Kent



PARABOLIC ANTENNA DESIGN

Guidelines for designing and constructing parabolic antennas are presented here. Theoretical background, applications and how the prime-feed configuration is affected by reflector parameters are discussed and emphasis is given to problems that arise when constructing such an antenna using a minimum of facilities.

Within the past decade or two, developments in technology caused by the demand for more frequency allocations and the need to use frequencies where background noise is less obtrusive have allowed good use of the radio spectrum above 1GHz to be made. At these frequencies reflector-type antennas come into their own. The parabolic-dish antenna – symbol of the modern communications world of satellites and microwave links – is just one variety of reflector antenna, but one with which high gains can be realized in a modest physical space, provided that it is correctly made and fed. This article discusses the theoretical background to the design and application of parabolic antennas, and how a prime-feed configuration is affected by reflector parameters.

The gain of a parabolic dish over an isotropic antenna is given by

$$G=\frac{4\pi A\eta}{\lambda^2}$$

where G is the gain in real numbers (i.e. not decibels), A is the area of the aperture, λ is the wavelength and η is the overall efficiency of the system. η is always fractional and an efficiency of greater than 0.5 is difficult to obtain.

Much information about theoretical performance can be gleaned from this equation. Gain is directly proportional to area, and therefore to the reflector-diameter's square, and is also inversely proportional to the wavelength squared, so each time the diameter is doubled, or the wavelength halved, there is a possible increase of 6dB in forward gain. A difficult figure to estimate is efficiency. Apart from a reduction in gain predicted by the equation, efficiency is reduced as the wavelength becomes a significant fraction of the dish diameter. Further reduction in efficiency is caused by the presence of the prime feed, which also obscures part of the dish aperture.

For a given frequency there is a minimum dish size below which it may well be better to examine other forms of antenna. This occurs at around 10λ although that is by no means a sharp cut off. It may be of interest to compare the dish with another type of antenna which is more common at lower frequencies. The obvious alternative to a dish is a multi-element Yagi. These are much used at u.h.f. and there is no reason why they cannot be used in the microwave bands. It

by M. L. Christieson*

*Feedback Instruments Ltd

is very difficult to adjust a simple linear-element Yagi to obtain useful gain, but those with quad loops can provide excellent gain in the 1-to-3GHz region. Yagis that have more than 30 elements become inefficient and it is normal practice to stack several individual antennas. Each time the number of antennas is doubled a further 3dB is possible, but never realized, primarily because of additional loss introduced by the combiner. There is an upper limit when additional gain from further antennas is nullified by the ever more complex combiner. Parabolic dishes do not suffer from this drawback as they use a single antenna, making them the simplest type to design and adjust.

Highly directional arrays are generally used for two reasons and the type of paraboloid depends on which is more important in the particular application. The reasons are to

– reduce unwanted signals from other directions
– improve the signal from a very weak source.

The two effects are inseparable but any antenna may be optimized for one, usually at the expense of the other.

A parabolic dish may be either deep or shallow depending on the equation parameters. A deep dish obviously has its focus close to the surface while a shallow one has its focus at some distance. Rather than using the parabola equation to define shape, it is more convenient to use the focal-length-to-diameter ratio. This ratio is very important in dish specifications. Figure 1 shows two dishes with the same diameter but with different f/d ratios. Note that because the diameter is the same, the maximum gain is the same. Dishes with a low f/d ratio, of about 0.25, are usually designed to give a high degree of side-lobe suppression while those with f/d ratios of about 0.5 are designed for optimum forward gain. The main use of the former type is in terrestrial microwave links where signal levels are quite high. For amateur work, good forward gain is usually more important and methods of optimizing this are now to be examined more fully.

For a given size of dish, it is efficiency that determines the system gain. Main factors which reduce total efficiency are

– spill-over
– aperture efficiency
– phase errors
– blocking loss.

The first three are interdependent because spill-over, the amount of energy lost when the prime feed illuminates more than the dish area, is reduced by tapering the radiation pattern towards the edge of the dish. This however reduces the aperture efficiency which is greatest when the dish is uniformly illuminated. Phase errors, which may be caused either by a poor feed or by errors in the shape of the dish, are worse if no edge taper is used.

The first consideration of the dish builder is accuracy of the paraboloid. Clearly the nearer to the ideal shape the

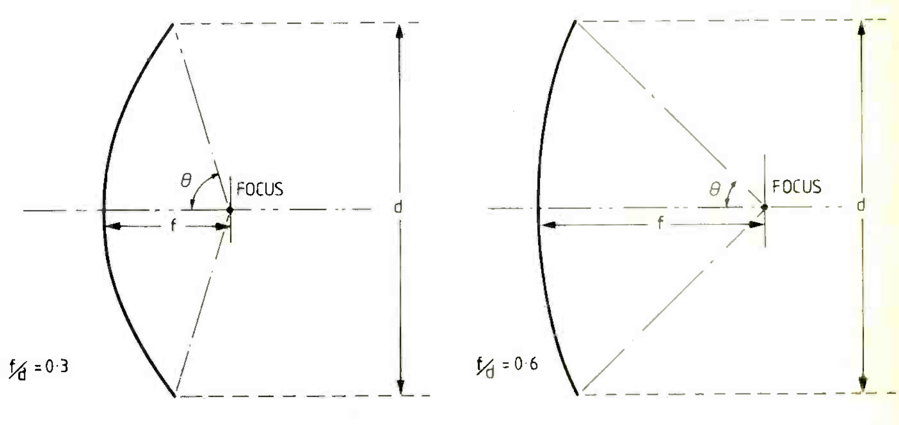


Fig. 1. *Two dishes with the same diameter but with different focus-to-diameter ratios. Dishes with a low f/d ratio usually give a high degree of side-lobe suppression while those with higher f/d ratios of around 0.5 are designed for optimum forward gain.*

better, but this is very difficult to obtain, particularly for the amateur constructor. It is generally accepted that little benefit is realized by reducing peak errors to less than ±1/8 wavelength. Sometimes this is quoted in terms of r.m.s. errors which results in a much smaller figure and may be off-putting. Peak error means that no part of the structure should be more than λ/8 in either direction away from the ideal shape, so the most serious type of error is when the dish smoothly departs from the true parabolic shape.

At 2GHz, for example, λ/8 is nearly 2cm so at the low end of the microwave spectrum there is considerable latitude for the constructor. At higher frequencies, such as those proposed for direct satellite broadcasting at 12GHz, surface errors are more of a problem.

Another factor concerning the surface is the material from which it is made. Most commercial dishes are made from spun aluminium, and clearly a solid conducting surface is ideal. For amateur purposes it is permissible to make a dish from wire mesh, providing that the holes are not too large. A good approximation is that the mesh size should not exceed λ/10. This means that various sizes of chicken wire are satisfactory at low frequencies and many good systems have been built for the 2-3GHz region using aluminium screening material. Dishes designed for operation above 10GHz should have a solid construction. The thickness need not be great; aluminium foil on a fibre-glass backing could be used. On large dishes a mesh surface reduces the wind loading and weight, although a build-up of snow or ice can demolish an installation designed on that assumption.

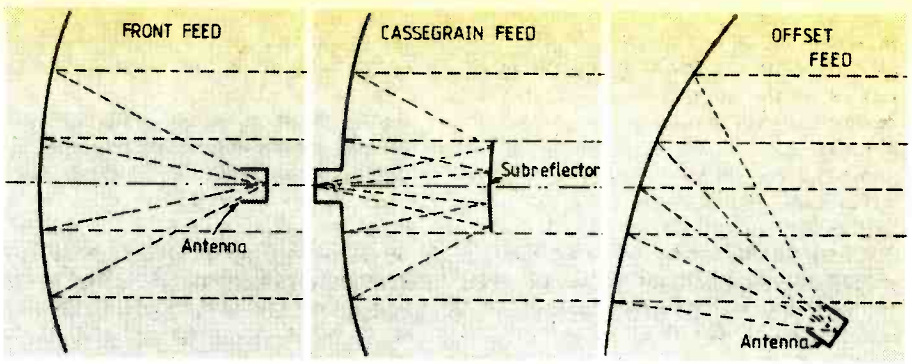


Fig. 3. Basic front-feed parabolic antenna and two variations. Cassegrain feed is used for antennas with unfavourable f/d ratios, but subreflector obscures part of the dish, causing problems with small antennas. The offset feed gives no blocking problems but is difficult to construct as the dish is neither symmetrical nor parabolic.

Feeds

Once the reflecting surface has been constructed the feed must be optimized. Referring to Fig. 1, to avoid wasting energy, the radiation pattern of the prime feed should all be within a solid angle of 2θ°. It is easier to visualize this in terms of a transmitting antenna but the same applies to a receiver. Ideally the radiation should be uniform over that area and then cut off sharply at the edge. This is impossible in practice and the compromise often used in amateur projects is a 10dB-beam width of 2θ°.

This is difficult to achieve for 2θ angle greater than about 150° because at that point the horn aperture required becomes smaller than the waveguide capable of supporting wave transmission. A simple dipole and splash plate (reflector disc) could be used but it is difficult to adjust and its performance never equals that of a horn. It is convenient to arrange the 2θ angle to correspond with the pattern from the open end of a square or circular waveguide: this simplifies construction considerably. There is a direct relationship between f/d ratio and 2θ angle so that the f/d ratio can be chosen to ease the construction of an efficient feed. This type of work cannot be exact without specialized test equipment, but it is surprising how efficient a system designed using these rules of thumb can be. Figure 2 shows the approximate relationships between these parameters. There have been several good designs for high-efficiency feeds developed by amateur radio operators, some of which are referred to at the end of this article.

Problems of feeding a dish with an unfavourable f/d ratio can be reduced by using a hyperboloid sub-reflector and feeding the dish from behind. This is called a Cassegrain feed and is shown in Fig. 3. The disadvantage of this is that the diameter of the sub-reflector needs to be several wavelengths, depending on its position, and so it obscures part of the dish area. This blocking loss also occurs with front fed systems and is a factor worth considering when dealing with a small dish. Larger dishes have much greater surface areas compared with their associated sub-reflectors, and Cassegrain feeds are common on communication-satellite earth stations.

One method of preventing blocking loss is to use an offset feed, also shown in Fig. 3. Although an improvement in efficiency would be obtained using this method, it is not easy to construct as the dish is no longer symmetrical or paraboloid, which makes it particularly unsuitable for amateur construction.

Another loss which may occur is polarization loss, where the polarization of the incoming signal is not matched to that of the prime feed. High loss can occur when two linear polarizations are crossed. A linear to circular mismatch will usually result in a 3dB loss, but between left- and right-hand circular polarization a high degree of isolation is possible. This effect may be exploited to re-use frequencies on the same satellite. It is worth remembering that, when reflected from the dish surface, the sense of a circularly-polarized wave is reversed.

The method by which the dish is mounted depends on its use. In some applications it is not necessary to move it, as in a ground microwave link for example. Many dishes are used with geostationary satellites which only move a small amount each day. This small movement, which is non-cumulative, is often within the beamwidth of the dish so a simple fixed mounting will suffice. Where very-high gains are

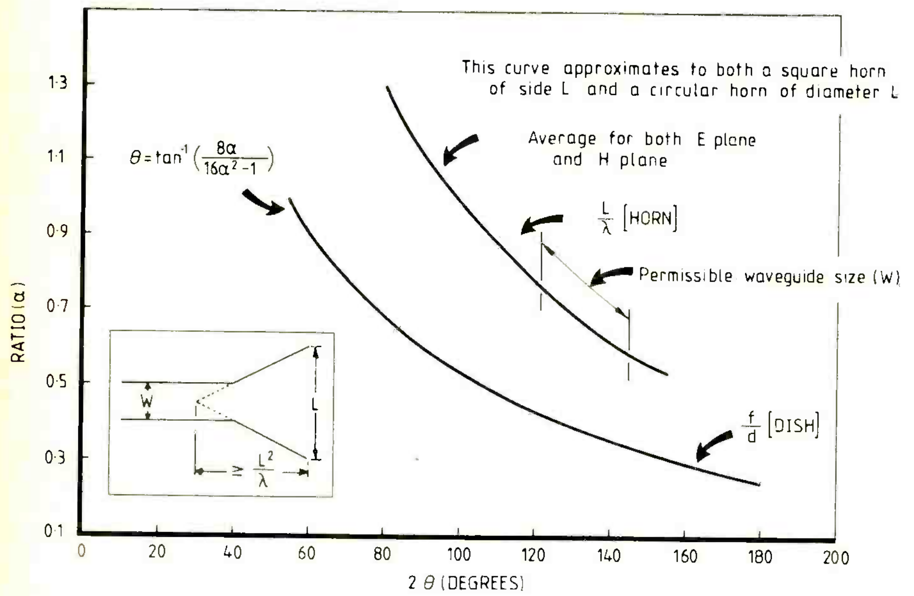


Fig. 2. Once the required f/d ratio has been judged, the dish's 2θ angle and the horn's L/λ ratio (α) can be found from this graph. There is a direct relationship between f/d ratio and 2θ angle so the f/d ratio can be chosen to ease construction of the feed. The feed is easiest to make when the 2θ angle chosen corresponds with the waveguide opening. Approximate relationships between these parameters are shown here.

required it may be necessary to use some form of automatic-tracking system. These can be simple or complex and a decision between performance and cost is not easy to make.

Many methods have been used to construct paraboloidal dishes and the exact method depends on the facilities available. Most traditional methods rely on the reflecting surface being supported by struts or pulled into shape by nylon cord. These struts can be made from metal or wood providing that it is well protected. A method that is beginning to find favour, particularly for higher frequencies, is a glass-fibre shell with a thin conductive surface which is sometimes sprayed on. Once a former has been made several dishes can be cast, so it might be worth several individuals combining their skills. A fibre dish has the overwhelming advantage of being very light but it may need to be made with a turn-over at the rim to prevent it distorting when mounted.

Any system designed for outside use must be protected against weather. Reference has already been made to the effect of snow and ice, but excessive heat can be equally damaging. At high frequencies, dimensional changes due to temperature can be a considerable problem as can distortion caused by a gust of wind, but these effects are not often noticeable on small dishes. Front-fed systems can also focus the sun's heat on the prime feed. It would be slightly annoying to see an expensive amplifier burst into flames on the first sunny day. If the amplifier is located at the feed the rain must be kept out of it by using a sealed container, preferably with a dessicator. My view is that if rain cannot be kept out it is far better to have a semi-open cover to make sure it runs out again. Precautions such as mounting the amplifier upside down so that water cannot collect in it, and a supply of plastic dustbin liners have kept several amplifiers operational for a number of years.

It is hoped that these ideas have equipped readers with the knowledge to start designing and building dish antennas with a reasonable trade-off between performance and economics. It is likely that with the interest in satellite television many more articles will appear describing individual practical designs; they will however all be based on the basic design parameters outlined here. WW

Further reading

– The ARRL Antenna Book, American Radio Relay League (latest edition)
– Performances of Fixed-Mount Earth-Station Antennas, S. E. Dinwiddy, *ESA Journal 81/3*
– Gain-Beamwidth Product and other Reflector-Antenna Relationships, A Saitto, *ESA Journal 81/3*
– Tubular Radiator for Parabolic Antennas, *VHF Communications* 4/1976, Verlag UKW-Berichte
– A Dish Anyone Can Build, Michael Brown, *73 Magazine*, February 1982
– VHF-UHF Handbook, RSGB
– Pyramidal Horn Feeds for Parabolic Dishes, D. Evans, *Radio Communications* March 1975
– Dish Antenna, D. Wardley, *Break-in*, May 1982
– Reference Data for Radio Engineers, Sections 25 and 27, Sams

PROGRAMMABLE GPIB-TO-SERIAL INTERFACE

Development of an earlier interface with talker/listener capability to remotely program functions within the instrument interface.

by Chris Jay

The GPIB-to-serial interface featured in the July 82 issue of *WW* was conceived as a low-cost interface solution for instruments with a serial data link such as an RS232C port. When configured to a keyboard and addressed as a talker, characters typed on the keys are converted by the interface from serial to parallel data and transmitted over the bus data lines. A printer interfaced to the bus is addressed as a listener; data bytes received are serially encoded and fed to the serial input port of the printer. The interface used 13 i.cs including a 96LS488 to perform interface functions and message decoding, an IM6402 uart for the serial/parallel encoding of data, and an MC14411 as a frequency reference for serial transmission and reception at four link-selectable rates. During the talker-active state the interface could automatically recognize an end-of-text character, and assert the EOI line concurrent with the transmission of the final data byte in the character string. A 74F521 octal comparator achieved this by comparing the binary data waiting for transmission with an 8-bit data pattern set with switches.

The original interface design (see panel) was extended to accommodate a secondary addressing feature to allow remote initalization of the uart control register, the instrument data speed generator, load an end-of-message byte into a latched comparator, and address the instrument as a GPIB/RS232C interface. These remote programmable facilities permit the designer to dispense with some of the switch packs used in the first design, adding a degree of programmable flexibility.

On any one contiguous bus up to 15 devices are permitted, but the primary address range is 31 talk and 31 listen addresses using single byte addressing. A controller may issue a primary address to identify an instrument then issue a secondary address to indentify a function within that instrument. For example, before an instrument can be operated effectively it may require initialization and range information, which could be programmed into latches selected by unique secondary addresses (Table 3 shows the range of addresses). When the controller issues the primary address over the bus the instrument will be conditioned to receive a one-of-four secondary address. For example, my listen address followed by my secondary address 1 (MSA 1) selects the instruments control register, MSA 2 selects the instrument data rate register, and MSA 3 selects an octal latched comparator so a unique end-of-text code may by programmed[1]. MSA 0 is the secondary listen address that selects the uart transmit buffer register. When addressed into the listener active state, data bytes sent to the uart are serially encoded and transmitted to the RS232C interface at a programmed speed and in the character format specified by the uart control register.

The 96LS488 may be configured for extended addressing by wire-linking the mode inputs M0-3 to the appropriate binary code as shown in Table 2 on page 72 of the July article. There are five choices of extended addressing but for a talker/listener there are two choices of TE/LE low

*Chris Jay was formerly with the Fairchild European Design Centre, Bristol and is now working at Marion Electronics, in Stroud.

1. The end-of-message latched comparator is used when the interface is an active talker. A string of data bytes may be sent over the bus, terminated by the unique end-of-text character. When this character is transmitted the comparator automatically recognizes the bit pattern and asserts the bus end-or-identify (EOI) line to indicate end-of-message.

speed, or TE/LE high speed. The choice of high speed is selected for instruments using three-state driver devices; in this design the mode inputs M0-3 are all configured to V_{cc}.

Table 4 illustrates a typical initalization procedure that should be completed by the controller-in-charge (c.i.c.) prior to the interface becoming an active talker. It does this by asserting the $\overline{\text{ATN}}$ management line; any current active talker relinquishes control of the bus lines. The first message issued is the unlisten command to ensure that unscheduled listeners do not receive data bytes intended for the interface circuit. To address the interface the c.i.c. issues the primary listen address (MLA); after receipt the interface expects to see one of its four secondary addresses. Assuming that the uart control register is to be initialized first, the controller sends MSA 1. When selected, the register is capable of receiving a data byte (DAB 1) over the bus lines. The control register is a five-bit latch in the 6402 uart; format of the control-bit pattern is shown in Table 6a. If the c.i.c. addresses itself as talker it can release the assertion on $\overline{\text{ATN}}$ and send the initalizing data byte to the instrument. After sending DAB 1 it regains control of the bus by asserting $\overline{\text{ATN}}$.

It is necessary to un-address the control register by sending the unlisten message before sending the primary listen address of the interface, followed by the secondary address MSA 2 to select the data-rate generator latch. The controller releases the true assertion of $\overline{\text{ATN}}$ and as an active talker issues DAB 2 to program the correct speed code – Table 6b gives the format. When the data byte has been sent, it re-asserts the $\overline{\text{ATN}}$ line to regain control of the bus and complete initialization. The unlisten command is sent followed by MLA and MSA 3 which selects the end-of-message latched comparator. When selected the controller releases the true assertion of $\overline{\text{ATN}}$ to send the end-of-message byte DAB 3. When latched it re-asserts the $\overline{\text{ATN}}$ line, sends the unlisten command to unaddress the latched comparator and then sends the talk address of the interface (MTA), followed by the secondary address MSA 0 of the receiver register. The controller addresses the listeners by sequentially transmitting each listen address. On completion of addressing the controller releases the assertion in $\overline{\text{ATN}}$, enabling the interface to enter the talker active state for transmission of data bytes[2].

In the circuit configuration of the programmable interface, the 96LS488 handles the interface functions and message decoding. An Intersil IM4602 uart converts parallel data to serial and serial to parallel and an MC14411 bit rate generator gives a wide range of frequencies for rate generation[3]. Other logic circuits used are 74LS t.t.l. devices and two 74F i.cs, one of which is an inverting bus driver to buffer the cmos outputs from the uart onto the bus data lines because it satisfies the 48mA sinking requirement by the IEEE 488A specification. The μA1488 and μA1489 provide signal conditioning for RS232C line driving and reception.

2. Data is transmitted in ASCII, a seven-bit code representation, with the eighth bit for parity checking.

3. Both the MC14411 and IM6402 devices are cmos requiring a VIH of $V_{cc}-2$ volts. The 74LS outputs have a guaranteed VOH of 2.7V for a V_{cc} of 5 volts. To ensure good noise immunity provide passive pull-up resistors of 2.2kΩ on each LS output that drives a cmos input.

Table 1. Talk and listen address assignment

$\overline{DIO_8}$	$\overline{DIO_7}$	$\overline{DIO_6}$	$\overline{DIO_5}$	$\overline{DIO_4}$	$\overline{DIOO_3}$	$\overline{DIO_2}$	$\overline{DIO_1}$	
X	H	L	$\overline{A_5}$	$\overline{A_4}$	$\overline{A_3}$	$\overline{A_2}$	$\overline{A_1}$	Primary listen address
X	H	L	$\overline{L}$	$\overline{L}$	$\overline{L}$	$\overline{L}$	$\overline{L}$	Unlisten
X	L	H	$\overline{A_5}$	$\overline{A_4}$	$\overline{A_3}$	$\overline{A_2}$	$\overline{A_1}$	Primary talk address
X	L	H	$\overline{L}$	$\overline{L}$	$\overline{L}$	$\overline{L}$	$\overline{L}$	Untalk
X	L	L	$\overline{S_5}$	$\overline{S_4}$	$\overline{S_3}$	$\overline{S_2}$	$\overline{S_1}$	Secondary address

Addressing

Secondary addressing is acheived by the quad two-to-one multiplexers of IC_{11}, 74LS157, which select the primary and secondary addresses. The 96LS488 ASEL output is low when the primary address is being received, and high for secondary address selection. Address inputs A1-4 of the 96LS488 are driven by the 74LS157 multiplexer outputs which select a one-of-four binary code set by switches 2-5. Note that A5 is configured directly to switch 1; this effectively reduces the secondary address range to 496 but saves on the multiplexing hardware. The primary address range of the interface is therefore configured on the switches 1-5. Secondary addressing is acheived when ASEL drives the select input of IC_{11} high. The bit pattern on switches 6 & 7 routes through to the inputs A4 & 3. Address inputs A1 & 2 are derived from the bus data lines 1 & 2 respectively. So a one-of-four secondary address will select the interface, putting it into the talker or listener-addressed state. On receipt of the secondary listen or talk address the 96LS488 outputs $\overline{\text{LAD}}$ or $\overline{\text{TAD}}$ go low producing a rising edge at the output of gate 1, connected to the clock input of IC_7, a dual D-type latch.

So the logic state on inverted data lines 1 & 2 is strobed into the 74LS74 latch when the instrument is addressed. A one-of-four logic condition is stored, enabling the instrument to receive a data byte which can be sent to either the uart transmitter, uart control register, bit rate generator latch, or the $\overline{\text{EOI}}$ end-message comparator latch. When statisized the information remains programmed until the instrument is unaddressed then re-addressed. The Q outputs of the 74LS74 latches are wired to the address inputs of IC_8, a dual one-of-four demultiplexer 74LS139. Outputs of IC_{8a} route the RXST signal to the selected latch or register; IC_{8b} outputs O0 and O3 are used as enable signals $\overline{\text{ENBL0}}$ and $\overline{\text{ENBL3}}$ Signal $\overline{\text{ENBL0}}$ drives the S input of IC_{12}, a quarter of 74LS157, which selects the correct handshake for the one-of-four instrument functions. The $\overline{\text{ENBL3}}$ IC_{8b} output, selects the load function at theS0 and S1 inputs of the 74F524 latched comparator.

Table 2. Status codes

TAD	LAD	D/S/E	State
H	H	L	Off line
H	L	L	Addressed to listen (LADS)
L	H	L	Addressed to talk (TADS)
L	H	H	Serial poll mode (SPM)
H	L	H	Receiving end-message (LACS)

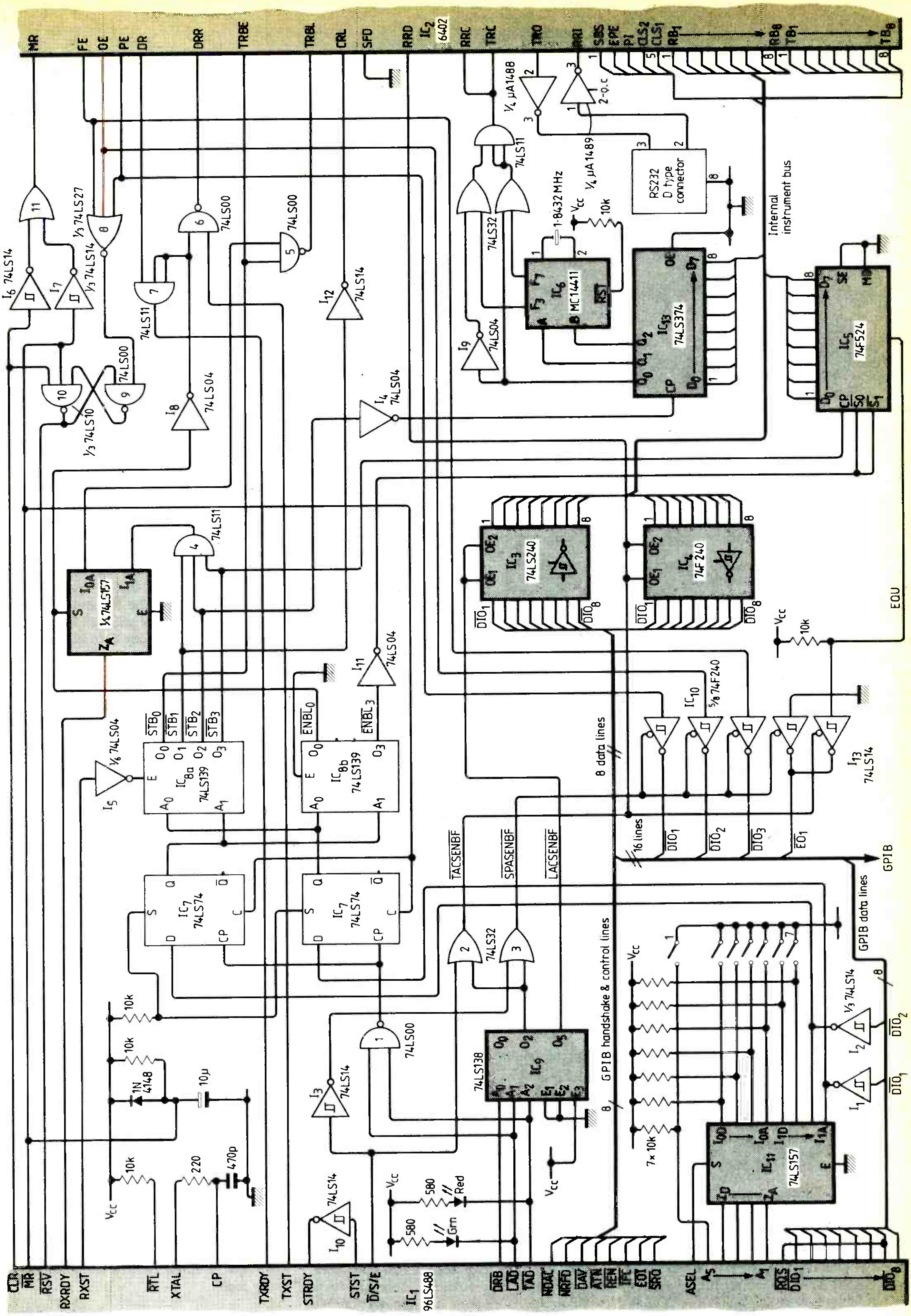
DRB goes low when the interface is in talker active or serial-poll active state.

Status decoding

To perform the necessary interface status decoding the 96LS488 $\overline{\text{LAD}}$, $\overline{\text{TAD}}$ and $\overline{\text{DRB}}$ outputs drive the A2, A1, A0 inputs of a 74LS138, one-of-eight decoder, IC_9. Output O2 of IC_9 will be active low when the interface is either in the talker active state, or the serial poll active state, see Table 2 for status codes. Gate 2 is enabled by the $\overline{\text{D}}$/S/E signal to provide a low output when the instrument is talker-active. The $\overline{\text{D}}$/S/E signal when inverted by I_3, provides an enabling low for the input of gate 3. The gate 3 output goes low when the interface enters the serial poll active state. These or-gate outputs and the output O5 of IC_9 are labelled $\overline{\text{TACSENBF}}$, $\overline{\text{SPASENBF}}$ and $\overline{\text{LACSENBF}}$ and used as low enable inputs for the three-state buffer-drivers. When talker-active the 6402 receiver buffer register outputs, buffer devices IC_4 and I_{13} (the $\overline{\text{EOI}}$ driver circuit) are enabled. During the serial poll, one half of IC_{10} is enabled to drive data lines 1 to 3 with status bits and a second $\overline{\text{EOI}}$ buffer driver is enabled. During the listener active state the 74LS240, IC_3 (input buffer) is enabled. Appendix 2 gives a brief description of serial and parallel poll.

Buffering

Although the 96LS488 data lines are connected to the bus, it is necessary to use buffer circuits (with hysteresis inputs essential for the listener function) to provide a data path to or from the instrument's internal logic circuitry. An internal instrument bus, eight bits wide, is isolated from the bus data lines by inverting LS240 and F240, IC 3 & 4 respectively. It is also necessary to use hysteresis buffering and inversion to the address multiplexer IC_{11}, acheived by the two inverters I_1 and I_2, of a 74LS14. The 74LS240 will be enabled by $\overline{\text{LACSENBF}}$, going low when the instrument is listener active. In this state, the octal inverter drives the internal instrument bus with valid data. The IM6402 receive buffer register is disabled so no data conflict occurs on the internal bus. During the talker-active state, the IM6402 r.r.d. input is driven low by $\overline{\text{TACSENBF}}$, which also enables 74F240 buffer circuit.



IC2 6402
IC1 96LS488
RS232 D type connector
Internal instrument bus
1·8432 MHz
IC6 MC14411
IC13 74LS374
IC5 74F524
IC3 74LS240
IC4 74F240
IC8a 74LS139
IC8b 74LS139
IC7 74LS74
IC9 74LS138
IC11 74LS157
IC10 5/8 74F240
1/4 μA1488
1/4 μA1489
½ 74LS157
8 data lines
16 lines
GPIB
GPIB data lines
GPIB handshake & control lines
7× 10k
Red
Grn
EQU
TACSENBF
SPASENBF
LACSENBF

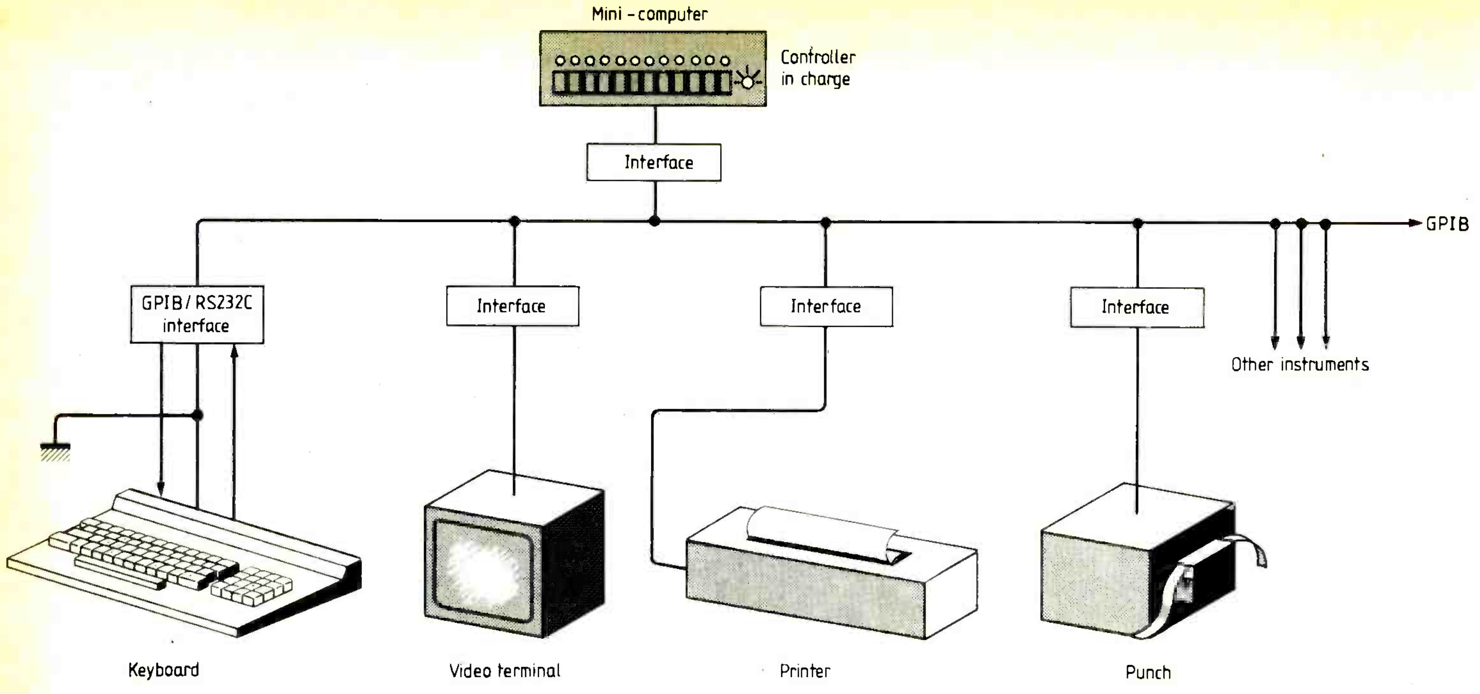


Table 3. Primary and secondary address of the interface.

MLA	My listen address, primary listen address of the instrument
MSA 0	My secondary address for g.p.i.b. uart, to provide serial/parallel conversion of data
MSA 1	My secondary address for uart control register
MSA 2	My secondary address for bit rate generator latch
MSA 3	My secondary address for end-of-message latched comparator
MTA	My talk address, primary talk address for the g.p.i.b./RS232C instrument
MSA)0	My secondary address for g.p.i.b./uart, to privide parallel/serial conversion of data
MSA 1	
MSA 2	Not used
MSA 3	

Table 4. Interface initalization procedure and talker addressing.

ATN	MSG	FUNCTION
1	UNL	Unlisten to clear the bus of listeners
1	MLA	Listen address of the instrument
1	MSA 1	Address of uart, control register
0	DAB 1	Issue the uart control register byte
1	UNL	Unlisten the control register
1	MLA	Listen address of the instrument
1	MSA 2	Address of data Speed control latch
0	DAB 2	Issue the data speed control byte
1	UNL	Unlisten the speed control latch
1	MLA	Send listen address of the instrument
1	MSA 3	Send address of the end-message latched comparator
0	DAB 3	Send end-of-message byte to the latched comparator
1	UNL	Unlisten the 'end-of-message' comparator
1	MTA	Send talk address of instrument
1	MSA 0	Send secondary address of uart
1	MLA 1	
1	MLA 1	
1	MLA 1	Address listeners on to the bus
1	MLA 1	
1	MLA n	
0	DAB	Instrument addressed as a talker, sends first data byte
0	DAB	
0	DAB	

This establishes the data path from the RB1-8 outputs to the data bus.

Loading registers from internal bus

On receipt of MLA followed by MSA 1 the Instrument latches the binary code of 01 into IC_7 which drives the A1, A0 inputs of IC_8. Signal $\overline{ENBL0}$ drives the S input of IC_{12} high, selecting the RXST to RXRDY handshake through inverter I_5, multiplexer IC_{8a} onto the $\overline{STB1}$ input of AG_3. The output of AG_3 drives the selected input I_{1a} of IC_{12}, and the output Za drives the RXRDY 96LS488 input. This local automatic handshake path is identical for $\overline{STB2}$ and $\overline{STB3}$. In the acceptor data state a data byte present on the data lines, inverted by IC_3 onto the internal instrument bus, is clocked into the uart control register, data bits one to five, as RXST drives the control register load input high via the path through I_5, output O1 of IC_{8a} and inverter I_{12}. The bit rate generator latch is loaded in a similar manner. When the interface receives UNL, MLA followed by MSA 2, the binary code 10 is latched into IC_7. The A1 and A0 address inputs of IC_8 select output O2 of the decoders. In the acceptor-data state the rising edge of the RXST output clocks the CP input of IC_{13}, 74LS374 through the path I_5, O2 of IC_{8a} and I_4. The RXST/RXRDY handshake is acheived automatically, as described for the loading of the u.a.r.t. control register. Data present on the internal instrument bus, bits one to three of IC_{13} are clocked through to the Q outputs on the rising edge at the CP input. The bit rate generator latch, IC_{13}, uses three of the eight internal D-type flip-flops, the other five latches are available for functional expansion. The latched code on Q0-2 outputs are used to select clock frequencies for the u.a.r.t. and inputs. See Table 5b for code input versus bit rate selection; the frequency input is 16 times the data rate. The Q0 output of IC_{13} selects either the F3 or F7 outputs from the clock generator chip IC_6. When high, the clock output F3 is selected through the multiplexer circuit comprising OG3, OG4 and AG_2. When low the F7 clock output is selected. The Q1 and Q2 74LS374 outputs select an internal divider in IC_6, which provide the clock outputs in Table 5 (part 2). To provide a good stable frequency source for the MC14411 it is necessary to connect a 1.8432 MHz crystal to the crystal inputs.

If the instrument is to be used as a talker it will be necessary to load the $\overline{EOI}$ latched comparator. The select inputs of IC_5 are enabled high by the inversion of $\overline{ENBL3}$, the O3 output of 74LS139 IC_{8b}. This output goes low when MSA 3 is received. Inverted by I_{11}, it drives the select inputs S0 and S1 of the 74F524 latched comparator high.

To be continued

EPROM EMULATOR

by Peter Nicholls, M.A.

Shown here is the software for the eprom emulator featured on page 83 of last month's *Wireless World*. This emulator, based on the 8060 microprocessor, has its own hexadecimal keyboard/led display and uses two memory i.cs, one rom and the other ram, a parallel-interface adapter and three 'LS' t.t.l. devices.

These and a handful of other components, including batteries for memory retention and cassette-interface components, may be mounted on a single-sided board measuring 233 × 220mm. Photo-copies of an overlay used to produce such a p.c.b. can be obtained by sending an s.a.e. to *Wireless World* Emulator, Room L303, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Fully etched but *undrilled* fibre-glass boards, also single-sided, and programmed eproms for the emulator are available from PKG Electronics, Oak Lodge, Tansley, Derbyshire at £8 and £5 respectively. Prices include vat, postage and packing.

Referring to last month's article, Fig. 4, C_4 should be replaced by a 100nF polyester type to avoid leakage-current problems. In Fig. 5, $R_{23\text{-}25}$ are 47kΩ and, of course, digits 2 and 6 are not used and will confuse the display if connected. We apologize for these inaccuracies.

```
1   08 C4 08 36 C4 00 32 C4 07 35 C4 60 31 C4 00 C9
2   C4 C4 FF C9 C2 C4 07 C9 C3 C4 20 C9 28 C4 05 37
3   C4 17 33 3F C4 05 37 C4 00 33 3F C1 C1 D4 98 E4
4   98 9C 02 90 F5 C1 C1 C9 23 3F C1 C1 E1 23 D4 07
5   9C F7 C1 C1 D4 98 E4 98 98 02 90 ED 8F 01 C1 23
6   94 22 C1 21 1C 1C 1C 1C DC 08 C9 20 C1 21 1E 1E
7   1E 1E D4 F0 C9 21 C1 23 D4 0F D9 21 C9 21 32 C1
8   20 36 90 A9 E4 18 9C 06 C4 20 C9 28 90 A6 C1 23
9   E4 1A 9C 0B C6 01 C4 05 37 C4 17 33 3F 90 17 C1
10  23 E4 1B 9C 0B C6 FF C4 05 37 C4 17 33 3F 90 06
11  C1 23 E4 19 9C 7A C4 21 C9 28 C4 05 37 C4 00 33
12  3F C1 C1 D4 98 E4 98 9C 02 90 F5 C1 C1 C9 23 3F
13  C1 C1 E1 23 D4 07 9C F7 C1 C1 D4 98 E4 98 98 02
14  90 ED 8F 01 C1 23 94 9C D4 0F C9 23 C2 00 1E 1E
15  1E 1E D4 F0 D9 23 CA 00 C4 05 37 C4 4E 33 3F 90
16  B9 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
17  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
18  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
19  C1 23 E4 1C 9C 7A C4 07 C9 C0 C4 00 C9 C1 C4 05
20  37 C4 A0 33 C4 08 36 C4 00 32 C4 20 C9 30 C4 AA
21  C9 31 C1 30 98 0C C4 AA 01 69 30 9C 03 C4 69 01
22  90 08 C6 01 01 C1 31 60 C9 31 3F 8F 00 3F 8F 00
23  3F 8F 00 3F 8F 00 3F 8F 00 3F 8F 00 3F 8F 00 3F
24  36 D4 0F 98 05 08 08 36 90 C8 08 08 36 C1 30 9F
25  32 C4 12 C9 2B C4 04 C9 2C C4 48 C9 2E C4 07 C9
26  2F C4 7F C9 28 C9 2A C9 30 C1 31 01 90 BC FF FF
27  C1 23 E4 1D 9C 6D C4 2F C9 C0 C4 00 C9 C1 C4 05
28  37 C4 C0 33 C4 08 36 C4 00 32 C4 30 C9 30 3F C4
29  AA 60 98 05 C4 55 60 9C F1 B9 30 9C F1 3F C4 69
30  60 9C FA 3F 3F 3F 3F 3F 3F 3F 3F CE 01 36 98 03
31  36 90 F0 C4 08 36 3F 3F 3F 3F 3F 3F 3F 3F E6 01
32  36 98 03 36 90 F8 36 E4 AA 9C 1A C4 2F C9 2B C4
33  04 C9 2C C4 27 C9 2E C4 21 C9 2F C4 7F C9 28 C9
34  2A 93 12 90 19 C4 2F C9 2B C9 2C C9 2F C4 06 C9
35  2A C4 23 C9 2E C4 7F C9 28 90 E6 08 08 08 C1 23
36  E4 1F 9C 6D C4 02 07 C4 20 C9 30 8F 40 C1 C1 E4
37  9F 9C 40 B9 30 9C F4 C4 04 C9 C0 C4 00 C9 C1 C4
38  08 36 C4 00 32 C6 01 36 D4 0F 98 05 36 8F 02 90
39  F4 C4 00 07 C4 03 C9 2A C4 63 C9 2B C4 2F C9 2C
40  C4 2B C9 2E C4 07 C9 2F C4 7F C9 28 C4 05 37 C4
41  D2 33 3F C4 0E C9 C0 C4 00 C9 C1 36 C9 30 36 32
42  C9 31 32 C4 FF CE 01 36 D4 0F 98 07 36 8F 02 90
43  F4 90 1D C4 08 36 C6 01 8F 02 32 01 C1 31 60 98
44  04 01 32 90 F1 36 01 C1 30 60 98 A5 01 36 90 E6
45  C4 00 37 C4 00 33 3F FF FF FF FF FF FF FF FF FF
46  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF

80  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
81  3F B9 22 D4 07 C9 C1 02 F4 28 01 C1 80 C9 C0 8F
82  01 C4 FF C9 C0 90 E9 08 36 C9 20 36 32 C9 21 32
83  C1 20 D4 0F 03 FC 08 94 02 90 40 02 F4 90 01 C1
84  80 C9 2A C4 40 C9 29 C1 21 D4 0F F4 90 01 C1 80
85  C9 2C C1 21 1C 1C 1C 1C F4 90 01 C1 80 C9 2B C2
86  00 D4 0F 02 F4 90 01 C1 80 C9 2F C2 00 1C 1C 1C
87  1C F4 90 01 C1 80 C9 2E 3F 08 08 C4 2F C9 2B C9
88  2C C9 2F C4 06 C9 2A C4 23 C9 2E C4 05 37 C4 00
89  33 C4 06 C9 22 C9 25 3F C1 22 9C FB B9 25 9C F7
90  C4 00 37 C4 00 33 3F FF FF FF FF FF FF FF FF FF
91  3F C4 01 50 19 98 0D C4 38 8F 00 C4 00 01 19 01
92  C4 4D 8F 00 C4 50 8F 00 01 19 01 C4 40 90 E1 08
93  3F 06 D4 20 9C FB 06 D4 20 98 FB C4 60 8F 00 19
94  40 90 ED C4 05 37 C4 00 33 3F C1 C1 D4 98 E4 98
95  9C 02 90 F5 C1 C1 C9 23 3F C1 C1 E1 23 D4 07 9C
96  F7 C1 C1 D4 98 E4 98 98 02 90 ED 8F 01 C1 23 E4
97  18 9C D6 C4 00 37 C4 00 33 3F FF FF FF FF FF FF
98  FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF

111 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
112 40 79 24 30 19 12 02 78 00 18 08 03 46 21 06 0E
113 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF

128 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
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NEWS

UK nearer to US tv encryption

Racal Electronics plc and Oak Industries Inc. of California are to form a joint company "to exploit the anticipated explosive growth of pay television services following the expansion of cable and satellite service in the UK and Europe". The new 50:50 company is formed in anticipation of Government support for the operation of cable systems for television programme distribution before the end of the year.

Although based on the UK the new company, Racal-Oak Communications, will have a mandate covering the whole of Europe,a nd in addition to producing equipment the joing benture will also seek to operate, license and supply pay television systems.

Commenting on the announcement, Sir Ernest Harrison, chairman and chief executive of Racal Electronics, said: "The potential in the UK alone is exciting, but total European demand is huge. Oak's imported technology will provide an opportunity to build a new and important export business. The pay television business can be measured in billions of pounds over the next 20 years and the UK must win its share". Kenneth Baker MP, Minister for information technology, said of the deal: "There have been several contacts over the years between Oak and the Government. Most recently I met Mr Carter, Oak's Chairman and Chief executive, in June when he told me of his interest expanding Oak's European interests. I am delighted that he has decided to bring Oak's technological expertise in encryption technology to the UK."

Founded in 1932, Oak Industries evolved from a manufacturer of radio switches and television tuners into a diversified supplier of products and services in electronics. In 1977, Oak's first year in the entertainment business, it started over-the-air subscription television in Los Angeles and now owns five systems in the US with around 600,000 subscribers and a turnover of $500 million. Oak developed both the hardware and computer software to manage the systems and later adapted its software for pay cable television. It claims to be the only cable tv manufacturer which supplies all the software necessary for a pay television operation, and produces converters for American cable television, computer-addressable converter and decoders and decoders for pay cable and subscription tv.

It developed an encoding and decoding technique for satellite television signals called Orion, a more sophisticated version of the encryption technology for subscription tv. Over 8,000 Orion decoders are already in use or on order in Canada and deliveries have recently begun to Satellite TV pic (see "Cryptic satellite tv"). Through a subsidiary it is also a major supplier of programming for both pay cable and subscription television, comprising recently-released movies, sports, concerts, comedy, dramatic productions and other entertainment special events.

Last July, Oak filed an application with the FCC to construct, launch and operate communications satellites to eventually serve all four US time zones.

Digital radio outshines lightline

The fanfare surrounding BTs ceremonial opening of its longest fibre route last July was well justified. The BICC 8-fibre line between London and Birmingham took only nine months to install and is the longest BT fibre route at 204km. Though only two fibre pairs are currently operating, at 34Mbit/s, the other two pairs will be brought into use next year at 140Mbit/s. More significant perhaps is that it is the first to operate at the long wavelength of 1300nm, using high radiance l.e.ds instead of the more expensive lasers. At 1.5dB/km loss they have lower attenuation than the earlier 850nm systems and allow repeaters at 10km intervals instead of 8km.

It's interesting timing in view of the Project Mercury London to Birmingham announcement. But what BT didn't sing about was the fact that only the day before GEC had announced the start of a multi-million pound digital network with steam radio, albeit using q.p.s.k. This was a world first in being the first national 11GHz high-capacity digital link and yet it was largely ignored in the press. The network will cover routes from London to various points in the UK including earth stations at Goonhilly and Madley and forms part of BTs plan to convert the entire UK telecommunications to digital operation by the early 1990s. Ironically, at 140M bit/s the capacity is far greater than the new fuss-making light-fibre link of 34Mbit/s.

Coinciding with the London to Birmingham Mercury project, BT open 34Mbit/s optical fibre and 140Mbit/s digital microwave links.

Electronics for peace

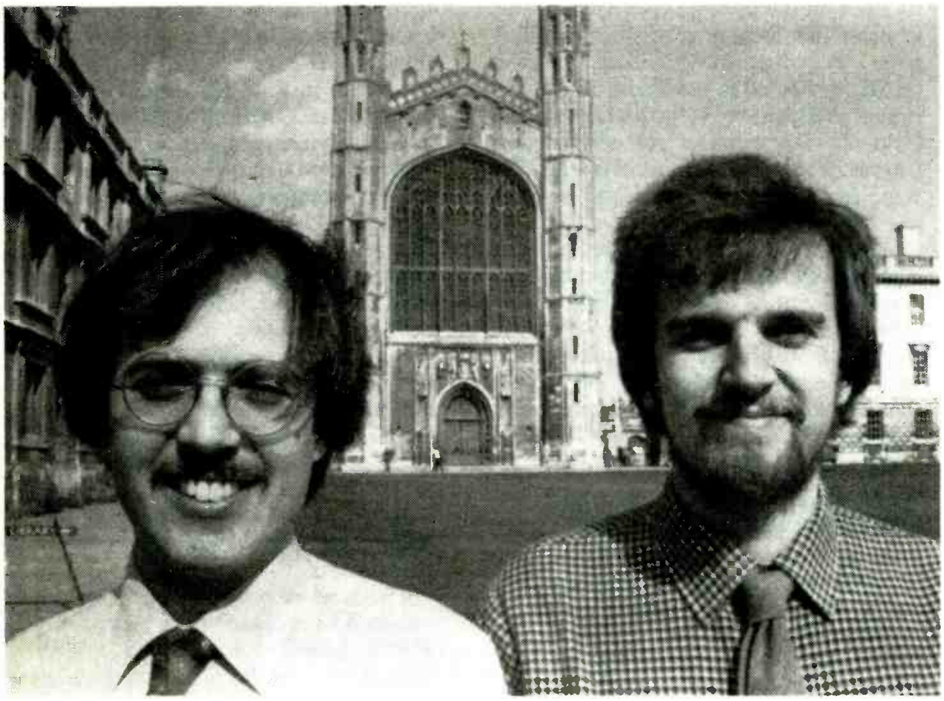
Two electronics engineers who are concerned at the involvement of the electronics industry in the arms trade and the nuclear arms race are intending to do something about it. They plan to set up a network to link those in the industry who feel that their skills should not be used in the cause of war, nuclear or conventional. Possible functions of this network would be to encourage conversion of military electronics research, development and production to creative and socially useful purposes; to stimulate discussion and where possible disseminate information on military electronics and constructive alternatives, both within the industry and among the general public; and to provide technical advice and information where appropriate to the peace movement.

They propose a preliminary meeting in November, in or near London, to discuss the aims and structure of the network. Interested engineers should contact either Tim Williams, Weir Cottage, The Dens, Wadhurst, East Sussex or Steve Holmes, 151 Courthouse Road, Maidenhead, Berks for further details of the meeting.

Forth they went, together

The designers of Britain's latest microcomputer have chosen the Forth programming language in a bid to gain advantage in the crowding micro market. They claim its principles are so simple that newcomers to computing need only a few minutes to learn how to calculate, and at the same time, it is easy to invent extensions to the language. The two originators of the Jupiter Ace computer, Steven Vickers and Richard Altwasser (see caption), both discovered Forth at the same time (they read the same issue of Byte) and immediately recognised it, they say, as the ideal language for microcomputers.

Forth is fast and easier to write in as well as more compact in memory because it is



"Leading computer designers with a reputation for pushing technology forwards" is how Altwasser and Vickers describe themselves in their promotional copy for their new computer. Vickers, left, who previously had joined a software consultancy near Cambridge with a doctorate in algebra, adaptated the 4K ZX80 rom into an 8K for the ZX81. He wrote the manual for the ZX81 as well as most of the Spectrum rom. Altwasser, an engineering graduate, worked on the application of microprocessors in automation before joining Sinclair. He was soon made responsible for computer research which included the hardware development of the Spectrum. "It's about time someone got away from Basic" says Vickers. Developed in 1965, it was then a lot easier to use than Fortran. "But it is hardly the language of the future; our money is on Forth".

First shown at last month's Personal Computer Show at London's Barbican Centre, this £90 mail-order computer features full-size keyboard, user-defined high resolution graphics, programmable sound generator, upper and lower-case ascii characters, 24×32 flicker-free display, 1500baud cassette interface, and the Forth language. Jupiter Cantab are at 22 Foxhollow, Bar Hill, Cambridge, tel 0954 80437.

compiled, yet its compiled code is accessible to the user in the simplest way possible, say Jupiter. One gives each compiled routine a name, a Forth word, and to run it just type in the word.

Stringing old words together can define new words, which process lies at the root of Forth's power and enables one to define an infinite variety of one's own words from the standard words provided in the firmware. Older languages make assumptions about how they will be used that inevitably lead to a straight-jacket for the programmer; Forth is not based on any such assumptions they argue and allows the programmer "to do absolutely anything". If one doesn't have exactly the instruction needed in Forth, it is simply invented.

Forth usually relies on disc-based virtual memory for editing the source program but the designers say unique editing facilities operating on the compiled word definitions mean that words can be defined, listed, debugged, edited and redefined without using any external storage. This they say makes Forth even easier to use on the Ace than on other implementations.

The memory saving coded form used to store programs allows it to work much faster than it would do in another language the company say – typically in less than a tenth of the time, which makes it ideal for games. Capacity is 8Kbytes of rom and 3K of ram but because of the language it is more effective than, say, the 1K memory of the ZX81. Expansion to 16K (costing £35) should be available by the year end, as well as a printer interface board (costing £25), and later next year a colour board. By then, the company hope to be selling 3000 units a month.

Cost effective satellites

The postponed launch of the second European maritime communications satellite should take place while this issue is in the press. Though European in origin, this satellite's station is over the Pacific ocean and like its Atlantic partner will be leased to Inmarsat for international telecommunication at sea.

The two Marecs satellites grew out of the earlier, lower power Marots proposal and had their frequencies reduced down to 4/6GHz for compatibility with installations for Marisat, which they replace. The delay, from April last, has given time for modifications in the light of experience with the interference from electrostatic discharge in the Atlantic satellite (see News, May issue).

(Vienna. – According to Olof Lundberg, the director general of Inmarsat, speaking at the Unispace '82 conference, the number of ships and oil rigs fitting earth stations for Marecs increased by 30% in the first half of this year, to 1,350.)

Simultaneously with Marecs B, a second Sirio satellite is launched, using Italy's spare model built as a back-up for a 1977 communication satellite. In addition to providing meteorological data for the African continent, the satellite carries retroreflectors and time markers for laser pulses sent from ground stations. Object is to provide a laser-based method for long-distance synchronization of atomic clocks with sub-nanosecond accuracy, as well as giving an opportunity of comparing both laser and microwave time synchronization methods, using information gained from Sirio 1.

After the first six operational satellite launchers – ordered back in 1978 – are spent next year, the responsibility for Ariane launches transfers from ESA to Arianespace, a private company formed to exploit Ariane in 1980 and ratified by ESA last year. With a capital of 120 million francs its shareholders are the 36 principal European aerospace firms, 11 banks and CNES, in 11 countries, with France having the lion's share of 60%, Germany next with about 20% and the remainder having

NEWS

DATE	NAME	AUTHORITY
1982 Sept	Marecs B +	ESA
	Sirio 2	ESA
Nov	Exosat	ESA
1983 Jan	ECS 1 +	ESA
	Oscar 9B	Amsat
Mar	IntelsatV F7	Intelsat
May	IntelsatV F8	Intelsat
Jul/	ECS 2 or	ESA
Aug	Telecom 1A or	France
	IntelsatV F9	Intelsat
Oct	IntelsatV F9 or	Intelsat
	ECS 2 and/or	SEA
	Telecom 1A or B	France
	or ECS 2	ESA
1984 Feb	Spacenet 1 +	Southern Pacific
	Arabsat or	Arabsat
	Telecom 1B	France
May	GStar1 +	GTE
	Telecom 1B or	France
	Arabsat 1	Arabsat
Aug	GStr 2 +	GTE
	Spacenet 2	Southern Pacific
Oct	Spot 1 +	CNES
	Viking	Swedish Space Corp
Dec	Slot available	
1985 Feb	SBTS 1 +	Brazil
	Spacenet 3 or	Southern Pacific
	ECS 3	ESA
Mar	Intelsat VA F14	Intelsat
May	TV-Sat 1	Germany
Jun	Intelsat VA F15	Intelsat
	or TDF-1	France
Jul	Giotto +	ESA
	STC-1	Satellite TV Corp
Aug	Aussat 1 +	Australia
	SBTS 2	Brazil
Sept	TDF-1 or	France
	Intelsat VA F15	Intelsat
Oct	Ariane 4-01	
Dec	Aussat 2 +	Australia
	Anik D	Canada

shares varying from 0.25 to 4.4% in similar proportions to their ESA funding. Current orders with Arianespace – see table – are said to be worth 3,000 million francs at 1980 prices.

With competition in satellite launch facilities on the increase cost per kilogram in orbit has become a significant selling point. Together with increasing mass of satellites, this led to the dual launch experiment of September 10 with Marecs B and Sirio 2. To increase cost-effectiveness further it's planned to recover the first stage rocket by parachute. And if that's not enough, the thrust of the first two stages is set for a 10% increase, together with 25% for the mass of third-stage fuel. That will put a payload of 2000kg into orbit. And that's not all; this up-rated Ariane 2 launcher will be ripe for augmentation by adding two first-stage boosters so that 2580kg can be orbited (or two lots of 1195kg).

For satellite launches from 1985 onwards, the ESA earlier this year approved development of Ariane 4, with 50% more stage-one fuel with either two or four boosters with solid or liquid propellants and a flexibility to match a range of payloads between 2000 and 4300kg. Such a rocket would reduce mean cost per kilogram to 60% of that for Ariane 1, and have the capability to launch the Intelsat VI series, scheduled for 1986 onwards.

To accommodate the launch of this vehicle a second site is being completed for 1984, but equally important, this will allow time between launches to be reduced to a month. ESA/CNES studies of requirements beyond Ariane 4 suggest that Europe could one day be in a position not only to put 15 tonnes into low orbit in 1992 but also to recover launchers, returning payloads, and perhaps humans too.

Four today, how many tomorrow?

Only 87% of the UK population will be able to receive Sianel 4 Cymru and Channel 4 television services when they start up on the first and second days of November. This is because only 31 of 51 major transmitters will come into operation by that date, and about 100 of 600 low-power relays. Twelve main stations will need to be equipped next year to bring coverage up to 94%, the remaining eight waiting till 1984. But it will take until the end of 1986 for the relay stations to be completed. Coverage for Wales is higher at 90% with all six main transmitters operational and at least 80 local relays, with 13 more for 1983. If Wales gets better than average cover, Scotland comes off worse with only three main transmitters completed in time for the launch. Three more come into use next year but it's not until 1984 that it catches up, with six of the eight main transmitters for installation being scheduled for Scotland. The IBA, who are responsible for all the UK transmitters (but not the Welsh programming, this belonging to the Welsh Fourth Channel Authority), say the rest of the relays will be equipped as soon as possible from 1984 onward to bring the new services to everybody now receiving ITV, BBC1 and BBC2 on u.h.f. They point to the sheer size of the undertaking; the number of transmitters is far greater now than it used to be with the 405-line v.h.f. broadcasts, necessitating a massive investment in new equipment amounting to some £50 million. And, they emphasize, this will be the first time a television service will have been started in all 14 regions at the same time . . .

Cryptic satellite tv for Europe

Satellite Television plc will be transferring its European subscription tv service started earlier this year from OTS-2 to the ECS satellite next year, when OTS reaches the end of its planned life. To clear a space for ECS OTS has already been moved from its old 10°E position, to a new location at 5°E.

Based in London, Satellite TV transmits programmes between 18 and 20h u.t. every night via the OTS-2 spotbeam transponder on 11.64GHz. The service, financed by advertising and consisting of a wide variety of programmes from many countries including Britain, USA and Australia, is described as an "entertainment channel". It is received by licensed cable companies in European countries, among them Finland, Malta, Netherlands, Norway and Switzerland, although reception is not permitted by UK Home Office.

The transmissions are unfortunately encrypted at the insistance of Eutelsat, the European organisation of telecommunication authorities, to prevent "unauthorized use". There seems no prospect of an early liberalization of this rule which would make it possible for individuals to receive the programmes without having to hire or buy expensive decoders. The encryption method is the Oak Orion system developed for US cable tv (see "UK nearer to US tv encryption") and is generally accepted to be fairly difficult to break, particularly as the sound is carried on the sync pulses.

The level of power from the spotbeam transponder means that for reception with a good signal-to-noise radio a dish of around two metres diameter is needed. Although the transponder channel is 120MHz wide only a single 18MHz channel is used, with two transponders on the same frequency, one horizontally polarized and one vertical. On the present evening schedule, one carries the programmes of STV, and the other a French programme TV Tunis for North Africa.

Smart card, smart price

Known variously as the electronic chip card, debit card, payment card, pocket data card, memory card and smart card, the electronic credit card has spawned its own (non-electronic) publication. "Electronic chip card report" is a four part work, with updates, issued in 50 page instalments over a year for intending makers and users of the cards, and containing market research reports of card developments, especially in France, Germany, Italy and the USA. The most popular format for a card, consisting of memory and microprocessor circuitry embedded inside a card that is physically indistinguishable from an ordinary plastics credit card, is already in use for payment applications in France, according to the Report's promotional blurb. It is published by Steve Sziram of HTE at $2,500, and is available through Geoff Coole in the UK at 26 Pamber Heath Road, Pamber Heath, Basingstoke, Hants (0734 700543) – but not by electronic credit card.

● Coole Marketing Services otherwise represents Micropower Systems Inc of California, Catalyst Research Corp (maker of lithium iodide cells for cmos ram), Inmos to specific UK customers, and SIBS Report, a $400 p.a. semiconductor industry newsletter from the same publisher.

IMPACT OF THE PHOTON

The experimental discovery of photons at the turn of the century showed finally that electromagnetic theory had failed. Waves or particles, or both or neither? "Double-think" became the order of the day, a required belief; but are we sure that the last word has been said about this logical conflict?

BY W. A. SCOTT MURRAY
B.Sc, Ph.D.

The impression given by writers of scientific textbooks is that everything in classical physics was tidy, or about to become tidy, until 1899 when Max Planck came along and spoiled it with his quantum hypothesis. We have seen that this popular history misrepresents the truth. Electromagnetic theory, which formed one of the three structural pillars of classical physics, had already been placed in extreme philosophical difficulty by the Michelson-Morley result – no physical ether, therefore no electromagnetic waves. The whole of fundamental thinking at this time was based on electromagnetics; even the ordinary mechanical mass of an ordinary physical particle, such as an electron, was considered to be "electromagnetic mass', attributable to the inertia of its electromagnetic field, so that this field could be thought of as replacing the electron's material mass and even, by some physicists, to *be* the electron itself. In these circumstances the suggestion that anything could be seriously wrong with electromagnetic theory just didn't bear thinking about. One simply had to soldier on, hoping that some solution would turn up to relieve the anxiety.

However, the inconvenient absence of a physical ether was not the only evidence of failure of the électromagnetic theory. Serious difficulty was also encountered in describing the processes of radiation and absorption of light. The trouble in the radiation process was resolved by Planck by means of the revolutionary hypothesis which finally shattered the complacency of his times: *the radiation of energy in the form of light by a material substance is not a continuous process.* Individual mechanical oscillators in the material – atoms or molecules – radiate individual quanta of light energy. In the case of the absorption of light there is additional evidence of a discontinuous process: the photoelectric effect, which had similarly defied analysis by classical theory, was readily explained by Einstein on the basis of Planck's new hypothesis. The only possible interpretation of this high-quality experimental evidence is that the whole of an individual package of light energy or quantum must always interact, at any rate in the first instance, with one individual microsystem in the photocell surface. The light energy seems to be localized in space.

There was on the face of it, and in retrospect, nothing very surprising about this deduction. The essential granularity of matter on the microphysical scale, atoms and molecules, had been recognized for a hundred years. These newly discovered quantum interactions suggested that light energy also is packaged granularly into "photons" which behave as discrete corpuscles or particles, as Newton believed. The reason for the fuss was that the concept of a light beam as a shower of photons was in direct conflict with electromagnetic theory, because the latter, being a theory of linear force fields, depended absolutely on the *continuity* and extension in space of the quantities it was dealing with. By contrast, the concept of a particle or photon epitomizes discontinuity. Electro-magnetic theory *was bound to fail* when confronted with this discontinuity – and fail it did.

To those physicists who had believed the beautiful electromagnetic theory to be universally true and who had accordingly espoused it with a quasi-religious fervour, and likewise to those who so revere it by tradition today, its overthrow in the face of the quantum evidence, undeniable though that evidence might be, was simply not to be tolerated. Human feelings at levels deeper than mere reason were involved in this conflict. If mysticism was to regain its lost foothold in science, here was fertile ground.

Naturally, various attempts were made to compromise. The most hopeful of these led to the concept of the wave-packet. In certain circumstances, chief among which is that the physical medium in which they travel must be dispersive – a technical term – a group of water waves will propagate together across a pond and will remain concentrated together in the form of a package. The energy represented by the wave system travels at the speed of the group, which is not the same as the speed of the individual waves. (The mathematics of this situation is quite elegant). Hence it was suggested that the quantum, the particle-like concentration of light energy which was deduced from the experiments, might be merely a wave-packet of dispersive electromagnetic waves. That was the view which Planck himself took of the matter and maintained with some vehemence.

The trouble with this idea – it is distressing but noteworthy how often one is forced to say "the trouble with this idea . . ." – the main trouble with this idea is that although a suitable wave-packet could remain stable indefinitely in the longitudinal direction, no configuration of linear (Maxwell) waves can be devised which would prevent a wave packet from dissipating *across* the direction of the propagation. Now a beam of light will dissipate laterally, exactly like a wave system, but the individual quanta of which it seems to be composed *do not dissipate.* The unimpeachable experimental evidence for this is that the intensity of light decreases with distance from its source (the beam becomes more widely spread out), but the energy of its individual photoelectric impacts (its colour) does not change with distance. For this reason, Einstein, the radical, disagreed with Planck and came to regard the quanta as photons, essentially indivisible whilst in transit and therefore of the nature of particles. The wave-packet concept was a non-starter, disproved by the evidence, but it is still offered to physics students today as though it were valid and relevant.

In the end, and in my view prematurely, a thoroughly unsatisfactory compromise based on mysticism seems to have won the day. Modern physics as now taught accepts the doctrine of duality, which says that light radiation (sunlight, radio waves and x-rays) consist of both waves and particles at the same time. Whether its wave-like or particle-like properties predominate will depend on the details of the particular experimental set-up. If I use a diffraction grating I shall see waves; if I use a photocell I shall see photons; if I follow a diffraction grating by a photocell I shall see both forms of light within the confines of the same experiment. It matters not that waves (as in electromagnetic theory) and photons (quantum theory) are mutually-exclusive concepts, each of which specifically denies the validity of the other. If I am to make a successful career in physics I must learn to ignore that logical conflict and get on with the remainder of my job as though the conflict did not exist.

The duality doctrine can be fully accepted only by a person who is able and willing to "double-think" in the George Orwell sense. For every other professional physicist the choice is either to live with the doctrine – reluctantly and with resignation, no doubt, knowing it to be unsound – or to try to do something about it: but what? The problem of the true nature of light radiation is recognized to be one of surpassing difficulty which may "for fundamental reasons" actually be insoluble. There even exists a powerful school of thought which believes that matters of this fundamental kind are intrinsically beyond the power of the human mind to understand, so that it would be wrong to expend time, effort, or public money on attempting to understand them. It is asserted by this school that modern quantum theory is "complete" (Niels Bohr), and since that ultimate theory offers no solution to the problem there *can be* no solution to it (von Neumann).

Believe me about this, please, for I am telling you the truth: that view is the accepted dogma of today's scientific establishment. It follows from the arguments of the so-called Copenhagen School during the 1930's, while the body of doctrine now known as the quantum mechanics was under development. That doctrine is no more sacrosanct than was electromagnetic theory, and it rests on very much less secure experimental foundations (see later). It categorizes the fundamental nature of light as a *non-problem* for physics, about which it would be improper to ask further questions. Its bland assertion that there "can be" no further progress toward understanding in this and similar areas constitutes the ultimate in defeatism. For myself, I do not accept it.

Now if I declare that I do not accept one of the currently established doctrines of physics, in this case the doctrine of duality, the onus is on me to provide an alternative that I and others may find more acceptable. This I cannot yet do; nor, I expect, will anyone now be found who is able to review and revise the whole of modern physics single-handed. What I can do is invite those of my colleagues who are interested and not too busy to take a fresh look with me at the duality paradox, and I can start the ball rolling by mentioning a few neglected facts that may help us on our way.

My first hopeful factor is this. It is not waves as such, but *electromagnetic theory* – a field theory – which is inconsistent with the existence of discrete, particulate photons. When we are dealing with the most familiar waves of all, sound-waves in air, we do not normally have to remember that the true picture is one of interactions on the microphysical scale between myriads of individual air molecules. Rather than seek to follow and account in detail for the motion of each and every air molecule, which would be an impossible task anyway, it is sufficient for almost all purposes to consider their average behaviour. We speak in terms of local mean pressure and local mean velocity, and using these terms we can describe the propagation of sound as "waves" of pressure and velocity moving through the gas. Now the point to be made is that the *mathematics* of this description of sound is concerned with waves in a continuous medium, yet we know from other experiments that the true nature of a gas is not that of a continuous medium but of discontinuous, discrete molecules. The sound waves are real waves, however; their crests and troughs represent concentrations of air molecules which move progressively and systematically through the gas; and those density changes remain wavelike even though the gas is not mathematically continuous. It is not the waves but the mathematical theory of the waves which is inconsistent with the molecular nature of the gas. Clearly the theory is *an approximate description*, valid only in limited circumstances.

In electromagnetic theory the roles corresponding to local gas pressure and velocity are played roughly, but not exactly, by Maxwell's field potentials and displacement currents. It is these mathematical artefacts of the field theory, demanding as they do continuity in an ether medium, which are in conflict with the quantum evidence for the granularity of light. Light waves might very well consist of periodic variations in the density of photons as they travel in bunches through empty space at velocity c. If this should be so the infamous dualistic doctrine would be shown up for the mystical nonsense that I, for one, believe it to be. And the conflict would no longer lie between the concepts of light waves and photons, no longer incompatible, but between the electromagnetic theory and the experimental evidence. That theory also would be no more than a limited analogy at best.

It would be quite wrong to pretend to any originality for this idea, which Sir Karl Popper has quoted as representing Einstein's view. The concept that light waves consist of bunches or concentrations of photons is so obvious that one has to ask why it has not been generally accepted in place of the duality doctrine. Part of the answer would seem to lie in a general belief that it has been disproved experimentally. I am now going to argue that despite popular belief the concept has not in fact been disproved, but that it deserves at least one further, careful examination.

Typical of the experiments in question is one involving the interference of light, which is so readily accounted for on a "pure-waves" theory. I cannot do better than quote from an article written by Professor Frisch, of Cambridge, in 1969:

> "But what happens to the *photons* in an interferometer? At first it was thought that interference occurred when two or more photons came together; but that was disproved when G. I. Taylor (1909) showed that interference fringes were formed just the same whether the light was strong or whether it was so weak that hardly ever two photons passed through the apparatus together. It follows that single photons can exhibit interference, that 'a photon can interfere with itself'. It would seem that something does travel along both paths in the interferometer even when only one photon is admitted; but what is it?
> "Such questions were discussed a good deal when photons were new, and similar questions arose out of wave-particle duality of 'material' particles such as electrons. Some agreement has been reached on the way they should be answered, but the agreement is not unequivocal, and many of us are not sure what to tell our students . . ."

Summary
The crisis in electromagnetic theory threatened the whole of 19th-century physics. The threat became extreme when evidence of the radiation law (Planck, 1899) and the photoelectric effect (Einstein, 1905) showed that on these issues at least the electromagnetic theory had already definitely failed. The concept of the wave-packet, proposed by way of compromise, proved to be untenable. Eventually the mystical doctrine of the simultaneous waveparticle duality of light radiation came to be accepted, perhaps with resignation, together with the parallel doctrine that no fundamental understanding of this duality could ever be achieved. The onus was thereby placed on those who do not accept such negative doctrines to provide more acceptable alternatives to them. One such alternative, attributable originally to Einstein, proposes that light "waves" may consist of periodic variations of photon density. It is generally believed nowadays that this concept was disproved long ago, but careful investigation suggests that this is not so. Modern technology provides the possibility of a series of more rigorous experiments which could decide this very fundamental question once and for all. The main difficulty with such experiments is the practical one of obtaining financial support, because the concept underlying them is in conflict with the established dogma of modern physics.

The G. I. Taylor referred to was a research student at Cambridge under Sir J. J. Thomson. In his experiment he set up and recorded interference fringes on photographic plates, and the essence of his result was that no change could be discerned in these fringes whether the light was of visible intensity or so weak that to record the patterns required an exposure lasting three months. In the latter, extreme, case it could be calculated that if photons existed they must on average be separated by 30cm, which was appreciably more than the dimensions of the apparatus. Hence on average only one photon was present at any one time; yet the interference fringes still appeared in the photographs.

I submit that a point may have been missed by Taylor, by Thomson, by later experimenters who may have repeated the test, and by all who have accepted this result as evidence that "a photon can interfere with itself".* Everybody seems to have assumed that natural photons are evenly distributed in space, and that their density will be diluted evenly when the light intensity is attenuated toward zero. That is the assumption on which the deduction rests in this and similar experiments, but I suggest that it may be a false assumption. I propose in its place the idea that photons generated naturally – by a black-body radiator for instance, or in a discharge tube – are generated not singly but in very large bunches. Then in the experiments of Taylor and others the photons, although infrequent in an average sense, would nevertheless have continued to manoeuvre in bunches. There never was a time when the apparatus contained only a single photon, and interference *between* photons, rather than within individual photons, remained the order of the day.

Can I substantiate this proposal? Yes, I believe I can. In 1917 Einstein published a derivation of Planck's quantum law which later became the theoretical basis of the modern laser, and is therefore quite likely to be true. In this derivation he deduced the existence of two kinds of radiating mechanism which he denoted A and B. The A-type was spontaneous emission, self-triggering, while the B-type was stimulated emission, in which an atom or molecule previously primed with energy was triggered by the arrival of a photon already in flight. Following from Einstein's proposal, in the radiation of visible light the occurrence of B-type (stimulated) emission may be up to a thousand million times more frequent than A-type (spontaneous) emission.

We may interpret this result in non-mystical, mechanical terms. It should mean that photons are normally radiated in a cascade process: that is, in bunches. Each bunch would consist of up to a thousand million stimulated emissions, triggered ultimately from the one photon that is emitted spontaneously to initiate the cascade. This would represent the biggest snowball effect known to man – going on all the time on our doorstep, without our having noticed it. (I have coined the phrase *semi-laser action* to describe this process; the emission of *wave trains* can be explained in a natural way by interpreting Planck's $E=h\nu$ as $E=h/\tau$, where τ is the delay-time for emission of a photon of energy E).

If this argument should prove to be even moderately near to the truth (and I would gladly settle for a bunch of a million photons rather than a thousand million, not being greedy), we would have good reasons for repeating the Taylor experiment with modern photon-counting equipment. At sufficiently low light levels the interference phenomenon should simply fade away, like sound in sufficiently rarefied air. It would not be an expensive experiment by modern standards but it would be *very* fundamental and I say, worth the trouble of performing it. (I would have done it myself at home if I could have found the necessary £50,000 for equipment!) The key to the test would be to ensure and demonstrate that the photons were constrained to pass through the apparatus truly one-at-a-time. To forestall misinterpretation in these mystical and doctrinally-loaded surroundings would call for the greatest care. Also we may note that there is nothing "impossible" about this experiment, except that according to the Copenhagen dogma the question it asks is an improper question – just a bit too fundamental for comfort.

If it were thus to be shown that, contrary to current doctrine, the interference of light is a group phenomenon not evidenced by individual photons, we would be well on the way to a resolution of the duality paradox. A series of options in physics would be re-opened, which for fifty years have been dismissed as old-fashioned, "unphysical", or merely "unrealistic" – epithets which, in context, carry a pleasing irony. In the meantime we may examine some of the consequences to which a positive experimental result might lead. WW

*The wording of Taylor's report makes it clear that his boss, Thomson, did not hold with the new-fangled quantum ideas. Having obtained a result in accord with classical theory he was not disposed to investigate the issue further . . .

Next month

Two-metre transceiver. Complete design for a two-metre band, six-mode transceiver for mobile use by T. D. Forrester, call-sign G8GIW. Microprocessor control simplifies functions such as scanning, tuning, frequency display and use of the unit's nine memories. The transmitter power rating is 16.5 watts in the f.m. mode.

Technological choices for the UK. Robin Howes sets out to bring the discussion about educating engineers in social responsibility down to earth in this first of two articles. Written in response to Peter Hartley's article on educating engineers, it relates the ideas to the current industrial situation: part one deals with technological choices for the UK.

Heretics guide to physics. Instead of trying to ignore Planck's quantum hypothesis because it conflicts with electromagnetic theory, suppose we were to afford it more than lip service; what then? In A More Realistic Duality Dr Murray continues the Heretics Guide to Physics series by discussing new situations that could be tested by experiment.

Interfacing the Nanocomp. Bob Coates describes how to expand i/o interfacing for the nanocomp and gives connection details for the Cuban interface.

On sale Sept 15

FLOPPY-DISC DRIVES

Despite the floppy-disc drive's disadvantages in relation to the hard-disc drives already discussed, it is widely used and popular, particularly with microcomputer systems, because of its low cost. John Watkinson looks at the progress of floppy-disc drive technology this month.

by J. R. Watkinson
B.Sc., M.Sc.

Floppy discs are the result of a search for a convenient and fast, yet cheap non-volatile memory for storing instruction-coverting data used with a processor under development at IBM in the late 1960s. Both magnetic-tape and hard-disc storage were ruled out as means of quickly restoring the system's data after a supply interruption on grounds of cost, since only intermittent duty was required. The device designed to fulfil these requirements – the 8-inch floppy-disc drive – incorporated both magnetic-tape and disc technologies.

The floppy concept was so cost effective that it transcended its original application to become a standard in industry as an on-line data-storage device. The original floppy disc, or diskette as it is commonly called, is 8in in diameter and the more recent 'mini-floppy' is 5¼in in diameter. Still more recently, the 'micro-floppy', measuring around 3½in in diameter has been introduced.

Strictly speaking the floppy disc is a disc-storage medium since it rotates and repeatedly presents the data on any track to the heads, and it has a positioner to give the fast access characteristic of disc drives; but the device is also very similar to a tape drive in that the medium consists of an oxide coating on a flexible substrate which deforms when the read/write head is pressed against it.

Being stamped from a tape, a floppy disc is anisotropic, owing to the oxide being oriented along the tape during manufacture. On many brands this can be seen by the naked eye as parallel striations on the surface. A more serious symptom is the presence of sinusoidal amplitude modulation of the head output at the rotational frequency of the disc, illustrated in Fig. 1.

Standard and 5¼in floppy discs have straight radial apertures in their protective envelopes to allow access by the linear head positioner, but micro-floppy discs have curved slots since they use the lower cost rotary positioner, Fig. 2. A further aperture in the envelope allows a photo-electric index sensor to detect a small hole in the disc which gives an output signal once per revolution to synchronize the read/write circuits (discussed in an earlier article).

The disc is inserted into the drive edge first, and slides between an upper and lower hub assembly, Fig. 3. One of these assemblies has a fixed bearing which transmits the drive and the other is spring loaded and mates with the drive hub when the door is closed, causing the disc to be gripped firmly. The moving hub is usually tapered to accurately centre the disc. To avoid frictional heating and in the interests of longevity the spindle speed is restricted to about one tenth of that used for hard discs. The spindle is commonly driven by an induction motor, but more recent units incorporate electronically-governed d.c. motors, which have the advantage of needing no modification to run on different supply frequencies, and generate less heat.

Since the rotational latency of the slowly turning disc is so great, there is little point in providing a fast positioner so the carriage is moved by a stepping motor driving a leadscrew in the case of standard and mini-floppy discs, Fig. 4. This approach also provides detenting. To appreciate why this is so, it is necessary to understand how a stepping motor works.

Digital Equipment Co.

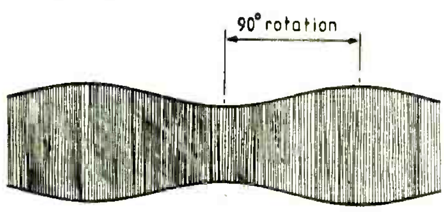


Fig. 1. Being stamped from tape, a floppy disc is anisotropic. This can cause sinusoidal-amplitude modulation of the type shown.

Figure 5 shows that this type of motor consists of a multi-lobed iron rotor and a stator with the same number of poles, each of which has a coil. If current is passed, the rotor lobes will be attracted by the poles, and will move into alignment. A smaller current, known as a holding current, will maintain this alignment against considerable external torque.

In smaller motors the holding current can be dispensed with as the rotor is a permanent magnet which naturally has a detenting action. A simple stepping motor of this type will only work if it is push-started at the frequency of the coil pulses. Motors of this type can be found in most a.c. electric clocks. To permit starting under load, extra poles and windings with seperate connections are interposed between the original windings. If the windings are pulsed in turn, the rotor will jump round, following the pulses, and detent at the last coil to pass current. This is the basis of the poly-phase-stepping motor, which is the type used in floppy-disc and many 'mini-Winchester' drives. A typical standard floppy-disc drive uses a stepping motor with four windings and two steps correspond to a one cylinder seek.

Figure 6 shows a typical drive circuit, in which a 2-bit counter counts up or down according to pulse from the controller, and this count is decoded to one of four outputs which will be in the correct sequence for the chosen direction of travel. Although the pulses from the controller may

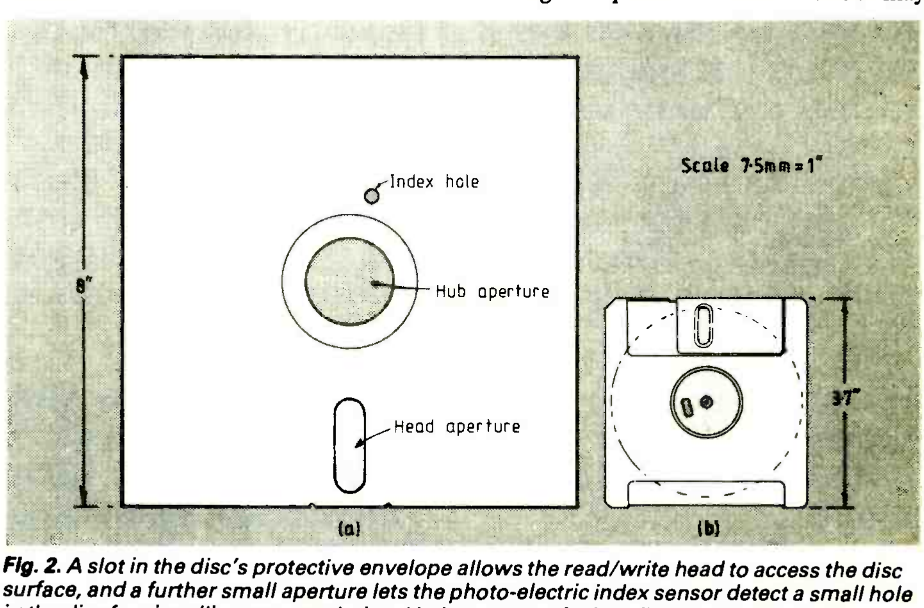


Fig. 2. A slot in the disc's protective envelope allows the read/write head to access the disc surface, and a further small aperture lets the photo-electric index sensor detect a small hole in the disc for signalling one revolution. Various types of micro-floppy disc-drives are appearing, one of which has a rotary positioner to keep costs down. Micro-disc shown is for the Sony SMC-70. Relative sizes shown are approximate.

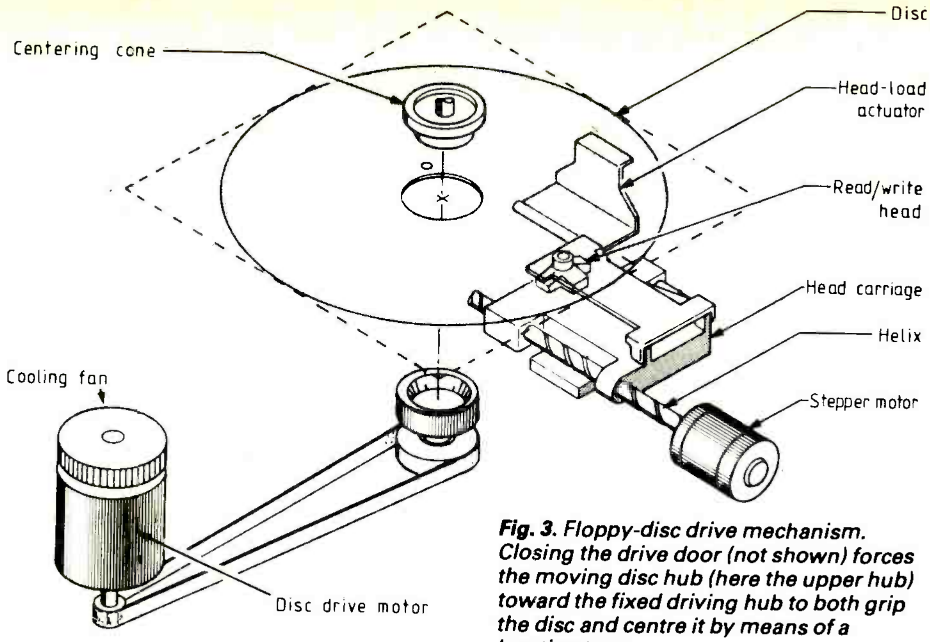


Fig. 3. Floppy-disc drive mechanism. Closing the drive door (not shown) forces the moving disc hub (here the upper hub) toward the fixed driving hub to both grip the disc and centre it by means of a location taper.

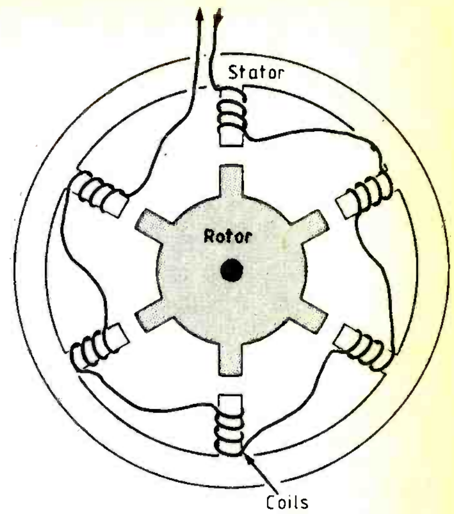
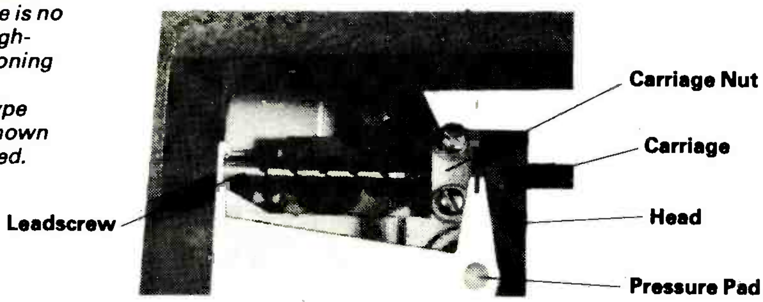


Fig. 5. Stepping motors are used to turn the floppy-disc drive positioner's leadscrew. The most basic form of stepping motor, shown here, requires external torque to start it, and if the rotor is a permanent magnet, detenting is obtained when the rotor is stationary. This type of motor may be found in mains-driven electric clocks, but a commonly used, more advanced type with extra, separately-driven windings and poles is used to turn a floppy-disc-drive positioner's leadscrew in either direction without starting torque from outside.

Fig. 4. Floppy discs turn much more slowly than hard discs so there is no need for a high-speed positioning system. The leadscrew-type positioner shown is usually used.



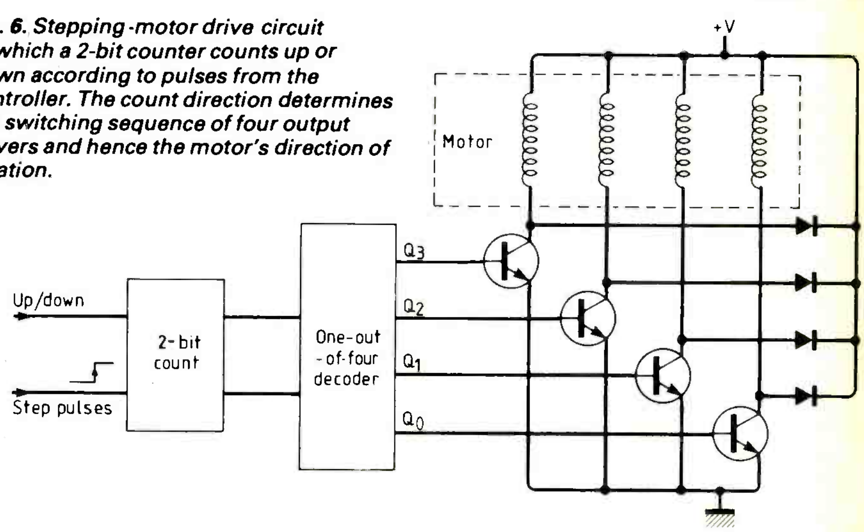
only be a few-hundred nanoseconds long, the motor drive circuit stretches these to about 10 milliseconds.

All incremental positioners need a reference from which to start counting. At the rearward limit of carriage travel, the carriage interrupts a slotted light-beam-type sensor which generates a logic signal indicating cylinder zero. From then on, the controller must remember the sum of how many pulses forward and how many back have been sent in order to know what the current cylinder is. Should this count be lost, say due to a power failure, it is necessary to execute a recalibrate function. In this case the drive is sent reverse pulses until the cylinder-zero sensor is activated.

Head alignment. One of the less endearing features of plastics materials is lack of dimensional stability. Temperature affects plastics much more than metals, and they also change their dimensions as a function of humidity. For this reason the track spacing has to be generous, being only 77 tracks on the industry-standard floppy, and 35 on the basic mini-floppy disc. Owing to this coarse track spacing, head alignment in the field is seldom necessary, but is nevertheless quite easy on a leadscrew drive. After loosening a clamp screw, the stepping motor can be turned bodily while dentented, which has the effect of rotating the leadscrew, hence moving the head. It is also important that the cylinder zero sensor be at the correct radial position, or a recalibrate could cause the positioner to detent on the wrong track.

The read/write head of a standard floppy-disc drive operates on the lower surface only, and is rigidly fixed to the carriage. Contact with the medium is achieved with the help of a spring-loaded pressure pad applied to the top surface of the disc opposite the head. To reduce head wear, the pressure pad is often retracted when data is not actually being transferred.

Fig. 6. Stepping-motor drive circuit in which a 2-bit counter counts up or down according to pulses from the controller. The count direction determines the switching sequence of four output drivers and hence the motor's direction of rotation.



Some drives have provision for adjusting the pressure-pad loading. The pressure-pad solenoid can often be heard operating in an otherwise virtually silent drive. The recording technique used with standard floppy-discs is f.m. (described earlier in the series). Owing to the indifferent stability of the medium, side-trim or tunnel erase recording is used, which can withstand considerable misregistration.

Figure 7 shows the construction of a side-trimming head, and the extra erase poles can be seen. Figure 8 shows a typical write circuit from a double-sided drive which incorporates a head-select matrix. During writing, the erase poles are energized by switching power to a fourth head connection.

At the inner tracks, writing density becomes higher, and the write current needs to be reduced. This is the function of the

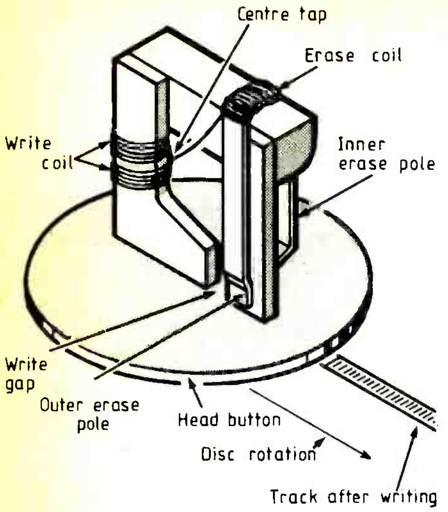


Fig. 7. If a head writes over a track that it is not accurately aligned with, chances are that some of the data that should be overwritten will be left at the edge of the new track. On a subsequent read, signal-to-noise ratio may be significantly worsened by the presence of the remaining unwanted signal. A plastic floppy disc has poor dimensional stability and would suffer from this problem were it not for two small erase heads at either side of the read/write head which clean the track edges during a write.

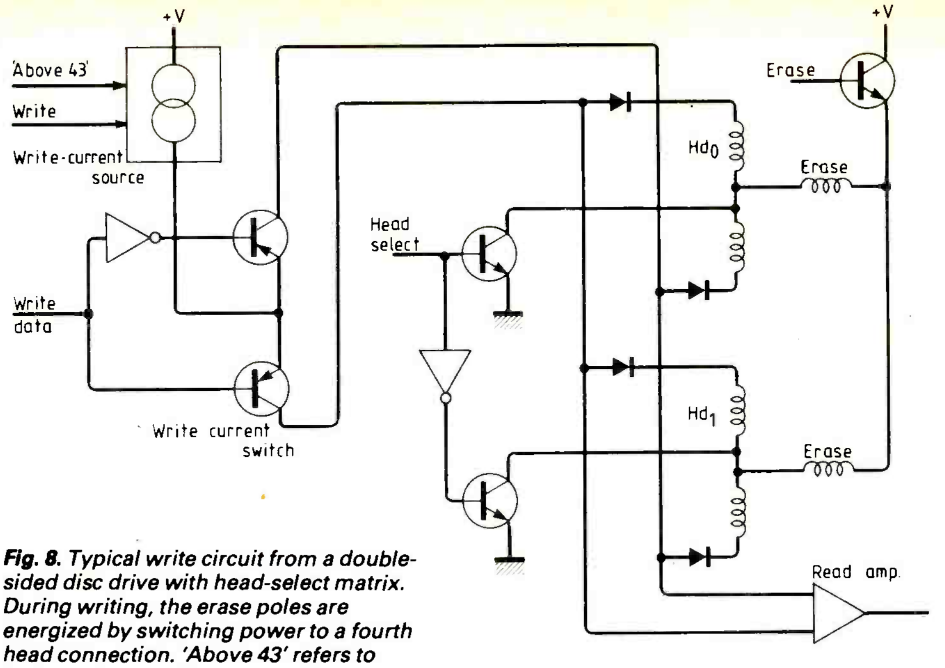


Fig. 8. Typical write circuit from a double-sided disc drive with head-select matrix. During writing, the erase poles are energized by switching power to a fourth head connection. 'Above 43' refers to higher cylinder addresses and is a signal used to reduce write current at the inner tracks where the writing density is higher.

signal 'above-43', which refers to the higher cylinder addresses.

The major signals between the drive and its controller have now been introduced and are summarized in Fig. 9.

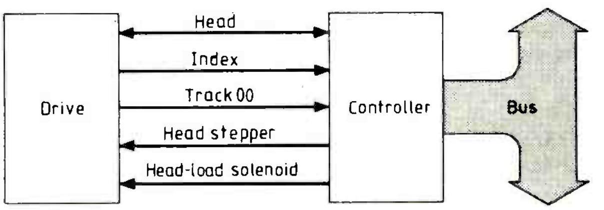


Fig. 9. Main signals between a floppy-disc drive and its associated control logic.

Formatting

Since it has become a standard, the format of the floppy-disc warrants inclusion here.

Figure 10 shows that there are 26 blocks on each track, which commence at the index point. A considerable tolerance gap is left after the last block to allow for variations in disc speed changing the length of blocks written at constant write frequency.

Figure 11 details each block, and shows that the header contains the cylinder and sector address of the block for the purpose of position confirmation before transferring data. The header finishes with a cyclic-redundancy-check character (c.r.c.) which is used to establish that the header was correctly read. Between the header and the data block proper is a space where the write current can be turned on. The block contains 128 bytes of data followed by a 2-byte check character. The IBM specification also details which tracks are to be used for particuluar purposes, but this is not adhered to by other manufacturers of floppy disc drives.

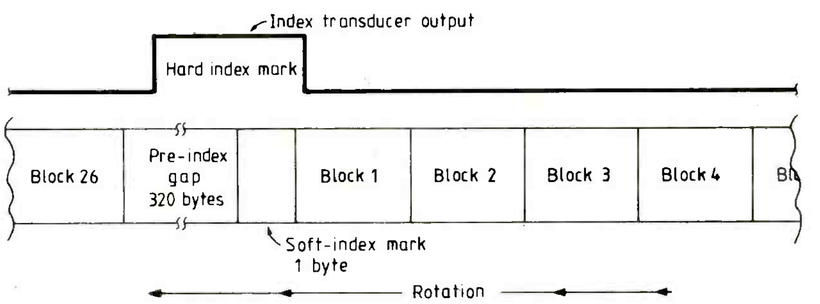


Fig. 10. There are 26 blocks on each track of a standard floppy disc commencing at the index point. A considerable gap is left at the end of the last block to allow for rotational-speed changes, which will change the length of blocks written at a constant write frequency.

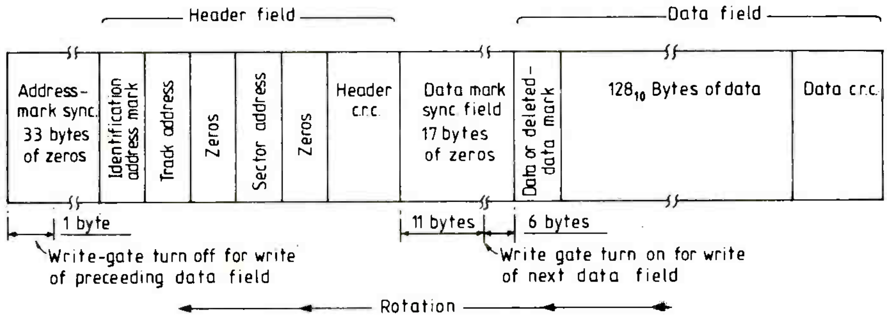


Fig. 11. Details of a data block. In the header-field section, the first byte is a unique pattern decoded by the controller to identify the beginner of the header field, called the identification-address mark. The last two bytes in the header-field section are for cyclic-redundancy checking (c.r.c.). The data field is broken into 131 bytes of information and is preceded by a field of zeros and the header field just mentioned. Here, the first byte is also a unique pattern but for identifying the beginning of the data field, called the data- or deleted-data-address mark. Bytes two to 129 comprise the data field used to store 128, 8-bytes of information. Bytes 130 and 131 are a cyclic-redundancy-check character.

Developments

As with all disc drives, developments have increased the storage capacity of the floppy disc. The first step was to use modified f.m. (m.f.m.) encoding instead of f.m., which effectively doubles the capacity (described in the second article). Such drives are referred to as double-density, and are to be found in both sizes. Some drives have been built which are capable of

continued on page 84

METEOSAT HIGH-RESOLUTION IMAGES

Final details of circuits for receiving Meteosatll high-resolution pictures on a home-built station. The original weather-satellite receiver, designed for Tiros-N high-resolution images, was described towards the end of last year.

by M. L. Christieson

Word and frame synchronization is achieved by passing the serial data through a 24-bit shift register and detecting the sync. sequence. This is similar to the system used for h.r.p.t. but a more straightforward method of detecting a clock-phase error is used. The effect of this type of error is that the data appears inverted, and with an increased error rate. This situation is detected by checking the serial data for $\overline{\text{sync}}$. as well as sync. and correcting the clock if sync. is found.

Figure 5 shows the circuit of the serial-to-parallel converter together with the associated sync. detector. The error signal is fed back to the bit conditioner. This circuit should replace the sync. detector section of the serial-to-parallel converter used for h.r.p.t. The counter that provides the word clock should be changed to divide by eight because of the different word length. The sync. guarantee counter which resets at 11090 for h.r.p.t. should be decoded to reset at 364 for p.d.u.s. In the prototype station, switching between the two systems is controlled by the computer.

Data handling and display

One of the advantages of using computer software to process the data is that different types of image can be handled easily. In the prototype station, the computer interface was modified to receive two 8-bit words and flags as one 18-bit word rather than the original four, 4-bit words of the experimental h.r.p.t. system. This change was made to accommodate a more advanced colour display which stores 6-bit words to give 64 colours. Reception of h.r.p.t. data is now also through this interface and colour display.

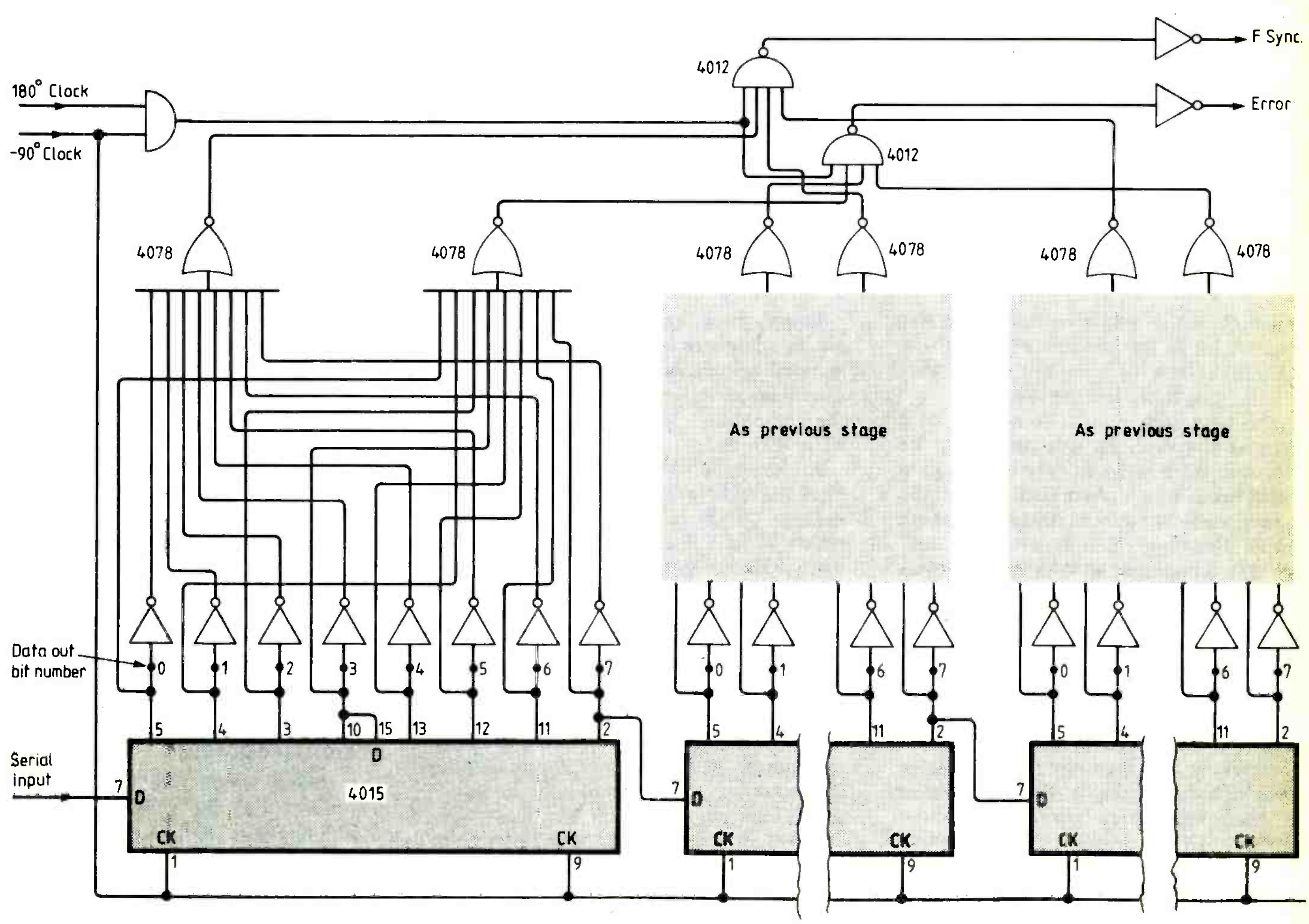
The software that controls data from the interface for the tape drive in real time has first to locate frame zero and hence the label. Subframes containing the required image data are stripped of unwanted words, such as syncs, and the 6 most significant bits stored in the main memory. Data is then transferred to tape in a similar manner to that used for h.r.p.t., i.e., with data channel and interrupts.

The colour display, which operates as a

Fig. 5. Sync. detector with serial-to-parallel converter. The error signal if fed back to the bit conditioner, Fig. 3.

Meteosat now relays GEOS pictures

As pointed out in this article, Meteosat's schedule is subject to occasional revision, and since the time of writing a new schedule has been introduced. This includes formats containing data from the GEOS-E satellite situated at 75°W. These formats are relayed via CMS-Lannion in France, and comprise both p.d.u.s. and s.d.u.s. images of the Americas and the Western Atlantic. The p.d.u.s. formats, called LX, have been successfully received by the prototype station.



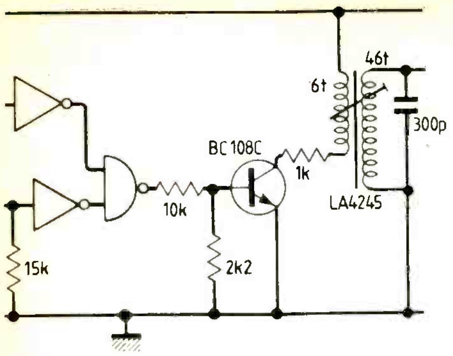


Fig. 4. This is how the top-middle section of the circuit diagram on page 64 of last month's Wireless World *should have looked; we apologize.*

computer peripheral, has a basic image of 315 lines by 384, 6-bit pixels. The raster store is made from dynamic mos memory and uses the line rate as the refresh. A one-line buffer is used to transfer data to and from the main store. The output is fed to a d-to-a converter from a hardware adder and subtracter loaded by the computer. This means that the colours may be changed without loss of the stored image.

Adjustment and results

Final adjustment is simplified by the continuous nature of the Meteosat signal and a satellite simulator was not necessary. A final check on the system is most easily made by using the computer to check for errors in the sync. sequences. This information may be used to calculate an approximate error rate which was better than 1 in 10^7 in the prototype.

A large number of images have been received and the quality has been excellent. There are relatively few p.d.u.s. users at the moment, possibly because of the high cost of commercial equipment and the apparent reluctance of people to make it.

It is hoped that these ideas may form the basis for further exploitation of the service and facilitate further work on the interpretation and use of the data, a field where much important work remains to be done.

Further reading

Use of data from Meteorological satellites, Technical conference, Lannion, Sept. 1979, ESA, SP143
Satellite meteorology of the Mediterranean, ESA, SP159
Climate and man's environment, J. E. Oliver, Wiley and Sons
Proceedings of the second Meteosat scientific user meeting, Mar. 1980, ESA
Publications relating specifically to Meteosat may be obtained from ESOC, MDMD/OPS, Robert Bosch Strasse 5, D-6100 Darmstadt, W. Germany. Other ESA publications, for which there is a charge, should be obtained from Scientific and Technical Publications Branch, ESTEC, Postbus 299, 2200 AG Noordwijk, The Netherlands.

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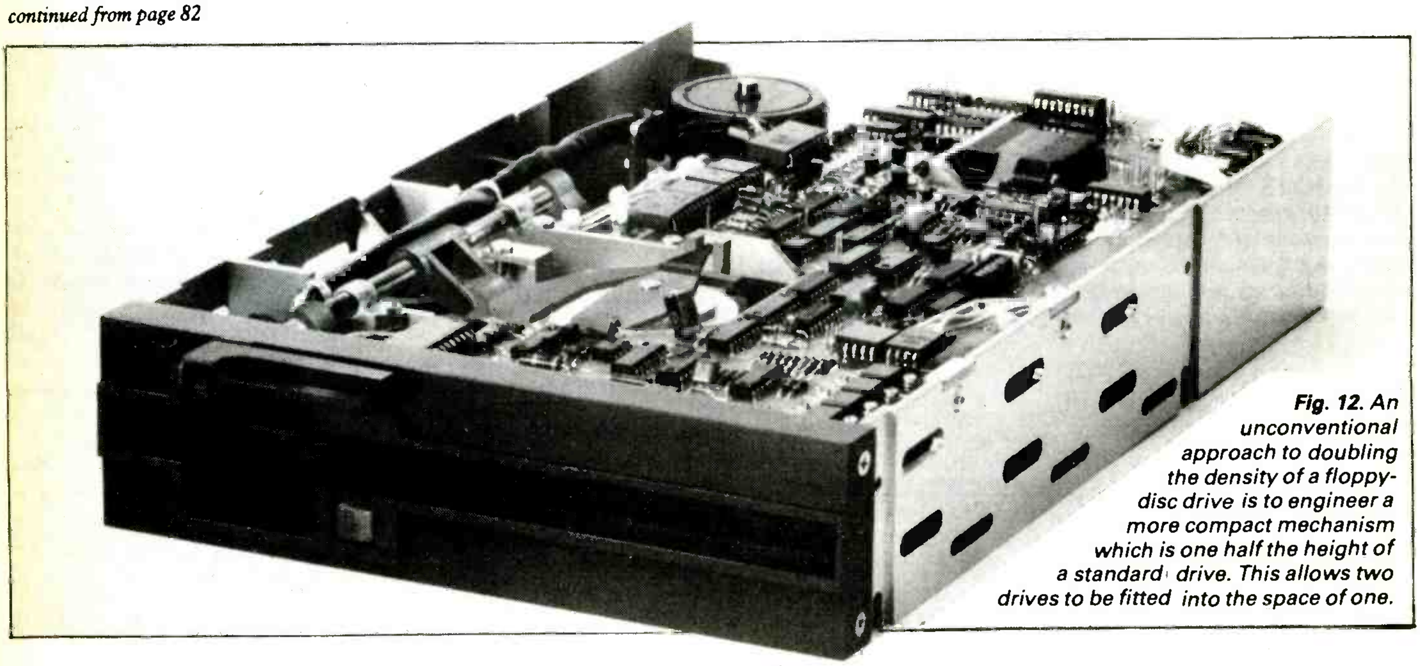


Fig. 12. An unconventional approach to doubling the density of a floppy-disc drive is to engineer a more compact mechanism which is one half the height of a standard drive. This allows two drives to be fitted into the space of one.

accepting either single or double-density discs. A bit in the headers will tell if the subsequent data is f.m. or m.f.m., the disc format being otherwise the same.

The next step was to record on both sides of the disc. In this approach, the pressure pad is replaced by a second gimballed head, which constrains the medium to pass neatly between in contact with both heads. The floppy disc is somewhat thinner than a hard disc so to reduce crosstalk the magnetic gaps of the two heads are displaced slightly along the track from one another. The two heads are always at the same distance from the spindle. A double-sided double-density drive yield four times the storage capacity of the standard product. As the recording density increases, however, it becomes more important to have high quality media. Recent advances in head technology permit continuous contact with the medium, thus eliminating the solenoid mechanism, making it especially important to use discs recommended by the manufacturer.

Dimensional instability is compensated for in some drives by a section of disc material in the positioner baseplate. As the disc changes its dimensions, so too does the baseplate, reducing the resulting misregistration.

An unconventional approach to doubling the density of a floppy disc drive is to engineer a more compact mechanism which is half the height of a standard drive. This allows two drives to be fitted in the space of one. A unit of this type is shown in Fig. 12.

The most recent development is the use of vertical recording, where the magnetic domains in the medium are arranged on end throughout the thickness of the coating. Research has now provided a suitable medium in the form of Chromium-Cobalt crystals which are sputtered onto the substrate. It is predicted that this technique will increase the capacity of a floppy disc by initially a factor of 3 to 5. This technology can then be expected to migrate to hard discs with staggering results.

In mainframe and minicomputer applications, the floppy disc provides an excellent low-cost medium for loading diagnostic programs, particularly useful if the hard disc subsystem is faulty. In microcomputers, the floppy disc is the only product which is of the same order of cost as the other components of the system, and the disc needs less consideration in handling than the hard disc. With the current popularity of microcomputers, the floppy disc is a significant growth area.

This article concludes the information on disc drives themselves. Future articles will discuss the control logic required to support the drives, and techniques used to ensure data integrity.

Acknowledgments

The author would like to thank HAL Computers Ltd for photographs of the mini-floppy and half-height drives, and Digital Equipment Co. Ltd for permission to use the standard floppy-disc drive photograph.

SIDEBANDS: PAST, PRESENT AND FUTURE

The debate on the existence of sidebands was recently revived by letters in Wireless World. Professor Bell thinks they are here to stay – for the moment, at least.

by D. A. Bell,
F. Inst.P., F.I.E.E.

A recent letter in *Wireless World*[1] recalled rather nostalgically some of the writer's earliest experiences of radio in the 1930s. In those days engineers did not always rely on mathematics – after all, Marconi successfully defied the predictions of diffraction theory about the propagation of short waves – and there was substantial argument as to whether sidebands really existed. The extreme point of the argument came when J. Robinson produced a type of receiver which he named "Stenode Radiostat" ("Stenode" from the Greek for "Narrow path") which he claimed utilized the modulated carrier and ignored sidebands[2]. This receiver used a single, high-Q resonant circuit (quartz crystal) to give high selectivity. The higher modulation frequencies were admittedly attenuated by the slow response of the high-Q element to changes in carrier amplitude but this effect was compensated by a suitably large top boost in the audio-frequency circuits.

Now, in a truly linear system, the attenuation of high frequencies in one stage followed by their restoration in a later stage would restore the original condition, with no net advantage. But the Stenode Radiostat worked! It was claimed that an interfering station only one kilocycle (kilohertz) off the wanted station could be eliminated. (The weakness of the system was that the large top boost in the audio stages also magnified any harmonic distortion which might have been generated in the detector stage). The success of the Stenode Radiostat also tied in with something which had already been puzzling other experimenters. If one had, for example, a simple crystal set with a single tuned circuit of very modest Q, it was possible to separate two local medium-wave broadcasting stations much more completely than one would have calculated from the resonance curve of given Q.

A demonstration of the existence of sidebands was given at one of the Physical Society's Annual Exhibitions. One exhibit (from the N.P.L.?) showed a carrier of comparatively low frequency (perhaps 15 kHz) modulated by a single audio frequency; and a wavemeter with galvanometer indication of response (there were no spectrum analysers in those days) could be tuned across the frequency band, showing separate responses to each sideband and the carrier.

As sidebands could be shown to exist, why did the Stenode Radiostat work? Remember the qualification above that *in a truly linear system* no net advantage was to be expected. The fact is that a 'linear' detector, in the sense of one which has a linear relationship between input and output, is not *linear* in the circuit-theory sense of obeying the law of superposition which requires the output due to two signals applied simultaneously to be equal to the sum of the outputs obtainable from the two signal applied separately. Put very crudely, and assuming the two signals to be of very different amplitude, the opening and closing of the conducting path through the rectifier is controlled by the stronger signal and any signal of different frequency is 'mashed up' because some cycles which coincide periodicially with those of the stronger carrier are allowed through but others are blocked. It turns out that only the modulation of the weaker signal is suppressed, to an extent depending on the ratio of carrier amplitudes, any heterodyne note between carriers remaining. In the *Wireless World's* then sister journal, originally entitled *Experimental Wireless* but later *Wireless Engineer*, there was a sequence of papers under the title "Apparent Demodulation of a Weak Station by a Strong One". The first was a mathematical paper by Beatty[3], but the mathematics of non-linear systems is notoriously difficult and Butterworth[4] disagreed with the results of Beatty's mathematical analysis. Then a paper by Colebrook[5] was concerned to present a simpler mathematical treatment and finally a paper by Appleton (later Sir Edward Appleton) and Boohariwalla[6] from King's College, London, reported an experimental verification of the theory. This last paper has a footnote suggesting that the effect in question might have some relevance to the Stenode Radiostat. So one now takes account of the effect of relative carrier amplitudes in receiver design, while using a flat-topped pre-detector filter to avoid the problem of harmonic distortion exaggeration by audio-frequency top boost.

So at the present time sidebands are universally accepted, as indeed they should be. To anyone of modest mathematical competence, the statement $\sin \omega t.\sin pt = \frac{1}{2}[\cos(p-\omega)t - \cos(p+\omega)t]$ is just as true as $2 + 2 = 4$. (The modifications to the trigonometric formula to provide for a non-negative carrier and defined depth of modulation are trivial.) The important thing to remember, however, is that an equation has two sides, so that carrier-of-varying-amplitude and constant-carrier-plus-sidebands are equally valid representations of the modulated carrier: one finds whichever one is looking for, whichever one's test apparatus is capable of detecting. Thus, if one uses an oscilloscope one will see only a carrier of varying amplitude, but if one uses a spectrum analyser one will see carrier and sidebands. The idea of time/frequency duality was not well developed in the 1930s, when one thought of applying Fourier series only to the analysis of repetitive waveforms of non-sinusoidal shape, as in the treatment of harmonic distortion.

The most graphic example of time/frequency relationships (though in a different context) was given by Gabor[7] in 1946. A pure sine wave will appear in the spectrum (frequency) analysis as a line of zero width, but to have zero width it must extend over an infinite range in time. Conversely, a pure pulse is concentrated in an infinitesimal time but in the frequency domain is spread over all frequencies (as evidenced experimentally by its potentiality for causing interference). Any intermediate waveform – e.g. a chopped sinusoid or a lengthened pulse – will occupy a finite range in both time and frequency. The idea that the communication of information requires a finite bandwidth has somehow become associated with 'information theory' and has thereby acquired an unquestionable authority. Nowadays we expect to be able to shift between time and frequency descriptions of a phenomenon as the immediate problem may demand, by the (mathematical) Fourier Transform, where an analytic description is possible, by the (computer) Fast Fourier Transform (F.F.T.) where numerical transformation of an arbitrary signal is required or by the Wiener-Khintchine Transform to find the power spectrum of a random signal.

So sidebands are firmly with us at present, but will they always be in future? For a long time the frequency domain of sinusoids has seemed inherent in nature: there are so many natural phenomena which involve harmonic oscillation, in fact anything which involves inertia and a restoring force proportional to displacement from a central state. The most obvious electrical version of this is the combination of inductance and capacitance, and at moderate frequencies the LC resonant circuit seemed a natural part of most tuned systems. Perhaps a hint of the future lay in the low-frequency RC oscillator which avoided the use of an inconveniently large inductance. Now we have integrated circuits which are unable to produce reasonable magnitudes of *either* L *or* C but are appropriate for digital working with an external driving clock.

This brings us to consider Walsh functions[8] as an alternative to trigonometric functions. The use of non-sinusoidal signals has been surveyed in detail by Harmuth[9] who has shown how to construct (with operational amplifiers) circuits analogous to the ordinary resonant circuits, but which respond selectively to particular non-sinusoidal waveforms. Direct digital transmission (without a carrier) is used for high-speed transmission over optical fibres; and Harmuth describes the use of a radar with non-sinusoidal waveform for the detection of buried pipes. As long as one is concerned with local or confined transmission there is no problem, though in optical fibres one may tend to go to a frequency description of the *dispersion* as a property of the medium, while still speaking of a time delay to the signal. But modulated sinusoids seem essential in free radio communication for three reasons:

1. Maxwell's equations imply sinusoidal radiation.
2. Changing the whole world's "channel" allocations from frequency-division to time-division would be a worse problem than changing the rule of the road from right to left throughout Europe and America – for in the radio case it would be necessary for everyone throughout the world to change simultaneously.
3. Time-division would require synchronism with a world-wide standard clock, in phase as well as frequency, and this could not be maintained over a long distance of propagation.

It therefore seems that modulated-carrier radio, and thus sidebands, will be with us for the foreseeable future. WW

References.

1. D. C. Sutherland, *Wireless World*, vol. 88, p.50, June 1982.
2. J. Robinson, The Stenode, *Wireless World*, vol. 28, pp. 9-11, January 7th, 1931.
3. R. T. Beatty, Apparent Demodulation of a Weak Station by a Stronger One, *Experimental Wireless*, vol. 5, pp. 300-303, 1928.
4. S. Butterworth, Apparent Demodulation of a Weak Station by a Stronger One, *Experimental Wireless*, vol. 6, pp. 619-621, 1929.
5. F. M. Colebrook, A Further Note on the Apparent Demodulation of a Weak Station by a Stronger One, *Wireless Engineer*, vol. 8, pp. 409-412, 1931.
6. E. V. Appleton and D. Boohariwalla, The Mutual Interference of Wireless Signals in Simultaneous Detection, *Wireless Engineer*, vol. 9, pp. 136-139, 1932.
7. D. Gabor, Theory of Communication, *Journ. I.E.E.*, vol. 93, part III, pp. 429-441, 1946.
8. Thomas Roddam, The Function of Functions. An Approach to Walsh Functions from Telecommunications History. *Wireless World*, vol. 87, pp. 36-39. December 1981.
9. H. F. Harmuth, Nonsinusoidal Waves for radar and radio communication. Academic Press, 1981 (Advances in Electronics and Electron Physics, Supplement 14).

continued from page 62

The author
Mr Tierman is currently manager of British Telecom's Prestel computer network. He has spent the last 12 years being largely concerned with the design and management of on-line computer systems for use within British Telecom, and the LACES air cargo control scheme. Prior to that, 12 years RAF service was spent in close company with radar and associated computers. This article is the result of a consuming interest in audio systems, to which much of his leisure time has been devoted in the past 25 years.

Construction

The only item mounted directly on the main front panel are the 4mm sockets for Sync, Common, and output; a 5 pin DIN socket with pins 2 and 3 connected to Common and output respectively; and the led D_3.

With one exception, there were no special screening or wiring constraints observed in making up the unit, but there has been a penalty in so far as there is some slight, but obvious, high-frequency breakthrough at the output (thought to be picked up at the junction of R_{13}/R_{15}) when the attenuators are set for something less than maximum output. The exception is the connexion between P_2 and TBG/B; this is a link between two high-impedance points and a screened lead should be used to prevent spurious triggering of $IC_{2/1}$ via Tr_4. There may also be slight notching of the output sinewave at points corresponding to the switching of $IC_{2/1}$, and this may be minimized by using a 4069 (hex. inverter) i.c. for IC_2 in place of the 4584. If this is done, the led driver circuit will not work properly on battery operation and C_{16}/R_{29} should be omitted.

Readers who would like copies of Mr Tiernan's suggested p.c.b. pattern sketches should send a stamped, addressed envelope to Wireless World, Room L302, Quadrant House, The Quadrant, Sutton, Surrey. Mark the envelope 'Oscillator'. WW

Wireless World index and binding

The index for Volume 8 (1982) of **Wireless World** is now available, price 75p including postage, from the General Sales Department, IPC Electrical-Electronic Press Ltd, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

Our publishers also offer a service of binding volumes of **Wireless World**, each complete with the appropriate index. If you wish to use this service send your copies to Press Binders Ltd, 4-4a Iliffe Yard, Crampton Street, Walworth, London, SE17 with your name and address enclosed. Confirm your order to the General Sales Department (address in first paragraph) and with this letter to Quadrant House send a remittance of £6.90 for each volume (this price includes the index).

In both cases cheques should be made payable to IPC Business Press Ltd.

LITERATURE RECEIVED

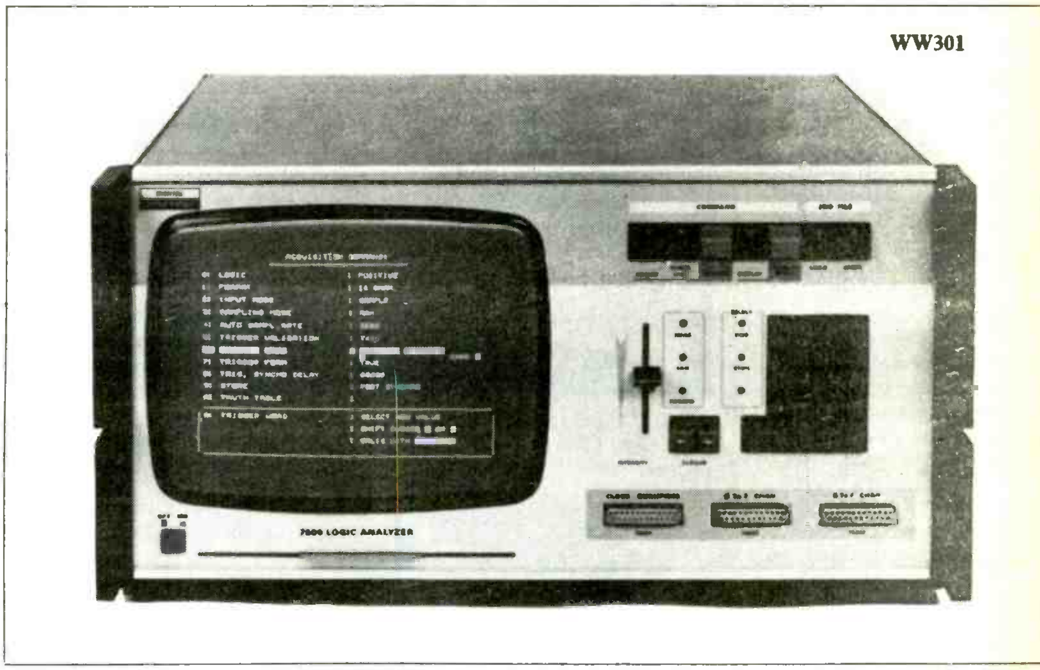
Motorola now manufactures some 15,000 semiconductor devices and selection can be somewhat overwhelming. To make it easier they have published a **European Master Selection** which lists approximately 4,000 preferred devices that correspond to the majority of customers' needs in Europe. This is still quite a daunting volume but includes all the microcomputer components, integrated circuits for digital and linears operation; a wide selection of discrete components and packaged devices for hybrid circuits. Motorola Ltd, York House, Enfield Way, Wembley, Middlesex. WW401

The Technit 10-section **Electro Magnetic Interference Shielding Design Guide** is a source of reference for design engineers who are faced with EMI shielding problems. It is available from MCP Electronics Ltd. 38 Rosemount Road, Wembley, Middlesex. WW402

Perdix Components, of 98 Crofton Park Road, London SE4, have expanded with five new divisions and have produced a product guide to list the components available. There are liquid crystal, vacuum fluorescent and gas plasma display panels; switching power supplies; microprocessor application boards and video monitors. WW403

Within the Catalogue of the **Open University Press** is a technology section which includes some interesting titles on the social implications of technology. *The Future of the Printed Word* is a collection of papers edited by P. Hills. A book by David Collingridge is entitled *The Social Control of Technology*. There is also *The Future with Microelectronics* by I. Barron and R. Curnow, and *Microelectronics and Society* edited by T. W. Jones. The books are not written for specific OU courses. WW404

NEW PRODUCTS

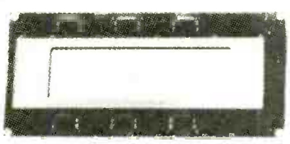


'SIMPLE' LOGIC ANALYSER

A microprocessor-based logic analyser with a minimum of controls, the 7600, has been added to Enertec Instrumentation's range of laboratory instruments. Screen information is divided into two sections, one containing processed and labelled data from the analyser and the other containing prompts for the operator, supplemented by l.e.d. indications on the control keys. One of two 4096-bit memories is used for data storage, in either four, eight, 16 or 32-bit-word form, and the other is a truth-table memory. Four possible operating modes are automatic step, manual step, externally-triggered step and 'halt-if-different-from-truth-table'. Stored data can be displayed in seven different ways. When operated synchronously, the 7600 has a frequency range of 0 to 30MHz, or, when operated asynchronously, up to 100MHz, with thresholds adjustable in 50mV steps between ±6.35V. Propagation delay difference between channels is 5ns and glitches 10ns wide at 3V p-p can be detected. Enertec Intrumentation Ltd, Progress House, Albert Road, Aldershot, GU11 1SZ.
WW301

DISPLAYS

Liquid-crystal displays from Sharp with 240 by 64-dot matrixes, orange and green 40-character by 12-line plasma displays from Oki, and colour and monochrome monitors for low and high-resolution applications are stocked by an offspring of the Vako group formed in June called Vako Display Systems Ltd. VDS claim to be one



of the few companies that stock the whole Sharp display range, including a 40-by-two-line character display, and they supply Oki plasma displays for graphics and character applications. They also supply 5½ to 12in monochrome chassis monitors with various phosphors and 12 to 20in colour monitors for either low or high resolution. These products will be shown at the Electronic Displays Exhibition on October 5, 6 and 7 at the Kensington Exhibition Centre. Vako Display Systems Ltd, Pass Street, Werneth, Oldham, Manchester OL9 6HZ.
WW302

STORAGE FOR PETS

Eproms are the basis of Progstor – a unit which turns the Pet into a dedicated microcomputer with a selectable initiate-on-switch-on facility that makes the computer suitable for use by untrained operators. The program for the task concerned is written in Basic or machine-code or both and then, after debugging, is automatically stored in between 2 and 28Kbyte of eprom (2716 or 2732), so mechanically less reliable and physically more vulnerable magnetic-storage media are not required. Progstor, mounted inside the computer, can be set to operate automatically when the computer is switched on, or on receipt of a system command, and is intended for use in hostile environments, by untrained operators and in any application where the same program is used frequently. Of course, it may also be used as an eprom programmer. Microscience, P.O. Box 14, Bramhall, Stockport, Cheshire SK7 2QS.
WW303

VIDEO PRINTER

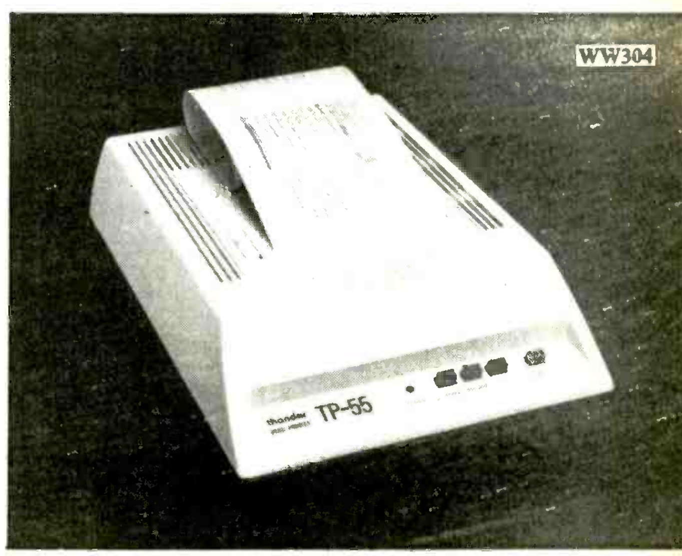
Hard copy can be obtained from any standard composite video signal using an electro-sensitive dot-matrix printer called the TP55 from Thandar Electronics. Both positive and negative prints of information on the screen can be produced, on a 5in-wide paper roll, in 12 seconds for normal resolution, which gives 480 by 350 points, or 24 seconds for high resolution, giving 480 by 640 points. We rang to check whether a decimal point had been left out of the price, stated as £753. There wasn't, but we were told that the actual price is £737. Thandar Electronics Ltd, London Road, St Ives, Huntingdon, Cambs PE17 4HJ.
WW304

64K EPROM

Customers with industrial or commercial applications for a 64K eprom can obtain one free from Rapid Recall. The Intel device concerned is a 2764-4, 450ns eprom which draws 100mA from a 5V supply when enabled or 40mA in standby mode. Other versions, not free, are for ±10% supply-voltage variation tolerance, and with 200, 250 or 300ns access times. Rapid Recall Ltd, Rapid House, Denmark Street, High Wycombe, Bucks.
WW305

HIGH-VOLTAGE, AND 250W POWER MOSFETS

Two high-voltage mos devices, one rated at 350V, the MTM15N35, and the other called MTM15N40 rated at 400V can dissipate 250W according to a recent product announcement by Motorola. Both 15A transistors have a 0.4Ω on resistance and 70A peak drain-current rating. Two high-voltage p-channel mosfets, one with a 50V-higher rating than the other at 500V, are also available from Motorola, Both p-channel devices can carry 2A continuous drain currents or 8A peak. Motorola Ltd, York House, Empire Way, Wembley, Middlesex HA9 OPR.
WW306



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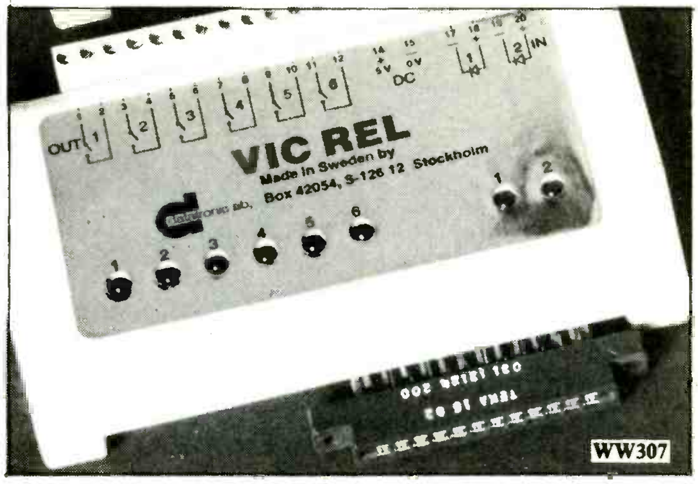
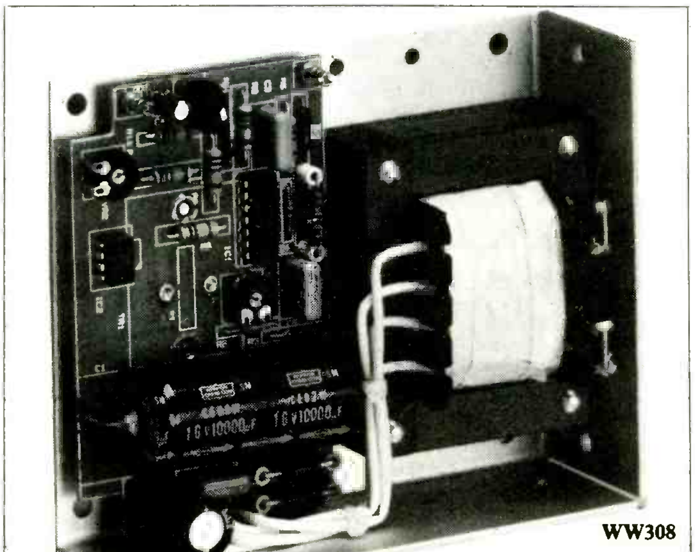
English is not the best language that human beings could use from a technical viewpoint, but what is perhaps more important, most English-speaking people believe that it is. Basic, the microcomputer world's equivalent of English, is contested by Forth, even in the domestic microcomputer world (note the introduction of a popular microcomputer from Jupiter Cantab Ltd with Forth as its basic language). This purportedly more practical language is also one subject of four plug-in cartridges from Adda Computers. All four cartridges, of which VicForth with 3Kbyte of additional memory is one, are designed for the Vic 20 computer. One cartridge of the remaining three has six 24V by 10W relay-switch outputs and two 5-to-12V-'on' d.c. inputs. The remaining two cartridges are statistics-calculation and graph-plotting aids. A forth cartridge costs £38.95 including vat and the other three cartridges cost under £30 including vat. Adda Computers Ltd, Mercury House, Hanger Green, Ealing, London W5 3BA.
WW307



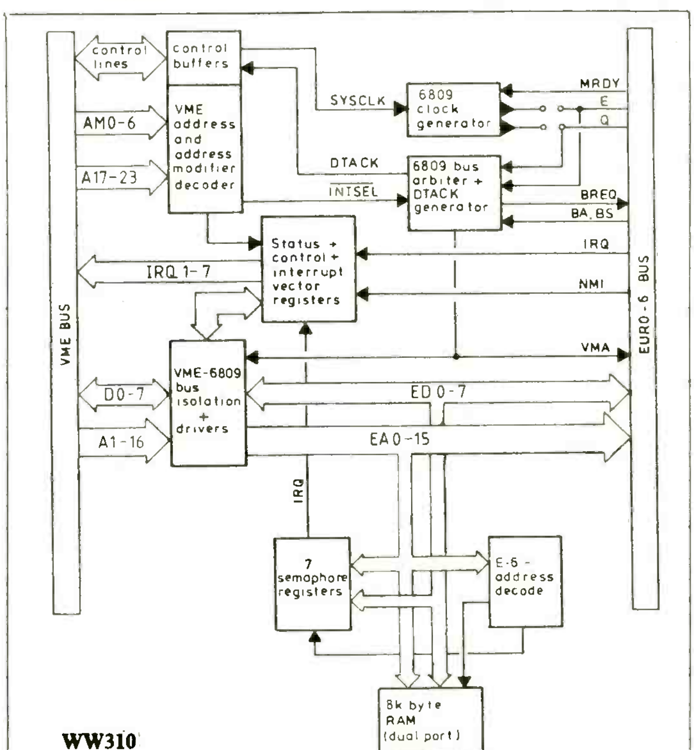
POWER SUPPLIES

Open-frame power supplies providing 5V at 3A and 3.75kV isolation form a new series from ITT Power Components. Efficiency of these units is typically 45% and output ripple 3mV pk-pk. A 10% input-voltage change produces an output change of ±0.05% and transient response is 30µs for a 50% load change. Dimensions of the series 15 power supplies are 125 by 102 by 52mm. STC Ltd, Edinburgh Way, Harlow CM20 2DE.
WW308



1 MEGABYTE FLEXIBLE DISCS

A 5¼in flexible-disc drive similar in appearance and interface requirements to a standard 5¼ in drive but capable of storing one magabyte of data is available from Hi-Tek. 96-track double-sided discs are recorded using the modified frequency-modulation technique through ceramic read/write heads. Up to four CDC 9409T disc drives may be used with one controller. Hard or soft sectored discs may be used, and a write-protect function is incorporated. Hi-Tek Distribution Ltd, Trafalgar Way, Bar Hill, Cambridge CB3 8SQ.
WW309



VME-TO-EURO-6 INTERFACE

Connection between 68000-based circuit boards with VME buses (VME is a bus standard for Eurocard boards based on 16/32-bit microprocessors, agreed by a number of companies including Philips/Signetics, Motorola and Mostek) and boards with a Euro-6 bus for 6800, 6802 and 6809-based systems is possible using Euroka's VMEI interface board. With this board, various Euro-6-bus input/output modules designed for 6800 6802 and 6809 processor systems can be used with 68000 VME boards and, using a secondary processor, software written for the 6809 processor can be implemented on 68000 VME systems. Clock signals can be generated for timing i/o boards in single-processor applications, where the clock from a 6809 secondary processor is not present. Hawke Electronics Ltd, Amotex House, 45 Hanworth Road, Sunbury-on-Thames, Middlesex.
WW310

TURNTABLE KIT

Main elements of this basic turntable kit from Input Design are a synchronous motor, glass platter with felt mat, belt, spindle components, instructions and base-plate drawings, leaving tonearm, plinth, base-plate and cover construction to the customer. The drive motor, claimed to be used in decks costing £350, is manufactured for 110V operation and an inefficient but cheap mains adapting device called a resistor is placed in series with the motor for 240V operation. (Why not have two motors driving together?) The British manufacturers, who also produce another turntable kit and an assembled deck, say they will be pleased to offer any advice, assistance or further information about the product after purchase. Each Home Constructor Turntable kit costs 49.50 including vat (an 'introductory-offer' price of £44 will run until mid-December). Input Designs Ltd, Palace Street, Biggleswade, Bedfordshire SG18 8DP.
WW311

Professional readers are invited to request further details on items featured here by entering the appropriate WW reference number(s) on the mauve reply-paid card.

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923705	TC-22	.4 inch	11.10
923714	TC-24	.5/.6 inch	11.77
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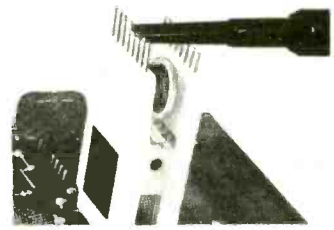

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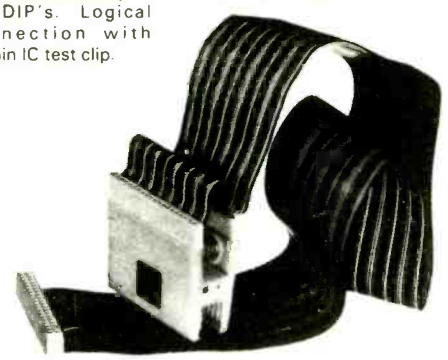

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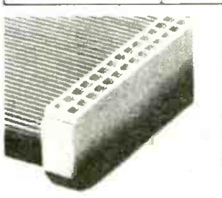
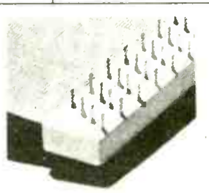
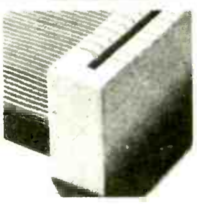
923883-40	LC-403	PCB Connector	35.88
923884-40	LC-404	DIP Plug	32.13







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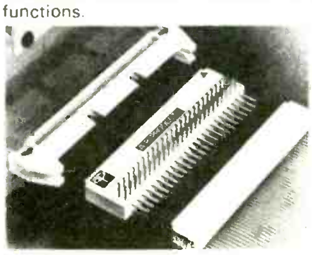

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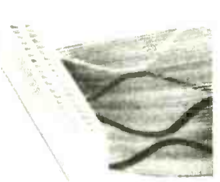

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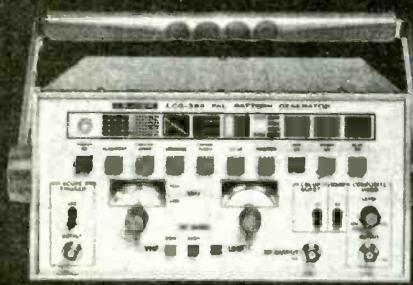

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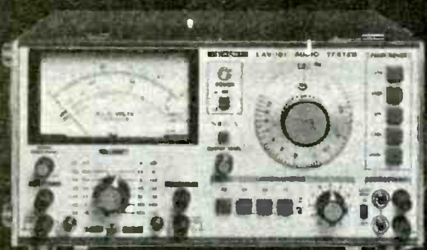

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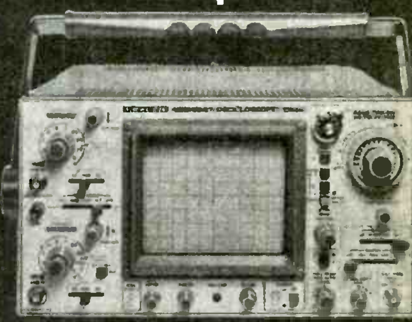

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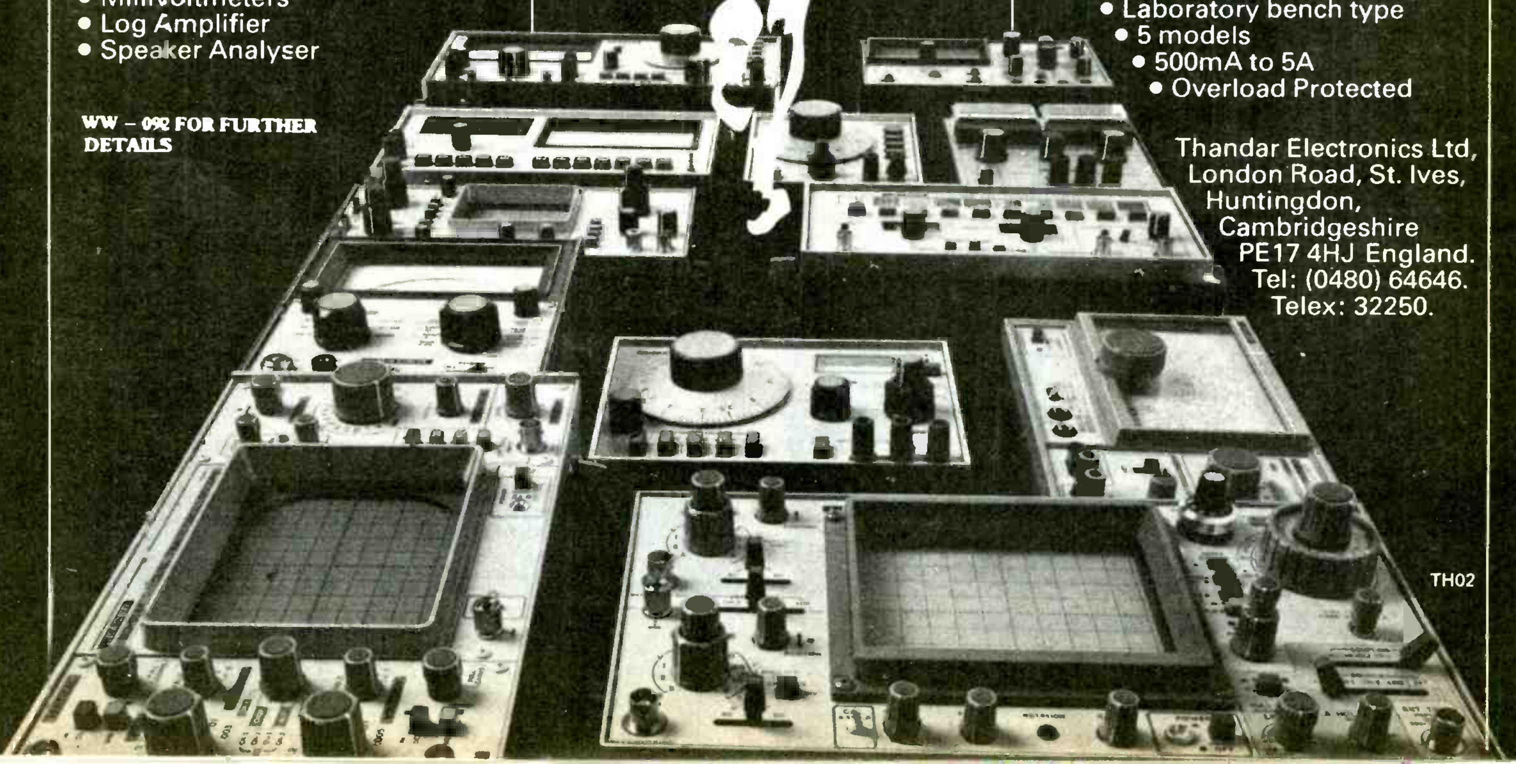

TH02

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[redacted] **HM307.4 £138**
Y: Bandwidth DC-10MHz (-3dB) — Sensitivity 5mV-20V/cm (±5%)
X: Timebase 0.2s-0.5μs/cm (±5%) — Triggering 2Hz-30MHz (3mm) — Built in component tester — Calibrator — Screen 6 x 7 — 2kV.

[redacted] **HM203 £220**
Y: Bandwidth DC-20MHz (-3dB) — Sensitivity 5mV-20V/cm (±3%) — Dual trace
X: Timebase 0.2s-40ns/cm incl.x5 Magn. — Trigger 3Hz-30MHz (4mm) — X-Y operation — Calibrator — Screen 8 x 10cm — 2kV.

[redacted] **HM412 £350**
Bandwidth DC-20MHz (-3dB) Sensitivity 2mV/cm - 20V/cm(±3%) Timebase 40ns/cm Triggering DC - 40MHz (5mm) Algebraic Add., Sweep Delay, x5 Mag., Overscan Ind., Var. Holdoff, Single Sweep.

[redacted] **HM705 £580**
Bandwidth DC-70MHz (-3dB) Sensitivity 2mV/cm -20V/cm(±3%) Timebase 5ns/cm - 2.5s/cm -Triggering DC - 100MHz (5mm), Algebraic Add , Sweep Delay, x10 Mag.| Alt. Trigger, Trig. After Delay, CRT 14kV.

For free data sheets of the full range contact:

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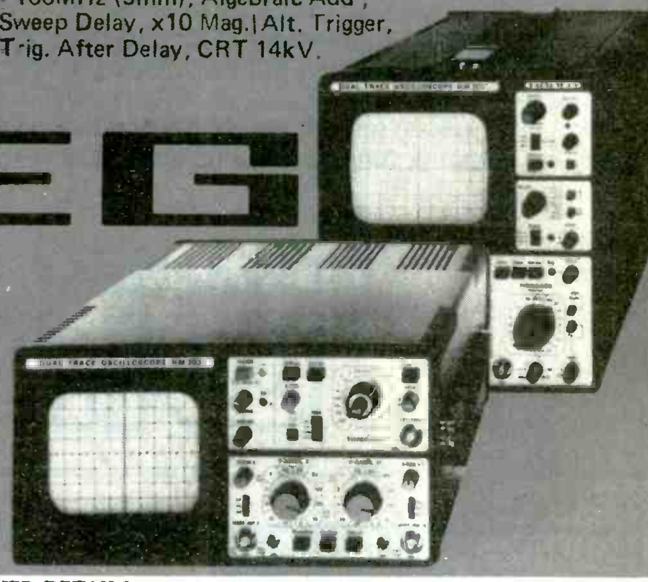

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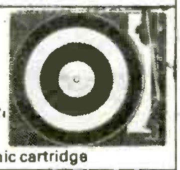
BSR SINGLE PLAYER DECKS



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RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, 2p: 2W **10p.**
HIGH STABILITY. ½w 2% 10 ohms to 1 meg. **10p.** Ditto 5%. Preferred values, 10 ohms to 10 meg. **3p.**
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De luxe pocket size precision moving coil instrument. Impedance + Capacity – 4000 o.p.v. Battery included.
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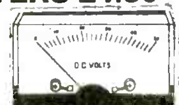

50µa, 100µa, 500µa, 1ma, 5ma, 50ma, 100ma, 500ma, 1 amp, 2 amp, 25 volt, VU Meter.
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Kit of parts to build a 3 channel sound to light unit. 1,000 watts per channel. Suitable for home or disco. Easy to build. Full instructions supplied. **£15** Post 95p
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This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£14**; Stereo, **£20.** Specification 10W per channel; size 9½×3×2in. SAE details. Full instructions supplied. 240V AC mains. Post £1.

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and PC Board. Can be ganged to make multi-way stereo mixers **£2.95** Post 65p

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	Price	Post
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A	£5.00	£2
350-0-350V 250mA, 6.3V 6A CT	£12.00	£2
220V 25ma 6V lamp £2. 220V 45ma 6V 2 Amp	£3.00	£1
250V 60mA, 6V 2A	£3.75	£1
AUTO 115V to 240V 150W £9. 250W £10. 400W £11. 500W	£12.00	£2

GENERAL PURPOSE LOW VOLTAGE

Tapped outputs available

	Price	Post
2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	£8.00	£2
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£8.00	£2
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£10.50	£2
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£12.50	£2
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£16.00	£2

5-8-10-16V. ½ amp.	£2.50	80p	15-0-15V. 2 amps	£3.75	£1
6V. ½ amp.	£2.00	£1	20V 1 amp	£3.00	£1
6-0-6V. 1½ amp.	£3.50	£1	20-0-20V 1 amp	£3.50	£1
9V. 250ma.	£1.50	80p	20-40-60V 1 amp	£4.00	£2
9V. 3 amp	£3.50	£1	25-0-25V 2 amps	£4.50	£1
9-0-9V. 50ma	£1.50	80p	28V 1 amp Twice	£5.00	£2
10-0-10V. 2 amps	£3.00	£1	30V 1½ amp	£3.50	£1
10-30-40V. 2 amps	£3.50	£1	30V 5 amp and 17-0-17 2a	£4.50	£2
12V. 100ma	£1.50	80p			
12V. 750 ma	£2.00	80p	35V 2 amps	£4.00	£1
12V 3 amps	£3.50	£1	TOROIDAL 30-0-30V 4a		
12-0-12V. 2 amps	£3.50	£1	and 20-0 20V ½a	£10.00	£2

CHARGER TRANS	Post	RECTIFIERS	Post
6-12 volt 3a	£4.00+£2	6-12 volt 2a	£1.10+80p
6-12 volt 4a	£6.50+£2	6-12 volt 4a	£2.00+80p

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TEAK VENEERED CABINET
11×8½×7in, 15 watts
50 to 14,000 cps. 4 ohm or 8 ohm

OPUS TWO 15×10½×7¾in 25 watt 2-way system **£39 pair.** Post £3.

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2000mF 6V **25p**; 25V **42p**; 40V **60p**; 1200mF 100V **£1.20.**
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2/500V	45p	8+8/450V	75p	32+32+16/350V	90p
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16/350V	45p	8+16/450V	75p	150+200/275V	70p
32/500V	75p	32+32/350V	50p	220/450V	95p
32/350V	50p	32+32/500V	£1.80	32+32+32/325V	75p
50/450V	95p	50+50/300V	50p	50+50+50/350V	95p

CAPACITORS WIRE END High Voltage
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Size 11×9×⅛in. Operating voltage 240V, 250W approx. Suitable for Heating Pads, Food Warmers, Convector Heaters, Propagation, etc. Must be clamped between two sheets of metal or ceramic, etc.
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MODEL	INCHES	OHMS	WATTS	TYPE	PRICE	POST
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DELUXE MK II	12	8	15	HI-FI	£14	£2
SUPERB	12	8-16	30	HI-FI	£24	£2
AUDITORIUM	12	8-16	45	HI-FI	£22	£2
AUDITORIUM	15	8-16	60	HI-FI	£34	£2
GROUP 45	12	4-8-16	45	PA	£14	£2
GROUP 75	12	4-8-16	75	PA	£18	£2
GROUP 100	12	8-16	100	Guitar	£24	£2
DISCO 100	12	8-16	100	Disco	£24	£2
GROUP 100	15	8-16	100	Guitar	£32	£2
DISCO 100	15	8-16	100	Disco	£32	£2

BAKER 150 WATT MIXER/POWER AMPLIFIER £89 Post £2

For Discotheque, Vocal, Public Address. Three speaker outlets for 4, 8 or 16 ohms. Four high gain inputs, 20 mv, 50K ohm. Individual volume controls "Four channel" mixing. 150 watts 8 ohms R.M.S. Music Power. Slave output 500 M.V. 25K.ohm. Response 25 Hz – 20kHz ± 3dB. Integral Hi-Fi preamp separate Bass & Treble. Size – 16"×8"×5½". Wt – 14lb: Master volume control. British made. 12 months' guarantee. 240v A.C. mains or 120V to order. All transistor and solid state.
MONO SLAVE VERSION £75. 100 Volt Line Model £104.
New Stereo Slave Model 150 + 150 watt £125. Post £4.
BAKER'S NEW PA150 MICROPHONE PA AMPLIFIER £129. PP £3.
4 channel 8 inputs, dual impedance, 50K-600 ohm 4 channel mixing, volume, treble, bass. Presence controls, Master volume control, echo/send/return socket. Slave input/output sockets.

BAKER £69 Post £2 50 WATT AMPLIFIER

Ideal for PA systems, Discos and Groups. Two inputs, Mixer, Volume, Controls, Master Bass, Treble Gain.

RCS offers MOBILE PA AMPLIFIERS. Outputs 4-8-16 ohms
20-watt RMS 12v DC, AC 240v, 3 inputs. 50K **£46** PP £2.
40-watt RMS 12v DC, AC 240v, 4 inputs. 50K **£75** PP £2
Mic 1; Mic 2; Phono; aux. outputs 4 or 8 or 16 and 100v line
60-watt RMS, Mobile 24 volt DC & 240-volt AC mains. inputs **50K.** 3 mics + 1 music. Outputs 4-8-16 ohm + 100 volts line **£95** PP £2

Battery only Portable PA Amplifier 10w max. Includes mike and speaker, OK for meetings, crowd control, stalls, fetes, traders, parties, etc. Batteries included (6 of U2) **£27.50** post £1.50.

R.C.S. 100 ROBUST VALVE AMPLIFIER

4 Channel mixing. Master treble, bass and volume controls. 5 Speaker outlets, suits 4, 8, 16 ohm. Black cabinet. **£125.** Carr. & ins. £15.

FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

MAKE	MODEL	SIZE	WATTS	OHMS	PRICE	POST
SEAS	TWEETER	4in	50	8	£9.50	£1
GOODMANS	TWEETER	3½in	25	8	£4	£1
AUDAX	TWEETER	4in	30	8	£6.50	£1
SEAS	MID-RANGE	4in	50	8	£7.50	£1
SEAS	MID-RANGE	5in	80	8	£12	£1
SEAS	MID-RANGE	4½in	100	8	£12.50	£1
GOODMANS	HIFAX	7½×4¼	100	4/8/16	£22	£2
GOODMANS	WOOFER	8in	25	4/8	£6.50	£1
GOODMANS	HB	8in	60	8	£12.50	£1
RIGONDA	GENERAL	10in	15	8	£5	£2
SEAS	WOOFER	10in	50	8	£16	£2
GOODMANS	HPG	12in	120	8/15	£29.50	£2
GOODMANS	GR12	12in	90	8/15	£27.50	£2
GOODMANS	HPD	12in	120	8/15	£29.50	£2

SPEAKER COVERING MATERIALS. Samples Large S.A.E.
B.A.F. LOUDSPEAKER CABINET WADDING 18in wide **35p** ft.

MOTOROLA PIEZO ELECTRIC HORN TWEETER, 3¾in. square **£5**
100 watts. No crossover required. 4-8-16 ohm, 7¾x3¼in. **£10**

CROSSOVERS. TWO-WAY 3000 c/s 30 watt 8 or 15 ohm **£3.**
3-way 950 cps/3000 cps. 40 watt rating. **£4.** 3 way 60 watt **£6.**
LOUDSPEAKER BARGAINS
3 ohm. 5in, 7×4in, **£2.50**; 6½in, 8×5in, **£3**; 8in, **£3.50.** 10in, **£5.**
8 ohm, 2½in, 3in, **£2**; 5×3in, 7×4in, 5in, **£2.50**; 6½in, 8×5in, **£3**; 8in, **£4.50**; 10in, **£5**; 12in, **£6.**
15 ohm, 3½in, 5×3in, 6×4in, **£2.50.**
25 ohm, 3in, **£2**; 5×3in, 7×4in, **£2.50.** **120 ohm,** 3¼in dia. **£1.**
CASSETTE MONO REPLAY. Complete working **£12.50**
CAR CASSETTE MECHANISM. 12V Stereo Head **£5**

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS **£3.95.** Post 65p
All parts and instructions with Zener diode printed circuit, mains transformer 240V a.c. Output 6 or 7½ or 9 or 12V d.c. up to 100mA or less. Please state voltage required.

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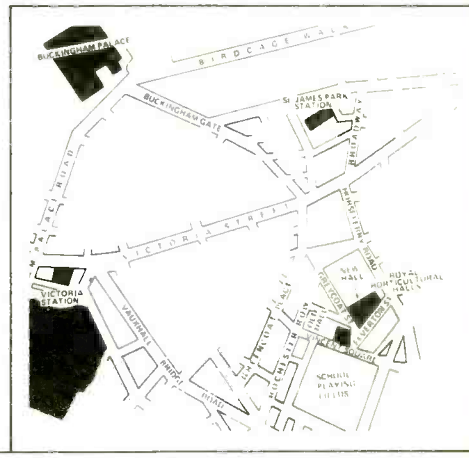

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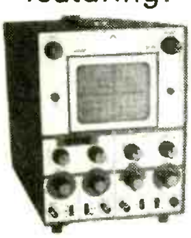

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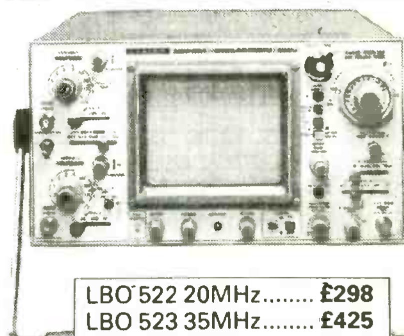

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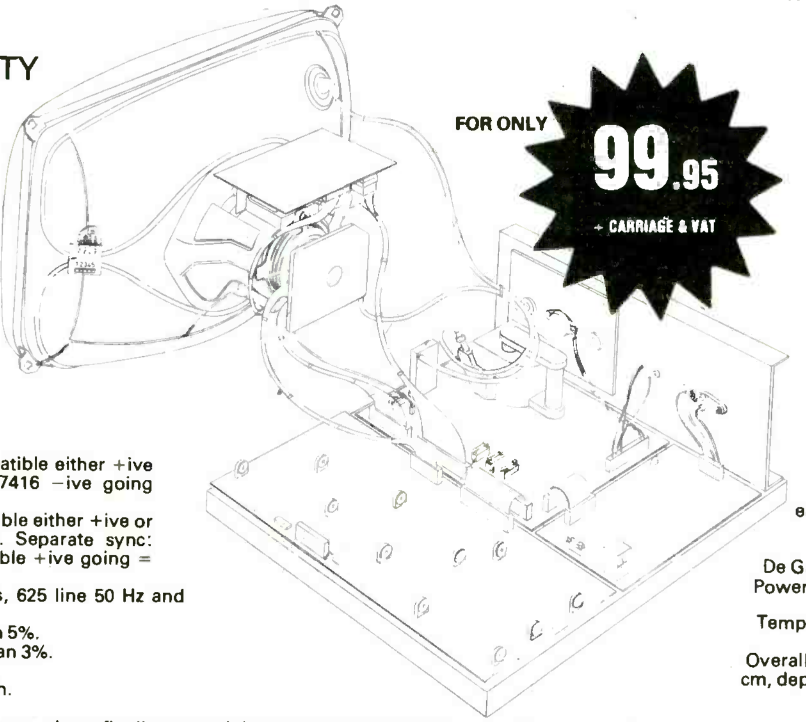

FOR ONLY **99.95** + CARRIAGE & VAT

FREE

ISOLATING TRANSFORMER ON FIRST 100 ORDERS

Specification: The VMC 22 Colour Monitor is designed to meet the high reliability and performance standards associated with the games, data and computer colour graphics industries.
Input levels: Video-TTL compatible either +ive or −ive going for RGB (IC37416 −ive going 7417 +ive going).
Composite Sync: TTL compatible either +ive or −ive going set by PCB link. Separate sync: (Frame and line) TTL compatible +ive going = video response 10 MHz.
Deflection: Scanning systems, 625 line 50 Hz and 525 line 60 Hz.
Scan linearity: Errors less than 5%.
Scan geometry: Errors less than 3%.
High voltage: 25KV.
X radiation: Less than 0.5MR/h.

A fabulous 22 inch colour monitor. Featuring: Mullard 22 inch 110° C.C.R.T.
Controls: Brightness, RGB video amp bias, height, width, vertical hold, horizontal hold, linearity, east-west correction, phase, focus, H.T. adjust, beam cut-off switch, convergence controls.
De Gaussing: Automatic on switch on.
Power requirements: 155 VAC, 44-60Hz 120VA (isolated suplly).
Temperature: Storage −10°C to +70°C. Operating 0°C to 50°C.
Overall sizes: Height 40.3 cm, width 51.0 cm, depth 39.5 cm (inc. tube neck P.C.B.). Weight 19 kgms.

After months of negotiation we have finally secured the computer user's dream. We have bought the complete manufacturer's production of these superb British made R.G.B. Colour Monitors and can offer them to you at this unrepeatable price. This offer, available to readers of "Wireless World" also includes a ***FREE*** isolating transformer. So with a little of your time and our buying power – you can save pounds. For shipping purposes the C.R.T. and scan coil assembly are separate from the chassis. The lugs of the C.R.T. allow it to be mounted in a standard 22" colour TV cabinet or a unit of your own design. The unit is assembled by plugging the wires from the chassis to the tube, soldering the input connector, power connector and isolating transformer. The monitor has been fully tested and adjusted prior to packing thus simplifying assembly. A comprehensive instruction sheet will be supplied with each unit.

OPUS A computer supplies company have established an enviable reputation for reliable service and value for money – so pick up your telephone and discuss your supplies requirement with us.

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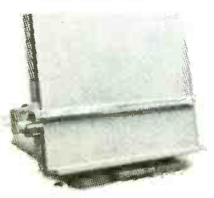

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2114-300ns	.85	.80	.75
2114-450ns	.80	.75	.70
2114-L-200ns	.95	.87	.83
4516-100ns			
BBC RAM	3.10	2.95	2.80
4164-200ns	4.80	4.60	4.20
6116-150ns	4.20	3.95	3.50
2716-5v-450ns	2.40	2.15	2.00
2716 Triple Rail	6.00	–	–
2732-450ns	3.95	3.75	3.25
2532-450ns	3.95	3.75	3.25
8080A	1.90	1.70	–
8212	1.40	1.30	–

25-WAY D SOLDER CONNECTORS

25P	£1.30 each
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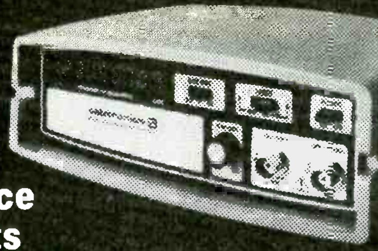

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FREQ. CONVERTERS I/P 240v AC O/P 115v 400c/s 100 Va 1 phase sine wave, all solid state, low dist o/p, new, unused, **£115.** INSULATION TEST SETS, 240v I/P provides 3 O/Ps of 15/20/25kv, uses contact breaker (Vibrator) from 12v DC with test leads in fitted wood case, size 14 × 8 × 9in., thought to have been used for testing Ignition Harnesses, **£27.** BENCH P.U. Solartron, 200/250v I/P O/P var. from 0 to 40v DC in 100 Mill/V steps current var from 0 to 5 amps, will operate in constant voltage or current mode, O/P volts, set by dig swt, current by swt and pot, % load meter tested with book, **£75.** A.M. MOD UNIT, Marconi TF1102, will mod Sine, Sq, Pulse or Video on to un mod RF, req ext mod signals, for 240v with book, **£25.** BENCH P.U. Army 240v I/P provides 2 low HT and 2 low LT O/P all DC and Var, fitted 4x meters, volts and Ma on all circs, intended to power Army radios normally using dry batteries, two-part unit, **£28.** PYE PF.1 UHF FM Pocket phone Rxs nom 450Mc/s req 9v batt. with circ, **£9.50.** AUDIO TEST SET CT373 240v I/P AF osc 17c/s to 170Kc in 4 ranges, VTVM 30 Mill/V to 100v FSD, Dist meas set 20c to 20Kc in case, size 14 × 17 × 21 in new cond. with book and leads, **£115.** VIDEO RECORDERS, Philips type N1500, no cassettes, **£75.** Also Philips LDL.1000 reel-to-reel with 3 tapes, ½in., both with circ., **£75.** SPEAKER UNITS, ex-A/C, cabin spk., size 17 × 3½ × 2½in., fitted 4x 3 ohm, 3 × 3in. spks., black, crackle case, **£6.50.** Also small amp that fits into spk. case, need pre-amp, **£3.50.** HANDSETS, lightweight, with M.C. mike, 50 ohm, ext. cord and press to talk swt., **£4.50.** ROTARY CONVERTERS, 24v DC I/P O/P 230v AC 140-watt sine wave, in case, **£45,** or Rot Conv, only s/h, tested, **£27.** H.F. Trans Amp, part of STR.18 Equip, 2/18 Mc/s, 100-watt O/P req. ext. power and RF drive, 2x 4 × 150 in P.A. with circ., etc., **£37** (new cond.) or **£27** (S/H), other units available. Q BAND TEST EQUIP., RF sources and N.G. available inc. w.g. swts, etc. RADIOSONDE UNITS, old British Mk. II, new cond. with chart, **£7.50;** also new type M.60, **£12.50.** POWER UNIT, 240v I/P O/P nom 28v DC at 15 amps load range for reg. O/P, 5 to 15 amps, made by Plessey for testing A/C RT sets, tested, **£38.** AUTO TRANS 200/250 to nom 115v at 560 watts, fully enclosed, size 6½ × 4 × 3½, new cond., **£14.50.** ARMY-TYPE HEADSETS WITH THROAT MIKES, new cond. with control box, **£7.50.** BLOWER UNITS, single-ended, 240v, outlet size 2½ × 3½in., very powerful, new condition, **£13.50.** OSC AMP UNITS, 240v I/P, comprises amp 150 watt and var. freq. Osc 30c to 30Kc; the amp can be connected for various O/Ps down to 16.7 ohm, fitted O/P voltmeter, can be used as normal amp or can be used with Osc to provide var. freq. AC O/P in table case valve unit, **£115.**

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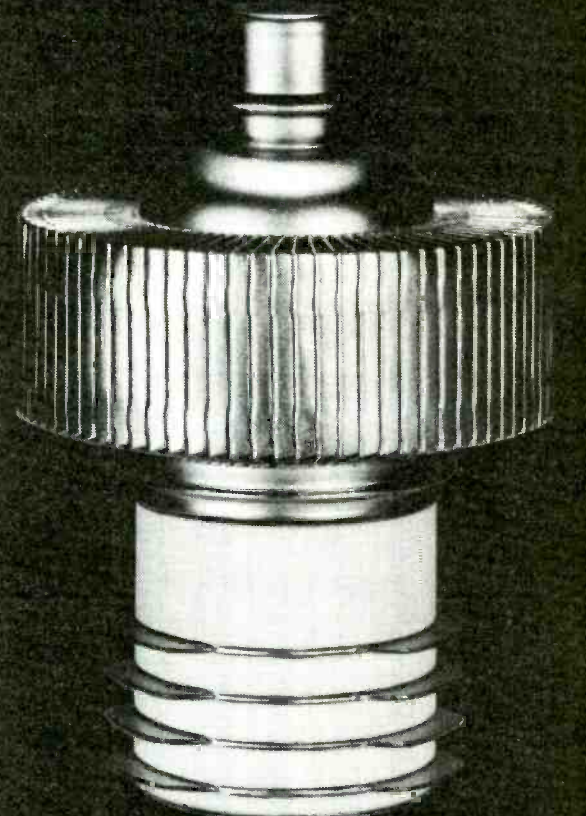
TO YOU IT'S JUST A POWER VALVE



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AAY32	0.48
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AAZ15	0.17
AAZ17	0.17
AC107	0.63
AC125	0.29
AC126	0.29
AC127	0.29
AC128	0.35
AC141	0.32
AC141K	0.40
AC142	0.32
AC142K	0.40
AC176	0.35
AC187	0.32
AC188	0.32
ACY17	1.50
ACY18	1.32
ACY19	1.27
ACY20	1.27
ACY21	1.32
ACY39	2.88
AD149	0.86
AD161	0.40
AD162	0.40
AF106	0.40
AF114	0.86
AF115	0.86
AF116	0.86
AF117	0.86
AF139	0.38
AF186	1.15
AF239	0.45
AFZ11	4.60
AFZ12	4.60
ASY26	1.61
ASY27	1.04

ASZ15	1.38
ASZ16	1.27
ASZ17	1.15
ASZ20	2.64
ASZ21	2.88
AU113	2.88
AUY10	3.45
AU110	2.88
BA145	0.15
BA148	0.17
BA154	0.12
BA155	0.13
BA156	0.12
BAW62	0.06
BAX13	0.07
BAX16	0.07
BC107	0.18
BC108	0.18
BC109	0.18
BC113	0.17
BC114	0.17
BC115	0.21
BC116	0.22
BC117	0.26
BC118	0.21
BC125	0.21
BC126	0.21
BC135	0.17
BC136	0.22
BC137	0.22
BC147	0.14
BC148	0.14
BC149	0.15
BC157	0.15
BC158	0.15
BC159	0.15
BC167	0.13
BC170	0.13
BC171	0.12

BC172	0.13
BC173	0.13
BC177	0.32
BC178	0.16
BC179	0.32
BC182	0.13
BC183	0.13
BC184	0.13
BC212	0.13
BC213	0.13
BC214	0.13
BC237	0.13
BC238	0.13
BC301	0.38
BC303	0.39
BC307	0.13
BC308	0.13
BC327	0.14
BC328	0.14
BC337	0.14
BC338	0.14
BCY30	1.44
BCY31	1.73
BCY32	1.73
BCY33	1.27
BCY34	1.15
BCY39	3.91
BCY40	3.22
BCY42	0.35
BCY43	0.35
BCY58	0.22
BCY70	0.20
BCY71	0.21
BCY72	0.20
BCZ11	2.01
BD115	0.48
BD121	1.96
BD123	3.22
BD124	2.30

BD131	0.51
BD132	0.55
BD135	0.46
BD136	0.46
BD137	0.46
BD138	0.55
BD139	0.55
BD140	0.58
BD144	2.30
BD181	1.38
BD182	1.36
BD237	0.62
BD238	0.62
BDX10	1.05
BDX32	2.30
BDY20	1.73
BDY60	3.16
BF115	0.40
BF152	0.18
BF153	0.18
BF154	0.20
BF159	0.20
BF160	0.20
BF167	0.28
BF173	0.35
BF177	0.40
BF178	0.40
BF179	0.40
BF180	0.32
BF181	0.32
BF182	0.35
BF183	0.32
BF184	0.32
BF185	0.35
BF194	0.16
BF195	0.14
BF196	0.15
BF197	0.16
BF200	0.46
BF224	0.29
BF244	0.32

BF257	0.31
BF258	0.31
BF259	0.32
BF336	0.39
BF337	0.38
BF338	0.41
BFS21	4.60
BFS28	2.58
BFS61	0.23
BFS98	0.23
BFW10	1.12
BFW11	1.10
BFX84	0.35
BFX85	0.35
BFX87	0.35
BFX88	0.35
BFY50	0.29
BFY51	0.29
BFY52	0.29
BFY64	0.35
BFY90	1.09
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BSX20	0.31
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CRS1/40	0.69
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GM0378A	2.02
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MJE340	0.69
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MPF102	0.40
MPF103	0.40
MPF104	0.40
MPF105	0.40
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NE555	0.52
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NKT404	2.53
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OA7	0.69
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OA47	0.14
OA70	0.29
OA79	0.14
OA81	0.20
OA85	0.20
OA90	0.09
OA91	0.09
OA95	0.09
OA200	0.17
OA202	0.17
OA211	1.73
OAZ200	1.73
OAZ201	1.73
OAZ206	1.73

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OC16	2.88
OC20	2.88
OC22	2.88
OC23	4.60
OC24	3.45
OC25	1.15
OC26	1.73
OC28	2.30
OC29	2.30
OC35	1.73
OC36	1.73
OC41	1.04
OC42	1.04
OC43	1.73
OC44	0.98
OC45	0.75
OC71	0.63
OC72	1.15
OC73	1.15
OC74	0.81
OC75	0.75
OC76	1.15
OC77	1.15
OC81	0.75
OC81Z	1.38
OC82	1.04
OC83	0.92
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OC122	3.16
OC123	2.30
OC139	3.45
OC140	4.60
OC141	4.93
OC170	1.44
OC171	1.44
OC200	1.73
OC201	2.88
OC202	3.16
OC203	3.45
OC204	3.45

OC205	3.16
OC206	3.16
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T1L209	0.18
T1P29A	0.49
T1P30A	0.52
T1P31A	0.38
T1P32A	0.41
T1P33A	0.62
T1P34A	0.77
T1P41A	0.51
T1P42A	0.48
T1P2955	0.81
T1P3055	0.64
T1S43	0.49
ZS140	0.29
ZS170	0.24
ZS178	0.62
ZS271	0.26
ZS278	0.65
ZTX107	0.14
ZTX108	0.14
ZTX109	0.14
ZTX300	0.15
ZTX301	0.16
ZTX302	0.21
ZTX303	0.21
ZTX304	0.23
ZTX311	0.15
ZTX314	0.29
ZTX500	0.16
ZTX501	0.16
ZTX502	0.21
ZTX503	0.22

ZTX504	0.24
ZTX531	0.28
ZTX550	0.29
1N914	0.06
1N916	0.10
1N4001	0.07
1N4002	0.07
1N4003	0.07
1N4004	0.08
1N4005	0.10
1N4006	0.13
1N4007	0.14
1N4009	0.08
1N4148	0.05
1N5400	0.15
1N5401	0.15
1S44	0.05
1S920	0.09
1S921	0.10
2G301	1.15
2G302	1.15
2G306	1.15
2N404	1.50
2N696	0.37
2N697	0.37
2N698	0.37
2N705	1.44
2N706	0.29
2N708	0.29
2N930	0.29
2N1131	0.35
2N1132	0.35
2N1302	1.38
2N1303	0.92
2N1304	1.38
2N1305	1.15
2N1306	1.73
2N1307	1.27
2N1308	2.01
2N1309	1.38
2N1613	0.37

2N1671	5.75
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2N2148	4.31
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2N2219	0.37
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2N2221	0.23
2N2222	0.23
2N2223	4.89
2N2368	0.29
2N2369A	0.29
2N2484	0.29
2N2646	0.58
2N2904	0.37
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2N2926	0.17
2N3053	0.30
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2N3055	0.75
2N3440	0.81
2N3441	0.98
2N3442	1.44
2N3614	2.53
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2N3709	0.13
2N3710	0.12
2N3711	0.12
2N3771	1.61
2N3772	1.84
2N3773	2.07

2N3819	0.35
2N3820	0.45
2N3823	0.69
2N3866	1.15
2N3904	0.20
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2N4058	0.23
2N4059	0.23
2N4060	0.18
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2N4124	0.18
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2N4286	0.17
2N4288	0.21
2N4289	0.21
2N5457	0.37
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2N5459	0.37
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2S103	1.73
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2S303	4.03
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A2087	13.58
A2134	20.13
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A2426	17.63
A2521	24.38
A2900	14.43
A3343	51.75
AZ31	1.26
AZ41	1.26
BK448	110.27
BK484	149.09
BS90	52.27
BS810	86.25
BT5	58.13
BT17	106.89
BT19	36.17
BT29	327.69
BT69	333.50
BT75	102.46
BT95	127.02
CBL31	2.30
CL33	2.30
CY31	1.15
C1K	21.30
C3A	11.50
C3JA	23.23
DA41	28.75
DA42	21.51
DA100	97.93
DAF91	0.46
DAF96	1.15
DET22	32.78
DET24	52.90
DF91	0.46
DF96	1.15
DK91	1.21
DK92	1.44
DK96	1.26
DL92	1.26
DL94	1.38
DL96	1.26
DLS10	9.48
DLS15	12.37
DLS16	12.37
DLS19	12.37
DM70	1.44
DM71	1.44
DM160	3.96
DY87	0.74
DY802	0.96
E55L	25.17
E80CC	11.27
E80CF	12.96
E80F	14.19
E80L	13.98
E81CC	6.62
E81L	14.06
E82CC	7.03
E83CC	7.16
E86C	13.23
E88C	7.12
E88CC	3.86
E90CC	9.94
E90F	11.39
E91H	5.34
E92CC	9.40
E99F	10.16

E130L	19.39
E180CC	11.39
E180F	7.83
E182CC	13.80
E186F	12.58
E188CC	9.40
E280F	25.88
E283CC	9.02
E288CC	18.54
EA52	28.18
EA76	2.30
EABC80	1.38
EAC91	0.92
EAF42	1.44
EAF801	2.02
EB41	2.30
EB91	1.01
EBC33	2.02
EBC41	1.44
EBC81	1.26
EBC90	0.97
EBF80	0.58
EBF83	1.44
EBF89	0.97
EBL31	5.75
EC90	1.28
EC91	9.33
EC92	1.44
EC157	349.26
ECC33	4.02
ECC35	4.02
ECC40	2.30
ECC81	1.01
ECC82	0.82
ECC83	1.01
ECC84	1.36
ECC85	1.38
ECC86	2.30
ECC88	2.07
ECC89	1.88
ECC91	10.27
ECC189	1.90
ECC807	2.02
ECC808	2.59
ECF80	1.24
ECF82	1.38
ECF86	1.73
ECH35	2.30
ECH42	1.32
ECH81	1.38
ECH83	1.44
ECH84	1.47
ECL80	1.15
ECL81	1.73
ECL82	1.15
ECL83	1.73
ECL84	1.61
ECL85	1.28
ECL86	1.38
EF37A	4.02
EF39	3.16
EF40	3.45
EF41	2.30
EF42	2.30
EF50	1.73
EF54	5.75
EF55	2.88
EF80	0.92
EF83	4.03
EF85	0.92

EF86	1.74
EF89	1.84
EF91	2.07
EF92	6.68
EF93	1.15
EF94	1.24
EF95	6.27
EF98	1.44
EF183	0.92
EF184	0.96
EF804S	12.65
EF805S	12.65
EH90	1.61
EK90	1.24
EL32	1.73
EL33	4.02
EL34TH	2.53
EL34MUI	3.16
EL36	1.84
EL41	1.44
EL42	2.02
EL81	4.03
EL83	4.03
EL84	1.15
EL86	2.88
EL90	1.10
EL91	8.21
EL95	1.51
EL156	27.60
EL360	9.77
EL500/504	2.16
EL509	3.63
EL821	11.96
EL822	12.55
EM34	5.75
EM80	1.26
EM81	1.15
EM84	1.73
EM85	1.44
EM87	1.73
EN32	13.66
EN91	2.94
EN92	5.23
EY51	2.02
EY81	1.89
EY83	2.02
EY84	10.57
EY86	0.96
EY88	2.02
EY500A	2.23
EY802	94
EZ35	97
EZ40	1.44
EZ41	1.44
EZ80	0.96
EZ81	0.96
EZ90	1.38
FW4-500	2.88
FW4-800	2.88
G1.371K	41.40
G551K	12.65
G180.2M	18.42
G240.2D	12.85
G400.1K	19.28
GN4	8.62
GN4A	8.62
GS16	10.35
GT1C	14.38
GU50	14.31
GU51	13.62

GXU1	16.10
GXU2	28.43
GXU3	30.49
GXU4	32.77
GXU50	17.25
GY501	3.16
GZ32	1.44
GZ33	4.60
GZ34	2.88
GZ37	4.60
KT61	4.02
KT66	11.50
KT88	13.80
KTW61	2.02
KTW62	2.02
KTW63	2.02
M8079	12.29
M8080	9.49
M8081	11.30
M8082	9.87
M8083	8.54
M8091	11.99
M8096	4.31
M8097	4.09
M8098	5.50
M8099	5.98
M8100	9.49
M8136	9.98
M8137	9.73
M8140	5.17
M8141	5.52
M8142	7.77
M8144	4.31
M8149	5.86
M8161	9.11
M8162	10.36
M8163	5.17
M8190	5.29
M8195	4.25
M8196	7.47
M8204	6.57
M8212	12.47
M8223	3.80
M8224	4.66
M8225	2.99
M8248	13.32
MU14	1.73
MX119	58.65
MX123	67.85
MX145	62.10
MX151	17.25
MX152	143.75
MX161	166.75
MX163	23.11
MX164	27.95
MX166	161.00
MX168	48.30
N78	20.13
OA2	2.30
OA3	5.69
OA4	4.02
OB2	1.44
OB3	2.20
OC2	3.04
OC3	2.20
OD3	2.20
OZ4	1.84
PC86	1.61
PC88	1.61
PC95	1.49

PC97	1.38
PC900	1.38
PCC84	1.15
PCC85	1.38
PCC88	1.38
PCC89	1.56
PCC189	1.61
PCC805	1.51
PCC806	2.17
PCE82	2.37
PCF80	1.15
PCF82	1.15
PCF86	1.84
PCF87	1.84
PCF200	3.74
PCF201	2.45
PCF801	1.84
PCF802	2.19
PCF805	1.84
PCF806	1.84
PCF808	1.84
PCL82	1.15
PCL83	2.30
PCL84	1.15
PCL85	1.24
PCL86	1.24
PCL805/85	1.24
PD500	4.14
PE06-40N	31.40
PFL200	2.07
PL36	1.38
PL81	1.38
PL81A	1.38
PL83	2.55
PL84	1.24
PL504/5	1.61
PL508	2.07
PL509	5.75
PL519	5.75
PL801	1.27
PL802	3.40
PY33	1.27
PY81	0.97
PY82	0.92
PY83	0.81
PY88	1.01
PY500A	2.07
PY800	0.97
PY801	0.97
QQV02-6	16.17
QQV03-20A	20.13
QQV06-40A	47.15
QQV07-50	60.66
QQZ03-20A	59.80
QQZ06-40A	63.37
QU37	14.38
QV03-12	5.62
QV04-7	2.88
QV08-100	137.08
QY3-65	57.06
QY3-125	62.40
QY4-250	77.05
QY4-400	80.44
QY5-500	168.83

QY5-3000A	356.66
QZ06-20	34.16
R10	5.75
R17	1.89
R18	4.89
R19	1.38
R20	1.66
RG3-250	35.77
RG3-250A	37.49
RG3-1250	63.94
RG4-1250	43.13
RG4-3000	90.36
RR3-250	53.54
RR3-1250	94.83
S11E12	55.20
S130	3.45
S130P	4.03
STV280-40	11.50
STV280-80	24.15
SU41	2.88
SU42	10.35
TD03-10	32.78
TD03-10E	32.78
TD03-29F	33.93
TT15	34.50
TT21	16.98
TT22	16.98
TT100	59.51
TY2-125	69.01
TW4-400	74.07
TY4-500	105.97
TY5-500	187.45
TY6-800	193.20
TY6-5000A	356.50
TY6-5000B	264.50
TY6-5000W	316.25
TY7-6000A	368.80
TY7-6000W	322.00
TZ40	28.75
U18-20	2.88
U19	15.81
U25	1.33
U26	1.66
U37	10.35
UABC80	1.44
UAF42	1.44
UB41	1.44
UBC41	1.73
UBF89	1.38
UCC84	1.26
UCC85	1.38
UCF80	1.32
UCH42	1.38
UCH81	2.67
UCL82	1.20
UCL83	1.66
UF41	1.15
UF42	1.44
UF80	1.66
UF85	1.66
UF89	1.66
UL41	2.88

UL84	1.38
UM80	1.15
UY41	1.44
UY85	1.20
VLS631	15.24
XG1-2500	58.02
XG2-6400	113.50
XG5-500	28.23
XG2-6400	155.42
XR1-1600A	58.88
XR1-3200	87.15
XR1-3200A	93.15
XR1-6400	108.30
XR1-6400A	164.23
YD1120	264.50
YD1240	366.62
Z759	19.32
ZM1000	6.03
ZM1001	6.19
ZM1020	10.83
ZM1021	10.17
ZM1022	10.60
ZM1023	8.81
ZM1040	22.26
ZM1041	19.16
ZM1042	20.44
ZM1051	100.05
1B3GT	2.58
1B24	11.50
1B35A	28.75
1B63	57.50
1R5	1.21
1S5	0.46
1T4	0.46
2AS15	11.50
2C39A	21.85
2C43	20.70
2D21	2.94
2E26	17.86
2J42	109.25
2J55	239.97
2J70A	442.75
2J70B	418.34
2K25	40.25
3-400Z	57.50
3-500Z	63.25
3A5	2.70
3B24	9.20
3B28	16.50
3B29	11.50
3B240M	17.25
3B241M	17.25
3C23	26.83
3C45	28.18
3CX100A5	40.25
3E29	29.67
3S4	1.26
3V4	1.38
465A	29.15
4-125A	41.99
4-250A	41.99
4-400A	52.05

4B32	29.16
4C35	74.75
4CX250B	51.75
4CX350A	80.50
4X150A	24.41
4X150D	28.75
5B254M	23.12
5B255M	23.12
5C22	74.75
5J180E	1380.00
5R4GY	4.03
5U4G	1.75
5U4GB	2.90
5V4G	1.75
5Y3GT	0.98
5Z3	1.73
5Z4G	1.75
5Z4GT	1.75
6-30L2	1.79
6AB4	1.44
6AB7	1.73
6AC7	1.61
6AF4A	1.84
6AG7	2.30
6AH6	5.52
6AK5	4.15
6AK6	2.81
6AL5	1.01
6AM4	2.65
6AM5	8.21
6AM6	2.07
6AN5	4.45
6AN8A	3.97
6AQ5	1.10
6AS6	5.73
6AS7G	9.49
6AT6	0.98
6AU5GT	4.97
6AU6	1.24
6AV5GA	4.52
6AV6	0.98
6AX5GT	3.57
6B7	1.73
6B8	2.02
6BA6	1.15
6BA7	5.89
6BA8A	4.31
6BC4	4.27
6BE6	1.24
6BH6	1.75
6BJ6	1.24
6BK4	4.84
6BL6	97.75
6BL7GT	4.44
6BM6	97.75
6BN6	1.89
6BQ7A	4.28
6BR7	4.60
6BR8	2.02
6BS7	4.60
6BW6	4.60
6BW7	1.75
6BX7GT	5.70
6BZ6	2.73
6C4	1.01
CB6A	2.86
6CD6GA	5.83
6CG7	2.62
6CH6	11.96
6CL6	4.12

6CW4	8.83
6D2	1.01
6DK6	3.00
6DQ6B	4.69
6EA8	3.38
6EB8	2.44
6EW6	1.73
6F6	2.02
6F23	1.84
6F28	1.33
6F33	34.50
6H1	14.38
6H2N	1.21
6H3N	1.21
6H6	1.73
6J4	6.10
6J6	6.21
6J7	2.88
6K4N	1.44
6K6GT	1.50
6K7	1.73
6K8	2.02
6KD6	7.31
6L6G	2.88
6L6GA	1.73
6L6GT	2.24
6L6GC	2.88
6L7	2.30
6N2P	1.21
6N3P	1.21
6N7	1.73
6P25	4.14
6Q7	2.53
6R7	2.07
6SA7	1.67
6SC7	1.73
6SF7	1.84
6SH7	1.73
6SJ7	1.84
6SK7	1.50
6SK7GT	3.08
6SN7GT	1.84
6SQ7	1.50
6SR7	1.73
6SS7	2.07
6U5G	2.30
6U8	0.92
6U8A	3.38
6V6GT	1.84
6X4	1.38
6X5GT	0.97
7B7	1.96
7C5	3.40
7C6	2.60
7H7	2.30
7R7	1.73
7S7	2.59
7Y4	1.84
7Z4	2.13
11E3	60.82
12AT6	1.38
12AT7	1.01
12AU6	2.97
12AU7	0.83
12AV6	2.55
12AV7	4.00
12AX7	1.01
12AY7	4.69
12B4A	3.62
12BA6	2.52

12BE6	2.79
12BH7	1.29
12BY7	3.11
12E1	19.67
12E11TT	19.26
12E14	34.50
13E1	123.05
19H4	28.75
19H5	40.25
24B9	55.20
30C15	1.84
30C17	1.84
30C18	1.84
30F5	1.93
30FL1/2	1.28
30FL12	2.07
30FL14	1.84
30L1	1.15
30L15	2.07
30L17	2.07
30P4	1.06
30P19	1.38
30PL1	2.88
30PL14	1.93
30PL15	2.07
35W4	0.69
50C5	0.81
75B1	5.38
75C1	2.70
85A1	8.63
85A2	2.75
90AG	14.90
90AV	14.90
90C1	3.35
90CG	16.72
90CV	17.50
92AG	14.90
92AV	14.90
95A1	7.48
150B2	3.47
150B3	6.39
150C2	2.21
150C4	2.75
211	21.85
723AB	40.25
803	11.50
805	23.00
807	4.31
811A	21.08
812A	21.08
813	91.15
833A	153.57
866A	17.56
872A	24.69
922	5.01
931A	18.15
1624	2.59
1625	1.96
2050	8.00
4212E	304.75
4212H	304.75
5544	62.10
5545	67.85
5551A	123.51
5552A	166.98
5553A	259.10
5642	6.45
5654	3.93
5651	4.66

5670	5.18
5675	21.47
5687	6.31
5696	4.35
5718	7.87
5725	5.62
5726	3.62
5727	6.47
5749	5.14
5751	4.80
5763	4.66
5814A	4.26
5840	5.06
5842	13.90
5876A	19.55
5879	5.38
5886	12.08
5963	3.38
5965	4.00
6005	5.62
6021	5.13
6057	4.02
6058	12.47
6059	4.60
6061	4.89
6062	4.31
6063	4.20
6064	8.54
6067	4.02
6072	5.80
6080	7.88
6097AxBxC	166.75
6146A	12.24
6146B	9.34
6159B	19.91
6189	10.03
6201	10.92
6442	17.25
6883B	14.64
6973	4.38
7025	2.73
7551	6.45
7586	11.66
7587	20.11
7609	36.57
7868	5.04
7895	13.25
8005	86.40
8068	6.33
8122	60.11
8136	2.48
8417	6.76
18042	8.63
18045	12.06

Tested Ex-Equipment

4CX250B 5.75

BASES

37G unskirted	0.25
37G skirted	0.35
39A unskirted	0.25
B9A skirted	0.35
Int Octal	0.40
Loctal	0.63
Nuvistor base	0.86
8 pin DIL	0.17
14 pin DIL	0.17
16 pin DIL	0.20
Valve screening cans all sizes	0.35

CRTs

2AP1	9.78
2BP1	10.35
3BP1	11.50
3DP1	5.75
3EG1	11.50
3FP7	6.90
3GP1	6.90
3JP1	9.20
3JP2	9.20
3JP7	11.50
3KP1	17.25
3RP1	40.25
3WP1	23.00

5ADP1	40.25
5BP1	11.50
5CP1	11.50
5CP1A	46.00
5FP15A	17.25
5UP7	28.75
DG7-5	72.82
DG7-31	66.78
DG7-32	66.78
DH3-91	67.65
DH7-11	130.09
VCR97	13.80
VCR138	11.50

VCR138A	14.38
VCR139A	9.20
VCR517A	11.50
VCR517B	11.50
VCR517C	11.50

Tube Bases Prices on application

INTEGRATED CIRCUITS

7400	0.18
7401	0.20
7402	0.20
7403	0.20
7404	0.21
7405	0.21
7406	0.49
7407	0.49
7408	0.23
7409	0.23
7410	0.20
7412	0.33
7413	0.37
7416	0.37
7417	0.37
7420	0.21
7422	0.23

7423	0.38
7425	0.35
7427	0.35
7428	0.50
7430	0.20
7432	0.35
7433	0.46
7437	0.37
7438	0.37
7440	0.37
7441	1.04
7442	0.83
7447AN	1.35
7450	0.21
7451	0.21
7453	0.21
7454	0.21

7460	0.21
7470	0.44
7472	0.38
7473	0.44
7474	0.44
7475	0.62
7476	0.48
7480	0.64
7482	0.86
7483	1.15
7484	1.21
7486	0.45
7490	0.69
7491	0.94
7492	0.69
7493	0.69
7494	0.94

7495	0.84
7496	0.94
7497	3.62
74100	1.77
74107	0.52
74109	0.84
74110	0.59
74111	0.82
74116	2.13
74118	1.15
74119	1.77
74120	0.95
74121	0.49
74122	0.71
74123	1.36
74125	0.67
74126	0.67
74128	0.72
74132	0.83

74136	0.59
74141	1.02
74142	2.64
74143	2.99
74144	2.99
74145	1.15
74147	2.30
74148	2.02
74150	2.07
74151	1.08
74154	2.07
74155	1.04
74156	1.04
74157	0.86
74159	2.53
74170	2.76
74172	5.06
74173	1.63
74174	1.84

74175	1.17
74176	1.33
74178	1.56
74179	1.56
74180	1.38
74190	2.19
74191	2.19
74192	2.19
74193	2.19
74194	1.44
74195	1.38
74196	1.55
74197	1.55
74198	3.11
74199	2.64
76013N	2.02
TAA570	2.65
TAA630S	4.02
TAA700	4.50

TBA480Q	2.12
TBA520Q	2.65
TBA530	2.28
TBA540Q	2.65
TBA550Q	3.70
TBA560CQ	3.70
TBA673	2.52
TBA700	1.75
TBA720Q	2.65
TBA750Q	2.38
TBA800	1.38
TBA920	3.34
TBA920Q	3.34
TBA990Q	3.34
TCA270Q	3.34
TCA760A	1.59

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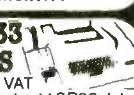

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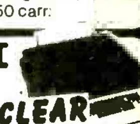

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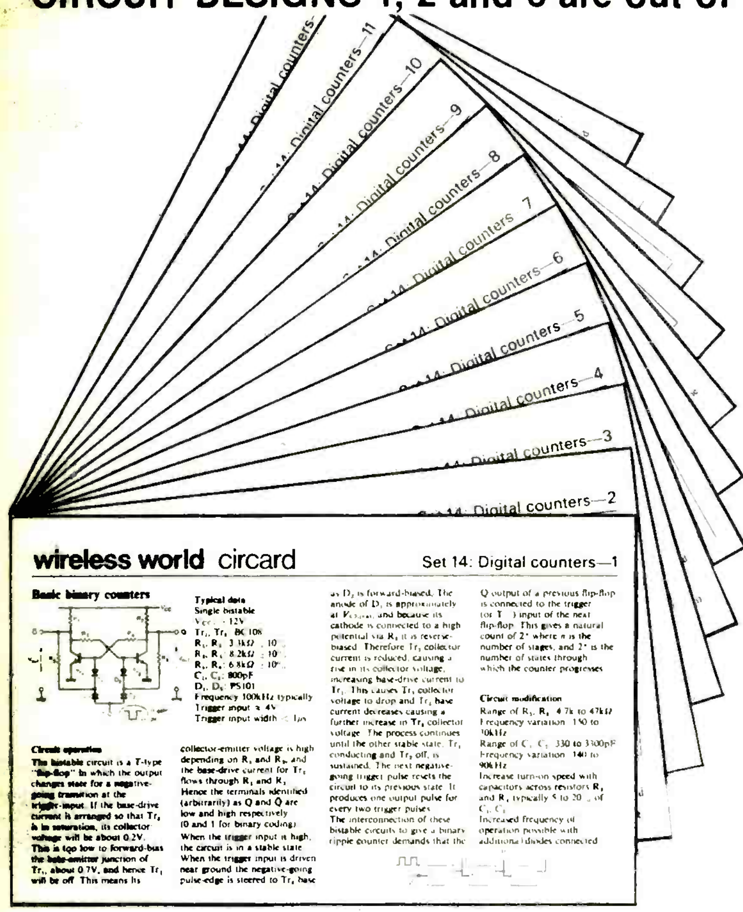

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We are looking for candidates with HNC qualifications and one or two years practical experience — particularly in prototype wiring for circuit boards and digital electronics. It is likely that you will also have experience in one or more of: technical drawing; analogue systems; microprocessors; and/or prototype testing.

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WW8

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(1786)

ROYAL OBSERVATORY, EDINBURGH

PROFESSIONAL AND TECHNOLOGY OFFICERS (2 POSTS)

There are two vacancies for Professional and Technology Officers at the Royal Observatory, Edinburgh which is an establishment of the Science and Engineering Research Council. Both vacancies are in the Technology Unit which provides engineering support to the three national facilities for which the Royal Observatory is responsible – the UK Infrared Telescope Unit, the UK Schmidt Telescope Unit and the Image and Data Processing Unit – and also to in-house research programmes.

PROFESSIONAL AND TECHNOLOGY OFFICER GRADE II – £6868 to £9241 pa

This vacancy is in a small team of engineers and scientists currently working on infrared techniques in the 1-5μm and 7-13μm bands on applying these techniques to the design and development of astronomical instruments such as photometers and spectrometers for use on the 3.8m UK Infrared Telescope in Hawaii.

DUTIES

The successful applicant will be responsible to the team leader, a PTO I, and will work closely with a project astronomer, who is a physicist, and will be required to:
1. Assist in the evaluation of infrared detectors, both single elements and arrays to determine their performance and optimum operating conditions using the necessary electronic and cryogenic apparatus.
2. Develop low noise preamplifiers for use with the above detectors under low infrared radiation levels.
3. Develop suitable thermal and mechanical mounting and packaging methods for detector preamplifier combinations for use in instruments.
4. Assist in the design, development, test and commissioning of such instruments both in respect of the above detector/preamplifier packages and also the associated optics, mechanics and cryostats.

The successful candidate may also be required to work abroad on short term detached duty or on postings of up to three years. It is a prerequisite of working in Hawaii that a special high altitude medical examination be taken and passed.

QUALIFICATION AND EXPERIENCE

Applicants are expected to have a degree or equivalent in an appropriate subject such as Electronic Engineering, Applied Physics or Physics leading to corporate membership of the appropriate professional body.

Recent experience of the theory and practice in any of the following would be an advantage: Low light level imaging systems, especially at infrared wavelengths, cryogenics, low noise, low-level analogue signal amplifiers, optics design.

Applicants are expected to be able to programme in a high level language such as FORTRAN, or be prepared to acquire such ability, as the instruments are controlled by means of minicomputers.

Applicants are expected to be skilled in the use of a wide variety of laboratory instruments and must possess manual skills appropriate to assembly and disassembly of small electromechanical devices and to the handling of cryofluids. Applicants must have good eyesight (with glasses if worn).

PROFESSIONAL AND TECHNOLOGY OFFICER GRADE III – £6868 to £7876 pa

This vacancy is in the Laboratory Workshop which is currently working on a variety of devices for the measuring of photographic plates and on instruments for use on telescopes at visual and infrared wavelengths.

DUTIES

1. Supervise the electronic and wiring activities of the Laboratory Workshop.
2. Organise and maintain the electronic instrument, tool, component and wire stores of the Technology Unit.
3. Be directly involved with Technology Unit Scientific and Technical staff in the instruction, development, testing and maintenance of instrumentation and equipment associated with the national facilities, in-house research and the work programmes of the Technology Unit. Preparation of drawings may form a part of these duties and training will be provided as required.
4. Deputise in the general Laboratory Workshop supervision as and when required.

QUALIFICATIONS AND EXPERIENCE

Applicants must have an ONC/SCOTEC or equivalent and should have served a recognised apprenticeship in electronic engineering. Experience in light electrical or electronic wiring and assembly is essential and knowledge of the mechanical assembly and test of complex instruments would be an advantage.

Application forms for both posts are available from the Personnel Officer, Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, and should be returned by 1 October 1982.

(1783

Appointments

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Crowborough, Sussex and Orfordness, Suffolk

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Salary: £5980-£8180; London £1087 more. Starting salary may be above minimum for those with additional relevant experience. Promotion prospects.

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For further information and an application form (to be returned by 7th October 1982) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). *Please quote ref: T/5782.*

Foreign and Commonwealth Office

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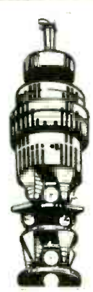

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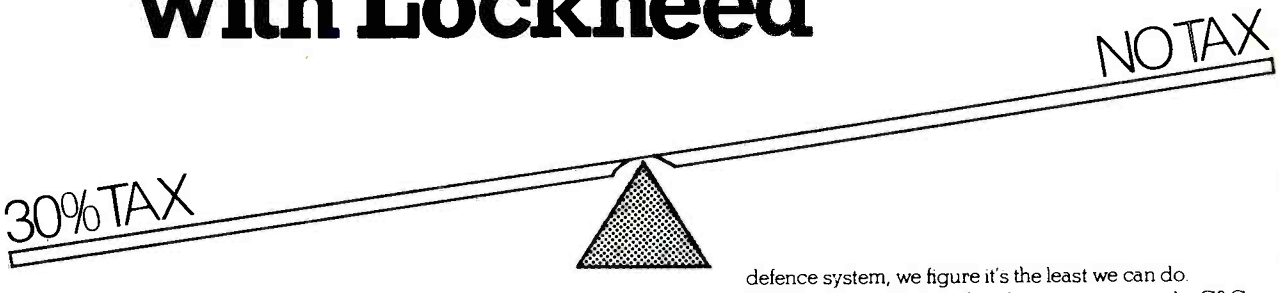

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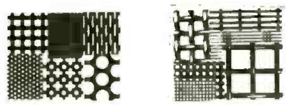

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Printed in Great Britain by QB Ltd., Sheepen Place, Colchester, and Published by the Proprietors IPC ELECTRICAL-ELECTRONIC PRESS LTD., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS, telephone 01-661 3500. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co, CANADA: The Wm. Dawson Subscription Service Ltd, Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd: William Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Distribution Inc., 14th floor, 111 Eighth Avenue, New York, N.Y. 10011.

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