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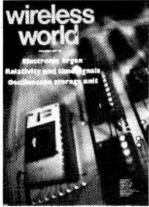
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Front cover shows part of an ITT equipment for programming microprocessors (itself a form of m.p.u.).
Photograph by Paul Brierley

IN OUR NEXT ISSUE

Character rounding for the W.W. teletext decoder. An additional board to improve the appearance of displayed characters.

Reduce wideband noise in tape recording by 30dB with i.c. compander that uses pre-emphasis to reduce pumping effect. (D. L. Harrison)

Breadboard survey. This article explains how various breadboard systems are constructed and used. A number of commercial types are described and compared in terms of flexibility, ease of assembly and cost.

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wireless world

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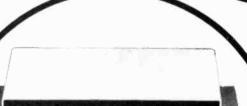
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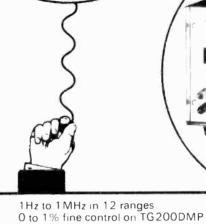
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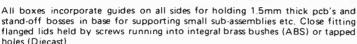
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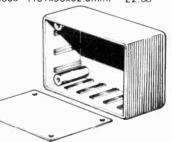


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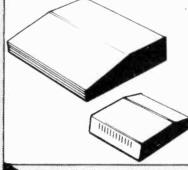
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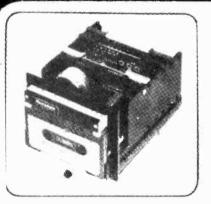
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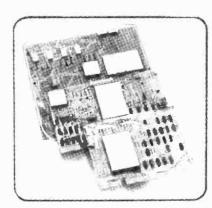
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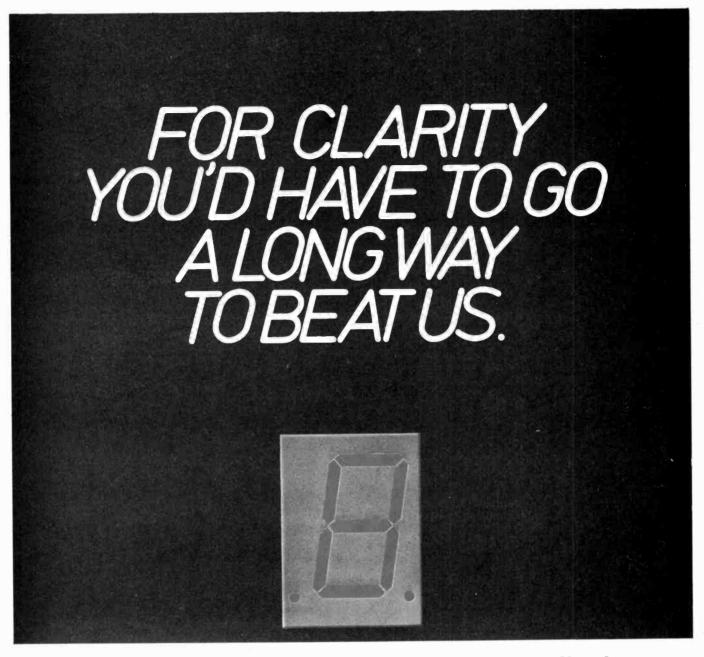
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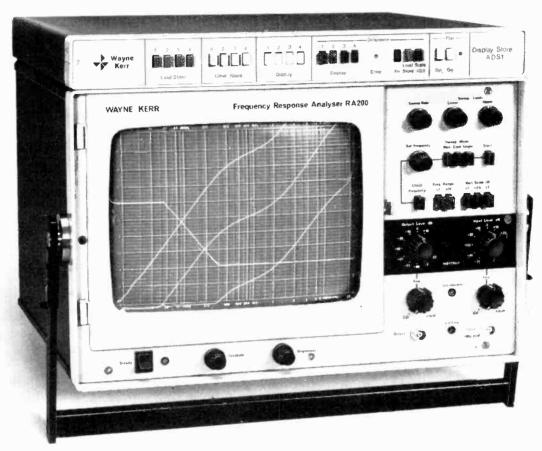
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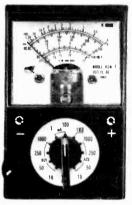
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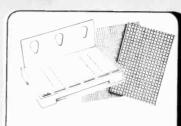


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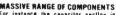


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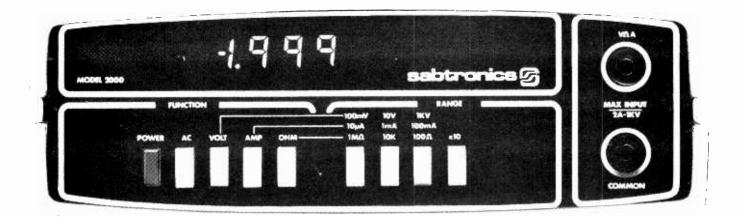
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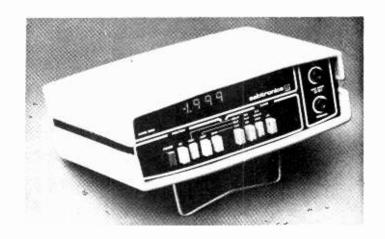


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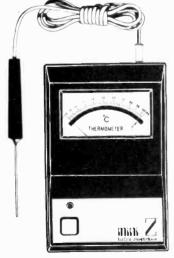
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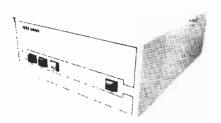
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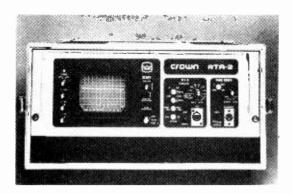
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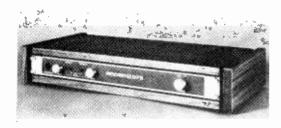
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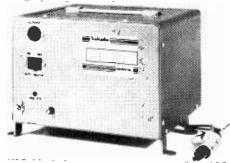
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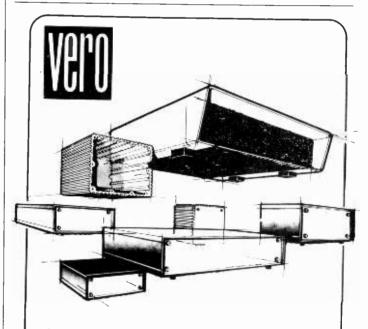
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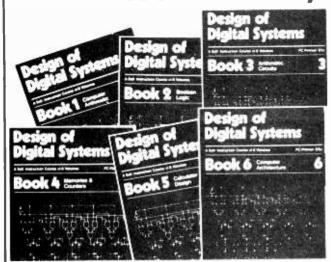
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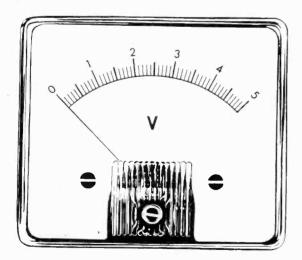


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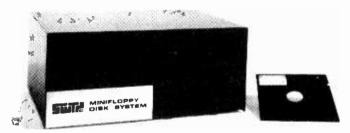
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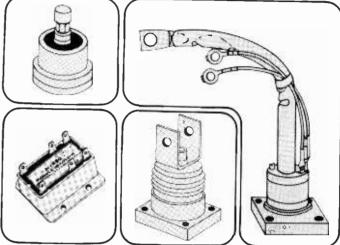
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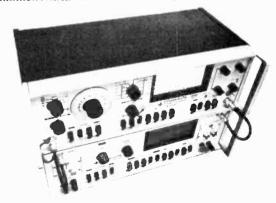


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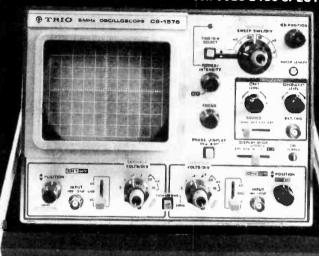
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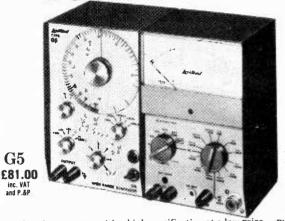
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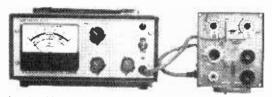
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21 22 23 24 25A 25B 26A 26B 27B 28B 29A 28B 29A 30B 31A 31B 62 63 64 65 66	6½" 8½" 10½" 12½" 6½" 8¾" 12¼" 12¼" 14" 14" 10" 12" 14" 14" 17½" 16½" 17½" 16½"	4½" 5½" 6½" 4½" 4½" 5¾" 7½" 10½" 10½" 4" 4" 5" 6" 7½" 8½" 9½" 9½"	4½" 5½" 6½" 4½" 6¼" 6¼" 6¼" 8½" 6½" 8" 6" 8" 9½" 12½" 12½"	5.10 5.45 7.15 7.50 7.85 8.50 9.25 10.10 6.50 6.50 7.10 7.40 7.70 8.10	5.35 5.90 7.00 7.65 5.70 6.05 7.75 8.10 8.55 9.95 10.80 7.10 7.45 7.80 8.10 8.40 8.80 11.75 13.60 13.60 15.50	1.10 1.10 1.20 1.20 1.20 1.20 1.20 1.20					

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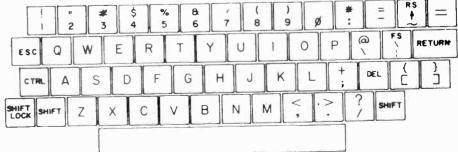
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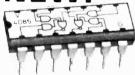
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CA3080 CA3081 CA3089 CA3090	70p 125p 180p 400p	NE567V SN76003N SN76013N SN76023N	170p 200p 140p 140p	7421 2 7422 1 7423 2	2p 74142 20 8p 74145 9 2p 74147 1 1	Op BC 100 8p BC 100 Op BC 100	3C 10p 8p 3C 10p	BFX88 BFY50	23p 20p 20p 15p	2N706A 2N708 2N914 2N918	13p 20p 22p 30p	2N4037 2N4058 2N4059 2N4060	30p 12p 10p 12p	Subminiature type available in horizontal or vertical mounting 0.1W rating 100 ohms to 2M 6p each Special development of 5 of each value from 100 ohms to 2M,
CA3123 CA3130 CA3140E LM300H	150p 90p 70p	SN76033N TAA621A TBA120S	200p 215p 65p	7426 2 7427 2 7428 2	4p 74150 7 4p 74151 5 3p 74153 5	Op BC148 Op BC149 Op BC15	7p	BFY51 BFY52 BU105 BU205	15p 15p 170p 140p	2N919 2N920 2N929 2N930	50p 54p 25p	2N4061 2N5179 2N5457	12p 50p 32p	Ceramic Capacitors Miniature plate type 50V PC mounting. Available (1999)
LM301AN LM304H LM308N	130p 28p 70p 65p	TBA540 TBA641 TBA800 TBA920	200p 240p 70p 320p	7430 1: 7432 2: 7433 3: 7437 2:	3up 74155 5 2up 74156 5	5p 8C158 2p 8C159 2p 8C167 3p 8C168	9p	MJ2955 MPF 102 MPSA06	180p 98p 38p	2N1131 2N1132 2N1302	20p 23p 23p 38p	2N5458 2N5459 2N5777	30p 32p 50p	Polyester Capacitors 2p each
LM318N LM324N EM339 LM380N	125p 50p 50p 75p	TCA270SQ TDA1002 TDA1022 TDA2020	200p 450p 570p 320p	7438 22 7440 13 7441 53 7442 43	op 74161 6 p 74162 6	Op BC 169 5p BC 169 5p BC 170 5p BC 170 5p BC 171	8p C 9p 9p	MPSA56 TIP29 TIP29A	30p 30p 40p 44p	2N1303 2N1304 2N1613 2N1671	54p 54p 22p 130p	0A47 0A91 0A200	10p	Mullard C280 series. 250V PC mounting 0.01, 0.015, 0.022, 0.033, 0.047, 0.068, 0.1, 5p ; 0.15, 0.22, 7p ; 0.33, 0.47, 10p ; 0.68, 14p ; 1.0, 17p ; 2.2µ F, 28p each .
CMOS from	105p	ZN414	75p	7443 - 75 7444 - 75 7445 - 70	p 74164 7 p 74165 7 p 74166 8	Op BC172 Op BC173 Op BC177	7p 9p 14p	TIP29B TIP29C TIP30 TIP30A	40p 60p 40p 48p	2N2160 2N2243 2N2297 2N2368	100p 28p 45p 15p	1N914 4 1N916 1N4001 1N4002	3p 4p	Special development pack of 5 of each value £6.20
4001 4002 4007 4008	15p 15p 15p	4042 4043 4046	54p 55p 100p	7446 55 447 55 7448 55 7450	74170 12 74172 40 74173 9	BC179	14p 10p	TIP30B TIP30C TIP31 TIP31A	55p 70p 50p	2N2369 2N2484 2N2846	16p 22p 70p	1N4006 1N4148	4р 6р 3р	0.1 0.15, 0.22, 0.33, 0.47, 0.68, 1.0, 2.2 @ 35V 4.7 @ 25V, 68 and 10 @ 25V 22 @ 16V, 4.7 @ 6V, 68 @ 3V, 100 @ 3V Development pack 5 of each value £8,30
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4012 4013 4015 4016	35p 60p 35p	4066 4069 4069	100 100	7470 23 7472 23 7473 25	74178 80 74181 141 74182 60	р ВС207 р ВС208 р ВС209	10p 8p 10p	TIP32A TIP32B TIP32C TIP33	60p 75p 80p 75p	2N2906 N2906A 2N2907 2N2907A	22p 22p 23p 25p	7818 7824 78L05 78L12	60p 30p	0.2 in 9p 15p 18p 0.2 in 9p 13p 18p Displays DL707 90p DL704 90p
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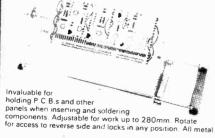
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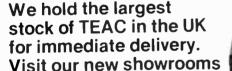
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WW-021 FOR FURTHER DETAILS

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This stereo module uses multiple input transistors to achieve 65dB s/n. Sensitivity is switched 70 or 160µV for 3 5mV output

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The regulator module REG I provides 15-0-15v to power the CPR I and MC I. It can be used with any of our power amp supplies or our small transformer TR 6. The power amp kit will accommodate it

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AD162	ı		0.40	*BC183						2N1613
APIGE / 10.00	J		0.40	*BC184						2N1711
AF109 0.20 *86212 0.10 8F173 0.20 MLE3055 0.70 2M193 AF109 0.28 *86213 0.10 8F177 0.25 *MPSAG6 0.25 2M218 AF125 0.25 *86237 0.14 8F179 0.30 0.16 1.20 2M210 AF126 0.25 *86237 0.14 8F180 0.30 0.26 0.25 2M2218 AF126 0.25 *86239 0.17 8F181 0.32 0.26 0.90 2M2369 AF139 0.35 86301 0.40 8F182 0.35 0.22 0.28 1.30 2M244 AF239 0.40 8C303 0.55 8F183 0.40 0.25 1.30 2M244 AF239 0.40 8C303 0.55 8F183 0.40 0.25 1.30 2M244 AF239 0.40 8C303 0.55 8F183 0.40 0.25 1.30 2M294 ASZ16 1.00 *86303 0.55 8F183 0.40 0.25 1.30 2M294 ASZ16 1.00 *86308 0.17 8F184 0.30 0.26 1.30 2M294 ASZ16 1.00 *86308 0.17 8F184 0.30 0.26 1.30 2M294 ASZ18 1.00 *86327 0.20 8F185 0.30 0.245 0.48 2M296 ASZ18 1.00 *86328 0.17 *8F194 0.10 0.71 0.20 2M2907 AUI06 2.50 *86328 0.17 *8F196 0.12 0.74 0.65 2M295 AUI113 1.60 *86338 0.17 *8F198 0.12 0.75 0.55 2M3053 AUI113 1.60 *86338 0.17 *8F198 0.12 0.75 0.55 2M3054 AUI110 1.50 *86338 0.17 *8F198 0.12 0.75 0.55 2M3054 AUI110 1.50 *86338 0.17 *8F198 0.12 0.75 0.55 2M3054 AUI110 1.00 *86549 0.20 *8F245 0.50 0.20 1.50 2M3442 8E109 0.10 8E771 0.20 8F258 0.32 0.20 1.50 2M3442 8E109 0.10 8E771 0.20 8F258 0.32 0.20 1.50 2M3442 8E109 0.10 8E771 0.20 8F258 0.32 0.20 2M3442 8E109 0.10 8E771 0.20 8F258 0.32 0.20 2M3442 8E113 0.14 8CY71 0.20 8F258 0.32 0.20 2M3054 8E115 0.14 80115 0.50 8F336 0.45 0.2006 2.00 2M3705 8E115 0.14 80115 0.50 8F336 0.45 0.2006 2.00 2M3705 8E115 0.14 80115 0.50 8F336 0.45 0.2006 2.00 2M3705 8E115 0.14 80115 0.50 8F336 0.30 TP294 0.00 2M3706 8E117 0.20 8B131 0.50 8F336 0.30 TP294 0.30 820108 1.80 2M3708 8E115 0.14 80115 0.50 8F336 0.30 TP295 0.30 0.2007 2.00 2M3706 8E115 0.14 80115 0.50 8F336 0.30 TP295 0.30 0.2007 2.00 2M3706 8E115 0.14 80115 0.50 8F336 0.30 TP295 0.30 0.200 2M3705 8E115 0.14 80113 0.50 8F336 0.30 TP295 0.30 0.200 2M3705 8E115 0.14 80113 0.50 8F336 0.30 TP295 0.30 0.200 2M3705 8E115 0.14 80113 0.50 8F336 0.30 TP295 0.30 0.200 2M3706 8E115 0.14 80113 0.50 8F336 0.30 TP295 0.30 0.200 2M3706 2M3710 8E113 0.14 80113 0.50 8F336 0.30 TP295 0.30 0.200 2M3706 2M3710 8E113 0.15 8B133 0.30 8E1166 0.	I		0.96							
AF129 0.28 *86213 0.10 8F177 0.25 *MFSA06 0.25 2M2218 AF125 0.25 *86237 0.14 8F178 0.28 *MFSA06 0.25 2M2218 AF125 0.25 *86237 0.14 8F179 0.30 0.16 1.20 2M222 AF127 0.25 *86238 0.14 8F179 0.30 0.26 0.90 2M2369 AF139 0.35 86391 0.40 8F182 0.35 0.29 2M2389 AF139 0.35 86391 0.40 8F182 0.35 0.29 1.30 2M2484 AF239 0.40 8F382 0.35 0.29 1.30 2M2586 AF239 0.40 8F382 0.30 0.265 1.30 2M2596 AF239 0.40 8F382 0.30 0.265 1.30 2M2596 AF239 0.40 8F382 0.30 0.40 0.25 1.30 2M2596 AF239 0.40 8F382 0.30 0.45 0.48 2M2596 AF2318 1.00 *86327 0.20 *8F185 0.30 0.45 0.48 2M2596 AF2318 1.00 *86337 0.18 *8F197 0.12 0.71 0.20 2M2597 AM110 1.50 *86337 0.18 *8F197 0.12 0.74 0.65 2M3053 AM113 1.60 *86338 0.17 *8F198 0.12 0.75 0.55 2M3054 AM1210 2.00 *86548 0.18 *8F199 0.12 0.75 0.55 2M3054 AM1210 2.00 *86548 0.18 8F200 0.30 0.201 1.50 2M3442 8C109 0.10 8C770 0.17 8F259 0.30 0.202 1.50 2M3442 8C109 0.10 8C770 0.17 8F259 0.30 0.202 1.50 2M3442 8C109 0.10 8C770 0.17 8F259 0.32 0.202 1.50 2M3442 8C114 0.14 8C772 0.17 8F259 0.32 0.202 1.50 2M3442 8C114 0.14 8C772 0.17 8F259 0.34 0.205 2.00 *2M3703 *8C114 0.14 8C171 0.20 8F258 0.32 0.204 2.00 *2M3703 *8C114 0.14 8C171 0.20 8F258 0.32 0.204 2.00 *2M3703 *8C114 0.14 8C171 0.20 8F258 0.32 0.204 2.00 *2M3703 *8C115 0.14 8B1135 0.50 8F338 0.50 R20088 1.80 *2M3708 *8C125 0.16 80116 0.65 8F338 0.50 R20088 1.80 *2M3708 *8C125 0.16 80133 0.35 8FX87 0.30 TIP390 0.55 2M3741 *8C1137 0.15 *8B133 0.38 8FX87 0.30 TIP390 0.55 2M3718 *8C137 0.15 *8B133 0.38 8FX87 0.30 TIP390 0.55 2M3718 *8C137 0.15 *8B133 0.38 8FX87 0.30 TIP390 0.55 2M3718 *8C137 0.15 *8B133 0.38 8FX87 0.30 TIP390 0.55 2M3718 *8C137 0.15 *8B133 0.38 8FX87 0.30 TIP390 0.55 2M3718 *8C137 0.55 *8B133 0.30 8FX87 0.30 TIP390 0.55 2M3718 *8C137 0.55 *8B133 0.30 8FX87 0.30 TIP390 0.55 2M	ı			*BC212						
AF124	ı			*BC213						
AF125	ı			*BC214						
## 126	Ш		0.25							
AF127	ı		0.25							
AF139 0.35 BC301 0.40 BF182 0.35 0C29 1.30 2R2644 AF219 0.40 BC35 1.30 12R2646 ASZ115 1.00 BC303 0.55 BF183 0.40 0C35 1.30 2R2646 ASZ115 1.00 BC303 0.55 BF183 0.40 0C35 1.30 2R2646 ASZ115 1.00 BC308 0.17 BF185 0.30 0C45 0.48 2R2906 ASZ118 1.00 BC327 0.20 BF185 0.30 0C45 0.48 2R2906 ASZ118 1.00 BC327 0.20 BF185 0.30 0C45 0.48 2R2906 ASZ118 1.00 BC327 0.20 BF185 0.09 0C72 0.40 2R2907 ASZ118 1.00 BC337 0.18 BF185 0.09 0C72 0.40 2R2907 ASZ118 1.50 BC337 0.18 BF185 0.09 0C72 0.40 2R2907 AMI10 1.50 BC337 0.18 BF195 0.12 0C74 0.65 2R3053 AMI13 1.60 BC338 0.17 BF196 0.12 0C75 0.55 2R3053 AMI13 1.60 BC338 0.17 BF198 0.12 0C75 0.55 2R3053 AMI210 2.00 BC347 0.18 BF199 0.25 0C77 1.00 2R3405 BC107 0.09 BC548 0.18 BF200 0.25 0C77 1.00 2R3440 BC109 0.10 BC770 0.17 BF257 0.30 0C202 1.50 2R3441 BC109 0.10 BC770 0.17 BF257 0.30 0C202 1.50 2R3442 BC109 0.10 BC771 0.20 BF258 0.32 0C204 2.00 2R34703 BC114 0.14 BC771 0.20 BF258 0.32 0C204 2.00 2R34703 BC115 0.14 B0115 0.50 BF338 0.45 0C205 2.00 2R3703 BC117 0.20 BD131 0.50 BF338 0.45 0C205 2.00 2R3703 BC117 0.20 BD131 0.50 BF338 0.45 0C205 2.00 2R3703 BC117 0.20 BD131 0.50 BF338 0.50 R2008 1.80 2R3703 BC135 0.18 BD135 0.35 BF388 0.30 TIP39C 0.50 2R3703 BC137 0.15 BB138 0.35 BF388 0.30 TIP39C 0.50 2R3703 BC137 0.15 BB138 0.38 BF387 0.30 TIP39C 0.50 2R3703 BC137 0.15 BB138 0.38 BF387 0.30 TIP39A 0.45 2R3710 BB135 0.38 BF388 0.30 TIP39C 0.50 2R37103 BC137 0.15 BB138 0.38 BF387 0.30 TIP39C 0.50 2R37103 BC137 0.15 BB138 0.38 BF387 0.30 TIP39C 0.50 2R37103 BC137 0.15 BB138 0.38 BF387 0.30 TIP39A 0.45 2R3710 BB137 0.15 BB138 0.38 BF387 0.30 TIP39C 0.50 2R37105 BB137 0.15 BB138 0.38 BF387 0.30 TIP39A 0.45 2R3710 BB137 0.15 BB138 0.38 BF387 0.30 TIP39C 0.50 2R37105 BB137 0.15 BB138 0.38 BF387 0.30 TIP39C 0.50 2R37105 BB137 0.15 BB138 0.38 BF388 0.30 TIP39C 0.50 2R37105 BB137 0.35 BF388 0.30 TIP39C 0.50 2R37105 BB137 0.35 BF388 0.30 TIP39C 0.50 2R37105 BB137 0.30 ER3711 BB137 0.35 BF388 0.30 TIP39C 0.50 2R37105 BB137 0.30 ER3717 0.30 ER3711 BB137 0.35 ER3817 0.30 TIP39C 0.50 2R37105 BB137 0.3	ı		0.25							
AZ-239	ı		0.35							
ASZ16	ı		0.40							
ASZ117	ı		1.00							
ASZ18	Г		1.00		0.18					
ASZ18	L		1.00	*BC308	0.17					
AU106	ı		1.00	*BC327	0.20	*RF105				
Au1110	ı		2.50	*BC328						
Au113	1		1.50	*BC337						
AU210	ı		1.60	*BC338						2N3D54
BC107	ı		2.00	*BC547						
BC108			0.09	*BC548						
BC109			0.09	*BC549						
*BC113			0.10							
*BC114			0.14	BCY71						
*BC115		*BC114	0.14	BCY72						
*8C116 0.16 80116 0.65 8F337 0.30 0C207 2.00 *2N3705 *8C117 0.20 80131 0.50 8F338 0.50 R2008 1.80 *2N3707 *8C125 0.16 80132 0.52 8FX84 0.30 R20108 1.80 *2N3708 *8C126 0.18 *80135 0.34 8FX85 0.30 R1P29A 0.38 *2N3709 *8C136 0.14 *80137 0.35 8FX87 0.30 TIP29A 0.30 *2N3709 *BC137 0.15 *80133 0.38 8FX86 0.30 TIP30A 0.45 *2N3710 *BC137 0.15 *80138 0.38 8FX86 0.30 TIP30A 0.45 *2N3711 *BC147A 8.C 0.98 *80133 0.38 8FX85 0.30 TIP30C 0.55 2N3711			0.14	B0115						
*BC117		*BC116	0.16	80116						
*BC125 0.16 BD132 0.52 BFX84 0.30 R2108 1.80 *2N3707 *BC126 0.18 *BD135 0.34 BFX85 0.30 TIP29A 0.38 *2N3709 *BC135 0.14 *BD136 0.35 BFX87 0.30 TIP29A 0.30 *2N3709 *BC136 0.18 *BD137 0.37 BFX86 0.30 TIP30C 0.50 *2N3710 *BC137 0.15 *BD138 0.38 BFY50 0.28 TIP30C 0.45 *2N3711 *BC147A, B, C 0.09 *RB137 0.40 *8FY50 0.28 TIP30C 0.55 2N3771			0.20	80131						*2N3706
*8C126 0.18 *8D135 0.34 8FX85 0.30 TIP29A 0.38 *2N370B *28C1395 0.30 TIP29A 0.38 *2N370B *2N370B 0.30 TIP29A 0.38 *2N370B 0.30 TIP29C 0.50 *2N371D 0.37 8BC136 0.18 *8D137 0.37 8FX88 0.30 TIP39A 0.45 *2N371D 0.37 8BC137 0.15 *8D138 0.38 8FX85 0.30 TIP39A 0.45 *2N371D 0.37 8BC147A 8.C 0.09 *8D139 0.40 8FX50 0.28 TIP39C 0.55 2N3711			0.16	B0132						
*BC135										
*BC136 0.18 *B0137 0.37 BFX88 0.30 TF390 0.45 *2N3710 *BC137 0.15 *B0138 0.38 BFY50 0.28 TIP30C 0.55 2N3771										
*BC137										
*BC147A.B.C 0.09 *R0139 0.40 0780 0.28 11730 0.55 2N3771										
0.50 2N3771		*BC147A. B. C								
	L					01101	U.24	HEATA	U.5U	2N3771

	TIP31C	0.50		2.50	1 N5403	0.12	LEDS		AT44700	
	TIP32A	0.55	5 2N3819	0.30		0.12		0.10	*TAA790	1.90
	TIP32C	0.80		0.40		0.16		0.16		0.70
_	TIP33A	0.85	5 2N3866	0.75		0.16		0.16		1.50
	TIP33C	1.00	D *2N3904	0.15		0.16		0.18		2.00
-	TIP34A	1.00	D *2N3905	0.15		0.18		0.18	*TBA530	1.90
	TIP34C	1.20	D *2N3906	0.15		0.20		0.18		2.00
	TIP41A	0.60	D *2N4O58	0.14			5mm YELLOW	0.18		3.00
	TIP42A	0.65		0.14					°TBA560C	3.00
	TIP2955	0.75		0.14			LINEAR IC'S		*TBA570	1.10
	TIP3055	0.50	2N4061	0.15		0.16		2.20	*TBA641B11	1.48
	2N404	0.60	2N4062	0.15		0.16			*TBA750	2.00
0	2N696	0.25		0.16	DT 100 981 169	0.09	*MC1307P	4.00	°TBA800	0.68
0	2N697	0.18		0.50			*MC1310P	1.60	*TBABIDS	0.85
9	2N698	0.40		12.00			*MC1327P	1.80	*TBA81DS	0.90
í	2N7D6	0.19					*MC1330P	1.60	*TBAB20	0.75
•	2N708	0.19		1.80 2.00	BRIDGE		*MC1351P	0.85	*TBA920	2.60
)	2N930	0.13		1.50	RECTIFIERS		*MC1351P	0.90	*TBA950	1.80
í	2N1131	0.18			BY164	0.60		1.50	*TBA990	2.75
)	2N1132	0.18		1.25	BY179	0.60	°MC1355P	1.60	*TCA270SQ	2.50
J	2N1304	0.70			IA 50V	0.60	NE555 *CL1227	0.40	°TCA800	3.80
J	2N1305	0.70			1A 190V	0.23	*SL1327	1.55	°TCA940	2.00
J	2N1306	0.70			1A 200V	0.27	*SN76001N *SN76003N	2.30	*TDA1327	2.45
1	2N1307	0.70			1A 400V	0.28	*SN76003N *SN76013N	2.40	*TDA133D	0.85
	2N1308	0.70			1A 600V	0.50	*SN76013N	1.40	°T0A2020	3.80
	2N 1308 2N 1309	0.70		0.07	2A 50V	0.35	*SN76013ND *SN76023N	1.40	*TDA2590	3.85
	2N1613	0.70			2A 100V	0.30	*SN76D23N	1.40	*T0A2600	4.15
	2N1711	0.22		D.15	2A 100V 2A 200V	0.35	*SN76023N0		709 DfL	0.35
	2N1711	1.80		0.15	2A 400V	0.38	*SN76033N	2.30	741 BPOIL	0.22
	2N1893	0.25		0.10	3A 200V	0.44	*SN7611DN *SN76236HD	1.65	747 14PDIL	0.70
	2N2102	0.25 0.40		0.11	3A 600V	0.55	*SN76226ND		748 14PDIL	0.76
	2N2218	0.40 0.20		0.14	3A 600V 4A 100V	0.70				0.00
	2N2219		BA 15B	0.18	4A 100V 4A 400V	0.80				
	2N222	0.20 0.22	BA159 BAY13	0.18	4A 400V 6A 50V	0.90	TUNERDIODES			
	2N2369		BAX13 BAX16	0.07	6A 100V	0.90	*BP1056	0.14		
	2N2309 2N2484	0.18 0.30	BAX16	0.07	6A 400V	0.95	*TAA550B	0.20		
	2N2646		*BY126	0.10	DM 4004	1.20	°SN76227N	0.85		
	2N2046 2N2904	0.60	*BY127	0.10			°SN76228N	1.25		
	2N29U4 2N29O5	0.22	BYX55-350 BYX55-600	0.40			*SN7653DN	1.00		
	2N29U5 2N29O6	0.24	BYX55-600	0.60			*SN76532N	1.55		
		0.28	DA47	0.08	DIAC		*SN76533N	1.60		
	2N2907 2N2026	0.24	DA7D	0.25	BR 100	0.28	°SN76544N	1.50		
	2N2926 2N3053	0.12	DA79	0.25			°SN76550N	0.54		
		0.30	DA81	0.18			*SN76660N	1.00		
	2N3D54 2N3D55	0.60	DABS	0.18			*SN76666N	1.35		
	2N3055 2N3440		DA90	0.08	SCR - THYRIST		°TAA570	2.20		
	2N3440 2N3441		DA91 DADS	0.08	BT106	UKS	#118AAT*	2.40		
	2N3441		DA95	0.00		1.00	*TAA621A	2.00		
	2N3442		OA200	0.00	C106D 2N4443	0.60	*TAA630S	2.00		
	*2N3702		DA 202	0.10		0.95	*TAA6618	1.10		
	*2N3703		1N914	0.07	2N4444	1.80		****		
	*2N3704		10916	0.07						
	*2N37D5		1N4001	0.05			21110			
	*2N3706			0.05			C.W.O.	. P.&P.	25p	
	*2N37D7			0.06			Minimu	m Ord	ler £2.00.	
	°2N37DB		1N4004	0.06	VOLTAGE		Plance	111 010.	dr 52.00.	
	°2N3709		1 N4005	0.06	REGULATORS		Flease a	add V.F	A.T. to total	al.
	*2N3710				LM309K	1.40	Mail Ord	der onl	ly.	
2	°2N3711				LM309H	0.80	All item	ac 8% '	V.A.T. exc	cant
	2N3771				TBA625B	1.15	All Items	15 0 70	V.A.I. EX	sept
4	2N3771	1.55	1N5402	0.12	UA723	0.40	Where II	narked	1 at 121/2	%.
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TIP31C

0.50 283771

new from international

Ambit stoppress....news on items available.....KV1210: triple AM tuning diode with 2-9v bias only £2.75.....DTI200 Digital frequency readout module 911223 ultra low THD/IMD mpx decoder module £9.95......944378 'Hyperfi' mpx decoder with post decoder muting and pilot cancel £19.95...... VMOS

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a couple of really excellent products that will shortly feature as "standards"

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E4.95

ICM7208 A seven decade counter for use with the 7207

E14.95

ICM7217 Four decade presettable counter/timer with carry out & LED drive

E9.50

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CD 4000 CM 05

		_			
4000	17p	4059	563p	4522	149
4001	17p	4060	115p	4527	157
4002	17p	4063	109p	4528	102
4006	109p	4066	53p	4529	14
4007	18p	4067	400p	4530	90
4008	80p	4068	25p	4531	14
4009	58p	4069	20p	4532	125
4010	58p	4070	20p	4534	614
4011	17p	4071	20p	4536	380
4012	17p	4072	20p	4538	150
4013	55p	4073	20p	4539	110
4016	52p	4075	20p	4541	14
4017	80p	4076	90p	4543	174
4018	80p	4077	20p	4549	399
4019	60 p	4078	20p	4553	44
4020	9 3p	4081	20p	4554	15
4021	82p	4082	20p	4556	7
4022	90p	4085	82p	4557	386
4023	17p	4086	82p	4558	11
4024	76p	4089	150p	4559	38
4025	17p	4093	50p	4560	21
4026	180p	4094	190p	4561	69
4027	55p	4096	105p	4562	53
4028	72p	4097	372p	4566	15
4029	100p	4098	110p	4568	28
4030	58p	4099	122p	4569	30
4031	250p	4160	90p	4572	. 2
4032	100p	4161	90p	4580	60
4033	145p	4162	90p	4581	31
4034	200p	4163	90p	4582	16
4035	120p	4174	104p	4583	8
4036	250p	4175	95p	4584	6
4037	100p	4194	95p	4585	10
4038	105p	4501	23p		•
4039	250p	4502	91p	1	
4040	83p	4503	69p		-

85p 85p 80p 150p 130p 99p 60p 55p 65p 65p

4049 4050

Micromarket

п					_	
J	6800 se	ries	8216 8224	£2.25		£10
П	6800P	£13			2708	£10.55
1	6820P	£'6	8228	£5.25	Develo	pment
.	6850P	£6.75	8251	£8		00 £220
	6810P	£4	8255	£5.40	TK80	£306
١	6852	£15	MEMO		AMI, Si	
	8080 se	rios	2102	£1.70	TI. Inte	
٠			2112	£3.40	Harris e	
.	8080	£16	2513	£7.54	rigitis c	ic. On
.	8212		4027	£5.78		

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l	7800 series UC TO220 package 1A	all 95p
ı	7900 series UC TO220 package 1A	all £1
ı	78MUC series TO220 package ½A	all 90p
l	78LCP series TO92 100mA	all 35p
	L200 up to 3A/adjustable V&A	195p
	78MGT2C ½amp adjustable volts	175p
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ı	MAINS FILTERS FOR NOISE/RF	etc
۱	1 amp in IEC connector	£4.83
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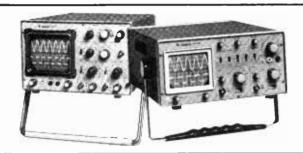
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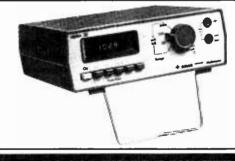
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Electronic voting

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Publishing Director: GORDON HENDERSON AS ANOTHER general election draws near many people in electronics will be reflecting on the antiquated system we now use for electing our representatives in parliament and how it could be transformed by modern technology. It seems extraordinary in an age of computers, data transmission and all the techniques described in our recent articles "The paperless revolution" (July and August issues) that we are still voting with bits of paper marked with crosses dropped into tin boxes. And it is particularly bad that the ordinary citizen is restricted to this crude instrument of democracy while those who seek to persuade him of the rightness of their policies and their fitness to govern have at their disposal all the resources, the subtlety and power of modern mass communications including of course the electronic medium of television. It is a one-sided arrangement more appropriate to oligarchy than true democracy. But with two-way electronic information systems such as viewdata about to come into operation the means are now available to make a

There is no point, of course, in setting up a straightforward electronic equivalent of the ballot-box system. That would be nothing more than trivial gadgeteering. What we need to do is to exploit the immediacy, flexibility and information bit-rate of the two-way electronic system to redress the balance in favour of the citizen and give him a more direct say in decisions, in the manner of ancient Greek democracy, rather than leave these decisions entirely to so-called representatives whom he chooses at infrequent intervals, often hastily, while bemused and emotionally disturbed by electioneering propaganda. Two centuries ago Rousseau pointed out "The commands of the leaders may pass for the general will if the people, being free to oppose, does not do so." (The Social Contract), and Tom Paine added later "There ought to be a method of ascertaining

public opinion, to find out what the sense of a nation is and to be governed by it." (The Rights of Man). They would be glad to know that the technical means are now available to make referendums quickly and easily. With two-way information systems it is possible to have a national vote on any policy or issue at any time. And this would not be restricted to simple binary decisions but could easily allow a range of choices which could be voted for in order of preference.

A correspondent, Stephen Frost, has suggested a complete scheme for such voting based on the regional viewdata computers soon to be established round the UK and using public polling booths, rather like public telephones, containing computer terminals. (It could be a long time before there is a viewdata terminal in every home.) Voters would be identified and authenticated by coded cards rather like credit cards which, to ensure only one vote per person, would be read by the terminals before allowing votes, made by push-button, to be entered. Frost suggests that the secrecy of the ballot could be maintained and "rigging" avoided by arranging that the computer would not record who had voted and how. Nonetheless there is a danger of abuse here if the system came under the control of an unscrupulous government. Another weakness, pointed out by Frost, is that voting could be done by people other than the rightful owners of the cards. In some cases they could be genuine proxies, but in others they could have obtained and used the cards unlawfully. It remains to be seen if such drawbacks could be overcome.

Of course, the electronic referendum would make the traditional Member of Parliament redundant. In our present version of democracy, in which he is no longer basically a personal representative of a group of people but a mere counter rigidly controlled for parliamentary voting purposes by a party machine, this would be no great

Relativity and time signals

"The theory is so rigidly held that young scientists dare not openly express their doubts"

by L. Essen, D.Sc., C.Eng., F.R.S.

Perhaps best known for his quartz ring clock — which revealed variations in the earth's rotation — L. Essen's main activity during his 44 years with NPL was the measurement of frequency and time, "but with sidelines" he admits. He built the first caesium clock in 1955, later used with the US Naval Observatory to define the atomic second. One of his early sidelines was a determination of the velocity of light by cavity resonator which showed Michelson's value to be 17 km/s too low. (Which illustrates a peculiarity of Nobel prizes — Michelson got one, Essen didn't.)

He's always been interested in relativity, and repeated the Michelson-Morley experiment with quartz crystal in 1937 and with radio waves in 1955, when he first pointed out a basic error in the theory. "No one has attempted to refute my arguments," Dr Essen told us, "but I was warned that if I persisted I was likely to spoil my career prospects."

ONE OF THE EARLIEST applications of radio was the transmission of time signals as an aid to sea navigation and today signals are used to synchronise atomic time throughout the world for navigational and other purposes. The comparison of distant clocks by radio is now a precise and well known technique. This was not the case in 1905 when Einstein published his famous paper on relativity and there is some excuse for the mistakes he made in the thoughtexperiments which he described in order to determine the relative rates of two identical clocks in uniform relative motion. But there is no excuse for their repetition in current literature.

The mistakes have been exposed in published criticisms1 of the theory but the criticisms have been almost completely ignored; and the continued acceptance and teaching of relativity hinders the development of a rational extension of electromagnetic theory. It could be argued that the truth will eventually prevail but history teaches us that when a false view of nature has become firmly established it may persist for decades or even centuries. We cannot afford to wait that long. The energy reserves are dwindling rapidly and if there is to be a scientific breakthrough to solve the crisis it will possibly be in worthwhile therefore making another attempt to weaken the strangehold of relativity by explaining the basic mistakes in still greater detail.

Measurement of time and the comparison of clocks

The passage of time is measured by counting the number of repetitions of some regular periodic event such as the revolution of the earth, the swings of a pendulum, the vibrations of a piece of quartz, or the radio waves emitted by an atom. Whichever event is chosen the result of the count is converted for convenience into one-second ticks which are then counted on a clock dial and expressed as hours and minutes.

"The general public is misled into believing that science is a mysterious subject which can be understood by only a few exceptionally gifted mathematicians."

The only way of comparing distant clocks is to transmit the ticks by radio so that at each station there are two clock dials, one counting the ticks from the local clock, and the other the ticks from the distant clock. In practice a continuous count may not be necessary because the result may be known approximately from experience or may be given by a coded message on the transmission, but the principle remains the same. The relative rates of the clocks are found by comparing the rates at which the readings on the two dials increase, and the complication of synchronizing the two clocks before the start of the measurement does not arise.

Einstein's prediction

Einstein predicts, to use his own words, that "the time marked by the moving clock, viewed in the stationary system, is slow by $\frac{1}{2}(v/c)^2$ second per second", where v is the relative velocity between clocks, and c is the velocity of light. In practical terms the only meaning that can be attached to this rather vaguely worded statement is that

the reading on the clock dial recording the ticks from the distant moving clock increases more slowly, by $\frac{1}{2}(v/c)^2$ s/s than the reading on the dial recording the ticks from the local clock. According to Einstein's relativity postulate either of the clocks can be regarded as the moving one and the full prediction is therefore

clock B, viewed at A, goes slower than clock A by $\frac{1}{2}(v/c)^2 s/s - (1)$ clock A, viewed at B, goes slower than clock B by $\frac{1}{2}(v/c)^2 s/s - (2)$

This result is not logically impossible but it has an important consequence which does not appear to have been appreciated by Einstein or subsequent writers on the subject. More ticks are transmitted than are received and this process continues indefinitely whether the clocks are approaching or receding from each other, the effect being proportional to v^2 . This loss of ticks is inexplicable but it is inherent in Einstein's prediction. However being unaware of the consequence, relativitists, including Einstein, later make the more reasonable assumption that all the transmitted ticks arrive at the other clock in the course of the measurement. They thus unknowingly make two contradictory assumptions and naturally they obtain paradoxical results.

Einstein's prediction contains no mention of the ordinary Doppler effect, which is proportional to v/c. This is eliminated by Einstein's definition of time — a point which is not discussed by relativitists. The measurements will in practice include the term for the Doppler effect but for simplicity the prediction is given here exactly as Einstein gave it.

The clock paradox

Einstein described the following thought experiment. Two identical clocks, A and B say, are side by side. One of them B moves in a straight line at uniform velocity away from A to a point x. Einstein states that, in accordance with his result (1), B will be slow compared with A. Now this is not in accordance with (1), the phrase "viewed at A" having been omitted. The clock B continues to travel in a number of straight line paths until it arrives back at A, when it will be found to read less than A.

Einstein calls the result peculiar but gives no explanation.

The paradox is not immediately obvious because Einstein gives only half of the result. Although accelerations must be applied to obtain the round trip, no correction is made for them and they are not even mentioned. As far as the experiment is concerned the clocks are in uniform relative motion and either clock can be taken as the moving one. The full result is

clock B goes slower than clock A by $\frac{1}{2}(v/c)^2 s/s$

clock A goes slower than clock B by $\frac{1}{2}(v/c)^2 s/s$

which is obviously paradoxical.

There is no problem if the experiment is carried out correctly. The ticks from B are received on a dial at the position of A; and another dial travels with B to receive the ticks from A. At the end of the experiment the dials will record the result (1) and (2) as they must do since a thought experiment cannot give a result that contradicts the initial postulates.

Consequences of Einstein's mistake

The paradox result follows from a simple "experimental" error but it was accepted by Einstein and has been accepted by relativists ever since and it is important to consider the consequences. It is based on the assumption that no ticks are lost. This assumption is reasonable but it contradicts the prediction (1) and (2). By accepting the result they thus reject the relativity theory. They still accept the existence of the second-order time contraction but it is now a real physical effect just as in the Lorentz theory from which Einstein started.

Introduction of gravitation and acceleration

In 1918 Einstein published a paper³ which took the form of a discussion between a relativist and a critic. The relativist admits that the paradox result contradicts his initial postulates.

"Students are told that the theory must be accepted although they cannot expect to understand it. They are encouraged right at the beginning of their careers to forsake science in favour of dogma."

He then describes a thought experiment in which gravitational fields are switched on and off at different points of the path of the moving clock as it makes a round trip; and concludes that the result obtained earlier by assuming that acceleration has no effect is due to the gravitational fields. It is not surprising that this paper with its damaging admission, its irrational assumptions and its "experimental" mistakes is seldom mentioned in the literature. Many writers on relativity nevertheless advance a similar argument. They conceal the paradox, as Einstein did, by giving only one half of the result, and justify this by pointing out that the two clocks are not symmetrical, overlooking the fact that they have made them symmetrical, as far as the experiment is concerned, by assuming that accelerations have no effect. Without this assumption they would not be able to obtain any result at all. Vague suggestions are then made that the result is due to the accelerations.

Does it matter?

It has been explained how Einstein, in the course of his paper, rejects the relativity postulate and returns to the Lorentz theory, which is still found to be useful. It might be asked therefore whether the mistakes are important. I suggest that they are immensely important. Students are told that the theory must be accepted although they cannot expect to understand it. They are encouraged right at the beginning of their careers to forsake science in favour of dogma. The general public are misled into believing that science is a mysterious subject which can be understood by only a few exceptionally gifted mathematicians. Since the time of Einstein and of one of his most ardent supporters Eddington there has been a great increase in anti-rational thought and mysticism. The theory is so rigidly held that young scientists who have any regard for their careers dare not openly express their doubts.

Experimental checks

It is often claimed that the special theory of relativity has been confirmed by experiment. In fact no experiment has been carried out in which symmetrical measurements have been taken at each of two stations moving relatively to each other with the required high velocity; and there has therefore been no check at all on the relativity aspect of the theory, which is of course its essence. Any checks that have been made can only relate to the Lorentz theory to which Einstein returns by accepting the paradox result. Moreover even with this limited interpretation the checks are always far from convincing.

This is true for example of a recent experiment in which four atomic clocks were compared with similar clocks at an observatory after they had travelled round the world in both an eastward and westward direction. It was claimed that the result provided an unambiguous resolution of the clock paradox. Now the paradox result was deduced, mistakenly, from the special theory which was concerned only with

uniform relative velocity, but the results predicted for this experiment were based on gravitational and kinematic effects. It does not seem therefore to have any connection with the clock paradox, as described by Einstein. The untreated results given in the paper indicate that the average clock lost 132ns (nanoseconds or 10-8s) for the

"... the continued acceptance and teaching of relativity hinders the development of a rational extension of electromagnetic theory."

eastward journey and gained 134ns for the westward journey, but since the difference between individual clocks was as much as 300ns little, if any, significance can be attached to these average values. The authors do not use all the results and apply a statistical analysis, details of which are not given, to those they do use. They conclude that the average clock loses 59ns on the eastward flight and gains 273ns on the westward flight in close agreement with the predicted values. These criticisms were rejected by *Nature* but subsequently published elsewhere⁵.

A hope for the future?

There are fortunately a few writers who are breaking with tradition and developing new ideas which may be fruitful. In this country there are two small volumes by H. Aspden and in France R. L. Vallee has published at theory of energy which appears to be gaining in spite of much opposition. A society, the S.E.P.E.D. has been formed for the promotion of his ideas. One important conclusion he reaches is that space contains an unlimited amount of high frequency energy which could possibly be extracted and used with safety and efficiency.

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Digital PAL coder

Binary inputs produce composite PAL signals for primary or complementary colours, black and white.

by O. J. Downing, Ph.D., **& J. E. Tully,** M.Sc., Postgraduate School of Electrical & Electronic Engineering, University of Bradford.

The increasing use of television as a display medium for digital signals has stimulated the present design of a PAL coder capable of accepting binary R(ed), G(reen) and B(lue) input signals and of producing a composite PAL video output corresponding to the relevant primary or complementary colour, black or white.

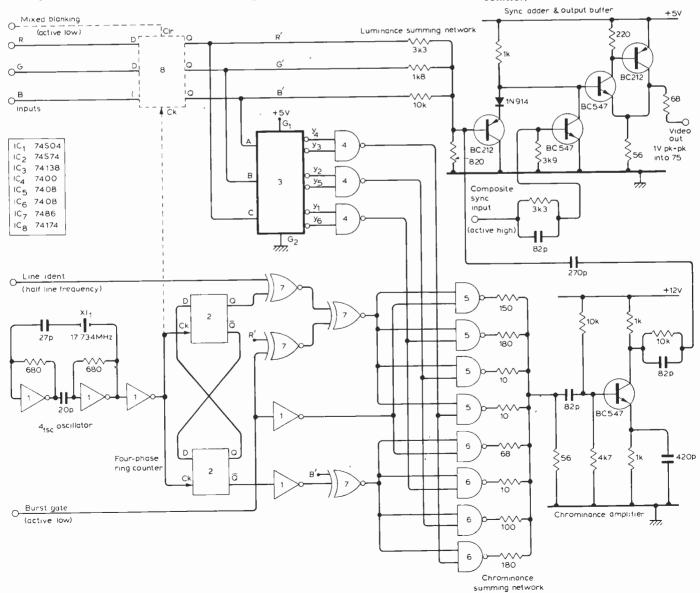
A QUICK GLANCE at the PAL equation suggests that the chrominance part of the video signal can be obtained by adding colour subcarrier frequency (f_{sc}) sinusoidal and co-sinusoidal components, of suitable amplitudes, to the luminance signal. In this design these are obtained by counting a $4 \times f_{sc}$ clock signal IC_1 with a four-phase ring counter, IC_2 to give square-wave subcarrier phases of $-90^{\circ}, 0^{\circ}, 90^{\circ}$ and 180° .

It is found, firstly, that the phases of the sine and cosine components, i.e. + or -, are controlled by the values of B and R respectively during active line (the phase of the sine term must be complemented during burst). And secondly that the amplitudes of these components are the same for each colour and its complement, thus requiring a total of three different amplitudes. The phases of the sine, cosine terms are selected using exclusive-NOR gates, IC₇, one of which complements the cosine component from line-to-line to give phase-alternation. The relevant amplitudes are obtained by switching weighted currents into a low-resistance node via 3-8 line decoder IC3. The luminance component is obtained in a similar way direct from the R, G and B signals.

The nearest 10% tolerance resistors to the theoretical values were used in the prototype and gave well-defined primary and complementary colours; alternative selections of resistor values could be used to provide an alternative set of colours.

The input latch shown in broken lines is optional but provides a convenient means of blanking and de-skewing the inputs, and of presenting defined logic levels to the luminance scanning network. The use of this latch and a fairly wideband chrominance amplifier also minimizes colour fringing at vertical edges and obviates the need for luminance "delay".

Chrominance signal is obtained by counting 4 ≤ subcarrier-frequency clock signal and four-phase ring counter.



Negative feedback and non-linearity

Exploring the fallacy that n.f.b. reduces all harmonics equally

by 'Cathode Ray'

MR M. G. SALEM has recently called attention (in the July issue, pp. 59-60) to the fallacy, apparently not yet extinct, of supposing that negative feedback reduces all distortion harmónics equally, by the same factor as it reduces the gain of the amplifier to which it is applied. In doing so he mentioned, in effect, that I had put an explosive charge under this particular fallacy quite a long time ago - actually April 1961 under the above title, repeated as Chapter 19 in Essays in Electronics. Having myself forgotten doing so, I feel confident that few other than Mr Salem are so familiar with the said work that the following revised version of it will be greeted with widespread cries of protest against excessive repetition.

Undoubtedly the first thing to learn about negative feedback is that it is never so simple as it looks. Superficial study gives one the impression that it reduces undesirable things such as distortion of all kinds and noise, mains hum, etc., dividing them by (1-AB) or (1 + AB), depending on the conventions adopted. Also that the input and output impedances of the amplifier to which it is applied are either decreased or increased - in the same ratio? The truth is that, even if such complications as phase shifts are excluded, none of these things is necessarily so. The effects on impedance will not be in the same ratio. In general, noise reduction won't be, either. Some kinds can even be increased by negative feedback. In simple cases the reducing effect on distortion is more dependable, but even there one can easily go wrong, as in the example Mr Salem pointed out. That example concerned non-linearity distortion, the effect of which is to introduce signal frequencies (harmonics and intermodulation) not present in the original. Reducing non-linearity is usually the main object of negative feedback, because that causes the most objectionable kind of distortion. No amplifier with any claim to be suitable for highquality sound reproduction would be without negative feedback.

So let us start with a reminder of how it is commonly said to reduce nonlinearity distortion. Fig. 1(a) shows an amplifier with an A-fold voltage gain. For every millivolt (say) applied to the input it gives A millivolts out. To simplify things later, we assume that the amplifier is a phase-reversing one, as

indicated by the gain being shown as -A. Now feed back a fraction B of this output, as at (b). The voltage fed back is thus -AB. From the point of view of the input terminals of the amplifier the -AB fed back is in opposition to the signal required between those terminals (=1). The signal needed between XX to maintain the amplifier signal level as before is therefore 1 + AB, of which the + AB offsets the -AB fed back, leaving a net input of 1*.

Fig. 1 thus shows that negative feedback reduces the overall or gross gain of the amplifier from A to A/(1 + AB) – often denoted by A'. At this point all the books mention that if the design makes AB so much larger than 1 that 1 can by comparison be neglected, A' becomes (as near as makes no matter) 1/B. The great significance of this is that B usually depends solely on something like a potential divider that is perfectly linear, so the non-linearities involved in A are more or less removed. These and other advantages are paid for by the extra amplification needed to make AB very much larger than 1 and at the same time to ensure enough net input.

We now switch attention to the distortion created inside the amplifier by its non-linearity. It can be considered as if due to an additional input, say d millivolts; or, hopefully, microvolts. At first we might suppose that because applying negative feedback reduces the gain from A to 1/(1 + AB) then the legitimate signal and the distortion would both be reduced in the same ratio, so the percentage distortion

*If no assumption is made about the polarity of the amplifier output being negative with regard to the input, the gain being called just A, then the gross input works out as I - AB. This is correct for positive feedback, but for negative feedback either the amplifier or the feedback arrangement has to be phasereversing, represented by making the value of either A or B negative, thus cancelling out the minus and giving I + AB as in Fig. 1(b). As we are considering only negative feedback, it seems rather pedantic and unnecessarily confusing to have to remember to use a double negative every time. In practice there are only (usually) two frequencies at which AB is simple plus or minus; for all the rest one has to consider other phase angles than $\boldsymbol{0}$ and 180 , using 'complex' algebra. But it is a very simple recap we are having, with a view to making just one point, not an exhaustive treatise on negative feedback.

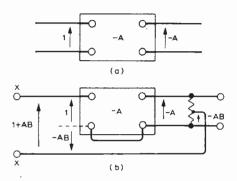


Fig. 1. (a) represents an amplifier without feedback, and (b) the same amplifier with feedback, a fraction B of the output voltage being tapped off and returned to the input. In this case the amplifier is a phase-reversing one, so its voltage gain is shown as —A. The voltage fed back is therefore in opposition to the input voltage, which has to be increased accordingly; i.e., the feedback is negative.

would be unchanged. However, comparing (a) and (b) in Fig. 1 we see that the signal level inside the amplifier, and therefore the amount of distortion, is the same in both cases, whereas the gross signal input is much greater in (b). Therefore distortion as a percentage of the signal has been reduced by feedback in the same ratio as the gain.

That is the point at which writer or reader (or both) tend to suppose that this important feedback law has been duly established and they can go on to something else. As an optional extra it may have been noted that if the gain of the amplifier is assumed to be (near enough) the same at all audio frequencies — as of course it ought to be — then the distortion harmonics and intermodulation products are all equally reduced by negative feedback.

But before hurrying on let us consider precisely what we have been meaning by A. We defined it — or, to be fair to you, I defined it — as the number of signal millivolts received at the output (Fig. 1(a)) for every millivolt applied at the input. But I didn't insist on millivolts, or on any particular signal level. The same A was assumed to hold good for the (presumably) much lower level of the distortion. In other words, A was assumed to be linear. That being so, it wasn't very clever to use it in a calcula-

tion concerning amplifier non-linearity. True, we guarded against complete absurdity by making the signal voltage in the amplifier the same in both Fig. 1 diagrams. But if the non-linearity is considerable, so that the distortion is a significant part of the total output, that safeguard isn't good enough. For, when the feedback is applied and reduces the distortion, the total output will be different.

The correct procedure, now that an element of doubt has been found to exist in the basis of the argument, would be to embark on a comprehensive and rigorous mathematical analysis that would cover every case. But you know me too well to expect that. Anyway, the higher the level of maths the greater the risk of going wrong or of the truth being obscured. (Mathematicians, don't bother to write to me on this, for I shall decline to answer.)

The 'line' in 'linearity' is the graph of output against input. These come in two kinds. One of them could be plotted by connecting a calibrated signal generator to the input of the amplifier and varying the signal strength there while measuring the corresponding peak or r.m.s. voltages at the output. It might look something like Fig. 2. There would

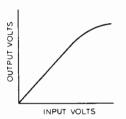


Fig. 2. This is one kind of output/input graph, in which the voltages are peak or r.m.s. values.

be no point in reversing the connections with the idea of extending the curve into the negative region, for its shape would necessarily be the same in reverse. The other kind, which is the one we are going to study, is seen by substituting the Y plates of a cathode ray oscilloscope for the output voltmeter, and connecting the X plates (with suitable distortionless amplification) across the input. The positive and negative half-cycles obviously swing the curve in both directions from the origin as their instantaneous values are shown on the screen, and their shapes are not necessarily the same.

A perfectly linear amplifier would yield a perfectly straight 'curve', as in Fig. 3(a). In the case of a power amplifier this would merely show it was being uneconomically under-driven. In a commercial world it is necessary to work up to some distortion, even though it be limited to less than 0.1%. Most amplifiers, so long as they are not over-driven, tend to show curves of two main shapes (or combinations of both), as in Fig. 3(b) and (c). The first has a

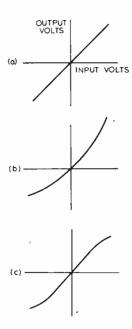


Fig. 3. In this kind of output/input graph, instantaneous voltages are plotted. (a) is a linear (distortionless) characteristic; (b) and (c) are non-linear curves, representing respectively second and third order distortion.

square-law term in its output/input equation, which generates a second harmonic of the signal, and second-order intermodulation. The second has a cubic term and generates third-order distortion, which sounds worse.

Now A (being output/input) is represented in these Fig. 3 diagrams by the slope of the curve. In (a) the slope is the same throughout, so A is constant and (assuming, as we usually can, that B is likewise) there need be no question as to exactly what 1 + AB means. But in such a situation there is no need for feedback! In (b) and (c), A is varying all the time, so one doesn't know what figure to insert for it when using the formula. We can say that Fig. 3(b) indicates a smaller A at the negative peaks than at the positive, so presumably the negative part of the curve is straightened out less by negative feedback than the positive part, but the effect on the distortion is difficult to assess without a large-scale mathematical operation. Let us see what we can do without

In order to find out whether the harmonic structure of the distortion (as distinct from its amount) is affected by feedback there should be no need to consider any particular practical amplifier. That is just as well, because it would be quite tricky to represent typical crossover distortion mathematically. A single transistor is easier, because it does have a Fig. 3-type graph that is a good approximation to an exponential curve, and (with suitable assumptions) the corresponding array of harmonics in the output can be derived as a basis for calculation. But why bother? Things will be much easier and clearer if (at least for a trial) we assume we have a hypothetical amplifier with a pure square-law characteristic, like Fig. 3(b), and plotted quantitatively as Fig. 4, using the equation.

$$v_o = 100v_1 + 1000v_1^2$$

where v_o is the instantaneous output voltage and v_i the sinusoidal input voltage. This gives the amplifier a gain of 100 as regards the fundamental.

A simple calculation shows that with a peak v_i of 0.04V the $1000v^2$, term causes 20% second-harmonic distortion. We can do it graphically by drawing a straight line joining the tips of the curve, noting how far up the v_o axis it comes (1.6V in this case) and lowering the line half the distance. It is then the linear part of the characteristic responsible for the fundamental, shown (dotted) as a pure sine wave in Fig.5 (a) The actual amplifier curve I have plotted in Fig. 4 is 0.8V lower at zero v_i and 0.8V higher at posititve and negative peaks. The points can be transferred to Fig. 5(a), and when joined up by the full line show what comes out of the amplifier when 0.04V peak is put in. The difference between this and the fundamental has been plotted below, (b), and is clearly a second harmonic. Both Fig. 4 and Fig. 5 show that its peak value is 0.8V, which in relation to the fundamental's 4V is 20%.

Anyone with the most elementary knowledge of the differential calculus will realize that the easiest way of finding the slope (which is A) at any point on the Fig. 4 curve is to differentiate its equation, thus:

$$A = \frac{dv_o}{dv_1} = 100 + 2000v_1$$

So at zero v_i it is 100, which is what one would expect, since an input confined to very small values of v_i would yield neligible distortion, and 100 is the slope of the fundamental line, corresponding to an amplification of 100. At the

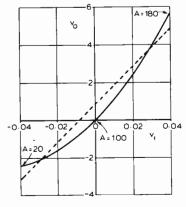


Fig. 4. The full line is a graph of the Fig. 3 (b) type. The broken line shows its fundamental part; the vertical difference between the two represents second-harmonic distortion, as shown in Fig. 5.

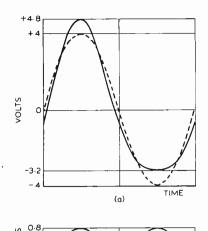


Fig. 5. The full line in (a) shows the output waveform of an amplifier with the characteristic shown in Fig. 4, when the input is a pure sine wave. The broken line is the fundamental part, corresponding again to Fig. 4. The difference between the two, shown by itself at (b), is the second harmonic.

positive peak it is 100 + 80 = 180 and at the negative peak it is 100 - 80 = 20. So 20% distortion, which is not as horrible as you might expect, if it is all second harmonic, is associated here with a no less than 9 to 1 variation in amplification over each cycle of signal. We can hardly be surprised, then, if we find that negative feedback doesn't work entirely according to plan.

Perhaps the best way of seeing how it does work is to plot a with-feedback curve to compare with Fig. 4, which can be done by making a table to calculate some points. Remember, the voltage fed back at any point is equal to Bv_0 , and this added to v_1 gives v_1' , the with-feedback input needed.

To make it easy to compare the two curves, the ν' scale of the new one should be the ν_i scale of the old multiplied by as many times as ν'_i must be greater than ν_i to maintain the same output. A convenient figure for this, which is also reasonable for feedback practice, is 10. (1 + AB) being 10, AB is 9 and B is 0.09.

(1)	(2)	(3)	(4)
$\mathbf{v_i}$	$\mathbf{v_o}$	$0.09v_o$	$\mathbf{v}'_{\mathbf{i}}$
0.01	1.1	0.099	0.109
0.014	1.596	0.1436	0.1576
0.02	2.4	0.216	0.236
0.03	3.9	0 351	0.381
0.04	5.6	0.504	0.544
-0.01	-0.9	-0.081	-0.091
-0.02	-16	-0.144	-0.164
-0.03	-2.1	-0 189	-0.219
-0.04	-2.4	-0.216	-0.256

Column (1) contains a selection of points covering the peak-to-peak swing of v_i . Column (2) contains the corresponding output voltages calculated from the equation, which were needed for plotting Fig. 4. Column (3) shows the voltages fed back, equal to $0.09v_0$. Lastly column (4), which is got by adding (3) to

(1), shows the input required at XX in Fig. 1(b) to maintain the same output (2) as before.

Plotting Fig. 6 from columns (2) and (4) we are at once impressed by the success of negative feedback in straightening out the amplifier curve. It is now hardly distinguishable from a straight line, especially on the positive side.

Becoming a little more critical, we note that we need considerably more than 10 times the former peak input; to be exact, 13.6 times. But 10 was calculated on the basis of A=100, whereas we have already noted on Fig. 4 that A varies from 100 to 180 during the positive half-cycle, and if we calculate the average multiplier for this range of values of A we find that it is 13.6. Rather than find fault here we might thank feedback for raising the positive fundamental peak output from 4V with 20% distortion to 5.5V with about $1\frac{1}{2}$ % distortion.

On the other hand any satisfaction that might at first be derived from seeing that the input needed for the negative peak has been increased only 6.4 times is damped by the unfortunate accompanying fact that the fundamental negative peak has been reduced from 4V to about 2.5V. And of course a 5.5V positive peak is no good with a 2.5V negative peak — unless use of the amplifier is confined to rather unusual waveforms.

It seems, then, that if at least our original 4V peak sine-wave output is to be maintained it will be necessary to bring up the negative input, as we would be able to do, seeing that we were prepared to find at least ± 0.4 V. To see what we get we shall have to extend our plots in the negative direction. If we proceed to calculate column (2) we find that beyond $v_i = -0.05$ V a complication sets in; increasing $-v_i$ reduces $-v_o$ making the curve bend up. This is because the curve is derived from the equation for A, which makes A negative if v_i is more negative than -0.05V.

In a real amplifier, however, the de-

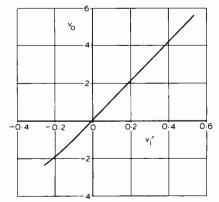


Fig. 6. This, for comparison with Fig. 4, is the result of reducing the small-signal gain A-fold by negative feedback and correspondingly increasing the external input (v') to yield the same net input (v_i) as before.

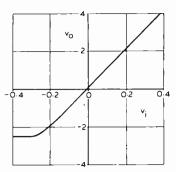


Fig. 7. The result of further adjusting the input v_i to ± 0.4 V. Audibly, the result would be worse than without feedback (Fig. 4), and the output less.

cline of its gain to zero during the signal cycle is normally due to the cutting off of one or more transistors. In the usual push-pull configuration — in which distortion is largely third-order — the gain recovers as the signal goes more negative; indeed, if the biasing is correct it shouldn't fall off in the first place. But we are considering a square-law amplifier, to which the nearest practical approximation is a single-ended type, which cuts off altogether if the signal goes too negative. So a realistic procedure will be to continue the curve horizontally to the left:

$\mathbf{v_i}$	$\mathbf{v_o}$	$\mathbf{0.09v}_{o}$	\mathbf{v}_{i}
-0.05	-2.5	0.225	-0.275
-0.06	-2.5	-0.225	-0.285
-0.07	-2.5	-0.225	-0.295

At this rate it is obviously going to take us a long time to reach $v_i' = -0.4$, but we now have enough information to omit the intermediate stages and boldly write

$$v'_i = -0.4$$
; $v_0 = 2.5$

Continuing beyond our original $\pm 0.4 V$ (to match the $\pm 0.04 V$ in Fig. 4) is clearly not going to make the picture any prettier, so in Fig. 7 I have kept within those limits. Now we see the truth about negative feedback, and it doesn't look as good as we may have supposed. And if anyone is thinking I've fiddled it by arbitrarily departing from the simple quadratic equation at the negative end, I invite him to stick to the equation. The result will be even more ghastly than Fig. 7.

That is quite bad enough, for on analysing Fig. 7* I find that the fundamental output is only just over 3V peak, compared with 4V in Fig. 4 (a power reduction of 44%) and in exchange for our 20% second-harmonic distortion we have received the following mixed bag:

Harmonic	Percentage
2	13.2
3	7.4
4	3.3
5	1.24
6	0.16
1	0.83

^{*}By the method described in M. G. Scroggie's Radio & Electronic Laboratory Handbook, 8th edition. Sec. 11.10.

plus undetermined amounts of higher harmonics which, judging from the sharpness of the bend in Fig. 7 and the magnitude of the 7th harmonic, are likely to be very significant aurally if not numerically. It is true that the total harmonic distortion, found by taking the square root of the sum of the squares of the above lot, is only 15.6% But if anyone thinks this is an improvement on the 20% without feedback he oughtn't to be let out alone in the hif-fi market. He would be an easy prey to the merchants, whose motive in quoting t.h.d. figures is only too clear to those who have compared actual sound reproduction with the harmonics present. Though opinions of authorities differ as to the factors by which harmonics higher than the second should be multiplied to give some idea of their relative unpleasantness, the most conservative suggest (without necessarily admitting that it is adequate) a weighting factor equal to half the harmonic order. For instance, the 0.83% 7th harmonic would have to be multiplied by 31/2, raising it to 2.9%. D. E. L. Shorter of the BBC considered the square of this factor not excessive. That would raise the 7th-harmonic figure for comparison with the second to over 10%.

At this point a red herring labelled 'intermodulation' is almost certain to be seen crossing our path. But if any benefit is to be derived from the time you have so self-sacrificingly spent in following me thus far, I advise that we refrain from spending any more in chasing after it. No doubt we know that the products of intermodulation, being in general not musically related to the tones present in the original sounds, are more objectionable than at least the lower harmonics, which are; but it doesn't follow that one must insist on intermodulation data and refuse harmonics as worthless substitutes. For, when measured under comparable conditions, harmonic percentages are more or less proportional to intermodulation percentages, so can be used as comparative indexes of intermodulation, easier to measure. And anyway, in this case we are getting the higher harmonics, which are discordant in their own right.

Another possible red herring is one that isn't nearly as fresh as it is often made out to be by means of new-fangled terms such as transient intermodulation distortion and slewing-rate distortion. It is in fact many years old, and although it too is an undesirable product of ill-designed negative feedback it also is an avoidable one, not directly related to the present subject.

Getting back to our uneasy contemplation of Fig. 7, we see that there is nothing for it but to reduce the input signal until the sharp bend is cleared; say ± 0.25 V peak. The output, which by then is nearly all fundamental, is barely 2.5V, or less than 40% of the power we got in Fig. 4, admittedly with lots of

second harmonic too. But if we reduce the fundamental without feedback to the same level, the second harmonic comes down to 12½%, which on paper is certainly not hi-fi, but wouldn't greatly offend as many listeners as you might think.

It is now time to sum up:

- (1) The common belief that negative feedback reduces non-linearity distortion in the same ratio as it reduces amplification is strictly true only if there is no non-linearity to reduce.
- (2) However, provided that the original non-linearity is not so bad that the slope of the output/input curve (which is the amplification) falls seriously below the nominal value at any point within the maximum signal amplitude, the common belief is fair enough.
- (3) It follows from (1) and (2) that any idea that one can sling an amplifier together any old how and pull it straight with liberal supplies of negative feedback is unsound even apart from the practical difficulties of this treatment.
- (4) While negative feedback works like a charm on amplifiers with moderate non-linearity, run well within their capability, it doesn't necessarily increase the amount of power that can be drawn; on the contrary, it may reduce it. (5) In any case, once the signal amplitude runs past the nearly-undistorted limits, it abruptly becomes very distorted, not only as regards quantity but even more as regards quality. In other words, even a moderately overloaded amplifier sounds a lot worse with feedback than without.
- (6) The fact that hi-fi fans insist, especially in America, on vast numbers of output watts being available, in spite of the surprisingly small average power needed for even quite loud reproduction, is thus explained.
- (7) The fact that demonstrations of 'hi-fi', unless conducted by masters of the art, are usually such painful experiences, is also explained. The demonstrator so often doesn't reckon that he is doing his job if the output falls below the maximum rating.

Except by dividing signal voltages by 10 in order to be more appropriate for modern transistors than were those in the valve version of 1961, and writing a new introduction on Fig. 1, I have followed much the same lines as in the original and have arrived at the same conclusions. Present readers will no doubt be thinking I ought to have reduced the distortion figures by a factor of at least 10 to be more in accord with present-day amplifiers. But it must be remembered that, with the larger amounts of feedback now used, its effects on overloading can be even worse than are shown here, intentionally exaggerated though they were to get the message across. This has been dramatically confirmed as recently as the July 1978 issue, where on p.57 James Moir showed a curve which clearly illustrates my very point — that distortion without feedback is, at a certain output level, suddenly and vastly overtaken by distortion with feedback.

I hope that, by confining the nofeedback distortion to only one harmonic, I have left no room for the fallacy that all distortion harmonics are necessarily reduced by negative feedback in the same ratio as the gain — or even at all, since we have seen that many harmonics can actually be created by feedback that were not there without it.

LITERATURE RECEIVED

Illuminated push switches illustrated and described in 28-page catalogue from Licon, Norway Road, Hilsea Industrial Estate, Portsmouth PO3 5HT WW414

Power supplies and components for use with equipment vulnerable to transients and poor line regulation and in conditions where a supply must not be broken are all described in the Topaz catalogue from Euro Electronic Instruments Ltd, Shirley House, 27 Camden Road, London NW1 1YE WW415

Single-board computers in the Intel iSBC range of o.e.m. equipment have been summarized by Rapid Recall in a pocket guide, obtainable from Rapid Recall at 9 Betterton Street, Drury Lane, London WW416

Turntables from Collaro are updated and described in leaflets from Magnavox Electronics Company Ltd, By-pass Road, Barking. Essex 1G11 0TF WW417

Picoammeter from Keithley, Model 480, is discussed in general and specified in a brochure from Keithley Instruments Ltd, 1 Boulton Road, Reading RG2 0NL . WW418

"DC Motors, Speed Controls, Servo Systems" is the title of a 500-page handbook from Electrocraft. It is available at £3 from Unimatic Engineers Ltd, Granville Road Works, 122 Granville Road, Cricklewood, London NW2 2LN.

Add-on oscilloscope waveform store — 1

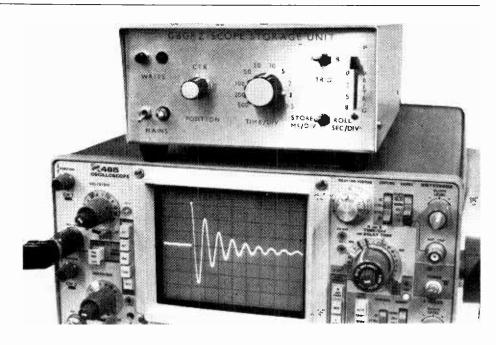
Digital unit for audio waveform storage and display using a dual-channel oscilloscope

by R. D. Fastner

The instrument described here employs digital storage techniques to allow an ordinary dual-channel oscilloscope to function as a storage type. The input signal to the oscilloscope is extracted, converted to digital form, stored, converted back to the analogue form and displayed on the oscilloscope screen. A useful feature is that the waveform before the trigger pulse can be displayed. Circuitry is included to remove the "steps" in the waveform which would ordinarily be the result of a sampling process. Interfacing with the oscilloscope is not dealt with in detail, since requirements vary with facilities existing already.

THIS IS a mains-powered instrument designed to give a storage facility to a non-storage oscilloscope. The instrument consists of an analogue-to-digital converter, 8000 bits (1000×8) of memory, a digital-to-analogue converter and a step eliminator, which converts the normal step output of the d.a.c. to straight lines. This greatly improves the presentation of stored waveforms with few samples. There is also some control circuitry to control the read/write, sync. and blank functions. A crystal oscillator is used for simplicity and stability, and its frequency is divided down in a 1, 2, 5 sequence to give 10 time/division ranges. There is also a roll mode of operation which gives an extra nine time/division ranges below that of the normal storage mode. A useful pretrigger function enables the unit to store the waveform leading up to and away from the trigger point - a mode which is not possible with normal c.r.t. storage. An advantage of this system of storage is that the waveform may be expanded and analysed after being stored.

Since the unit may be used to store digital waveforms with fast transitions a tracking a-d converter was rejected because of its slow full-scale slew rate. The successive-approximation type used will reach any level in a maximum time of 2% of a division, assuming the input changes state during the first of the two samples. On the other hand, the slew time of the tracking type of converter depends on the input levels, and has a maximum time of 2ⁿ clock pulses. Reduction of this time can be accomplished by increasing the clock frequency when the difference between input and digital output is greater than



The storage unit in use, displaying a test waveform.

a specified amount. The frequency can then be reduced when the difference between the levels has been reduced. There is the disadvantage, in this mode of operation, that more complex circuitry is needed to detect the levels at which the higher speed clock is gated in and out.

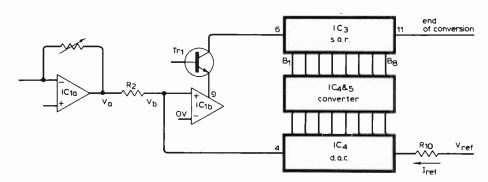
Random-access memory i.cs were rejected as storage elements in favour of shift registers, because the register's sequential operation suited the circuit operation. One disadvantage of r.a.ms is the need for address lines, which results

Fig. 1. Block diagram of the input circuit and d-a converter.

in more components and greater complication in p.c.b. layout. Another is the increased complexity of the circuitry, especially regarding roll and pretrigger functions.

Analogue-to-digital converter

Analogue input waveforms are converted to 8-bit binary form to provide 256 discrete levels on conversion back to analogue form for display. The converter, shown in Fig. 2, is in action continuously, whether the instrument is reading or writing. It uses three integrated circuits to perform its major functions: a MC14559 c.m.o.s. successive-approximation register (not the locmos version, which has a higher propagation delay); a MC1408-L8 bipolar, 8-bit digital-to-analogue converter; and MC1407 bipolar a-d control circuit, which is a wideband amplifier and comparator. Transistor Tr1 shifts vol-



tage levels from the bipolar 5V of the MC1407 (IC $_{\rm l}$) to c.m.o.s. 15V for IC $_{\rm 3}$ and, similarly, the eight buffers in IC $_{\rm 2.5}$ shift levels back to 5V for the bipolar MC1408-L8 - IC $_{\rm 4}$

Operation. In essence, the converter is an analogue-digital-analogue feedback loop. The block diagram of Fig. 1 shows the input amplifier, IC _{la}, whose output is taken to a voltage comparator, IC _{lb}. Via the level shifter, Tr _l, the comparator controls the successive-approximation register, IC ₃, which is clocked. The digital outputs of the s.a.r. are buffered and applied to the digital-to-analogue converter, IC ₄, whose output is then taken back to the comparator. The loop circulates until the two comparator inputs are zero.

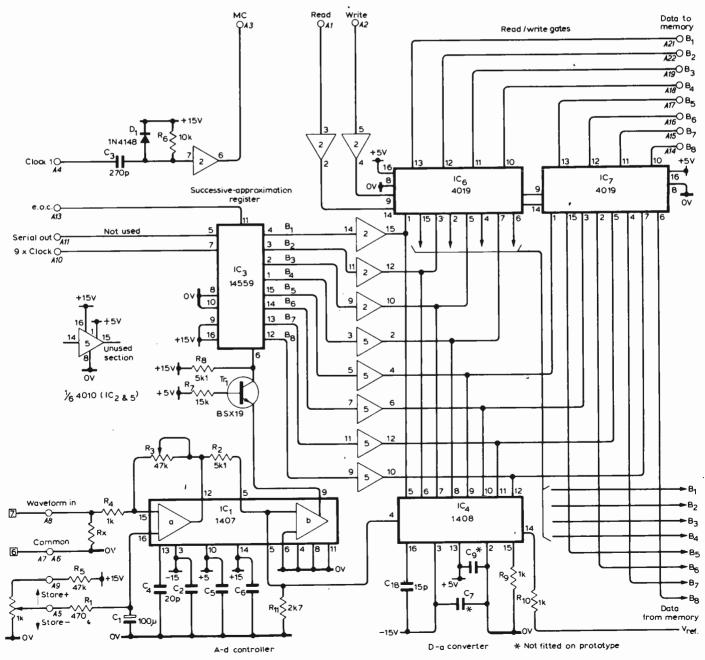
Assume that, in Fig. 2, the s.a.r. is reset, with B1 to B8 low: IC₄, the d-a converter in the a-d loop, is drawing no

current via its output pin 4. Also assume some positive output, V_a , from IC₁, pin 12. The comparator sees a positive voltage, V_b , on its non-inverting input, IC₁, pin 5; its output, pin 9, is high. Transistor Tr₁, the 5V-15V level shifter, is off and its collector is high. This high voltage is fed into the s.a.r. D input, IC₃, pin 6 which, on receipt of the first clock input, enables B1, the most significant bit, which appears on IC₃, pin 4, to be set. When the m.s.b. goes high, it is converted down to the 5V level and is fed into IC₄, pin 5. IC₄ now draws $I_{ref}/2$, and V_b , the voltage at the comparator

Fig. 2. Circuit of the a-d converter. The gates in $IC_{6,7}$ are controlled by the read/write circuitry and connect the digitised input to the memory or the output of the memory to its input for re-circulation.

input is now $V_a - I_{ref}/2 \times R_2$ If this voltage is positive, the comparator output will be high; if negative, the output will be low.

If it is high, the next clock pulse sets IC₃, pin 3, which is bit 2, high. This causes IC₄ to draw $I_{ref}/2 + I_{ref}/4$, hence the current corresponding to each bit is half that for the previous one. Now, V_b = V_a - $(I_{ref}/2 + I_{ref}/4 \times R_2)$ and is again compared as before. This time, if V_h is negative, the comparator output is low and the next clock pulse simultaneously resets B2 and sets B3. The output of IC3 draws $I_{ref}/2 + I_{ref}/8 \times R_2$ and again the IR product is subtracted from V_a and the result compared. This sequence is continued for all eight bits, each being generated, added to the previous bit, compared and reset or remaining set to keep $V_b = 0$. At the end of the sequence, IC₃, pin 11, which is "end of conversion" (e.o.c.), goes high and is used to



O- A numbers indicate board terminations

WIRELESS WORLD, OCTOBER 1978

generate a pulse, which sets a flip-flop and strobes the data into memory by means of a write pulse and IC_{6,7}. The complete sequence is nine clock cycles long, the e.o.c. being half a cycle wide.

Memory

Sixteen NE2528, dual 250-bit, c.m.o.s. shift registers are used for the memory, operated from +5V and -8V (no 0V). The data is clocked through by a modified end of conversion (e.o.c.) pulse generated by the a-d converter.

Since the memory is, in effect, eight large shift registers, as seen in Fig. 3, all that is required for operation is a clock and some read/write gating. Two 4019 and-or gates, seen in Fig. 2, are used for this gating, controlled by the read and write inputs. The latter enables the gates from the a.d.c. to the memory input, whilst the latter inhibits the gates from the memory output to input. When

the unit is in a 'write' condition, the first bistable in the memory acts as a latch, eliminating the need for separate

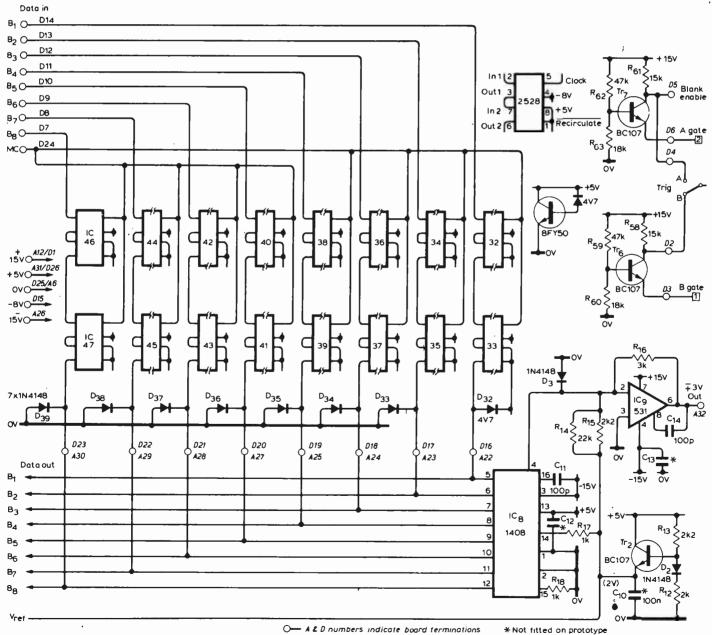
The NE2528 shift registers require a high clock pulse width of not less than 200ns and a low pulse width of not greater than $100\mu s$; if the clock pulse is low for longer than 100µs data is lost, but it may stay high indefinitely. For this reason, R_6 and C_3 in Fig. 2 are required to form a pulse generating circuit, whose function is to limit with width of the clock pulse to approximately 3µs when on low clock rates. Omission of these components results in the stored waveform deteriorating as the memory i.cs warm up.

Fig. 3. Circuit of the memory and d-a converter. IC9 provides the output for the step eliminator of Fig. 5.

Outputs B₂₋₈ are clamped by 1N4148 diodes to prevent them forcibly switching on the d.a.c. inputs. Output B₁ is clamped by a 7.4V zener diode from +5V because it was found that if this input went 0.7V negative, the output appeared to have "crossover distortion." Several d.a.c. chips were tested and all showed this distortion. No mention of this phenomenon was found in the specifications of the d.a.c. chip.

D-a converter

A second MC1408-L8 i.c., IC, is used for the d-a conversion as shown in Fig. 3. Since the device has a constant current-output it is followed by a current-to-voltage converter, IC. The inputs to the d.a.c. are taken from the outputs of the memory.' A positive current corresponding to B₁ is fed into the output of the d.a.c. via R_{14} and R_{15} , causing the output of IC9 to become



* Not fitted on prototype

bipolar. If B_1 were presented to IC $_{8/9}$, pin 4 would draw $I_{ref}/2 = V_{ref}/R_{17} \times \frac{1}{2} = 2V/1k \times \frac{1}{2} = 1$ mA. R_{14} and R_{15} in parallel equal approximately $2k\Omega$. R_{14} , the "select-on-test" resistor, is chosen so that with B_1 only the final output from the unit is 0V; i.e., it is an offset adjustment. R_{14} and R_{15} are connected to V_{ref} and, assuming their combined value is $2k\Omega$, supply the 1mA to IC $_{8}$ pin 4. As IC $_{9}$ input is a virtual earth, $IR_{16} = 0$ and therefore the output will be 0V. The voltage output from the circuit ranges from:

$$-IR_{14}R_{15}R_{16} = -V_{ref}R_{16}/R_{14}R_{15} = -3V$$
 to
$$-I_{d.a.c.(max)} + IR_{14}R_{15}R_{16} = 2.97$$
 or about $\pm 3V$.

The characteristics of the d.a.c. are such that the m.s.b. current switch is the fastest to operate and the least signficant bit is the slowest, with the intermediate bit-switching times increasing with decreasing significance. the transition B_1 off $-B_{2-8}$ on, to B_{2-8} off - B₁ on, results in some period of time when B₁ has switched on but B₂₋₈ (or any combination) have not switched off. During this short period of time all eight bits appear to be on and the output of the d.a.c. tries to draw maximum current, resulting in a negative-going spike. Diode D₃, a 1N4148 or similar, is included in the circuit to "fill in" this spike. If this diode is omitted IC9 output would try to follow the spike and a positive glitch would appear at the output.

The reference voltage generator is basically a potential divider buffered by an emitter follower Tr₂. The 1N4148 diode is included for thermal stabilisation

Clock

A 1.8 MHz crystal oscillator, seen in Fig. 4, is used to generate the maximum clock frequency required, which is nine times the maximum sample rate. This is divided down under control of the time/division switch, S_{5a} , to give a nine times clock output for each of the normal store mode ranges. As the output is fed only to the s.a.r. the whole circuit is operated from a +15V supply. MC14510 decade counters are used for the first two stages, IC_{20-21} , and a CD 4029 binary/decade counter, IC_{22} , for the third.

The output from the crystal oscillator is divided down by gating it into, or around, counters as required. Gates are operated in pairs and are enabled from the time/div. switch by diode logic. Ranges above 0.5s/div. use decade counters in the first two stages and a binary counter in the last. Binary out-

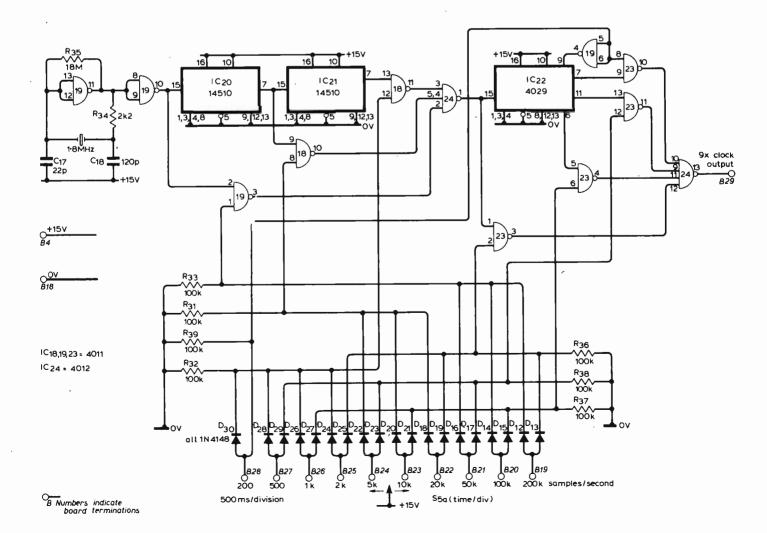
Fig. 4. Crystal oscillator and dividers, with gating for selection of final clock frequency.

puts 1 and 2 are used to give divisions of 2 and 4 respectively. The 0.5s/div. range is derived in a similar manner, except that the third counter is operated in the decade mode and the output is taken from the terminal count. If starting of the oscillator is unreliable the 18 megohm resistor in the circuit may be reduced to 10 megohms. This resistor sets the bias level at the input of the nand gate.

Step eliminator

The function of this circuit, shown in Fig.5, is to convert the normal step output of the d-a converter to something more presentable. It consists of a differential amplifier, followed by a sample-and-hold circuit and an integrator. The output is taken from the integrator, IC_{29} , via an inverting buffer, IC_{29} . The integrator time constants are selected by the time/div. switch.

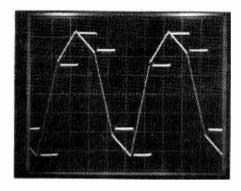
Assuming the input and output of the circuit are at 0V, the differential amplifier IC_{25} will also be at 0V and, when the 4016 analogue gate IC_{26} is strobed, the storage capacitor C_{28} will also be at 0V. When the strobe pulse is removed, the 4016 gate is disabled and has an impedance of several megohms. The voltage stored by C_{28} is buffered by IC_{27} , a LM301 voltage follower, and fed to the input of the integrator, which will remain at 0V by virtue of the virtual earth configuration.



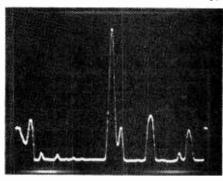
If an input step of 2V is now received, the output from IC_{25} will go to -2V, since it has unity gain. After approximately 2.5 µs, which is the time allowed for settling, IC₂₆ is strobed by a $0.5 \mu s$ pulse, the storage capacitor being charged to -2V, and is fed via IC₂₇ to the integrator, which is made to perform a positive-going ramp at a rate determined by the -2V and the timing components R₅₀₋₅₂ and C₃₁₋₄₀. Since the storage capacitor imposes a heavy load whilst charging, a reservoir capacitor, C₂₄, is connected from the output of IC₂₅ to 0V to supply the current during the strobe time.

The integrator output voltage is shown simply in Fig. 6. Input current $I_{in} = \text{fed-back}$ current $-I_F = V_{in}/R$. $V_c = Q_c/C$ and $Q_c = I_F t$, therefore $V_c = -I_F t/C$. But $I_F = V_m/R$, so $V_c = -V_c = -V_m t/CR$. CR is chosen to equal the same period t, so that $V_0 = -V_m$ by the end of the sample period, and therefore the integrator output = +2V.

If the second sample is also +2V, the output of IC_{25} will be (+2)-(+2)=0V, i.e. there will be no difference between the two inputs. After the next strobe, 0V will be presented to the integrator input and, since $I_{in}=0$, I_F must also be zero, and the output will remain at +2V. A third sample of -1V will make IC_{25} output (=2)-(-1)=+3V. This, when fed to the integrator, will cause it to fall linearly by 3V from +2V, resulting in a



The action of the step eliminator, using a waveform with a fewer number of steps than normally seen to illustrate the effect. The result of inaccuracy in the choice of integrator capacitors can be seen. Frequency in was 40kHz at 200 kHz sampling rate. Oscilloscope sweep 20µs/div., storage unit speed 2ms/div.



Pre-trigger of 5 divisions (graticule very faint). Large pulse is trigger.

Typical trace at 100 samples per cycle of the input.

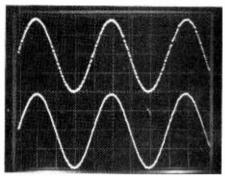
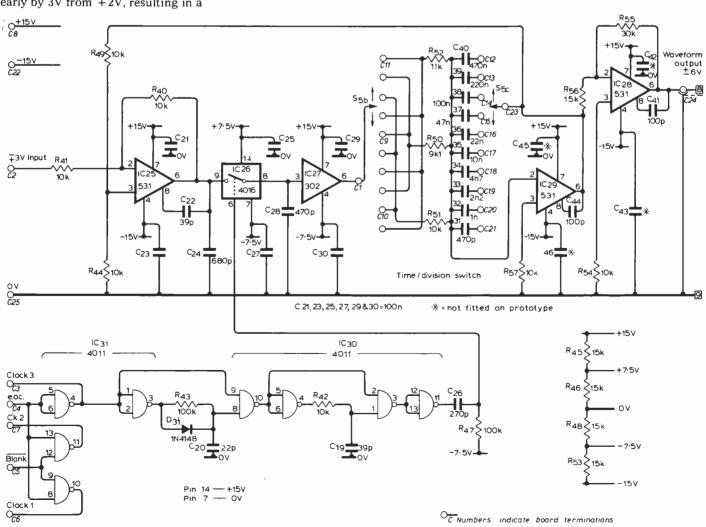


Fig. 5. Step eliminator and output amplifier. The faster ranges of the integrator should have close-tolerance capacitors to achieve the correct slopes.



voltage of -1V by the next strobe pulse. Photograph 1 shows the resulting effect, the slight errors in levels being due to the timing components not being selected for the correct time constants.

The input to the analogue gate is limited to slightly less than the supply voltage to the device. For the bipolar inputs required by the integrator, IC $_{26}$ is operated from a $\pm 7.5 \mathrm{V}$ supply. Thus, for safety, the input is limited to $\pm 6 \mathrm{V}$. This, in turn, limits the d.a.c. and integrator outputs to $\pm 3 \mathrm{V}$ since, if both were at opposite extremes, the resulting output from IC $_{25}$ would be $\pm 6 \mathrm{V}$.

Strobe pulse generation. The circuit, $IC_{30.31}$, consists of a positive transition detector, following an inverter, which gives a positive transition approximately $2.5\mu s$ after the negativegoing edge of the e.o.c. pulse. This delay

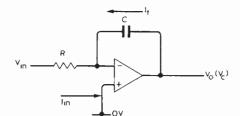


Fig. 6. Derivation of the integrator output voltage.

is required to allow for the data to emerge from the memory, the d.a.c. to settle and to allow the output of IC_{25} to charge C_{24} after the step input. The first positive transition detector is followed by a second one which gives a low going $0.5\mu s$ pulse after the positive going edge of the previous stage. Level shifting of the 0 to +15V pulse to -7.5V to +7.5V to be compatible with the gate IC_{26} is by

capacitive coupling in C26 with a pull down to -7.5V by means of R_{47} . For use with oscilloscopes with 8 divisions horizontally the 1.8MHz crystal, which gives 1,000 samples in 10 divisions at 0.5ms/div., may be replaced with one of 2.25MHz or 1.125MHz. The former gives 1,000 samples in 8 div. at 0.5ms/div. and the latter 1,000 samples in 8 div. at 1ms/div. The higher of the two may be too high for the a-d converter to operate reliably, and the lower reduces the unit time/div. ranges to 9. The time constants of the step eliminator will need to be reduced from 5 to 4µs, 10 to 8µs and 20 to $16\mu s$ and their decades (330 + 69, 680 + 120pF, 1500 + 100pF used with 10k Ω).

Printed circuit boards

A set of four double sided p.c.bs is available, at £14.00, including postage and packing, from M. R. Sagin at 23 Keyes Road, London N.W.2.

Mobile radio users campaign for more frequencies

FOR THE FIRST TIME in its twenty-five-year history, the Mobile Radio Users' Association (MRUA) is mobilising its membership to begin battle for the allocation of more frequencies for mobile radio. Warren Taylor, head of the MRUA, believes that, because the number of UK companies now switching to mobile radio is rising annually by more than fifteen per cent, the direct industrial and economic benefits from mobile radio could be tripled in the next five years. "Unless the whole business grinds to a halt in the next eighteen months," he says.

The results of a number of independent surveys, which have estimated that private mobile radio systems currently in use by British industrial and commercial organisations are providing direct savings in the region of £200 million each year, give an idea of what these economic benefits could be.

MRUA members, who include organisations ranging from multinationals like Shell and IBM to local mini-cab operators throughout the country, met in Bristol during July for the first "Freedom of the Air" Conference, to begin to build an international claim for more frequencies.

The Conference Bulletin, released in August, said that it was unanimously agreed that any restrictions, because of lack of frequencies, in the use of mobile radio would seriously affect the competitiveness of British industry. It said, "The UK economy requires free and unfettered use of enough spectrum to cope with industry's demand until the 21st century. The mobile industry had to succeed in deterring Governments (nationally and internationally) from increasing use of spectrum by broadcasting. It was essential that the broadcasting authorities give up duplicated and wasteful use of Bands I, II and III. These would provide enough spectrum to secure industry's use for the next decade"

It was put to the Home Office that the Users' Association might better handle the problems of users where frequency congestion and interference occurred. The Home Office said that it would consider this and reply shortly. It was unanimously agreed

that the Home Office, the Department of Trade and Industry and other Government Agencies should be asked to agree in writing to the extension of the spectrum for industries needs in the field of mobile radio communication.

In addition, according to the Bulletin, the radio manufacturers agreed to assist the users in strengthening the lobby for national and international recognition of the importance of mobile radio in industry. The Officers and the Committee of the Users' Association were asked to attack the inertia and apathy of the Government in not recognising the importance of mobile radio to their industrial strategy.

One result of the Conference was that it

was decided by the Committee to expand the Users' Association by appointing a Technical Consultant and a permanent Secretariat and to seek more help from all manufacturers and users

The really important date for the MRUA will come in 1979 when the WARC is held in Geneva. About this, Mr Taylor said before the Conference, "We are determined that our representatives at the World Conference will be in the strongest possible position to make a greater claim for more frequencies for private mobile radio use than has so far been proposed. Our research has shown quite clearly that even ten per cent annual growth in the use of mobile radio in this country will shortly exhaust available channels."

British Post Office telecommunications compare unfavourably with overseas — Government White Paper

THE GOVERNMENT'S White Paper on the Post Office, published in July, agrees with the Carter Committee that efficiency in the British Telecommunications service appears to compare unfavourably with some of the highest standards attained overseas. "There is, indeed, much to be achieved in improving the quality and efficiency of the basic telephone service and of data communications links for industry and commerce."

To improve this situation the paper suggests that "the basic aim must be to achieve reduction in real unit costs through increased utilisation of existing assets and through more efficient methods of working with new equipment." The Government has agreed with the Post Office that it would be reasonable, taking 1977-78 as a base, to look for a general reduction in the real unit cost of the telecommunications services of some five per cent per annum over the five years to 1982-83.

The Government has also encouraged the Post Office to move as rapidly as possible towards the next generation of equipment, including computer-controlled exchanges integrated with economical systems of

transmission. All of these developments are being brought together in the System X programme, intended for introduction in Britain in the early 1980's (see News, p51 Sept. '77, and p72 June '78), and the Post Office is giving this programme the highest priority.

The paper also referred to another White Paper on the Nationalised Industries, which envisaged that the industries would select a number of key performance and service indicators, including historic series and valid international comparisons, and publish them prominently in their annual reports. The Post Office paper then suggested that it was important that the Post Office, as a monopoly, should demonstrate to the public that it was using its vast resources efficiently to provide the best possible service at the lowest prices. Relevant information is now being compiled by the Post Office, who intend to make a start on this in their forthcoming annual report, and the Government is welcoming their decision to publish, each quarter, the key national and regional statistics on telecommunications performance.

PREPARATION FOR WARC 1979

Your comment in the July issue (page 47) on the Home Office Radio Regulatory Department's publication "Preparation for the World Administrative Radio Conference 1979" omitted to emphasise that the proposals discussed in the report are stated to be still "tentative." (The word is repeated several times in the document.) There is a promise that the UK's formal submission might be published in the spring of 1979.

That admission that our national stance is not yet finalised may give some hope to those who believe that the summary does not, as it states, "represent a balanced . . . plan for all frequency bands." But the time left for a true comparative evaluation of the relative value, to the nation, of alternative uses of specific parts of the spectrum is now terribly short. One may, therefore, doubt whether this or any government can now assess that balance in time.

Referring only to the mobile radio use of frequencies, the Home Office offical view (that an additional 70-90MHz will be required below 600MHz to satisfy the demand for civil land mobile services up to the end of the century) is not supported in their proposals by any firm plan to make it available unless Bands I and III are given up by the broadcasting service. On the one hand, several contributors suggested the 70-90MHz should be more than 100MHz. On the other hand, the broadcasters submit that they not only want to keep Bands I and III but also to extend Band III and to extend Band II at the expense of mobile radio.

When does the nation have a chance to choose between double coverage on radio and television and fuel and cost saving? Do even our representatives in Parliament have a debate planned on this issue so vital to our future? Which will we go for at WARC?

Perhaps the root cause of the absence of any analysis of such issues is the tendency for politicians to take the easy way out by reacting to the most powerful lobby, and then only on those issues which the voting public can fully comprehend. Thus, there are no unbiased and accepted, economic and sociological value analysis criteria for spectrum usage, and no careful weighing of conflicting use proposals. Yet, unlike other natural resources to be managed, there will be no new spectrum 'finds' to ameliorate wastage.

J. W. Carlton
Pye Telecommunications Ltd
Cambridge

DISCRIMINATIVE METAL DETECTOR

The problem of distinguishing between ferrous and non-ferrous metal (July issue, p.43) is not quite as straightforward as it looks. To the search coil of a metal detector a piece of iron looks like a combination of two things: first, a loosely coupled 'short-circuited turn', since it conducts and loads the circuit, and secondly an iron core, since it has permeability which tends to increase the effective inductance of the coil. These effects oppose one another so the response of a detector to a piece of iron depends on their relative strengths. A detector operating at 100kHz or more is likely to 'see' iron more clearly by its conductance than its per-



meability, in which case it is not distinguishable from non-ferrous metal.

The present generation of metal detectors of the kind used by 'treasure hunters' attempts to solve this problem by means of a much lower operating frequency. Frequencies down to about IkHz are in fact used. The permeability of a piece of iron is effectively greater and usually predominates over the conductance.

Working at audio frequency rather than a low radio frequency brings an additional bonus. At 100kHz, skin effect restricts current flow to the outside layer of metal, and all' pieces of metal tend to look similar, if they are the same size and shape. At audio frequency current penetration is much greater; a piece of silver paper the size of a coin is 'seen' by the search coil as an object of lower O. In the more sophisticated type of 'discriminator' detector this difference in Q is translated to a distinctive difference in the way the detector responds, and the 'treasure hunter' combing a holiday beach for coins can then avoid the time-wasting process of digging up endless ice cream wrappers etc.

There is, however, a continuing problem in the shape of the 'ring-pull' from a can of beer. This is aluminium and high-Q. A detector set to ignore it will also ignore valuable objects such as low-carat gold rings!

George Wareham London WC2

Dr Macario's article on a metal detector (July issue) does not give the inductance of the search coil or the tuning capacitance but refers to Mr Waddington's, which I looked up. There the inductance is again not given so I assumed a diameter of 6 inches and a length of ½inch, and, using Nagaoka's constant, found an inductance of $680\mu H$ which with 500pF tunes to 250kHz, not 120kHz as stated by the author.

I wound the coil on a disc cut with a pocket knife from scrap polystyrene and the measured inductance agreed with the calculated. I then worked out the resonant frequency of the 625kHz oscillator and I found that it does not tune to 625kHz.

I have built several coils and cannot make the oscillator run anywhere near 125kHz except by adding about 2000pF.

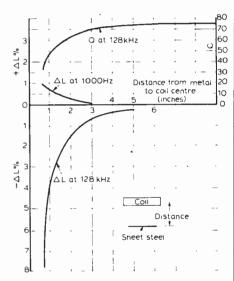
I used two different coils in the 625kHz oscillator. Mine runs at 750kHz.

The Waddington detector does have Home Office approval so it must work at the correct frequency.

The Macario oscillator has a lot of drive and a rough calculation indicates an r.f. voltage much larger than the supply voltage which is not possible with protective diodes on the c.m.o.s. input. The actual oscillator has a poor waveform because the tuned circuit is driven hard into the diodes. I could not deduce the actual oscillator frequency so I increased the capacitance to about 2400pF giving 130kHz.

All this has nothing to do with the point I originally intended to make, which is that I cannot see how the Macario detector can tell the difference between ferrous and nonferrous metals. Over many years I have used a Q meter to measure r.f. coils mounted on a ferrous or non-ferrous chassis and I have always found the inductance is reduced by the proximity of any metal except, of course, dust iron or ferrite. The reason is that steel, which has magnetic properties increasing inductance at low audio frequencies, is a conductor and the eddy currents reduce the effective inductance. Which effect is more important depends on conductivity thickness and frequency.

The accompanying graph shows the change in inductance when a thin steel sheet 5½ in x 3in, from a Polaroid film pack) is moved near the coil. Measurements of inductance were done both at 1000Hz and 128kHz. At 1000Hz the inductance increases slightly but at 128kHz there is a large change in the opposite direction. I have tried rusty steel. One piece increased the inductance, the rest decreased it



My friends in the Chemistry Department cannot predict which oxide will be formed because it depends on the available water and oxygen. Most of the oxides will be non-magnetic but some magnetite might be formed and the remaining iron could be so divided that the eddy currents would be reduced. This would increase the inductance.

At 1000Hz it would be possible to make a detector to discriminate between ferrous and non-ferrous metals but not at r.f. using the beat frequency method of the Macario detector

Another point concerns "pulling." When two oscillators work at nearly the same frequency one pulls the frequency of the other and they lock unless they are completely separate. In this case they are on the same circuit board and I am surprised to see that they can be adjusted to within a fraction of a Hz of one another. I built the Macario oscillator and set it up to give a Lissajous figure to check for locking. With 9 volts peak-to-peak from a signal generator (Marconi TF867) the exposed output lead (about 3 inches and a croc clip) was 4 inches at the nearest point from the oscillator. It locked over a range of about 12Hz.

Whether it locks on the complete detector will depend on the precise layout. If C_{14} and

its wiring goes within a few inches of the 9-volt 120kHz reference from 1C₂-point B, for example, it will lock.

There is other evidence for locking. When I removed the signal generator to avoid locking it was almost impossible to keep the Lissajous figure stationary because hand capacitance causes a shift of several hertz. After bringing the figure to rest, removal of the hand causes the figure to rotate. The oscillators should be in a screened box, not a plastic box.

If the two oscillators are free-running and the l.e.d. display is stationary this implies an oscillator stability and an accuracy of adjustment of a part in a million, which seems unlikely in a portable oscillator on the end of pole. Although I have not built the complete detector I am reasonably certain that the oscillators are not free-running but are in fact phase locked, not by design but by accident.

One last point, an l.e.d. display is almost invisible in sunlight.

M. D. Samain Electrical Engineering Department University of Salford

Dr Macario replies:

The letter by M. D. Samain is of importance as it outlines points which have been raised by a considerable number of other readers following my article in the July issue. Actually, the article was originally entitled "A different metal detector"; the word "discriminative" came in later, but as Mr Samain points out this is a much more complicated matter than just one word in a title allows. I did make it clear in the text that "the potential to differentiate exists ... ", and I would be interested to hear of any comprehensive reference on the effects of various small metal objects in the vicinity of a search coil. I did make a brief reference search at the time but without success.

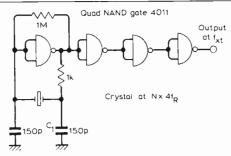
I had also made a few simple tests at 85kHz and noted the following:

- 1. Small solid brass/iron objects can be discriminated as theory suggests.
- Large metal objects, such as Samain uses, cause a lowering of inductance due to eddy currents.
- 3. Small metal objects with holes such as washers act as a shorted turn and are not necessarily discriminated.
- 4. The orientation of a flat object with respect to the plane of the coil can alter the above findings.

I will return to the idea of using a lower frequency later.

The next point is that of not showing the coil inductance and tuning capacitance. The coil shown in the photograph in the article was a Waddington coil provided by a colleague and was simply tuned to 125kHz and/or 85kHz for test purposes. The capacitance C₁ used had to be much larger than that given by Waddington. The sensitivity of a metal detector may well depend on the number of the turns in the coil, rather than its inductance being matched to a particular tuning capacitor, and this is another area of useful investigation. The only data available to us at the present time is Waddington's.

The choice of inductance, tuning capacitance and frequency also affects the best ratio of feedback capacitors C_4 : C_4 : C_5 . As the frequency is lowered they should all be made correspondingly larger. Then increase C_4 to obtain a good sinewave at the oscillator input. An excellent sinewave of about 2V peak-to-peak is available. A square wave



occurs at all other outputs except at the input of C_{τ}

Although the voltage swings of the two oscillators are large, in fact equal to the supply, the current is very small, and locking of the two oscillators is minimal. This is partly due to the use of a double sided p.c. board (which is always good practice when dealing with r.f. circuits) while all the components are inserted tight to the board. The board size shown in the article is, however, about the smallest one can use in practice. The circuit is also balanced and therefore the supply current remains constant for all phases. Actually, the circuit does just show a tendency to lock within the nearest Hz. This is useful in a way, because the display has a chance to settle down. Two improvements are: (1) put $10k\Omega$ between points A and A¹, (2) place the earphone outlet between Q and \overline{Q} of either 4013 output in series with $22k\Omega$.

This brings me to my main point which is that, like Mr Samain, I am extremely doubtful of the long term practicality of building an LC oscillator of very high stability with the inductor being waved around at the end of a pole. I did discuss this briefly in the article and put forward some ideas for experimentation. However, let us look at the question of going to a lower frequency again. If, for example, a detected object which caused a 10Hz change in frequency at 100kHz, only caused a 1Hz change at 10kHz, the sensitivity problem is not solved. However, if the change was 2Hz because there were more turns on the coil etc., then an improvement would result. As I said earlier, some information in this area is needed - at least by me.

Finally, the detector described is sensitive in theory to a change in frequency of ${}^{1}\!\!\!/ Hz$ in one second. This sensitivity can be increased by making the reference oscillator frequency $4f_R$ a multiple of this frequency, i.e. $N \times 4f_R$. For example, using a coil at 30kHz requires $4f_R=120$ kHz. Making this a crystal oscillator running at 1.920MHz makes the detector eight times more sensitive (and also to variations of the search coil). A suitable crystal oscillator (stable to within 1Hz) is shown in Fig. 1. This uses a quad NAND 4011) or quad NOR (4001) device as already available in my detector, and replaces the reference oscillator. The frequency is set by adjusting capacitor C_1 .

R. C. V. Macario University College of Swansea

BICYCLE DYNAMOS

The "Circuit Idea" of Mr B. J. Pollard in the June issue entitled "Standby battery for dynamo lighting" gives a quite remarkable idea of the common bicycle dynamo.

These devices are variable-speed single phase alternators with rotating permanent-magnet field systems, output being taken from a stationary coil system. The output rating is typically 6 volts 0.5 amp.

The stator generated e.m.f. is basically proportional to the speed of rotation of the field, as is also the frequency of the generated e.m.f. When the road speed of the bicycle increases, the voltage applied to the lamps and the current through them hence tends to rise.

The complete dynamo lighting set is however designed so that the main factor controlling the magnitude of the alternator output current is, at speeds above say 8 m.p.h. or so, the inductive reactance of the stator circuit. When generated e.m.f. and frequency increase, so does the reactance. The terminal voltage of the alternator is arranged to rise only to 7-7.5 volts on load even at 30 m.p.h.

Forty years ago the Philips concern designed a new cycle dynamo with an 8-pole rotating magnet, an excellent effort, and published an article about it in the Philips Technical Review which explained the principles of design involved. Since then I would have thought that nobody could be in doubt about cycle dynamos. Those curious should measure the open-circuit output voltage with an Avometer while riding the bicycle at various speeds on the road.

Mr Pollard says that the typical output of "a bicycle dynamo" is "around 4.5V r.m.s." The usual reason for low output voltage is that investigation by an inexperienced person has reduced the magnetism of the rotating field magnet. To bring the output voltage up by putting series capacitance in the output circuit, thus vitiating the voltage regulation built into the original design, is quite absurd.

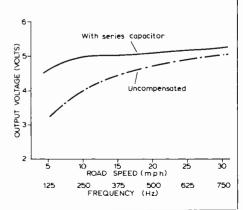
P. Short University of Newcastle-upon-Tyne

Mr Pollard replies:

I wonder if Mr Short rides a bicycle with a dynamo, as I do, or better still, has taken the trouble to notice the almost uniformly poor efficiency of dynamo-driven cycle lighting, particularly at city-centre speeds of around 10 m.p.h.

I have owned two bicycle dynamos, both manufactured by H. Miller & Co. of Motherwell. The first, purchased 18 years ago, produced an output which rose inexorably with increasing speed and regularly burnt out the tail lamp at speeds of over 20 m.p.h. The second, purchased a year ago, is much better behaved. Its rated output seems a little uncertain: the instruction book quotes 5 volts 3.6 watts, while on the dynamo itself is stamped just "6V". The lamps supplied are 6V 0.5A and 6V 0.04A.

The actual output voltage of this second model (into the correct load), measured with an Avo at various road speeds is shown in the accompanying graph and compared with that obtained when the series capacitor is in



circuit. The capacitor produces a marked improvement in the voltage regulation at speeds above 3 m.p.h. and its use does not seem to me, therefore, to be "absurd" at all.

I have never dismantled either dynamo, but I carried out some measurements on the "modern" version - with the bicycle stationary I might add! - and the results are summarised below. The dynamo source impedance (i.e. the stator impedance) at any particular frequency is somewhat dependent on the current used to measure it, and the figures given are for a 35mA drive which is only 6% of the normal output current, but nevertheless serves to illustrate that this dynamo is not quite as simple as Mr Short would like to believe.

Fre-		R'ac	L	z		0/c Out- put
(Hz)	(m.p.h.)	Ω	(mH)	(Ω)	φ	(V)
125	5	4	8	7.5	55 .	8
250	10	6.5	6.5	12	60	13
375	15	8	6	16.5	60	17.5
500	20	8.5	5.5	20.5	65	21
750	30	11.5	5	26	65	28

 $^*R_{dc} = 2.5 \,\Omega$

Varying the position of the rotor did not significantly affect any of these measurements.

There is a good deal of loss resistance in series with the winding inductance; furthermore, both the open-circuit output voltage and the internal impedance modulus ("Z") are almost proportional to precisely (frequency) 0.7

I find the index of proportionality of 0.7. instead of the expected unity rather puzzling. I wonder if any of your readers have an explanation for this?

Brian Pollard

Coventry

ELECTRET RADIATION DOSEMETER

The report in the June issue News of the Month (p.45) concerning the electret detector as a personal dosemeter and alarm described what may be a device of value to those engaged in work with radioactive materials. However, some of the terms employed are confusing since they are not, to my knowledge, used in English-speaking countries. The "stylodosimeter" presumably refers to a quartz fibre electrometer and "flowmeters" to dose rate measuring instruments. The reference to radioactive contamination is surely misleading; the device appears to measure radiation exposure, a totally different and not necessarily related quantity.

The triggering threshold range quoted for the device (1-40 rem) makes it rather insensitive compared with those currently employed and this could well prove a limitation to its use for dose control at the low levels presently achieved.

With regard to the general tone of the report and the suggestion that the use of the device will reveal any official cover-ups of radiation exposure, it should be pointed out that there are strict legal limitations on radiation doses received by workers. The exposures of all workers are recorded and there has, for a long time, been a clear legal

requirement for these records to be freely available for inspection by the employee concerned. The measurements on which these records are based are required to be made by Government-approved laboratories.

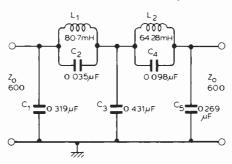
In these circumstances it is difficult to see what purpose would be served by illegal actsof concealment and I believe that it would bedifficult to find an informed critic of the nuclear industry who would seriously think otherwise. There may be genuinely felt concern about a nuclear future in some quarters but dose concealment is not a significant factor in this in the United Kingdom.

G. C. Meggitt UK Atomic Energy Authority Safety and Reliability Directorate Warrington

1kHz SOURCE CLEANING FILTER

In your July issue J. Vanderkooy and S. P. Lipshitz underlined the difficulty of generating a sufficiently pure sinewave for measuring the distortion of modern amplifiers

A frequently used method of obtaining a pure waveform is to employ low-pass filters to remove unwanted harmonics from the oscillator output but this is very expensive if a wide range of frequencies is of interest. Readers who are satisfied with a spot check



253 turns 28 swg 35mm VINKOR LA1211

L₁-C₂ Tune to 3kHz

226 turns 28 swg 35mm VINKOR LA1211 L_2

Tune to 2kHz L2-C4

made at 1kHz only may be interested in a 5th-order Cauer low-pass filter designed for this purpose (see accompanying diagrams).

Economy of design has been achieved by carefully positioning the peaks of attenuation so they coincide with the second and third harmonics. In this way a "50dB" filter may be made to attenuate both these frequencies by 65dB, and all higher harmonics by at least 50dB.

J. A. Hardcastle, G3JIR Huyton

Liverpool

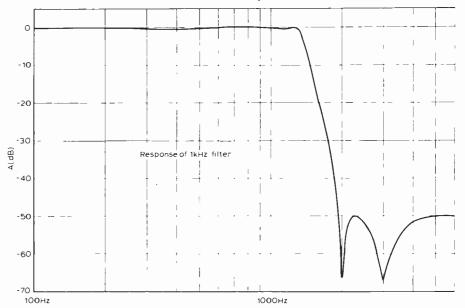
SPELLING FOR TECHNICAL JARGON

I have read with growing frustration the correspondence in your journal on the spelling of programme, or is it program?

It will obviously come as a great surprise to all your correspondents that the OED (surely the final arbiter in any dispute between English and American) clearly states that the form 'programme' was a reintroduction from French in the 18th and 19th centuries. It has since ousted the preferred form 'program' which was the correct English prior to this. It also displaced the alternative, and presumably more etymologically-correct, form 'programma' - a straight transcription from Greek.

It seems that there was (and still is) a misplaced snobbery in the attribution of foreign characteristics to English words without good reason. Surely few of the proponents of the 'me' version are habitual recipients of telegrammes or readers of circuit diagrammes.

Technical jargon necessarily contains many newly-invented words of dubious pedigree, and it is a mistake to attempt to make them conform to inappropriate grammatical rules. The correct form of spelling and pronunciation is that which is accepted in this context, otherwise the purpose of jargon - clear communication - is negated. Even so, dual standards will and do occur. I wonder if an uninformed reader of your journal would be able to deduce a single clear definition of 1K. Is it 1000 or 1024? It depends on context although it is not un-



known for both meanings to be used within a single article. 2.4% is not a large tolerance in a resistor, but if one is dealing with integers it is beyond the pale. For the informed reader there is little chance of serious error in this particular case.

A language is a living entity; it would be a serious disservice to English to try and fossilise it like a fly in amber (elektron in Greek – but that is another rabbit).

J. E. Chester Wavertree Liverpool

Editor's note: By current convention, the lower-case letter 'k' (abbreviation for 'kilo' in SI units of course) stands for 1000, while the upper-case form 'K' has been adopted for $1024 \ (= 2^{10})$.

DIVIDE-BY-THREE CIRCUIT

With regard to the letter from Mr D. Stuart Smith (August issue), I feel it must be pointed out that his claim that his novel divide-by-three circuit produces an accurate unity mark/space ratio is misleading. In fact, this will only be true if the input waveform itself has a unity mark/space ratio.

As Mr Stuart Smith shows in his waveform diagrams, the exclusive OR function results in the transitions in the output of Q_2 being alternately synchronous with the positive and negative edges of the input signal. Therefore the mark/space ratio of the output must be proportional to that of the input.

Of course, one could take steps to ensure unity mark/space ratio of the input waveform but that, in principle, is the same as using a conventional divide-by-three and modifying the output, as in Mr Eaton's original Circuit Idea (June issue).

K. Clayson Merstham Surrey

TRI-STATE DEVICES IN LOGIC SYSTEMS

Messrs. Catt, Davidson and Walton in "Interconnections of Logic Elements" (June issue, page 62) made the following statement: "Any function which is possible with tri-state devices can be more easily implemented with open collector t.t.l. Tri-state is an unfortunate development caused by the misunderstanding of the requirements for transmission line driving."

By definition open collector devices require a collector load which would take the form of resistors on the bus, introducing more components, and more complexity. Catastrophic power dissipation caused by progressive collapse of tri-state devices is only partially relevant as most m.o.s. devices have current limited outputs preventing such failure. Surely all the design engineers of bus orientated microprocessors by Motorola, Intel, Texas, Zilog, etc., could not have misunderstood line driving requirements?

B. A. Hutchinson
Department of Electrical &
Electronic Engineering
University of Newcastle upon Tyne

The authors reply:

Mr Hutchinson quotes two sentences from the article in which the following statements are made:

- 1. Open collector t.t.l. is a superior replacement for tri-state t.t.l. in all applications in which the latter is used.
- 2. Tri-state t.t.l. is an unfortunate development

3. Tri-state t.t.l. is a product of the same wrong-thinking which originally led to t.t.l., viz. a basic misunderstanding of how to model the interconnection between logic gates.

Mr Hutchinson appears to be taking issue with (1) and (2) but he gives no reasoned argument for dismissing the discussion leading to (3).

His objection to (1) seems to be based on the assertion that tri-state t.t.l. requires considerably more components to implement a particular bus arrangement because of pull-up resistors. This argument is presumably based on the idea that each open-collector gate requires its own pull-up resistor. This is not so. Pull-ups are only required at each end of the bus connections (i.e. two places) where they serve as terminations matched to the characteristic impedance of the bus lines. These resistors would normally take the form of d.i.ps and hence represent small overhead in terms of cost, failure modes, etc.

Mr Hutchinson goes on to discuss protection of m.o.s. tri-state outputs against catastrophic failure. He may be correct. Our article, however, is concerned with t.t.l. and its variants and it was not our intention to make any assertions concerning m.o.s.; this would require a separate article. In the case of tri-state t.t.l., I have two communications from semiconductor manufacturers stating that the failure mode we described does exist.

His final argument, a variation on the theme of "So many people cannot be wrong," hardly requires an answer. Fortunately correctness or incorrectness is based, not on a democratic consensus, but on reasoned argument and experiment. We are prepared to demonstrate the validity of our conclusions before any scientific or engineering audience which Mr Hutchinson cares to assemble

I. Catt, M. F. Davidson and D. S. Walton

MPU CONNECTOR PIN STANDARDIZATION

In my work at this laboratory on microprocessor development I have come across a pressing need for the professional standardisation of pin connections for Eurocard indirect connectors. I know from my contact with a number of organisations and companies that the need is urgent and that some initiative would be welcomed. Consequently. I have drawn up a framework for a proposal for standardisation which I am circulating to all interested parties for comment and suggestions. In brief, it is that the 96-way indirect connector should have rows a and c assigned standard functions and that row b be reserved for non-standard use. I am asking for preferences and suggestions from professional microprocessor users for the allocation of pin numbers to microprocessor address, data and control lines, serving principally the Intel 8080, 8085, 8086; Zilog Z80 Z8000; Motorola M6800, 6802, 6809, MOS Technology 65XX, which I see to be the most widely used devices and ones likely to afford most benefit when used with Eurocard and double Eurocard size boards under a standardisation scheme.

Would interested readers please write to me as soon as possible giving their views? I will then, in consultation with my professional colleagues, draw up a proposed standard, which I will distribute for approval, and, subsequently will submit to the relevant institutions (IEE, BSI, etc).

I believe the matter to be in need of urgent action (if we are to avoid the emergence of an unsatisfactory standard as has occurred in the USA with the S-100 bus). For this reason I will try to avoid a discussion of any but the most important aspects of the definition of the standard.

Paul L. Borrill Mullard Space Science Laboratory University College London Holmbury St Mary Dorking, Surrey

RADIO FROM 1917

Readers of your journal may be interested to know of the recent donation to the IEE Library by John Scott-Taggart O.B.E., M.C., F.I.E.E., of some seventy books on early radio, radar and electronics. These works, which valuably augment the Institution's already strong historical collections, are from both British and foreign publishers and date from 1917. A list of the books is available for those interested from the IEE Library.

John Gurnsey Librarian Institution of Electrical Engineers London WC2

NOSTALGIA CORNER

It was good to learn from Mr E. J. Williams (Letters, August) that the record music sessions at RAF Yatesbury c. 1942 are still remembered with pleasure. Of course one could go on reminiscing indefinitely, but I do feel it should be added that also on the teaching staff at No. 9 'Radio' (actually r.d.f., now radar) School at Yatesbury was the now world-famous Arthur C. Clarke. He was distinguished from the other three Clark(e)s on the camp by the forename 'Spaceship', notwithstanding that this was before even the V2 gave a hint of things to come. It was, of course, Spaceship Clarke who in this journal back in 1945 first envisaged the use of geostationary satellites for worldwide broadcasting of television, now normal prac-

M. G. Scroggie Bexhill Sussex

Capacitance meter

Measurement of capacitance in the 1pF-100µ F range by the diode-pump principle.

by K. Holford, M.I.E.R.E., Philips Research Laboratories, Redhill.

A direct reading capacitance meter is described which has no balance controls to adjust. The range covered is from 1 pF to 100 μ F with an accuracy of about 0.5 pF plus 3%. The lowest range is 0-30 pF. The indicator is a 100 μ A meter.

The circuit requires a 9V supply and is intended to be portable. The electronics are simple, one integrated circuit and five small transistors.

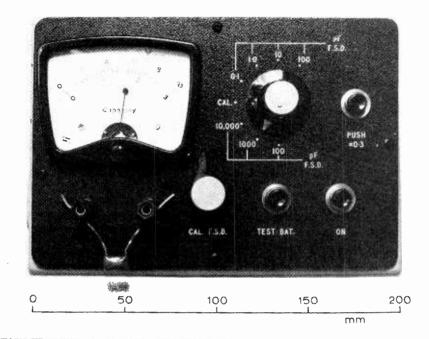
THE BULK of commercial capacitor measuring equipment is based upon the use of sinusoidal voltages with bridges. For investigating the quality of capacitors this is fine. But where just a simple capacitor size selection is involved the process is elaborate. The balancing tedium is reduced with automatic equipment, but this is expensive.

The capacitor is, of course, a component for storing charge, C = Q/V, (farads, amp-seconds and volts respectively) and it is possible to make direct measurement of stored charge per applied volt (farads) rather than use the capacitor's reactance which derives from charge modulation brought about by applying a sinusoidal voltage. Indeed, equipments are now appearing based upon this concept, such as injecting a constant current into the capacitor and measuring the time it takes to achieve a predetermined voltage. The larger the capacitor the longer the time, in a direct proportional relationship.

The equipment is well suited to the measurement of large capacitors which can be difficult to measure by the reactance technique. It can be built using digital techniques including a clock for the time measurement. Other techniques can also lead to the design of simple equipment.

If an upper limit for the capacitor size is set at about $100\mu F$ and a $100\mu A$ meter is suitable as a display, the capacitors can be measured using a repetitive charging technique which involves applying only a few volts to the capacitor, the value of which can be read from the meter in terms of the current flow. Even a capacitor as small as 30 pF will produce a $100~\mu A$ reading, provided the charge repetition is made high enough, in this case about 1 MHz.

The scale of the meter is linear and there is no need of special calibration. A wide range of capacitors can be catered for by making use of a few widely spaced frequencies and by altering the



meter sensitivity using shunts. Readily achievable measurement errors are about 3% plus 0.5pF. Capacitors can be matched as accurately as the meter can be read, say to within 1% with a reasonable size of meter.

The basic circuit is that of the diode pump ¹ and is shown in Fig 1, where the charging and discharging of the capacitor is accomplished with a square wave drive voltage. The charge and discharge currents are separated by diodes, so that only one of these flows through the meter. The circuit description is simplified by assuming the square wave has its lower level at 0V and upper at +V. When the voltage moves from 0V to +V the capacitor charges round the loop including diode D₁ and the meter.

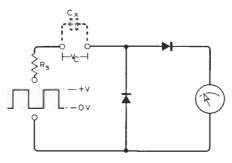


Fig. 1. Diode pump principle

The diode D_2 is nonconducting. It is intended that the capacitor obtains a substantially complete charge during this time. When the square wave returns to 0V the capacitor can discharge round the loop including D_2 , with D_1 being nonconducting. The square wave input can be looked upon as a short circuit at this time since any current flow does not change the input voltage.

Thus, the meter has only the charging current flowing through it and the nature of a moving coil meter is to average the current flow. Current flow multiplied by time is charge and the current is therefore a measure of the size of the capacitor. It only remains to apply a suitable scale factor to allow for the number of volts being used and the number of times per second the capacitor is being charged. A capacitor able to deliver or absorb a current flow of one amp for one second while showing only a voltage change of one volt has a capacity of one farad.

By making the number of charges per second large the instrument will measure small capacitors. The large capacitors are charged less times per second in order to keep the current down to a manageable amount. But not so low as to cause excessive meter pointer jitter.

With capacitors as large as 100 μF the meter sensitivity had to be reduced to a full scale reading of about 2mA in order to comply.

The objective of the design is to have a linear scale and so the voltage change across the capacitor during charging and discharging must be independent of the particular size of capacitor being measured. Thus, a doubling in capacitor size must result in twice the charge. The resistance shown as Rs in Fig. 1 must be small enough to ensure that even the largest capacitor can be charged to within a small percentage of completion within the time allowed by the square wave. The choice of square wave frequency is a matter for design and calibration and will be returned to later. But first some of the characteristics which are not of prime importance.

The square wave, for instance, need not be particularly square or have an equal mark-space ratio. But it should move between well defined voltage levels and have a flat top and bottom of sufficient extent to allow for substantially a full charge and discharge of the capacitor; 1% loss of charge voltage means a 1% low current reading. The square wave may have some ringing, say after changing from one level to the other, but must settle before the capacitor charge is complete to avoid over charging. The single polarity nature of the applied voltage will not be conducive to a mini-charge-discharge process during the ring unless the ring amplitude is very large. Finally the direct voltage associated with a square wave is not very important. Any d.c. is blocked by the capacitor after the first charge and plays no part in subsequent measurement. The d.c. level may need to be kept small however, to enable low voltage rated capacitors to be measured.

Improved circuit

The circuit of Fig. 1 has the disadvantage that the meter is in the capacitor charging circuit and its series resistance or inductance could affect the accuracy of a measurement, particularly at high frequencies with small capacitors. The diode feeding the meter can be replaced with the emitter-base junction of a transistor and the meter transferred to the collector circuit, as shown in Fig. 2.

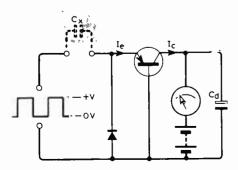


Fig. 2. Transistor isolates the meter circuit from the capacitance

Collector current is not quite equal to emitter current but with modern, high h_{FE} transistors the difference is small and easily taken out in calibration:

 $I_c = I_e h_{FE} / (1 + h_{FE}).$

For instance if $h_{\rm FE}$ is only 49 with collector current is only 2% less than the emitter and if $h_{\rm FE}$ changes 10% with temperature the calibration error is a mere 0.2%. Clearly there are more important matters.

In Fig. 2 the collector is decoupled with $C_{\rm d}$ which avoids effects due to meter coil inductance and Miller/Blumlein feedback reducing the transistor frequency response.

Also the circuit is tolerant of appreciable meter series resistance which means that the shunts which control the meter sensitivity can be made from convenient value resistors, as in Fig.3.

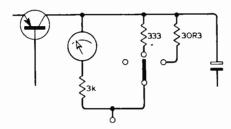


Fig. 3. Meter sensitivity switching.
Tolerance to meter resistance allows
the use of shunts of reasonable values
– in this case chosen to give 0.1, 1.0 and
10mA.

The electrolytic decoupling capacitor C_d needs a low leakage if the equipment is to be of the highest possible accuracy. For instance, if this were $2\mu A$ and the meter $100\mu A$, then 2% of the meter reading may be time-dependent as the capacitor polarises. It is not difficult to find selected tantalum capacitors with a leakage current below $0.5\mu A$ in the size required.

Square wave voltage. Referring again to Fig. 1 it can be seen that the voltage drop across the diode D₁ reduces the amount of the square wave voltage applied to the capacitor and that across D₂ allows voltage to remain on the capacitor when it should ideally be discharged. However, as long as the required voltage change occurs across the capacitor, the measurement will be accurate and the square wave voltage can be increased to allow for the diodes. A voltage increase of 1 volt for the two silicon diodes is about correct since, if the equipment is being designed to be accurate, the capacitor must be substantially fully charged and discharged, and so the voltage increase required is that corresponding to a small diode current.

Another concern is that the voltage used to charge the capacitor shall be large enough to swamp any change in diode voltage with temperature. For indoor use, the equipment is not likely to be subject to great temperature change

and an allowance of $\pm 20^{\circ}\text{C}$ will be more than enough. Such a temperature range would cause a diode voltage change of about ± 40 mV for each diode. Thus a square wave voltage of 4V pk-pk, plus another 1 volt for the diodes, should keep the effect of this upon calibration to 1% per diode. This 5 volts can be provided by a 9V transistor radio battery and is also small enough not to exceed the rating of most electrolytics. Thus the equipment should have a wide application.

Square wave source resistance. The square wave generator must be able to supply an adequate current to charge and discharge the capacitor in the time available, and this imposes constraints on the allowable source resistance. Assuming, in Fig. 1, that all the resistance can be lumped as $R_{\rm s}$, the charge law is:

 $V_c = V_s(1-e^{-t/CR_s})$... (1) With an infinite charging time the term e^{-t/CR_s} goes to zero and the capacitor voltage V_c attains the voltage V_c . With a time t equal to $4CR_s$ the term accounts for a 2% loss of charge. The capacitor will also not discharge by 2%. Thus compared to an infinite charging time there will be 4% less charge change and 4% lower current reading on the meter. If C is reduced the error reduces, but the error is not linear and cannot therefore be compensated by simply increasing the voltage.

The equation can be used to examine whether R_s is likely to be a cause of error in a completed equipment since the error with an increase in C or R_s grows rapidly; 2.7 times for a factor two increase in C and T times if T is increased four times.

The current flow through the meter in Fig. 1 is given by:

$$I = CVf$$
 ...(2)

where I is in amps if C is in farads, V in volts and f is the number of charges per second.

Assuming a 30 pF capacitor and a full scale reading of 100 $\mu A,$ together with an effective square wave voltage of 4 volts, the frequency $\it f$ works out to be 833kHz. For a 100 μf capacitor the meter sensitivity must be reduced to avoid an absurdly low frequency. For 2mA the frequency required is 4 Hz, which is near to the lowest useable because of the need to smooth out needle jitter and still have a reasonable response time.

From equations 2 and 1 it can be shown that a large I causes most difficulty with ensuring that the capacitor can be charged/discharged in the time available. If the values of I and V are made the same for each range the problem is much the same on all ranges. For instance the frequency must be decreased by a factor 10 each time the capacitor range is increased by a factor 10 and so the charge time constant CR_s , equation 2, always has the same relationship to t, i.e. t/CR_s is fixed. In other words, the charge error is the

same fractional amount on each range at the same meter reading, irrespective of the size of capacitor being measured, unless the meter sensitivity is changed. More current flows if t is kept fixed and C is increased but t/CR_s is reduced (negative power) and the error increases.

In the equipment to be described the meter sensitivity is reduced to its lowest of 1.666 mA on the 100 μF range and so this range is chosen as an example of error due to inadequate charge time. The other ranges use 5 times less current and from equations 1 and 2 the error can be expected to be e^5 times less and will be negligible unless the 100 μF range is very poor.

From the equation 2 the average current required to charge a $100 \, \mu F$ capacitor once per second with an effective 4V supply is $I_{av} \times 10^{-4} A$. Since the meter is shunted to read 1.666mA, the frequency needs to be 1.666/ $10^{-4} \times 4$) = 4.17 Hz, which has a half-cycle time of 0.12 seconds.

This range is for electrolytics which often have a tolerance of -20% + 50% and precision measurement is not usually required. Thus a time of 4 CR_s was deemed acceptable and means a 4% error at full scale, with less error at lower readings. From $4CR_s = 0.12$ it can be calculated that R_s should not be more than 300 ohms and it will be seen later that the design achieves 330 ohms.

Square wave generator. The square wave voltage should be well defined in amplitude and change little in magnitude with temperature — an f.e.t. output stage is ideal. The LOCMOS integrated circuits have this type of output and the hex. inverter HEF4049 in particular has six stages, of which some can be connected in parallel to get a lower output resistance. Measurements on a few samples of these showed that a single stage had a typical output resistance of $1 \mathrm{k}\Omega$ and thus three in parallel

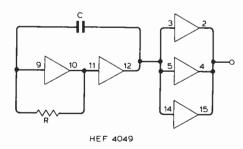


Fig. 4. Five of the six inverters in the HEF 4049 i.c. used to generate square waves.

would achieve, or nearly achieve, the target of 300 ohms. The connexion is shown in Fig. 4 and the square wave frequency is controlled by a single C and R and is easily changed to permit a number of different frequencies. Five of the stages are used and the sixth is put to a use which will be seen later.

THE author, Ken Holford, is a principal engineer with Philips (previously Mullard) Research Laboratories and has been involved in circuit design for about 20 years. His electrical engineering started just after the 1939-1945 war, when equipment was in short supply. Power supply failures were common, your own generator a luxurious necessity, and a permit required for a new electric motor. He joined a Midland engineering company rewinding and redesigning equipment, often war surplus having the wrong voltage rating. He obtained an HNC from evening studies and moved to the research and development lab. of a motor vehicle component manufacturer.

Having an interest in electronics he joined Mullard and studied semiconductor circuit design. By 1960 such knowledge was in great demand and he teamed up with colleagues to lecture other Mullard engineers, extending this activity to many surrounding colleges. He was a contributor to the book "Reference Manual of Transistor Circuit Design" (1960) which was produced in thousands by Mullard at that time.

More recently, in September, 1972, he wrote a "Doppler with-sense" microwave



article for *Wireless World*. He designed the Mullard microwave vehicle detector of the automatic portable traffic signals used at road-work sites in the UK.

The capacity meter was a hobby project.

This does the job although, due to the input stage not being of the high gain op-amp type with an accurate threshold at half supply voltage the square wave mark/space ratio is up to 20% different from unity. The circuit produces a respectable square wave at frequencies up to 1 MHz, as shown in Fig 5.

Earlier, the designer had considered using a modern f.e.t. op.-amp., such as the RCA CA3130, but this did not have the frequency response to produce a satisfactory square wave at 1 MHz. It would also need an output stage buffer. The 555 was also a possibility but a need for two timing resistors was a disadvantage. No doubt other i.cs could be found to do a similar job, or perhaps better. But as this circuit proved adequate and, as time was not unlimited, the design was frozen.

In a battery-powered measuring equipment used casually, the greatest loss of battery power is caused by the instrument being inadvertently left on. One way of avoiding this is to dispense with the normal switch and have a push button which activates the circuit for a

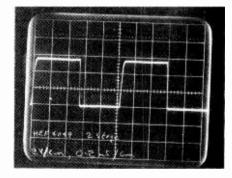
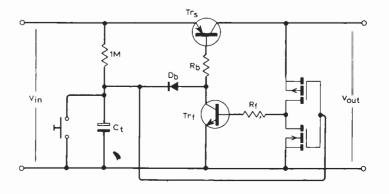
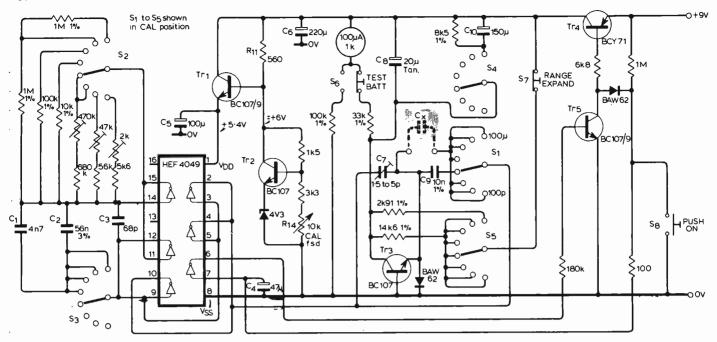


Fig. 5. Output waveform of circuit of Fig. 4. Oscilloscope sensitivity 2V/cm, timebase speed 200ns/cm. In this case timing resistor was $4.7k\Omega$ and capacitor 68pF.

Fig. 6. Power supply switching and timing circuit. Inverter is part of HEF 4049.





fixed time. If more time is required the button can be re-pressed to extend the period. The use of f.e.ts makes this easy. A measurement can easily be completed in 15 seconds and a timer was made for 30 seconds. One of the LOCMOS stages was used for this and the basic principle is shown in Fig. 6.

Normally Ct is charged and the output voltage of the circuit is zero because the series transistor is off. Pressing the push discharges Ct and turns on the series transistor Ts by allowing current to flow through R_{b} and D_{b} . The input voltage Vin is then applied to the f.e.t. inverter T_i, the gates of which are now low and their centre at substantially supply line voltage. This centre supplies votage to T_f base and T_f in turn supplies transistor T_s. Upon release of the push the capacitor starts to recharge and when the voltage gets to about half the V_{out} supply voltage the supply to R_f is reduced and the circuit shuts down. Since C_t remains charged in the off condition it is kept well polarised and the leakage current should be low. Any, leakage is not significant in affecting battery life, only timing.

Complete circuit

The complete circuit is shown in Fig. 7 and has seven capacitor ranges increasing from 100 pF to 100 μ F for a full-scale meter reading. On one further position a 1% tolerance capacitor is switched in so that the 100 μ A calibration can be checked and rest if necessary. A push button will remove a meter shunt so that any range can be expanded from 0-100 to 0-30. Thus, except for capacitors of less than 10 pF, no capacitor need be measured such that the reading is below 0.3 of full scale. The meter is scaled 0-30 and 0-100.

Before describing the complete circuit further it is worth listing the functions of the various switches which have been numbered for this purpose.

Fig. 7. Complete circuit diagram. Capacitor C₈ should not exhibit more than 1µA leakage and the voltage supply must not fall below 7A.

S₁ Connects a calibration capacitor across terminals and disconnects the unknown.

S₂ Selects the frequency timing resistor for the square wave.

S₃ Selects one of two timing capacitors for the square wave.

 S_4 Changes the meter shunt and the size of smoothing capacitor on the 100 μF range.

 S_5 Selects the value of the meter shunt which will be removed when the range expansion button is pressed. This is different on the 100 μF range to that on the others.

Note that S_1 to S_5 are 1-pole, 8-way switches.

S₆ Battery test single-pole, changeover push button.

S₇ Range-expand single-pole, normally-closed push button.

S₈ "Switch-on" single-pole, normallyopen push button.

Most of the circuit will be recognised from the previous description. Tr_4 is the series switch, turned on by Tr_5 , which itself is turned on by the output at terminal 6 of the hex. inverter when the push button S_8 discharges C_4

The voltage supplied to the hex. inverter controls the magnitude of the square wave and in turn the magnitude of the meter current reading for a given capacitor size. The method of setting the calibration is to adjust this voltage by R₁₄.

The regulator, Tr_1 and Tr_2 is simple but sufficient because of the use of a built-in precision capacitor which enables the calibration to be checked and reset if necessary. Tr_1 is an emitter follower which transfers the voltage from Tr_2 collector which, in turn, is set by R_{14} . Only about 0.6V is lost across R_{11} when the battery voltage is low in order to conserve battery life.

The oscillator frequency is determined by the value of R and C selected by S2 and S3. On the four highest capacity ranges the resistors should have a tolerance of 1% and, as can be seen, are fixed. Calibration is made correct using the CAL control using a precision capacitor in the test position. Afterwards the voltage at terminal 1 of the i.c. should be measured and, if it is not 5.4V $\pm 0.2\overline{V}$, the capacitor C₂ is probably not quite correct. If voltage is high, the battery life will be shortened, since at design centre a minimum voltage of 7V is recommended and the battery starts with 9V.

On the other ranges, the value of the timing resistor is adjustable and so each range can be set as accurately as the standards available for calibration. The CAL range and the 0.01 µF range are common, so setting the CAL using the instrument's own internal standard should be sufficient. On the 100 pF range, the trimmer C7 across the measuring terminals will need adjustment - best done with the range expand in use. The best setting was found to be that which caused a reading of 0.3 pF with nothing being measured. The measuring error was then not more than 0.5 pF anywhere on the range. With no C₇ the error was 2pF.

The battery timer is set for about thirty seconds, depending a little on leakage currents. This can be extended if required, or the push button omitted and a normal on-off switch used. The advantage of the push button is that battery life can be more than 12 months with the equipment in casual use.

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1. A thorough explanation of the circuit is given in "The diode-transistor pump," by D.E. O'N. Waddington, Wi: eless World, July 1966, p.338.



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Digital picture coding

When widespread use of digital video signal transmission comes about the techniques to allow realistic bit rates should be available

by David Webster, M.Sc., M.I.E.E.E.

Of the many methods that are available for reducing the transmission bit rates of the digital video signals it is very difficult to say that one technique is best. In general techniques that use a frame memory give better results than those that do not. It was once the case that the degree of improvement could not be justified because of the high cost of a suitable memory. But in the past few years the advent of m.o.s. l.s.i. shift registers and other devices has gone a long way to enable frame memory techniques to be used.

Predictive coding techniques are normally superior to sub-sampling and conditional replenishment techniques and need little, if any, extra hardware. Fortunately transmission errors can be handled by the careful choice of predictors and forced up-dating. Transform coding techniques look promising for the future. They have good transmission error immunity and are capable of large reductions in bit rates. Their drawback is their need for much hardware and the fast signal processing required in their operation.

CONTRASTING SHARPLY with the rapidly expanding use of digital transmission techniques in the world's telephone networks, the transmission of television signals has been an almost exclusively analogue process. As the television signal is often transported from studio to transmitter site by the same transmission network as used for the more humble telephone signal, it seems logical to investigate the digital encoding of television signals. In recent years some interest has been shown in video telephones and again it seems logical to integrate such a service into the ever more digitally orientated telephone transmission network.

Digital techniques offer important advantages in the transmission of video signals, particularly for long distance transmission. The signal impairment brought about by long distance transmission of a digital signal is much less than that experienced by an analogue signal. Additionally when a television signal is sent from one country to another there is the problem of standards conversion. Standards conversion of a digital signal is much easier to achieve than that of an analogue signal.

The conversion of an analogue signal

into a digital format involves two processes, sampling and quantization.

Sampling involves measuring the amplitude of the analogue signal at regular time intervals. Nyquist showed that the theoretical minimum sampling frequency is twice the bandwidth of the analogue signal. In practice the sampling frequency must be slightly greater than the theoretical minimum, due to imperfections in the sampling pulses and filters. When a video signal is being sampled the sample points are often called picture elements or pels. Thus each line of a television picture can be represented by a number of pels.

Quantizing involves converting the sampled value into a binary number which is used to represent that value. The binary number can then be transmitted, in a serial fashion, as a digital

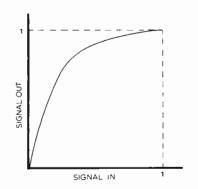


Fig 1. In speech small amplitudes are more common than large amplitudes — one reason for using a non-linear companding law between incoming signal level and the binary number representing it in telephony.

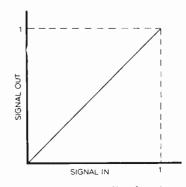


Fig 2. Linear companding law is more appropriate for television signals. Maximum signal level has been normalized to unity.

signal. When a telephony signal is being quantized it is normal to use a non-uniform relationship between the incoming signal level and the binary number derived from it (in speech small amplitudes are much more common than large amplitudes). The relationship between the incoming signal level and the resulting binary number representing it is the companding law, Fig. 1.

In a normal television signal there are just as many high signal levels as there are low signal levels and so it is normal to use a straight line relationship for the companding law, Fig. 2. Good results can be achieved by using eight bits to represent each pel.

As an example of the digital transmission rate required, consider the British 625-line system. This has an analogue transmission bandwidth of 5.5MHz and a practical sampling rate is 13MHz. Thus, by representing each pel by an eight-bit binary number the digital transmission rate is 13 x 8 = 104Mbit/s. Equipment to handle such a large transmission rate is available but the cost of transmission is very high. There is thus a considerable amount of interest being currently shown in techniques that can reduce this transmission rate, while of course maintaining picture quality.

Basis of transmission rate reduction

The techniques that have been applied to reducing digital transmission rates fall into two main categories. The first category involves reducing the amount of redundancy that is present in all video signals. The second involves the examination of those characteristics of the eye that can be exploited in fooling it into believing that it is seeing a much better quality picture than it actually is.

Consider a typical television picture. Normally there will be some object, probably in motion, set against a stationary background. The background is not changing and thus conveys no new information from frame to frame. Also large areas of moving objects can have very little detail (try and observe detail in a moving object) and so there is little new information displayed in each progressive frame. Thus the major part of a typical television frame is much the same as the

previous frame. This represents a very considerable amount of redundancy, which if it can be reduced would result in the requirement for a considerably reduced transmission rate.

Around moving edges and when the scene displayed is suddenly changed there is very little redundancy and at first sight this would appear to present major problems in any attempt to reduce transmission rates. However, it is in these areas that certain characteristics of the eye can be exploited to great advantage.

The eye is very tolerant to the blurring of moving objects. This is very evident from a television picture. The camera integrates the picture over a period of 1/25th of a second and so any object that has undergone appreciable movement during this period must then be represented by a blurred image. This may be a fundamental property of the eye or a property arrived at through prolonged conditioning; either way, the fact remains that the viewer does tolerate a significant reduction in resolution.

The eye is very tolerant to inaccuracies in the presentation of sharp edges. Fig. 3 shows three transitions in video signal level that the eye will accept as sharp edges. In a similar way

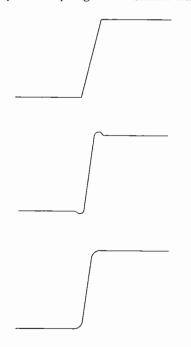


Fig. 3. Human eye is very tolerant to innacuracies in sharp-edged scenes – all three transitions appear as sharp edges.

the effect of a glitch is much less objectionable to the eye when it is close to a sharp edge in the picture, Fig. 4. From this it can be deduced that inaccuracies in the reception of the video signal representing a sharp edge in the picture are not too serious. And if the edge is the boundary of a moving area, its accurate representation is even less important.

Another property of the eye that can be exploited is that when the scene displayed on a television suddenly

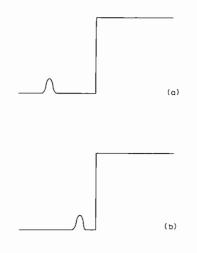


Fig. 4. The "glitch" is much less objectionable to the eye when close to a sharp edge.

changes, the eye only gradually begins to perceive the detail portrayed in the new picture. At first all that is noticed is the outline shape of the object in the new scene and it is only later that the detail is noticed. This process can take a significant fraction of a second and in this time several frames can be displayed.

Spatial and temporal sub-sampling

One technique that exploits the effects mentioned above is spatial and temporal sub-sampling. The equipment involved in converting the analogue signal into a digital signal, prior to transmission, detects moving areas and misses out some pels. After transmission and before converting to an analogue signal again, values are derived for the missing pels by interpolation from the two surrounding pels. This is spatial sub-sampling and exploits the allowable loss in definition in moving areas of a picture.

In stationary areas or in slowly moving areas certain pels can again be missed out prior to transmission. Before the signal is converted back into an analogue form the value from the previous frame of the missing pel can be inserted. This is temporal sub-sampling and removes some of the statistical redundancy in the signal.

To carry out spatial and temporal sub-sampling a decision has to be made as to whether a pel is in a stationary or a moving section to the picture. One method of doing this is to derive a difference level between the pel under consideration and the equivalent pel in the previous frame. If this difference is larger than a set level the pel is said to be part of a moving area. This requires a memory capable of storing all of the data from the previous frame.

Because there can be large differences in the same pel between frames even in stationary areas, because of noise, it is usual to decide on an area basis if there has been significant movement or not.

Much work has been carried out on

sub-sampling techniques for video telephone signals. This has shown that 2:1 sub-sampling, i.e. halving the transmission rate, can give acceptable results but the quality deteriorates rapidly if coarser sub-sampling is attempted. Although the quality obtained is acceptable for video telephones it would be difficult to achieve good transmission rate reduction and still maintain the quality of broadcast standard television.

Conditional replenishment

A technique that makes use of the great similarity between consecutive frames is conditional replenishment. The difference in the value of the same pel in consecutive frames will be very small except in areas of the picture containing moving objects and even in these areas it is possible that only the pels around the boundary of the object will be experiencing significant changes.

If frame memories are provided at the transmitter and the receiver then only the values of those pels that have changed between frames need be transmitted. To enable the receiver's frame memory to track the signal successfully, the memory location of the change must also be transmitted. To economize on the amount of transmission capacity required for specifying the position of the changed pel, it is normal to decide on an area basis if a significant change has taken place or not. Then only the memory location of the area need be transmitted.

As there is a wide range in the rate of change of a television picture, the rate of information transmission will vary widely unless special techniques are employed to even out the flow. This can be achieved by means of a buffer memory. Information relating to changes enters the buffer as and when it occurs and leaves the buffer at a constant rate. To accommodate large changes in the picture content a very large buffer is required, however, buffering introduces a delay in the transmission process and it is the length of an acceptable delay that limits the size of the buffer that can be used.

To prevent the buffer overflowing it is necessary to increase the difference value, deemed to represent a significant difference between frames, as the buffer fills up. During very active periods the changed pels can be sub-sampled and interpolation used at the receiver for the non-transmitted pels. These techniques lead to a loss of resolution, but as they are only used during periods of rapid change in the picture the effect is tolerable.

The conditional replenishment technique is useful in applications where the picture is not constantly in a state of rapid change and so it is more applicable to video telephone use than to broadcast television. Video telephones show almost exclusively the human head and

so the video telephone picture experiences much less in the way of rapid change than that observed on broadcast television.

Predictive coding

High correlation between a pel and its neighbours in space and time is the basis of predictive coding. A prediction is made for the pel from the neighbouring pels. This prediction takes the form

$$P_{o} = \sum_{i=1}^{n} a_{i} P_{i},$$

where P_0 is the predicted value of the pel, the set of P_i are the values of the neighbouring pels and the set of a_i are normalized constants.

The difference signal, $P-P_0$ where P is the acutal value of the pel, is derived and it is this difference signal that is actually transmitted. With an appropriate choice for the set of a_i the difference signal should be small. It is then possible to represent the difference signal with fewer bits, but still with the same resolution as the original signal. If large difference signals are occasionally encountered they can be catered for by using a non-linear companding law. Small increments for small signal levels and large increments for large signal levels. Large difference signals are associated with steps in the original signal level and inaccuracies in the representation of such steps go unnoticed by the eye.

Differential p.c.m.

The simplest predictive coding technique is differential pulse code modulation (d.p.c.m.). An implementation of this is shown in fig. 5. The input to the transmitter is an eight-bit p.c.m. representation of a pel, from which is subtracted the same value as the receivers representation of the previous pel in an eight-bit p.c.m. format. The

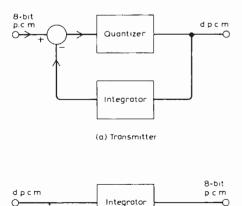


Fig. 5. In predictive coding, a prediction of a picture element is made from its neighbours and the difference between this and the actual value transmitted.

(b) Receiver

resultant difference signal is passed through a quantizer with a non-linear companding law and then transmitted. At the receiver the incoming difference signal is integrated and the original signal restored.

Differential p.c.m. makes use of the previous pel for the determination of a difference signal and it thus makes use of the horizontal correlation in the picture.

Field predictive coders

There are many reasons why the exploitation of the horizontal correlation is preferable to the vertical correlation. In a non-interlace system access to the vertically adjacent pel requires the storage of one picture line. With the more common 2:1 interlace system this becomes a field minus a line of storage. If in a 2:1 interlace system the vertically adjacent pel in the same field is used as the predictor, requiring one line of storage, the vertical correlation is significantly less than the horizontal correlation as the vertical pel is now two lines away.

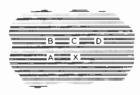


Fig. 6. Simple predictive codings can be improved in various ways. In predicting the X pel, elements can either be averaged, e.g. (A+D)/2, or based on differences between lines, such as A+(C-B).

A predictive scheme that makes use of horizontal correlation can give a good quality representation, but unfortunately it does have problems in handling sharp vertical or diagonal edges in the picture. Such a predictive scheme produces blurring at these edges. In attempting to overcome this "edge busyness" the vertical correlation in the picture can be exploited as well as the horizontal. This is because vertically adjacent pels can give a prediction of edges in the picture.

Consider Fig. 6 which shows some pels in the same field. X represents the pel that is currently being predicted, A is the previous pel in the same line, and B, C and D are pels in the previous line. One form of prediction that can be made is the average of pel A and one or more of B, C and D. This is "averaged" prediction. Alternatively the prediction can be the sum of A and a normalized difference between two of the pels in the previous line. This is "planar" prediction. Average predictors such as (A+D)/2 and the planar predictors such as A + (C-B) both give an improvement over the simple d.p.c.m. scheme which uses only A as the predictor.

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Frame predictive coders

A further improvement in performance can be achieved by using pels from the previous frame in the predictor. This improvement is due to the high correlation between frames. But to exploit such predictors frame memories are required.

Comparison of predictive coders

As the number of pels used to create a predictor increases the predictor provides a better and better estimate of the pel. With a very good predictor the difference between the predictor and the actual value of the pel becomes very small and so the difference signal can be transmitted with very few bits. With an appropriate choice of frame predictor, excellent quality can be achieved by means of a three-bit difference signal for each pal.

Unfortunately complicated predictors require complicated equipment to produce them. This is particularly true of frame predictors which, of course, require frame memories.

Problems arise with predictive coders when there is a transmission error. The

receiver integrates the incoming difference signals and so any transmission error is incorporated into all signals emanating from the receiver. Fortunately it is possible to choose a predictor which causes the effect of transmission errors to diminish as time progresses. Average predictors are better in this respect than planar predictors.

One technique often used to eliminate accumulated errors at the receiver is "forced updating." Every so often a line is transmitted in its original p.c.m. format rather than its difference format. This of course requires the use of small buffer memories to allow constant transmission rates.

Transform coding

In transform coding a mathematical

transform of an image is made. It is the transform coefficients that are quantized and transmitted. At the receiver the inverse transform is carried out, allowing the original image to be reconstructed.

Many of the changes between frames of a television picture can be represented by simple translations of an object. If these translations remain constant over many frames, the frame difference will be very similar over many frames.

The Fourier transform of a time-shifted signal differs from the original signal by a phase shift $\omega \Delta t$. Thus the two-dimensional Fourier transform of a frame difference will be very similar to that of the previous frame difference transform except for a phase difference

 $\omega_x \Delta x + \omega_y \Delta y$. Thus for transmission only Δx and Δy need be sent plus information relating to those regions of the picture that are not in true translation.

The Fourier transform is not the only transform that can be used for coding purposes and the cosine transform in particular looks very promising.

Theoretically transform coding techniques are capable of excellent results. In the future it may be possible to transmit signals with the equivalent of 1 bit/pel. The technique shows excellent immunity to the effects of transmission errors.

Unfortunately transform coders require several frame memories to implement them and the amount of signal processing involved is at present very difficult to do in real time.

V.h.f.-only aircraft fly out of control

During the recent French air-traffic control dispute, aircraft normally flying to and overflying France and Spain were permitted by the Civil Aviation Authority (CAA) to use a route, designated the 'Spanish Track', which passed over part of the Atlantic Ocean between Lands End and Madrid. Normally only aircraft equipped with h.f. radio, and consequently capable of maintaining contact with the air traffic control centres, are allowed over the Atlantic Ocean: v.h.f.-only aircraft are usually restricted to the overland routes. However, because of the holdups resulting from the dispute, the special Atlantic route was available for both types of aircraft. This was a dispensation of a rule in the normal procedures which said that v.h.f.-only aircraft could not fly over the Atlantic.

A warning was given to the operators of the v.h.f.-only aircraft that, due to the lack of communication with Shanwick Oceanic, who control the Atlantic Ocean traffic, normal air traffic control service would not be available over a major portion of the route. Instead, control service to these flights was limited to basic separation provided by the clearance to enter the Shanwick flight information region. The operators were also warned that normal air traffic control action in the event of emergencies might not be practical.

Fortunately many of the aircraft using the route were originally designed for Atlantic crossings and did in fact have h.f. radio as well as v.h.f. radio. However, the use of the route by undiscriminated aircraft proved to be far from satisfactory, and one week later the CAA issued the following statement: "The CAA has decided that in the event of the reintroduction of the Spanish Track, airline operators will be required to be equipped with h.f. radio. There is nothing basically unsafe in the arrangements made for flights using the Spanish Track provided that all concerned strictly comply with the detailed procedures. This has led to a detailed review of the arrangements and it has become evident that the degree of noncompliance was such as to give rise to difficulties in the management of the air traffic flow."

Shanwick Oceanic, at Prestwick in Scotland, normally use a teleprinter link to their transmitter and receiver station in Ballygreen, Southern Ireland, for all of their air traffic control communications. Atlantic flights on the American side of the ocean are controlled by Gander in Newfoundland, Canada.

Aircraft which normally fly trans-atlantic require navigational equipment in addition to h.f. radio if they are to fly at heights above 27,500 feet. The Spanish Track flight path, which incidentally may still be used by h.f.-equipped aircraft in the event of further air-traffic control disputes, uses height levels from 24,000 to 27,000 feet.

UK headquarters for Japanese-owned broadcast company

SONY BROADCAST BV. the subsidiary of Sony Corporation of Tokyo, formed on January 2 of this year, is to have new headquarters in Basingstoke. The decision to use a UK-base to handle marketing operations for Europe, the Middle East and Africa was made a few months ago, but a spokesman for the company could give no reason for the move, other than that they preferred to operate from the UK. The old headquarters, in Vianen, Holland, are to retain their distribution facilities for the company.

In addition to a marketing division, the Basingstoke headquarters will house research laboratories, sales administration and customer training. A separate building near the headquarters will provide warehousing, special projects and quality assurance facilities, and spare parts stocks to supplement Sony's service centre in Antwerp.

Mr Howard Steele, Managing Director of Sony Broadcast, and ex-Director of Engineering for the IBA, said of the move, "The spearhead of our marketing operations from Basingstoke will be Sony Broadcast's range of equipment for electronic news gathering, studio and field production requirements. The equipment has been subjected to rigorous testing over recent months by a number of broadcasting organisations and has met with universal approval. We are particularly gratified by the way in which our range of U-matic high-band recorders has been received, with general acceptance of third generation recordings for on-air use."

The full address of the new headquarters is City Wall House, Basing View, Basingstoke, Hampshire RG21 21 A.

EDITORIAL WRITER FOR WIRELESS WORLD

Wireless World needs a new person on its editorial staff. Technical experience in electronics and/or communications and an ability to write are essential. The work is varied and includes writing technical news reports and other material, attending conferences, exhibitions, press conferences and other events, some abroad, and editing contributed technical articles. A good deal of freedom will be given to a person who shows ability and responsibility. Preferred age range 25 to 35. Write to: The Editor, Wireless World, Dorset House, Stamford Street, London SE1 9LU.

NEWS OF THE MONTH

Responses to Government White Paper on broadcasting

ON THE DAY FOLLOWING the publication of the White Paper on broadcasting, Lady Plowden, the Chairman of the IBA, said that it was "a major disappointment" that the Paper had decided that the fourth channel should go to the Open Broadcasting Authority (OBA). While the Paper suggested that a unique opportunity would be missed if the fourth channel was not used for innovative programming, the IBA considered that it was only necessary to look at the awards won by ITV programmes to see new innovative programming of quality. "New talent does not magically arise because there is a new organisation," said Lady Plowden. "Television does not produce innovative programmes in limbo."

The IBA believe that the White Paper's proposal reflects a failure to understand the practicalities of running a tv network, and that a fourth channel service integrated with ITV, under the IBA's control, would give the public a more effective service, more quickly and more economically.

The White Paper lays on the IBA fresh responsibilities in the coming years. These include the extension of local radio — which will also be effected by the BBC, the equipping of transmitters for the fourth television channel, and the development of paytelevision and community services by cable. The IBA welcome these proposals, according to an IBA publication.

On the subject of Independent Local Radio (ILR), the publication says that the IBA will be co-operating with the Home Office and the BBC on a proposed working party to settle the assignment of frequencies, and they hope to get ahead quickly with the acquisition of sites and planning permissions for the ILR areas. It continued by saying that the IBA's engineering division is ready to undertake the expansion of ILR and the building and operation of transmitter networks for the fourth channel, and this may well involve heavy concentration on Wales, where, according to the White Paper, a Welsh language service is to be given priority.

It also welcomes the Government's indication that the IBA would not be excluded from any international discussions on the subject of future satellite broadcasting.

The White Paper says that the IBA has spent some £5 million on the engineering work needed to put the fourth channel on the air, and the Government has agreed with the Annan Committee that, in order to keep the cost to a minimum and to avoid unnecessary delay, the IBA should be responsible for engineering the channel and its transmission. The Paper says, "The IBA estimates that to provide a network of transmitters for the fourth channel with a population coverage of 80 per cent of the population in each of the existing ITV franchise areas would cost some £14.5 million (at current prices) over four and

* Broadcasting, presented to Parliament in July 1978.

a half years. The aim will be, however (as for the existing u.h.f. tv services), to extend the coverage to just over 99 per cent of the population of the UK. This would cost an additional £13.5 million and take a further four and a half years. The OBA will reimburse the IBA for the cost of engineering and transmitting the fourth channel service, but the Government will be prepared, if necessary, to make loans to the IBA for the engineering work."

Engineering requirements for the fourth channel will include new transmitters and distribution links between studios and the transmitters. Most of the IBA's aerials have sufficient bandwidths for four channels so these are not expected to present much of a problem.

Com-Com's view

The Community Communications Group (Com-Com) deplores the Government's rejection of a local broadcasting authority, and instead proposes a 'Community Broad-

casting Agency'. They believe that attending to local communications needs should be a higher priority in the 1980s than expanding national network broadcasting. "Nevertheless," says a Com-Com report, "if a fourth u.h.f. tv channel is to be allocated, Com-Com is in favour of an Open Broadcasting Authority along the lines proposed in the White Paper."

The Group members propose that the 'Agency' be established, along the lines of the Cooperative Development Agency Act of May 1978. Its functions, briefly, would be to look after small communities, perhaps no larger than a group of residents in a block of flats or a town of 100,000 people in the case of local radio, issuing licences, and taking responsibility for hospital and university broadcasting and cable radio and tv transmissions. It would also represent the interests of community broadcasting at a national level, for example in the assignment of frequencies, and make development grants available to groups wishing to establish stations. More importantly, the Agency would be financed from a variety of sources, structured as non-profit-distributing entities and owned and operated by the communities they served.

Government grant of £4.5m to foreign-owned UK company

THE MINISTER OF STATE at the Department of Industry, Mr Alan Williams, announced recently that the Government was making a grant of £4.5m to Mullard Ltd, who are owned by the Dutch company N.V. Philips' Gloeilampenfabrieken. This grant, provided under Section 7 of the Industry Act 1972, has enabled Mullard to launch a £24m, three year investment plan, known as Project Vanguard, to modernize the manufacturing facilities at the company's tube assembly plant at Durham, and to establish a new 20in 90° tube production line at their Simonstone plant.

The investments at Simonstone and Durham will total £13.1m and £7.8m respectively. Further investments of £2.4m and £0.9m will be made at Philips Washington, which makes the neck components for the tubes, and at Crossens, where the incorporated magnetic components are produced, respectively.

In answer to a written parliamentary question from Mr Doug Hoyle MP, Mr Williams said, "By specialising in the production of 20in and 22in tubes, Mullard will be well placed to meet the growing demand within the EEC for tube sizes below 26in. The Government has consistently stated its determination to maintain a viable colour television tube making capacity in the UK. In order to assist this major investment programme, the Government reaffirms its support for the Radio Industry Council initiative of October 1977 under which the UK setmakers agreed to increase their use of UK

made tubes, in particular the 22in tube. The Government is taking steps both to enable UK set-makers to increase their proportion of 22in tubes made in the UK up to 75% by 1980 and to monitor systematically the achievement of this objective."

Project Vanguard is aimed at providing an enhanced and expanding range of tubes and ancillary components which will prove fully both technically and competitive economically in the 1979 market environment. At the same time it will contribute towards job security at the four plants involved. The project will also aim at increasing Mullard's share of the UK tube market from around half in 1978 to over two-thirds in 1981, both figures being based on a total market of 1.8m tv sets. By 1981, therefore, two out of every three tv sets made in the UK could be equipped with a Britishmade tube.

Mullard, who, following the closure of the Thorn plant at Skelmersdale in 1977, are the UK's only tv tube manufacturer, plan to achieve an increase in exports and a reduction in tube imports, thereby contributing significantly to the national balance of payments.

In answer to a query about the award of grants to foreign-owned companies, a spokesman for the Department of Industry said that, under the Industry Act 1972, all companies based in the UK, whether they are foreign-owned or not, are treated the same.

Teletext aids the deaf

THE BBC AND THE IBA are both researching the possibility of using teletext to provide optional subtitling on television screens to enable the deaf and hard-of-hearing to benefit more fully from television programmes.

The BBC are working with Leicester Polytechnic to find a way of using a computer to transcribe the output from a palantype shorthand-writing machine into normal English at speeds in excess of 200 words per minute. If they succeed, the system could be used on the BBC's Ceefax service, and would allow deaf people to follow all the programmes while those who are not so afflicted would not have to see the subtitles on their screens. The work was described recently by Mr Lyndon Thomas of Leicester Polytechnic at a seminar held by the National Deaf Children's Society in London.

Similar work by the IBA is being carried out jointly with the Independent Television Companies Association (ITCA), supporting a research project at Southampton University. Their work is expected to cost over £50,000 and is aimed at providing optional subtitling for the deaf by means of the Oracle teletext system. The project, which will probably take three years, is being carried out under the supervision of Dr Alan Newell of Southampton University.

Both the BBC and the IBA have recognised

that conventional techniques of producing subtitles are expensive and time-consuming and palantype machines, of the sort used by Mr Jack Ashley, MP in the House of Commons, could greatly increase the speed of subtitling.

Mr Ashley, having become profoundly deaf, found that the brief notes that colleagues wrote for him were less than adequate for him to take an active part in the House, because he needed to know wordfor-word what was being said in the speeches. The palantype machine he used enabled him to see a display of a written version of the words being spoken. It used a form of shorthand because it was impossible for his typist, who acted as his ears and fed the machine with the contents of the speech. to record the words, letter-for-letter, real time. Unfortunately, the machine output was also in this coded phonetic form, where the words were split into syllables, and one could only read it quickly after a long period of

Research work had already been carried out at the National Physical Laboratory to translate palantype outputs into standard spelling, but this used a large and expensive computer and had to remember 75,000 words and how to spell them in both English and palantype. Mr Newell thought that a small

portable electronic processing unit was capable of performing the task if one did not go to great lengths to spell each word correctly, and so he set out designing one at Southampton. Two such units were built and tested in the House of Commons by Jack Ashley by February 1977. The displays were not in true English but in a form which was relatively easy to learn. Since then improvements have been made to the accuracy of the spelling.

The problem with subtitling is that it can take one person about 30 times the length of a programme to produce a subtitled version of that programme. It is hoped that subtitling of the palantype form will overcome this problem. "It has become clear," said the IBA, 'that before a regular service of optional subtitling can be introduced, much needs to be known about the human factors involved and suitable operational equipment.' They hope that ITV will be able to start transmitting some programmes with experimental subtitles for deaf viewers during the next 12 months. However, before viewers will be able to take advantage of this form of subtitling, it will be necessary for them to have teletext decoders in their tv receivers.

Ref. 'Palantype Transcription Units' by Alan Newell, 'Palantype in the office' by Geoff Hayward, *Hearing*, journal of the Royal National Institute for the Deaf, May/June 1978

A cerebral palsied child using a pointer fixed to a headcap to type a message on the keyboard of an experimental computer-assisted communications system, designed by Bell Laboratories and the Telephone Pioneers of America.

Few alternative modes of communication are available today for people with severe speech and muscle impairments, and most of these limit vocabulary. This experimental minicomputer-based keyboard system is claimed to go a long way towards overcoming this. Using the system, a disabled person can compose messages by simply pressing large buttons on an oversized portable keyboard. The buttons are recessed in one inch diameter, well-separated holes. The message typed by the person appears on a video screen and may be supplied on hard copy at the press of two more buttons. To reduce the amount of typing, the computer stores abbreviations fpr words, word endings and phrases which it can automatically recognize and write out. Bell Laboratories have preprogrammed a standard list of these electronic abbreviations and is preparing instructions explaining how a person can add others.



Home Office comments on NEC c.b. report

THE HOME SECRETARY, The Rt. Hon. Merlyn Rees MP, has replied, in a letter, to the National Electronics Council's report on c.b. radio (see page 38, August) forwarded to him by HRH The Duke of Kent, Chairman of the NEC. According to the National Electronics Review, July-August 1978, the Home Secretary said that they (the Home Office) would certainly take the NEC's views on board, but that if they did not feel, on balance, that a c.b. should be introduced, the conclusion was one which was not lightly arrived at and was not simply the product of cautious, overbureaucratic thinking. They were quite prepared to keep an open mind on the issue. While welcoming the report's recognition that it would not be appropriate to introduce c.b. in the country on 27MHz, the Secretary said that the pressure on the v.h.f. and u.h.f. bands was such that they must be satisfied that its use for c.b. could be justified in the face of competing claims for other mobile services. The letter continued by saying that the other area where the Home Office still had misgivings was in relation to the control of possible misuses of the facility and the need to minimize the risk of interference to other services. According to the letter, to regulate c.b. radio in the way the NEC report suggested would require a considerable increase in manpower. There would also be expenditure complications and the undesirability of an army of regulatory officials.

Robert Bosch GmbH has recently acquired a computer-controlled v h f /u h f test assembly to hunt down sources of radio interference in car parts such as ignition systems, electric motors and generators, and in film cameras and emergency generator units. The assembly, which was supplied by Rhode & Schwarz, uses a receiver, type ESU 2, capable of measuring frequency over a range of 25 to 1000 MHz in compliance with VDE guidelines 0875, 0877 and 0879, CISPR publications 2, 4, 12, 13 and 14, and European Community directives. It has a voltage range of -10 to +120 dB (μV) over the frequency range and can measure two-port transfer constants from -90 to +40 dB. A Tektronix 4051 desktop computer is employed and evaluates the test results and presents them in graphic and tabular form on a video display. The computer results may also be recorded on a tektronix hard copy unit, type 4631. Other equipment used in the assembly include a frequency controller, type EZK, two code converters type PCW, all from Rhode & Schwarz, a digital voltmeter and a frequency counter.



Is ARI in the grave?

A STORY IN THE German journal Funkschau recently reminded Wireless World of the traffic information service, ARI (automotive road information), which was being tested in the UK about two years ago. (See p47, Dec. 76 issue.) The story gave some indication of how the countries who have ARI seem to take it for granted, and how some countries are almost slaves to the service, while others are still not sure that they want it at all. "We Germans in the central country of Europe which is well provided with ARI often do not know that this kind of traffic communication radio is either still rejected in other parts of Europe or is just being discussed or tested. Even progressive Switzerland is still debating (the last time was at the end of December last year), when representatives of the general management of the PTT, the Radio Society, the Automobile Clubs, the Accident Advisory Centres and the Police authorities were all of the opinion that a communication radio similar to ARI would be useful, especially when, in choosing the system, the tendencies of neighbouring countries are considered. . . In this country it does not often happen, but in other countries from time to time there are splendid street maps which indicate precisely in which part of a street UKW stations can be heard", said a translation of the story. So, what did happen after the one month test in the UK two years ago? Wireless World has been finding out.

The test was carried out by the London Broadcasting Company, LBC, using the Blaupunkt ARI system from 19th October to the 18th November 1976. ARI decoding equipment was fitted to thirty journalists', police, and other public representatives' vehicles to help them tune to radio LBC on 93MHz v.h.f./f.m. or 261m medium wave whenever traffic information was broadcast. Of these thirty people, only 26 replied to the questionnaire. However, a spokesman for Robert Bosch Limited, who own Blaupunkt Radio, said that these 26 people included two IBA officials, the Minister for Industry, the shadow Minister for Transport, a leader of the GLC, AA and RAC representatives, a visiting Ambassador, a dozen motoring journalists, and representatives from a chauffeur hire firm and two motor companies, including Ford. "Of these participants, all but the IBA officials, who could not comment because it would prejudice IBA policy, said that the test was a success," said the spokesman. Twenty-two of these considered that the system required wide scale testing or nationwide introduction.

An analysis of the questionnaire response by the participants is in our possession but is too large to be dealt with in detail here.

After the results of this experiment were announced, four radio companies, LBC in London, BRMB in Birmingham, Piccadilly in Manchester and Clyde in Scotland, asked the IBA to apply to the Home Office for a wide scale test for a period of six to twelve months. The IBA did so in May 1977. The Department of Transport, who had set up a working party to study area broadcasting of traffic information, refused them permission because they wished to wait for a report from the Traffic Road Research Laboratory (TRRL). The working party included four BBC representatives, five people from the TRRL, four Home Office representatives, two policemen and one IBA official. The AA and the RAC were not represented.

Some of the pro-ARI people we spoke to said that the TRRL committee, who they say have been studying the BBC Carfax system (see p28, Jan 78), on submitting their report to the Home Office, considered that the ARI test would not be helpful in their work. A TRRL spokesman, when asked about this, said that the TRRL do not get involved in technical matters but are more likely to look at whether telling drivers of problems on particular roads would be of any benefit to them. The TRRL is responsible to the Departments of the Environment and Transport.

According to a Bosch spokesman, at least six local radio companies, supported by the Society of Motor Manufacturers and Traders, who represent the British motor industry, are now pressing for another test to coincide with the Motor Show at the NEC, birmingham, in October this year. The Bosch spokesman said that Metro Sound, a Newcastle station, had got all the commercial

stations to agree to ARI being 'pressed ahead' and that they had asked the IBA to approach the Home Office again. This they had not done. However the pro-ARIs believe that the IBA have been deterred by comments in the recent Government White Paper on broadcasting, and are unlikely to take the initiative to apply. The only proviso now, they say, is if the Government asks the IBA to conduct tests.

A member of the IBA information service confirmed that they would not press for further tests unless asked by the Department of Transport and said that, while they were not convinced of the worth of the BBC's Carfax, they were convinced that local radio had a part to play in traffic assistance. However, they had no strong feelings about the ARI system either.

This brings to mind one point raised by Bosch; that is, that Germany and Austria, when trying to decide whether to have ARI, asked the question "do we need traffic information". This was their big issue and finding the answer cost them a lot of money. In the UK the Department of Transport do not have to ask this question, we have been transmitting road reports for many years. "What we need now," say the pro-ARIs, "is to get it to the people in the correct way."

News in Brief

Within the framework of Telecom 79, the third World Telecommunication Exhibition which will take place in Geneva from 20 to 26 Sept. 1979, the ITU is organising the first World Telecommunications and Electronics Book Fair. This will be the first ITU event to feature exclusively books and publications on the subject of telecommunications.

AMI Microsystems Ltd, of Swindon. have reached an agreement in principle, for the merger of Millennium into a wholly-owned subsidiary of AMI. The transaction is subject to the negotiation of mutually satisfactory agreements and to the final approval by both Boards of Directors and Millennium shareholders. Millennium is a supplier of microprocessor support products.

Vapour ignition hazards can be controlled — HSE

THE MAIN PROPOSAL in a Health and Safety Executive (HSE) report¹, published in August, said that the IBA's (Radio Forth's) transmitter at Barns Farm on the Forth estuary should be moved three kilometres away from a proposed Shell plant at nearby Braefoot Bay, because of the risk of radio frequency sparks igniting concentrations of vapour at the plant. The plant would be storing liquefied butane and propane and would be linked by pipeline to other plants at St Fergus, Aberdeenshire and Moss Morran, Fife (see p43, Dec. '77 issue).

Mr John Locke, Director of the HSE, said in a letter to the Secretary of State for Scotland, "It is the view of the HSE that if the recommendations outlined in the report are fully implemented the risk of radio frequency sparks igniting flammable concentrations of vapour would be insignificant. This being so we see no reason why objection need be raised to the proposed developments at Braefoot Bay and Moss Morran on the grounds of hazards from radio transmission."

Giving an indication of the probability of ignition due to radio interference the report says, "Prevention of large scale vapour releases is an integral part of plant design and operation and the probability of such releases occurring will be reduced to an acceptably low level as a result of the hazard audit which will be carried out during the design and construction stages of the operation, Radio frequency transmissions will not cause releases to occur and will not ignite releases of flammable vapour even if both are present together unless some third factor, that is the release of radio frequency transmission power as a spark, also occurs." Such an event was considered to be very remote especially if practical safeguards were implemented.

The report says that by using the latest available information on the British Standard on such hazards, calculations indicate that radio frequency sparks capable of igniting vapour would not occur on the majority of structures proposed at Moss Morran and Braefoot Bay. "The possible exception to this would be some pipes which would cross a road at Braefoot Bay," it says. However, it points out that an assessment based on the same criteria, but using gas ignition values derived by the German researcher Herr Dr. Bittner, indicates that there would still be a possibility of r.f. sparks capable of igniting vapours at both plants, and although moving the Barns Farm transmitter would again remove any r.f. risk from Braefoot Bay a problem could remain at the Esso Moss Morran plant.

To verify the theoretical assessments, and control any other problems which might be revealed, the report proposed other conditions. These were that comprehensive tests should be conducted at the proposed sites during erection to determine induced power levels in site structures and that safeguards should be installed on any plant where these tests confirm the need. Where the possibility of the existence of flammable vapour in the atmosphere cannot be completely ruled out, the report recommends permanent bonding, screening and earthing and the use of special maintenance procedures.

In making its assessment, the HSE considered a number of matters raised by objectors to the proposed developments. These included the effect of amateur radio transmis-

sions on the overall assessment, the use of medium and high frequency radios by merchant vessels in the Forth estuary, and the presence of high-power naval radar.

It was concluded that the effect of amateur radio transmissions on the overall assessment was negligible. Fortunately, at the most sensitive frequency for sparks, the amateur's transmitter power is restricted to 10W d.c. input or 27W p.e.p. output. Also, at this frequency, maximum aerial gains are approximately 5dB, because any additional gain would require large structures which are normally impracticable for radio amateurs. Typical peak effective radiated power (p.e.r.p.) levels at both ends of the amateur scale were quoted as 85W for the 1.8 to 2MHz band and 25200W for the 144 to 146MHz band. A total of 111 amateurs, located within I6km of the plants, were considered in the report, and the expected field strengths in each band were calculated and modified to take account of the number of transmissions, the amount of power normally used and the directional properties of the transmissions.

Similar calculations were made for commercial transmitters, naval shore-based transmitters, RAF transmitters and shipboard transmitters. The field strengths formed the basis of the calculations for the margins of the safety and the final results gave values for the combined effects of these transmissions for ethylene, alkanes and hydrogen. Some v.h.f. and u.h.f. transmitters used by the Scottish Development Department, RAF Pitreavie and Turnhouse airport, and an experimental radar transmitter at Burntisland were ignored in the calculations. The reasons given were that the radio transmitters were considered to have low powers outside the sensitive h.f. band and the radar beamed down the Forth estuary rather than across the sites

According to the report, sparks may be formed when two conductors at different potentials touch each other. This might happen in practice when maintenance or construction work takes place. Mobile cranes have been singled out as worst case unintentional receiving structures, although these are not normally permitted to work in classified areas unless special precautions are taken. Another example is scaffolding which might, by itself or in conjunction with adjacent structures, form aerial loops in which r.f. currents could be induced.

Precautions include the connecting of flanged joints in pipes were there is any likelihood of a loss of conductivity across

them, the connection of large structures which are either closer than 50mm or are not otherwise electrically connected, and the r.f. earthing of structures to minimize potential differences at ground level. R.f. earthing provides ground paths for r.f. currents, which might otherwise circulate through extensive portions of the plant, and breaks up possible resonances in long pipe runs. The manner in which structural parts are connected to earth is important because earth leads which are of a significant proportion of a quarter of a wavelength begin to assume high impedances and this presents a limitation on the effective application of the earthing techniques. The Executive's Working Group considered that screening would be a practical safeguard for limited use on the sites. It was envisaged that close steel meshing would provide useful attenuation of radio waves because if wires were fractured, currents would flow in the many other paths provided by the meshing without causing a spark.

Two more reports 23 were published at the same time as the above report. One2 is the report of a working group, chaired by the HSE, who have been examining r.f. hazards at two plants, at St Fergus in Scotland, arising from anticipated levels of low frequency electromagnetic radiation from the Royal Naval Wireless Transmitter Station at nearby Crimond. Unfortunately, the group was unable to arrive at a positive conclusion mainly because the results of recent researches in this country and in Germany had given widely differing results. Since the report, the HSE has proposed a programme of further tests. The second report3 was prepared by the HSE after a request from Mr Tony Benn, the Secretary of State for Energy, for assistance in considering an application by Shell for a pipeline construction authorization. The authorization was for two gas pipelines from St Fergus to Moss Morran, Fife, and St Fergus to Boddam, Peterhead. The report said that the level of risks presented by the pipelines would not be sufficient to justify the HSE objecting to their construction on health and safety grounds.

i. Assessment of the Hazard from Radio Frequency Ignition at the Shell and Esso Sites at Braefoot Bay and Moss Morran, Fife. 2. Report of a Working Group on Radio Ignition Hazards at St Fergus, Scotland.

3. A Safety Evaluation of the Proposed St Fergus to Moss Morran natural gas liquids and St Fergus to Boddam gas pipelines.

News in Brief

The 1979 Montreux International Television Symposium and Technical Exhibition is to be held from May 27 to June 1. There will be two sessions, one devoted to progress in systems design or technology and the other to equipment innovations.

Park Air Electronics Ltd has signed an exclusive sales agreement with Comco, Coral Gables communications company, of Miami, Florida. Comco, who will represent PAE in the USA, Central and South American markets, are major suppliers of v.h.f. ground-to-air communications equipment and have extensive dealer and distribution networks in the Americas.

Hy-Gain Corporation, manufacturer of amateur aerials, has been purchased by Telex Corporation, and resumed manufacturing. The original firm ran into financial problems due to the erratic demand in the USA for citizen's band equipment.

The Electronic Components Division of Ferranti Ltd has become Ferranti Electronics Ltd. Correspondence should now be addressed to the new company and contracts and orders previously placed with the Electronic Components Division will be managed on behalf of Ferranti Ltd by Ferranti Electronics Ltd as will all future contracts and orders. There will be no change in company contracts.

Frequency synthesizers — 2

The generation of wanted frequencies from other frequencies

by R. Thompson, M.I.E.E.

Part 1 of this article described circuits which generate wanted frequencies from other frequencies using frequency addition and multiplication. This second part describes circuits for a third method, that of frequency division. It also introduces prescalers and explains how they can be used to extend the frequency range of frequency division circuits.

FREQUENCY DIVISION, even at frequencies up to 1GHz, is now almost exclusively carried out by circuits based on the digital binary counter. Alternative methods such as synchronising subharmonic oscillators or tuned regenerative loops have been outdated by the low cost of digital integrated circuits.

Simple cascading of binary counting elements provide division ratios of 2^N , where N is the number of elements. Generally, however, the division ratios required in synthesizers will not be a 2^N number, in which case the binary counters must be modified. The modifications normally involve the use of feedback loops which either cause binary elements to change state or inhibit clocking pulses. For instance, a divide-by-10 function is obtained with four binary circuits. These would count from 0 to 15, resetting to 0 on the 16th clock input if connected in simple cascade. After 8 counts, however, the last stage changes from 0 to 1 and this change in state can be used to bypass stages 2 and 3. Only two pulses are therefore required to return the counter to all zeros. The arrangement and logic table for this circuit are shown in Fig.

A very common requirement in synthesizers is for a divider which can be readily varied by switches or control logic. Normally the approach to this requirement is to use standard counting blocks, 2" or 10, in conjunction with either recognition or presetting logic. These arrangements are shown in Fig. 11. In (a), the setting switches programme the recognition circuits to the required division number. The counter then starts at zero and counts up to the required number, the recognition circuits produce an output pulse and this is used to reset the counter to zero. In (b), the required number is preset into the counter, which then counts down to zero. This produces an output

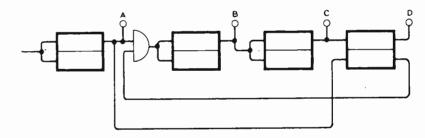
pulse which again presets the counter. Alternatively, the "nines complement" of the number may be preset and the counter counted up to all nines.

A problem of frequent concern with dividers is the time delay introduced by the logic elements. These can accumulate to very significant times when many elements are cascaded. Synchronous counters avoid this accumulation by clocking all stages with the same pulse, as shown in Fig. 12. Arrangement (a) is a ripple-through counter where clocking is effected by the change of state of the previous stage. In arrangement (b) all stages are clocked in parallel with the clock pulses, the pulses being gated by the state of all "previous" stages. This achieves the same

counting action as (b) but with almost synchronous output changes.

When operating in the synchronous mode, differential delays throughout a logic circuit are reduced. This makes the logic processing easier because the changes occur at defined times. It does not, however, increase counting speed, on the contrary it slows it down since time must be allowed for gates to be set between clock pulses.

Variable divider circuits are typically three times slower than straightforward counters because terminal states have to be detected and the counter reset once every count cycle. This resetting action must be completed between input clock pulses in order that no input pulse is missed. One method of exten-



Count	0	1	2	3	4	5	6	7	8	9	10
A	0	1.	0	1	0	1	0	1	0	1	0
8	0	0	1	1	0	0	1	1	0	0	0
С	0	0	0	0	1	1	1	1	0	0	0
D	0	0	0	0	0	0	0	0	1	1	0

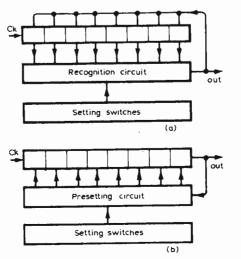


Fig. 10. Circuit and logic table for a digital binary counter which can be used to provide frequency division. See text.

Fig. 11. Dividers whose division ratios can be varied by switches or control logic. In (a) the setting switches programme the recognition circuits to the required division number and the counter starts at zero and counts up to the required number. In (b) the required number is preset into the counter, which then counts down to zero. This produces an output which presets the counter.

ding the frequency range of the variable divider is to use an "early decode" circuit, as in Fig. 13(a). The counter is preset and commences counting, in this case downwards, in the normal manner. The most significant stage reaches zero first, followed by the next most significant and so on until all but the least significant are at zero. All of these zeros are gated together with a signal from the least significant stage whose signal is taken not from the zero butfrom some higher state such as 2. The early decode gate therefore produces an output two clock pulses before the counter would have reached all zeros. The next clock pulse can now trigger the early decode bistable whose output resets all counter stages and the final clock pulse of the counting cycle resets the bistable releasing the reset from the counter. At this stage the counter is ready to start counting from the reset state at the next clock pulse. This particular arrangement allows a full clock cycle for the counters to reset: obviously the decoding could be made even earlier to provide longer resetting times. Earlier decoding would require further bi-stables in the decoder circuit to count off the clock pulses missed while the main counter was resetting.

Another method of extending the frequency range is to use a higher speed divider ahead of the main variable divider. This "prescaler" could be a fixed divider as shown in Fig. 13(b). Since the maximum frequency to be handled by the variable divider is reduced by a factor P, say, the arrangement has the disadvantage that changing the variable division ratio by one now changes the overall division ratio by P. This can be overcome by using a prescaler providing two alternative division ratios.

Figure 13(c) shows the arrangement for such a variable modulus prescaler. If the A and the N counters were connected in cascade, we would have a counter with a least significant digit (l.s.d.) equal to that of the l.s.d. of A and, with the clock input applied to A, the maximum input frequency would be set by the speed of the A counter. With a variable modulus prescaler the output of the prescaler is tapped up the variable counter, splitting it into A and N as shown.

With a prescaler division ratio of P, the l.s.d. of N represents division increments of P. The purpose of having an alternative prescaler ratio greater than P, that is (P + M), is to count off the digits in the required division ratio which are less significant than P. These digits are of course those in A whose l.s.d. will represent increments in M.

The count cycle starts with A-plus-N set to the required division number and the prescaler set to divide-by-(P + M) such that the prescaler produces an output after every (P + M) input pulse. This decrements the N counter by one, registering P pulses, and also decrements the A counter, registering M

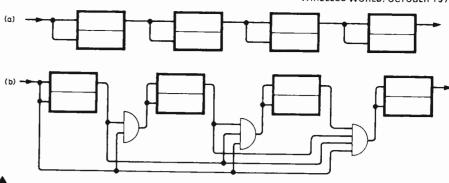
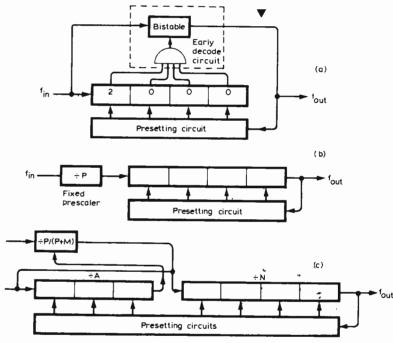


Fig. 12. Synchronous counters avoid the accumulation of time delays by clocking each stage with the same pulse. (a) is a non-synchronous ripple-through counter where clocking is effected by the change of state of the previous stage. In (b), which is synchronous, all stages are clocked in parallel with the clock pulses, which are gated by the state of all previous stages.

Fig. 13. Arrangements for extending the frequency range of variable dividers. (a) uses an 'early decode' circuit, and (b) employs a prescaler. See text. Arrangement (c) is a variable-modulus prescaler which provides two alternative division ratios.



pulses. The total change in A and N therefore directly indicates the total input count. When the A counter reaches zero, that is after trhe required number of M decrements, it switches the prescaler to a division ratio of P. Although the A counter stops, the N counter continues to decrement until it too reaches zero. When this occurs an output pulse is generated which is also used to reset the A and N counters.

It can be seen that the significance of the l.s.d. of the variable divider is set by the difference of two division ratios. The maximum input frequency, however, is increased by the smaller of the two prescaler division ratios. For instance, if the prescaler ratios are 10 and 11, a ten times extension of frequency can be obtained with no alteration to the l.s.d. significance.

The prescaler will only work when the number set in A is less than that in N. Since the A count can only be decremented by (P + M) input pulses the N counter must always be able to correctly register the P portion as part of the total count.

We can derive the ratio of input and output frequencies for the variable modulus divider quite easily, as follows:

Input pulses to decrement A to zero = (P + M)A

Count in N when A reaches zero = N - A

Number of further inputs for N to reach zero = (N - A)P

Therefore the total count in one cycle = (P + M)A + (N - A)P

= MA + NP

and $f_{\text{out}} = f_{\text{in}}(MA + NP)$

Where very-high-speed working is required it may be necessary to use the "early decode" technique described earlier to provide time for the A and N counters to be reset.

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Electronic organ tone system

Modular design uses sine wave synthesis to produce a high quality pipe organ sound

by A. D. Ryder, M.A., Ph.D., F.I.E.E.

ALTHOUGH ORGANS take many forms, the pipe organ is generally the standard by which others are judged. The main role of electronics is to provide an acceptable replica of a pipe organ at a fraction of the cost. This electronic organ tone system design differs from many commercial instruments by using a harmonic-synthesis approach. It provides for a full-size two-manual organ with 61 keys on each manual, and 32 on the pedals, which may be played polyphonically. Several variations and additions are possible including comprehensive coupling. Keying is by d.c., and only one contact per key is needed. The design is suitable for modernising an existing instrument or for a new console. Shorter keyboards may of course be used, with some saving in components. The pedal department is based on a 16ft pitch and the manual departments are on an 8ft pitch. Apart from a multiple frequency-divider, all components are general purpose types, and the basic system is condensed onto 19

Fig. 1. Assembled system in a 17in rack. The illustration does not show the mains transformer which is mounted separately. Twelve connectors are used to bring in the key signals to the front of the gate cards.

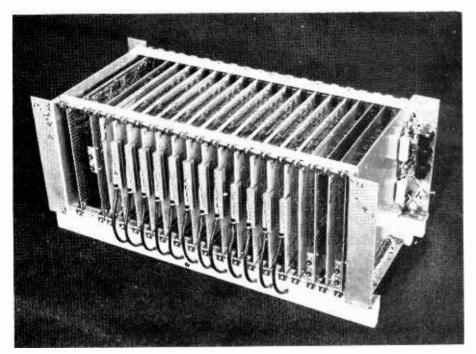
boards which can be housed in a standard 17in rack. Component cost for the basic system is around £450 and optional coupling circuits add about £65

Introduction

If the playing tones for an electronic organ are to be derived from a common source, rather than from individual oscillators, there are two main methods of producing the different waveforms required for stops of different tone colours. A harmonically rich waveform, such as a sawtooth, may be selectively filtered, or individual harmonics as sine waves, may be combined in different proportions. A practical substitute for a sawtooth is the staircase waveform obtained by mixing square waves in octave pitches, thus filling in the even harmonics, and this method is currently popular because square waves are easily generated and manipulated. The second method, known as sine wave addition, was used in the original Compton and Hammond designs based on electro-mechanical' generators. In principle, any required waveform can be produced by either method, but in practice there is a

significant difference because of the frequency range needed for a four or five octave keyboard. If a sawtooth of constant amplitude is fed to a filter, the output will vary with frequency, in both waveform and amplitude. However, with the sine-addition method, in its simplest form, these factors remain constant. Neither of these is ideal, but the second is closer to a pipe organ stop. Variations in tone-colour and loudness often represent the main restriction of an instrument which uses subtractive filtering. The sine wave addition technique was primarily adopted because the problems of achieving a musically satisfactory result by the filter method appeared very consider-

In the basic system, seven sine wave pitches of ratios 1, 2, 3, 4, 5, 6 and 8 are, provided for each manual and for the pedal, the pedal pitches being set an: octave lower, starting at 32.7Hz. Different stops or tone-colours are directly produced by different combinations of harmonics. The harmonic spectrum can' be widened by coupling, or by providing. additional waveforms. There is a total of 154 keys, and, although the harmonics do not extend beyond about 10kHz, there are more than seven tone-gates per key if provision is made for upward coupling. Much of the design effort has been directed to minimising the space required, and the complexity of interconnection for the large number of



Frequency generation

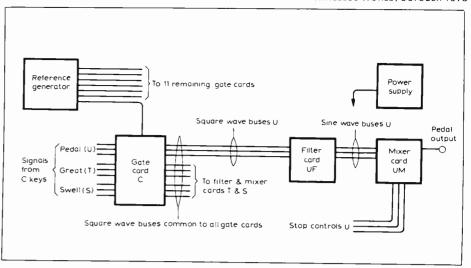
All of the frequencies are derived from one master frequency of about 1MHz, which is controlled by a crystal with a variable offset. This gives approximately 1% tuning above and below standard pitch so that the organ may be tuned to another instrument. The master frequency is fed to a multiple divider which provides 12 reference frequencies closely approximating an equal-tempered scale. All of the playing frequencies, 300 in all, are derived from these references. The use of a common frequency source is practically convenient and economical, but it cannot give the effect of different ranks of pipes, slightly out of tune, sounding together as a chorus. This effect is most closely reproduced by instruments which use a separate oscillator for each note of each stop. However, the present design does allow for a "quasi-chorus" effect, which is described later. The playing frequencies are generated and gated as square waves which are then filtered into sine waves with approximately 4% harmonic content. The filtering takes place before the mixing process, and does not affect balance.

Voicing and regulation

In organ terminology, voicing is the adjustment of the sound quality of a pipe, and regulation is the adjustment of loudness. Each pipe is adjusted to build up the stop of which it forms part. In the most advanced sine wave organs, complex wiring and mixing circuits allow the amplitude of each harmonic to be independently adjustable note by note for each stop, so that voicing and regulation are similar to a pipe organ. In the present design, there is only one signal line for each harmonic pitch of each keyboard, so that each harmonic combination can easily be set up, but has to suffice for the whole keyboard. As already mentioned, a constant amplitude is not satisfactory, therefore each harmonic is independently preregulated by choosing appropriate resistor values. The level is set, note by note, to give an aurally satisfactory balance over the frequency range. With this method, combinations of harmonics also tend to be balanced and free from major variations of loudness or tone quality. It is possible to vary the relative strength of any chosen harmonic for different notes by using RC combinations at the mixing stage so that the built-in regulation can be modified for better voicing of a particular stop.

Harmonic accuracy

In some older sine wave organs, harmonics were borrowed from higher notes. For example, the 3rd harmonic for C1 (note C of the lowest octave) would be taken from the generator for G2, the 5th harmonic from E3, and so on. Apart from the octaves, the equal tempered scale does not provide true harmonics. The frequency of G2 is close to $3 \times C1$, but E3 differs by nearly 1% from $5 \times C1$. An error such as that of E3 would probably produce a rough tone, but a more serious objection to borrowing is that it detracts from the richness of chord sounds by eliminating some of the frequencies which should be present. In the present design each harmonic is generated in relation to its own fundamental from the same reference.



Starting transients

An organ pipe may take a few tens of ms to speak fully, and some types sound harmonics before the fundamental. To simulate such pipes it is necessary to control the build-up of each harmonic independently, note by note. In a sine wave system this is not difficult, but requires a number of keying circuits which are individually adjusted for each stop.

This design uses a common keying circuit for all harmonics together. The attack is graded so that, within limits, high notes speak faster than low notes.

Coupling

Coupling is not very common in electronic organs and, if offered, may be limited and expensive. In pipe organs however, coupling is nearly always used to connect more pipes to each key. This can enhance the sound and extend the variety of registration (combination of stops) available. Couplers may be local or interdepartmental. The action of the first kind is to couple each key to a higher or lower note of the same keyboard. The most common is an octave coupler, which causes key CK1 to sound C2 as well as C1, DK1 to sound D2 and D1, and so on. Others are the sub-octave, and the super-octave which is two octaves higher. A drawback of local coupling is the missing notes. If, for example, CK1 is pressed there is the addition of C3 but no more sound at C2 level.

The most common interdepartmental coupler is the great-to-pedal, which makes the great manual playable from the pedals and simultaneously with any stops drawn on the pedal organ. This coupler works only one way so that the pedal department is not connected to the great manual. Usually, a full set of upward couplers is available which, for a two-manual organ, would consist of great-to-pedal, swell-to-pedal, and swell-to-great. Couplings such as swell octave-to-pedal are also used as well as

Fig. 2. Block diagram of basic system which comprises 12 gate cards, 3 filter cards, and 3 mixer cards. If the coupling circuits are used they are interposed between the key signals and the gate cards.

a unison-off coupler, actually an uncoupler, which allows the octave, or a coupled department, to be sounded alone.

For an electronic organ, couplers offer similar advantages. In a sine wave instrument, coupling the octave and/or the twelfth locally or from another department, also provides a means of broadening the harmonic spectrum. Although the present design can be used without couplers, suitable circuits will be described which can be added to the basic system. For coupling purposes, the manual departments each have 68 keying inputs, extending up to GK6, and the pedal has 44, up to GK4. The swell-octave provides the pedal with stops at a 4ft pitch, i.e. two octaves above normal.

A special feature is that the relative strength of the coupled note, or of the unison, may be adjusted so that, for example, the degree of brilliance added by the octave may be varied. Also, if the octave is used at reduced strength, the missing note effect is mitigated because when the octave key is played it makes an additional contribution at its own pitch level.

Other options

The coupling system and the quasichorus effect are options particularly associated with this design, but other additions are possible and some practical circuits will be described. Arrangements for volume control are optional but, if orthodox practice is followed, only the swell department will be controlled by the swell pedal and the loudness of the other departments will be determined by the selection of stops provided. To avoid electrical noise the volume pedals should work on d.c.,

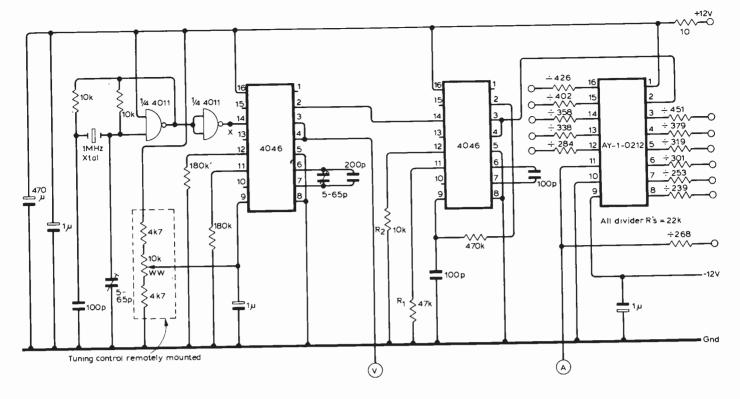
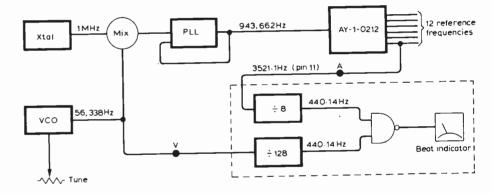


Fig. 4. Tunable reference generator circuit. The $2k2\Omega$ and $4k7\Omega$ resistors, R_1 and R_2 should be 2%. For fixed tuning the two 4046 i.cs and associated components are omitted and the 1MHz signal at point X is taken directly to pin 2 of the AY-1-0212.

rather than'directly on the signal. Vibrato, frequency-modulation, may be applied to the generators to affect all departments together or, by using an external modulated delay device, to an individual department. Tremulant, amplitude-modulation, may be applied selectively to a single department. Chiff, starting transients, can be introduced but are restricted because all of the harmonics are keyed together. A noise busbar can be provided for adding to stop mixtures of each department. The keying envelope can be given a long decay, sustain, which can be graded over the keyboard, but the inherent attack rate is not fast enough to simulate a piano sound.

In pipe organ practice, pistons or press-buttons are often provided to bring in pre-selected stop combinations. This facility can be achieved using a c.m.o.s. memory.

Although it is not intended to deal with power amplifiers, an electronic organ provides a fairly severe test for loudspeakers, therefore a suggested design using an active crossover will be described. The ability to regulate each harmonic independently allows compensation for irregularities in loudspeaker response and this is especially useful in the region below 100Hz.



Mechanical description

To reduce interconnections, the circuits are assembled on plug-in cards which ease construction, testing and settingup. The printed circuit boards are the same size as general purpose boards on the market so that both types can be used in the same assembly. Edge connections are mainly straight buses, and a motherboard is not necessary. The card size of 8in imes 6½in can accept 59 edge connections at 0.1in spacing, and in the basic form the design uses 19 cards of four types. Gate cards; these are specially designed and 12 are required. Filter cards; also specially designed, one per department. Mixing cards; one per department, constructed using plug-in Veroboard. Oscillator card; assembled on one plug-in Veroboard, with some space for additional circuits. The photograph in Fig. 1 shows the rack containing the basic system. There is space for a 20th card which can be used for further options. The power supply components are

Fig. 3. Tunable reference generator system for providing frequencies shown in lower part of table 2. The standardising circuit in the dotted area has frequencies shown for zero beat. This circuit may be omitted.

mounted on one of the side panels, and the mains transformer is mounted separately. Due to space limitation the coupling circuits cannot fit into the main rack, but can be assembled on a large Veroboard mounted horizontally below. It is possible to add a second set of cards to provide three more independent departments which could be coupled to the keyboards and would allow a third manual to be used. The harmonic range can be extended, and there are possibilities for independent treatment of keying and differential tuning. The descriptions to follow will show how the elements of the system may be adapted to meet various requirements.

Circuit nomenclature

The octaves of each keyboard are numbered from the bottom so that the lowest key is CK1 and the next is C'K1, followed by DK1, D'K1 and so on up to BK1. The next octave starts at CK2. Apostrophes are used for sharp signs. On a 61-note manual, the highest key is CK6, starting the sixth octave, and on a 32-note pedalboard, the highest is GK3, about halfway up the third octave. The fundamental frequencies for the manual departments range from C 65.4 to C 2,093Hz, and from C 32.7 to G 196Hz for the pedal. For the notes C and their harmonics, there are six keying signals from each manual and three from the pedals, but for other notes there are fewer. The gate card design provides 16 keying inputs for use with couplers as previously described. The three departments are called pedal — U, great — T, and swell - S, so on any gate card the keying inputs run from UK1 to UK4, TK1 to TK6, and SK1 to SK6. On cards G' to B, the highest numbers are not used, so they have 13 inputs only.

The length of an open organ pipe sounding note C at 65.4Hz is about 8ft, and a pipe sounding twice this frequency is about 4ft and so on. Table 1 shows some of the lengths, intervals and typical names used. Descriptions in the text will use harmonic numbers unless otherwise stated.

Circuit description

A block diagram is show in Fig. 2. The 25 or so frequencies generated on each gate card have their mean values tied to the one incoming reference, but the complete card may be frequencymodulated independently of the reference. The locally generated frequencies are selectively switched onto the outgoing square-wave buses under control of the key signals via a keying matrix. For example, depressing CK1 on the great, assuming the unison coupler is on, will cause the C card to output 65.4Hz on the T1 square-wave bus, twice this frequency on the T2 bus, and so on. The three sets of buses are shared by all 12 gate cards, though each uses a different reference, and is wired to different keys.

Each departmental set of squarewave buses connects to a filter card which feeds a group of sine-wave buses to the mixer for that department. The mixer card carries a virtual earth mixing amplifier and switching circuits for connecting different combinations of harmonics to the mixer. The strength of each harmonic, and thus tone-colour and loudness of each combination or stop, is determined by a resistor or an RC circuit as already mentioned.

An octave adjustment by wire link is provided on the gate cards to allow some freedom in the design of the reference generator. The G.I.M. AY-1-

Table 1

Harmonic No.	Footage	Interval	Typical name
1 1½ 2 3 4 5 6 7 8 10	8 5½ 4 2½ 2 1¾5 1½ 1 1,7 1 4/5 2/3	5th (8th) 12th 15th 17th 19th Flat 21st 22nd 24th	Principal Quint Octave Nazard Fifteenth Tierce Larigot Septime Used in mixtures, also higher
16	1/2	29th	pitches

Pedal pitches are usually set an octave lower, starting at 16ft. The quint is not a harmonic but, if used with the fundamental, it can produce a sub-octave effect due to the subjective difference tone. Each pipe has its own spectrum of harmonics in addition to the pitch sounded.

Table 3. Frequencies relating to Fig. 3 for a tuning range of 1% either side of a zero beat frequency.

Deviation	Divider input kHz	V.c.o. output kHz	Beat frequency Hz
+1.0%	953.1	46.9	78.1
+0.8%	951.2	48.8	62.5
+0.6%	949.3	50.7	46.8
+0.4%	947.4	52.6	31.3
+0.2%	945.5	54.5	15.6
0	943.7	56.3	0
-0.2%	941.8	58.2	15.6
-0.4%	939.9	60.1	31.3
-0.6%	938.0	62.0	46.8
-0.8%	936.1	63.9	62.5
-1.0%	934.2	65.8	78.1

Table 2. Two possible sequences of reference frequencies from the divider.

Input frequency 1MHz													
Pin	-	3	16	15	4	14	13	5	6	12	11	7	. 8
Note	С	C.	D	D	Ε	F	F.	G	G ·	Α	Α.	В	
Hz	2093	2218	2350	2490	2637	2794	2960	3136	3322	3520	3729	3951	4186
Pin	3	16	15	4	14	13	5	6	12	11	7	8	
Input frequency 943.7kHz													

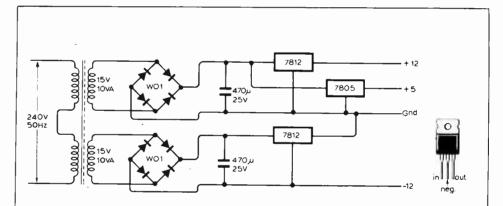


Fig. 5. Power supply.

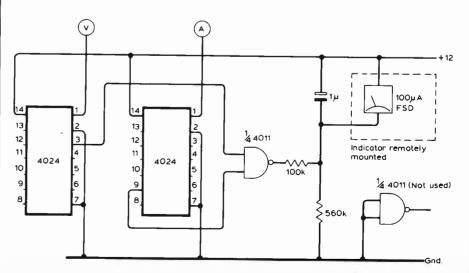


Fig. 6. Tuning standardising circuit. The two resistors can be altered to suit different meter movements.

0212 divider gives 12 whole-number divisions of its input frequency in the ratio of $^{12}\sqrt{2}$, about 1.059, which is that required for an equal-tempered chromatic scale. As shown in table 2, if the input is 1MHz, the outputs range from C 2 2218Hz to C 4186Hz, and if the input is a semitone lower at 943.7kHz, the outputs range from C 2093 to B 3915Hz. Appropriate routing of the outputs and the octave adjustments allows either frequency to be used or a number of others.

A tunable reference generator system is shown in Fig. 3. The frequency at one semitone below 1MHz is derived using a v.c.o. together with a mixer, and is recovered by a p.l.l. Instability of the v.c.o. has only a second-order effect, and it allows a $\pm 1\%$ tuning range for adjusting the organ to another instrument. The tuning control may be scaled with a frequency counter at the p.11. output, and table 3 shows the relevant frequencies.

At various points in the tuning range there will be a more or less simple whole-number ratio between the v.c.o. output frequency and its difference from 1MHz. The system in Fig. 3 exploits a convenient numerical coincidence and allows the tuning to be set up precisely to the crystal. Pin 11 of the divider, shown as the A reference, gives 1/268 of its input frequency, and this is the same as 1/16 of the v.c.o. frequency when the deviation from standard pitch (A is 440Hz, A reference is 3520Hz) is only +0.03%. This condition can be detected using a visual beat indicator as shown. The sensitivity, as table 3 indicates, is about 0.8Hz beat rate for 0.01% deviation. Because of the whole-number divisions, the AY-1-0212 can produce a theoretically correct frequency on only one output at a time, but if the pin 11 output is set 0.03% high, all outputs will be within 0.1%, which is sufficient for most purposes.

The circuit in Fig. 4 uses c.m.o.s. devices so the inputs of unused sections should be connected to a supply rail. The $10M\Omega$ resistor sets the d.c. working point, the $10k\Omega$ resistor gives some control of loop gain, and the trimmer capacitor allows some frequency adjustment. The first 4046 p.l.l. is not used in a loop, but forms the v.c.o. and mixer. Mixing is achieved by using the pin 2 phase comparator of the i.c. which exclusively-ORs its v.c.o. signal output with the 1MHz signal at point X. An output is generated at the difference frequency along with other frequencies. The v.c.o. frequency is controlled by the voltage at pin 9, and the working range is set by two 100pF capacitors, a trimmer, and the $180 k\Omega$ resistors. The trimmer should be set so that the v.c.o. frequency at pin 4 is 56.3kHz with the tuning control in the centre position. With an R₁:R₂ ratio of 1:1 as shown, the frequency swing available should exceed that shown in table 3, and only the trimmer should need adjustment.

The second p.1.1. is used convention-

Component summary for basic sy	stem
	Νo.
P.c.b. E01 (special design)	12
P.c.b. E02 (special design)	3
Veroboards (code 09-0091D)	4
Mains transformer 15-0-15V 20VA	1
Bridge rectifier (e.g. W01)	1
Regulators, +12, +5, -12V	3
AY-1-0212 (GIM) multiple divider	1
4011 guad NAND	1
4016 quad switch	9
4024 7-stage counter	36
4046 phase-lock loop	14
4520 2 × 4-stage counter	24
741 op-amp	25
Transistors (e.g. Mullard BC548C)	1250
Diodes (e.g. 1N4148)	280
Crystal 1MHz	1
Edge connector, 59-way plus key po	osition
-	19
Edge connector, 24-way plus key po	osition
	12
Tantalum bead capacitors,	400
1μF/35V	
Ceramic capacitors, 100pf 2%	41
Trimmers 5-65pF	14
Filter capacitors	156
Other capacitors	25
Resistors 1/2-watt	2100
The list includes 4×741 and $9 \times$	4016
for mixing and stop switching.	

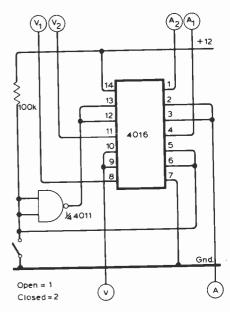
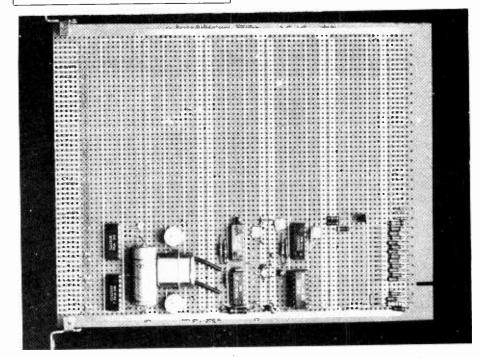


Fig. 7. Change-over switch.



ally so that when its v.c.o. output frequency coincides with the incoming signal, the output of the phase comparator at pin 2 contains a d.c. component dependent on the relative phase. This output is fed back to pin 9 via a low-pass filter to hold the loop in lock. The p.l.l. is set up initially with the loop opened and pin 9 fed from a variable direct voltage. The required mid-frequency of 943.7kHz should be obtained with pin 9 at the middle of the range, between +4 and +6V. Because this frequency is near the device limit, it may be necessary to vary R slightly. After this adjustment the frequency range in table 3 should be well inside the control range of about 0 to 10V on pin 9. All p.l.l. settings should be finally checked using the permanent power supply shown in Fig. 5.

Fig. 8. Prototype master oscillator including the standardising circuit. Space is available for additional functions.

The locked output of the second p.l.l. also drives the divider. An optional standardising circuit is shown in Fig. 6. The first 4024 divides the v.c.o. frequency by 128, and the second 4024 divides the A reference by 8. A 4011 acts as a comparator so that when its inputs are in antiphase the output is high, and when in phase, the output is low for half of each cycle. Indicator calibration is

continued on page 91

American audio

Reports on the Consumer Electronics Show, Chicago, and High Fidelity Show, Atlanta

by Jack Dinsdale and George Tillett

ONCE AGAIN the venue for Chicago's Consumer Electronics Show in May this year was the McCormick Place exhibition centre and the adjacent McCormick Inn. But there was a further display of so-called "esoteric high fidelity" exhibits at the nearby Pick Congress Hotel, and it was this that provided the greatest interest for me.

The largest area was in McCormick Place itself, which accounted for 132 hi-fi exhibits at Mall and Lobby levels and in 34 sound rooms; 300 radio, audio compact and tape equipment exhibits; 100 personal calculator and watch manufacturers; 75 television and video systems; some 200 autosound, citizens' band and telephone accessories, and another 75 exhibits by trade associations and magazines. In nearby McCormick Inn, hi-fi exhibitors were using 71 sound rooms and over 60 hospitality suites. A number of manufacturers had taken space in two or even all three of the locations.

Two trends emerged strongly from the exhibition: the proliferation of extremely high quality equipment, often from small specialist companies, and an increasingly "systems" approach to the subject of sound reproduction. It is now being realised that a complete sound reproducing system must contain a signal source (tape, cassette, radio tuner or disc replay system), amplifying means. and loudspeakers headphones. In the past, too little attention has been given to the matching and interface connections (both electrical and mechanical) between these items, and the result has often been that a complete system consisting of well-matched, middle-priced components can sound better than a similar system made up from top quality units throughout but with little thought given to the problem of matching.

Amplifiers

With the current emphasis on the subjective "sound" of amplifiers, there were examples shown of a range of circuitry for both signal and power amplifiers, aimed at improving the realism (musicality?) of the sound. A number of manufacturers were using thermionic devices as their active elements. The question whether to call them "valves" or "tubes" has been ingeniously resolved by the expression

"vacuum state." The majority of mainstream amplifiers, especially those marketed by companies offering complete audio packages, made use of conventional circuitry and provided fairly conventional "hi-fi" sound (i.e. not particularly musical). However, the specialist amplifier manufacturers are now becoming aware of the principal audio shortcomings of so many amplifiers, and are taking effective steps to reduce the effects of transient distortion, premature operation of protection circuitry, and overloading of disc-input stages through insufficient headroom (an overload factor of 35 to 40dB appears to be necessary).

Power amplifiers were available with several ingenious circuit configurations designed to minimise distortion, for example Sony's pulse width modulation (class D), Hitcahi's use of m.o.s.f.e.t. output devices, and several variations on the class AB theme. The specified figures for distortion, frequency response, and signal/noise level are now so good as to be almost meaningless, and yet subtle subjective differences can still be detected under certain listening conditions. It is likely that further studies of transient effects and psychoacoustics will be necessary to identify and eliminate these remaining imperfections

A particularly interesting development was the increasing use of "biamplification," whereby the hitherto conventional passive crossover network interposed between the output of a single power amplifier and the loudspeakers is replaced by an active electronic crossover operating at small signal level, generally after the preamplifier, and feeding separate power amplifiers for bass, middle and top. A number of companies, including Series 20 and Audio Research, were offering electronic crossover units, while others were marketing split loudspeaker systems complete with electronic crossover and individual power amplifiers for each loudspeaker. A wellengineered system of this sort can exhibit audible advantages in terms of reduced intermodulation distortion, and although the cost of four or six power amplifiers will clearly be higher than the more conventional two amplifiers (one per channel) it is worth remembering that in general the power handling capability of each biamplifier will be

lower, thus offsetting at least some of the extra cost. Furthermore, the bass amplifiers can use l.f. transistors in a well-protected circuit, while the mid and top amplifiers, although requiring h.f. transistors, are not required to handle such high power levels.

Pre-amplifiers and processors

Advanced pre-amplifiers claiming to offer audibly lower distortion than conventional units were being shown by David Hafler, Marcof and Audio Research. A growing number of companies and magazines in the USA are starting to extol the virtues of moving-coil pickups, and at Chicago there were several pre-pre-amplifiers which accommodated with varying degrees of success the challenge of achieving the correct cartridge loading, adequate dynamic range, signal/noise ratio, and frequency response with minimal distortion.

There were several interesting developments in the field of "audio processing." One of these, the Digital Time Delay System by Audio Pulse, provides successive, attenuated, time delayed outputs to be played via a second amplifier through loudspeakers behind the listener, thus simulating concert hall acoustics in a living room. The original signals are sampled at 250kHz, and components below 8kHz are then delayed by amounts from 8 to 94ms by means of digital shift registers before being fed to the rear loudspeakers. The Audio Pulse system can also be used to provide attenuated reverberation effects from 0.2 to 1.2 seconds. One of the most impressive demonstrations of the whole exhibition was by R. G. Dynamics, whose Dynamic Signal Processors act as expanders to recreate the full dynamic range of music, normally lost in the recording process. By concentrating on the psychological effects on the listener, and employing low noise low distortion circuitry, R. G. have produced a device which restores up to 16dB of dynamics and thus brings music to life in an effortless and remarkably realistic way which does not pall even after prolonged listening (via the superb Dahlquist DQ10 loudspeakers). Indeed, switching the Dynamic Processor out of circuit left one with a very flat and uninteresting sound altogether.

Although there was much discussion on digital recording and replay, there appeared to be no actual hardware on demonstration. An enquiry on the Philips stand regarding that company's recently-announced opto-electronic digital system (August issue, p.39) resulted in a statement that it would be "at least three years" before hardware would be available.

Tuners

Major developments are taking place in tuner circuitry, especially in the areas of digitial waveform synthesis and advanced electronic frequency display. Lux, Mitsubishi and Sony were exhibiting tuners in which the local oscillator frequency is controlled by a binary-divided crystal-controlled oscillator as part of a phase-locked-loop system to ensure continuous positive locking of the phase of the local oscillator to that of the transmitted carrier. This gives extremely accurate tuning with automatic frequency stepping in 200kHz intervals. A further innovation by Mitsubishi was to cancel the 19kHz stereo pilot tone not by a filter (which would inevitably affect the audio signal) but by the addition of a further 19kHz signal identical in amplitude to the pilot tobe but in exact anti-phase to it. Many tuners incorporated digital (l.e.d.) frequency display, and also microprocessor memory facilities for up to seven preselected stations.

Loudspeakers

Developments in loudspeakers continue to offer the greatest degree of invention. Listening to the wide range of loudspeakers at Chicago illustrated without doubt that these, together with the listening room and placing, contribute by far the greatest colouration to the subjective "sound" of a system. There is little agreement at present over the ideal driver, and so one could listen to moving-coil units, electrostatics, the Motorola piezoelectric tweeter (previously usable only above 3kHz, although a mid-frequency drive from 2kHz is now available) and most esoteric of all, the Plasmatronic Hill type I plasma driver, which claimed to provide exceptional clarity of reproduction (zero colouration and laser-like phase coherence) from 700Hz to above the limit of audibility, and operated via a biamping system with a 12-inch subwoofer and 5-inch/mid-range unit. The plasma driver requires "topping-up" with helium "available in cylinders from your local welding supply company' every 300 hours listening time, and the cost of this is claimed not to exceed $30\,\mathrm{to}$ 40 cents per hour.

There was little unanimity of agreement over the acoustic loading of even conventional moving-coil drivers, which were housed in so-called infinite baffles, an assortment of ported enclosures, and even folded horns were in evidence. For those living in very small apartments, ADS (Analog & Digital Systems Inc) and Adcom (Braun) were

demonstrating extremely small, almost pocket-sized, loudspeakers, the latter offering a frequency range of 50Hz to $25 \mathrm{kHz}$ from only $6\% \times 4\% \times 4\%$ inches. The sound from these minute units sounded rather constricted alongside the larger units, but in certain situations they would undoubtedly hold their own.

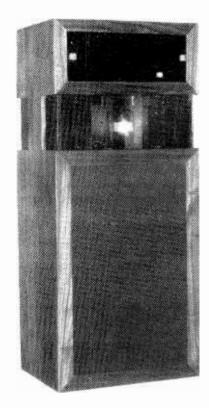
The full-range multiple horns by Frazier, Beta and Technics showed again the effortless way in which this particular type of very efficient loading can deal with a wide range of musical signals, although the difficulties of avoiding colouration were also evident (see however the footnote to this report).

Of particular interest were the unusual loading techniques employed by Qysonic, who utilised the interference of elliptical wavefronts coupled with a laminar-flow vent port arrangement in a cabinet only 8in deep, the minimum diffraction approach by Avid, and the use by Electrovoice in their Interface range of loudspeakers of electronic equalising (active crossovers again) to provide a better bass response than the unaided enclosure could give.

Two very realistic-sounding systems were those by Design Acoustics and Janis. The former were showing their uniquely-shaped dodecahedron loudspeaker some 22 inches in diameter containing ten separate drive units, together with a range of conventional reactangular cabinets for those who could not accept the dodecahedron into their decor. The units provide a close approximation to essentially hemispherical wavefronts and a very high ratio of reverberant to direct sound. Janis were showing their "ultimate sub-woofer," only 22 \times 22 \times 18in, which provides a response wihin 1dB from 30 to 100Hz (it is only 2dB down at 25Hz). The unit contains a slot-loaded 15in driver with a 4in dia. speech coil, which is mounted facing upward. Because of the non-directional nature of frequencies below about 150Hz the sub-woofer can be placed anywhere in the listening room, and one unit will normally cope with the bass of two or four channels. Inevitably, the unit must be driven via a biamplifier system. At Chicago the Janis subwoofer was augmenting the bass of two Quad electrostatics to provide one of the most natural, almost ethereal, sound of the entire show. To listen to this loudspeaker was to appreciate the inadequacy and naivety of statements such as "only 6dB down at 30Hz," and also to experience perhaps more so than from any other loudspeaker, the sheer bass power produced by a symphony orchestra.

Accessories

Among a plethora of audio gadgets, goodies and gimmicks, one of the most remarkable and potentially useful was the Discofilm record cleaning process, to be marketed shortly by Audiogroome



The Plasmatronic loudspeaker system, showing light produced by the high frequency plasma driver mounted just above the large bass unit.

division of Empire Scientific Corp. (better known for their pickups and turntables). Discofilm consists of a clear, treacle-like substance that one pours crudely over old or dirty vinyl records, using a plastic "spreader" to ensure that the complete playing surface is covered. After the "goo" has dried (in 30-40 minutes) the complete film is peeled away, using a small strip of sticky tape to grip it initially, and the manufacturers claim that all dust and dirt particles, including deposits of former socalled cleaners, will be removed, leaving the disc cleaner (and hence quieter) than when new. Only time will confirm the effectiveness (or otherwise) of this new product, but to one with a record collection started in the mid-1950s when standards of cleanliness were not (nor needed to be) as high as today, the Discofilm could be the answer to a prayer.

After a tentative start in the early 1970s, direct cut discs have clearly arrived, and at Chicago most demonstration rooms had at least one of these discs available with which to display the full glory of their wares. (Paradoxically, the extreme dynamic and frequency ranges cut into these discs can be a mixed blessing, and some manufacturers would be better advised to confine their demonstration discs to conventional pressings.) Although the quality varies considerably, there is no doubt that the very best of the direct cut discs convey a remarkably lifelike quality through those systems able to do justice to them.

It is always instructive to examine what auxiliary components are in use by exhibitors; for example, what is the most favoured pickup used by exhibitors of (say) amplifiers or loudspeakers. At Chicago, the Shure V15/IV and Stanton 681EEE cartridges were much in evidence, both giving a very clean undistorted sound quality, although not in the writer's opinion as naturalsounding as the best moving-coil designs. The up-market loudspeaker most in evidence was the Dahlquist DQ-10, and although it has been accused of having a slightly harsh "top," listening evidence at Chicago indicated that this impression could have been caused by problems elsewhere in the system or by non-optimum matching.

Jack Dinsdale

BY A COINCIDENCE. the Institute of High Fidelity in the USA, yielding to internal pressures, decided to stage a high fidelity show in Atlanta, just three weeks before the Chicago CES. This had about 200 exhibitors, many of whom attended both events. The following notes are a selection of the most interesting items I saw at both of these shows.

Big news in the tape world is the introduction of the new pure metal or "metal film" tapes which use fine iron particles instead of oxides. Efficiency can be as much as 7dB higher with lower distortion, improved signal-tonoise ratio and less high frequency saturation. Tape heads have to be redesigned and bias current increased but at least three companies were demonstrating modified cassette decks with the new tapes. They were JVC, Nakamichi and Tandberg - the lastnamed using a 3M tape called "Metafine" which will apparently be made in two versions, one requiring 70µs equalization. Nakamichi were using a modified Model 1000 studio cassette deck and comparisions were being made with a Revox open-reel machine which were most impressive. Nakamichi were also demonstrating a machine equipped with both Dolby and Telcon (Telefunken) noise reduction systems. As the last mentioned gives 20dB of noise reduction, its use by Nakamichi might well start a trend . . .

It has long been taken for granted that the Philips cassette licence precludes the marketing of decks having a 3¾in/s speed. Well, either this assumption is incorrect or a separate agreement has been negotiated because B.I.C.-Avnet introduced three models, all using 3¾in/s speeds in addition to the standard 1¾in/s. The top model has a monitor head and the response at the higher speed is claimed to be within ±3dB up to 22kHz. Playing time is of course cut in half: no doubt the next step will be to redesign the C.120 cassette – maybe for metal tapes!

At the moment Marantz seem to have won the receiver power race with their

new Model 2600, which delivers 400 watts per channel! Like its smaller(!) brother, the 270-watt Model 2500, this new model uses a heat sink tunnel with a small fan and among the features is a quartz frequency standard, an oscilloscope display and a special low distortion (t.i.m.) circuit. A number of frequency synthesized f.m. tuners and receivers were to be seen, some using complete synthesis like the Sherwood MPU model, while others featured manual tuning with a display. The Sherwood tuner displays the station's call letters as well as the frequency and it has an auto-scan plus preset switches for four stations. Nakamichi's 730 receiver is another sophisticated unit and it uses a motor-driven 4-gang capacitor controlled by touch sensors. Another motor operates the volume control - also, like the rest of the functions, being operated by touch sensors. An optional remote control unit employing a pulse operated infra-red system can function up to 45 feet away. Dynaco's Model 2501 f.m. tuner has no less than six tuned stages in the varactor front-end. When the tuning knob is touched the station read-out is displayed, but as soon as the hand is removed the display becomes a clock!

One of the most interesting amplifiers on show was Threshold's Stasis 1, a "feedforward" model using a separate amplifier for error nulling. Unlike other feedforward designs, the error nulling section is connected directly to the load. It is claimed that near perfect operating parameters are achieved because the distortion of the current source amplifier, which handles the energy, is divided down by the high damping factor of a "stasis" section and becomes nearly unmeasurable up to actual clipping. Power output of this admittedly prototype unit was 300 watts into 4 ohms with a rated t.h.d. of less than 0.002%. Threshold were also showing an all-cascode class A amplifier which has a 1 kilowatt power supply. The output stage uses a dynamic biasing circuit which is claimed to track the bias voltage to maintain constant class A operation under all conditions.

At both the Atlanta and Chicago Shows an overwhelming variety of loudspeakers was seen and heard, ranging from tiny shoebox models to super-large systems like the Infinity Quantum Reference which stands over 6 feet high and 4 feet wide. It is best described as a semi-line source with two vertical arrays of flat electromagnetic induction speakers reinforced by a smaller line at the rear. The bass driver is a 15-inch dynamic type which uses the Watkins dual speech coil.

The full-range electrostatic systems were demonstrated, one from Acoustat and the other from Dayton-Wright, while Beveridge had an even larger e.s.l. panel augmented by a dynamic bass unit. But perhaps the most interesting systems was the Plasmatronic, dealt with by Jack Dinsdale above. It was

designed by a laser physicist and the plasma driver is something like an enlarged Ionophone. Jack Dinsdale mentioned the need for topping it up with helium. As the poet said: "What's come to perfection, perishes" and I well remember having to change the quartz tube on my Ionophone loudspeaker every few weeks...

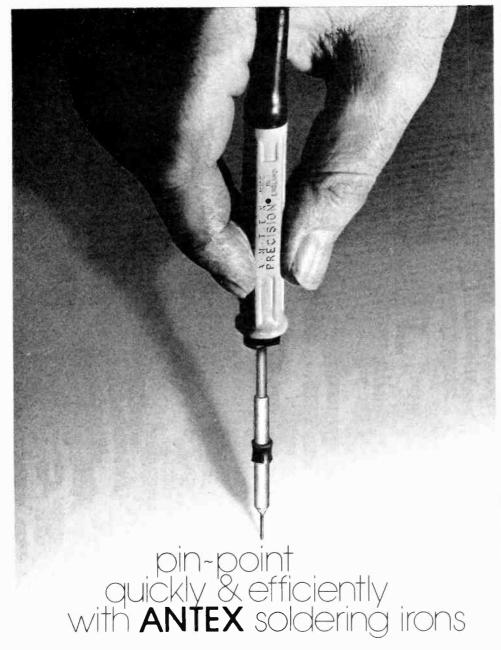
Another fascinating loudspeaker was the Barcus-Berry glass diaphragm system which consisted of a sheet of glass measuring about 7 by 5 inches and mounted in a small box. A transducer – probably a piezo type – is fixed to the glass at the rear and a crossover is mounted in the box as the unit is sold as an add-on tweeter. But the curious thing is this: radiation is almost omnidirectional and response extends to well above 30kHz...

In brief

A new firm, Nagatronics, introduced a ribbon pickpup (anyone remember the Ferranti?) . . . DBX were demonstrating a "bass synthesizer" which created low frequency harmonics from a fundamental: it is called a "Boom Box" . . . Optonica had a turntable which uses a laser to count the grooves on the record for programming with the aid of a microprocessor . . . Dolby were demonstrating a system which could use the f.m. station's 19kHz pilot tone to switch on the decoder in the listener's receiver . . . One company was showing a small breathalyser unit which used red, green and amber l.e.ds to indicate alcoholic content of a person's breath. Not far away, a salesman at another stand was demonstrating battery indicators consisting of a figure of W. C. Fields with a red nose that lights up. A pity the two companies did not get together!

Finally, a few words about television: projected sales of colour tv in the USA for 1978 vary between 8 and 9 million. units, while monochrome forecasts are around the 5 million mark - both slightly less than last year's figures. The last few months have seen increased activity in projection tv and Advent is now faced with competition from several Japanese manufacturers. Sharp introduced a two-piece system with three projection tubes, using a 72-inch (diagonal) screen. Among the features are a built-in crosshatch pattern generator, electronic channel selection and an ultrasonic remote control. The audio section uses a pair of six-inch loudspeakers. Price will be in the \$3000 range. GE's new W1000 uses a different approach, and here a specially developed 13-inch two-gun tube rearprojects the picture to a 1000 square inch plastic Fresnel lens screen. (Translated, this works out to 45 inches, diagonally). There are two mirrors plus a three-element coated plastic lens. Price is about \$2800. Other models from Mitsubishi, Panasonic. Quasar and Sony are two-unit systems with separate screens.

George Tillett



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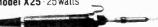
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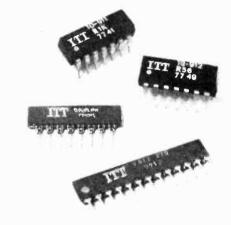
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WW-038 FOR FURTHER DETAILS

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Components

The new RAE

The City & Guilds of London Institute has issued a list of 40 "sample items" of the new multi-choice Radio Amateurs' Examination to be introduced next May, together with a breakdown of how the papers will be composed. The first part (1 hour) will consist of 35 items: 66% on licensing conditions, 34% on transmitter interference. The second part (1% hours) will include 60 items: 8% operating practices and procedures; 18% electrical theory; 12% semiconductors; 15% radio receivers; 13% transmitters; 24% propagation, and aerials; and 10% measurement. Valves no longer form part of the syllabus, despite their continued use by the majority of amateurs.

My first impression is that the adoption of multiple choice has not meant any lowering of the technical or regulatory standard; if anything the reverse. Candidates who have not carefully prepared for the exam will need to be extremely lucky gamblers to pick enough winners to scrape through.

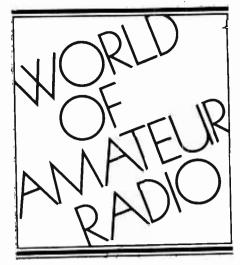
More questionable is whether the authorities recognise sufficiently that amateur radio is a form of "self-training" and that this is defeated by erecting a formidable barrier at the outset or to insist that newcomers should, for instance, be able to handle calculations in microcoulombs. The main result of a stiff RAE is surely to increase the demand for a Citizens' Band. Those of us who acquired amateur licences before the days of the RAE were fortunate indeed!

Machine-telegraphy and data

A number of readers have commented on the "Revolutionise amateur radio?" item in the July issue. Some of these have made the valid point that gaining experience in various modes such as h.f./r.t.t.y., high-speed data on v.h.f., the use of terrestrial and space repeaters and so on is all part of useful selftraining, and should be encouraged. For example, it is argued that with so many Service and commercial users now on r.t.t.y. rather than manual c.w., amateur experience and understanding of this could be as important today as were his skills on manual c.w. in 1939. Robin Addie, G8LT, makes this point strongly.

Well, yes. Most of us would agree that these various modes can and do form an interesting and rewarding part of the hobby. My main reservation is that some of them are tending to be oversold to newcomers who are led to believe that digital non-return-to-zero transmissions (i.e. Morse) is now technically out-dated. A recent writer in Break-in, for example, argued that as the Services now place more emphasis on machine — than manual — telegraphy, this proves that r.t.t.y. is a better system than c.w. and that amateurs should cease learning Morse!

Norman Sedgewick, G8WV, in



Short-wave Magazine takes the diametrically opposed view that in r.t.t.y. "amateurs are perpetuating an out-dated system which was used professionally as a stop-gap until the development of fully synchronous error-correcting systems and the completely different approach of Piccolo."

Peter Martinez, G3PLX, while recognising the limitations of basic h.f. r.t.t.y., is exploring ways in which microprocessors could be used by amateurs to implement fully synchronous techniques such as forward error correction, duplex ARQ (automatic repetition of errors). He has already made considerable progress and would be interested to hear from others working along such lines. His address is 11 Marchwood Court, Broadsands Drive, Gosport, Hants (Gosport 21563).

A general appeal to r.t.t.y. enthusiasts is that they recognise the high interference-potential of this mode and keep contacts reasonably short, remembering that the recent French move towards "exclusive" r.t.t.y. allocations was rejected by IARU Region 1.

Need for Novice licence?

Trevor Tugwell of the Stevenage & District Amateur Radio Society feels that the progressive development of amateur radio should be encouraged. However, he points out that geostationary OSCAR satellites could virtually "destroy" the present Class A licence, since it would open the way for regular long-distance operation by those holding Class B licences. This, he believes, would "reduce to a trickle" those prepared to learn Morse.

He feels that the only way to retain interest in h.f. operation would be by stressing the technical merits of c.w. and by pressing the Home Office to introduce "novice" h.f. licences akin to those in many other countries, based on, say, a 5w.p.m. code test, and providing facilities for low-power operation within segments of the 3.5, 21 and 28 MHz bands. This would provide a useful stepping-stone between Class B and

Class A licences. One could go further and suggest in addition a simplified form of RAE for novices.

Around the bands

The RSGB has protested that a pulsed Syledis location system being used by oil companies at several locations in the UK is causing widespread interference to amateurs. Centred on 432.5MHz (a "secondary" allocation to amateurs) it is causing interference over several MHz and it is argued that such a system need not have been put in a popular amateur band.

The 10GHz beacons on Alderney (GB3ALD) and Isle of Wight (GB3IOW) are back on the air. Beacon stations in the Faeroes Islands (OY6VHF on 144.885MHz and OY6UHF on 432.885MHz) have been heard as far away as Hamburg. A 50.5MHz beacon station on Cyprus (5B4CY) began operation in May and has been received at good strength in the UK.

The Home Office has agreed that fascimile transmissions will be permitted in the 3.5 to 3.8MHz band provided that bandwidth does not exceed that of telephony signals. It has also agreed to issue licences for a further series of repeater stations (Phase 3) and agreed in principle to an r.t.t.y. repeater.

July saw several Sporadic E openings extending up to 144MHz and resulted in what are believed to be the first contacts on 144MHz between Greece and the UK.

In brief

Dr John Allaway, G3FKM, a tormer president of RSGB, is the Society's first honorary h.f. manager. There are now managers for h.f., v.h.f. and microwaves The Swiss PTT is to issue a special stamp in Autumn 1979 to mark the 50th anniversary of the formation of USKA, the Swiss national amateur radio society. There are some 2,000 amateurs in Switzerland Russian amateurs sent out over 2-million QSL cards during 1977 and received some 1.5million The first all-OSCAR award has been issued to W2BXA . . . Microwave stations in the UK are being urged to use horizontal polarisation as the standard The Intruder Watch, founded by the RSGB in 1957, is this year celebrating its 21st anniversary; it has spread world-wide with some 30 countries now participating The RSGB expects to run two centres for the December RAE at London and Derby "Narrow bandwidth television association" is the new name of the former "Low definition television association". Aim remains the encouragement of highest possible quality moving television pictures within the audio bandwidth (or bandwidth of an audio tape recorder) By April 1978, US amateur operator licences totalled 337,959, up 11% in a year.

PAT HAWKER, G3VA

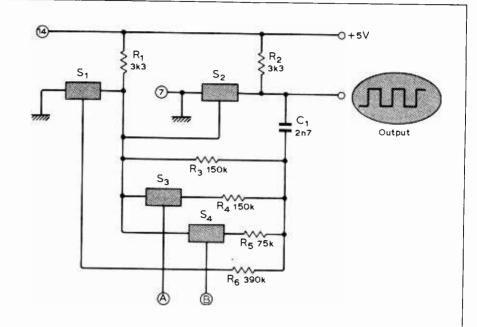
CIRCUIT IDEAS

Programmable oscillator

AN I.C. OSCILLATOR produces a range of output frequencies which are programmable using the two digital inputs. The circuit, which has a number of applications such as a multitone alarm or variable frequency clock for a digital system, is based on a single 4016 c.m.o.s. quad bilateral-switch i.c. Switches S1 and S2 are used as invertors together with R₃, R₆ and C₁, to form an astable multivibrator. Frequency variation is achieved by opening either S3 or S4 or both, with control inputs A and B. This connects R4 and R5 in parallel with R3 which changes the time constant of the multivibrator, and hence its frequency. With the components shown, output frequencies of 2, 4, 6 and 8kHz are available. By changing the capacitor and resistor values, higher or lower frequencies can also be achieved.

Frequency modulation is possible by feeding a varying digital signal into the control inputs. Also, by the addition of a second 4016 and four extra resistors in parallel with R₃, the number of output frequencies available can be raised to 64

D. Turner, Plymouth, Devon.



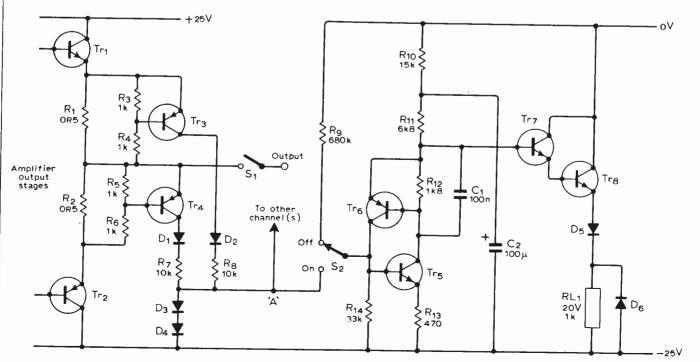
Overload protection and transient elimination

THIS CIRCUIT is suitable for use with d.c. coupled audio power amplifiers, and combines protection against current overloads with delayed switch-on for the elimination of output transients. Transistor Tr_5 is initially turned off, and C_2 charges via R_{10} . After a delay of about 1.5s the relay switches on which closes S_1 and connects the load to the amplifier. If a large current flows in Tr_1 or Tr_2 of the amplifier output stage, Tr_3 or Tr_4 will turn on. This turns on Tr_5 and the relay switches off. The circuit is reset by switching off the amplifier until

the supply has dropped to a few volts, and ${\rm Tr}_5/{\rm Tr}_6$ are no longer saturated.

Capacitor C₁ reduces the susceptibility to spurious operation, and D₅,D₆ provide protection for Tr₇ and Tr₈. Point A is a virtual earth summing junction so other amplifier channels can be accommodated. The circuit can also be modified for different supply voltages, overload currents and delay times.

T. J. Moulsley, Barton-le-Clay, Bedford.



continued from page 83

unimportant, and a different meter movement can be accommodated by changing the resistors. This indicator and tuning control may be remotely

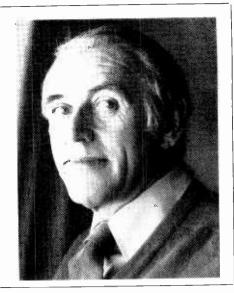
mounted.

If two sets of gate cards are used in an expanded system, it is possible to drive both sets from the circuit in Fig. 4 by changing the output resistors from $22k\Omega$ to $10k\Omega$. This does not prevent the two sets from being independently frequency-modulated, but it does restrict them to the same tuning. To permit independent tuning the complete circuit of Fig. 4 should be duplicated beyond point X, which gives two sets of references from the crystal. The standardising circuit can be made switchable, and to avoid long a.c. leads a 4016 switch may be used as shown in Fig. 7.

The power-supply components are mounted on one side of the rack, which serves as a heat-sink for the regulators, see Fig. 1. The reference generator card uses a Veroboard as shown in the prototype assembly in Fig. 8. Edgeconnection details are shown in Fig. 9. For the reference generator, positions 3 to 15, omitting 7, are reference outputs, position 16 is tuning and 17 is for the indicator.

For testing it is convenient to start with the crystal oscillator. The various frequency adjustments have already been referred to. If a frequency counter is not available an oscilloscope with a calibrated timebase can be used to measure the beat frequencies in table 2. If the crystal trimmer is set to mid range, the crystal should be very close to IMHz. Supply currents for the proto type were +25 and -6mA.

David Ryder read Natural Sciences at Cambridge, but his career has been mainly in engineering. After a short spell in an instrumentation laboratory, he worked in the lift-manufacturing industry, and in the last few years has been concerned in the development of machinetool controls. A lifelong interest in pianoplaying, and a growing appreciation of the music of J. S. Bach led him recently to take up the organ. He says, "It is not surprising that an instrument with 600 years of development behind it can be an inexhaustible study, my organ lessons have been a first-class investment".

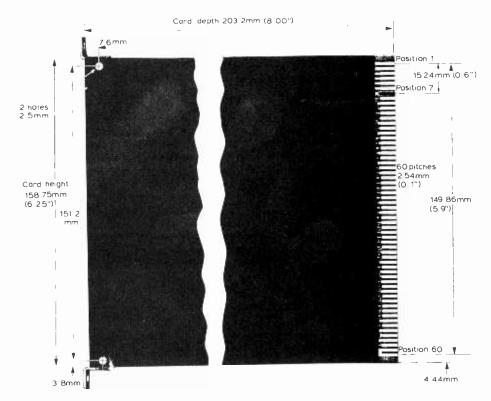


A 15 min cassette recording of the prototype is available for £2.00 c.w.o. A set of 15 special printed circuit boards (12× E01, $3 \times$ E02) is also available for £117.32 c.w.o. Both items are post free in the UK, and delivery is about 2 weeks and 4 weeks respectively.

Purchasers of these will also receive supplementary component and procurement details. Hiykon Ltd, Woodside Croft, Ladybridge Lane, Heaton, Bolton, BL1 5ED.

To be continued

Fig. 9. Standard edge connections looking onto the copper side. The slot occupies position 7, and connections 59/60 are both ground. On cards requiring + 12V, this is supplied via connections 1 and 2. The special cards E01 and E02 have 2.5mm fixing holes as shown.



Corrections

Tunable audio equalizer. The photograph shown in Martin Thomas's design for a tunable audio equalizer in the September issue was of David Russell, author of Trends in microprocessors (who says for "single-chip microprocessor" read single chip microcomputer). "No disrespect intended" responds Dr Thomas "but I hope that the article with my photo doesn't turn out to be about a UFO detector, electronic personal vibrator or a remote-controlled plant waterer, to name but a few diabolical

Apologies to both authors, and to readers for other errors in that article. In Fig. 3 the bottom end of R₅ should be disconnected from earth and connected to IC5 output. The right-hand side of the expression for bandpass centre frequency on page 59 should have been within a square-root sign. An oblique stroke should appear in the $s^2\omega_0^2$ term in the transfer function beneath to read s^2/ω_0^2 . And in the state-variable filter box on page 62, HPinput should have appeared as HP/input.

Loudspeaker system design. In Fig. 13 of Siegfried Linkwitz' article (June), the bottom end of the 34.8k Ω resistor at the inverting input of the lower-left op-amp should connect to the other channel, and not to earth as shown. In Fig. 18 the square-root sign should not extend over the term including frequencies. Mr Linkwitz adds "the B110 is connected out of phase relative to the T27 and B139 because of a 180 phase difference between the channels in Fig 13." And that "741 op-amps should not be used in the buffer and tweeter stages if more than 2V peak is required from the tweeter channel to drive the power amplifier into clipping. Instead, faster and wider badwidth amplifiers are recommended to avoid potential s.i.d.' Finally, on page 53 of the May issue, centre column, for 85dB read 95dB.

Developments in cassette recorders

New materials and techniques for magnetic tape recording

by Basil Lane

MODERN hi-fi systems now usually include a cassette recorder and because of the popularity of these machines there is a continuing pressure on designers and manufacturers to come up with improvements at annual intervals. Many of the so-called improvements seen in the past few years have, in reality, been no more than tidying up the sloppy designs of previous years. At times it has seemed that those employed to design cassette recorders have just come straight out of university and are not aware of the lessons learned from other branches of audio design!

Analogue recording is as old as recording itself and the limitations of the system have always been painfully obvious. Neglecting the future promised by the application of digital techniques to audio recording, there is still a surprising amount of "steam" left in this technique. This year, quite large steps have been taken with the introduction of pure iron particle tapes and the necessary changes to the designs of the cassette recorders produced to accept this tape.

The significance of the design changes lies in the large increase of coercivity in the new tape. For example, where existing high coercivity tapes are specified at about 500 oersted, the later generation of pure iron particle tapes have coercivities in the region of 1000 oersted. A bar to the introduction of tapes of this type in the domestic recording field has been that the existing generation of machines cannot provide the high magnetic fields required to satisfactorily record and erase tapes above 500 Oe. Two factors have been dominant: first is the design of the record head, which requires that flux saturation is avoided while providing good short wavelength resolution; the second is that the record head amplifier should be able to accommodate the additional drive conditions imposed without suffering from signal limiting.

At the time of the introduction of Cr0₂ tapes and the subsequent cobalt modified ferric oxide equivalents, both these parameters emerged as being of great importance. The limitations of the ferrite heads in use at the time had not been fully appreciated: neither had the requirement for an adequate dynamic range in the drive amplifier. Often record amplifiers had to produce a large amount of pre-emphasis to compensate

for the shortcomings of the replay head above 2kHz. The result would either be distortion due to core saturation in the head or distortion due to limiting in the drive amplifier.

Tape heads

The use of a single head for record and playback purposes has tended to add to the designer's difficulties and it is understandable that most of the modern top performance machines have now adopted the practice of having separate record and replay heads.

Because of the high values of gap flux now required to effectively magnetise a tape, great care has to be taken over the magnetic properties of the material and also the physical constraints of the core with respect to the saturation flux level at the pole tips. In selecting the material, the designer starts with the obvious magnetic and electrical properties and then considers such aspects as the hardness, the porosity (relevant in the case of moulded ferrites), and the wear characteristics using the various types of tape available.

Table 1 shows some of the parameters for the most popular materials and the

latest ones which are now being adopted by some manufacturers. These fall into three typical groups, being based on the ferrites which are derived from magnetic oxide powder compounds, metal alloys used in a laminated form, such as the Permalloys, and a third type which is a pure metal alloy powder called Sen-Alloy. This has been applied in other fields since 1937, but only recently has been adopted for tape heads.

Where recording is the prime requirements, the saturation flux density, resistivity and Curie temperature of the core material are of the greatest importance. Since tape materials with high coercivities are now being developed, large leakage flux fields are needed in the head gap area. These will be easier to obtain using core materials with high saturation, since the pole tip design to produce the necessary sharp field gradient which enables high density recording necessarily involves small gap dimensions.

Although some ferrites are capable of displaying quite high saturation flux densities, from Table 1 Sen-Alloy and Permalloy offer the best. What militates against Permalloy is that, in the harder

Table 1. Magnetic and physical properties of record head materials.

magnetic and physical proper	ties table			Single crystal ferrites	Perm	alloy	Ser	-allov
Poly	crystalline f	errites		M'n-Zn-Fe-O	Standard Fe-Mi	Hard Fe-M-Mb-Ti	Standard Fe-Al-Si	SCA Fe-Al-Si-Ti
	Mn-Zn-Fe-	0		.Z.n	itanda Fe-Mi	Hard M-Mb	ang -Al	Y S
	41M	60M	71M	Α'n	St	့	St	્રું જ
Permeability (µ)				-				-
a 10kHz, 10m0e	20000	15000	5000		5000		13000	10,50
@ 1MHz	2000	2500	2500					
⊕ 5MHz	400	300	900					
Flux density (B_{10}) gauss	3300	4500	5000	4080	6300	5050	9000	8000
Coercive Force (H_c) oersted	0.03	0.03	0.05	0.04	0.01	0.015	0.022	0.03
Sat. Flux Density (B _S) gauss	3800	5000	5500	4700	7200	5800	10500	8700
Curie temp. (T_c) °C	110	150	200	240	350	250	500	500
Resistivity (ρ) Ω .cm	>10	>1	>1	5	60	80	80	85
Hardiness H ₁ kg/cm ²	650	650	650	640	120	200	500	590
Thermal expansion coeff. I/°C $\times \times 10^{71}$	110	120	130					
Average grain size μm	50	50	50					25
Porosity (P) %	0.05	0.05	0.05			,		
Density (d) gm/cc	5,1	5.1	5.1	5.15	8.62	8.7	7.0	7.0
Wear rate μm/1000hr.	1	1	1	3	2	2	2	1

form, saturation flux figures are only marginally better than the ferrites normally used (these are compounds containing between 60% and 70% manganese oxide), and are much more difficult to manufacture because of the need for thin laminations to keep the core resistance high. Sen-Alloy therefore comes out with distinct advantages, except that it has always proved to be a very difficult material to work. Recently, both Matsushita and Yamaha have developed manufacturing processes which seem to have not only solved the problem of its extreme brittleness, which made machining almost impossible, but also improved the basic magnetic characteristics.

For replay heads, a narrow and extremely accurate gap is essential, suggesting that the material used for the core should be easily machined. Permeability, which affects the head sensitivity,, should be high, as also should be the resistivity, the hardness and the quality of the surface finish. Within the audio band permeability can vary considerably for the materials listed. Ferrites have a relatively slow decline in permeability over the audio range, while Permalloy and similar laminated metal cores display much more disastrous drops from 50,000 at 100Hz to about 5,000 at 10kHz. Although Sen-Alloy shows quite a large drop over the audio band, at 10kHz the figure is significantly higher than some ferrites and much higher than laminated metal.

To illustrate some of the problems in head design, three examples follow, using typical data as listed in Table 2 and Fig. 1. This is an illustration of the contours of equal magnetising force (H) around the gap of a recording head. Units used in these examples are the old c.g.s. system, which has unfortunately persisted in the magnetic materials industry. Initially, it is to be assumed that the tape to be recorded is a Cr0₂ type, having a typical coercivity of 500 oersted.

The ideal critical zone marked in Fig. 1 indicates a region where the recording field should be of the same value as the tape coercivity. The zone is actually a band of variable width, due to the addition of the time-variable flux caused by the presence of the audio signal. The length of the critical zone is thus dependent upon the relative values of bias and signal levels which are determined solely by tape coating parameters.

Assuming a saturation flux density (B_s) for head 1 of 5500 gauss, the maximum value of magnetising force in the gap (H_g) , will be

 $B_s = H_g = 5500$ oersted assuming that the gap is air or of a similar permeability. (In c.g.s. units, permeability in air is unity).

At this point reference should be made to Fig. 1. This has been devised from original papers by Westmijze¹, Hoagland², and Camras³ and is based on the assumption that where the fringing field is calculated at distances

Table 2. Examples of parameters for three hypothetical heads.

Parameter	Head l	Head 2	neua s
Core material	Ferrite	Ferrite	Sendust
Core permeability (10kHz)µ	5000	5000	11000
Core length (l ₂)	10mm	10mm	10mm
Gap and	7 3	7 2	7 2
core cross-sectional area (A)	$6 \times 10^{-7} \text{m}^2$	$6 \times 10^{-7} \text{m}^2$	$6 \times 10^{-7} \text{m}^2$
Saturation flux density (B.)	5500	5500	5500
Gap length (l _o)	1.25×10^{-6} m	$6 \times 10^{-6} \text{m}$	1.25×10^{-6} m

greater than 0.4 times the gap length the field pattern is cylindrical. The near field pattern is drawn using the data provided by Westmijze¹. In simpified form, if the gap field H_g is normalised to unity, then the far field strength (H_c) will be given by:

$$H_c = \frac{s}{\pi d}$$

where d is the coating thickness of the tape. In Fig. 1 the scale of dimensions is given, for simplicity, by the ratio y/s where y is the distance along the y, y' axis and s is the gap length.

The value of H_c can now be calculated, assuming the ideal critical field will lie on a radius where y=d. Thus, for example 1, the maximum field available in the critical zone where the tape thickness is $6\mu m$ will be 364 oersted. In practice, the coating will experience a zone of higher field strength, but this is much closer to the gap where the contours curve considerably, causing distortion of the signal and a reduction in the short wavelength (maximum output level).

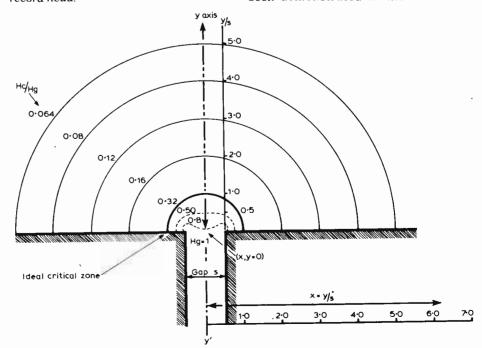
If the gap is widened, as in the example given for head 2, although the same value of $H_{\rm g}$ previals the location of the 364 oersted curve has moved further away from the gap to a radius of $29\mu{\rm m}$

Fig. 1.Contours of the relative value of equal magnetising force (H) around a record head.

from the gap centre. Since the practical zone width will also have been increased, recording resolution at short wavelengths will suffer due to bias erasure. To obtain the correct 500 oersted contour for the tape thickness of $6\mu m$, the level of H_g should be adjusted down to a value of only 1570 oersted, well within the limits of the maximum flux density for the core material selected. Clearly head I cannot produce the bias fields suitable for low distortion recording on tapes above about 360 oersted and this helps to explain the dilemma of the designer who is forced to adopt a narrow gap configuration in cases where the head is used both for record and replay.

However, the same core material will not only adequately cope with $Cr0_2$ tapes with a coercivity of 500 oersted when used with a design having a gap length of $6\mu m$, but is also capable of operating correctly with $6\mu m$ coatings having coercivities up to 1590 oersted! In this example a ferrite with a typically median value of B_s has been selected deliberately, to illustrate a worst case condition.

If the narrow gap version is selected, but this time using Sendust as a core material, the value of B_{\star} rises to 10,500 which now permits a maximum value of magnetising force in the ideal critical zone of 696 oersted — well above that required for $\text{Cr}0_2$ tape, but insufficient for correctly operating the new pure iron tapes. Nevertheless, as has been demonstrated in the first two



cases, a simple and small increase in the gap length up to about $2\mu m$ will allow the correct conditions to be obtained.

Admittedly these examples are crude, as the core design used has a uniform cross section which would certainly not be the case for a practical head. In addition, no attempt has been made to allow for design devices which alter the distribution of the fringing flux, or to take account of core losses, or even to calculate using the more practical figures of B_{max} for the core, instead of the more readily obtained saturation figures. As a first order approximation, the examples do serve to clearly demonstrate the marginal magnetic properties of ferrites when used as a narrow gap audio record head, even when dealing with contemporary Cr02 tapes. They also indicate that Sendust is clearly superior, even to the extent that this material comes close to having the desired properties permitting narrow gap heads to be fabricated for the next generation of magnetic tape.

It is interesting to note that Tandberg, who are among the first to produce a cassette recorder for pure iron particle tape, have chosen to use a ferrite head for recording, having a gap of 5µm. (See appendix). This machine, the TCD340A, has other novel features which will be described later.

Yamaha and Matsushita have published details of Sendust heads which could record high coercivity tapes and because of the obvious value of this material to designers, some details are offered here.

Sendust audio frequency heads

Sendust or Sen-alloy comprises a combination of about 84% iron (Fe); 9.7% silicon (Si and 5.8% aluminium (Al). It was first used in 1932 by Professor Matsumoto as a core material for r.f. coils. In its original form it was a powder compressed with a binding material to form a solid. As such it was far from ideal for tape head cores and it was not until about 1972 that methods were developed for producing a form suitable for video head applications. 4.

Since the alloy is both brittle and hard, it is difficult to machine and so casting techniques have been developed to produce extremely accurate core forms ^{5,6}. In the methods adopted by Yamaha and Matsushita, long core sections are produced which then only require slicing. Machining is made easier with the addition of small percentages of rare earth elements such as titanium (Ti), yttrium (Y), or cerium (Ce). Matsushita head cores, for example, contain 0.5% Ti. Inevitably, these additions do modify the magnetic performance, as shown in Table 1.

The manufacturing process used by Matsushita starts with melting the alloy components at a temperature of 1440°C in an argon atmosphere and then, in the same atmosphere, pouring the melt into moulds. Pressure is then quickly applied to between 500 kg/cm² and 1000 kg/

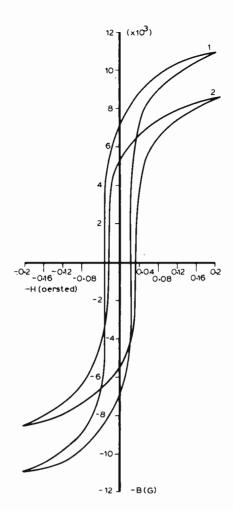


Fig. 2. The B-H magnetic characteristic for (1) pure Sendust; (2) Sendust with added titanium and zirconium.

cm², followed by a rapid quench. This method is called squeeze casting and is said to produce improved magnetic properties due to the elimination of inclusions. It does, however, have the disadvantage that a 10hr annealing is required to restore the permeability. The Yamaha process is more involved, but does seem to offer some advantages in the better magnetic properties of their material. The alloy is produced from high purity raw materials and contains no rare earth additions. Comparisons of the B-H and relative permeability curves of Sendust with and without additives are given in Figs 2 and

Table 3.Characteristics of the Hall element used in the Hitachi record head.

Specifications of the Hitachi Hall element

	0.2mm wide	
Size of element Product	nt 1mm long	.InSb thin films
sensitivity	37mV/mA. kgauss	•
Output	4.0mV	10 gauss field, bias 11.2mA
Noise	0.56μV(r.m.s.)	bias 11.2mA, 100Hz-10kHz
S/n ratio	77 dB	4.0mV, 0.56µV
Resistivity Temperature coefficient	$1.2 \times 10^{-2} \Omega.\text{cm}$	·
of output	-1.6%/deg.	0-50°C

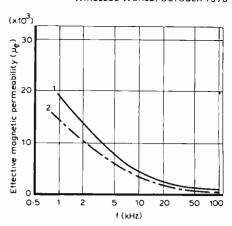


Fig. 3. Effective permeability plotted against frequency for (1) pure Sendust; (2) Sendust with added zirconium and titanium.

The melt is made in a vacuum of 10^{-5} torr and, in the same vacuum, is poured into capsules which are then rotated at 18000 r.p.m. From these, the Sendust is poured into graphite moulds and allowed to cool. The centrifuging produces an isotropic crystalline solid, formed into core shapes of very precise dimensions.

As with most other head designs, the cores are fitted into Permalloy cases, with the core tips showing through a window. Because the wear rate of these two materials is different, which could lead to later recording losses, Yamaha then coat a thin film of Sendust over the entire front face, using a vacuum plasma deposition process. This ensures a uniform surface with a high resistance to wear.

Alternative tape head technology

Until recently the most practical technique for converting fluctuations in a magnetic field into a varying electric signal has been electromagnetic induction. However, probably as a result of a very complete analysis of methods undertaken by M. Camras some years ago, the Hall effect suggested itself as a practical alternative for magnetic recording. This is named after E. H. Hall, who in 1879 discovered that if a current carrying conductor is fixed in a transverse magnetic field the moving electrons are forced to one side (Fig. 4). This creates a potential difference between the edges of the conductor that is directly proportional to the flux density B, the value of the current flowing, I, and the density of the moving charges in the conductor. Thus

$$V_{H} = \frac{K_{H}I.H}{T}$$

Where V_H = the Hall voltage, H is the field strength, T is the thickness of material through which H passes and K_H represents the Hall coefficient of the material given by

$$K_H \frac{1}{ne}$$

where n = number of charge carriersand e = the charge per carrier.

Clearly, K_H will be large when the number of charge carriers is small, but in a metal, there are very large numbers of carriers, so the Hall voltage will be small. This suggests the use of some semiconductor materials, those proving most suitable being germanium and indium antimonide (InSb), the latter having a value of K_H of 30,000.

These encouraging figures suggest that a practical replay head can be made which offers a number of advantages over normal heads. First, because the Hall voltage is dependent upon H, the head is flux sensitive, rather than being sensitive to the rate of change of flux as in conventional heads. This should improve low frequency reproduction and make it possible to transduce signals down to d.c. Second, because the electrical element is a straight conductor, the circuit will be purely resistive and an improved transient performance is obtained.

Although the principles of the Hall element suggest that a replay head without magnetic materials could be produced, two difficulties lay in that path. At the flux levels available from recorded magnetic (approximately 200mM/mm at low frequencies) output levels from the element would be low and the signal to noise ratio would suffer. Also, the need to establish a connection on the edge that would be in contact with the tape would create engineering difficulties. Methods which use alternative points of connection simply reduce sensitivity.

In fact, the simplest method is to use a conventional core assembly with the Hall element placed in a rear gap of the magnetic circuit. Fig. 5 shows an actual record-play head produced by Hitachi for their new D7500 cassette deck. Table 3 gives details of the Hall element used. The InSb element is laid as thin film directly onto one of the ferrite core pole pieces, thus making it possible to fabricate an extremely thin element to give a high sensitivity. In addition, Hitachi apply a heat treatment which is said to improve the Hall coefficient.

Record amplifier improvements

The limitations of magnetic tapes and record heads for casssette recorders have all too often led to the practice of attempting to compensate for declining short wavelength flux on the tape, either by reducing the bias to below the optimum level or by applying high levels of pre-emphasis in the record amplifier. Because the head preamplifier also generally performs the function of record equalisation, problems of slew rate limiting and intermodulation tend to arise. In addition, signals with large high frequency energy (made worse by companders such as Dolby B) may suffer from limiting due to the small overload margin available from the devices and the supply voltage normally used.

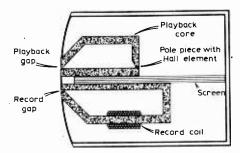


Fig. 4 Construction of the Hitachi D7500 cassette record-replay head.

Tandberg have come up with a different approach which seems to eliminate many of the difficulties. They start by separating the functions of preemphasis from the function of driving the head cores (Fig. 6). Since the equalisation amplifier then only has to operate at small signal voltages, the effects of intermodulation and slew rate limiting are reduced. In addition, the buffering of the bias oscillator from the equalisation amplifier by the drive amplifier has considerably reduced the interactive effects that can sometimes occur.

Finally, the idea of using a "constant current resistor" to provide the source for head current has been rejected in favour of a transformer used as a constant current load for the final stage. Rejection of the bias tending to feed back into the drive amplifier is obtained by an LC filter between the output stage and the point injection of the bias signal. This combination has been the subject of a recent world-wide patent application by Tandberg and is called the Actilinear recording system.

Appendix

At a recent conference to launch Tandberg's 1978 cassette recorders, additional information provided by Herman Lia, Tandberg's designer, was produced which is of considerable elegance. A simple formula which encompasses the graphical solutions used here may be quickly used to establish first order criteria for far fringing fields.

$$B_c = \frac{\mu_0 \pi dH_c}{s}$$

Fig. 5.Block diagram of the Tandberg Actlinear recording amplifier

where $\mu_o = 1$ (c.g.s. units), d = thickness of tape coating, $H_c =$ tape coercivity, s = gap length and $B_c =$ core flux density. The core flux density will equal the gap flux density, thus equating to H_g used in the body of this article. Using data supplied by 3M (UK), who have developed the Metafine 4 pure iron tape, and a ferrite core material having a maximum operating flux density of 4000 gauss, the following design results were obtained.

$$d = 4\mu m, H_c = 1050, B_c = 4000$$

$$s = \frac{\mu o \pi d H_c}{B_c}$$

$$= \frac{3.142 \times 4 \times 1050}{4000}$$

$$= 3.29\mu m$$

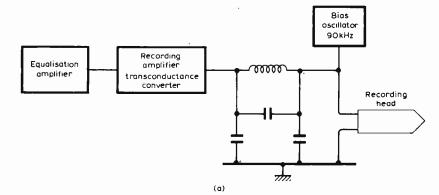
By allowing a margin for future developments, and setting the gap length at $5\mu m$, the maximum value of H_c for coating thicknesses from $4\mu m$ to $6\mu m$ is 1060 to 1590 Oe, thus offering considerable margins of safety.

They also suggest that by taking the saturation flux density figures for core materials, Sendust looks better than it really is. This is because the B-H curve for Sendust shows a considerably larger ration for B_{max} versus B_{sat} than ferrites, thus reducing the total working range of the material.

Clearly wide gap heads are necessary with existing materials, but Tandberg are working with Trondheim University to optimise an "amorphous" magnetic material which will permit gap lengths down to the lµm region. This suggests a working flux density of at least 13,300 gauss in the core material.

I am indebted to Tor Sivertson and Herman Lia for this additional information and to Herman Lia for the elegantly simple formula given above.

- Philips Res. Report. 8, R2i4, 1953 pp. 1161-183.
- 2. Hoagland, A. S. "Digital Magnetic Recording" pub. John Wiley & Sons pp. 90-97.
- 3. U.S. Patent 2,628, 285 1953.
- 4. NHK Laboratories note, Serial No. 154, July 1972.
- 5. I.E.E.E. Trans/Mag. Sept. 1977, vol. Mag 13, No 5, pp. 1473.
- 6. Internal document issued by Yamaha, Japan.



NEW PRODUCTS

Digital multimeter

A portable instrument, the Jugoslav-made Iskra Digimer 10 is a 31/2 digit multi-function, digital meter providing for measurements of alternating and direct voltage, alternating and direct current, and resistance. Automatic polarity indication is provided and the unit is powered by rechargeable batteries which last for eight hours. The display is a 7-segment type, 7.62mm high. Ranges are: voltage (alternating and direct) 200mV to 2000V fullscale; current (a.c. and d.c.) 20µA to 2A; resistance 0.1Ω to $20m\Omega$. Iskra Ltd, Redlands, Coulsdon, Surrey CR3 2HT.

WW304

Power supply

A power source intended mainly for use with prototype mixed linear and digital integrated circuitry, the TOPS2 can also be economically used to power microprocessors. The outputs are 5V at 5A and 15V at 1A, positive and negative, although they may be adjusted about these levels. Overvoltage protection is provided for the 5V output, while the 'linear' outputs have overcurrent protection: autoreset is present on all three. Overload is indicated. Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorkshire LS22 4DH.

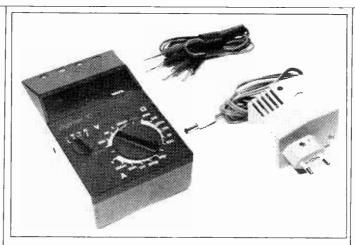
WW302

Transistor sockets

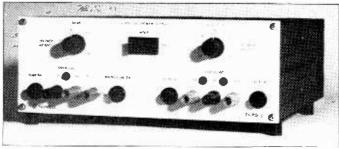
Sockets for power transistors in TO-3 or TO-66 cans are announced by Astralux. The



sockets are made from glassfilled diallyl phthalate, and contacts are of either beryllium copper or brass, gold or tin-plated. Current rating is up to 10A, with a 30A version also available, and one or two ground straps of tinplated brass are provided. Astralux Dynamics Ltd, Brightlingsea, Colchester, Essex CO7 OSW. WW303



WW304



WW302



WW313

Wide angle I.e.d.

The Opcon OSL-1 and OSL-1S are one-lead and two-lead l.e.d.s which offer a viewing angle of 180° and are claimed to be the smallest devices commercially available. Both versions have a typical luminous intensity of 1.1mCd with a forward current of 15mA. Norbain Optoelectronics Division, Norbain House, Arkwright Road, Reading, Berkshire RG2 OLT.

WW313



Solenoids

Freedom from mechanical noise and the necessity for end stops are claimed for rotary and linear solenoids made by Roxburgh Electronics. Maximum effort is exerted at the beginning of the stroke and the armature is stopped by electromagnetic braking.

The rotary type will work at voltages from 6 to 48V over a rotary excursion of 20°, 30° or 45°: moments of rotary inertia range from 3.8 × 10° 3 to 870 × 10° 3gr/cm/s². No axial movement is exerted. The linear variety accept supplies of 6-100V, maximum torques, as in the rotary type, varying between 0.15kg to 0.95kg for the smallest version to 1.5kg-3.6kg in the largest model. Roxburgh Electronics Ltd. 22 Winchelsea Road, Rye, East Sussex TN31 7BR.

WW315

Frequency synthesizer

The model S1-107 can synthesize frequencies from 0.1Hz to 16MHz with a resolution of 5½ digits. An



internal reference oscillator provides a stability of \pm 10 p.p.m. in the temperature range 0 to 50°C. Circuit optons include external b.c.d. programming, and \pm 1 p.p.m. refreence oscillator. The unit measures 216 \times 81 \times 229mm. Syntest Corporation, 169 Millham Street, Marlboro, Mass. 01752, U.S.A.

WW311

Variable-height l.e.d.s

Printed-circuit board mounting l.e.d.s by Marl can be adjusted in height above the board by the insertion of extender sections,

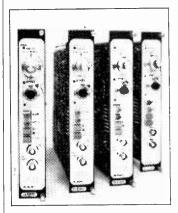


which fit directly to the base of the l.e.d. and which have flowsoldering contracts. The l.e.d.s themselves are the PC201 series and are obtainable in red, amber and green. Marl Associates Ltd, The Ellers, Ulverston, Cumbria LA12 OAA.

WW301

Waveform memory

This is a memory module for the Datalab 2000 series of waveform recorders. Analogue waveforms are applied to the input of the module, he DL2005, digitized and stored in a 40K memory, from



which it can be read, converted back to analogue form and displayed or used as computer input. Maximum sampling rate is 2MHz. Input amplifier gain is step variable to provide for inputs of between 100mV and 5V full scale, with a 'fill-in' control, and the preamplifier output is presented at the front panel. An offset control reduces the effect of superimposed direct voltage. Data Laboratories Ltd, 28 Wates Way, Mitcham, Surrey CR4 4HR. WW309

Phase meter

A direct meter display of phase difference between two signals is presented by the Prosser PSI A200 analogue phase meter. A taut-band meter is used, with a scale calibrated from 0-180, and lights indicate which of the two inputs is leading. A switch increases display sensitivity to 18



and an output of the phase information is provided for external use. Input amplitudes between 50mVpk and 5Vpk are recommended, though in the frequency range 10Hz to 100kHz, an input of 5mV will operate the instrument. Inputs must be symmetrical for maximum accuracy in measurement, but slight distortions are acceptable. Prosser Scientific Instruments Ltd, Lady Lane Industrial Estate, Hadleigh, Ipswich IP7 6DQ.

WW307

Counter i.c.s

The eight-digit i.c.s, from Intersil. called universal counters, can function as a frequency counter, period counter, frequency ratio counter, and a time interval counter. The devices are designed to display frequency in kHz and time in µs with a decimal point output and leading zeros blanked. The ICM 7216 and ICK7226 are housed in 28 pin and 40 pin packages respectively, but the last mentioned device offers additional accumulation times and b.c.d. outputs. The only external components required are a 10MHz crystal, switches, tuning capacitors and an eight digit l.e.d. display. Intersil Inc., 8 Tessa Road, Reading, Berkshire RG1 8NS. WW312

Pulse generators

A pulse transition time of less than 0.1ns is exhibited by the AVK series of pulse generators made by the Canadian firm of Avtech, who say that it is particularly intended for use with fast logic devices, going on to say that they think it might be the fastest solid-state pulse generator available commercially. The unit requires a trigger of between 2 and 5 volts, producing either 5V fixed-amplitude or 0-15V variable outputs, depending on model, polarity being fixed by the user. Width is either 1-50ns or 4-100ns, input trigger being either 0-20kHz at 100ns output or 0-1MHz at Insoutput. The generators are distributed by Lyons Instruments Ltd, Hoddesdon, Herts.

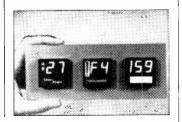
WW306

Pyrometer

The portable pyrometer by Oryx is intended to provide an accurate indication of soldering iron temperature in the range 200-450°C. The unit needs no power supply and has a detachable thermocouple probe with a nonburn lead of neoprene. Greenwood Electronics, Portman Road, Reading, Berkshire RG3 1NE. WW314

Alphanumeric indicators

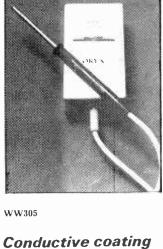
Eight-bit coded inputs can be used to illuminate alphanumeric displays or as alarm identification in an area about the size of a pilot lamp. The displays are 21/2 digit, programmable indicators, incorporating in different versions 8-bit decoders, a 25MHz counter, an 8-channel failure surveillance unit with alarm, or a 2-digit display with sense for use with shaft encoders, the decoder providing linearization of a nonlinear signal. Sufficient output power is obtainable to drive a relay. Centrelco S.A., CH-1211 Geneve 26, Case Postale 241, Switzerland. WW308



Oscilloscope for power

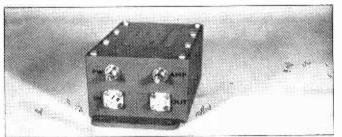
Voltage, current, phase and time are the important quantities in measurements at power frequencies, between 25 and around 2000Hz. An oscilloscope by the Australian BWD company, the 880 Powerscope, is intended for workers in power engineering and is said by the makers to be particularly useful for measurements on devices such as thyristors, triacs and magnetic amplifiers. Four channels are provided on a 10cm square screen, the ranges coping with voltages from 0.1 to 1000V, current up to 100A, time from 100ns to 100s and phase. The frequency of the majority of supplies is measured by a phase-lock loop and the instrument measures phase by the provision of a pulse in 1° steps, which can be used either to trigger the timebase or as a bright-up marker. The unit is said to have been designed with the safety aspect in mind, since it is likely to be used at high voltages. BWD Electronics Pty Ltd. Miles Street, Mulgrave, Victoria 3170, Australia.

ww310

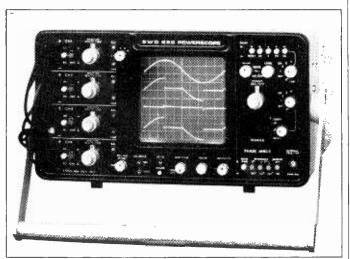


The use of plastic cases for elec-

tronic equipment is convenient but affords no protection against radiated interference and no possibility of earthing. A conductive coating, which can be brushed, sprayed or screened, is made by Metex in America and named Xecote. It consists of a thermoplastic resin binder with a suspension of metallic particles and will adhere to most plastic surfaces, a primer being needed for very smooth parts. Xecote dries in air in around two hours and is fully cured in 24. Finish is matt black, which can be used as an undercoat for a normal paint. Components Division, MCP Electronics Ltd, Alperton, Wembley, Middlesex HAO 4PE. WW305



WW306



Who? Me?

The leisured, microprocessed society of the '90s, in which the mere utterance of the word 'work' will mean cancellation of one's annual holiday in the nearest factory, can't come too quickly for the average A-level school leaver, if a recent essay competition in the *Guardian* is any guide. Most of the essayists — school leavers and their teacheradvisers — are of the opinion that a career in industry is, if anything, slightly less attractive than a life stretch at the Scrubs, and intend to devote their attention to finding alternative ways of scraping an existence.

What a refreshing attitude! They're not going to be forced into anything they don't like, these youngsters. Any suggestion of being made to perform "boring" tasks in exchange for their daily bread is obviously going to be met by an offended stare. They're absolutely right, of course; why on earth should anyone who has been freely provided with an education up to the rarified atmosphere of A levels be required to spend his time doing anything but medicine and law? There are, after all, masses of ill-educated, dull, unimaginative and probably dirty workpersons available who are only too happy to do the necessary, mundane, productive work (sorry! – a slip of the pen) to keep the bright young minds supplied with life's necessities.

One of the prize-winning essayists makes the valuable point that no industrial talent scout has thought fit to approach him and attempt to entice him into any particular dark mill, satanic or otherwise. I do so sympathize with this kind of predicament. I suffered from that same lack of interest in me, as an asset to an employer: it even became necessary to find out for myself about my prospective career and eventually I came to realize that I was going to have to abase myself and apply for a job. The R.A.F. showed every sign of being interested in me, to the point of insistence, but that only lasted a short time and doesn't count.

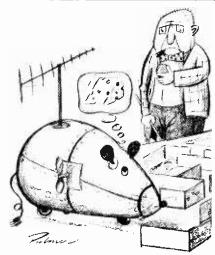
So, to all school-leavers, I would say: stick to your principles — and for heaven's sake don't give anyone the impression that you're alive, or they'll get you into a job, sooner or later.

Tricky Mickey

Well, it's happened. We've been to the brink before — heard the rustlings in the snake pit several times and once or twice our collective toes have been over the edge, but I can now reveal, as they say, that our collective lid has thoroughly and irretrievably flipped.

It's all the fault of these infernal computer contraptions. I've complained before that I have trouble finding out what they all do, and it seems now that the sooner I learn to keep my mouth shut, the better. I should explain myself, and I can do no better than





to quote from a press handout lately received. "New York, June ... Entries have been received from approximately 6,000 engineers worldwide, for the first running of the "Amazing Micro Mouse Maze Contest" sponsored by both Spectrum Magazine of the Institute of Electrical and Electronic Engineers, IEEE, and Computer Magazine." It goes on to explain that the robot creatures have to negotiate a maze without remote control and with no wires. They don't have to look like mice, apparently, which is just as well because they aren't allowed to fly or jump over the walls.

Six thousand engineers! One hopes, assumes even, that the research and development needed to build these distracted rodents will be done in time not otherwise occupied by gainful employment. The thought of some vital project grinding to a halt because the lab. is ankle-deep in panic-stricken beasts is one I, for one, don't care to contemplate. Last year, we are told, 54 people entered, but only six official mice (lovely phrase, that!) made it to the starting gate because the other 48 couldn't be made to work. I dare say they were being fed on the kind of cheese that comes in aluminium foil and were suffering from short-circuited guidance mechanisms.

Sight and sound

London Bridge, far from falling down, is being rebuilt. The station, that is. It's now a mass of bright yellow girders, brown tiles and natty little yellow cabins for the ticket collectors to lurk in. When it's finished, it will probably look very nice indeed — they've even given the bit where the trains come in a lick of paint. There is a brand-new public address system too, and that's where I stop being quite so delighted. Straining to hear where the Epsom Downs train was, last evening, all I could catch was the usual, grotesque Bill and Ben double-talk, like Stanley Unwin with a head cold, translated into Urdu and articulated through a roll of roof insulation.

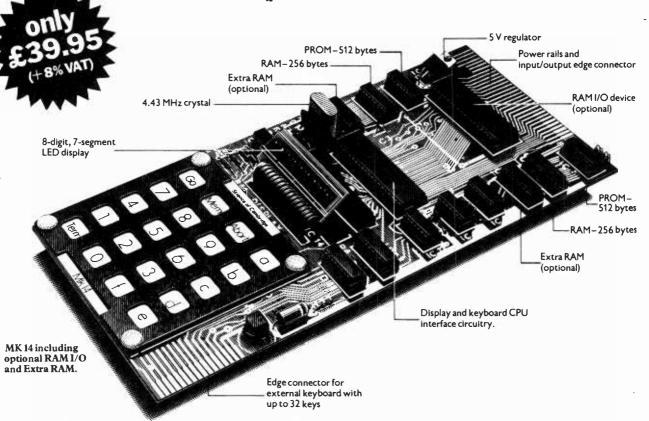
It must be very difficult, in a great echoing vault like a main-line station, to provide a decent p.a. service, what with the noise of locos and the vast area it is necessary to cover, but it must surely be possible to design something that is at least intelligible. I did notice that the lady announcer was a sight more readable than the man, who mumbled, so maybe a course of training in microphone technique would be a help.

But it seems to me that sound is perhaps not the best way of letting passengers know that the 17.38 to Epsom Downs has just become the 18.12 to Brighton, calling at every tenth sleeper on the way. There is already a good deal of racket in there and, unless the threshold of pain is to be approached, it is difficult to see how an audio message can be certain of competing successfully. So why not sprinkle a few v.d.u.s about the platform, as they do in airport lounges, so that those of us who can read run less risk of ending up in Brighton when our slippers are warming in Croydon? I dare say the words are already forming on the chairman's lips - something to do with cost and the likelihood of disgruntled Celtic supporters potting at the displays with empties. It isn't my job to sort out details like that, however - I just get the ideas.

Series of events

When Free Grid, of fond memory, was writing this page, it was a poor month indeed when he didn't have a gentle poke at the technical language we use. I can't pretend the same easy familiarity with Latin and Greek displayed by my predecessor (the classics master at my old school would be very happy to confirm that) but I am tempted to join in this programme/program argument, if only because it strikes me as almost unbelievably idiotic. The Concise Oxford prefers the mme spelling, and that is good enough for me. It may be inconsistent with diagram and all the others, but who's talking about consistency? The argument seems to be that a computer programme is somehow different from any other kind of programme and should therefore look different: this is sophistry and is unworthy. Computers are confusing enough without inventing difficulties. In any case, does anyone seriously mean that either spelling is difficult to understand?

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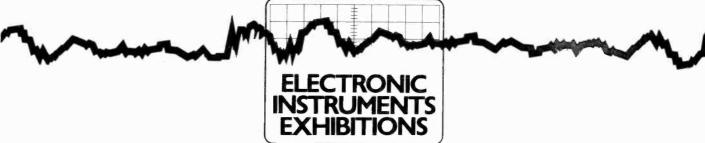
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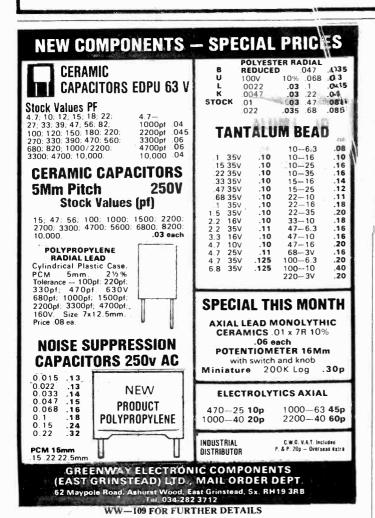
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A range of integrated circuit audio amplifiers with fret data and printed circuits. JC12 6 watts £1.60, JC20 10 watts £2.95. JC40 20 watts £3.95. Send sae for

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SWANLEY ELECTRONICS



Build this large-screen colour receiver - using far fewer components than any other TV set on the market!

Part 1 of this exciting project is in this month's issue. The set is based on the latest technology (110° PIL tube, thyristor line timebase, single-chip decoder, etc.), and gives a very high quality colour picture. Full instructions will also be given for the cabinet in which to house it.

OPTIONAL EXTRAS WILL INCLUDE * Remote control * Teletext decoder

OCTOBER ISSUE OUT NOW 50p



Latest transistorised Telephone Amplifier is completely automatic with detachable plug-in speaker. Placing the receiver on to the cradle activates a switch for immediate two-way conversation without holding the hand-set. Many Ipeople can listen at a time. Increase efficiency in office. shop, workshop. Perfect for "conference" calls: leaves the user's conference calls: leaves the user's hands free to make notes consult files. No long waiting. On/Off switch, volume control. Model with tape-recording facility £19.95 + VAT £1.60. P. & P. 89p.

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Made to High Safety and Telecommunica-tions Standards. The modern way of instant 2-way communications. Supplied with 2-way communications Supplied with 3-core wire Just plug into power socket. Ready for use. Crystal clear communications from office to office. Operates over ½-mile range on the same mains phase. On/off switch. Volume control. Useful as office intercom, surgery and homes, between office and warehouse. Full price refund ifferentiation 10 days. Six months' service. guarantee, P. & P. 99p.

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WW-015 FOR FURTHER DETAILS

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- * High sensitivity.
- * Excellent gain flatness.
- ★ Digital read out.
- * High accuracy.
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The instrument is specifically designed for the measurement of radio noise and incorporates many features to eliminate measurement inaccuracy.

Other receivers and accessories available covering the frequency range 10KHz-1000MHz.

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W/W-118 FOR FURTHER DETAILS

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240v Plug-In Relays 3 pole c/o 10 amp contacts 85p P P 15p

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Forming ¼in, wide strip 10m — 75p 50m — £3 100m — £6 P&P 1p per metre
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Input 240v 50 hz Type 1 0 / P 8kv @ 15 watts £8 75 P&P £1
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STABILISED POWER SUPPLY (APT) 5-14 volts @ 6-amp Pre-Set (with manual) 620 P P 62

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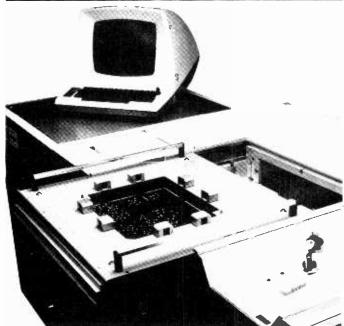
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Introducing n-circuit tester.



Membrain's new MB9280 In-circuit tester gives a fast, accurate cost-effective diagnosis of PCB faults no manual test method can match

It's a simple-to-use, low-cost system.

It tests correct insertion, value and polanty of every component individually and supplies a detailed fault printout-instantly

Resolves a wide range of faults.

The MB9280 will locate assembly faults from incorrect component values to solder bridges. Detection before functional testing-particularly helpful with complex analog PCB's-makes this stage a highspeed operation, as few faulty boards get through

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Production of In-circuit test programs for the MB9280 is extremely simple. The program language is clear and easy to learn Programs are stored on fast-access floppy discs-an inexpensive, convenient

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MB9280 Hardware.

The MB9280 is packaged ın an ergonomic desk-style mainframe with control panel, mini-printer and pull-out bed-of-nails test fixture as standard.

A custom-built bed-of-nails.

The user can quickly and simply create a custom bedof-nails from a kit supplied. Altematively, Membrain will construct one to the user's specification Interchanging of beds-of-nails is quick and easy to facilitate testing a range of different board designs

The MB9280 is available immediately.

If you want the hard facts about how In-circuit testing with Membrain's new MB9280 can increase productivity on your production line, use the reader reply card service or contact.



Automatic testing WW - 116 FOR FURTHER DETAILS

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SOCKETS £0.13 £0.14 £0.15 £0.40 £0.45 £0.12 £0.35 £0.12

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P	ositive			
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N	VR7812 v.a	7812	TO220	£1.00
N	IVR7815 v a	7815	TO220	£1.00
N	IVR7824 v a	7824	TO220	£1.00
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	VR 7905 v a	7905	TO 220	£1.40
N	VR7912 v.a	7912	TO220	£1.4Q
N	VR7915 v.a.	7915	TO 220	£1.40
N	VR7924 v.a	7924	TO220	£1.40
V	a 723C TO9	9		45p
7	2123 14 pin	DN		45p
EI	M309K TO3			£1.50

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400mw (8zy88) DO7 Glass encapsu lated range of voltages available 1 3v 2 2v 2 7v 3 3v 3 9v 4 3v 4 7v, 5 1v 5 6v 6 2v 6 8v 7 5v 8 2v, 9 1v 10v 11v 12v 13v 15v 16v 18v 20v 22v 24v 27v 30v 33v 39v

No. Z14 8 p.es.

1w-1.6w Plastic and metal encapsu
lated Range of voltages available 1 3v
5 1v 5 6v 6 2v 6 8v 7 5v 8 2v
9 1v 10v 11v 12v 13v 15v 16v
16v 20v 22v 24v 27v 30v 43v
47v 51v 68v, 72v 82v 91v 100v
No. Z13 15p ea.

10w Metal stud type SO10 case
Range of voltages available 1 3v.
2 2v 2 7v 3 3v 3 9v 4 3v 4 7v
5 1v 5.6v 6 2v 6 8v, 7 5v 8 2v
9 1v 10v. 11v 12v. 13v. 15v. 16v
18v 20v 22v 24v 27v, 30v 33v,
43v 47v 51v 68v 72v 75v 82v
91v. 100v
No. Z10 35p ea.

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£0.06

200mA IS920 50v

£0.06 £0.07 £0.08 £0.09
£0.04 ½ £0.05 £0.06 £0.07 £0.08 £0.09 £0.10
£0.09 £0.10 £0.11 £0.13 £0.41 £0.16 £0.20
£0.14 £0.15 £0.16 £0.17 £0.21 £0.25 £0.30
£0.16 £0.21 £0.23 £0.35 £0.42 £0.51 £0.60
£0.56 £0.69 £0.93 £1.25 £1.76 £1.94 £2.31 £2.88
£0.75 £0.84 £1.80 £1.75 £2.25 £2.50 £3.00 £0.45 £0.60

POTENTIOMETERS

CARBON POTS (Linear Track) Single gang with wire end terminations. $6mm \times 50mm$ plastic shaft 10mm bushes supplied with shake proof washer 8 nut. Tolerance \pm 20% of resistance.

1831 1k ohms £0.26	1836 47kohms €0.26
1833 4k7ohms £0.26*	1837 100kohms £0.26* 1838 220kohms £0.26*
1834 10kohms £0.26*	1839 470kohnis £0.26* 1840 1 Meg £0.26*
	£0.26

CARRON POTS (Log Track)

1842 4kohms	£0.26	1846 100kohms £0.26
1834 10kghms	£0.26	1847 220kohms £0.26
1844 22kohms	£0.26	1848 470kohms £0.26
1845 47kahms		1849 1 Meg £0.26
185	0 2M2	€0.26

DUAL CARBON POTS

(Lift Lifack)	
These high quality dual gang pots are litted with write end terminations and 6mm × 50mm plastic shaft 10mm. bush and supplied with shake proof washer & nut track tolerance ± 20% but matched to within 2db of each other VC3	1852 10kohms 60 78

DUAL CARBON POTS (Log Law)

1864 100kohms £0.78*
1865 220kohms £0.781
1866 470kohms £0.78*
1867 Meg £0.78*
2 £0.78

SINGLE GANG SWITCHED (Lin Law)

These potentiometers are fitted with double pole on-off switches. The switch is incorporated within the rotary action of the pot. Specification of pot is as VC1.
Switch rating 1.5 amps at 250v AC.

	1878	2M2	€0.60	
1873 47				€0.60
				hms £0.60*
				hms £0.60
				hms £0.60
	g	ripo di E c		

SWITCHED POT (Log Track)

Specifications as	VC2 but	track having (log) law
1879 4k70hms	€0.60	1833 100kohms £0.60*
1880 10kahms	£0.60°	1884 220kohms 60 60"
1881 22kohms	£0.60*	1885 470kohms €0.60
1882 47kahms	£0.60°	1886 1 Meg £0.60*
100	7 7 2 4 2	

O/No 1943 15 watt high quality soldering iron totally enclosed in a ceramic shall littled with 3/32 bit 63.80 O/No. 1947. Replacement element for 1943 iron 1949.

O/No. 1947. Replacements occurred to 1940. September 20/No. 1944. Iron coated bit 3/32 for 1943 iron O/No. 1945. Iron coated bit 1/8 for 1943 iron €0.46 for 1943.

0/No. 1949. Iron coated bit 3/32 for 1948 iron
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O/No. 1951. Iron coated bit 3 16 for 1948 iron £0.46
O/No. 1931. Highly popular X25 and 25 wait
Quality soldering iron ceramic shafts to provide

O/No. 1946. Iron coated bit 3/16 for ron £0.46
O/No. 1948. General purpose 18 wattiron fitted with iron coated bit
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DUAL GANG LOG-ANTI-LOG POT 1886 Track specification as dual gang pots VC3 as above, but tracks mounted to log-anti-log action £0.75°

SPECIAL VOLUME CONTROLS

A mini								
control								
Resista	nce v	alue	5koh	ms	Tole	rance	4	20%
½watt r	ating							
1889		£	0.27		VC8			

MINIATURE ROTARY VOL

COMIN	UL				
5kohms	log law	with c	n / off	switch	20mm
	spindle				
Supplied	with fixin	g nut l	Jsed ma	anly for	replace
ment					
1890	£	0.54	VC9		

WIRE WOUND POTS

A range of wire wound single gang pots with linear tracks of 1 wati rating, fitted with 10mm bush and supplied with shakeproof washer and nut

VC6		
1891 10ohms	£0.80 1895 220phms	€0.80
1892 220hms	£0.80 1896 470ohms	€0.80
1893 47ohms	£0.80 1897 1kohms	€0.80
1894 20ohms	£0.80 1898 2k2ohms	€0.80
1000	11.7ah	

PRE-SET POTS
HORIZONTAL MOUNTING
Minature type for transistor circuits. The wiper of
the preset is provided with a slot for screw driver
adjustment. The tags of the preset will fit printed
wring boards with a pitch of 2.54mm. All tracks
are linear law.

1801 100ohms £0.08*	1808 22kohms €0.08°
1802 220ohms £0.08*	1809 47kohms £0.08*
1803 4700hms £0.80*	1810 100kohms £0,081
1804 1kohms £0.08	1811 220kohms €0.08°
	1812 470kohms €0.08°
1806 4k7ahms £0.08*	1813 1Mohms £0.08*
1807 10kohms £0.08	1814 2M2ohms £0.08*
1815 4M 7oh	ms £0.08*

PRE-SET POTS VERTICAL MOUNTING

Miniature type for transistor circuits. Wiper adjustment is made by a screw driver slot. Designed to fit 2.54mm mitch board. All tracks are linear law vc7.

1816 100ohms €	0.08	1823 22kohms	£0.08
1817 220ohms €	0.08	1824 47kohms	€0.08
		1825 100kohms	
		1826 220kohms	
1820 2k2ohms €	0.08	1827 470kohms	£0.081
1821 4k7ohms €	0.08	1828 1Mehm	£0.08
1822 10kahms €	0.08	1829 2M2ohms	€0.08
1830	4M 7oh	ms £0.08*	

near perfect insulation break-down voltage of 1500 volts ac and a leakage current of only 3-5uA and another shaft of stainless steel to ensure strength 63.60 O/No. 1935. Replacement element for 1931

O/No. 1932. Iron coated bit 1/8 | for 193 O/No. 1933, fron coated bit 3/16 for 1931 £0.50 £0.50

O/No. 1934. Iron coated bit 3732 for

O/No. 1953. SK1 soldering kit — this kit contains 15 watt soldering iron hitted with a 3/16 bit plus two spare bits, a reel of solder heat sink and a booklet how to solder In presentation display box. E5.55 O/No. 1939. ST3 soldering iron stand Stand made from high grade bakehite material chromium plated strong steel spring, suitable for all models includes accommodation for six spare bits and two sponges which serve to keep the soldering iron bits clean.

LEDs DISPLAYS & OPTOs

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1504	FLV115 led		2	RED	£0.10
1505	FLV 310 led		2	GREEN	£0.10
1506	FLV410 led			YELLOW	£0.10
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1511	BDL747 display		3	RÉD	€1.50
1512	BDL727 display		3	RED	£1.80
	-		J	KED	£1.80
1514	ORP12 Light di	ependent			
	resistor				£0.55
1520	OCP71 Photo t	ansistor			€0.35
	LED CLIPS				
1508/12		125 clips			€0.15
1508/2	pack of 5	2 clips			€0.18
100012	poen or o	£ clips			EO. 16

2n GRADE LEDa

A pack of 10 standard sizes and colours which fail to perform to their very rigid specification, but which are ideal for amateurs who do not require the full spec

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Cold cathode ITT 50875T Side viewing indicator tubes. Displays 019 and decimal points. Wide viewing angle Operates from 180v with 16Kohms series anode resistor. Character height 16 5mm. Pin connectors and supply details on pack.
One 1513 80p.

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400V RMS	BR1/400	£0.30
SILICON 2 amp		
50V RMS	BR2/60	£0.46
100V RMS	BR2/100	£0.48
200V RMS	BR2/200	£0.82
400V RMS	BR2/400	€0.58
1000V RMS	BR2 / 1000	£0.68
2 AMP	METAL STUD MOUNTING	
No KBS005	50 volt	€0.30
No KBS01	100 volt	€0.35
No KBS02	200 volt	€0.40

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600ma	TO 18 Case	7 amp	TO 48 Case
Voits Na	Price	Volts No	Price
10 THY600/10	€0.15	50 THY7A / 50	£0.48
20 THY600/20	€0.16	100 THY 7A / 100	£0.51
30 THY600 / 30	£0.20	200 THY7A / 200	£0.57
50 THY600 / 50	£0.22	400 THY7A / 400	£0.62
100 THY600 / 100	€0.25	600 THY 7A / 600	€0.78
200 THY600 / 200	£0.38	800 THY7A / 800	€0.92
400 THY600 / 400	€0.44		
		10 amp	TO 48 Case

		50
Volts No	Price	100
50 THY1A / 50	€0.20	200
100 THY 1A / 100	€0.28	400
200 THY 1A / 200	£0.32	600
400 THY 1 A / 400	€0.38	800
600 THY1 / 600	£0.45	800
800 THY1A 800	€0.58	-
		16 aı
		Volts
3 amp	TO 66 Case	50
3 amp	10 00 Case	100

3 amp	TO 66 Case
Volts No	Price
50 THY3A / 50	€0.28
100 THY3A / 100	£0.30
200 THY3A / 200	£0.33
400 THY3A / 400	£0.42
600 THY3A / 600	£0.50
800 THY3A / 100	€0.65

5 amp	TO 66 Case
Volts No	Price
50 THY5A / 50	£0.36
100 THY5A / 100	£0.45
200 THY5A / 200	£0.50
400 THY5A / 400	£0.57
600 THY5A / 600	£0.69
800 THY5A / 800	€0.81

5 amp	TO 220 Case
Volts No	Price
400 THY5A / 4	00P £0.57
800 THY5A / 6	OOP £0.69

000 THT TOM / 000	£1,22
16 amp	TO 48 Case
Volts No	Price
50 THY16A / 50	€0.54
100 THY16A / 100	€0.58
200 THY 16A / 200	£0.62
400 THY 16A / 400	€0.77
600 THY 16A / 600	£0.90
800 THY16A / 800	£1.39

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50 THY30A / 50	£1.16
100 THY30A / 100	£1.43
200 THY30A 200	£1.63
400 THY30A 400	€1.79
600 THY30A 600	€3.50
Νο	Price
BT101/500R	€0.80
BT102 500R	€0.80
BT106	£1.25
BT107	€0.93
BT108	€0.98
2N3228	£0.70

No	Price
BT101/500R	€0.80
BT102 500R	€0.80
BT106	£1.25
BT107	€0.93
BT108	€0.98
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2N3535	€0.77
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BTX30/400L	€0.48
C106/4	€0.60

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P&P 35p unless otherwise shown.

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BP930	€0.30	BP948	€0.50
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BP933	€0.30	BP962	£0.30
BP935	€0.30	BP9093	€0.43
BP936	£0.55	BP9094	€0.4
BP944	£0.30	BP9067	£0.4
BP945	£0.50	BP9099	€0.0
BP946	€0.30		

٥	0	•	0	0
TR315 €1.50		TR106 £1.65		TR731 £1.75
0000	9.0	00000	0.0	000000
0000	0.0	00000	0.0	000000

Draw your own boards with the new BI-PAK etch-resist transfers. Lay the symbols on the board, run over with a soft pencil. The transfer will adhere to the board. Then complete the circuit with your

TR120 TR101 TR053 TR203 TR205 £1.10 £1.10 £1.10 £1.10

PCB TRANSFERS

9	E1.6
31 75	00
3000	-

€0.46

ANTEX IRONS

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€0.50

BI-PAK etch resist pen 11 different paks available each containing transfers as illustration — approx 14 size — Special Introductory Set. 1 pak each of above £12.00.

D.I.Y. P.C.B. **ACCESSORIES**

1609 Eich resistant pe 1908 Paks of etchant	en 65p complete with instructions
C26 4 pieces 8 x Single-sided fibre glass	
C27 3 pieces 7 x Oouble-sided fibre glas	31/4 (approx) boards

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Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%

Signal-to-noise ratio. 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output

Dynamic Range > 90db

30mV sensitivity

Complete Kit PRICE: £39.90 + VAT

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Brief Spec. Amplifier Low field Toroidal transformer, Mag, input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2 aV. THD 0.3%. Pre-decoder 'birdy' filter. **PRICE: £58.95** + VAT

NELSON-JONES MK. I STEREO FM TUNER KIT

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



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IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

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Please send for details of the Nelson-Jones Mk. II Kit as in this month's W.W.



Sens. $30dB S/N mono @ 1.2 \mu V$ THD typically 0.3% Tuning range 88-104MHz LED sig. strength and stereo indicator

STEREO MODULE TUNER KIT

A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder 'birdy' filter Push-button tuning

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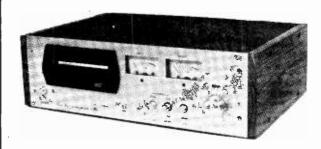
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2N2848	1.10	2N3716	1.70	2N4403	0.20	40363	1.45	BC118	0.22	BC263B	0.28
2N2904	0.31		0.21	2N4822	0.83	40389	0.70	BC135	0.22	BC264B	0.65
2N2905	0.31	2N3819	0.36	2N4870L	0.58	40408	0.82	BC136	0.21	BC307B	0.16
2N2906	0.25	-2N3820	0.39	2N4871L	0.51	40440	0.70	BC137	0.22	BC308B	0.16
2N2907	0.25	2 N3821	0.95	2N4898	1.55	40512	1.70	BC138	0.44	BC309C	0.16
2N2923	0.17		0.27	2N4901	1.65	40594	0.87	BC140	0.30	BC327	0.22
2N2924 2N2925	0.17	2N3854A	0.30	2N4902	2.20	40595	0.98	BC141	0.32	'BC328	0.20
2N3011	0.19	2N3855	0.30	2N4903	2.75	40573	0.80	BC142	0.32	BC337	0.20
2N3020	0.75	2N3856A		2N4904	1.85	AC126	0.48	BC147	0.13	BC414	0.17
2N3053	0.25	2N3858A		2N4905	2.40	AC127	0.48	BC148	0.15	BC415	0.16
2N3054	0.72	2N3859A		2N4920	0.83	AC128	0.48	BC149	0.15	BC416	0.17
2N3055	0.75		0.18	2N5086	0.30	AC151	0.43	BC153	0.30	BC547A	0.13
2N3108	0.75		1.98	2N5087 2N5088	0.30	AC152 AC153	0.54	BC154	0.30	BC547B	0.13
2N3133	0.50		0.30	2N5089	0.30	AC153K	0.59	BC157A BC158B	0.15 0.15	BC548 BC549B	0.13
2N3242	0.68		0.18	2N5129	0.62	AC176	0.54	8C159B	0.15	BC549B	0.14
2N3250	0.35		0.18	2N5130	0.22	AC176K	0.90	BC160	0.33	BC559	0.15
2N3301	0.45		0.95	2N5131	0.22	AC187	0.50	BC167B	0.13	BCY54	2.40
2N3302	0.39		0.55	2N5137	0.22	AC187K	0.65	BC168B	0.13	BCY56	0.27
2N3392	0.17		0.65	2N5143	0.22	AC188	0.54	BC1698	0.13	BCY70	0.21
2N3394	0.17		0.65	2N5180	0.58	AC188K	0.65	BC170B	0.19	BCY71	0.26
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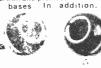
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ECC83	1.15	OA2	0.55	UBL21	0.75	68A6	0.40	12A6	0.60	803	6.00	multichannel telephone channel to 2,700 chan
ECC84	0.45	082	0.60	UCC84 UCC85	0.60	68E6 68G6G	0.50 1.00	12AT6	0.45	805	18.00	
ECC85 ECC86	0.50	PABC80	0.40	UCF80	0.50	6BJ6	1.10	12AT7 12AU7	0.55 0.50	807 813	1.00	
ECC88	1.25 0.60	PC85	0.50	UCH81	0.60	6BQ7A	0.60	12AV6	0.50	8298	11.00	MARCONI TF 867
ECC189	0.80	PC86 PC88	0.85	UCL82	0.75	6BR 7	2.30	12AX7	0.50	832A	4.50	Range 15KHz to 30MHz
ECF80	0.50	PC900	0.75 1.25	UF41	0.80	6BW6	2.80	128A6	0.50	866A	2.80	75 ohms. Impedance wi
ECF82	0.45	PCC84	0.45	UF80	0.45	6BW7 6C4	1.00	12BE6	0.60	931A	6.00	in crystal check facility w QT480 Signal Generator
ECF801	0.75	PCC89	0.55	UF85 UL41	0.40	6C6	0.40	12 BM 7 12CB	0.60	954	0.50	11kHz output up to 1mV
ECH34 ECH35	0.95 1.50	PCC189	0.65	UL84	0.75 0.75	6CH6	3.00	12E1	0.55 4.25	955 956	0.50	
ECH42	0.85	PCF80 PCF82	0.80	UM80	0.60	6CL6	0.75	1215GT	0.40	957	0.90	
ECH81	0.45	PCF84	0.65	UM84	0.40	6CY5	0.90	12K7GT	0.60	1625	1.00	LEVEL OSCILLATO
ECH84	0.95	PCF86	0.65	UY82	0.55	6D6	0.50	12K8GT	0.70	1629	0.70	Frequency from 0 3 to
ECL80	0.60	PCF200	0.90	UY85 VR105/30	1.80	6F6GB	0.80 0.90	1207GT 12SC7	0.50	2051	1.00	put from +16dB to - 75, 140, 600 ohms.
ECL82 ECL83	0.55	PCF 201	0.90	VR150/30		6F8G	0.75	12SU7	0.55 0.70	57 6 3 5842	2.00 5,50	75. 140. 600 0nms.
ECL85	1.20 0.65	PCF801 PCF802	0.55	Z66	075	6F12	0.65	12SJ7	0.55	5933	3.00	36' AERIAL MASTS CO
ECL86	0.55	PCF802 PCF805	0.65 1.80	X61M	1.50	6F14	0.80	12507	0.55	6057	0.85	21/4 dia Complete with
EF37A	1.50	PCF806	0.85	Z800U	3.00	6F15	0.60	12Y4	0.40	6060	0.85	instal
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EF40 EF41	0.70	PCH200	0.80	1A3	0.60	6F33	4.20	1457 19AQ5	1.00 0.75	6065 6067	1.20	LOW RESISTANCE
EF41 EF80	0.75 0.40	PCL81	0.60	1L4	0.30	6M6	4.20	19G3	10.00	6080	1.00 3.50	£1.50. 40p postage VAT AR88 D & LF SPARES
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EF91 EF92	0.65	PD500	2.25	1U4	0.40	6J6 6J7	0.50 0.75	20F 2 20L 1	0.60 1.00	8020	5.50	TELEPHONE TYPE "J"
EF92 EF95	0.75 0.45	PFL200 PL36	1.35	1X2B	1.10		0.50	20P1	0.40			10 LINE MAGNETO SWIT
EF183	0.65	PLS6 PLB1	0.80 0.75	2D21	0.55	6K7	0.70	20P3	0.60			tion P.O A
EF184	1.60	PL82	0.75		11.00	6K7G	0.35	20P4	1.10			
EF804	2.00	PL83	0.50	2X2 3A4	0.80	6K8GT	0.55	20P5	1.00			
EFL200	0.75	PL84	0.65	3D6	0.60	POSTA	F: 6	1-f2 2	On F	5-63 30	n	A lot of these valves are
EH90 EL32	0.60	PL504 PL508	1.40 1.30		20.00	£3-£5 40)	51060	Dougle	- C101-		imported and prices vary for
EL34	2.20	PL509	2.40	3E29 3S4	5.50 0.50						e.	each delivery, so we reserve
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126	1.0	5.58	.96
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40	5.0	13.95	1.64
120	6.0	15.66	1.84
121	8.0	20.15	OA
122	10.0	24.03	OA
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2.0	27.13	OA	S112	500
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214	300.300	0-20, 2-20	2.56	.78
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236	200. 200	0-15, 0-15	1.99	.38
208	1A. 1A	0-8-9, 0-8-9	3.53	.78
207	500.500	0-8-9. 0-8-9	2.59	.71
235	330, 330	0.9.0-9	1.99	.38
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113	15	0-115	-210-2	40V	2.48	.71
64	75	0-115	-210-2	40V	3.95	.96
4	150	0-115	-200-2	20-240V	5.35	.96
66	300				7.75	1.14
67	500				10.99	1.64
84	1000				18.76	2.08
93	1500				23.28	OA
95	2000				34.82	OA
73	3000				48.00	OA
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80s	40000	-10-115-7	200-220-2	40 67.50	UA
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	5VA	€4.9		90	113W

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	Carriage 65		

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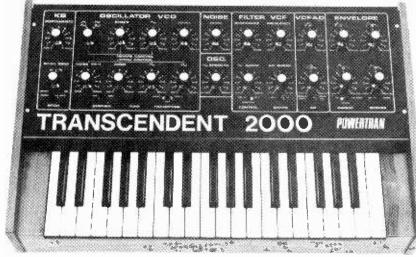
As featured in Electronics Today International (July, August 1978)

Live performance synthesizer designed by consultant Tim Orr (formerly synthesizer designer for EMS Ltd) and featured as a constructional article in Electronics Today International, the TRANSCENDENT 2000 is a 3 octave instrument transposable 2 octaves up or down with portamento, pitch bending, a VCO with shape modulation, a versatile VCF with both low and high pass outputs and a separate dynamic sweep control, a noise generator and an ADSR envelope shaper. There is also a slow oscillator and a new pitch detector amongst its many features

Kit includes fully finished metalwork, solid teak cabinet, filter sweep pedal and really is complete — right down to the last nut and bolt. Virtually everything is on one circuit board and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready built units selling for between £500 and £700!

INTRODUCTORY OFFER

Due to the fantastic success of the launching of this superb new kit we are able to continue the Special Introductory Offer of £172 for complete kit



ATIONAL POWERSLAVE 200 + 200 watt AMPLIFIER

As featured in Electronics Today International

400W rms continuous — 800W peak! 0.03% THD at FULL power! PLUS all the following features too!

- Each channel totally independent with its own stabilised power supply driven by custom designed TOROIDAL transformers!
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- * Value for money quality and performance comparable with ready-built amplifiers costing over

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1.	Fibre glass printed circuit board for power amp £4.20
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	circuit board, components, controls — required for PSI 4002 only
8.	Set of all miscellaneous parts including sockets, illum, mains switches, fuse holders, fuses.
	cut-outs. cable. etc
9.	Cabinet, including chassis, anodised silver on black panels, fixing parts, etc. Please state
	whether Slave or Studio model required

Nandbook £0.50 or free on request when ordering any of above packs.
 aech of packs 1-7 [A or 8]. 1 each 8. 9 and 10 are required for complete 200 + 200W professional amplifier.

Total cost of individually purchased packs

PS1 4001 PS1 4002 £208.20 £217.60

PSI 4001 SLAVE MODEL



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PS1 4001 - £187.50 PS1 4002 — £196.90

PSI 4002 STUDIO MODEL



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amp£1.15
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pre-amp£1.90
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	etc£8.20
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AVAILABLE AS SEPARATE PACKS PRICES IN OUR FREE CATALOGUE

SPECIAL PRICE FOR COMPLETE KIT

£99.30

The standard model of our kit tor Mr. Lonstey-Bood s 75 wait design has for a long time offered exceptional performance at a very modest cost with high quality high power ready-built units of comparable quality generally being over three times the price. Features of the amplifier include very low distortion (less than 0.01%), 75W rms per channel power output rumble finiter variable stope scratch filter variable transition frequency tone controls to tape monitoring facilities and individually adjustable imputs. This model is based on 5 circuit boards which not having the controls mounted on them can if desired be effectively used separately in high performance audio systems not based on our metaliwork.

Our new De Lui em model uses 14 boards which interconnect with gold plated contacts and are designed to have the potentiometers and switches mounted upon them. This system almost eliminates internal writing making installation after their assembly. delightfully straightforward and as each board can be easily removed in seconds from the chassis checking and maintenance is so simple that even newcomers to electronics will be able to cope competently chassis schecking and maintenance is so simple that even newcomers to electronics will be able to cope competently chassis schecking and maintenance is so simple that even newcomers to electronics will be able to cope competently when the standard control in the process of the proc

STANDARD LINSLEY-HOOD 75W AMPLIFIER



SPECIAL PRICE FOR COMPLETE KIT

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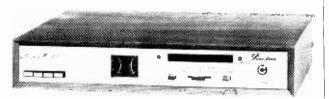
AUSTRIA

MALTA

Designed in response to demand for a tuner to complement the world-wide acclaimed linsley-Hood 75W Amplifier, this kit provides the perfect match. The Wireless World (Skingley and Thompson) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a milejection and temperature compensated varicap tuning, which may be controlled either continuously or by push-button pre-selection. Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set. The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal privide resistors are used throughout. stability metal oxide resistors are used throughout

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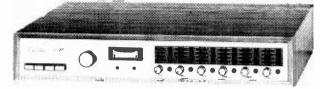
LINSLEY-HOOD CASSETTE DECK



SPECIAL PRICE FOR COMPLETE KIT

£79.60

WIRELESS WORLD FM TUNER



SPECIAL PRICE FOR COMPLETE KIT

£70.20

ck Price Stereo PCB (accommodates 2 rep. amps. 2 meter amps. bias/erase osc. relay) Stereo set of capacitors. M.D. resistors, potentiometers for above F.7.95 Stereo set of semiconductors for above E.8.50 Miniature relay with socket £2.90 5. PCB. all components for solenoid. speed Control circuits £3.80	Pack 1D Set of ca P.C.B. for 11. Set of mi holder, fi 12. Set of m panel, int 13. Construc 14. High Qua
3. Goldring-Lenco mechanism as specified £18.50 7. Function switch, knobs £1.90 8. Dual VU meter with illuminating lamp £6.95 9. Toroidal transformer with £.S. screen prim. 0-117V. 234V. Sec. 15V £4.90	3.1" One each of complete individua

Pack P	rice
10 Set of capacitors, reclifiers, I.C. voltage regul	ator
P.C.B. for power supply (Powerfran design) £2	.80
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panel, internal screen, fixing parts, etc . £7	
13. Construction notes EO	.25
14. High Quality Teak Veneer cabinet 18.3" x 12.7	"X
3.1" £10	
One each of marks 1-14 inclusive are required	for

alfy purchased packs £83.00 Matsushita WY 436 A7 head (optional extra) . £4.50

stereo cassette deck. Total cost

Published in Wireless World (May, June, August 1976) by Mr. Linsley-Hood, this design, although straightforward and relatively low cost, nevertheless provides a very high standard of performance. To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. Pushbutton switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both microphone userval of the microphone of the microphone userval of the

T20 + 20 and T30 + 3020W, 30W AMPLIFIERS



WWII TUNER



SPECIAL PRICE FOR COMPLETE KIT £47.70

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Following the success of our **Wireless World FM Tuner Kit** this cost reduced model was designed to complement the **T20+20** and **T30+30** amplifiers and the cabinet size, front panel format and electrical characteristics make this tuner compatible with either

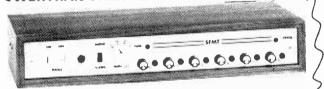
Designed by Texas engineers and described in Practical Wireless the Texan was an immediate success. Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimine T20+20 delivers 20W rms per channel of true Hi-Fi at exceptionally low cost. The **saw** to **build** design is based on a single F-Glass PCB and leatures all the normal facilities found on quality amplifiers including scratch and rumble filters adaptable input selector and headphones socket. In a follow-up article in Practical Wireless further modifications were suggested and these have been incorporated into the 130+30. These include RF interference filters and a tape monitor facility. Power output of this model is 30W rms per channel.

SPECIAL PRICES FOR COMPLETE KITS T20+20 KIT PRICE £33.10

T30+30 KIT PRICE £38.40

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POWERTRAN SFMT TUNER



PRICE FOR COMPLETE KIT £35.90

AVAILABLE AS COMPLETE KIT ONLY

This is a simple, low cost design which can be constructed easily without special alignment equipment but which still gives a first-class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. A phase-locked-loop is used for stereo decoding and controls include switchable afc. switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the T20+20. nd T30+30 amplifiers

Wireless World Designs: Full kits are not available for the projects below but PCBs and component sets are stocked. Further details of these and other packs are in our Free Catalogue.

30W Bailey Amplifier BAIL Pk 1 F. Glass PCB BAIL Pk 2 Resistors Capacitors BAIL Pk 3 Semiconductors	£1.00 £2.35 £4.70	Regulated Power Supply for Bailey Amplifier 60VS Pk 1 F Glass PCB 60VS Pk 2 Resistors. Capacitors 60VS Pk 6A Toroidal transformer	£0.85 £2.20 £3.10 £8.80
Linslay-Hood Low Distortion Oscillator. LDO Pk. 1 Fibreglass PC8 LDO Pk. 2 M.O. Resistors capacitors LDO Pk. 3 Semiconductors	£1.65 £2.60 £3.90	Stuart Tape Recorder TRRP Pk. 1. Replay Amp F. G. PCB (Stereo) TRRC Pk. 1. Record Amp F. G. PCB (stereo) TROS Pk. 1. Bias. Eraše F. G. PCB (stered)	£1.30 £1.70 £1.20

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Complete kit matches E40.75

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1

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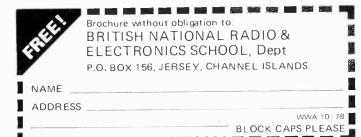
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HORIZONTAL AXIS (X) Deflection Sensitivity - 0-400mV/division Bandwidth (between 3dB points) - 1 Hz-

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positive to negative. POWER SUPPLY

Input Voltage - 115/220V AC± 10% at 50/60Hz Power Dissipation − 18₩ ✓

CRT DATA

- DATA 3" round display—single beam Maximum high voltage—750V Fitted with 10 section, blue filter graticule

PHYSICAL DATA

Dimensions — 15cm [h] × 20.5cm [w] × 28cm [d]
Weight — 3.8kg [approx.]
Stand — 2 position: flat and inclined
Case — Steel. epoxy enamelied
Colour — Light blue
Front Panel — Anodised aluminium. epoxy printing

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Developer	30р 40р	Pre-coated 1/16 204mm x 114mm 204mm x 228mm 460mm x 305mm	£1.50
Plain Copper-clad Fibre-glass. Approx 3 18mm thick sq. ft		Single-sided	Double-sided

Approx. 2 00mm thick sq. ft. Approx. 1 00mm thick sq. ft. £2.00 £1.50 €2 25 €1 75 Single sided Copper-clad Paxolin 10 sheets 245mm x 150mm Clear Acrylic Sheet for making master, 260mm x 260mm £2.50 10p

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tillio 0 1Hz to 10MHz (150MHz with piescaler)

from 0 5 m) oser mids to 10 sec with a cschild mid 0.1 mi ro seconds with a 0.1 microst condites of ities TIME INTERVALS

FREQUENCY RATIO | between two inputs

8-DIGIT TOTALISING counts up to 100 million by enti-

Full details of this and many other brand new digital display products are given in New Product Bulletin No. 3

£ 8% VAI & P& P Chart Finner 64 95 6 49 150MHz Prescaler 11 95 1 19 Mounting Bezel 1 95 () 39

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ALL PRICES SHOWN INCLUDE V.A.T. AT 12 1/2 %												EL509			
0A2	1,2	28 obsect	0.7	5 6L 18	0.6	0 1 12AU	7 0.6	2 30PL1	3 î.i		0.6			EM80 EM81	1
0B2	0.4		0.6		2.0		0.6				1.6		2.00 1.00		!
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IA3	0.6								0.9		1.0		0.84		i
IA5G1			0.7						0.9		0.5		0.84		03 Ž
1B3G1	0.5				0.4		LI				0.5	0 EC90	0.50	EY51	0.
1C2	1.0		1.5	607G			3.5		0.5				1.00		1.
1D5	1.0		0.4		0.7				0.80				0.75	EY83	1.
IG6	1.0				0.7		1.50								
1H5G1	T 0.9	6BR7	1.00		1.00		T 0.50		T 0.86 0.96		0.7				1.
11.4	0.2		1.25	6SA7	0.70		0.75		0.70		0.8			EY91 EY500A	. 0.
1LD5	6.7		3.75						G 4.00		0.3		0.52	EZ35	۰ 1. 0.
1LN5	0.7		0.65		0.70			50EH5	0.85		1.0		0.62	EZ40	L
1N5GT			0.40		0.70	12SC7	0.50		Γ 1.00		0.7		0.52	EZ41	- 13
1R5 1S4	0.50		0.45 1.50		0.76		0.55		1.00	DH76	0.50		0.50	F.Z80	0.4
155	0.35		0.50	6SK7 6SK7G	1.00		0.50		0.70		0.60	ECC85	0.50	EZ81	0.4
1T4	0.30		0.45	6SQ7	T 0.70		0.60		0.45		1.00	ECC86	2.00	EZ90	0.5
104	0.70		2.00	6U4GT	1.00		0.60		1.40		0.60		0.72	FC4	1,0
1Ú5	0.85		1.00	6U7G	0.55	12507	0.80		1.40		1.00		0.35	FW4/50	
2GK5	0.75		0.65	6U8	0.50	12SQ7G	T 0.80	90CV	1.50 5.50		0.50			FW4-80	
23(2	0.70	6C12	0.55	6V6G	0.50	12SR7	0.75	108C1	0.40		1.00			GY501 GZ30	1.4
3A4	0.55	6CD6C		6X2	0.80	13D8	2.00	150C2	1.20	DL33	0.70		7 2.80 0.65	GZ32	0.7
3B7	0.55			6X4	0.95	14117	0.75	215SG	0.60	DL63	0.70		0.50	GZ33	4.0
3D6 3Q4	0.40	6CL6	0.75	6X5GT	0.50	14S7	1.00	303	1.20	DL82	1.00		0.80	GZ34	2.2
3Q5GT	0.80	6CL8A 6CM7	0.95	6Y6G	0.95	17Z3	0.60	305	1.20	DL92	0.65		2.00	GZ37	4.0
3S4	0.70	6CS6	1.00 0.75	6Y7G 7A7	1.25	18	1.25	807	1.10	DL94	1.00	ECH42	1.00	HABC80	0.8
3V4	1.00	6CU5	0.90	7B6	1.00	19AQ5 19BG6G	0.65	956	0.50	DL96	1.00	ECH81	0.55	HL13C	0.6
4CB6	0.75	6D3	0.75	7B7	1.00	19G6		1625	2.50	DM70	1.25	ECH83	1.00	HL23	0.7
4GK5	0.75	6DE7	0.90	7D6	2.00	19H1	6.50 4.00	1821 5702	1.00	DM71	1.75	ECH84	0.75	HL23DD	
5CG8	0.75	6DT6A	0.85	7F8	2.00	19Y3	0.40	5763	1.20 3.65	DW4/3		ECL80	0.55	HIAL	1.0
5R4GY	1.00	6EW6	0.85	7H7	1.00	20D1	0.70	6057	2.00	DY51 DY87/6	2.00	ECL82 ECL83	0.60	HL41DD HL42DD	
5T4	2.00	6E.5	1.00	7R7	2.00	20D4	2.50	6060	200	DY802	0.50	EKL84	1.50 0.90	HN309) 1.0 1.7
5U4G	1.00	6F1	0.80	7V7	2.00	20F2	0.85	6067	200	E80CC	4,75	ECL85	0.80	HVR2	1.0
5V4G 5Y3GT	1.00	6F6G 6F12	0.70	7Y4	0.80	20L1	1.20	6146	4.70	E80CF	6.00	ECL86	0.64	HVR2A	1.0
5Z3	0.65 1.40	6F14	0.70	7Z4 8D2	0.80	20P1	1.00	6463	2.00	F.80F	5.50	ECLL80		HY90	0.5
5Z4G	0.75	6F15	0.85	8D8	0.50 0.52	20P3 20P4	1.00	6550A	6.75	E81CC	2.00	ľ	10.00	KT2	0.90
5Z4GT	1.00	6F16	1.00	9BW6	0.90	20P5	0.84 1.50	7025 7193	2.00	E82CC	2.00	FF22	1.00	KT8	3.00 1.00
6/30L2	0.90	6F18	0.60	9D7	0.70	25A6G	1.00	7475	0.60 1.20	E83F	3.50	EF40	1.00	KT32	1.00
6A8G	1.40	6F23	1.00	9U8	0.45	25L6G	1.00	9002	0.55	E88CC E92CC	1.20 4.50	EF41 EF73	1.00	KT41 KT44	1.00
6AC7	0.70	6F24	0.80	10C2	0.70	25Y5	0.80	9006	0.45	E180CC	5.00	EF80	1.75	KT63	1.00
6AG5	0.35	6F25	1.00	10C14	0.60	25Z4G	0.50	A1834	1.50	E180F	5.50	EF83	0.40 1.70	KT66	3.50
6AG7	0.70	6F26	0.45	10D1	1.00	25Z5	0.75	A3042	6.00	E182CC	5.50	EF85	0.45	KT7i	£,00
6AH6 6AJ5	0.70	6F28 6F32	0.85	10DE7	0.80	25Z6()	0.80	AC2PEN		E188CC	4.50	EF86	0.52	KT81	2.00
6AJ8	0.55	6G6G	1.00	10F1 10F9	1.00	28D7	2.00	AC2PEN		F.280F	12.50	EF89	0.55	KT88	6.75
6AK5	0.45	6GH8A	1.00	10F18	0.65	30A5 30C1	0.75		1,00	E283CC	2.00	EF91	0.70	L63	0.65
6AK6	1.50	6GK5	0.75	10FD12	0.65	30C15	0.80	AC6/PEN		E1148	0.60	EF92	0.70	LN119	0.75
6AK8	0.48	6GK6	2.09	10L14	0.45	30C17	0.90	AC/P4	1.50	FA50	0.40	EF93	0.65	LN152	0.55
6AL5	0.25	6GU7	0.90	10LD11	0.75	30C18	2.25	AC/PEN		EA76	1.30	EF94	0.55	LN309	1.20
6AM6	0.70	6H6GT	0.50	10LD12	0.45	30F5	0.70	AC THI	1.20	EABC80 EAC91	0.48	EF95 EF97	0.45	LZ319 LZ329	0.80
6AM8A	0.70	6J5GT	0.65	10PL12	0.75	30L1	0.39	AL60	1.50	EAF42	0.55	EF98	0.90	M8083	0.80
6AN8	0.78	6.16	0.35	10P13	0.80	30L15	0.75		0.60	EAF801	1.50	EF183	0.50		3.00 2.00
6AQ5	0.75	6J7G	0.50	10P14	2.50	30L17	0.70		0.50	EB34	0.50		0.50		2.00
6AQ8	0.50	6J7M	0.651	10P18	0.90		0.98	AZ1	0.50	EB91	0.25	EF804	6.25		2.00
6AR5 6AS7	1.05	6JU8A 6K7G	0.90	12A6	1.00	30P12	0.74	AZ31	1.00	EBC41	1.00		0.75		3.00
6AT6	1.50 0.60	6K8G	0.50 0.50	12AC6 12AD6	0.80	30P19/			0.50	EBC81	1.00	EK90	0.70	MHL4	1.00
6AU6	0.62	6K8GT	0.55	12AE6	0.80		0.90		2.00	EBC90	0.60	EL32	1.00	MHLD6	0.99
6AV6	0.65	6L1	2.50	12AT6	0.45		0.50		0.50	EBC91	0.65			MKT4	1.20
6AW8A	1.15	61.7(M)	1.50	12AT7	0.52				2.00	EBF80 EBF83	1.00		3.00	MU12/14 MX40	
6AX4	0.75	6L12								EBF89	0.45				1.00
		_			-	Sec.	_	-			W-10.		1.00	1100	1.00

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EL81	1.00		0.90		0.75	UY41	0.7	n Vei	0.00	ACV	0.0	Tours			
EL83	1.00	N339	1.2	PY31	0.50	UY42	0.7		2.00 1.40		0.35				0.50
EL84	0.48		0.50			UY85	0.7		2.00		0.50		0.3 2.0		0.58
FL86 EL90	0.60		0.48		0.50		1.00		2.00	AD16I	0.53				0.73
EL95	0.95				0.60	U12/1		Aron	0.75	AF102	1.04	CG64H			0.12
EL360	2.50		0.80		0.40	U16	1.00		0.60	AF106	0.58	FSYIL			1.31
EL506	2.00	PC88	0.80		1.12	U18/2	1.00 0 2.50		1.00	AFII4	0.30	FSY41	4 0.20	OC70	0.14
EL509	2.50	PC92	0.65		0.50	U19	4.00		1.00	AF115 AF117	0.30	GD4	0.38		0.20
EM80	1.00	PC95	1.00		2.05	U22	0.85		0.55	AF121	0.23	GD5	0.32		0.13
EM8I	1.00	PC97	0.75			U25	1.00		1.00 0.40	AF124	0.36	GD6 GD8	0.32		0.26
EM83 EM84	1.00	PC900 PCC84	0.65		0.60	U26	0.90	7,329	0.70	AF125	0.50	GD9	0.23		0.13
	1.00	PCC85	0.47		0.60	U3I	0.50	Z719	0.40	AF139	0.76	GDII	0.23		0.18
EM85 EM87	1.45	PCC88	0.61	PZ30 OP21	0.50	U33	1.75		0.52	AF178	0.79	GD12	0.23		0.18
EMM803		PCC89	0.49	QQV03.	1.10	U35 U37	1.75		1.00	AF180	0.56	GD14	0.58		0.18
EY51	0.90	PCC189		1 44,400	2.00	U43	2.00 0.80			AF186	0.64	GD15	0.47	OC79	0.47
EY81	1.50	PCC805		QS75/2		U45	1.20	1 1 643 123625		AF239 ASY27	0.44	GD16	0.23	QC81	0.30
Y83	1.50	PCC806		QS95/10	1.00	U47	1.00	and Die		ASY28	0.50	GATHS		OC81D	0.30
EY86/7	0.45	PCF80	0.80	QV03/1	2 3.65	U49	0.90	IN1124 IN4744		ASY29	0.38 0.58	GET573 GET587		OC82	0.13
Y88	1.00	PCF82 PCF84	0.45	QV04/7		U50	0.65	IN4952		BAI15	0.16	GET872		OC82D OC83	0.13
EY91 EY500A	0.50	PCF86	0.70	QV06/2		U52	1.00	2N404	0.21	BAII6	0.21	GET882		OC84	0.23 0.28
Z35	1.45 0.50	PCF87	0.90	R10 R11	5.00	U76	0.70	2N966	0.61	BA129	0.14	GET887		OC 123	0.26
Z40	1.00	PCF200	1.55	R12	1.00 0.80	U78 U81	0.95	2N1756	0.58	BA130	0.12	GET897	0.50	OC140	1.11
Z41	1.00	PCF201	1.45	R16	2.00	U150	0.80 1.00	2N2147	0.99	BA148	0.20	GET898		OC169	0.50
.Z80	0.42	PCF800	1.00	R17	1.50	U151	0.80	2N2297 2N2369	0.26	BA153	0.18	GEX113		OC171	0.40
Z81	0.45	PCF801	0.49	R19	0.75	U153	0.60	2N2613	0.16	BCY10 BCY12	0.53 0.58	GEX36 GEX45	0.58	OC172	0.41
Z90	0.95	PCF802	0.80	R20	0.90	U191	0.50	2N3053	0.38	BCY33	0.23	GEX55	0.87	OC'204	0.50
C4 W4/500	1.00	PCF806 PCF806	2.25	R52	0.75	U192	0.40	2N3121	2.90	BCY34	0.26	GT3	0.30	OC206	1.05
W4/800	2.50 2.50	PCH200	0.70 1.20	RK34	1.00	U193	0.60	2N3703	0.23	BCY38	0.26	MI	0.18	ORP12 SFT237	0.61 0.50
Y501	1.40	PCL82	0.62	SP4 SP13C	1.50	U251	1.00	2N3709	0.23	BC107	0.14	MAT100		SM1036	0.58
Z30	0.75	PCL83	1.20	TH4B	0.75 1.00	U281 U282	0.75	2N3866	1.16	BC108	0.14	MAT101	0.50	ST1276	0.58
Z32	1.00	PCL84	0.65	TH233	1.00	U291	0.70	2N3988	0.58	BC 109	0.14	OA9	0.14	SX1/6	0.21
Z33	4.00	PCL86	0.85	TP2620	1.00	U301	1.00	2S323	0.58	BC113	0.30	OA47	0.12	U14706	0.30
Z34	2.25	PCL88	1.50	ΓP22	1.00	U329	1.00	AA119 AA120	0.18	BC115 BC116	0.18	OA70 OA73	0.18	XZ30	0.30
Z37	4.00	PCL800	1.30	TP25	1.00	U339	0.50	AA129	0.18	BC118	0.26	OA79	0.18	Y543	0.21
ABC80	0.80	PCL801 PCL805/	2.20	UABC80		U349	0.60	AAZ13	0.21	BF154	0.30	OA81	0.11	Y728	0.21
	0.60	PCL500	0.85	UAF42	0.70	U381	0.70	AC107	0.18	BF158	0.21	OA85	0.11		- 1
	0.68	PEN4DD		UBC41 UBC81	0.70	U403	0.90	AC113	0.30	BF159	0.30	OA86	0.23		
	1.00	PEN25	1.00	UBF80	0.55	U404 U709	0.75	AC114	0.47	BF163	0.23	OA90	0.14		
	1.00	PEN45	1.00	UBF89	0.39	U801	0.45 1.00	AC126	0.14	BF173	0.44	OA91	0.11	ALI	. 1
	1.00	PEN45DE	T00	UBL21	2.00	U4020	1.00	AC127	0.20	BF180	0.35	OA95	0.11	PRIC	
N309	1.70	PEN46	1.00	UC92	0.50	VLS492	9.50	AC128 AC132	0.26	BF181 BF185	0.47	OA200 OA202	0.11		
	1.00	PEN453E		UCC84	0.90	VP2	1.50	AC154	0.23		0.26	OAZ201	0.12	INCLU	IDE I
	1.00	PENA4	2.00	UCC85	0.50	VP4(5)	2.00	AC156	0.30		0.23		0.50	V.A.1	r I
	0.55	PENDD/	1.00	UCF80	0.80	VP13C	0.60	AC157	0.30	BFY52	0.23		0.50		
	3.00	4020	1.00	UCH2I UCH42	2.00	VP23 VP41	0.65	AC165	0.30	BTX34/40	0	OAZ204	0.50	NOTH	
	1.00	PF1.200	1.35	UCH42 UCH8I	0.60	VT61A	0.90	AC166	0.30		2.31	OAZ205	0.50	EXTR	I A
	.00	PL33	1.00	UCL82	0.75	VUIII	1.00	AC168			0.21		0.50	TO	. [
Γ44	1.00	PL36	0.80	UCI83		VUI20	1.00	AC169 AC176	0.38		0.18		0.50		
63 (1.70	PL81	0.49	UF4I	0.70	VUI20A	1.00	AC176 AC177					1.46	PAY	′ ∥
	L50		0.75	UF42		VU133	1.00	ACY17					0.44		
	.00		0.50			VX6020	1.00	ACY18					0.44		
	200		0.50			W76	0.50	ACY19	0.35	BYY23			0.69		
	1.75		1.00			W81M W107	1.20	ACY20	0.35	BYZ10	1.30	OC29	0.73		
			0.90			W719	1.00 0.45	ACY21	0.35	BYZII (0.30		1.00		
		PL504/500				W729	1.20	MATC	UED =						
	.20		1.05				1.00	L P15 //	HED T	RANSIST	OR S	ETS			
319 0	80		2.55	UM84	2.50	XF.3	0.60	1/0081	Dand.	AC154, A 2/OC81,	C 157,	AA120),	61p pe	er pack	
			1.85	URIC	1.00	KFY12	0.60	L OC82	Dand	2 OC82	E1.00,	01.062.00	C00 ~	_	
			3.10				0.60						63, 7	6p. v. 5 lv. 1 3	
			3.75 0.74				1.20	15v. 16v	. 18v. 2	0v, 24v. 3	l0v. 12	. 5.51V. 4.3	v, 4 /	v. 5 IV 13	iv.
	.U0 -	1,701	r141	UUI2 (145	K41	1,00					p cacii,			
	90	All good	s are i	inused an	d subj	ect to the	e mani	itacturer		onteo					

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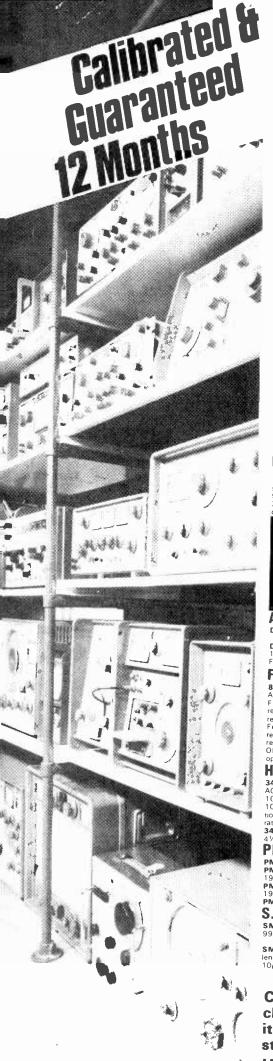


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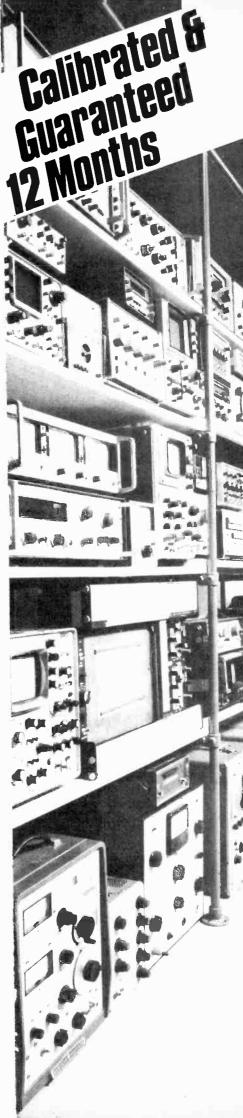
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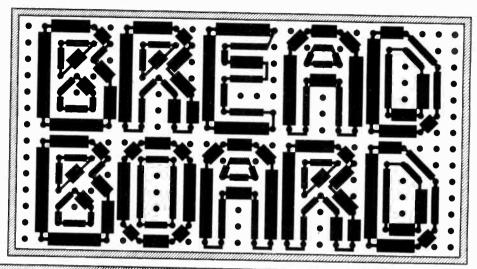


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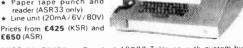
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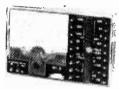
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Sensitivity Voltage ranges Current ranges Resistance Accuracy Oscillator output

20.000Ω /V 2.5-1000V A.C. / D.C 2.5-1000V A.C./D.C 0.05-500mA D.C. only 5Ω-1MΩ 5% F.S.D. 1kHz 50/50 squarewave 465KHz sinewave modulated by 1KHz squarewave

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D.C. Current A C. Current D C. Voltage A.C. Voltage Resistance Accuracy

TYPE U4324 0 06-0 6-60-600mA-3A

0.3-3-30-300mA-3A 0.6-1.2-3-12-30-60-120-600-1200V 3-6-15-60-150-300-600-900V 500Ω -5-50-500kΩ D C. 2 5% A.C. 4% (of F.S.D.)

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TYPE U4341 COMBINED MULTIMETER AND TRANSISTOR TESTER

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Transistors

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Voltage 1 5-7 5-30-150-300-750V A.C 2-20-200kΩ-2MΩ Resistance

Collector cut-off current 60µ A max D.C current gain 10.350 in two ranges

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Power Supply Selenium Bridge-35V DC from 210-250V AC 50Hz

built into chassis for LW and MW plus flying Aerial Fernite B

Power Output 5 walls per channe) Sine at 2 % THO into 15 Ohm

speech and music apa Sensitivity Playback 400mV 30K DHM for max output Record Tago Sensitivity Prayback 400mV 30K 0HM for max output Hecord 200mV 50K output available from 25kHz 1150mV 100K deviation, FM signal Fraquency Range (Audio) 50Hz to 17 kHz within 11dB Radio FM sensitivity for 30B below limiting better than 10 uV AM sensitivity for 20 dB S N MW 350 uV Metre LW 1mV Metre Size approx length 16 ± height 21% odepth 41% P&P £250 £19.95

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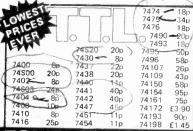
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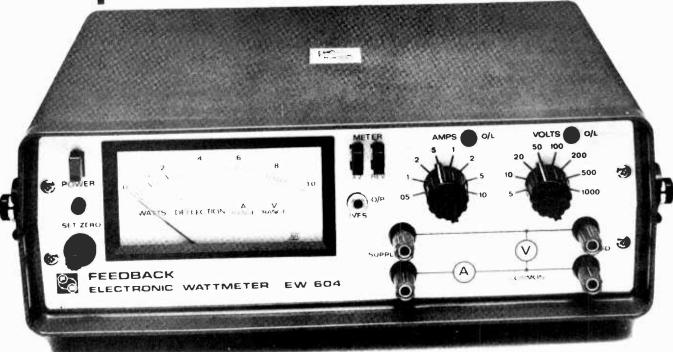
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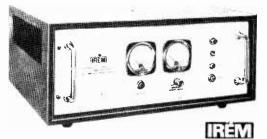
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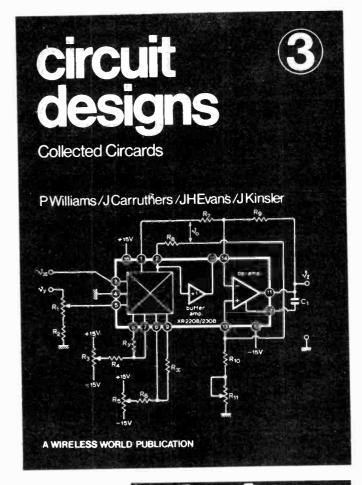
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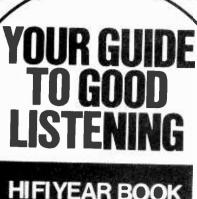
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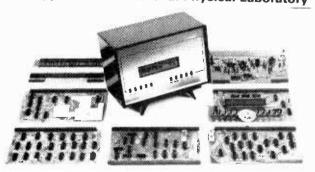
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TECHNICIAN GRADE 5

in the Psychology Department. Applicants should ideally possess HNC/HND in electronics or equivalent qualifications. Duties will include construction, repair and maintenance of electronic equipment as well as particular responsibility for the development of equipment for exprinental corects in the f equipment for experimental projects in the

Department. Salary according to qualifications and experience, will be on the scale £3,210x5 increments to £3,747 p.a plus £465 London Weighting Allowance.

Write for further details, enclosing a medium

sized self-addressed envelope, to the Personnel Officer, to whom applications should be sent by 29th September, 1978.

(8538)

SERVICE **MANAGER**

Applications for this post are invited from candidates who have previous experience of managing electronic servicing or testing departments, or, as experienced engineers now desire to enter management

now desire to enter management. The successful applicant will have overall control of a small specialised electronic instrument servicing department which undertakes the repair and calibration of the Company's range of ultrasonic and electronic measuring products, both on the bench and at customers' premises.

Please telephone or write to

Mrs. T. M. Wernham (Personnel)
DAWE INSTRUMENTS LIMITED
Concord Roed, Western Avenue
London W3 0SD
Telephone: 01-892 6751 (8524)

JUNIOR

TECHNICIAN/TECHNICIAN

REQUIRED. To assist with the operation and moletonece of the new 489' Yes do Craell accelerates at the Gray Laboratory, Condidents subody prefer bith years supersece of anne of the following electronic, electrical and vaccom systems, particle accelerators, remaining radialisms, Salary, including Lendon Weighting, and terms of employment similar to those in M.R.C.

isseraterias. Write for application form and information to: Deputy Director, CRC Gray Laboratory. Mount Vernon Hospital Northwood, Middlesex.

Telecommunications & Recording Specialists

A challenge to your skills — with the Metropolitan Police.

There are opportunities to put your specialist knowledge and training to the fullest possible use in the following sections:

Equipment Control—New Scotland Yard and Thornton Heath

... to lead teams of technicians engaged on installation, operation, modification and maintenance of a wide range of equipment from mobile radio to intruder systems and control centres. Sound theoretical knowledge and sufficient practical aptitude to maintain systems at peak efficiency essential.

Tape Recording—Denmark Hill

... work includes preparing tapes for specialised tape recorders; copying and processing tapes; giving evidence in Court about work carried out on tapes; occasionally analysing various phenomena on tape recordings. Candidates should have a thorough understanding of tape recorders and recording techniques, have experience of work in professional broadcast studios on audio and video recorders, and be fully conversant with checking tapes for quality and defects.

VHF/UHF Communications - Denmark Hill

. . . to be concerned with the use and modification of VHF and UHF communications equipment for specialised Police use together with the prototype design and development of electronic equipment. Candidates should have a good general knowledge of VHF and UHF communications. techniques and digital logic systems, some laboratory experience in the design and development field, and ability to innovate and develop ideas.

Intruder Alarm System - East Dulwich

. . work includes surveying and planning alarm systems for use by Met. Police, managing tests on alarm systems, and suggesting modifications to systems to reduce false calls. Candidates should have a clear understanding of the requirements for power supplies used in the alarm systems industry (active and standby). Current full driving licence essential.

A challenge to your skillwith the Metropolitan Police

(8497)

AMBITIOUS ELECTRONICS/AUDIO ENGINEER

Videotone are a highly successful fast-growing company in the audio field. We have become very well known for our loudspeakers and cartridges and are now entering the amplifier and professional markets

We need the help of a qualified ambitious Electronics Engineer to become head of our design and evaluation team.

Our opportunities are excellent and we are continuously investing. This is a remarkable opportunity for the right person, Salary range from £4300 to £6000 with many added benefits including foreign travel and possible use of company

Write or telephone Mr C. Hardcastle, 98 Crofton Park Road, Crofton Park, S.E.4. Tel: 01-690 1914.

INNER LONDON EDUCATION AUTHORITY

TELEVISION ENGINEER required for MASTER CONTROL SECTION, (STUDIO TECHNICIAN 3)

The vacancy for a fourth engineer in the Master Control section exists at the Battersea Television Centre of the Learning Materials Service

Television Centre of the Learning Materials Service
This highly operational post involves recording, editing and post production of programmes using broadcast video tape recorders, and, at the moment, their transmission over a large closed circuit network. Within a year the transmission network will be replaced with a video cassette distribution system and all technical facilities will be converted to colour. Applicants will therefore be expected to be familiar with the technical features of helical machines for school use as well as those of broadcast type.

The successful candidate should have the appropriate experience to operate and perform first line maintenance on the wide range of television equipment used in a central equipment area with special emphasis on VTR's Suitable academic, qualifications would be an advantage but experience of the right type will be the first consideration in filling the post. At present some evening work is involved connected with transmissions.

Salary within the scale £5.545-£5.905 inclusive of London Weighting and Phase 1, 2 and 3

Salary within the scale £5,545-£5,905 inclusive of London Weighting and Phase 1, 2 and 3

Application forms from EO/E stab. 2A/2, Room 365, County Hall, London, SE1. Tel 633 7456.

Closing date will be 4 October, 1978

Electronics Research and Development with Ferranti



Expansion and reorganisation within the Aircraft Equipment Department has created a number of interesting positions for Electronic Engineers (male or female) in the R & D Laboratories at Bracknell.

The Department is active in both the commercial and defence fields with airborne and ground based equipment and covers a broad range of activities extending from power conversion equipment to small signal microcircuit technology.

The laboratories are based in a pleasant manor house within Lily Hill Park on the northern outskirts of Bracknell. If you join us you will enjoy working conditions conducive to an R & D activity and share our amenities—which include a good dining room and ample car parking. Housing assistance may be available if required and generous relocation expenses are paid.

Areas of activity in which vacancies have arisen are highlighted below:

Power Conversion

A PROJECT ENGINEER is required to lead a team engaged in the development of power conversion equipment. He/she will be responsible for new developments of static invertors, battery chargers and other power equipment which Ferranti has been supplying for more than a decade. A proven capability of power

equipment design is essential and the candidate should be familiar with the requirements demanded by military users.

This is a senior position and is unlikely to be filled by a candidate with less than 5 years relevant experience.

Candidates with less experience may be considered for other positions in the group. (Reference A/211/WW).

Navigation/Guidance Systems

A SENIOR ENGINEER is required to work in a group specialising in the latest techniques of vehicle guidance. The candidate should ideally have some knowledge of strapdown inertial navigation but, more importantly, a good mathematical background. New projects under development are based on microprocessor control and, where required, training courses in the use of microprocessors will be provided.

Professional engineers with a minimum of two years experience could fill the above position. (Reference A/210/WW).

Flight Control Systems New developments in the field of helicopter flight

New developments in the field of helicopter flight control systems have led to a vacancy at senior engineer level. The candidate should have a good knowledge of control theory, and design capability with both analogue and digital systems is essential. This post offers a good opportunity for an analytically minded engineer to gain further experience in this interesting field. (Reference A/212/WW).

Communications

The Department is actively involved in areas of work covering signal processing. New projects demand a good knowledge of audio/low frequency communication systems using analogue and digital techniques.

Vacancies are at senior engineer level and candidates should preferably be of graduate status.

In addition we have a number of other interesting vacancies for recent graduates to join our professional development scheme. (Reference A/213/WW).

Details may be obtained by writing or telephoning (quoting the appropriate ref. no.) Mrs. J. Hunt, Ferranti Instrumentation Limited, Lily Hill House, Bracknell, Berkshire RG12 2SJ. Tel: Bracknell 24001 ext. 8.

FERRANTI Selling technology

(8496)





3M is a major international organisation with extremely diverse interests in world-wide markets. A graduate electronics engineer (or the equivalent) is currently needed to work as a member of a small, highly specialised team on the following products—

- * Professional audio multi track tape machines
- * Video character generators and ancillary equipment
- * Specialised test instruments
- * Data cartridge drives

The work will involve bench servicing and field service visits to customers' premises. Whilst full product training will be provided, candidates must possess both digital and analogue circuit design knowledge, with the emphasis on digital, due to the forthcoming introduction of a 32-track digital audio recorder for studio use

A first class salary plus large company fringe benefits are offered – including a company car after the initial training period. The position is based in West London and relocation assistance will be given if appropriate.

Please write with concise personal and career details, including your home telephone number, to P. G. English. 3M United Kingdom Ltd., 3M House, P.O. Box 1, Bracknell Berks RG12 1 JU



(8506)

GOVG

CTVC require a SENIOR VISION ENGINEER

A qualified engineer with experience of working as a Vision Controller in broadcast television and able to take responsibility for the output of a studio during production. Salary £5852.

Please apply to Chris Hillier or Peter Rudd, CTVC, Hillside, Merry Hill Road, Bushey, Herts. Tel: 01-950 4426.

Electronics Engineer

Telemotive U.K. Limited is a Company in association with a major U.S.A. manufacturer with world leadership in the radio control of industrial machines, systems, and processes, in collision prevention, in remote positioning, and in other industrial electronics activities.

Our principal products are founded on the Near Field Induction Effect and on other inductive techniques in the 300 kHz band. No other U.K. Company has a comparable product line, and our business therefore offers engineering experience of unusual interest. Training in our techniques is provided.

Our current requirement is for a young engineer with versatile abilities because at different times the work will involve application engineering, testing, commissioning of systems on customers' sites, field and base service, the anglicisation of designs originating in other countries, and a measure of production control. In each of these fields there is scope for personal engineering contributions.

The position involves some travelling within the U $\,\rm K\,$ and will take the engineer into a wide variety of industries

Telemotive is a good employer. It only employs people who are exceptional in their particular job, and it treats them accordingly. The salary will depend upon the capability of the chosen applicant.

A company car is provided

Please forward personal details to

Telemotive U.K. Limited

TELEMOTIVE HOUSE, 100 HIGH ROAD BYFLEET, WEYBRIDGE, SURREY BYFLEET 47117

(8505)



H.M.G.C.C.

ELECTRONIC ENGINEERS

Designers and Development Engineers are required for work in the HF and UHF fields and in general analogue and digital circuitry.

The Establishment is sited in rural surroundings in North Bucks, within easy reach of Northampton, Bedford and Milton Keynes. A frequent rail service and the M1 motorway provide easy access to London. House prices in the area are still at provincial levels.

Minimum academic qualification is HNC and, for Higher Scientific Officer, five years' post-qualification experience (for graduates with First or Second Class Honours this is reduced to two years' post-graduate experience).

Salaries are:

Scientific Officer £2839-£4415 Higher Scientific Officer £4101-£5448

DRAWING OFFICE STAFF

Drawing Office Staff are required in a supporting role to the above engineers.

Salaries are in the ranges: £3148-£4326

£4326-£4869

Salaries for Drawing Office Assistants are £2119-£3189, depending upon age, qualifications and experience.

For application form please apply to

The Administrative Officer (Dept. WW)
HM Government Communications Centre
Hanslope Park
Hanslope
Milton Keynes
Bucks.
MK19 7BH

(8376)



TEST ENGINEERS

When reliability matters, people come to Pye

Radio communication under battlefield conditions calls for equipment that is rugged, efficient, and above all reliable, and with the famous "88" Set, carried by the Allied Forces throughout the 1939-45 War, Pye achieved all three.

> Pye's reputation for reliability under arduous conditions has long been a byeword. Part of that reliability comes from the quality of the design and the components used, but the final seal is set by the highly skilled men and women who check our UHF/VHF systems to very exacting specifications prior to delivery.

If you already have experience of fault diagnosis, alignment and testing of electronic equipment, especially communication equipment, perhaps gained in the Armed Forces, then why not get in touch and find out for yourself exactly why people come to Pye.

There's not room to tell you all the details here, but we can assure you of a salary between £3500 and £3900 dependant on technical ability. There is also company stability, job security and satisfaction, well equipped workshops and a variety of equipment, using

both IC and transistor.

Openings are available at Haverhill, Suffolk and at Cambridge, both extremely pleasant places to live, with key-worker housing available at Haverhill. In addition, considerable assistance is provided for those moving from other parts of the country.

Please write or phone for further details (reversing charges if necessary) to Catherine Dawe, Pye Telecommunications Ltd., Colne Valley

Road, Haverhill, Suffolk CB98DU. Teiephone: Haverhill 4422 or Claire Barton, Pye Telecommunications Ltd., St. Andrews Road, Cambridge. Telephone: Cambridge 61222.



Pye Telecommunications Ltd







AUDIO ENGINEERS

We have vacancies for 2 Bench Engineers capable of working to a high standard, on Nakamichi and Yamaha high fidelity equipment.

Applicants should be fully conversant with present-day circuit applications and servicing techniques on stereo amplifiers, cassette decks and AM/FM tuners, and should possess a minimum of 3 years' working experience in

Please apply in writing or telephone for an application form to:

Terry Finn—Service Manager

Natural Sound Systems Ltd.

10 Byron Road Wealdstone, Harrow, Middx. Tel: 01-863 8622, Ext. 5

GOLD DUST OR ODD BALLS . . .??

When you or your application form enter these illustrious premises, you are classed as: Gold Dust (young, reasonably priced circuit designers, computer engineers, quality engineers). Saleable Goodies or Odd Balls — (the unusual, indeed inimitable engineer for whom even WE cannot find the right socket immediately).

> Some of our companies need ODD BALLS -please help us lay our hands on them. We need

VF ANALOGUE CIRCUIT DESIGNER

for work on Air Traffic Control systems i.e. amplifiers for speech compression, active filters and analogue aspects of modems. Middlesex. Salary to £6,500.

PROJECT MANAGERS
to supervise telecomms installations in Middle East (either telephone multiplexing. or microwave systems for telephony and T.V.) Bachelor status. £11,000-£15,000 + bonus.

TRAINING OFFICERS

to run course for service engineers and customers on the use of the very latest computer controlled graphic equipment. Lots of overseas travel. Circa £5,000. South Coast.

TEAM LEADERfor group engaged on design of CMOS for a wide range of applications — particularly telecomms. Experience in MOS design and some systems experience. To £8,000.

NO JOKING — whether you are an Odd Ball, Gold Dust or just an ordinary Electronic Bloke, someone, somewhere needs you.

Apply as usual to Charlies Angels, that sophisticated team of Electronic Talent Detectors . . . scores of satisfied clients and followers.

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"PROBABLY THE BEST KNOWN SUPPLIER OF ELECTRONICS ENGINEERS IN THE COUNTRY" —
FINANCIAL TIMES

155 KNIGHTSBRIDGE, LONDON, SW1. TEL: 01-581 0286

THOMSON FOUNDATION TELEVISION COLLEGE PROFESSIONAL BROADCAST **TELEVISION**

required to join a team specialising in training broadcast technicians and Senior Engineers from overseas television stations studio/transmitter/ communication techniques.

Desirable qualifications. Degree HND or equivalent, with several years' experience in television studios and/or transmitters. Salary: £5,155-£6,305 incremental, Starting salary dependent on experience. Contributory pension scheme.

The post is based in Glasgow with occasional trips abroad.

Applications in writing to the Principal, Thomson Foundation Television College, Kirkhill House, Broom Road East, Newton Mearns, Glasgow G77 5RH.

APPOINTMENTS IN **ELECTRONICS**

Take your pick of the permanent posts in,

MISSILES - MEDICAL COMPUTERS - COMMS MICROWAVE — MARINE HARDWARE — SOFTWARE

For expert advice and immedi ate action on career improve ment, 'phone, or write to. Mike Gernat BSc

Technomark

11 Westbourne Grove London W2 01-229 9239

UNIVERSITY COLLEGE LONDON COMPUTER CENTRE

> TECHNICAL OFFICER (COMMUNICATIONS)

required to develop and maintain a sophisticated computer telecommunications system. ONC/HNC or equivalent in electronic engineering is required plus several years' of practical experience with communications, particularly Post Office Datel and other services. Dutes will also include planning requirements, selecting equipment, supervising installation and maintenance of some design work. Salary will be paid on the academic Other Related IB/IA scales, 53,214 to \$6.178 plus £450 London Allowance, according to qualifications and experience.

elications, including full curriculum vitae and names of two referees should be sent to the nputer Manager (WW), University College don, 19 Gordon Street, London WC1 or phone 01-387 0858.

Engineers

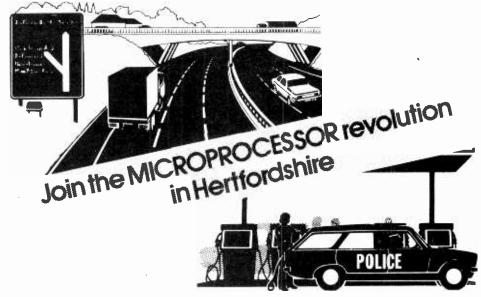
- DESIGN / DEV
- TEST
- FIELD SERVICE

High Salaries - Most Areas

Phone 01 - 731 4353 (8515) Sinex Personnel



Traffic Communication **Systems**



ELECTRONIC ENGINEERS up to £6,500 p.a.

Our business throughout the world is solving traffic management problems, ranging from systems for traffic control, point of sale terminals and automatic vehicle tracking-make it your job too! We particularly wish to appoint

PRINCIPAL ENGINEERS

to control design groups responsible for products. Five to ten years experience.

SENIOR ENGINEERS

for electronic design using microprocessors.

In addition to attractive salaries we offer excellent opportunities for career advancement with opportunities for overseas travel within a small and progressive subsidiary of the GEC Group.

FREEPOST – no postage necessary just write GEC TRAFFIC AUTOMATION LTD. FREEPOST, BOREHAMWOOD, HERTS, WD6 1BR or Telephone George Dann on 01-953 2030 Ext. 3934
I have experience over [] 4 years
My present salary is in the range of \$\frac{\frac{1}{2} \pm 4000/\frac{\pm 4500}{2} \frac{1}{2} \frac{\pm 4500/\frac{\pm 55000}{2} \frac{\pm 5000/\frac{\pm 5500}{2} \frac{\pm 1}{2} \text{higher}} \frac{\pm 1}{2} \text{higher}\$
Please tick affirmative
Name
Daytime phone No



AUTOMATIC TEST EQUIPMENT ENGINEERS

M.E.L., a division of the International Philips Electronic and Associated Industries Group is an established world leader in the development and production of sophisticated Electronic Systems.

Due to an expanding activity in digital circuit techniques, we have vacancies for A.T.E. programmers and test engineers to work in a team using GenRad Automatic digital test equipment to provide a service to all departments. This activity supports the design, development and production of digital circuits used in a wide variety of applications. Applicants should be qualified to H.N.C. or degree level with preferably test programming, testing or design experience of digital circuits.

These important A.T.E. positions offer high job interest and the equipment is the basis of one of the most advanced microwave/digital test facilities in the U.K.

All positions attract excellent starting salaries, generous holiday and sickness entitlements, staff shop and subsidised restaurant facilities.

Please write or telephone: Mr. A. G. Budd, Personnel Officer, M.E.L., Manor Royal, Crawley, Sussex. Tel. Crawley 28787 Ext. 364.



university of wales UNIVERSITY COLLEGE OF SWANSEA

Chair of Electrical Engineering

The Council of the College invites applications for the vacant post of

PROFESSOR OF ELECTRICAL ENGINEERING

Further particulars may be obtained from the Registrar/
Secretary, University College of Swansea, Singleton Park, Swansea SA2 8PP, to whom applications (10 copies) should be returned by 31 October, 1978.

ELECTRONIC DESIGN ENGINEER

Salary negotiable.

A leading manufacturer of artificial limbs and aids for the disabled require an electronic engineer to work in its research and development dept.

Applicants should have experience in digital techniques and small servo systems, preferably with a knowledge of microprocessors, HNC, HND or degree preferred.

Apply in writing stating age, qualifications, experience and present salary or telephone for further details.

Plephone for furtile funding.

D. Hawkins

HUGH STEEPER LIMITED

237 Roehampton Lane

London S.W.15 (Tel: (01) 788 8165
(8567)

R & D Engineers at senior and intermediate levels

required to work on digital and cable television systems for the domestic and surveillance market.

Engineers should hold a degree, HNC or equivalent qualification and have some knowledge of either HF video or digital circuit design.

Salaries will be commensurate with qualifications, age and experience.

Fringe benefits include a contributory pension, life assurance scheme, subsidised canteen, etc.

If you are seeking an enjoyable position in R & D, write, giving full details of your career to date, or telephone Dr. G. O. Towler, B.Sc., Ph.D. (Manager), Research and Development Establishment, British Relay Ltd., Cleeve Road, Leatherhead, Surrey. Tel. 76056.

8469

hritish relay

RADIO TECHNICIANS

Government Communications Headquarters has vacancies for Radio Technicians. Applicants should be 19 or over.

STANDARDS required call for a sound knowledge of the principles of electricity and radio, together with appropriate experience of using and maintaining radio and electronic test gear.

DUTIES cover highly skilled telecommunications/ electronic work, including the construction, installation, maintenance and testing of radio and radar telecommunications equipment and advanced computer and analytic machinery.

QUALIFICATIONS: Candidates must hold either the City and Guilds Telecommunications Part 1 (Intermediate) Certificate or equivalent HM Forces qualification.

SALARY (inc. supps.) from £2.927 at 19 to £3,700 at 25 (highest pay on entry) rising to £4.252 with opportunity for advancement to higher grades up to £4,706 with a few posts carrying still higher salaries.

Opportunities for service overseas.

Further particulars and application forms available from

GCHQ

Recruitment Officer (Ref. WW/9) GCHQ, Oakley Priors Road, Cheltenham GL52 5AJ Cheltenham (0242) 21491 ext. 2270

(8035)





Electronics Engineers on the move

INVEST 5 MINUTES IN YOUR FUTURE

DESIGN, TEST, Q. A; FIELD SERVICE, MANAGEMENT, ETC.

Take advantage of the best opportunities being offered in the Electronics Industry from amongst over 3000 U_*K_* Companies with whom we deal. We are seeking all categories of Electronics Engineers for equipment ranging from computers to communications.

By returning the application form below, your job requirements will be matched against our clients' numerous vacancies, many of which are not advertised. Your application will be treated in strict confidence and no approaches will be made to existing employers or to any other companies you care to specify. Please remember, our service is completely FREE to applicants.

So don't delay - act now to give yourself the best chance of finding the perfect job.

If you wish to discuss any aspect of the Electronics job market, you are welcome to phone anytime. Please ask for Brian Cornwell.

Capital A	ppointm	ents Ltd	1. 29/30	Windmill St. London	W.7.	~01-63	7 5551
NAME:	IN BLACK INK	*	ADDRESS:		155111		
Tel: (Home):		(Office):					
						76 . D	
Date of Birth:		Place of Birth	:	Nationality now:		If not Britis	•
Marital Status:		Car Driver:		Car ()wner:		Work Permi	it req'd?
Type of Position	required:			A	pprox.Sal	lary level:	
Please indicate	areas in which		ed to work:	Are you a houseowner?	Are yo	u willing to rela	ocate?
S.E. London	West Count		lidlands	Are you prepared to travel - 1	In U.K?	Overs	eas?
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College or Un Any Profession	ool Qualification iversity Qualns: nal Membership						
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Previous employment From:							
To: B. Previous							
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Please indicate any Companies you do not wish us to contact.

If you wish to detail further aspects of your experience or job requirements, please enclose on a separate sheet. WW41

PRODUCT SUPPORT SUSSEX

M.E.L. is the professional equipment division of the International Philips Electronic Group and is an established world leader in the design and manufacturing of a wide range of Electronic Equipments for defence and civil markets. Due to major expansion of our product support activities, the following vacancies have arisen

PRODUCT SUPPORT

To deal with 'post design' problems, resulting from the production and in service use of a wide variety of equipments and systems including military Radio and Radar. Engineers with a good knowledge of electronics up to H.N.C. standard will find these positions have the interest and challenge they require. Experience of similar work within H.M. forces and for knowledge of M.o.D. procedures would be extremely useful

SERVICE ENGINEERS

These positions require applicants willing to use their own initiative and skills in carrying out diagnostic fault finding, repairs and retest of a variety of equipments including airborne radar units. The work will also

involve some liaison with customers.
A good general knowledge of electronics, including semi-conductors circuits, is essential and H.M. Services 2nd/3rd line maintenance experience will be especially useful.

These positions attract good starting salaries and excellent conditions of employment in a stimulating modern working environment and generous relocation expenses will be given where appropriate. For further details or an Application Form please contact: MR. A.G.BUDD, Personnel Officer, M.E.L., Manor Royal, Crawley, Sussex. Tel. Crawley 28787 Ext. 364.

UNIVERSITY OF LIVERPOOL Department of Building **Engineering**

TECHNICIAN (Electronics)

within the Acoustic Group. The work involves research in the development and construction of signal processing equipment and is also concerned with computer interfacing problems. Post available for three years. Salary in a range up to £3,720 p.a. according to qualifications and experience

Application forms available from the Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote Ref. RV/914/

UNIVERSITY COLLEGE CARDIFF A TECHNICIAN Grade 4

is required to design, build and maintain equipment for the ELECTRONIC MUSIC STUDIO in the DEPARTMENT OF PHYSICS. Salary, range, Technical Grade 4 £2955-Salary range, Technical Grade 4 £2955 £3402 p.a. Duties to commence as soon as possible

possible.

Applicants should be interested in digital and audio electronics and be able to maintain analogue and digital equipment and tape recorders. For further information contact Dr Michael Greenhough, Physics Department Tel (0222) 44211, Ext. 2136.

Applications, together with the names and addresses of two referees, should be forwarded to the Vice-Principal (Administration) and Registrar, University College, P.O. Box 78, Cardiff CF1 1XL. Closing date 1st October 1978. Please quote reference 1588.

DEPARTMENT OF MEDICAL PHYSICS AND BIO-ENGINEERING University College Hospital

ELECTRONICS ENGINEER

To join a team engaged in design, development, maintenance and repair of a wide range of electromedical and physiological measurement equipment.

Qualifications: O.N.C. or equivalent in a relevant subject.
Salary, Medical Physics Technician Grade IV £3423-£4488 per annum, inclusive of London Weighting.

Apply to the Personnel Department, University College Hospital, Gower Street, London WC1E 6AU. Tel: 01-387 9300 Ext. 381.

Please quote reference EE/DMP/AP (8552)

DIXONS TECHNICAL LTD SERVICE ENGINEER £4,000 p.a.+

Dixons Technical is a specialist company involved in supplying CCTV and video equipment to commerce and industry. We are currently looking for a Service Engineer to be based at our Croydon Headquarters. Applicants should have a minimum of two years experience of VCR equipment. Service experience relating to cameras and monitors is not essential however, since we are prepared to give training in this field. The job will provide a great deal of variety and interest because of the wide range of equipment which we handle. We are offering a competitive salary of around £4,000 p.a. but it could be more if you have good solid experience and can convince us of your ability. Other benefits include four weeks holiday rising to five weeks, a company pension scheme and a special discount scheme. Relocation expenses will be available in appropriate circumstances. Interested! Then contact our Workshop Manager, Arthur Dyson at 68/70 Windmill Road, Croydon or 'phone 01-689 6021

Technician (Electronics)

Salary £3279-£3651 (includes latest pay supplement)

Man or woman required in the FINE ART DEPARTMENT, to demonstrate and maintain video and tape recorders and equipment, and to give technical advice to students and staff as to the means of achieving envisaged projects. Requirements are three years appropriate experience in radio/TV servicing or in industrial electronics. HNC or CGLI Final in electronic engineering or radio/TV servicing an advantage

S.A.E. for forms and details from CHIEF ADMINISTRATIVE OFFICER EXETER COLLEGE OF ART AND DESIGN EARL RICHARDS ROAD NORTH EXETER. Tel 0392 50381 Closing date

29th September, 1978





TEST EQUIPMENT REPAIR AND CALIBRATION OPPORTUNITIES.

We need Section Chiefs for Test Equipment Repair and Calibration.

The continued expansion of our Company's business in the design, production and installation of advanced radar systems, places an increasing demand on our "in house" facility for calibration and repair of test equipment. We are looking for experienced Test Equipment Engineers as Section Chiefs to run small teams

of engineers and technicians engaged in the calibration, fault diagnosis and repair of proprietary test equipment for the Company's establishments and, to a limited extent, customers in the field. The sections are set up to handle equipment in the following categories:

Display Instruments
Digital and Analogue Instrumentation
Signal Generation and Analytical Instruments
Microwave Instruments and Devices

If you are qualified to HNC or C & G Full Tech. Certificate or equivalent and have had several years' experience in one or more of the above fields, why not contact us to discuss your possible future in the Company. In addition to the Section Chief positions, we also have vacancies for Calibration and Repair Test Equipment Engineers.

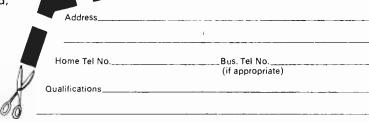
You would be working in a custom built clean air,

temperature controlled laboratory, using a wide range of standard and back-up equipment spanning DC to 18 GHz.

The Company offers excellent career progression prospects to both men and women, with generous salaries related to qualifications and experience, and excellent fringe benefits, including relocation expenses where appropriate.

Why not find out more by telephoning John Palmer on Chelmsford (0245) 67111 ext 2226 for an informal discussion. Alternatively complete the coupon and send it to him at Marconi Radar Systems Ltd., "Freepost", Chelmsford, CM1 3BR (no stamp required).





TECHNICAL WRITER

A Technical Writer is required to assist in the preparation of technical handbooks and similar documentation of VHF/UHF Radiotelephones, Radiotelephone Systems and related Test Equipment.

A sound technical background and the ability to write clear and precise English is essential.

Please apply to:



Mrs. A. Bowles
DYMAR ELECTRONICS LTD.
Colonial Way, Radlett Road
Watford, Herts.
Tel. Watford 37321, Ext. 27

(8500)

TEST ENGINEERS

Vacancies exist within our Radio Test, Final Test and Service Departments for experienced Test Engineers with knowledge of VHF Radiotelephone Equipment.

- ★ Good salaries.
- ★ Pleasant working conditions.
- ★ Subsidised canteen.

For application form and further details contact:



Mrs. A. Bowles
DYMAR ELECTRONICS LIMITED
Colonial Way, Radlett Road
Watford, Herts.
Tel. Watford 37321, Ext. 27

(8499)

Sound Operations Manager Brentford. Park Strand Sound has

Rank Strand Sound has c.£7,500 p.a. + car been set up as a new unit operating within Rank Strand Electric with the objective of achieving the same level of success in the field of professional audio and acoustic systems as the division already enjoys thanks to its sophisticated lighting equipment for auditoria and theatres.

We are confident of a bright future for the new unit as it will be able to capitalise on the division's technical and marketing expertise to develop fully-integrated, processor-controlled sound/lighting systems for a range of applications as broad as the world of entertainment itself.

But before things can really start to happen, we need the right person to fill the key position of Operations Manager.

Responsible for a design and sales team that is currently 15-strong, you will need to demonstrate a high degree of commercial ability and an in-depth knowledge of professional live sound systems plus a real understanding of the demanding needs of the professional entertainment industry.

In return for these talents, we can offer an attractive salary and benefits package including company car and the opportunity of overseas travel. Assistance with relocation expenses will also be provided where appropriate.

Please write with full career details to: Chris Hough, Personnel Manager, Rank Audio Visual, P O Box 70, Great West Road, Brentford, Middlesex. Tel: 01-568 9222.



RANK AUDIO VISUAL

(8498)

UNIVERSITY OF OXFORD DEPT OF HUMAN ANATOMY

ELECTRONICS TECHNICIAN

(Grade 6) Salary £3654

The Department of Human Anatomy requires an Electronics Technician to assume responsibility for running 3 Electron Microscopes, closed circuit television installation and other sophisticated equipment including the supervision of research students in

Application with details of qualifications and previous ex-perience (particularly of Electron Microscopes and closed circuit televi-sion) should be sent in writing together with the names of two referees, to

Professor C. G. Phillips FRS Dept. of Human Anatomy South Park Road Oxford OX1 3QX

IMPORT FIRM OF ELECTRONIC EQUIPMENT IN BENGHAZI, LIBYA

has vacancies for

SENIOR ENGINEER -video cassette recording and CTV

SENIOR ENGINEER

Both engineers are required to lead a group of local service technicians in the respective article groups. The responsibilities include assisting and training service engineers in the use of appropriate fault-finding methods. They should be able to organize the workshop accordingly. WF OFFFR

Salary for position a. LIBYAN DINAR 750/MONTH (appr. £1400./month)

Salary for position b. LIBYAN DINAR 600/MONTH (appr. £1100./month)

Bonus: One month's salary per year (both positions)

Holidays: One month annually plus one return ticket for each only. One furnished flat for two single technicians is available for the company's account.

Salaries are taxable according to Libyan law

Applications should be sent under number WW8549 of this magazine

BROADCAST

ENGINEER
WSM Community Radio. a capable radio station serving 20.000 people in the Telford. Salop area requires an experienced
Broadcast Engineer to join local residents
and professional broadcasters who are
designing and constructing a broadcast. designing and constructing a broadcast studio and associated transmission equip-

ment. The successful applicant must be sym pathetic to the concept of community broadcasting and will be required to build, install and maintain the appropriate equip-

ment. Rented housing accommodation can be made available through the Telford Deve-lopment Corporation.

6 months contract with the posibility of ar

to months contract with the posibility of an extension £300/month.

Application by 10 October 1978 to Secretary WSM Community Radio Ltd., 215 Willowfield, Woodside, Telford, Salop TF7 5NY Telephone (0952) 583520



UNIVERSITY OF SURREY LECTURER IN RECORDING TECHNIQUES

KEURUING TECHNIQUES
Applications are invited for the above post in the Department of Music.
The Lecturer will be responsible for teaching practical and theoretical aspects of recording for the Tonmeister Course leading to the degree of BMus(Surrey)(Tonmeister).
Applicants should have a thorough knowledge and experience of studio work in the recording/broadcasting industry.
Salary will the within the range. £3660-£7308 per annum.

E7308 per annum. Further particulars may be obtained from the Academic Registrar(LFG). University of Surrey, Guildford, Surrey GU2 5XH or Tel. Guildford 71281 Ext 452. Applications from men and women, in the form of a curriculum vitae, including the names and addresses of two referees should be sent to the same address by 6 October 1978 (8557).

BROMPTON HOSPITAL

SENIOR MEDICAL **ELECTRONICS TECHNICIAN**

Ta sadertako werk involveny amialaining, installing and developing medical electranics equipment. A knowledga of ulriasokics and micro-computer based systems worsid be edisinict advantage. Applicats should have a good general knowledge of electranics and be qualified to HKC [Electrical and Electronic Engineering] standard or equivalent, Provious hospital manerisms en al stantial.

Experience not essential.
Salary with been scale £4098-£5142 accerding to experience.
Further information from the Physicist in Charge, Mr. R.
B. Logan-Sinctair, Teb. 01-352 8121, Ext. 4252. s. Lugan-Sincian: 16t: 01-302 8121, Ext. 4292. Application forms and job descriptions from Miss J. A. Jenks, Personnel Manager, Brompton Hospital. Fulham Road, London SW3. Ext. 4357. [8518

RADIO COMMUNICATION ENGINEERS AND RADIO PAGING ENGINEERS NEEDED £4,900 AND £4,400

(Remuneration inclusive of bonuses)

Applications are invited for the above posi-tions. Due to continuing expansion we need engineers at our London depot and also our new branch at Harrow. Middx We are London's largest independent radiotelephone company, and would be inter-ested in hearing from you if you have knowledge of mobile V.H.F. equipment.

Contact Mike Rawlings or Bill Clarke, on D1-328 5344.

London

Communications

(Equipment) Ltd

Ondon NWB 01 328 5344

(8547)

—Calling all professional— Electronics Engineers and amateur electronics enthusiasts

The Electronics Industry has always been a breeding ground of professional talent, particularly within the specialist areas. At EMI, we have always attracted talented people, graduates and specialist engineers with valuable experience to contribute.

We're a flexible company, which is undoubtedly one of the attractions to professional people. We're also an acknowledged major force in the industry. Our training is excellent, our products ahead of the field. Our expertise has changed the face of electronics time and time again.

People joining us at any level rapidly acquire a great deal of knowledge and experience which puts them on a steady path to promotion. And right now, we have a very special need for a limited number of men and women as Semi-Conductor Consultant Engineers within our Engineering Standards Group.

We are extending our invitation to both experienced Electronics Engineers and men and women who have a particular interest, though not necessarily experience, in electronics as a hobby.

Your role with EMI Electronics will be to advise engineers, production personnel, buyers and Q.A.

staff on various aspects of semi-conductor and microprocessor products, to liaise with suppliers and initiate/ draft standards. You will also be expected to undertake laboratory testing, evaluate devices and be responsible for seeking out new products.

These varied duties require people with at least HNC qualifications but probably more important for this work, is the right personality. You must enjoy resolving technical problems and yet be capable of confident and effective communication with a wide and varied range of people. Knowledge of passive components, the foreign components markets and a working fluency in another European language, would be very useful though is not absolutely essential.

The men and women we envisage joining us will be aged between 20 and 40 and will be looking for a challenging and rewarding career with one of the major forces in international electronics.

For further information, please contact:
Neil Robotham, Personnel Department, EMI Limited,
135 Blyth Road, Hayes, Middlesex.
Telephone 01-573 3888 or Record-a-call anytime
on 01-573 5524.

EMI Electronics Ltd.

A member of the EMI Group. International leaders in music, electronics and leisure.

(8581)



SALES ENGINEER ELECTRONICS

N. ENGLAND & SCOTLAND

A rare opportunity for career advancement exists with Burr-Brown — a world leader in hybrid microcircuits. Our products are for instrumentation and data aquisition — specialised amplifiers, analogue functions and A-D, D-A converters.

We urgently need an ambitious, enthusiastic young engineer with some sales experience, or a very keen desire to achieve the rewards this sales position offers.

Applicants should have studied to HNC level or have solid experience in analogue signal processing and data acquisition.

The benefits include Top Salary

Bonus

Pension Scheme Life Assurance Company Car

Expenses

If you feel you can meet our challenge, phone Roger Isaacson at



BURR-BROWN INTERNATIONAL LTD. WATFORD (0923) 33837

8516)

AN INTERNATIONAL COMPANY BASED IN LONDON (HOLBORN)

requires

ELECTRONIC DEVELOPMENT/ SERVICE ENGINEERS

£4,500-£5,000 PA (Depending on experience)

The Service section is part of an expanding, fast-moving Research & Development Department. The successful applicants will spend approximately half their time on Research work, where their innovative abilities and skills will be fully utilised.

They will be able to demonstrate 2-3 years' experience in a calibration or servicing environment.

Duties include developing improvements to existing equipment and experimental work on electronic and mechanical systems; the maintenance and calibration of electromechanical systems, including electronic weighing systems and electronic test equipment.

Applicants should have experience of analogue and digital circuitry; a basic knowledge of microprocessors would be an advantage.

The successful candidates will have a minimum qualification of ONC, C&G finals or equivalent for electronic servicing and may be qualified to degree level.

There are above average fringe benefits, which include membership of a non-contributory pension scheme, free life assurance and staff restaurant.

Applicants should write with CV to

D. R. Pannett 2 Charterhouse Street LONDON EC1N 6RX

(8544

WHAT'S NEW IN **MODEMS AND MULTIPLEXERS?**

Uncle Sam has created a new generation. There's the Microprocessor based Modem, Time Multiplexing equipment and advanced Diagnostic Surveillance Systems for network con-

Launch these on the British user and you need considerable engineering and managerial back-up for your company. The circuitry needs evaluation. The products have to be incorporated into systems. The customer needs educating in up-todate applications (the products used to be the prerogative of Mr Big, now Mr Everyman needs to know that life is easier with data modems than without them). Technical support to the service department becomes more complex. The first new systems need the green fingered touch of one of nature's engineers as they are commissioned and installed.

If you are au fait with the equipment and wish to leave a type-cast engineering environment to develop broader based skills, please telephone for further details of our client company. Location: West London. Salary to £6,500. Fringe Benefits — in our opinion about the best in the country.

For further details please contact:

Charles Airey Associates

"PROBABLY THE BEST KNOWN SUPPLIER OF ELECTRONICS ENGINEERS IN THE COUNTRY" FINANCIAL TIMES

155 KNIGHTS8RIDGE, LONDON, SW1. TEL: 01-581 0286

FOREIGN AND COMMONWEALTH OFFICE **COMMUNICATIONS DIVISION**

has vacancies for

RADIO TECHNICIANS

to carry out shift duties concerned with MW and HF broadcasting systems involving frequency changing, fault finding and routine maintenance, keeping logs, and recordings.

Applicants should have minimum qualifications of City and Guilds Intermediate Certificate in Telecommunications or its equivalent.

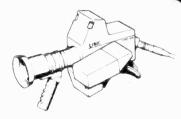
The successful candidates will serve initially at Crowborough, but may be required to serve elsewhere in the UK or overseas should the necessity arise.

Salary is according to age, e.g. £3,176 per annum at age 21, £3,435 at age 23, £3,700 at age 25 or over on entry rising by annual increments to a maximum of £4,252 per annum.

The appointments attracts 4 weeks ' paid holiday and prospects of pensionable employment.

Recruitment Section Foreign and Commonwealth Office Hanslope Park, Hanslope, Milton Keynes MK19 **7BH**

(8320)



TELEVISION SENIOR TEST ENGINEERS

WE ARE

Link Electronics Limited, a successful. expanding company with room for individual ability to make itself felt.

WE MAKE A full range of TV studio broadcast equipment, including colour cameras for studio and O/B applications.

WE NEED

Senior Test Engineers to undertake test and commission of advanced and complex TV cameras and associated equipment, including our multi-roll colour camera now going into production. This appointment is at a senior level, engineers are required with a good knowledge of modern circuitry and preferably with some broadcast television experience.

WE OFFER Salary above average, according to ability and not a rigid grade structure. generous holidays, free life and health insurance, pension scheme, staff restaurant, relocation expenses.

LOCATION A modern factory in a very pleasant part of Hampshire with no traffic problems and easy access to London, the South Coast, Midlands and many major towns.

HOUSING

A wide choice, in urban and rural settings.

TO APPLY

Either phone Jean Smith at Andover (0264) 61345 and ask for an application form or write to Mic Comber with enough information to make a form unnecessary.

INK

Telephone Andover (0264) 61345

ELECTRONICS

RADIO TECHNICIANS

At the Government Communications Headquarters we carry out research and development in radio communications and their security, including related computer applications. Practically every type of system is under investigation, including long-range radio, satellite, microwave and telephony.

Your job as a Radio Technician will concern you in developing, constructing, installing, commissioning, testing, and maintaining our equipment. In performing these tasks you will become familiar with a wide range of processing equipment in the audio to microwave range, involving modern logic techniques, microprocessors, and computer systems. Such work will take you to the frontiers of technology on a broad front and widen your area of expertise — positive career assets whatever the future brings.

Training is comprehensive special courses, both in-house and with manufacturers, will develop particular aspects of your knowledge and you will be encouraged to take advantage of appropriate day release facilities.

You could travel — we are based in Cheltenham but we have other centres in the UK, all of which require resident Radio Technicians and can call for others to make working visits. There will also be some opportunities for short trips abroad, or for longer periods of service overseas.



WORK IN COMMUNICATIONS R&D AND ADD TO YOUR SKILLS

You should be at least 19 years of age, hold (or expect to obtain) the City and Guilds Telecommunications Technician Certificate Part I (Intermediate), or its equivalent, and have a sound knowledge of the principles of telecommunications and radio, together with experience of maintenance and the use of test equipment. If you are or have been in HM Forces your Service trade may allow us to dispense with the need for formal qualifications.

You start on £2927 at 19, up to £3700 if you are 25 or over, rising to

You start on £2927 at 19, up to £3700 if you are 25 or over, rising to £4252, and promotion will put you on the road to posts carrying substantially more. There are also opportunities for overtime and on-call work paying good rates.

Get full details from our Recruitment Officer, Robby Robinson, on Cheltenham (0242) 21491. Ext. 2269, or write to him at GCHQ (Ref. WW/10). Oakley. Priors Road, Cheltenham, Glos GL52 SAJ. If you seem suitable, we'll invite you to interview in Cheltenham—at our expense of course.

(850)

A challenging career in the Medical Field

International X-Ray Company, a leader in its field, has several interesting positions for

X-RAY ENGINEERS

These vacancies occur in the North West and Southern England

Very generous salaries will be paid to the successful applicants

A Company Car will also be provided

There are excellent promotion prospects for the right persons

Those applying should be suitably qualified electronically and preferably have some experience in the X-Ray Field.

Please apply in writing to

C. G. R. Medical Ltd.

Astronaut House, Hounslow Road, Feltham, Middlesex

Giving full details of education, and career to date

(8520)



SENIOR ENGINEER VTR Cassettes

Salary £5,920 p.a. (Under Phase III Review)

Independent Television News has a vacancy for a Senior Engineer in their Facilities Centre in the West End of London.

The successful applicant will be employed on operation and maintenance in the busy Cassette VTR Section and is likely to have had previous editing experience. Broadcast VTR experience would be a plus but is not essential.

Benefits include contracted out pension scheme, life insurance, four weeks' annual holiday.

Please telephone our Personnel Department on 01-637 3144 quoting reference number 8314.

(8513

LOUGHBOROUGH CONSULTANTS LIMITED

Electronics Development Engineers

We wish to recruit additional Senior Engineers capable of accepting responsibility for the development of electronic equipment for the wide range of industries which our clients come. The Company is currently engaged in computer peripherals, microprocessors, video signal processing and industrial instrumentation. Much of the work is connected with our clients' large scale engineering projects and provides good opportunities for experienced engineers to develop their careers in an expanding Company.

Applicants with considerable relevant experience preferably with a degree of equivalent qualification should write to:

Mr. J. D. Britton, Director Loughborough Consultants Limited University of Technology Loughborough, Leicestershire LE11 3TU

Applications should include details of qualifications and experience, age and present salary. The Company offers good conditions of service including generous holidays and a first-class pension scheme. Starting salaries offered will be up to £5000 per annum.

(8512)

We are a well-established progressive, small company designing and manufacturing advanced electronic instruments. We have the following vacancies

SENIOR TEST ENGINEER

With comprehensive knowledge and experience of complex digital logic. Minimum qualification: C&G or I N.C.

JUNIOR TEST ENGINEER

With working knowledge of analog and digital circuitry

If you feel that you are the right person please contact us and we are sure we can make an offer which will satisfy your ambition.

Please write or ring Mr. D. Pearson: 01-649 5321, Data Laboratories Limited, 28 Wates Way, Mitcham, Surrey CR4 5HR. (8523)

-I FCTRONICS

When you see a good job advertised what do you look for next?

Obviously, before you contemplate a change of job and possibly area you must weigh-up your present job prospects, pay and surroundings and measure them against those that have attracted you.

Really that's all we want you to do NOW—we are confident that the combination of Marconi Instruments and its locations in St. Albans and Luton will persuade you to give very serious consideration to the appointments we have vacant.



Job Satisfaction

If you would like working for a successful Company you'll like us - 66% of our products ranging from microwave test equipment to automated test systems are exported. Unlike any other in the business we achieved the 'double' in 1977 with the Queen's Award for

both Exports and Technological Achievement-just two reasons why our people have every reason to be proud of their Company and its expertise.

Housing

The Hertfordshire/Bedfordshire area is probably one of the most picturesque of the counties surrounding London and contains some very reasonably priced housing both of the modern and rural varieties. The average family house is priced in the region of £16,000 to £22,000





Schooling

The family man will be particularly impressed with the local schools both Junior and Seniormodern, spacious buildings are the order of the day and individual successes are very encouraging

Sports and Social Activities

For the energetic our own sports and social club is very active, particularly with the recent addition of a squash court. Golf courses, cricket and football clubs abound and for the less energetic many social activities are available.





Local Amenities

If you still have time on your hands you will enjoy a visit to the theatre in either St. Albans, Luton or Watford. The local Rep. is very well supported.

All in all we can offer you a really worthwhile job, attractive pay, relocation and equally important, excellent local surroundings. Why not ring John Prodger, Personnel Officer, he lives locally and can give you first hand information about the jobs and surrounding districts.

> MARCONI INSTRUMENTS LIMITED Longacres, Hatfield Road, St. Albans, Herts. Tel: St. Albans 59292 or after 6pm and weekends St. Albans 30602 (8562)



A GEC MARCON ELECTRONICS COMPANY



Radio Engineer

Up to £7,990 (married) £5,752 (single) Inclusive of TAX FREE supplements'

Required by the Department of Civil Aviation, Ministry of Power, Transport and Communications

Requirements:

3 'O' levels, or Electronics or Telecommunications Engineering apprenticeship or appropriate Army. Air Force or Navy Trade Certificate, appropriate I.C.A.O. or D.C.A. Certificate of Competency, driving licence; knowledge/experience of two of the following communications groups:

- Medium-powered HD transmitters and associated receivers

- a) Neodal Typowered No Italismillers and associated receivers.
 b) Low and high-powered VHF AM direction finders.
 c) Instrument landing systems.
 d) Radar X & S, Bank Terminal and PPI talk-down equipment.
 e) Audio/remote-control equipment. PA's, inter-officer communication, underground control cables, impulses and D C
- Teleprinter telegraph (Torntape) and associated page printer type readers (autoleads), printing reperforators and associated switching equipment.

Responsibilities:

To ensure that telecommunications systems allocated are properly maintained, field technical duties at outstations plus reports

*The British Government pays TAX FREE supplements to British Nationals. These supplements are reviewed annually but at the present time are up to £5,046 (married) and £2,808 (single). The salaries quoted are at the current exchange rate with the Kwacha and subject to fluctuation

As well as salary and supplements you will also be entitled to a TAX FREE terminal gratuity, low cost accommodation and free passages. Together, these add up to exceptional real earnings The salary quoted is the maximum on the scale and starting salaries will relate to qualifications and experience

For those receiving supplements the British Government also gives appointment grants, education allowances, car loans medical aid assistance and free holiday visits for children educated in Britain

For further information please send full personal/professional details (without obligation and in total confidence), to Recruiting Officer, Zambia High Commission. 7-11 Cavendish Place London W1



AUDIO + VIDEO LTD. SENIOR VIDEO ENGINEERS AND HIGH GRADE TELEVISION ENGINEERS

Because Audio + Video are the largest video duplicators in Europe, we naturally have a lot of high-class equipment to produce our top quality video tapes. We have in house, the Marconi D.I.C.E., the Rank Cintel Flying Spot Telecine, the RCA TK28 Telecine, TR60, TR70c and Ampex 2000 2' Quad machines, Sony D100 duplicator, 2850, 2600, 2030, 2630, Betamax, Philips VCR 1500 and 1700, VHS. Keyline editor, etc

We now require Senior Video Engineers with experience of maintaining and servicing any or all of the above equipment and high grade Television Engineers who can be trained to help maintain most of it. We will pay salaries in excess of £5,500 for the right people who enjoy working in television.

Please contact Cliff Carroll on 01-580 7161.

(8446)

Electronics Engineer/ Technician

for Electronic Test and Measurement Equipment

The Lucas Research Centre, a modern spacious laboratory, situated in the green belt, provides an R & D service to the whole of the Lucas Group. The wide range of advanced technology being used requires an interesting and varied complement of electronic laboratory equipment.

We wish to recruit an engineer/technician to assist in fault finding, repairing and calibrating this equipment together with the provision of service records and safety checks.

Work situations range from fault finding on complex circuits associated with oscilloscopes, pulse/function generators, various analysers, DMM's, counter/timers etc. to the simpler but responsible task of checking equipment for safety.

Candidates are likely to be over age 30, educated to HNC/T6, with recent experience in this type of work

The location is 15 miles from Stratford-on-Avon with excellent social, housing, school and shopping facilities close at hand

Applicants, male or female, should write quoting this advertisement and state briefly their age, recent work experience and qualifications. They will be asked to complete an application form in detail

Apply to: The Personnel Manager, Lucas Group Services Limited, Lucas Research Centre, Monkspath, Shirley, Solihull, West Midlands B90 4JJ.



(8502

REW AUDIO VISUAL CO.

THE LEADING VIDEO DEALERS

GENERAL MANAGER

Due to reorganisation and expansion we have a vacancy for an energetic and self-motivated person. The successful candidate will be based at company head office at Colliers Wood, will be responsible for the efficient operation and co-ordination of various departments. Previous experience in a similar position essential. Excellent salary negotiable. Company car plus expenses.

TECHNICAL MANAGER

for Video / CCTV Systems Division. Due to expansion a vacancy occurs for a suitable person with previous experience in Video / CCTV fields. The successful candidate will be required to motivate and lead the existing team, should be able to negotiate at all levels and ideally will currently hold a similar position. Competitive salary, company car, expenses and excellent prospects for the right person.

VIDEO SALES REPRESENTATIVE

Professional representative required to sell video equipment, tapes and accessories to end users. An opportunity for an enthusiastic and self-motivated person to join a successful company. Product training given, competitive salary plus company car. Commission and expenses for the right applicant.

Please write in confidence to

M. Murray, Managing Director REW AUDIO VISUAL COMPANY Rew House 10-12 High Street, Colliers Wood London, SW19 2BE

(8554)



We require staff, male or female, to prepare and maintain the latest in communications equipment used by the Police and Fire Brigades in England and Wales.

You will need to be qualified at least to City and Guilds Intermediate Telecommunications standard and be able to demonstrate practical skills in locating and diagnosing faults in a wide range of equipment from computer based data transmission to FM and AM radio systems. You would live near to and work from our service centres located throughout England and Wales or our Headquarters in the London area. Specialised courses of training are run to assist siaff to keep up to date with developments and new equipment, and there are opportunities for day release to gain higher qualifications. Applications from registered disabled persons will be considered

Promotion prospects are good and the work represents a secure future with generous leave allowances and a non-contributory pension scheme

Possession of a driving licence is essential since some travelling will normally be involved.

The salary is £2627 (at 17), £3176 (at 21) and £3700 (at 25), rising to £4252.

If you are interested in working with us, then write for further details and an application form to—

Mr C B Constable Directorate of Telecommunications Horseferry House Dean Ryle Street LONDON SW1P 2AW Telephone: 01-211 6420

(8428)

Radio Communications Electronics Engineers and Software Designers

Mid-Sussex - S.W. London
Salaries up to £7,000

To join our expanding R & D Laboratories covering a wide range of the R. F. spectrum, from L.F. to V.H.F. Equipments include transmitters and receivers for marine and land based use, radio navaids and radio monitoring remote computer controlled systems.

Electronics Engineers should have experience in transmitter or receiver design, analogue or digital circuit design, micro processor applications.

Software Designers should be experienced Programmers with an interest in control, signal processing or navigational software. Attractive salaries are complemented by excellent prospects and generous benefits.

Contact: The Personnel Manager, Redifon Telecommunications Limited, Broomhill Road, Wandsworth, London, S.W.18. Phone: 01-874 7281 (Reverse charge).

(8315

Sound out your new career in Hi-Fi

Hardman's are now the No. 1 name in hi-fi retailing in Birmingham, Chester, Liverpool, Manchester and Preston with superb spacious showrooms offering the best hi-fi selection in town. But we're not just a single fast expanding company with five stores and more to follow; we're part of a large and successful Group with interests throughout the leisure industry. To you that means the big benefits that only a large Group can offer you: security plus the almost unlimited scope that an enthusiast like you will relish.

Expansion has created these vacancies in all five stores:

Senior Audio and Hi-Fi Sales Staff

You must have a proven sales ability and/or sound audio or hi-fi experience. We'll give you specific sales training and keep you up to date with regular seminars. Good salary plus commission. PLUS excellent opportunities for promotion to management within the group.

Hi-Fi Engineers

You're a qualified hi-fi/audio/video engineer, or you're mid way through an apprenticeship scheme with no immediate opportunities. You'd like to service, test and repair hi-fi equipment in our well-equipped premises. We'll tell you all about the equipment and keep you updated on new developments. Excellent salary.

Please write for an application form to:
The Managing Director, Hardman Radio Limited,
26 Exchange Street East, Liverpool, L2 3PH

(8401)

Talk to the helpful Hi-Fi people HARDIVANS

INSTRUMENT TECHNICIANS FOR THE OIL INDUSTRY

NEC Gas, the only British company offering formation mud logging services to the oil industry, is rapdily increasing its penetration in both North West Europe and Overseas.

This expansion has created excellent opportunities for experienced Instrument Technicians to become involved in a variety of development, commissioning and maintenance projects both on and offshore. Although based at Kilwinning, Ayrshire, offshore working would amount to a total of around 100 days per year and candidates would be expected to travel, sometimes at short notice, both in Europe and Overseas.

Applicants should be qualified to H.N.D. standard and have at least 3 years' experience in industrial electronics, electronic process instrumentation or a related field. Although not essential, experience with digital logic systems and/or gas analytical instruments would be an advantage.

Candidates in good physical shape who can show above average commitment both in initiative and in the ability to work under arduous conditions will be suitably rewarded by the company, financially as well as in terms of career progression.

Write or telephone:



NEC Gas Analytical Services International Ltd., 2/4 Simpson Place, Kilwinning, Ayrshire. Tel: 0292 41752

(8580)

Systems Test Engineer

for Pye TVT, the Broadcast Company of Philips

We now have vacancies in our Test Department for Systems Test Engineers.

The job carries responsibility for the preparation of complete TV systems to meet final acceptance by the customer.

Duties therefore include diagnosing deviation and changing faulty units and components, setting up and aligning complex systems and generally ensuring that the performance required of the system is achieved.

Pye TVT offer pleasant working conditions, generous holiday entitlement and relocation expenses.

For an application form, contact David Barnicoat, Personnel Officer, Pye TVT Limited, Coldhams Lane, Cambridge CB1 3JU Telephone Cambridge (0223) 45115.



Pye TVT Limited

The Broadcast Company of Philips

/8582\

£15,000 YOUR WAVELENGTH

If you are a successful **Sales Person/ Manager** but are not quite tuned in to your present career you could be the person we are looking for.

Please phone us on 01-580 9183
Penthouse Personnel
Consultants

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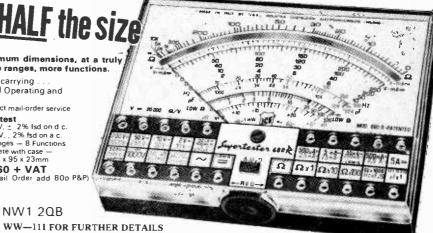
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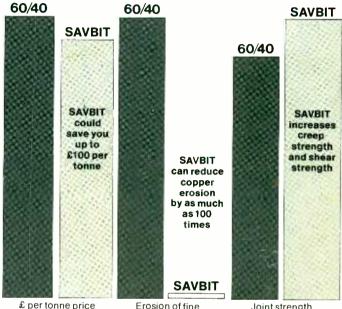
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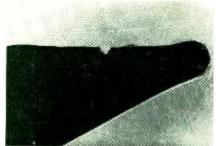
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