electronics today INTERNATIONAL

OCTOBER 1973

20p

THICK FILM CIRCUITS

PLUS:

THE PRINCIPLES OF
MAGNETIC LEVITATION

BUILD THE ETI
AUDIO WATTMETER

TESTING THE
SHURE V15 Mk III

EXCLUSIVE:—
KIT PREVIEW
ADVANCE CALCULATOR KIT

HI-FI ... CONSTRUCTION ... COMMUNICATIONS ... DEVELOPMENTS

electronics TODAY INTERNATIONAL

OCTOBER 1973 Vol.2 No.10

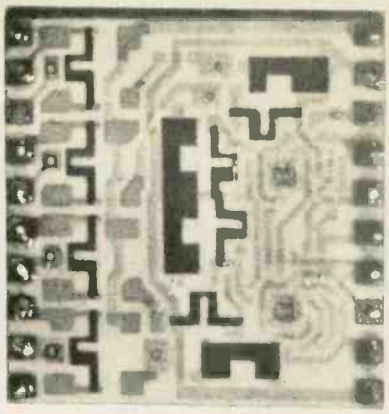
main features

projects

product tests

news & information

Cover: Thick film circuits are finding their way more and more into today's consumer electronics. See the article on page 14.



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kits

A FAIRLY MAJOR CHANGE is beginning to affect the home construction market — the tremendous growth in the number of kits. In some ways this is surprising for whilst kits were exempt from Purchase Tax, they are not from VAT.

We are in touch with several companies in the kit business and, to a man, they have never had it so good. Ten years ago kits were very popular but they declined rapidly; this we believe was due to some very shoddy kits which gave the whole field a bad name. Today the range of kits has never been greater and, with a few exceptions, bear little comparison to those on sale a few years ago. The housing was always a weak point but now even inexpensive kits have a truly professional finish.

One major reason for this growth must be the difficulty in obtaining components. The range now available means that one has to try a number of component suppliers and this can be both time consuming and frustrating: kits present no such problems.

The policy of ETI is to make available kits of the major projects whenever possible. We shall always publish complete details in the normal way so that those who wish to go it alone can still do so — after all some people have substantial stocks of components already.

When we arrange for a kit to be available this is done purely as a service to readers who wish to take advantage of it. In these cases the designer, the supplier and the magazine work closely together to produce what we hope is a better end product. We have no tie ups with any of the component suppliers and we are happy to consider any company who wish to take part in such a scheme.

As you will see on page 44, we have made arrangements for the supply of an Advance calculator kit at a remarkably low price (but please note that this offer does not start until the publication of the next issue). This is the sort of thing that we hope to do fairly often. — H.W.M.

INSTANT CLOCKS

Choose your combination from the tables below. If you need any help, please feel free to phone us.

CLOCK CHIP	12/24 HOUR	4/6 DIGIT	BCD OUTPUT	7-Seg output	MPXED	1 Hz OUTPUT	AM/PM IND	ALARM	DATE	SNOOZE	SLEEP	PIN COUNT	DISPLAY INTERFACE DL34	TIL360	DL707	DL62	DG12	SP151	LIQ.CRYS			Drive volts	Drive current mA		UNIT PRICE
MM5311	✓	✓	✓	✓	✓							28	✓	✓	✓	✓	✓	✓				11·19	8		£11.50
MM5314	✓	✓		✓	✓							24	✓	✓	✓	✓	✓	✓				11-19	8		£11.00
MM5316	✓	4		✓		✓	✓	✓		✓	✓	40					✓	✓	✓			8-29	4		£16.00
5017AA	✓	✓		✓	✓	✓	✓	✓		✓		24	?	?			✓	✓				5-24	8		£14.00
5017BB	✓	✓		✓	✓				✓			24	?	?			✓	✓				5-24	8		£14.00
5017AN	✓	✓		✓	✓	✓	✓	✓		✓	✓	28	?	?			✓	✓				5-24	8		£15.50

DISPLAY CODE	TYPE	PACK	DIGITS	HEIGHT (INS) DIG	PACK	DECIMAL POINTS	COLON	AM/PM	Drive Voltage	REMARKS	COST PER DIGIT	UNIT PRICE
DL34	LED	14 PIN	4	0.1	0.2	4			2v	CALCULATOR TYPE	£2.50	£10.00
TIL360	LED	16 PIN	6	0.1	0.2	6			2v	CALCULATOR TYPE	£2.50	£15.00
DL707	LED	14 PIN	1	0.3	0.7	1			2v	SIM TO MAN 7 TIL302	£2.00	£2.00
DL62	LED	16 PIN	1	0.6	0.9	1			2v		£6.50	£6.50
DG12H	PH-DIODE	TUBE	1	0.3	1.0	1			15v		£2.00	£2.00
SP151	SPERRY	FLAT	3½	0.5	1.2		✓		160v	SPECIAL SKT AVAIL.	£2.00	£7.50
TA8055	LIQ.CRYS	EDGE	4	0.6	1.3		✓	✓	60v AC	Reflective/Transmission	£3.25	£13.00
D.I.Y.	LED	VERO BOARD	1	3″	3″				2v	21 LED LAMPS	£5.00	£5.00

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MM5316 + PCB + SKT + TA8055R + INSTRUCTIONS. **£31** — AVAILABLE SEP/OCT
MM5316 + PCB + SKT + SP151 + INSTRUCTIONS. **£26** — AVAILABLE OCT/NOV

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news digest

SLIMMER COLOUR TV SETS ON THE WAY

Slimmer colour TV sets will soon be available in Britain as the UK industry switches to new slim-line "wide-angle" cathode ray tubes. Pilkington's pressed glass division started full-scale production of specially designed glassware for the new tubes in August. The new 110° angle tubes are flatter than the existing 90 degree tubes which currently take up most of the UK market. They reduce the depth of a standard 22" set by about four inches and also give a small weight saving bonus.

Dimensional tolerances are finer than for 90° glassware to ensure the electron beam - which produces the image on the screen - is accurately deflected over the arc caused by the wider angle.

Wide angle tubes are common in continental Europe, which completed the switch last year. In the UK, 110° set deliveries are expected to exceed £500,000 this year and the company envisages improved export opportunities for TV glassware as the UK product comes into line with Europe.

RAPID INTRODUCTION OF POST BOMB DETECTOR

In our May News Digest we gave details of a metal locator, the Treasure Tracer Mk III produced in both a kit and ready built form by Minikits Electronics.

Although Minikits only started at the beginning of this year, they are already one of the largest makers of metal locators in the country but their success to date has been as nothing compared to their sales of a modified version, designed for detecting letter bombs. All those so far found have made use of tin foil or silver paper for the contacts and this is easily detected by a metal locator at several inches.

The modified Treasure Tracer, which uses a shorter handle than the normal unit, was demonstrated on the main news of both BBC-1 and BBC-2 TV. Immediately Minikits were swamped with orders and now reckon that they have supplied 60 of the 100 largest companies in the country plus the British Government and a number of foreign embassies.

Although the letter bomb scare was short-lived, production has kept at record levels due to re-orders from companies who took only a few for appraisal. Production is running at over ten times previous levels according to Minikits.

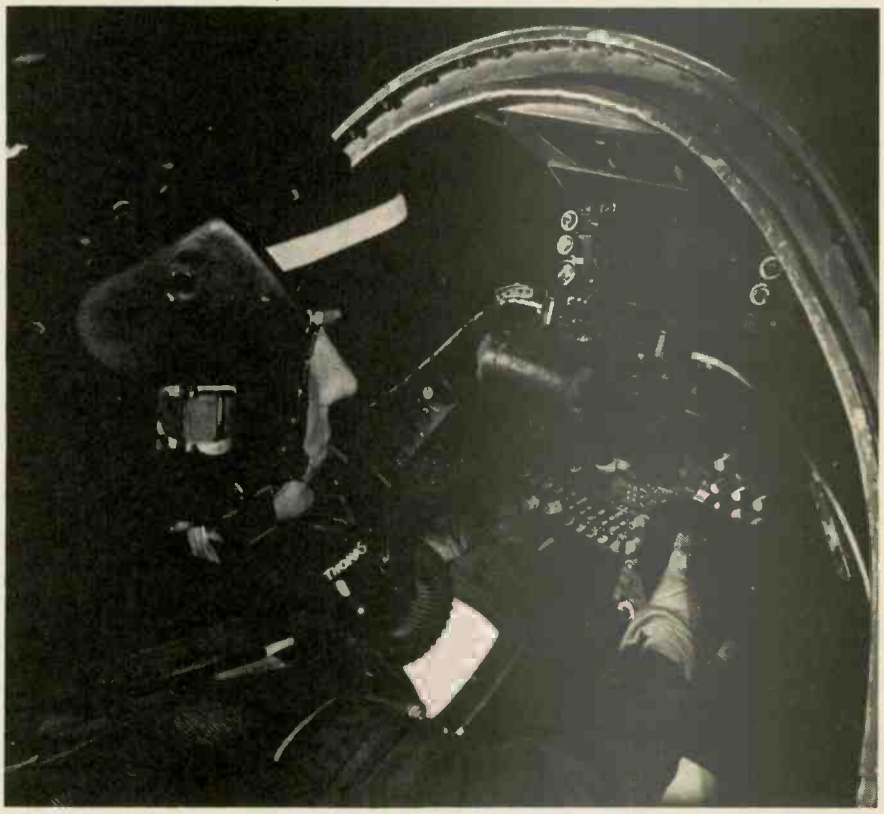
The Office Metal Detector, as the modification is known, retails for £13.75 inc. VAT plus 35p carriage with ex-stock delivery. Minikits, of Langley Drive, London, E11, are planning to introduce two new versions specifically designed for detecting letter bombs.

PLESSEY ABOARD HARRIER

This photograph, taken during a pre-flight check, clearly shows a Plessey Weapon Control System (WCS) installed in the cockpit of a Royal Air Force Harrier VTOL strike aircraft.

The WCS, designed and manufactured by Plessey Avionics and Communications for the Harrier, provides effective stores management and concentrates all the armament selections on one panel, thus reducing to a minimum the work load on the pilot.

Plessey has wide experience of complex stores management and has further systems installed in Jaguar and Nimrod.



UNATTENDED RADIO STATION OPERATION

With the interest of radio broadcasters worldwide firmly centred on the advantages of automated studio operations, Britain's EMI group has planned a major sales drive abroad to capture a substantial share of this potentially large equipment market.

Initially, EMI is launching a

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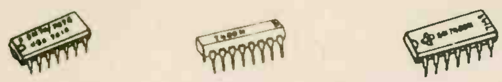

Type	1/11 £ p	12/29 £ p	30/99 £ p
SN7400N	0·20	0·18	0·16
SN7401N	0·20	0·18	0·16
SN7401AN	0·38	0·38	0·33
SN7402N	0·20	0·18	0·16
SN7403N	0·20	0·18	0·16
SN7403AN	0·38	0·38	0·33
SN7404N	0·24	0·21	0·18
SN7405N	0·20	0·18	0·16
SN7405AN	0·44	0·44	0·38
SN7406N	0·40	0·38	0·35
SN7407N	0·40	0·38	0·35
SN7408N	0·25	0·22	0·19
SN7409N	0·33	0·33	0·28
SN7409AN	0·44	0·44	0·38
SN7410N	0·20	0·18	0·16
SN7411N	0·25	0·23	0·21
SN7412N	0·28	0·28	0·25
SN7412AN	0·38	0·38	0·33
SN7413N	0·30	0·27	0·25
SN7414N	0·72	0·72	0·63
SN7416N	0·30	0·27	0·25
SN7417N	0·30	0·27	0·25
SN7420N	0·20	0·18	0·16
SN7422N	0·28	0·28	0·25
SN7422AN	0·38	0·38	0·33
SN7423N	0·37	0·34	0·32
SN7425N	0·37	0·37	0·32
SN7427N	0·37	0·37	0·32
SN7428N	0·43	0·43	0·37
SN7430N	0·20	0·18	0·16
SN7432N	0·37	0·37	0·32
SN7433N	0·43	0·43	0·38
SN7433AN	0·57	0·57	0·50
SN7437N	0·43	0·43	0·37
SN7438N	0·43	0·43	0·37
SN7438AN	0·57	0·57	0·50
SN7440N	0·20	0·18	0·16
SN7441AN	0·85	0·79	0·73
SN7442N	0·85	0·79	0·73
SN7443N	1·50	1·27	1·13
SN7444N	1·50	1·27	1·13
SN7445N	2·16	2·16	1·89
SN7446N	2·16	2·16	1·89
SN7447AN	1·80	1·80	1·57

Type	1/11 £ p	12/29 £ p	30/99 £ p
SN7448N	1·50	1·27	1·13
SN7450N	0·20	0·18	0·16
SN7451N	0·20	0·18	0·16
SN7453N	0·20	0·18	0·16
SN7454N	0·20	0·18	0·16
SN7460N	0·20	0·18	0·16
SN7470N	0·33	0·30	0·27
SN7472N	0·38	0·38	0·34
SN7473N	0·44	0·41	0·37
SN7474N	0·48	0·48	0·42
SN7475N	0·59	0·55	0·51
SN7476N	0·45	0·36	0·32
SN7480N	0·80	0·70	0·50
SN7481N	1·25	1·10	0·95
SN7482N	0·87	0·80	0·72
SN7483N	1·20	1·10	1·00
SN7485N	1·87	1·87	1·63
SN7486N	0·50	0·50	0·44
SN7489N	4·32	4·32	3·78
SN7490N	0·75	0·70	0·63
SN7491AN	1·10	1·00	0·90
SN7492N	0·75	0·70	0·63
SN7493N	0·75	0·70	0·63
SN7494N	0·85	0·80	0·75
SN7495N	0·85	0·80	0·75
SN7496N	1·00	0·90	0·83
SN74100N	2·16	1·89	1·89
SN74104N	0·60	0·53	0·45
SN74105N	0·60	0·53	0·45
SN74107N	0·51	0·51	0·45
SN74110N	0·57	0·57	0·50
SN74111N	0·86	0·86	0·75
SN74116N	2·16	2·16	1·89
SN74118N	1·00	0·90	0·83
SN74119N	1·92	1·92	1·68
SN74120N	1·05	1·05	0·92
SN74121N	0·57	0·57	0·50
SN74122N	0·80	0·80	0·70
SN74123N	1·44	1·44	1·26
SN74125N	0·69	0·69	0·60
SN74126N	0·69	0·69	0·60
SN74132N	0·72	0·72	0·63
SN74136N	0·63	0·63	0·55
SN74141N	1·00	0·90	0·80

Type	1/11	12/29	30/99 £ p
SN74142N	2·88	2·88	2·52
SN74145N	1·44	1·44	1·26
SN74147N	2·30	2·30	1·83
SN74148N	2·01	2·01	1·63
SN74150N	2·30	2·30	2·01
SN74151N	1·15	1·15	1·00
SN74153N	1·09	1·09	0·95
SN74154N	2·30	2·30	2·01
SN74155N	1·15	1·15	1·00
SN74156N	1·09	1·09	1·00
SN74157N	1·09	1·09	0·95
SN74159N	2·44	2·44	2·14
SN74160N	1·58	1·58	1·38
SN74161N	1·58	1·58	1·38
SN74162N	1·58	1·58	1·38
SN74163N	1·58	1·58	1·38
SN74164N	2·01	2·01	1·76
SN74165N	2·01	2·01	1·76
SN74166N	2·16	2·16	1·89
SN74167N	4·10	4·10	3·59
SN74170N	2·88	2·88	2·52
SN74172N	5·76	5·76	5·04
SN74173N	1·66	1·66	1·45
SN74174N	1·80	1·80	1·57
SN74175N	1·29	1·29	1·13
SN74176N	1·44	1·44	1·26
SN74177N	1·44	1·44	1·26
SN74180N	1·44	1·44	1·26
SN74181N	5·18	5·18	4·53
SN74182N	1·44	1·44	1·26
SN74184N	2·16	2·16	1·89
SN74185AN	2·16	2·16	1·89
SN74188N	6·48	6·48	5·67
SN74190N	2·30	2·30	2·01
SN74191N	2·30	2·30	2·01
SN74192N	2·30	2·30	2·01
SN74193N	2·30	2·30	2·01
SN74194N	1·72	1·72	1·51
SN74195N	1·44	1·44	1·26
SN74196N	1·58	1·58	1·38
SN74197N	1·58	1·58	1·38
SN74198N	3·16	3·16	2·77
SN74199N	2·88	2·88	2·52

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AC128	20p	BCY32	85p	BYZ13	35p	OC45	18p	ZTX300	14p	2N3714	1·60
AC187	20p	BCY39	1·00	CIO6D	55p	OC71	15p	ZTX302	18p	2N3771	1·75
ACY17	35p	BCY55	2·50	GET111	55p	OC72	25p	ZTX500	15p	2N3773	2·25
ACY39	65p	BCY70	15p	GET115	75p	OC77	55p	2G301	40p	2N3790	2·25
AD149	50p	BCY71	20p	GET880	55p	OC81	28p	2N697	15p	2N3819	35p
AD161	39p	BCT72	13p	LM309K	1·87	OC83	25p	2N706	10p	2N3866	75p
AD162	39p	BD124	80p	MAT121	25p	OC140	65p	2N930	20p	2N3903	15p
AF117	20p	BD131	45p	MJE340	50p	OC170	25p	2N987	45p	2N4002	14p
AF118	50p	BF115	22p	MJE520	85p	OC200	55p	2N1132	25p	2N4126	15p
AF139	33p	BF180	33p	MJE3055	75p	OC202	90p	2N1304	22p	2N4871	35p
AF186	40p	BF194	13p	MPF105	48p	OCP71	1·00	2N1613	20p	2N5457	36p
AF239	44p	BFX 13	25p	NKT217	45p	ORP12	55p	2N1671	1·00	2S001	3·00
ASY27	30p	BFX34	55p	NKT404	60p	ORP60	45p	2N2147	75p	2S026	8·90
BA115	10p	BFX88	22p	OA5	60p	P346A	20p	2N2160	69p	2S303	70p
BAX13	5p	BFY50	20p	OA81	10p	TIL209	25p	2N2926	10p	40250	45p
BC107	12p	BFY51	20p	OA200	8p	TIP29A	49p	2N3053	20p	40361	45p
BC108	12p	BFY64	45p	OA202	10p	TIP30A	58p	2N3054	45p	40362	40p
BC109	12p	BFY90	75p	OC16	85p	TIP31A	61p	2N3055	45p	40408	50p
BC109C	14p	BLY36	6·25	OC20	1·25	TIP41A	74p	2N3440	50p	40486	75p
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3 AMP RANGE Price ea.

Type	P.I.V.	
SC35A	100v	80p
SC35B	200v	85p
SC35D	400v	90p
SC35E	500v	£1·20
6 AMP RANGE		
SC40A	100v	90p
SC40B	200v	95p
SC40D	400v	£1·20
SC40E	500v	£1·50
10 AMP RANGE		
SC45A	100v	£1·05
SC45B	200v	£1·15
SC45D	400v	£1·45
SC45E	500v	£1·85
15 AMP RANGE		
SC50A	100v	£1·45
SC50B	200v	£1·65
SC50D	400v	£1·95
SC50E	500v	£2·25

TRIACS/Additional Types

40430 TRIAC (T066) **85p**

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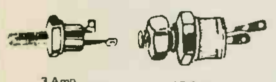
40486 TRIAC (T05) **75p**



3 Amp T048

15 Amp T048

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Type	P.I.V.	
ONE AMP (T05)		
CRS 1/05AF	50v	30p
CRS 1/10AF	100v	30p
CRS 1/20AF	200v	35p
CRS 1/40AF	400v	45p
CRS 1/60AF	600v	55p
THREE AMP (T048)		
CRS 3/05AF	50v	40p
CRS 3/10AF	100v	40p
CRS 3/20AF	200v	45p
CRS 3/40AF	400v	55p
CRS 3/60AF	600v	65p
FIVE AMP		
CRS 5/400	400v	60p
SEVEN AMP (T048)		
CRS 7/100	100v	60p
CRS 7/200	200v	67p
CRS 7/400	400v	85p
CRS 7/600	600v	95p
SIXTEEN AMP (T043)		
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CRS 16/200	200v	75p
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CRS 16/600	600v	£1·10

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460	FM signal generator	£9·91
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615	Power supply for 2 x 120	£4·85
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250M/A QUARTER AMP
B025/05 50 PIV **16p**
B025/10 100 PIV **18p**
$\frac{1}{4} \times \frac{1}{4} \times \frac{1}{8}$" dia.

$\frac{1}{2}$ AMP 1-11 Pricing

Type	P.I.V.	Price ea.
B05/05	50v	20p
B05/10	100v	22p
B05/20	200v	23p
B05/40	400v	25p
B05/60	600v	27p

$\frac{1}{2}$H x $\frac{1}{2}$L x $\frac{3}{8}$" dia.

1 AMP P.I.V.

B1/05	50v	25p
B1/10	100v	25p
B1/20	200v	28p
B1/60	600v	30p

$\frac{1}{2}$H x $\frac{1}{2}$L x $\frac{3}{8}$" dia.

1 AMP P.I.V.

W005	50v	29p
W01	100v	30p
W02	200v	32p
W06	600v	35p

$\frac{3}{8} \times \frac{1}{8}$" Tubular

2 AMPS P.I.V.

B2/05	50v	35p
B2/10	100v	40p
B2/20	200v	45p
B2/60	600v	50p
B2/100	1000v	55p

$\frac{1}{2}$H x $\frac{1}{2}$L x $\frac{3}{8}$" dia.

4 AMPS P.I.V.

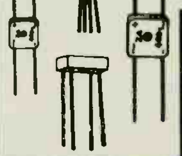
B4/100	100v	55p
B4/200	200v	59p
B4/400	400v	65p
B4/600	600v	75p
B4/800	800v	£1·00

$\frac{1}{2}$H x $\frac{1}{2}$L x $\frac{3}{8}$" dia.

6 AMPS P.I.V.

B6/05	50v	65p
B6/10	100v	70p
B6/20	200v	80p
B6/40	400v	90p
B6/6x0	600v	£1·00

$\frac{1}{2}$H x $\frac{1}{2}$L x $\frac{3}{8}$" dia.



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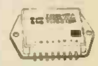

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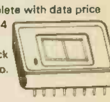

BUILD YOURSELF A POCKET CALCULATOR

A complete kit, packaged in a polystyrene container and taking about 3 hours to assemble—thats the Sinclair Cambridge pocket calculator from Henry's. Some of the many features include interface chip, thick-film resistor pack, printed circuit board, electronic components pack. Size 4$\frac{1}{3}$" long x 2" wide x $\frac{11}{16}$" deep.
Free of charge with the kit for the more advanced technologist is a 32-page booklet explaining how to calculate Logs. Tangents. Sines etc.
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Easiphone telephone amplifier	6·15 p & p 25p
D1203 Taleamp. with PU coil	3·60 p & p 20p
LL1 Door Intercomm. and chime	11·95 p & p 25p
Chattalite (lights as you talk)	13·90 p & p 20p
1 Kw Dimmer/controller	3·00 p & p 10p
9" Twin spring unit For	2·75 p & p 15p
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Car Tachometer Electronic	7·50 p & p 15p
VHF 105 Aircraft band converter	3·95 p & p 15p
VHF 205 Marine band converter	3·95 p & p 15p
B2005 4 Ch. mic. mixer	2·95 p & p 15p
B2004 2 ch. Stereo mixer	4·75 p & p 15p

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ELECTRONICS FOR EVERY PURPOSE
See facing page for addresses

TOP QUALITY SLIDER CONTROLS
60mm stroke high quality controls complete with knobs (post, etc. 15p any quantity).
Singles Log and Lin 5K, 10K, 22K, 50K, 100K, 250K, 500K, 1 Meg. **45p** each.
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(Quantity discounts available) Complete with knobs.

MARRIOT TAPE HEADS
4 TRACK MONO or 2 TRACK STEREO
'17' High Impedance **£2·00** '18' Med Impedance **£2·00**
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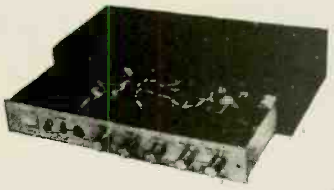
20 + 20 WATT IC STEREO AMPLIFIER

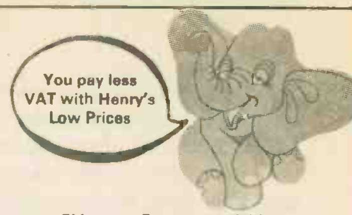
As featured by Practical Wireless 1972

Now built and used by thousands of satisfied customers. Features slim design overall size in cabinet 14½" x 2¾" x 6⅝". 6-IC's, 10 transistors, stabilisers Gardners low field transformer. Fibre Glass PC Panel, complete chassis work. Now available built and tested as well as in kit form. HIGH QUALITY & STABILITY ARE PREDOMINATE FEATURES — DEVELOPED BY TEXAS ENGINEERS FOR PERFORMANCE, RELIABILITY AND EASE OF CONSTRUCTION. FACILITIES. On/off switch indicator, headphones socket, separate treble, bass, volume and balance controls, scratch and rumble filters, mono/stereo switch, input selector; Mag. P.U., Radio Tuner, Aux. Can be altered for Mic., Tape, Tape-head, etc. Constructional details Ref. No. 21 30p. Distributed by Henry's throughout UK.

FREE—Teak cabinet with complete kit. Kit price **£28·50** (+ VAT + **50p** carr/packing) or built and tested **£35·00** (+ VAT + **50p** carr/packing) as illustrated.



BUILD THE NEW HENELEC STEREO FM TUNER



A completely new high stability stereo FM tuner. Features variable capacity diode tuning, stabiliser power supply, IC Decoder, high gain low noise. IF stages, LED indicators, Tuning meter, AFC, easy to construct and use. Mains operated. Slim modern design with fibre glass PC, teak cabinet, etc. Available as a kit to build or ready built. Overall size 8" x 2¾" x 6⅝". Produced to give high performance with a realistic price. (Parts list and constructional details Ref. No. 5 30p) Henry's are sole distributors UK and Europe. Kit price **£21·00** (+ VAT) or built and tested **£24·95** (+ VAT).

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OISCO MIXER/PREAMPLIFIERS
(OP for up to 6-100 watt amplifiers)
SDLI (rotary controls) **£49·50**
SDLII (slider controls) **£58·50**
OISCO VOX (slider controls) the complete disco unit **£69·50**
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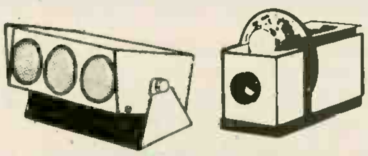
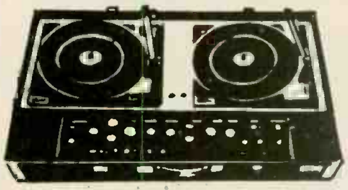
DJ30L 3 channel 3kw sound to light **£29·50**
OJ40L as 30L plus built in microphone **£38·75**
DIMANATIC 1 kw adjustable speed auto dimmer **£25·00**
SCENE STROBE £19·00. ROAD STROBE £25·00
Disco anti-feedback microphone **£11·95**
Colt 150 watt liquid wheel projector **£22·50**
150 watt QI liquid wheel projector **£50·00**





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TEXAN STEREO SYSTEM

PLUS PRICE SAVINGS

The Texan Stereo Systems include the high quality Texan Stereo amplifier assembled and ready to use. A pair of Type 200 20 watt Speaker-Tweeter systems size 21" x 12" x 10" and a choice of Garrard players built into a plinth with cover with Goldring G800 magnetic cartridge. Systems 25 uses Garrard SP25 Mk III and system 76 the Garrard AP76 de luxe turntable. All necessary leads are supplied.
System 25 (list approx. **£109**) **£79·50 System 76** (list approx. **£117**) **£89·50** (plus 10% VAT and plus **£1·45** carr/packing).

LOW COST HI-FI SPEAKERS SPECIAL OFFER

EMI 13" x 8"—full range speakers (post 20p each or 30p pair)
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*450 10 watt C/o Twin Tweeters 3, 8 or 15 ohms **£3·50** each or £6·90 pair.
EW 15 watt 8 ohms C/o Tweeter **£4·30** each or **£7·90** pair.
350 20 watt C/o Tweeters 8 or 15 ohms **£7·50** each or **£14·20** pair.
* Polished wood cabinet **£4·60** post 35p.

8 ohms full range (post 20p)

FR4	4"	5 watt	**£4·00**
FR65	6½"	10 watt	**£5·50**
FR8	8"	15 watt	**£7·60**
FR23	9 x 6"	15 watt	**£6·00**

BASS & MID RANGE—8 ohms (post 20p)

AA12	5"	15 watt	**£3·20**
B110	5½"	15 watt	**£5·60**
B200	8"	15 watt	**£6·45**
B139/2	13" x 8"	30 watt LF	**£10·25**

TWEETERS AND CROSSOVERS (post 20p)

K2006	10 watt	8 or 15 ohms	**£1·90**
FHT6	15 watt	8 ohms	**£3·20**
K2011	30 watt	8 ohms	**£3·75**
T27	KEF		**£4·25**
Axcent 100	30 watt	8 ohms	**£4·90**
K4009	1kHz/5kHz	C/o	**£2·00**
SN75	3kHz var.	C/o	**£1·75**

SPEAKER KITS (carr. etc. 35p)

20-2	8"	30 watt	**£10·00** each
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LINTON 2	20 watt		**£15·95** pair
GLENDALE 3	30 watt		**£28·95** pair
DOVEDALE 3	50 watt		**£42·00** pair
KEF KK2			**£20·40** each
KEF KK3			**£32·00** each

SINCLAIR & MINIATURE AMPLIFIERS

AMPLIFIERS (carr., etc. 20p)

4-300, 0·3 watt 9 volt	**1·75**
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608, 10 watt 24 volt	**4·10**
410, 10 watt 28 volt	**4·95**
Z30, 15 watt 30 volt	**3·57**
E1206, 30 watt 45 volt	**9·75**
Z50, 30 watt 50 volt	**4·37**
E1210, 2½ + 2½ watts 12 volt	**5·25**
RE500, 5 watt IC mains operated Amplifier with controls	**6·30**
SAC14, 7 + 7 watt Stereo with controls	**8·00**
SAC13, 15 + 15 watt Stereo with controls	**11·00**

SINCLAIR UNITS (carr. 20p)

Z30 3·57 Z50	**4·37**
Stereo 60 Preamplifier	**7·97**

PZ5 **£3·97**, PZ6 **£6·37** PZ8 (for Z50) **£4·77** (TRANS **£2·95**)
AFU **£4·45**

SINCLAIR PACKAGE DEALS Post 25p

2 x Z30, Stereo 60, PZ5	**15·95**
2 x Z30, Stereo 60, PZ6	**18·00**
2 x Z50, Stereo 60, PZ8	**20·25**
Transformer for PZ8	**2·95**
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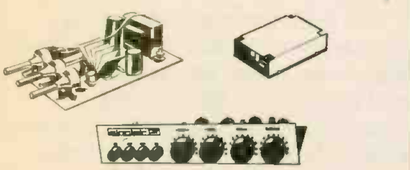

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470C 6/7½/9 volt 300 MA (includes Multi-Adaptor for Tape Recorders, etc.)	**1·95** post 20p
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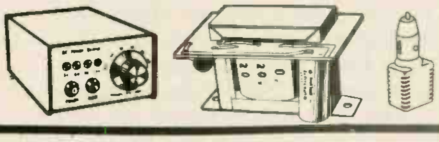
SC202 3/6/7½/9 volt 400mA	3·25 carr. 30p
HC244R Stabilised version	4·25 carr. 30p
P500 9 volt 500mA	2·80 post 20p
P11 24 volt 500mA (chassis)	2·80 post 20p
P15 26/28 volt 1 amp (chassis)	2·70 post 20p
P1080 12v 1 amp (chassis)	3·25 post 20p
P1081 45v 0·9 amp (chassis)	4·40 post 20p
P12 4½-12 volt 0·4-1 amp	6·75 post 30p
SE101A 3/6/9/12 volt 1 amp (Stab.)	9·15 post 25p
RP164 6/7½/9/12 1 amp (Stab.)	9·95 post 30p



TEST EQUIPMENT

MULTIMETERS
(carr. etc. 30p)

200H	20K/Volt Slimline with case	**4·95**
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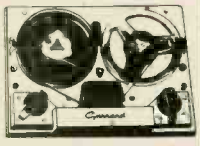
U437	10K/Volt Steel case. AC up to 40 KHz	**4·95**
U4324	20K/Volt with AC current ranges	**8·00**
AF105	50K/Volt with Leather case	**9·50**
U4313	20K/Volt AC current, Steel case	**10·50**
U4341	Plus Built In transistor tester	**10·50**
Model 500 30K/Volt		**9·95**

GARRARD BATTERY TAPE DECK
GARRARD 2 speed 9 volt tape decks. Fitted record/play and oscillator/Erase heads. Wind and rewind controls. Takes up to 4" spools. Brand new complete with head circuits. **£9·50** carr. 30p



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news digest

series of on-the-spot presentations both in Europe and Australasia of its EMI Schafer automated programming systems which enable a high proportion of a radio station's daily broadcasts to be selected and presented fully automatically, utilising prerecorded material. Designed to meet the full operational requirements of any radio station, these sophisticated systems can provide periods of non-stop broadcasting and pave the way for completely unattended station operation.

The company's Audio Automation Division, of Hayes, Middlesex, is starting these presentations in Portugal and New Zealand and, already, complete EMI Schafer systems have been airfreighted to Lisbon and Wellington in preparation for in-depth stereo demonstrations to radio station operators.

EMI Schafer automation systems utilise pre-recorded material on both reel-to-reel tapes and tape cartridges stored in carousels. Any number of tape play-back decks and carousels can be used depending on the level of automated operation required by an individual radio station. The equipment can switch automatically between live broadcasts and recorded material providing station operators with full flexibility in programme format.

In Britain, the lead in studio automation has been taken by London's Capital Radio, the largest station in the country's commercial network, which has been equipped with an EMI Schafer 903 system.

Incorporating a solid-state memory, this system selects on a time or sequential basis both live and pre-recorded 'events', including entertainment, commercials and station announcements, to provide long periods of broadcasting. Using a keyboard, an operator can insert a schedule of programmes in the memory, building up the programmes on a minute by minute basis if required.

Manufactured in the United States, EMI Schafer systems are marketed exclusively, outside North America and Mexico, by EMI Sound & Vision Equipment.

LOW COST AIR-POLLUTION MONITOR

A new range of portable, low-cost carbon-monoxide monitors, designed for making quick spot-checks or continuous monitoring of air pollution, has been announced by Analysis Automation Ltd of Oxford, specialists in the field of analytical instruments.

Six versions of this small, light-weight monitor, called the Ecolyzer are distributed in the UK by Analysis Automation and they cost less than half the price of equipment of comparable accuracy currently believed to be available.

Easy to operate and powered by integral batteries or an a.c. mains supply, the Ecolyzer incorporates an electrochemical sensor which is believed to be unique.

In operation the Ecolyzer draws ambient air through a detector cell where it passes over the catalytically-active diffusion electrode. Any carbon-monoxide present is oxidized to carbon-dioxide. The rate of oxidation is related to the concentration of CO, and can be read directly from the meter. Humidity and water vapour in the air do not affect the performance of the Ecolyzer.

The Ecolyzer is suitable for many different applications, including the continuous monitoring of urban areas as well as restricted areas such as tunnels, factories, bus depots, underground carparks and coal-mines. Industrial applications range from warehouses and factories where fork-lift trucks generate carbon-monoxide to mills and foundries with CO-producing furnaces.

In the medical field, the Ecolyzer can be used by cardiopulmonary experts to detect in the atmosphere significant amounts of carbon-monoxide which can reduce the ability of the bloodstream to carry oxygen to body tissues. The toxicity of carbon-monoxide and the high concentrations that can occur emphasise the need for more information on its generation and distribution in the environment, say Analysis Automation.

A feature of the Ecolyzer is its portability which permits fast vertical plotting of the varying levels of carbon-monoxide by spot-checking at different heights in cities.

PEKING SATELLITE EARTH STATION

The Peking satellite communications earth station supplied to the People's Republic of China by RCA Global Communications, Inc. has gone into commercial operation handling telephone, teleprinter and other communications services between China and the United States, it has been announced by RCA.

The earth station was installed under a co-operative arrangement with the Chinese Telecommunications Administration. In accordance with contracts signed August 16, 1972, for $5.7 million, the project included the supply of the Peking earth station and the expansion of the existing earth station at Shanghai, installed earlier in 1972 by RCA Globcom.

The Peking station is handling regular commercial traffic including telephone, leased channel, telegram and facsimile traffic, and has capability for live television between China, the United States and other locations in the Pacific.

The earth station is operating with the Intelsat IV satellite, located in a geostationary orbit 22,300 miles above the Pacific, and links Peking with the Jamesburg, California station and other countries' earth stations which are presently operating with the Pacific satellite.

The new earth station at Peking is equipped with a 98.ft diameter

news digest

antenna and has permanent buildings to house communications equipment. The Peking and Shanghai earth stations each will be capable of initial operation with four other Intelsat earth stations and have capacity for 60 voice-grade channels.

Chinese civil and electronics engineers and technicians were responsible for site preparation, building construction, and worked closely with RCA Globcom personnel on the antenna construction and erection as well as the electronic equipment installation at both stations.

COMPUTER AIDS IN RECONSTRUCTION OF FOURTH CENTURY SYNAGOGUE

A computer at the University of South Florida is helping to solve a 1,400-year-old architectural puzzle.

Using an IBM System/360 Model 65, Dr James F. Strange, an archeologist, has been reassembling a synagogue believed to have been levelled when an earthquake struck the Upper Galilee in 553 AD. Until recently, the synagogue and the surrounding village were covered by layers of soil and wind-blown materials.

Dr. Strange, who teaches biblical archeology, is a member of a team excavating the synagogue in the centre of Khirbet Shema - a remote Jewish community which once existed some 90 miles north of Jerusalem.

Restoration of the synagogue has progressed through three stages: excavation, planning and physical reassembly. The final piece of the puzzle is finding the type of roof which covered the structure.

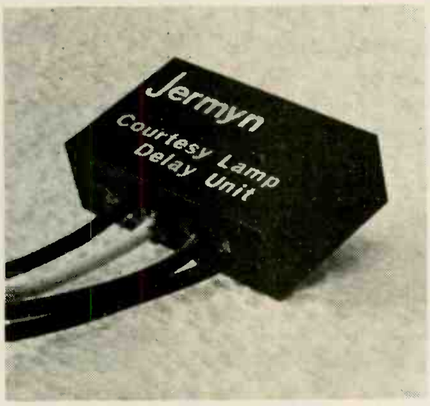
Since excavation began, some 4,000 artifacts including worked bone, ceramic stone, plaster, coins, and some examples of jewelry and organic materials have been found.

At first, the artifacts were manually listed. Later, the information connected with each item - its description and where it was found - was punched into cards and stored in the computer. Using statistical analysis and comparing the data derived from other excavated sites in the area, the computer then sorts out the data to help the team find patterns in the cultural composition of Khirbet Shema. The computer has become a valuable tool in the field of archeology, permitting findings to be quantitive, rather than intuitive.

Not only does the computer eliminate those alternatives that would take years to explore manually, but it also allows researchers to determine whether their conclusions make archeological sense.

COURTESY LAMP DELAY UNIT

Jermyn, in addition to providing a professional distribution service for electronics engineers, have always shown a keen interest in the consumer and are particularly adept at designing equipment for this market. Recent examples of this ability are the light dimmer, the capacitor discharge ignition system and the invertor which supplies 240V 50Hz from a 12V d.c. input. The latest product to be added to the range is a Courtesy Lamp Delay Switch for use in motor cars.



It was designed around Motorola's recently announced MC1455P timer integrated circuit by one of Jermyn's engineers. The unit causes a car's courtesy light to remain illuminated for about 8 seconds after the doors have been closed, allowing the occupants to see while fastening seat belts, switching on the ignition, etc, at night.

The unit is potted in epoxy resin, making it mechanically virtually indestructible. Installation is very simple, being limited to the connection of four wires (earth, supply, courtesy lamp and door switch) and the disconnection of the existing lead between the door switch and the courtesy light. Of course, the unit can be employed to operate anywhere where power has to be interrupted a fixed time after a pair of contacts open. The unit will cost £4.95.

ANTI-SHOPLIFTING SYSTEM 'CATCHES' 35 EMPLOYEES

Installed primarily to prevent shoplifting, the electronic security system at Carson Pirie Scott - the Chicago department store - has helped cut 'back-door' pilferage, too.

Say CPS: 'The effectiveness of the system has allowed the security staff to concentrate more on the problem of internal theft and register shortages in particular. Their efforts have resulted in the apprehension of 35 associates since the beginning of the year.'

Recently, the company's Director of Security reported the 'First significant change away from rising shortage figures' and he contributed much of the profitable results to his electronic security system which provides exit coverage at three stores in the Group and protects particularly vulnerable departments in other parts of the Chain.

Known in the UK as Senelco, this electronic anti-shoplifting system consists of an electronic scanner-cum-audible alarm at store, or departmental exit and small sensitised tags fixed to the goods needing protection. Cash-desk assistants remove the tags at the same time as price and swing tickets but if anyone tries to remove unpaid merchandise from the shop they trigger the alarm.

The CPS Security Chief has also stated that his system has 'saved Carsons almost £60,000 over and above the cost of the system and for this reason it will be expanded in the Chicago Retail Division.'

Shoplifting is such a problem in Chicago that the city has recently inaugurated a special Shoplifters Court! With UK shoplifters relieving retailers of £200 million goods a year, perhaps similar measures would be advisable this side of the Atlantic, too!

NEW UHF STATIONS

New IBA UHF transmitters have recently been brought into service. These are Glossop, Derbyshire on Channel 25 and Weardale, Co. Durham on Channel 41. Both are vertically polarised and will give reception to about 30,000 people.

ELECTRONICS ENGINEERS' SALARIES FALL BEHIND

The 'Survey of Salaries', published by the Management Survey Centre this August, shows that the salaries of electronic engineers working for large companies have stagnated whilst other engineers' salaries have increased. Senior chemists have done best - their salaries have increased 3-4 times more quickly than the average.

For a senior professional in development (with major responsibilities) the median salary is £4,174; for electronic engineers in particular the median at this level is £3,720.

Continued on page 74.

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SN7413	30p	SN7490	69p
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SN7447	99p	SN7493	74p

This range will be increased continuously. Please enquire about any device not yet listed.

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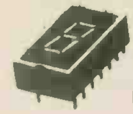


Ref. LED 1.

£1·99 + 20p VAT = £2·19

Veroboard

	Copperclad 0.1"	Copperclad 0.15"	Plain 0.15"	Extra p & p
2½" x 1"	6½p	6½p	—	
2½" x 3¾"	22p	18p	11p	
2½" x 5"	26½p	23p	13½p	
3¾" x 3¾"	26½p	23p	—	
3¾" x 5"	30p	30p	19p	
17" x 2½"	74p	55p	41p	10p
17" x 3¾"	99p	77p	57½p	10p
17" x 5"	—	—	82½p	10p
Dip Breadboard		4.15" x 6.15"		110p
Verostrip		8.5" x 1.5"		26½p
Spot-Face Cutter				40p
Pin Insertion Tool (state 0.1" or 0.15")				52p
Terminal Pins (packs of 36) state size				20p

I.C. SOCKETS

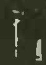
DUAL IN LINE

8 pin	13½p	16 pin	17½p	36 pin	39½p
14 pin	15½p	24 pin	26½p	40 pin	44p
		28 pin	30½p		

HEAT SINKS

TV2 for TO 66 15p. 5F for TO-5
TV3 for TO 3 16p. 18F for TO 18

5½p.



TV4 for TO 126
TV5 for TO 220

DIP10 2 for SL403D
DIP14 5 for EA1,000

14p

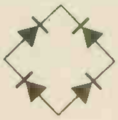
16p

10DN400 4
4Y 1 4

46p

35p

BRIDGE RECTIFIERS



P.I.V.	1 AMP	R.M.S.	2 AMP
100V	20p	50V	35p
200V	22p	100V	40p
600V	25p	200V	45p
1000V	38p	600V	50p

RECTIFIERS

P.I.V.	1 AMP		3 AMP	
50	1N4001	6½p	1N5400	15½p
100	1N4002	7½p	1N5401	16½p
200	1N4003	9p	1N5402	17½p
400	1N4004	9P	1N5404	22p
600	1N4005	11p	1N5406	26½p
800	1N4006	13½p	1N5407	30p
1000	1N4007	16½p	1N5408	33p
BY100		16½p	BY133	23p
BY103		22p	BY164	55p
BY105		16½p	BY176	£1.65
BY126		16p	BY182	£1.65
BY127		16½p	BY250	25½p

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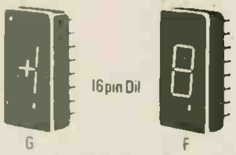

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RATING	TYPE	TOLERANCE	RANGE	PRICE EACH
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1/8 Watt	Carbon Film	± 5%	E24 Series 5.1Ω to 330KΩ	1½p
1/2 Watt	Metal Oxide Film	± 2%	E24 Series 10Ω to 1MΩ	4½p
1/2 Watt	'Cernet' thick film	± 2%	E12 Series 56Ω to 150KΩ	8p
1/2 Watt	Carbon Film	± 5%	E24 Series 10Ω to 10MΩ	1½p
1/2 Watt	Carbon Composition	± 0.5%	2.2Ω; 2.7Ω; 3.3Ω; 3.9Ω; 4.7Ω	4½p
1 Watt	Carbon Composition	± 10%	5.6Ω; 6.8Ω; 8.2Ω	5½p
1 Watt	Carbon Film	± 5%	E12 Series 10Ω to 10MΩ	3p
2 Watt	Carbon Film	± 5%	E12 Series 10Ω to 10MΩ	6p
2½ Watt	Wire Wound	± 10%	E12 Series 0.22Ω to 0.47Ω	10p
2½ Watt	Wire Wound	± 5%	E12 Series 1Ω to 270Ω	10p
5 Watt	Wire Wound		E12 Series 0.5Ω to 8.2KΩ	10p
10 Watt	Wire Wound		0.5Ω to 6.8KΩ	11p
10 Watt	Wire Wound	± 5%	10KΩ; 15KΩ; 20KΩ; 25KΩ	17p
15 Watt	Wire Wound		10Ω to 6.8KΩ	13½p

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CERAMIC DISC – Low Voltage
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0.1μF, 0.22μF, 0.47μF — 6½p

POLYSTYRENE – 160V from 10pf to 0.01μF in multiples of 10pf, 15pf, 22pf, 33pf, 47pf & 68pf — 5½p

MYLAR PLATE – 400V
1000pf, 2000pf, 5000pf — 2½p
0.01μF, 0.02μF, 0.04μF, 0.05μF — 3½p
0.068μF, 0.1μF 5p; 0.2μF — 6½p

MULLARD C280 – 250V Polyester
0.01μF, 0.015μF, 0.022μF, 0.033μF, 0.047μF — 3½p
0.068μF 4p, 0.1μF, 0.15μF 4½p, 0.22μF — 5½p
0.33μF 7p; 0.47μF 9p; 0.68μF 12p; 1.0μF — 14½p
1.5μF 22p; 2.2μF 26½p

MULLARD C281 – 400V Polycarbonate
0.01μF, 0.015μF, 0.022μF 5p; 0.033μF 6p
0.047μF 6½p, 0.068μF 6½p, 0.1μF 8p; 0.15μF — 9p
0.22μF 11p, 0.33μF 15½p, 0.47μF 16½p

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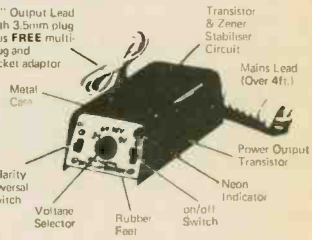

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AC126	13p	AF179	71½p	BC213L	11p	BF167	27½p	BFY51	16½p	OC83	22p	2N2646	55p						
AC127	13p	AF239	41p	BC214L	11p	BF173	22p	BR100	43p	OC140	22p	2N2905	46p						
AC128	13p	ASY26	33p	BC268	15p	BF177	28p	BRY39	44p	OC170	27½p	2N2924	18p	2N3905	23p	AA119	10p	BA222	7½p
AC176	15p	BC107	9p	BC327	26½p	BF178	29p	BSX20	18p	OC171	33p	2N2926 all	10p	2N3906	25p	AA120	10p	BAV10	11p
AC187	22p	BC108	9p	BC328	24½p	BF179	33p	BSX21	22p	TIC44	46p	2N3053	22p	2N4058	13½p	AA129	10p	BAW62	10p
AC187K	20p	BC109	9p	BCY70	17p	BF180	33p	BSY95A	13p	TIC226D	£1.97	2N3054	55p	2N4289	16½p	AAZ/3	11p	BAX13	9p
AC188	22p	BC114	15½p	BCY71	17p	BF181	35½p	BU105	£1.75	TIP41A	81p	2N3055	52p	2N4441	87p	BA100	10p	BAX16	10p
AC188K	20p	BC117	22p	BC210	28p	BF184	27½p	BU105/02	£1.92	TIP42A	99p	2N3391A	29p	2N4442	£1.06	BA102	27½p	BAY38	41p
ACY17	24p	BC147	9p	BC211	28p	BF185	27½p	D13V	53p	TIS43	36½p	2N3566	18p	2N4443	£1.45	BA110	45p	BB105	42p
ACY18	21p	BC148	9p	BD115	74p	BF194	15p	MJ4000	£1.49	TIS73	£2.10	2N3638	20p	2N4444	£2.09	BA111	55p	BB141	99p
ACY19	25p	BC149	9p	BD124	82p	BF195	17p	MJ4010	£1.49	TIS91	33p	2N3702	11p	2N4871	60p	BA112	99p	BB142	82p
ACY20	22p	BC157	13p	BD131	68p	BF196	16½p	MJE340	52p	2N697	16½p	2N3703	10p	2N5129	16½p	BA114	9p	OA5	99p
AD140	40p	BC158	12p	BD132	83p	BF197	16½p	MJE2955	£1 82	2N706	13p	2N3704	11p	2N5172	9p	BA115	19p	OA10	94p
AD149	38p	BC159	14p	BD131/2 pr.	£1.49	BF200	35½p	MJE3055	92p	2N708	16½p	2N3705	10p	2N5459	36½p	BA116	9p	OA47	11p
AD161	29p	BC168B	11p	BD133	83p	BF220	27½p	MPF102	27½p	2N914	24½p	2N3706	10p	2N5777	47p	BA128	11p	OA79	10p
AD162	29p	BC169	12p	BD135	42p	BF244B	27p	MPF103	41p	2N1302	20p	2N3707	12p	2N6076	14p	BA129	23p	OA81	8p
AD161/62pr.	59p	BC171	20p	BD136	50p	BF262	25p	MPF104	45p	2N1303	24p	2N3708	9p	3N140	£1.01	BA143U	75p	OA85	10p
AF114	14p	BC172	17½p	BD137	57½p	BF263	25p	MPF105	45p	2N1304	24p	2N3709	10p	3N141	89p	BA143V	67p	OA90	8p
AF115	14p	BC174B	35p	BD138	74½p	BF272	£1.21	MPF106	49½p	2N1305	24p	2N3710	11p	3N152	£1.01	BA144	20p	OA91	8p
AF116	14p	BC177	22p	BD139	78p	BF390	37p	OC28	33p	2N1306	24p	2N3711	11p	3N153	89p	BA145	22p	OA95	9p
AF117	14p	BC178	22p	BD140	91½p	BFS28	£1.01	OC35	38p	2N1307	27½p	2N3771	£1.82	40360	51p	BA148	22p	OA200	11p
AF118	92p	BC179	24p	BD201	£1 55	BFW10	67p	OC36	38p	2N1308	27½p	2N3772	£2.75	40361	50p	BA154	20p	OA202	12p
AF124	24p	BC182L	9p	BD202	£1.37	BFW11	67p	OC44	13½p	2N1309	27½p	2N3773	£2.20	40362	50p	BA155	15½p	OA210	19½p
AF125	22p	BC183L	9p	BD203	£1.55	BFW87	38p	OC45	13½p	2N1613	22p	2N3819	28p	40408	55p	BA156	16½p	OA211	30p
AF126	22p	BC184	9p	BD204	£1.37	BFX29	43p	OC71	13½p	2N1711	26p	2N3823	99p	40430	£1.39	BA182	26½p	1N914	8p
AF127	22p	BC184L	9p	BF109	75p	BFX30	37½p	OC72	43½p	2N1893	52½p	2N3903	16½p	40432	£2.17	BA220	7p	1N916	10p
AF139	35p	BC187	27½p	BF115	25p	BFX88	26p	OC75	15p	2N2160	£1.54	2N3904	19p	40673	55p	BA221	7p	1N4148	5½p

THICK FILM CIRCUITS

Slowly but surely, Thick Film Circuits are finding their place in a whole variety of electronic applications. Keith Pitt explains.

MANY OF US are now familiar with the silicon integrated circuit. Large numbers of them are beginning to spread from the digital world of computers to the field of consumer electronics. Specially designed integrated circuits are fulfilling many complex functions in radio and, especially, in colour television. Their uses range from detector and I.f. circuits to audio amplifiers. Integrated circuits can produce complex digital functions cheaply and with low power dissipation. The analogue circuits used in radio and television are not as cheap and consume rather more power. Nevertheless both cost and power are often less than they would have been using conventional components.

The twin governing factors in the production of a piece of electronic equipment are size and cost. Although a television set, for example, is limited to a minimum size by its tube, there is still much scope for reducing the complexity and volume of the electronics. A few integrated circuit packages will replace a large number of conventional components and simplify and cheapen the assembly. This is one aspect of the cost reduction, but the main scope for this is in the mass-production of a few standard building blocks.

Cutting the ten-times full size artwork for a microelectronic circuit. This pattern is reduced to manufacture the screen stencil. (Courtesy Middlesex Polytechnic)

However, we often find that after as much as possible of a piece of equipment has been made in silicon integrated circuits, there are still a large number of components left unaccounted for. A way of combining as many of these as possible into integrated packages is also required. The majority of these components will be resistors and capacitors. Whilst the latter do not lend themselves so easily to integration, there is a ready-made technology available for the former. This technology is known as "thick films". It was first developed for mass production of resistor networks for computers by IBM. It has since found widespread use in the automotive and professional electronics industries and is now coming into full production for radio and T.V. applications. Thick films lend themselves readily to cheap mass production of resistors which are rather better in quality than needed for many of their applications.

Manufacturers of electronic equipment are adopting thick film circuitry for a variety of reasons. Decreased size and enhanced reliability attract the professional and military markets. For consumer and automotive users mass production of uniform packages decreases assembly costs. When pushed to the limit, thick films are cost compatible with conventional components.

THICK FILMS

Thick film technology is based on glazes fired onto a ceramic substrate, usually alumina. The process is developed from and similar to that used in pottery and china making for producing the coloured patterns we see, for example, on tea services. For electronics the glazes may be conducting, resistive or insulating. They are usually about one thousandth of an inch in

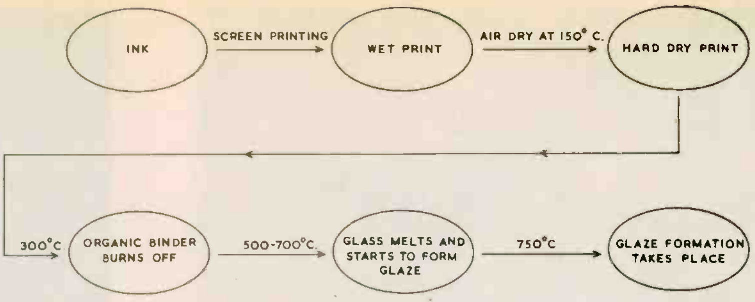


Fig.1. Principle of formation of a glaze, showing stages between ink and ***glaze.***

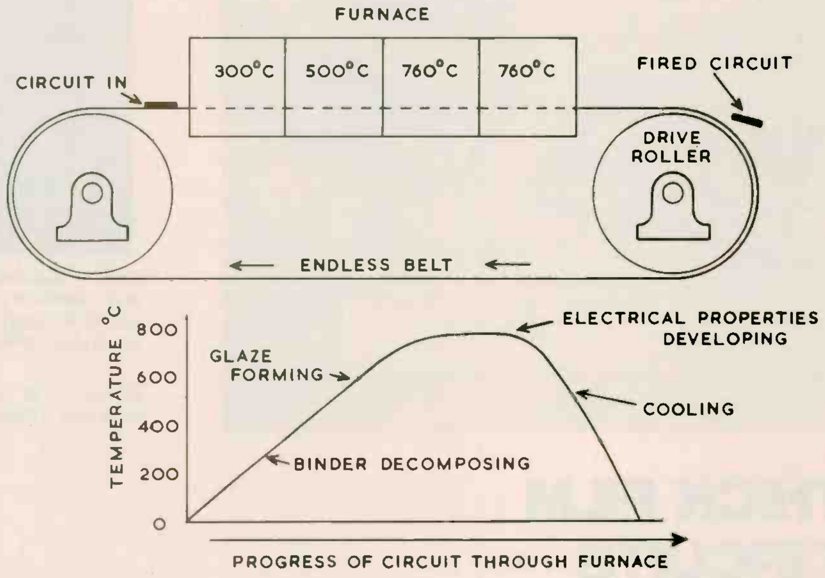


Fig.2. Principle of belt furnace for glaze making.

thickness. Like their decorative counterparts they are screen printed from an ink or paste and then kilned at a high temperature to convert the ink into a glaze.

GLAZES

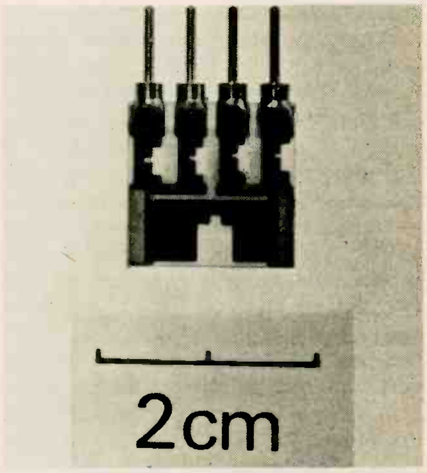
The principles involved in glaze making are very simple but the behaviour of the inks is rather complex giving rise to a number of technological problems. These have now been solved and the processes lend themselves to mass production with high yield, for both pottery and electronics applications. We will first look at the principles of the process and then concentrate on resistor glazes which, together with conductors, are the main application in electronics.

Figure 1 shows the basic stages of producing a glaze. The ink is a complex mixture of glass and pigment particles, an organic binder and a solvent. For resistors the pigment is generally a combination of precious metals and/or their oxides. (One of the best available systems is based on the oxide of ruthenium). The conductor pigments are precious metals such as silver or gold, usually in combination with palladium or platinum. The cheapest conductor which is widely used for consumer applications is a glaze of an alloy of silver and palladium. The pattern is produced from the ink by the screen printing process (we will look briefly at this later). The ink is printed onto a piece of ceramic, usually a high grade alumina for electronics purposes, this wet pattern dries partially in air as the solvent evaporates, but is usually force dried at about 150°C. The dry print can be handled with care and further printing may be done at this stage if necessary. If not, the ceramic substrate is then put into the kiln to produce the glaze. For convenience in mass production a belt furnace is used. This employs an endless belt moving through a furnace which is divided into a number of temperature zones. These are set in such a way that the heat treatment given is of a known and controlled nature. This is necessary in order to produce the correct electrical properties. Fig. 2 illustrates the use of a belt furnace for electrical glazes.

In this article we shall only consider resistors and conductors. Dielectric and insulating glazes are used but their applications are limited. When two conductive tracks need to cross, they are separated by a layer of insulating glaze. (Such patterns are known as crossovers and have applications especially in complex circuitry). Before discussing the technology and applications of thick films we will look at the type of patterns needed for resistor networks.

THICK FILM NETWORKS

A thick film network is rather similar to our old friend the printed circuit. It consists of conducting lines or areas on a board which will be used to interconnect other components. Unlike the p.c. board, however, some, at least, of the other components are themselves on the board or, as it is now called, the substrate. We must not take the analogy too far, but we can add surface components such as transistors or capacitors to a film network in the



Pluggable attenuator pad for digital and voice frequency transmission equipment. Courtesy Welwyn Electric Ltd.

SOME APPLICATIONS OF THICK FILM HYBRID CIRCUITS

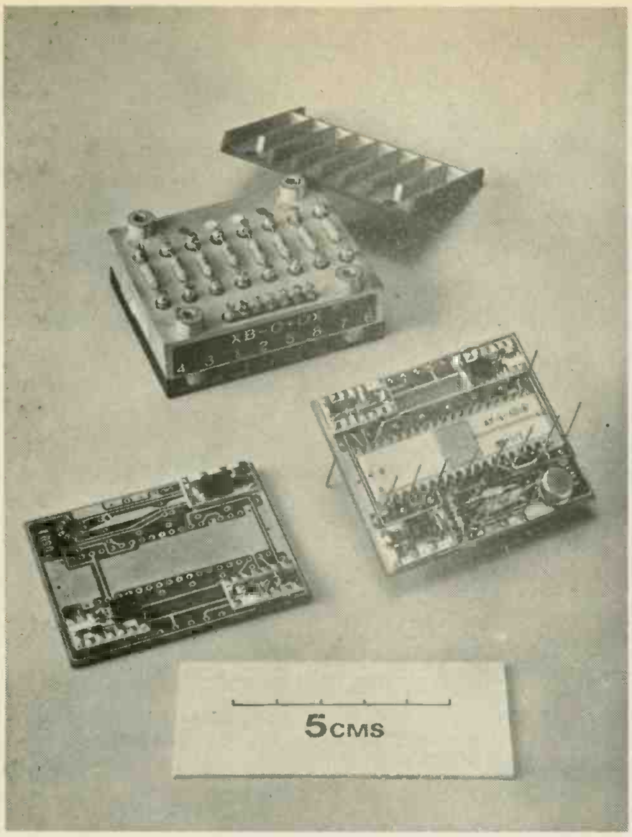
Military and Space Equipment

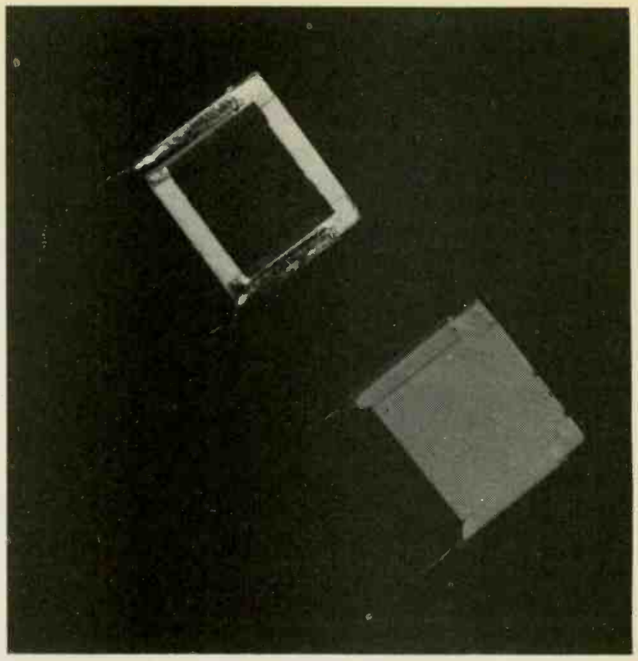
Professional Electronics
- Instrumentation
- Computers
- Communications Systems

Medical Electronics
- Deaf Aids
- Pacemakers
- Ultrasonic Aids for the Blind

Consumer Products
- Washing Machines
- Radio
- T.V.
- Audio

Automotive Industry
- Voltage Regulators
- Ignition Systems
- Electronic Instruments
- Braking Control





Left. Exploded view of a hybrid data selection unit. The unit combines thick film hybrid circuits with a double sided plated through hole printed circuit board and a package containing an L.S.I. silicon integrated circuit. Courtesy Welwyn Electric.

Above. A thick film power resistor for use in television receivers. Courtesy Erie Electronics.

THICK FILM CIRCUITS

same way as to a board (for example by soldering). In this case it becomes known as a hybrid circuit. Hybrids are also widely used in electronics and will be examined below.

The value of a film resistor depends on a number of factors. These are, briefly, shape, thickness and chemical composition. It can be shown that any square of a given resistor material of the same thickness will have the same resistance value. This helps to reduce the number of variables and allows us to set rules for making resistors. We produce our patterns by screen printing (see below) and this technique gives a constant value of thickness. As a result we find in practice that, using any particular resistor glaze, the value of the printed and fired components is solely dependent on their geometry. In a square the length, L, and width, W, are equal. If we make L = 2W, then L/W = 2, and the value is twice that of a single square. If, on the other hand, we make L = ½W, then L/W = ½ and the resistance value is half that of one square. By varying the ratio of L to W we can produce a range of resistor values. The principle is shown in Fig. 3. If we change the composition of the resistor, then we get a different value for the resistance of one square. Once again we can choose the exact value by varying L/W. Since inks are available

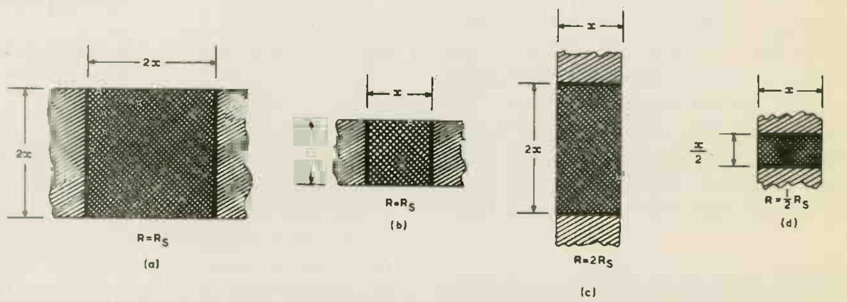


Fig.3. The principle of film resistors. Any square of the same material has the same resistance R_S. As both a and b are squares of the same thickness, they are both resistors of value R_S. Since c is twice as long as it is wide, it is a resistor of value $2R_S$ and d is similarly $\frac{1}{2}R_S$.

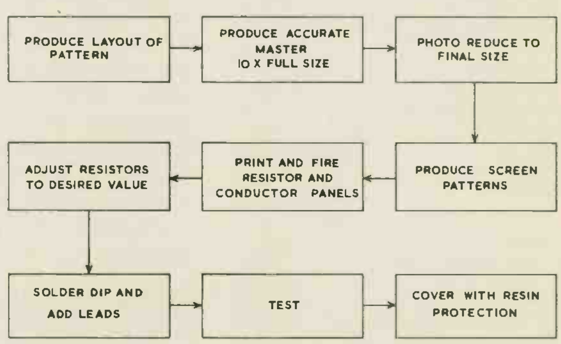
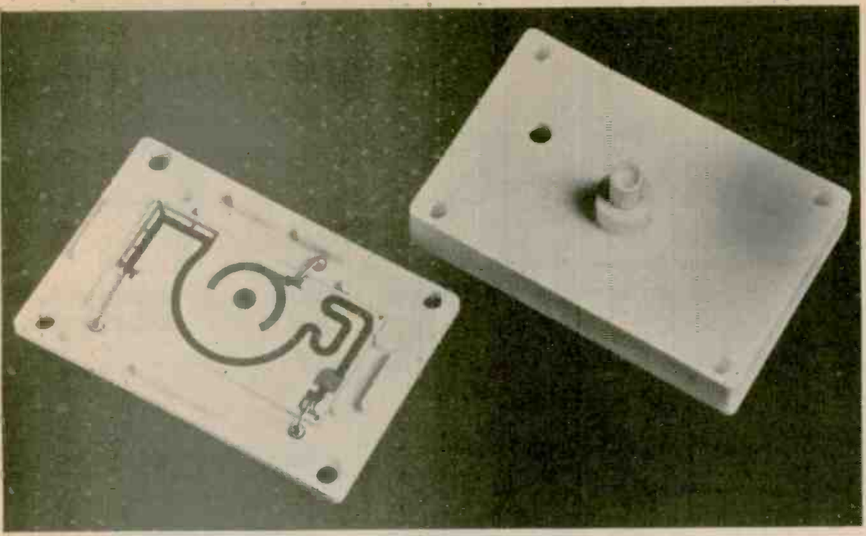
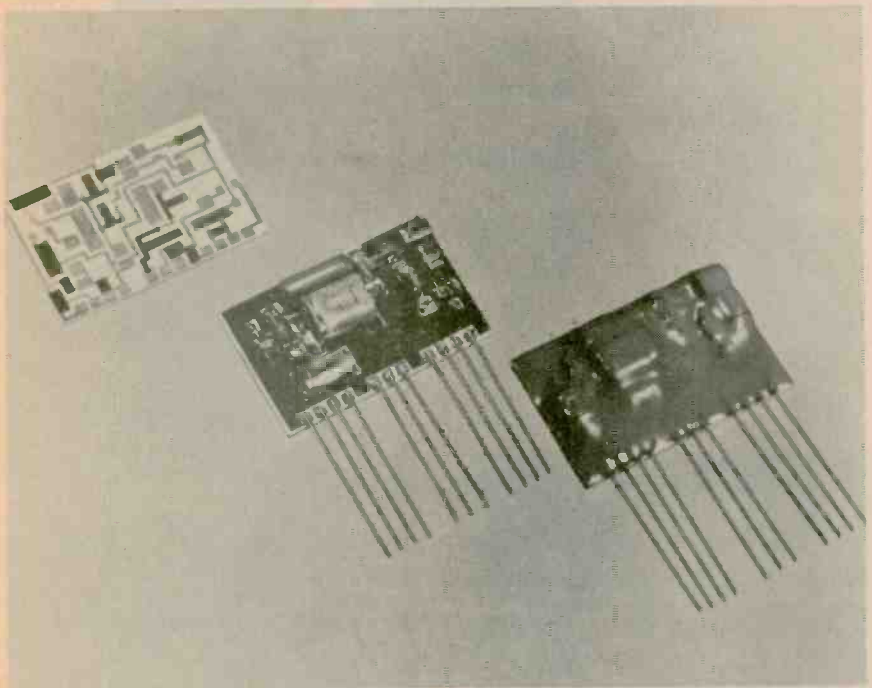
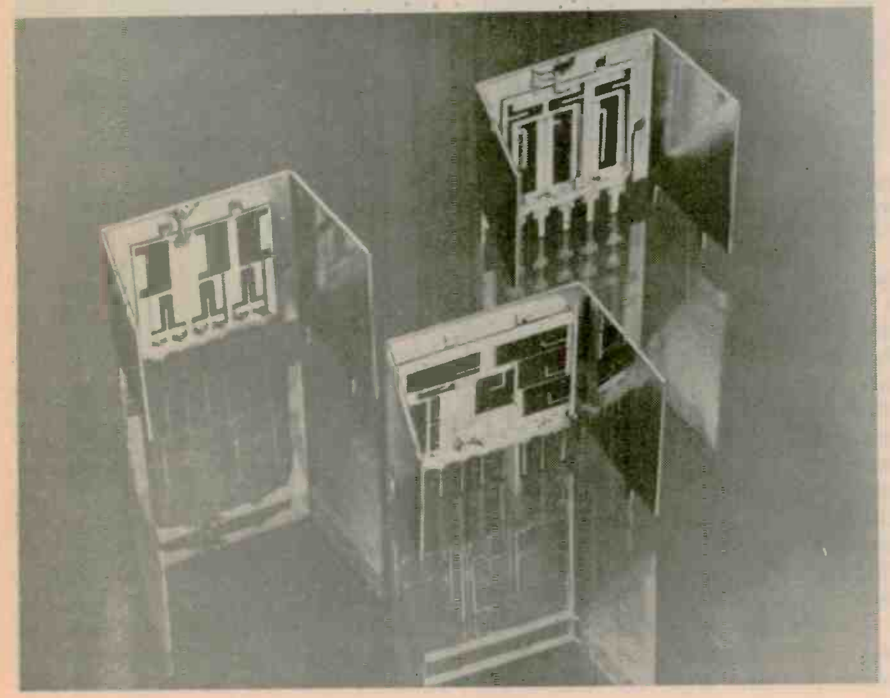


Fig.4. Schematic of thick film production processes.







Left. Focus potentiometer for colour television sets. Courtesy Erie Electronics.

Centre left. Custom built thick film hybrid assembly for the consumer market. The photograph shows from left to right the substrate with resistor and conductor patterns immediately after firing. The complete assembly prior to encapsulation and the module ready for assembly into a printed wiring board. Courtesy Erie Electronics.

Bottom left. High power multiple resistor assemblies with heat sinks for the consumer electronics market. Erie Electronics.

which produce a range of sheet resistances from fractions of an ohm for a square up to several megohm/square, by choosing the correct inks and geometry we can produce resistors from about ½ ohm up to many megohms. If need be we can print a range of inks in one network so that widely differing resistor values can be used in one circuit.

The conductor patterns serve to interconnect the resistors and to enable electrical contacts to be made between them and the outside world. Their dimensions are very much less critical than those of resistors. Some of the photographs show typical networks.

In the next section we shall look at some of the stages of production of a thick film resistor network.

THICK FILM PRODUCTION

Figure 4 shows schematically the main production stages for thick films. After a rough design of the pattern has been produced, it is drawn accurately, usually at ten times full size. This is photographically reduced to the exact size. The resultant negative is then used to produce the screens for the printing process. Fig. 5 shows the resistor and conductor patterns for a single power resistor for T.V. use and its final shape with pins for soldering into a printed circuit board. (Examples of similar resistors may be found in most current and recent colour T.V. sets).

In the screen printing process a mesh of polyester (terylene) or stainless steel mounted on a metal frame has most of its area blocked with an emulsion material. The only areas which are free are those where the pattern is required. The substrate is held beneath the screen and a hard rubber squeegee moves over it, forcing ink through the holes leaving a printed pattern on the ceramic; this is shown in Fig. 6.

In production, hoppers feed the substrates into position and automatic printing takes place at a rate of many hundreds per hour. The printed substrates are then fed onto a belt through a drying zone at 150°C before moving into giant belt furnaces for the firing of the glaze. They are then ready for the next stages of production. If the resis-

THICK FILM CIRCUITS

tor values are not very critical, the networks may already be within tolerances. If so, the leads or pins used for connection to the outside world are soldered in place. This eliminates one major production stage, keeping the cost down. In general, however, it is unlikely that a high yield of better

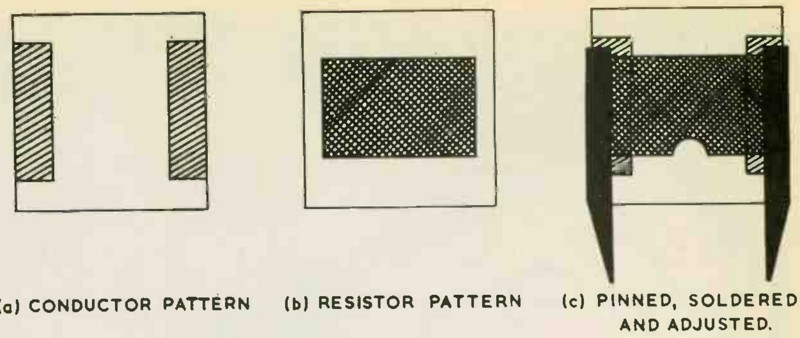
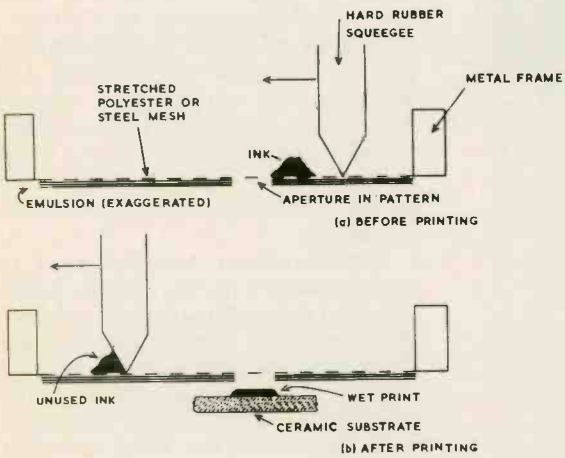


Fig.5. Thick film power resistor for plugging into a TV p.c.b.



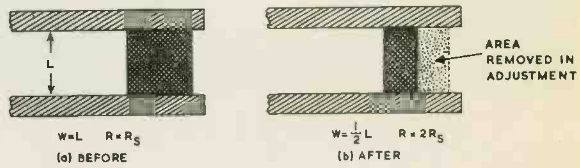


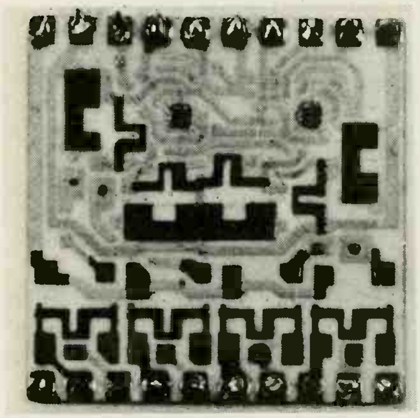
Fig.6. (left) The screen printing process.

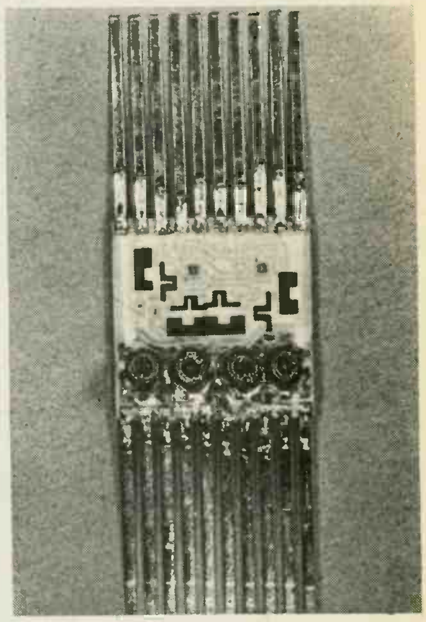
Fig.7. (above) Adjustment of thick film resistors.

than about 25% tolerance resistors will be obtained in this way.

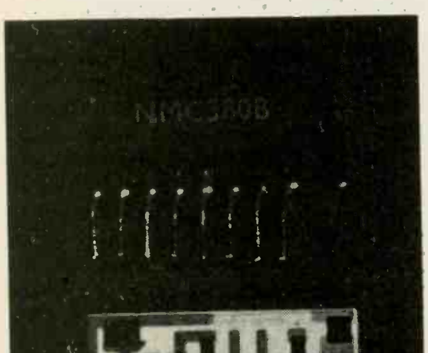
More commonly the resistors are adjusted upwards in value after firing and before soldering. We saw earlier that the value depends on the ratio of length to width. Adjustment alters this ratio by removing part of the resistor area, (Fig. 7). This may be done in either of two ways. In the older, but very commonly used process, a fine jet of abrasive particles is fired at the resistor until its value reaches a target. In production, machines are used which automatically adjust several resistors at a time to a target of ± 1% and then stop and pass onto the next substrate. Any reject is automatically thrown out. A much faster process using laser trimming is now taking over in mass production, especially for consumer products. The capital outlay of a computerised laser trimmer is about £60,000, but the fantastically fast through-put of accurately trimmed circuits leads to a lower unit cost than by air abrasion.

After soldering and attachment of leads, the network is coated with a protective resin layer and is available to the customer after a final electrical test.





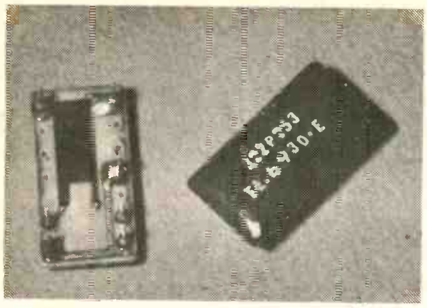
Thick film hybrid circuit for the military or aerospace market. The photograph on the right is of the same unit but with four miniature transformers. Courtesy AB Electronic Components Ltd.



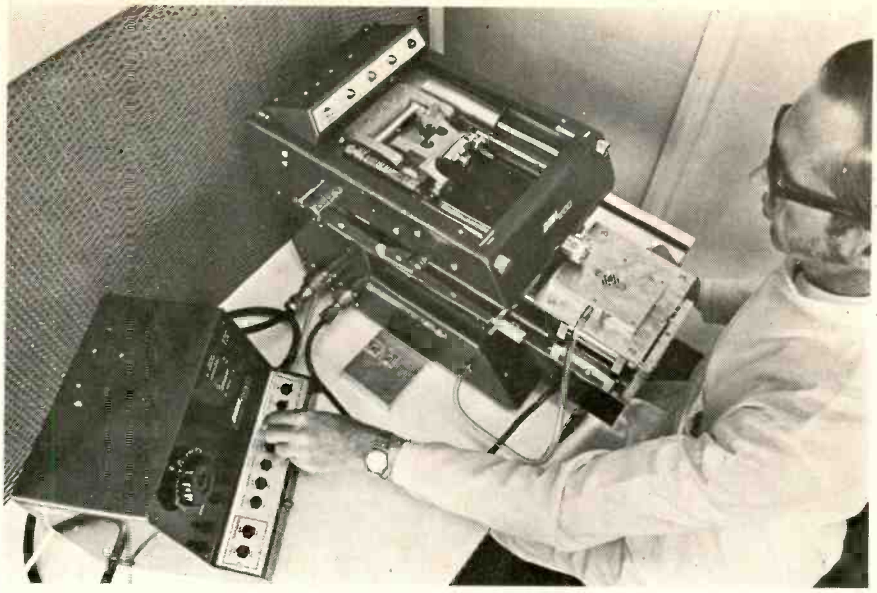
Professional electronics industry hybrid thick film module. Courtesy Newmarket Transistors Limited.

HYBRID CIRCUITS

For many purposes a plain resistor network is insufficient. Many of the thick film networks in use have transistors and other devices mounted on their surfaces: these are called hybrid circuits. Some very complex circuits are made in this way. The semiconductor devices are sometimes added as cheap plastic transistor packages soldered in place, but are also used unpackaged as chips of silicon mounted directly onto the film. Special minia-



Computer interface circuit showing a package which is used in large quantities by British computer manufacturers because its pins are dimensionally compatible with those of the standard integrated circuit DIL package. Courtesy Erie Electronics



Right. Thick film screen printing process. Courtesy Middlesex Polytechnic.

ture capacitors are also used. These may be ceramic chips for low values or dry tantalum for high values. The photographs illustrate a number of hybrid circuits with their added components. The completed and tested hybrid is finally resin encapsulated.

APPLICATIONS

Space only permits a brief mention of a few applications of thick films and hybrid circuits. A vast number of resistor networks and true hybrid circuits are still being used by the computer industry. Many leading radio and T.V. manufacturers are now including thick films in their sets. This demand is still growing and will probably continue to do so with the boom in colour television. Another growth area is the automotive market, many thick film circuits are now in production for use in cars. The pioneer for this in the British market was a voltage regulator made by Joseph Lucas which has been in production for several years. Other car and component manufacturers are using this new tool to produce cheap sophisticated electronic devices for their vehicles. Much of the new generation of car instrumentation coming into use employs a combination of thick film and monolithic microelectronics technology.

Loading printed substrates into a belt furnace. Photo courtesy Middlesex Polytechnic.

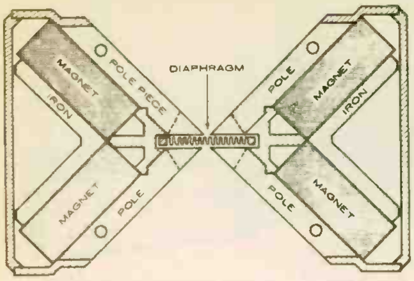
CONCLUSIONS

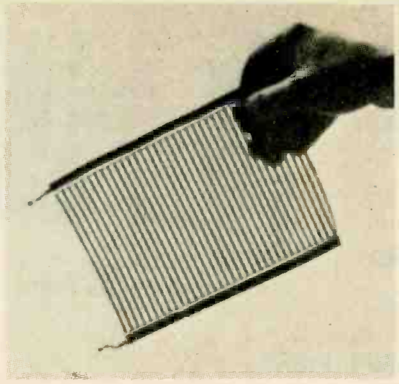
Since the mid 1960's the consumer and industrial electronics industries have changed greatly in their technologies. Firstly the take-over of transistors from valves produced a great revolution. The next stage which is with us now is the integrated package - integrated semiconductor circuits or thick film and hybrid circuits. The fallout of monolithic integrated circuits from industry is now making its full impact on the home constructor (this can be seen from the advertisements in this journal). These circuits are made to perform specific functions which have application in fields far from their original purpose. Thick film circuits and hybrids are less likely to hit this market because they are very rarely made as general purpose functions. Almost invariably they are made for specific applications and would have no value elsewhere. (One exception is a thick film hybrid power amplifier produced by one of the leading Japanese manufacturers for the home user. This is a sophisticated and complex product employing the technology very effectively). However, it is extremely probable that more and more of these packages will be met in the course of servicing equipment. In the event of failure they should always be replaced with a similar module from the manufacturer. ●

HI-FI – the state of the art

Editorial Director, Collyn Rivers, reports.

Photograph reproduced by courtesy of Trio Electronics, Tokyo





HEIL AIR MOTION PRINCIPLE

Diaphragm of Heil driver is a convoluted polythene membrane carrying a continuous-foil conductor analogous to the 'voice coil' in a conventional speaker.

This diaphragm is inserted between two large magnetic pole pieces.

When the electrical audio signal passes through the conducting foil, the folds of the diaphragm vary their spacing, thus altering the space between them and hence generating the acoustic signal.

The unusual action of the driver produces a very large air movement for a small motion of the diaphragm — thus it is very efficient — about 3 to 4 percent say Heil.

Not apparent from the drawing is that the magnetic pole pieces are in fact an open grip of parallel strips thus allowing the sound to be emitted from both sides of the diaphragm.

Practically unique in its operating principle, the Heil driver has extremely low inertia and no resonances within its operating range.

DESIGNERS, whether of hi-fi equipment, motor cars, or even houses, tend to fall into two main groups — categorised by the way in which they think, or are allowed to think.

The first type of designer thinks 'vertically'. He develops new devices by building on the accumulated experience of what went before — examples of this are the Shure V15 Mk III cartridge (reviewed in this issue), the Rolls Royce motor car and the majority of domestic architecture.

The second type of designer thinks 'laterally'. He takes advantage of modern technology but little heed of the form in which previous generations thought things should be. Here, examples of lateral thinking include the Beogram 4000 turntable, the Heil Air Motion loudspeaker, the ID Citroen and the BLMC Mini, and, the field of housing, Buckminster Fuller's geodesic domes. (readers interested in lateral thinking should study the numerous books by Edward de Bono).

Until recently, the hi-fi industry has been characterised by vertical design with very few truly fresh approaches to problems:

There have been a few exceptions — such as Henry Kloss' development of the AR range of acoustically suspended speakers, Ray Dolby's noise reduction system etc, but these are examples of what one might describe as 'diagonal thinking', owing as they do, something to both design approaches.

The biggest problem afflicting the designer committed to the horizontal approach is that he is almost invariably competing with conventional systems that despite their fundamental 'wrongness', have, nevertheless, been refined over decades of vertical development. A classic example of this is the reciprocating internal combustion engine, another is the deep keel yacht.

It is then all the more to the credit of Bang and Olufsen that their new Beogram 4000 turntable is so good.

Now, all over the world, design engineers are taking a fresh look at many areas of hi-fi equipment design and, in our opinion at least, the next two or three years will see some most dramatic developments in the recording and reproduction of sound.

VALUE FOR MONEY

On a more down to earth level, some very worthwhile developments have been taking place primarily in the upper and lower thirds of the hi-fi price range.

A couple of years ago it was said 'hi-fi starts around £200'. This is still very largely true today — although several companies are producing complete systems at £100 or even less. One example of these is Pioneer's new 'Prelude 500' system (sold only as a total package of amplifier, turntable and two speakers) at a recommended retail price of about $300. This system is not yet available in Britain.

Two years ago the optimum amount of money to spend on a hi-fi system — judged purely on a performance/price basis — was somewhere between £300 and £400. Surprisingly, despite inflation, the best value for money is now achieved by spending slightly less.

The reason for this is the recent introduction of a number of really good loudspeakers costing between £60 and £100. Many of these, such as the smaller products from AR, Advent, Dynaco, Audiosound, Rectilinear etc, compete with their larger and more costly counterparts in practically every way except power handling capability.

True, it is still not possible to obtain really deep bass from a small loudspeaker, but for the great majority of hi-fi enthusiasts the limitation on bass reproduction is the size of their listening room rather than the depth of their pocket. As this is a point rarely understood by hi-fi enthusiasts, we have included a table within this article listing the lowest bass frequency that can be realistically reproduced in rooms of various lengths.

TOP OF THE SCALE

At the upper end of the price scale, recent developments include the Beogram turntable previously described — even at its selling price of £160 plus, people are queuing up to buy it. Shure's new V15 Mk III is somewhat of a mile stone (kilometre stone ?) in cartridge design for it typifies what may well be the ultimate manifestation of this type of design. It is difficult to see what further improvements could reasonably be made whilst staying within the bounds of current technologies.

In the field of loudspeakers, the Heil Air Motion Loudspeaker may well be the first of a new generation of loudspeaker designs. At present it is available only as a mid-range and treble unit, but the manufacturers are actively developing a bass driver as well. We have not heard this unit ourselves, but authoritative sources in the USA are lavish in their praise. Hirsch-Houck Laboratories for instance wrote 'Even if we had never listened to . . . this speaker, its measured frequency response alone would invite the use of superlatives. This is one of the few speakers we have tested, in a normally 'live' room, whose overall frequency response and smoothness are comparable to those of a good high-fidelity amplifier — and that is no small achievement'.

For those who prefer a more conventional approach, Acoustic Research's LST is probably the loudspeaker equivalent of the new Shure cartridge. It is best described as the ultimate AR3a, and for those who can afford the room — and the price — it is well worth consideration.

Shure's superb new V15 Mk III cartridge.

Trend-setting 'Prelude 500' system from Pioneer retails for less than $300.

TAPE RECORDERS

Enormous improvements have been made in cassette decks and it is now possible to buy cassette machines that have a standard of reproduction virtually indistinguishable from reel to reel machines. Inbuilt Dolby or other noise reduction systems are now standard in all top quality cassette machines, and the use of these circuits has removed the tape hiss that was characteristic of cassette players until recent times.

Regrettably there is still a shortage of pre-recorded cassettes of any worthwhile standard and far too much pre-recorded material is produced on tape of such poor quality that one can but marvel at the sheer cynicism of the producers. This is rather a pity because some truly excellent tape cassettes are now readily available, and these high quality cassettes must be used if the performance built into the top cassette players is to be exploited.

The arguments and counter-arguments between protaganists of iron oxide and chromium dioxide tapes still rages. At the risk of losing all our good friends in the tape business it is our opinion that there is very little difference in listening quality between any of the tapes made by the leading contenders. It's a bit like the light platter versus heavy platter turntable affair – it doesn't really matter which technique is used just so it is used properly.

It is of course true that chromium dioxide tape must be used with a machine for which it is specifically intended as quite different bias levels and erase levels are required.

Equally important is to use the tape recommended by the machine's manufacturer, or, for those with the necessary technical ability, to optimize bias for one brand and type of tape and to use that tape only.

Advances in reel-to-reel machines are now confined almost entirely to those machines intended for professional use. Excellent reel-to-reel machines are still marketed for domestic use, but their sales seem to be mainly limited to tape enthusiasts who find that editing is so much simpler with this type of machine.

AMPLIFIERS

Amplifier development continues along conventional lines, although there is an increasing tendency toward higher power outputs. The justification for such large amplifiers is the inefficiency of many new types of speaker systems. In fact it is probably true to say that were it not for the availability of multi-hundred watt amplifiers, the transmission line speaker (and others) would not have been commercially feasible.

Performance of top quality amplifiers is now very good indeed – they are fast approaching the ideal of a piece of non-inductive wire with adjustable frequency characteristics and gain.

At the lower end of the scale there are now some excellent amplifiers priced between £60 and £100, which are more than adequate to drive the new generation of similarly priced speakers described above.

THE GREAT FOUR-CHANNEL WAR

One day in the future, battle scarred marketing executives are going to take their grandchildren on their knees and tell them wondrous tales of the Great Four-Channel War.

Now well into its third year, there is still not the slightest sign of a reconciliation between the competing matrix and discrete camps, although the battle lines are now more clearly defined, for, going along with that fine old Middle Eastern proverb that 'the enemy of my enemy is my friend', the various matrix proponents (with the possible exception of Sansui) now appear to see the RCA discrete system as their common enemy.

MATRIX SYSTEMS

Basically all matrix systems are the same in that they attempt to encode four channels of information onto a two channel record (or tape). Decoding circuitry built into the receiving equipment then decodes the encoded material – aiming (but not always succeeding) to direct each information channel to its 'correct' loudspeaker.

The only real difference between the competing matrix systems lies in the proportions and phase relationships in which the original four channels of programme material are mixed down to two – and expanded out to four again. Following some furious technical battles between a dozen or so companies, there now remain only two major contenders, Columbia's SQ system, and Sansui's QS system.

The Columbia SQ system is favoured in the USA, and, according to Benjamin Bauer of CBS Laboratories, 75 brands of audio equipment produced by SQ licencees are now available, or are about to become available, both in the USA and overseas. These 75 brands, claims Mr. Bauer, account for more than three quarters of the sales of audio equipment world-wide.

United States patent 3 708 631 has been issued to Columbia covering various and broad aspects of logic decoders, and cross-licencing agreements have been signed with Electro-Voice that enables SQ licencees to take advantage of developments from both companies.

The main advantage claimed for the SQ matrix is that it is compatible with both stereo and mono playback systems – and this is of prime importance when it is realised that at least 90 percent of record buyers listen to records on mono players.

Sansui's QS matrix – which is being adopted by an increasingly large number of Japanese companies – is far less satisfactory in this respect. QS encoding yields a disc that has very poor left to right hand separation when played on stereo equipment and very strange effects indeed played monophonically.

Against this, front to rear separation is much better than with SQ although the so-called 'gain-riding' circuits that are added to the more expensive decoders increase the channel separation on most programme material. These gain-riding circuits are available for both QS and SQ systems.

Actually it is slightly misleading to speak of QS and SQ matrices, for both systems have been modified several times during the past few months. Parameters of the two systems are becoming closer together, and, whilst QS decoding is still not very satisfactory for SQ discs – and vice versa – the differences between the two systems are now relatively small and it is more than likely that there will eventually be a common format or one so similar as to be virtually identical.

The SQ system has been chosen by the great majority of FM broadcasting stations. These stations transmit SQ records by conventional stereo broadcasting which are then decoded by the listeners' receiving equipment. In the US, over 200 stations broadcast four channel programmes in this manner.

Commercially, the cost of SQ decoders should fall substantially following Motorola's development of a solid-state integrated matrix chip (MC 1312). Two further associated chips from Motorola are logic module MC 1315 and power transfer module MC 1314.

The MC 1314 module is technically interesting in that it acts as a gain control and speaker balance element permitting the gain of all four channels to be adjusted simultaneously, with a tracking error of less than 1 dB over a range of 80 dB.

At present the highest degree of separation that any matrix system can achieve is 20 dB in all directions — but this can only be obtained with the most sophisticated of gain-riding systems. Neither system can reproduce different sounds from all four channels simultaneously.

DISCRETE FOUR-CHANNEL

Discrete four-channel sound suffers from few of the limitations of its matrixed counterpart, being recorded, as its name implies, on four quite separate information channels.

Initially, discrete four-channel consisted of reel-to-reel tapes and associated tape decks, but the system did not meet with any noticeable success until RCA's release of 8-track cartridges under the trade name Quad-8. Subsequent legal complications caused RCA to change the name to Q-8 and they are still marketed under that name.

In 1972, RCA introduced the Japanese-developed CD-4 disc. Unlike the matrix recordings that attempt to cram channel routing information into the two normal stereo channels, the CD-4 disc actually carries an additional two channels of information. This is achieved by extending the frequency range to 50 000 Hz. The frequency range up to 15 000 Hz is used to carry the combined front and rear signals for both right and left channels — and the higher frequency channels carry information necessary for separating front and rear channels.

A demodulator, operating in a very similar manner to decoding circuits in FM tuners, sorts out the various signals routing each (subsequently amplified signal) to the appropriate loudspeaker.

TABLE I

Length of room (in metres)	Lowest reproducible frequency (in Hz)
4	85.75
5	68.60
6	57.10
7	49.0
8	42.8
10	34.3
12	27.5

Sceptics — who almost without exception have not heard the CD-4 system in operation — doubt the ability of a stylus and pick-up cartridge to operate at frequencies as high as 50 000 Hz. Nevertheless the Shibata stylus (specifically designed for the CD-4 system) copes admirably and both JVC and Panasonic are producing the necessary cartridges and decoders.

Decoding circuitry for the CD-4 system is very complex but a well known manufacturer of specialised IC's will have a CD-4 decoding chip available in the very near future and this will reduce the complexity of the CD-4 decoders enormously.

All RCA records are now produced in the CD-4 format as the system is totally compatible with both stereo and mono record players. The use of a new vinyl formulation for the records has ensured that four channel information is not destroyed when the record is played on mono equipment.

Original CD-4 discs were cut at one third playing speed, however recent advances have enabled this to be increased to one half playing speed and it is hoped that they will eventually be cut at normal operating speed.

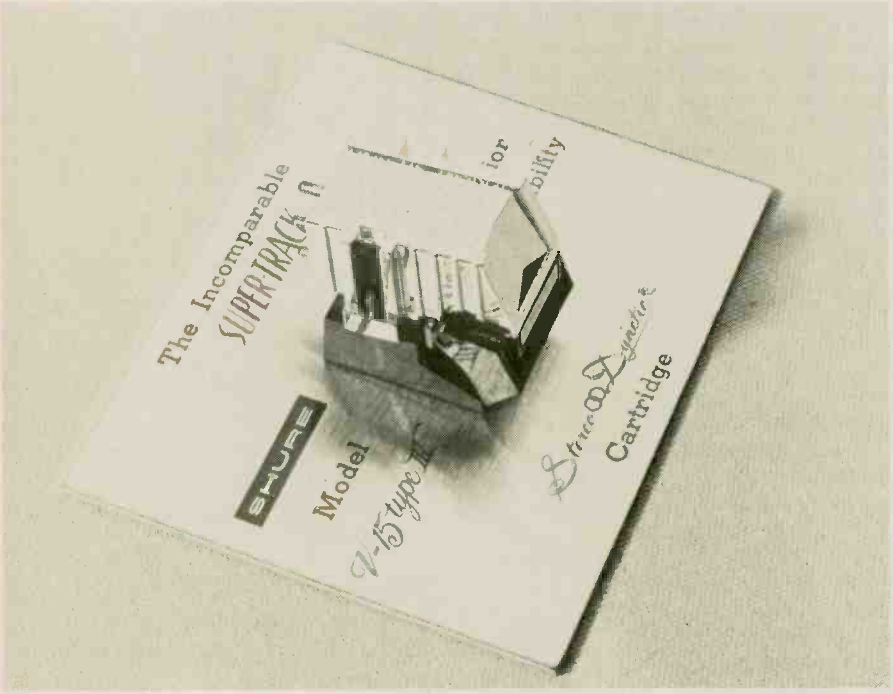
The discrete and matrix systems are totally incompatible. If both are to remain in use, equipment must either contain decoding circuitry for each — or the user must purchase two different systems — or at least decoders.

Although a number of world famous equipment manufacturers are not yet producing four channel equipment, it is now practically certain that four-channel is here to stay — the only remaining question seems to be the really big one of which system will win out — or will be have two competing systems with all the attendant complications?

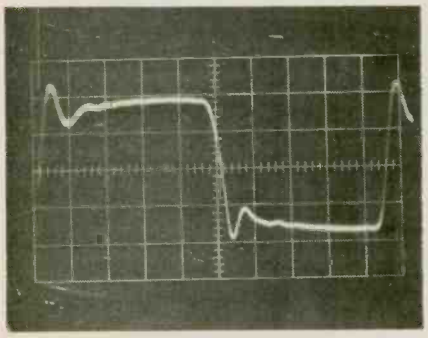
Or, although the equipment industry needs this like a hole in its head — will a lateral thinker come along with a new and brilliantly simple approach!●

SHURE V15 MK III PHONO-CARTRIDGE

"One of the world's top cartridges — it is quite probable that it is the best."



electronics TODAY INTERNATIONAL
product test



Shure V15 Mk III cartridge with 1 kHz square wave input (7cm/sec)

FOR many years, the Shure V15 Mark II cartridge has been regarded by audiophiles as being one of the best cartridges that money can buy. The reason for this is simply that in terms of the main criteria of fidelity, trackability and lack of colouration, the V15 Mark II has few peers. However, the linearity of the Mark II never quite matched the excellence of the rest of the cartridge, and in this one respect there are many cartridges which are undoubtedly superior.

This clearly bothered Shure and so, over a period of seven years, they have developed a cartridge which is a worthy successor to the Mark II. Quite naturally, the designation for the new cartridge is the V15 Mark III.

Each new cartridge that Shure Brothers have released has generally been a state of the art improvement over their cartridges that have gone before — the new Mark III is no exception.

The designers of the Mark III aimed at improving several aspects of performance; perhaps the most important of which was to flatten the frequency response in the region between 10 kHz and 20 kHz. Those familiar with the design of transformers will realise that the high frequency roll-off of the V15 Mark II was primarily attributable to the lack of an optimally laminated core structure. However, it is one thing to *propose* a laminated core structure and quite another to *produce* the type of lamination required when the miniscule size of such a transformer is appreciated.

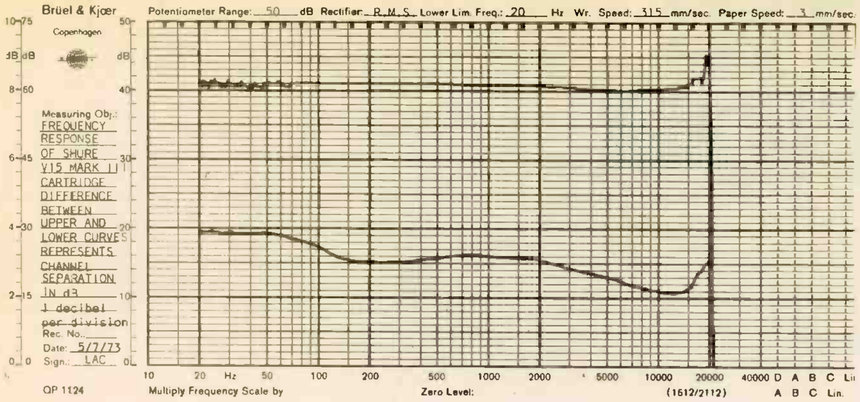
Nevertheless, Shure have developed manufacturing techniques that has enabled them to build laminated cores and these are now fitted to all Mark III cartridges.

A second major change was that the geometry of the pole pieces needed optimisation in order to eliminate — or reduce — the effect of non-linearities in the air gap. The result of this is improved efficiency, flatter frequency response and significant improvement in cartridge output at the top end of the frequency spectrum.

The next area attacked was in the actual stylus and stylus assembly. We know from simple mechanics that a lower mass is easier to move than a heavier one, hence the lower the effective mass in the stylus, the greater the ease with which the stylus can follow the record groove. But a simple reduction of mass itself is not the sole criteria. Rather it is the correct improvement of dynamic compliance in order to be able to cope with the high velocities that exist on many records. Whilst the V15 Mark II had an effective tip mass of 0.45 milligrams, the Mark III is reduced to 0.33 milligrams. This reduction is not dramatic, nor could it be, because of the need to produce a stylus lever strong enough to work.

Having looked at Shure Brothers' design philosophy, it now remains for us to see what the V15 Mark III achieves in practice.

When one has for review what may well be the best cartridge in the world,



the techniques available to evaluate its performance are critical. The Shure Brothers' test record "Acoustical Obstacle Course" TTR101 did not really provide a good enough test for the trackability of the Shure V15 Mark II, let alone the Mark III. So how do we evaluate the performance of the Mark III? This problem obviously worried Shure Brothers long before it became *our* problem, and their approach was to develop two new records. The first of these, the TTR110 "Audio Obstacle Course, ERA III" was specifically developed to show the difference in performance between the V15 Mark III and other "lesser" cartridges.

This record was not available at the time of the test, though it is now; cost is £2.97. However, cartridges distributed in Britain by Shure Electronics Ltd include a voucher for a free copy of this record.

The second record, the TT103 is designed for laboratory testing and costs £6.93 but once again was not available at the time we performed our tests.

Hence we were obliged to use programme material from standard demonstration records such as Shure's TTR101. Fortunately, apart from assessing trackability, we had no difficulty in measuring all other parameters, nor in subjectively evaluating the overall performance of the cartridge.

The frequency response of the Mark III has a maximum excursion of ±1dB between 20 Hz and 20 kHz when installed in the average tone arm, and ±0.5 dB when fitted to an arm such as the S.M.E. Whilst the level recordings show a rise at 18 kHz, this is a characteristic of the test record not the cartridge. This measured response is significantly better than that of the Mark II.

Cross-talk in the critical region between 200 Hz and 20 kHz showed a channel separation of not less than 25 dB generally, and nowhere less then 20 dB. Again the limitation here is the quality of the test record.

Square wave tests showed that the effective frequency response extends to at least 25 kHz without any significant resonance effects being apparent. The square wave response showed less ringing than any cartridge previously tested.

It is in the region of trackability and lack of colouration, however, that the Mark III really excels. This cartridge has the cleanest response of any that we have had the pleasure of testing, and can cope with the most demanding programme content that we have in our record collection. We could not fault it in any way.

The Shure V15 Mark III is a truly excellent cartridge, but for its full potential to be realized it *must* be used with a top quality amplifier and speakers (we used a Thorens TD125 table, plus an S.M.E. arm; a Pioneer SA1000 Amplifier, and JBL Control Monitors). Top line records are also necessary or the results are unquestionably poor. But provided that good quality equipment is matched to this new cartridge, the results will be truly superb.

The Shure V15 Mark III is one of the world's top cartridges — it is quite probable that it is the best. ●

MEASURED PERFORMANCE OF SHURE V15 Mk III CARTRIDGE

Frequency Response (20 Hz – 20 kHz)	±0.5 dB
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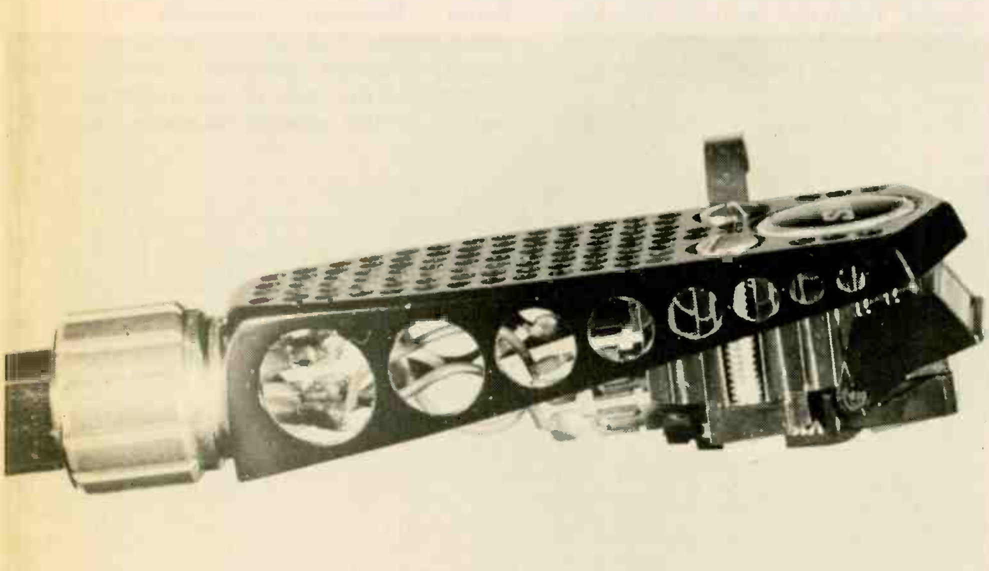


Shure V15 Mk III shown here in an SME tone arm.

MAGNETIC LEVITATION

by Dr. Peter Sydenham

Will magnetic levitation replace the wheel?

THE repulsive and attractive forces produced between magnetic poles have been experienced since magnetic lodestone was discovered many thousands of years ago. But on a comparative time-scale, our knowledge of the electric magnet is quite recent. It was only in 1820 that Ampere, Arago, Davy and Henry laid the theoretical and practical foundations of the design of electromagnets showing that they were, in fact, analogous to the permanent magnets already in existence. Forces produced with electromagnets were soon harnessed to build galvanometers, electric-wire telegraphs, generators and motors. Few, if any, worthwhile applications used the force as a suspension.

Theoretical considerations developed by Earnshaw in 1839 proved that it is not possible to site a strong magnetic pole (of either kind – permanent or electric) in a static magnetic field without added positional constraints. This was derived as the consequence that magnetic force increases as the inverse square of the separation between the force source and the magnet. Since then, numerous inventions have been devised attempting to make use of magnets to provide stable suspension, but it is only in the last decade that real success has been forthcoming.

Like. poles attract and unlike poles repel, so each offers the possibility of suspending one mass relative to another. If the polarities are opposite (or one pole is a magnetisable material) the magnet hangs, using attraction. The system, however, is unstable, for the closer they come altogether the greater the attractive force accelerating them toward each other – they end up tightly clamped.

Like poles repel, so the suspended magnet would, hopefully, sit above the other magnet. However, our experience shows any slight imbalance about the central position produces an unstabilising collapsing force that increases as the top magnet starts to slide off the top. An alternative suspension uses N-S and S-N pairs in a horizontal direction, as shown with

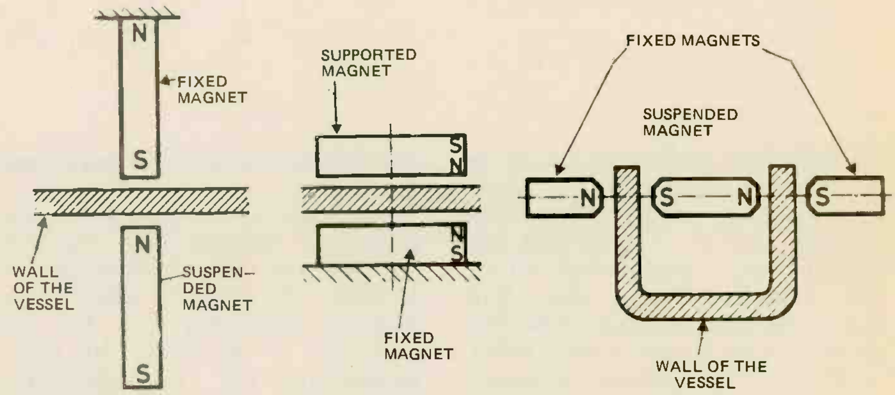


Fig. 1. Three basic alternatives exist for suspending a mass using a magnetic field.

the other alternatives in Fig. 1. This also will be unstable moving to one end or the other.

A unique feature of the magnetic suspension is that a physical (non magnetic) material can exist between the two magnets, a feature not offered by bearings or air cushions.

STABILISING A MAGNETIC SUSPENSION

An obvious way to produce a stable suspension is to incorporate extra devices to obtain stability in the vertical or horizontal directions as needed. These can be, in the repulsive system, low friction guides or more magnetic pairs placed in the vertical plane.

The usual way to stabilise the attractive system uses a servo-control that senses the relative closeness of the two poles (one may be induced by the magnet) using a displacement transducer signal to control the power of the electromagnet attracting the suspended mass. This, therefore, maintains the distance constant and the closed-loop feedback is, in effect, modifying the inverse square law to one having a highly stable region.

The principle is used in a recently marketed chemical balance with microgram resolution. A schematic of the system, having its origins in the work of Professor Gast of the West Berlin Technical University, is presented in Fig. 2. A permanent magnet provides attraction for the majority of the mass of the weighing pan; a control winding provides the

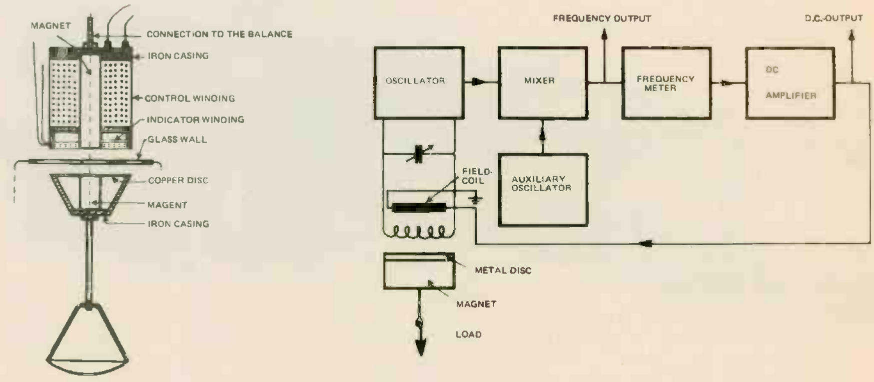


Fig. 2. Cross-section through the magnetic suspension used in a sensitive chemical balance. The schematic circuit arrangement shows how a variable frequency output is obtained and the suspension stabilised.

extra force required, both operating through the wall of the evacuated weighing chamber. The operation is as follows: As the pan moves up toward the magnet coil the copper disk reduces the inductance of the indicator/position-sensing coil. This, in turn, alters the frequency of the sensing tuned circuit providing a variable frequency output related to displacement. Stability of suspension is provided by converting the variable frequency to a direct current that then feeds the control winding, controlling its attractive force. If correctly phased, the feedback causes the pan to remain suspended.

The same setup can be used to measure flow by passing the fluid up against a drag-plate mounted where the pan would be. It can also measure density if the upthrust of the pan is monitored when it is immersed in a fluid. A gravity meter has been constructed using a superconducting suspension coil in this way, the feature of superconductivity being the smoothness of the field strength.

Another instrumentation example using magnetic suspension is the experimental magnetically suspended motor developed by NASA staff. The rotor (see Fig. 3), consists of a suspension cylinder, that rotates as part of the rotor, and imbedded magnets that produce the motor torque when reacted against with an external starter winding. There is no real difficulty with suspending the two ends of the rotor inside the suspension coils for it automatically aligns itself to be in the centre, the position of least magnetic reluctance. Active stabilisation is needed, however, to control the rotor position between the two coils for without it the rotor would pull to one or the other end. Here photocells sense the end of the cylinder controlling the solenoid field strengths so as to retain the rotor midway. A special design of motor was developed to reduce the radial forces experienced in a normal design of motor. The suspension is quite stiff — 20kg/mm, in fact, and the power needs relatively small — around 10W per bearing. This development leads the way to more reliable and more sensitive motors, especially in gyroscope application where the frictional torque of normal bearings provides an unwanted precession torque.

If the inductance of the magnet coil in an ac-excited attractive type suspension is series tuned with a capacitor, movement of the suspended magnetic material alters the resonant circuit current adjusting the suspension force to compensate. But this only holds well enough for a situation where the movements occur slowly or are static. Jayawant and Kaplan of the University of Sussex have continued on from earlier work on suspension design using this method and have researched, with working models, ways to improve the dynamic stability. A solution proposed uses a saturable reactor as shown in a schematic of their system given in Fig. 4. (Russian workers have also reported the use of this tuning idea, but to reduce forces, in a variable reluctance position sensor.)

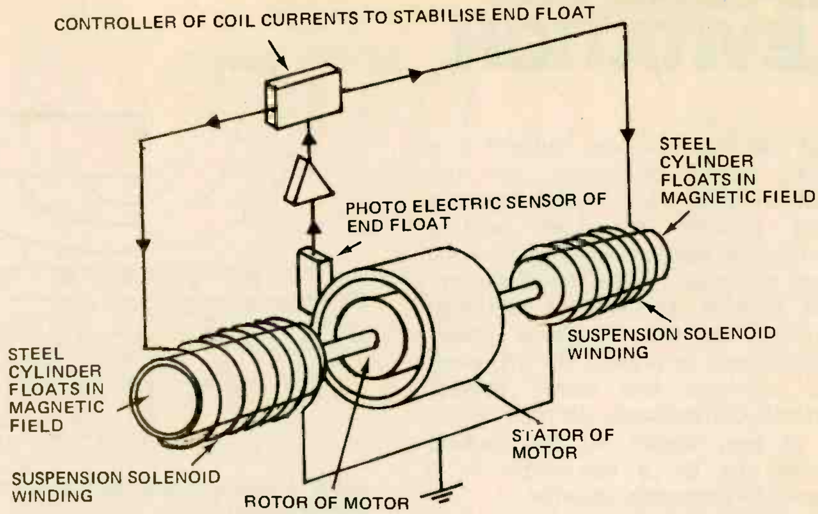


Fig. 3. Arrangement of a motor using magnetic suspensions instead of contact bearings.

There is a notable exception to the Earnshaw theory mentioned earlier: Braunbek showed in 1939 that the introduction of a material having a relative magnetic permeability (μ) less than unity into the field space would result in stable levitation. Diamagnetic materials have μ less than unity — bismuth and carbon being examples. The magnetic forces exerted in this case are, however, only capable of supporting minute loads so it offers little real advantage in normal situations. Superconductors, however, behave as almost perfect diamagnetic material (flux cannot penetrate the skin) so it is possible to provide a stable suspension in special cases without the need for auxiliary devices. A gyroscope, using a superconducting rotor has been built using this principle. Research has also been carried out on the use of levitated superconducting rings to confine plasma.

THE GREAT INTEREST — MAGLEV VEHICLES

We have already seen some of the proven uses of magnetic suspensions but these, although revolutionary, are fast becoming overshadowed by the growing interest in their application for the support of high-speed trains. To appreciate the designs suggested for maglev trains we must first consider the properties of magnetic suspensions when used as a continuous frictionless guided slide rather than as a single point stationary support.

A time varying field, such as that produced by an ac magnet, will produce a counter field that can provide lift. The so called "Foucalt railway" devised by Bachelet in 1912

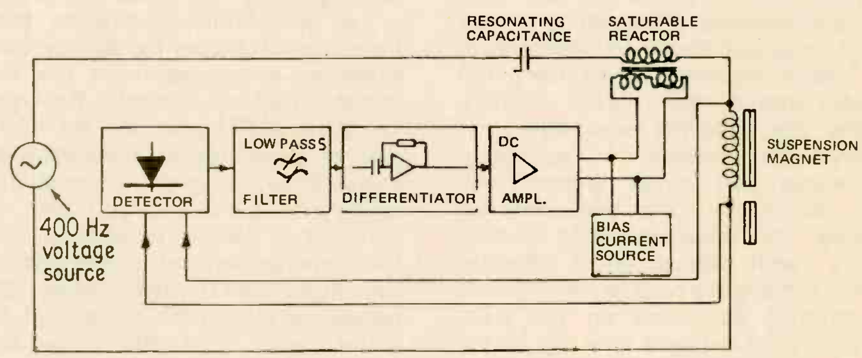


Fig. 4. This arrangement is used to obtain dynamic stability from a tuned ac attracting suspension.

MAGNETIC LEVITATION

used the eddy currents, induced in a thick aluminium plate by the fluctuating field, to provide a repulsive force between the plate and a continuous row of fixed coils lying along the track of the model system. This method, at the time, had high penalties, namely, excessive power requirements to provide the lift, small gap clearance and costly magnet systems. Consequently up to a decade or so ago, maglev by this method seemed to be a non-starter in a large-scale economic situation.

If, however, the magnet is moving relative to the conducting plate it is possible to make use of Bachelet's idea without the need for ac excitation of the electromagnet. For example, a magnet moving over the surface of an aluminium sheet will induce eddy currents that repel it. In effect, an image magnet is produced as shown in Fig. 5. (You might try mounting a bar magnet on wheels so that it just clears the surface and run it over an aluminium rail or surface — it should lift off as the speed rises.) This principle is now one of the main contenders for levitating trains. Changes in technology, from the 1950s onward, have enabled magnetic levitation to become a practical reality. Initially it was the new found ability to produce high coercivity ferrite permanent magnetic materials of relatively light weight that enabled a number of groups to build and test vehicles using repulsion between permanent magnets. A cross-section of a scale-model constructed by Polgreen around 1966 is shown in Fig. 6.

The next, and most relevant development, toward efficient maglev systems was the improved capability with superconducting technique — larger and more reliable refrigeration units were developed; unique conducting cables were devised and manufactured that do not lose their superconducting properties until very high magnetic fields are approached.

Superconducting magnets, being 100 times stronger than normal magnets, have the potential advantages that they can produce a suspension clearance ten times greater than normal magnets and that, once set going, the superconducting current only needs topping up at intervals, thus avoiding the need to carry current generating equipment on the train. The first advantage is very real for the cost of producing and maintaining a permanent way rises rapidly when tolerances exceed 10-50mm.

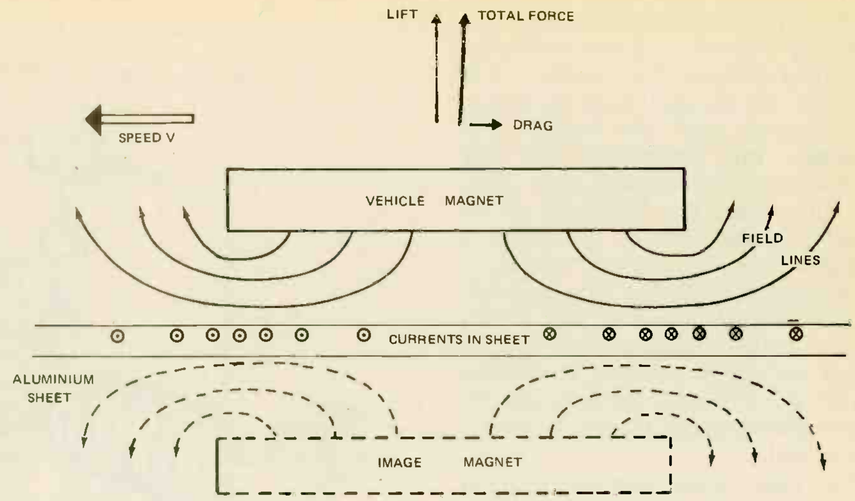


Fig. 5. A magnet moving over a conducting plate produces a field as though an image magnet existed below.

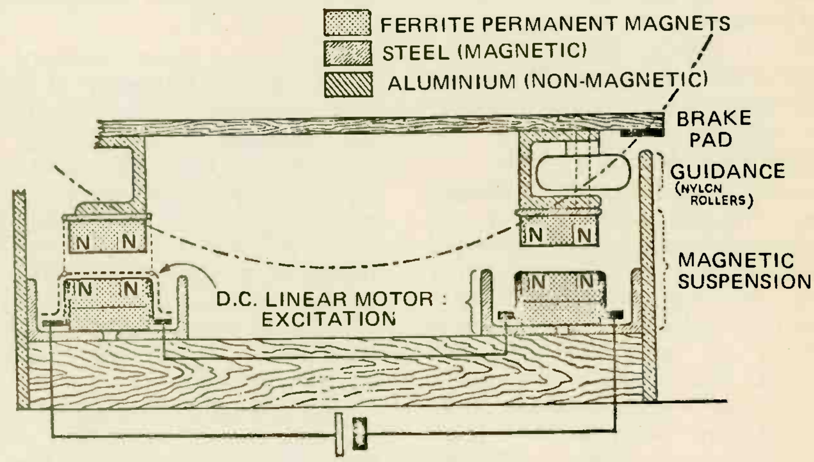


Fig. 6. Polgreen's maglev system using permanent magnets in a repulsive mode.

MAGLEV VERSUS AIR CUSHION

High speed surface transport has become one of the engineering musts of today. Until quite recently it was thought that the only way economically to overcome the friction and track wear problems experienced in high-speed rolling wheel railways (like the Japanese, 200km/h, Tokaido Express) was to use air cushions reacting against the inside of a tunnel or on a continuous concrete box. Indeed, much money has already been expended developing trains like the British Rail Advanced Passenger Transport (APT) unit. On the "for" side of hover trains is accumulated experience, with operational hovercraft carrying from two to hundreds of people. If, however, you have experienced a ride in one (such as the huge SNR1) that carries 200 people and many vehicles, you will, no doubt, agree that the noise and vibration levels are hardly insignificant — ear muffs are recommended for one newly developed air cushion vehicle!

For a while maglev lagged behind, but there is now evidence that it can economically provide a near noiseless operation, as much as fifty times reduction in operating costs of the high speed train, and an intrinsically more reliable suspension principle.

This year will see the real start of British interest in it. Jayawants' group at Sussex, and Rhodes' group at Warwick University, have received around £125,000 each from the Wolfson Foundation to build, to the prototype stage, both the attractive and repulsive maglev alternatives. Already several German private enterprises have made small, low speed systems for evaluation. Maglev vehicles developed by Krauss-Maffei and Messerschmitt-Bulkow-Blohm are shown in Fig. 7.

At this stage in time it is clearly too early to say which is the best for both concepts are not quite as straight-forward as appears on the surface; one of the main problems

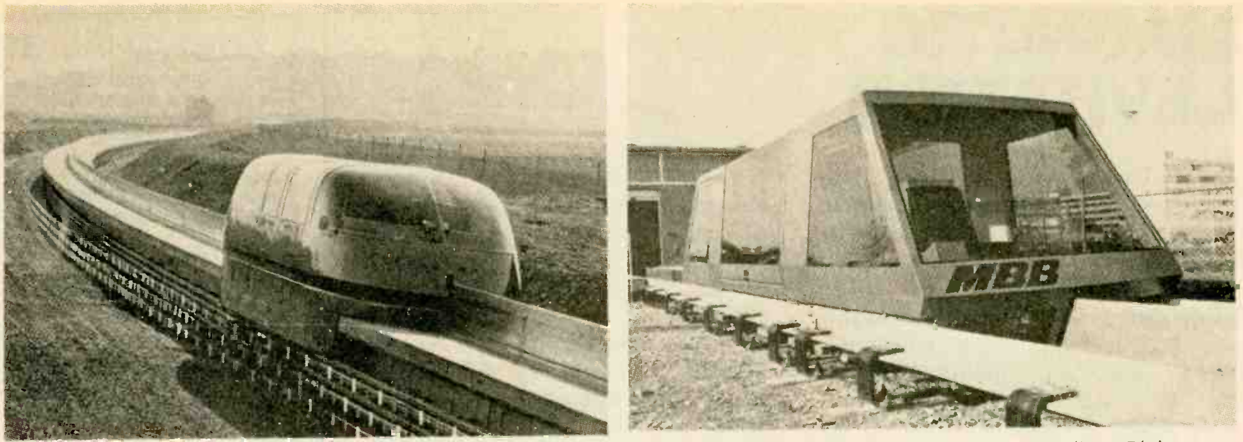


Fig. 7. In Germany these two maglev vehicles have been developed by Krauss-Maffei (left), and Messerschmitt-Bulkow-Blohm (right). Both vehicles are levitated by attractive ferromagnetic forces – the lift magnets being attracted to the bottom of an inverted U-shaped lift rail running alonn each side of the guide-way. Propulsion is obtained via linear induction motors. Three-phase power is picked up by the vehicles, and after conversion to the required frequency and voltage, is used to drive the linear induction motor's armature. The armature reacts against the vertical aluminium rail that can be seen in the centre of the guide-way.

being the reduction of the magnetic drag force.

THE MAGNETIC DRAG FORCE

The high field strengths available with superconducting magnet coils enables Bachelet's idea to be resurrected as an efficient suspension in which a magnet is moved over a fixed plate. The plate need not be thick provided it is well supported (10mm is envisaged for a 660km/h train), for the flux is unable to penetrate very far into the surface due to the rapid flux movement. Calculations show that a 30 000 kg. 100 passenger train should be lifted about 100mm by superconducting magnets.

In order to exclude the field from the plate the eddy currents must flow to provide the reacting field. These produce ohmic losses that result in a drag force being created that opposes the motion of the vehicle along the track. (The eddy current damper in watt-hour meters makes use of the drag force to slow the movement when power flow ceases). It has been shown theoretically that the magnetic drag force of a conducting sheet rail reduces as the velocity$^{1/2}$ and that it approaches a limiting value. In other words, the faster the train goes the less the increase in drag forces. Even so they are considerable. (It has been pointed out that the aerodynamic drag at high speed could be even more significant). Coffey and others, from the Stanford Research Institute have estimated that a 100 passenger train moving at 660km/h would experience a magnetic drag of 1.5 MW. A section across the maglev vehicle proposed by Coffey's group is given in Fig. 8. Note the simplicity of the levitation and guidance walls: the wheels would provide support at speeds less than 100km/h.

The price paid for using the simple L-shaped track is the high drag-force.

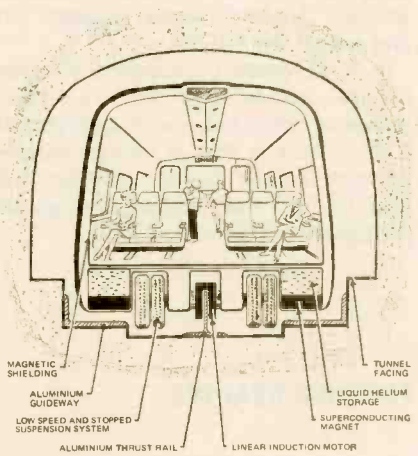


Fig. 8. Stanford Research Institute proposal for a train using the plane sheet suspension.

Another group (Powell and Danby) evolved what is known as the "null-flux" track that consists of loops of conducting material rather than a single flat sheet. Their original scheme (1966), provided levitation from a flat track, in which are embedded loops lying horizontally: mutual induction provides the repulsive lift force. Sideways control would be realised with the field from more loops set in the vertical plane, but not protruding above the top surface. Inside the vehicle could be superconducting loops of alternating polarity. This scheme also must dissipate losses (as a drag force to be supplied by the propulsion motor – the magnet strength is not affected). Their first idea for limiting the drag force was to reduce the loop losses by using series inductors. By 1969 they had realised a better method – the "null flux" concept – which made use of other coil configurations that provided minimized mutual inductance between track and train loops. This could be realised by having the train loop external to the body with a fixed loop

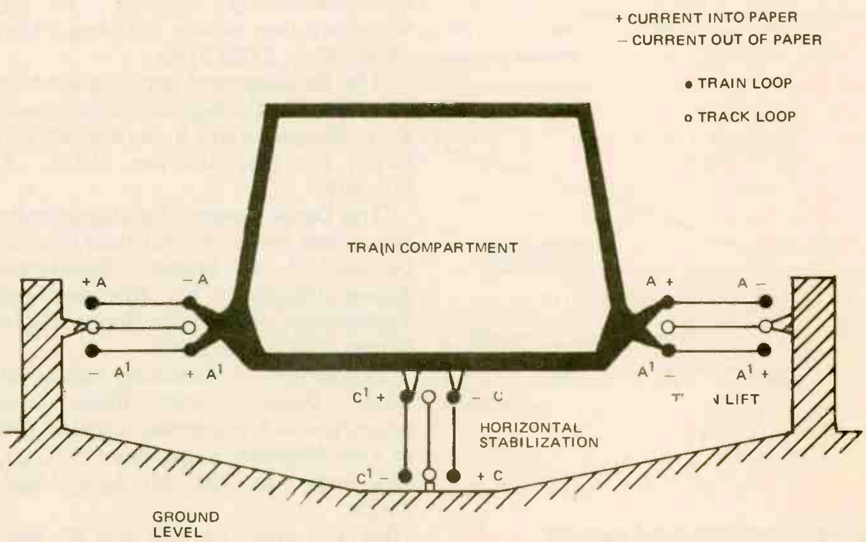


Fig. 9. Cross-section through train suspended by a null-flux loop arrangement of track.

MAGNETIC LEVITATION

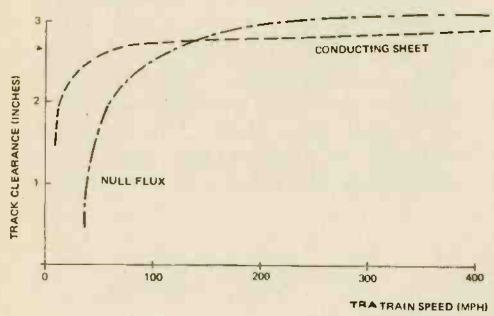
above and below it. They also suggested using one group mounted loop, the pair being on the train as shown in Fig. 9.

Sufficient theory has been established for the inducting sheet and null flux methods to be compared. Powell and Danby published curves comparing each in 1971, see Fig. 10. Drag power is reduced to 680 kW for the same example as stated earlier for the conducting plate method. The lift/magnetic drag force ratio is claimed to be increased from nine for the flat sheet to 63 for the recent null flux arrangement. Tables of the characteristics of each are listed in a maglev review by Rhodes (see reading list).

Now the trend seems to be pointing toward vehicles having no power sources aboard. Reasons for this are that it is no easy matter to carry or transfer megawatt powers needed for propulsion at 660km/h and that more payload would be available. The price paid will be the increased cost of the permanent way. Improved ways to transfer power include running a train along the focal point of a continuous linear microwave antenna, electromagnetic coupling between the pickup on the train and the current carrying conductors on the track and, of course, greatly improved brush systems.

We have not discussed the design of propulsion motors that will be used, but it seems assured that they will be some form of linear motor. As both motor and suspension, could be electromagnetic it would appear that both might be combined. Laithwaite has done just this. In a release made early in 1973 he proposed a scheme wherein 50Hz powered magnets lift and propel the vehicle.

It is at present uncertain whether maglev vehicles will carry on-board power or not — but one thing *is* almost sure — that is that it will be maglev vehicles, not air cushion vehicles that lead us into the forthcoming age of high-speed ground transport.



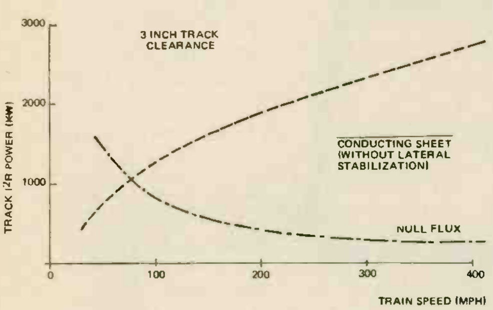


Fig. 10. Curves comparing expected performance of two possible repulsive superconducting maglev alternatives. (a) Lift with speed. (b) Drag power with speed.

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See also Proc. I.E.E.E. Vol 61 May 1973 (contains a number of papers on magnetic levitation and associated subjects).

Early TV Camera Tubes

It is easy to take the high quality of today's TV for granted but 40 years ago a group of young British engineers had to start from scratch to produce the first TV camera. This report outlines the way in which they set about tackling the problems.

TELEVISION, as we see it today, is the developed product of the work of a large number of pioneers all over the world. Despite this, however, it was the work of one team which resulted in the start of regular broadcasting from Alexandra Palace, London, on November 2nd, 1936, using a system which survives to this day. These early broadcasts were made using, alternately, Baird's 240-line system with 25-frames scanned per second and the Marconi - E.M.I. system using 405-lines at 50 interlaced frames per second.

The results of these broadcasts ended the Baird mechanical system, and the 405-line system was adopted, and is still used in Britain today, though it is being replaced completely by the 625-line system.

Looking back, it is difficult to imagine the immense difficulties the pioneers of the 405-line system faced. In contrast with Baird's methods which used well-established engineering and electronics, the Marconi-E.M.I. team were grappling with completely new fields at every stage of their work. The generation of timebases, the synchronisation of scanning, amplification and modulation were all new techniques, but the most remarkable innovation of all was the camera pickup tube.

The idea of completely electronic picture pickup was not new. A.A. Campbell-Swinton in 1908 had outlined a scheme for all-electronic television which visualised a camera-tube based on the cathode-ray tubes available at the time. The use of the cathode-ray tube as the receiving device had been suggested in the previous year by Boris Rosen, a lecturer at the Technological Institute at St. Petersburg in Russia, and his ideas had been thoroughly absorbed by one of the students, V.K. Zworykin, who emigrated to the U.S.A. in 1919 to join the Westinghouse Research Laboratories. Working there, he extended Rosen's ideas to the problem of picking up light signals and applied, in 1923, for a patent on the Iconoscope camera tube. This patent was not granted until 1938, since a working model of the tube could not be constructed with the techniques available in 1923. At the same time in the U.S.A., Philo Farnsworth had developed his dissector tube, which scanned a beam of electrons from a photoemissive surface past an aperture leading to an electron multiplier.

In 1932, the newly formed E.M.I. company at Hayes, Middlesex, decided to concentrate their television efforts on a completely electronic system. This decision required considerable courage, because the B.B.C. and the Baird Television Company had been making regular transmissions from Alexandra Palace since 1929, and Baird receivers had been on sale to the public since February, 1930, at a price of just over £26.

The E.M.I. team, led by Isaac Shoenberg, a former student of the Kiev Technological Institute took the gamble of attempting the development of an all-electronic high definition television system, a gamble which involved, as we have seen, a large number of untried ideas, an immense amount of faith and a great deal of money. The chanciest part of a gamble, which paid off many thousandfold, was the camera tube.

THE EMITRON

Faced with so many problems, the company allocated separate problems to research teams composed of young engineers at the peak of inventiveness. The problem of the pickup tube concentrated on making a working model of the Iconoscope patented by Zworykin, and the man in charge was Dr. J.D. McGee, now professor of Applied Physics at Imperial College, University of London.

The basis of the tube was simple. An insulating plate (Fig. 1a) was coated with isolated particles of silver which were made photo-emissive by treatment with caesium vapour. Light, in the form of an image cast by a lens on this "mosaic", as it was known, caused electronics to be emitted from each particle in proportion to the light signal, so that each particle ended up with a positive charge (having lost negative electrons) proportional to the light falling on it. The electrons lost by photoemission were to be replaced by scanning the mosaic with a beam of electrons, and the current caused by this replacement process, which constituted the output signal, caused a current in the metal plate on the other side of the insulator on which the mosaic was deposited, just as a pulse of current on one plate of a capacitor causes a detectable pulse on the other plate.

This scheme of operation sounded

fine but was, in fact, impossible. When a beam of electrons hits a mosaic surface at the voltages which were being used in the original Emitron, the effect is not to replace electrons and make the mosaic more negative, but to knock off more electrons and make the mosaic still more positive.

The team were faced with something which worked; to develop it further they had to understand how it worked and find better methods of making it a practical proposition. The situation was rather like Marconi's first transatlantic broadcast, which seemed theoretically impossible until accounted for by reflection of radio waves in the Ionosphere.

The Emitron was also very much less sensitive than had been hoped. On the original idea, the exposure of the mosaic to light should have been effective for the time between scans (one frame) because this was the time the mosaic had to charge up by losing electrons. Tubes such as the Image dissector were very insensitive because the "exposure" was simply the time taken to scan a small portion of image and it was hoped that the storage of the signal as a build-up of charge on the mosaic between scans would make the Emitron much more sensitive.

HOW IT WORKED

Figures 1b and 2 show simply how the Emitron was found to work. When the electron beam scanned the mosaic, it released electrons so that each portion of the mosaic charged positive. This process, called Secondary Emission, could not go on indefinitely, because the released electrons had to end up somewhere. The somewhere, in the case of the Emitron was a coating of silver round the inside of the tube which was connected to earth. Because of the distance between the mosaic and this silver coating (the "collector"), the voltage on the mosaic could rise to about 4V above earth when bombarded by electrons from the gun whose cathode was at minus 1,000V. When there was no scanning, the effect of light on the mosaic could charge up the mosaic by only 1.5V.

The action of the tube was that an area being scanned rose to about 4V. This now acted as a collector for the areas of mosaic round about, since it was the most positive portion of the tube and collected electrons released by photoemission. Since the scanned piece of mosaic lay in the same plane as the photoemitting pieces, this was not an efficient process, and only the pieces of mosaic immediate round the scanned portion ever emitted. Instead of having electrons lost through photoemission and replaced by the beam; the electrons were simply being redistributed as scanning proceeded. When

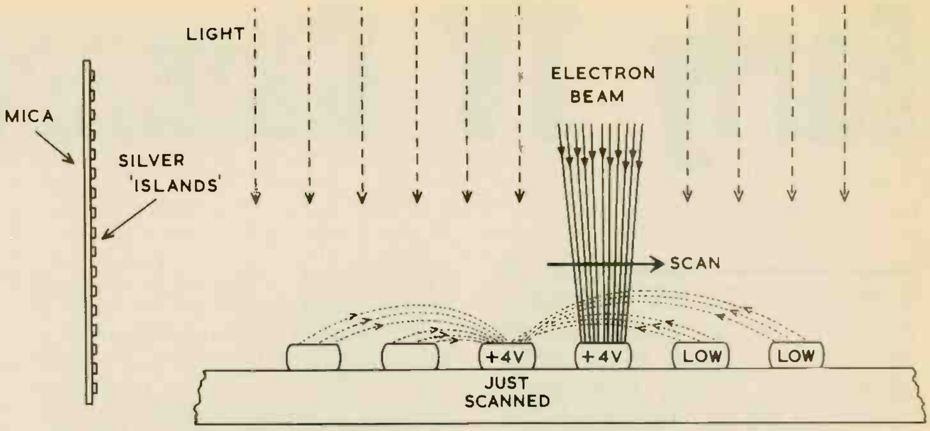


Fig.1. a) (left) Shows the silver islands on the mica. b) (right) When the electron beam scanned the mosaic, it released electrons so that each portion of the mosaic charged positive.

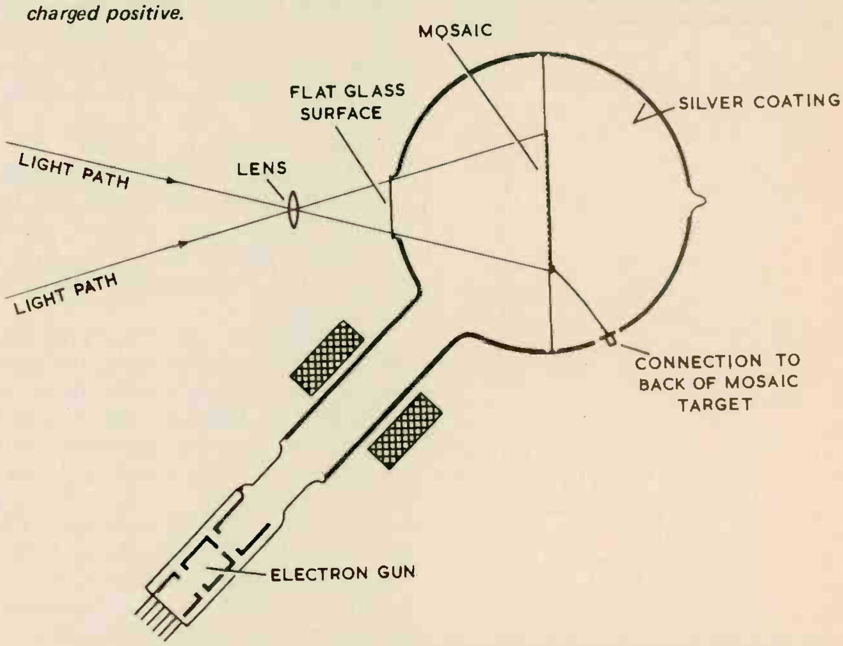
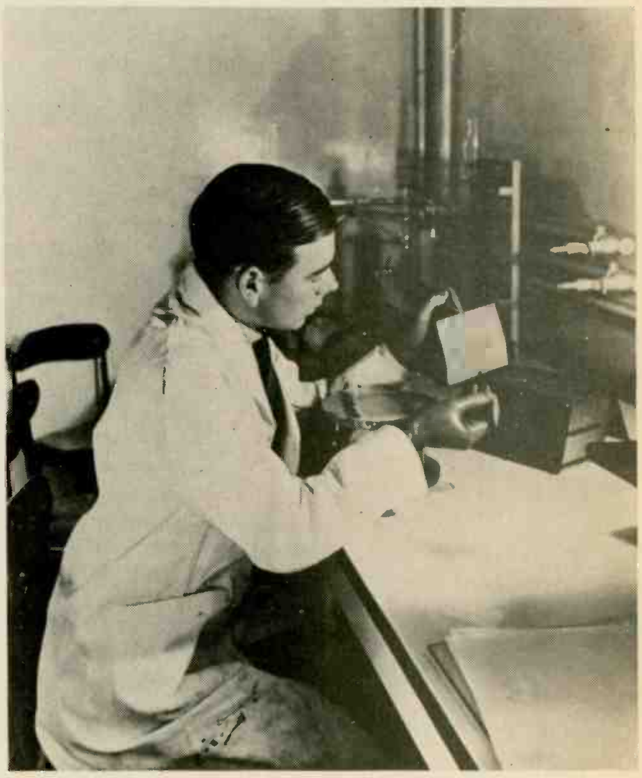


Fig.2. Overall construction of the Emitron - the first workable TV camera.



Preparing the mica sheet for one of the early experiments.

the beam scanned an unlit piece of mosaic (starting voltage = 0V) and raised it to 4V, 4V of signal could be obtained; for an illuminated piece of mosaic at 1.5V the signal would be 4V - 1.5V = 2.5V, so that the signal was negative, decreasing with increasing light. The electrons landing on the scanned portion would then quickly reduce its voltage to approximately zero again.

This action explained the insensitivity of the tube. The exposure time of the mosaic was not the time between scans but the time for a scan to pass near that area, which was much shorter.

This, then, was the camera tube with which T.V. broadcasting started, and the heart of the tube was the mosaic. It was the difficulty of constructing a mosaic which so long delayed the acceptance of Zworykin's patent of the Iconoscope and it was in the construction of this element that the Emitron mainly differed from the American tube.

THE MOSAIC

The mosaic started life as a sheet of mica, 4in x 5in x 0.001in thick which was specially selected for uniform transparency and lack of blemishes. One side was silvered by coating with a paste of silver oxide in resin and heating, the other side was covered with a very thin film of silver by vacuum evaporation. When the coated mica was heated in air again to 700°C, the thin silver film started to break into small droplets due to the high surface tension of silver. This process, called agglomoration, could be closely controlled to produce very small drops of silver fairly well insulated one from another. In the U.S.A., these silver islands had to be produced by evaporating silver on to the mica through a fine wire mesh, but this means that the smallest silver island was very much determined by the finest mesh which could be obtained.

The mosaic was then fastened to another thicker piece of silvered mica which acted as a support. The reason for making the mosaic on a thin sheet rather than on a thick one was that the capacitance between any silver island and the thick coating on the back had to be high, if signals were to be collected efficiently; and the capacitance of such an arrangement is higher when the separation between the metals is small.

After forming the mosaic and rivetting the pieces of mica together, the whole assembly, now known as the "target" was rolled up so that it could be inserted into the tube. Using long forceps, the target was unrolled inside the tube, and fastened in place with the spring contact for the output socket resting against the heavily silvered thick mica of the back of the target.

THE SUPER-EMITRON

By the time broadcasting had started using the Emitron, the tube was already near the end of its life. Everybody in television was working to the aim of televising the Coronation of the late King George VI and Queen Elizabeth, on May 12th, 1937. The Emitron cameras were not sufficiently sensitive for outside broadcasting, there were no mobile units, no suitable cables — and no time!

Fortunately, work had been going on to make the Emitron more sensitive even before the start of broadcasting. The Super-Emitron as the new tube was called, could be fitted into standard Emitron cameras with only a few modifications, and its sensitivity was very much greater. Fig. 3 shows the schematic of this tube. The photosensitive surface was no longer the mosaic, but a separate surface on a sheet of mica. Electrons released from this photocathode were accelerated by a potential of 400V towards the target, and an electron image could be focussed on this target by magnetic focussing coils near the photocathode.

ADVANTAGES

The Super-Emitron was about fifteen times more sensitive than the Emitron. This improvement in sensitivity, which made outside broadcasts considerably easier, came about in three ways.

One cause was the greater efficiency of the photocathode. The photocathode of the Emitron was the mosaic, which was not a continuous surface; the photocathode of the Super-Emitron was a continuous film, every portion of which contributed to the photo-emission. This film could also be processed to a higher efficiency, because the caesium vapour used to make the silver photocathode surface sensitive could be applied much more generously to the separate photocathode than it could to the mosaic, where an overdose of caesium caused electrical leakage between islands, so reducing resolution.

The second cause of higher efficiency stemmed from the greater use of caesium for the photocathode. Caesium vapour is difficult to control, and a fair amount of it landed on the target, though not enough to cause insulation difficulties. This layer of caesium was

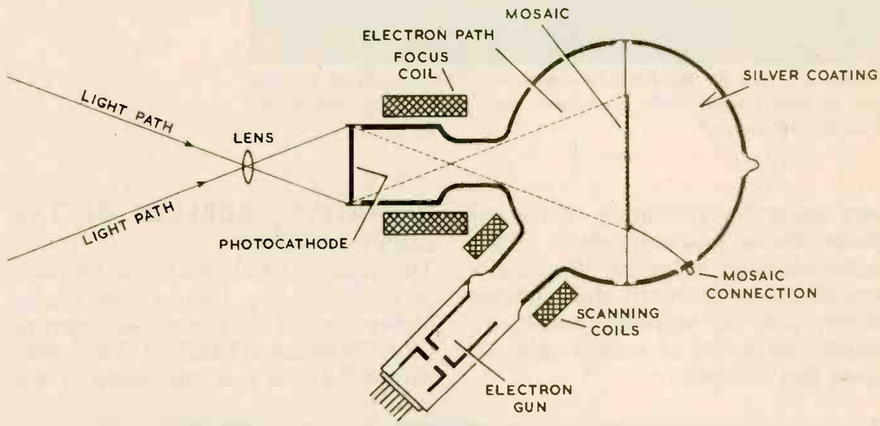


Fig.3. The Super-Emitron. Although similar in appearance to the basic Emitron, it worked rather differently and was much more sensitive.

The target was no longer a mosaic, but a continuous insulating sheet of mica; the scanning electron beam and the signal output from the silvered target backplate were unchanged.

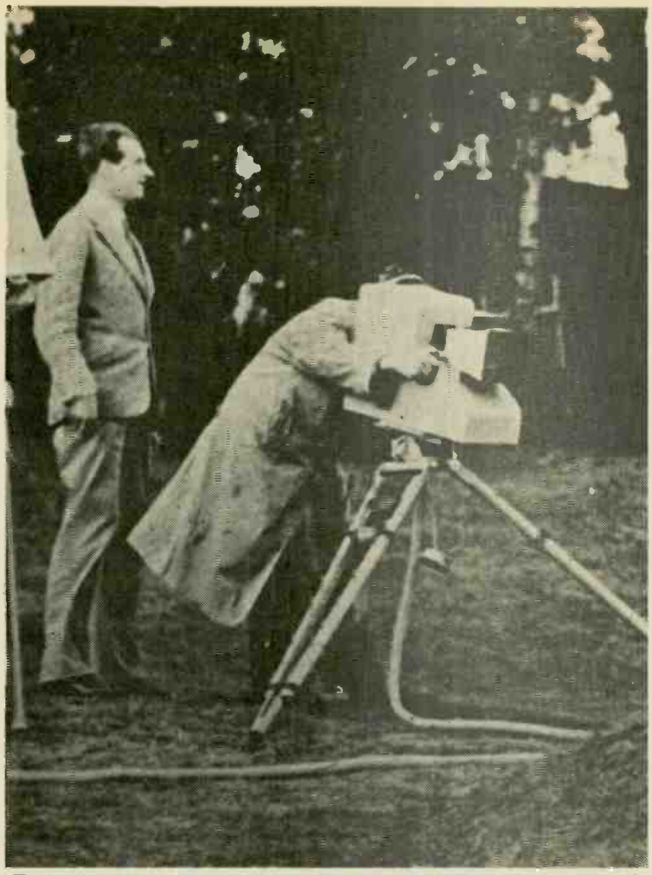
The action at the target was only slightly different from that of the Emitron. The scanning beam charged the target surface positive by secondary emission, and this positive area acted as an anode for electrons released from other parts of the target. In this case, though, these electrons were not released by photoemission, but were released by secondary emission due to the beam of electrons from the photocathode. Because these electrons had rather higher energies than the unaccelerated photoelectrons released from the mosaic of the Emitron, they could be taken from a wider range of the target, and the electrons of highest energy could end up on the silver coating around the tube.

of great benefit to the secondary emission, however, so that, for each electron reaching the target, about seven electrons took off again, giving the target itself a gain of about seven times.

The third benefit was due to the higher energy of the secondary electrons from the photocathode beam. As we have seen earlier, this caused a newly scanned area to gather electrons from a wider area of the target around it, and this effectively increased exposure time, making the tube that much more sensitive.

OTHER FEATURES

Because the photocathode was made on a smaller piece of mica, about 3½in diameter, it was easier to produce a uniform photocathode. The use of the magnetic focussing close to the photocathode caused the electron image on the target to be magnified about four times so that conditions on the target



Trying out one of the first TV cameras. The sensitivity of these was so low that outside broadcasts had to wait for the Super-Emitron to arrive.

were easier for resolution. Since the photocathode was now close to the end-window of the tube, the camera lens could be of much shorter focal length, and the increased sensitivity meant that lenses of smaller aperture could also be used.

OPERATING PROBLEMS OF THE SUPER-EMITRON

The business of using a Super-Emitron or Emitron in a camera was totally unlike that of using a modern camera tube, (Orthicon or Vidicon). One noticeable difference was the shape of the camera which had to project forwards under the lens to allow for the housing of the gun tube of the Emitron. Despite its awkward shape, though, the Emitron and Super-Emitron cameras were not too difficult to move about because their weight was considerably less than that of later Image-Orthicon outside-broadcast cameras. The reason for this was that the Emitrons did not use for focussing and scanning the high magnetic fields which are used now; much of the weight of a modern studio camera is due to the focussing and scanning yoke used with the camera tube.

Nor was there the same requirement for warming up the Super-Emitrons which were ready for service almost as soon as the camera was switched on, since conditions at the target were not greatly affected by its temperature.

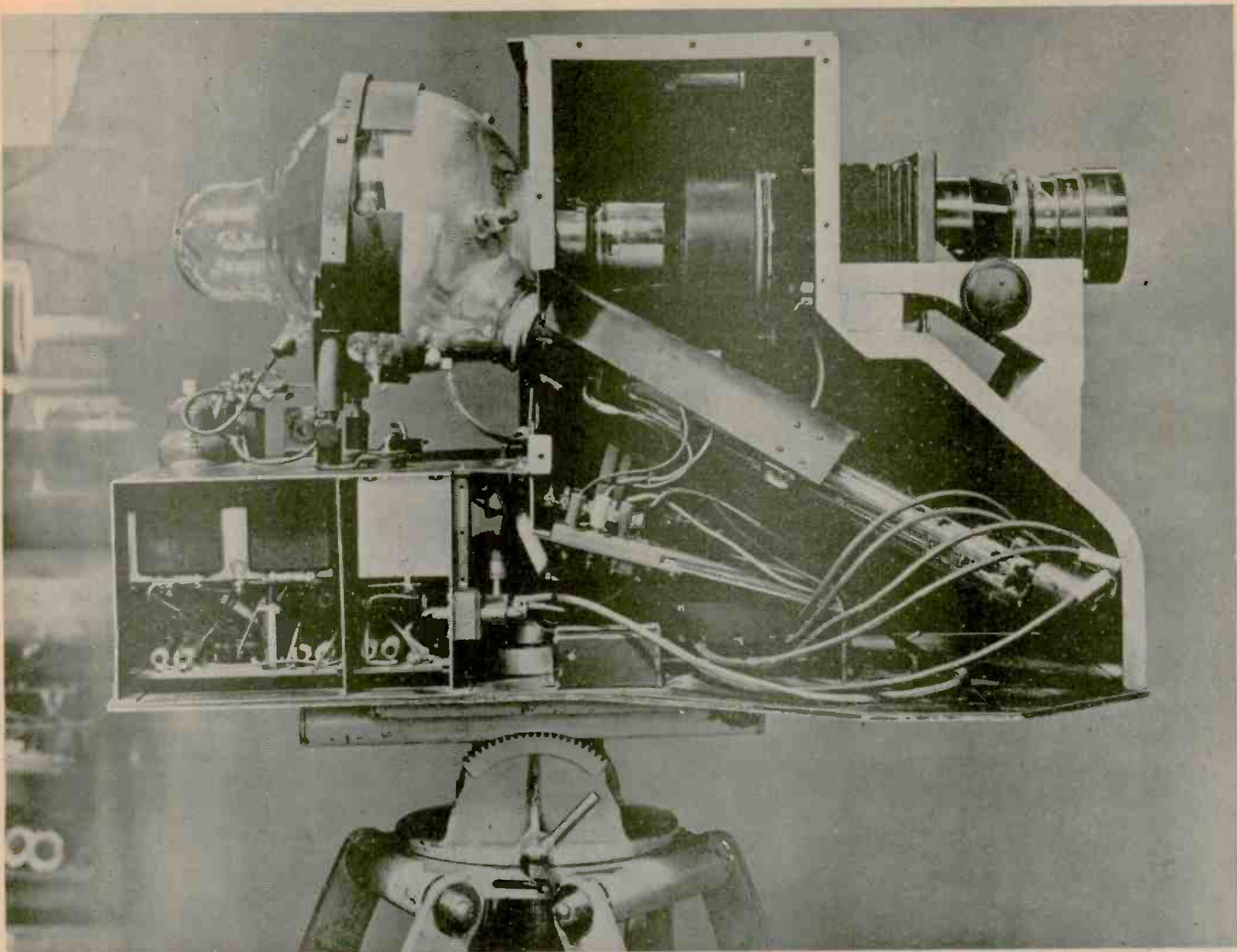
The great problem with both Emitron and Super-Emitron was that of getting a picture evenly shaded. At the centre of the target, the electrons released by photoemission (in the Emitron) were collected only by the newly-scanned areas of the target in the centre. At the edges of the target, some electrons could land on the silver coating around the tube. In the Emitron, only the electrons released from very close to the edge could land on the silver coating, and this caused the signal to rise sharply at the edge of the target. In the Super-Emitron, the change was more gradual due to the greater energy of the electrons, but in each case the uncorrected picture was too badly shaded to be useful. In addition to this, the angle of the gun tube to the target caused the beam to change in focus from one end of the target to the other, because the distance between gun cathode and target was changing.

The change of focus effect was easily dealt with by using a finer beam so that defocussing had no effect, but the shading effects were always troublesome. Some correction could be obtained by adding artificial correcting signals to the video-output. These correcting signals were obtained from the scans, but could be used only when the shading was proportional to the distance from the edge; this was the exception rather than the rule.

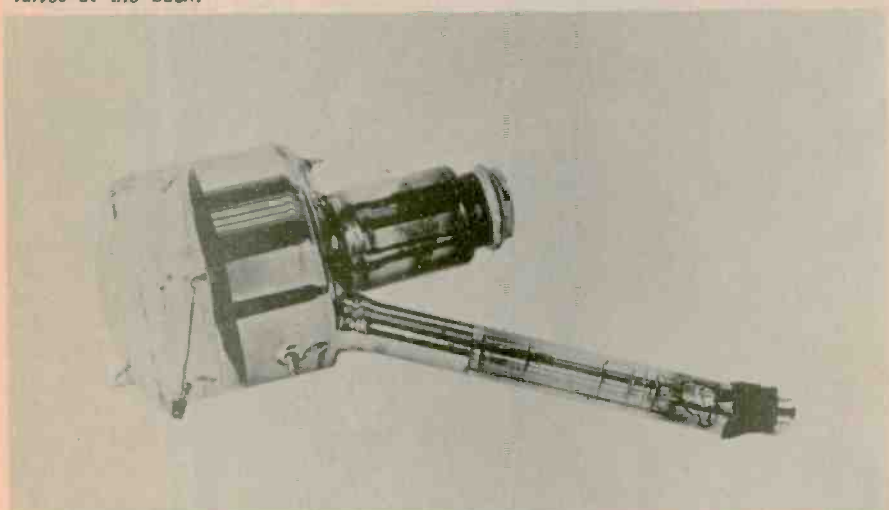
An early TV transmission. The regular BBC service started 37 years ago from Alexandra Palace — long before any other country.

THE CAMERA LAYOUT

The camera used for Emitron and Super-Emitron is shown partially dismantled in one photograph. The tube shown is an early version of the super-Emitron which has used most of the old Emitron components. The lens, together with the bellows for focussing takes up a large amount of the space in the upper portion of the camera. The region under the gun arm is occupied by the scanning stages and the power supply to the gun, whose cathode ran



Partially dismantled Super-Emitron. Despite its disadvantages it was light and warmed up very quickly. Note the shield on top of the gun arm and the valves at the back.



One of the early TV camera tubes.

at minus 1,000V so that the mosaic could be operated at about earth potential. Under the output contact of the tube can be seen the video amplifier, using pentodes run with very low anode leads and with a high standing current. In use, the bulb portion of the tube and the video amplifier were entirely screened to avoid electrostatic pickup.

Note the metal shield between the gun arm and the photocathode arm. This was to prevent defocussing due to the varying field from the scan coils affecting the magnetic focus of the photoelectrons. This field penetration was a weakness of the Super-Emitron layout which was never satisfactorily solved, though modern high-mu alloys would have helped considerably.

THE END OF THE EMITRON

Television transmissions from London ceased on September 1st, 1939, for the duration of the war. When broadcasting started again in 1946, the old Emitron cameras were dusted off and used again. At that time the Americans were playing with a gadget called an Image Orthicon, but the pictures obtained were so inferior to those from a Super-Emitron that few people took it very seriously at first. There is little doubt that the picture from a good Super Emitron under good illumination was excellent; for this reason the tube was still in use in some studios until about twelve years ago.

The first post-war competitor was the C.P.S. Emitron, an E.M.I. development of the original Orthicon concept, but the later work on the image orthicon and the vidicon made these tubes more and more competitive in terms of picture quality until eventually the Super-Emitrons were withdrawn. The story of these later tubes is equally fascinating, and is not yet finished, but must be told another time!

The Author would like to thank EMI Ltd, and especially Mr. Denis Farrell, for the photographs used to illustrate this article.

KILOVOLTS AND MEGAWATTS

Most people seem to think that valves died a natural death in the late '60's; in fact we have never made so many. Ian Sinclair tells us about the big valves behind this big business.

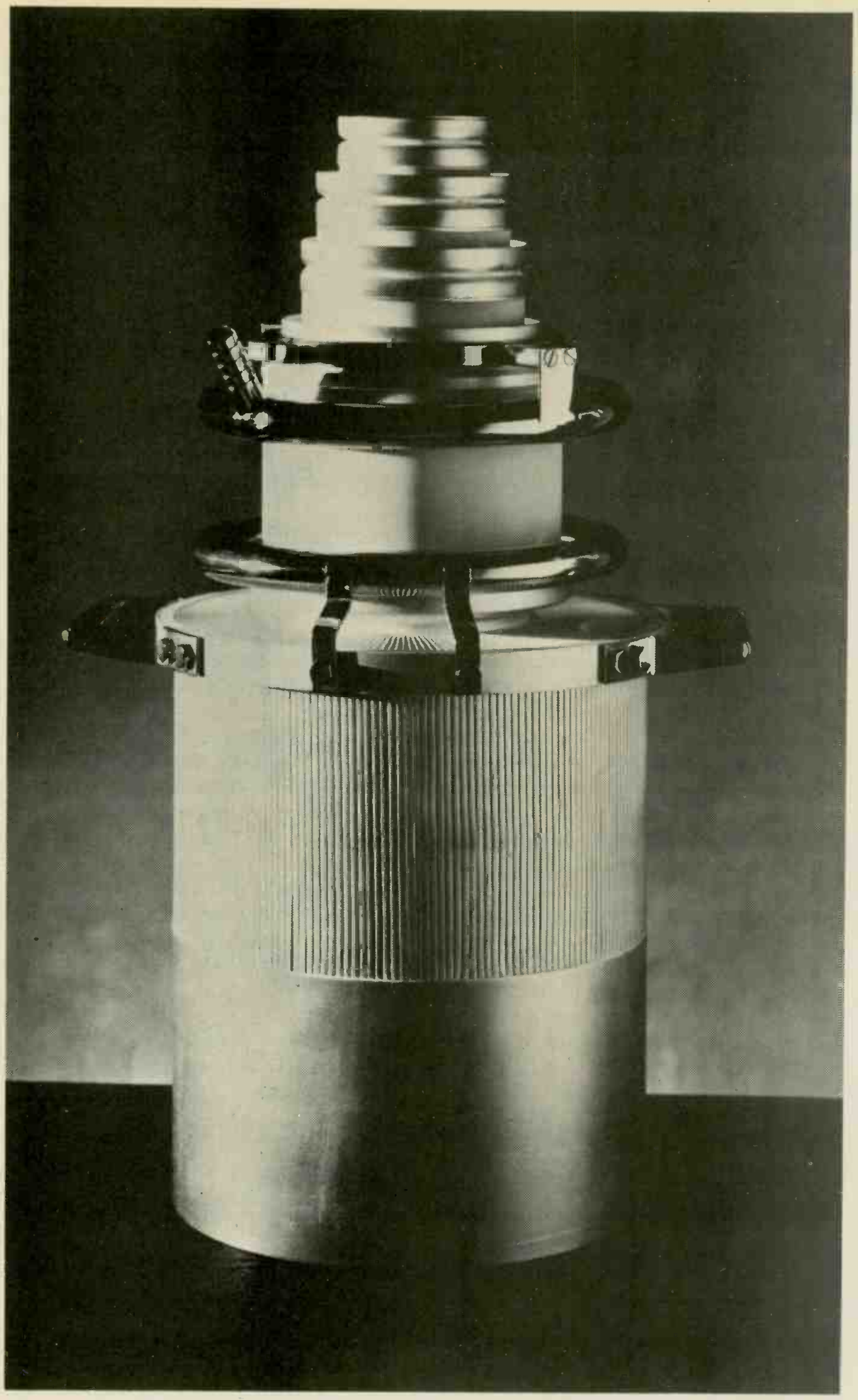
Nowadays, when integrated circuits seem to be taking over almost every aspect of electronics, and younger engineers confess to never having seen a valve, it comes as rather a shock to learn that the U.K. production of valves is the highest on record, and forms a major part of our exports in electronics, whereas integrated circuits and transistors form a major part of our imports. This odd situation is brought about by the steadily increasing industrial use of large valves, the increase in transmitters, in television cameras (for camera tubes are counted as valves), in cathode ray tubes and in microwaves, the sight of microwave ovens in roadside cafes and city pubs is now commonplate, and each of these represents one extra sale of a magnetron, plus spares, which did not exist five years ago. This article takes a look at the world of the large valves and how their construction differs from the small valves which have almost disappeared from everyday use.

Industrial valves each have a definite job to do, and are required to have a long operating life, to withstand a wide temperature range together with industrial atmosphere, shock and vibration. These considerations are important, for the time needed to replace a large valve may seriously disrupt a continuous process; unfortunately it is less easy to make large structures vibration proof. In most large valves the delicate portion is the electron emitting filament made of tungsten, an extremely brittle metal. Since this must operate at temperatures greater than 2000°C, it is difficult to support, as the supports must be made of brittle metals and they will also conduct heat away from the filament. The operating conditions also require efficient cooling, and the cooling by radiation which is satisfactory for small valves is useable only in the smallest sizes of industrial valves. There are three techniques used. These are forced air cooling, where the valve anode is part of the outer casing and finned like the cylinder of a motor cycle so that it can be cooled by a blast of air from a fan; water cooling where water is circulated round the anode and cooled in a radiator as in a car; and vapour cooling where the cooling is carried out by allowing liquid to boil and the vapour is condensed and recirculated.

Industrial heating triode with integral water jacket.
Filament 8V, 300A; Anode 13K Vmax, 10A max.

CONSTRUCTION

The construction methods used are more reminiscent of heavy engineering than of electronics. The use of glass (only the high-temperature Pyrex-type is used) is kept to a minimum by employing it only where insulation is necessary. Wherever possible metal structures are used, and ceramic is rapidly replacing glass as an insulation material. Though the process of sealing metal to ceramic is rather more complex than metal-to-glass sealing, the ceramic body



sections have great advantages. They can be constructed to finer limits, they absorb less water vapour from the air, and they withstand much higher temperatures.

The metal parts which form the major part of a large valve are made by a number of processes. Pressing, spinning and turning are the old favourites; pressing being particularly favoured since it enables large numbers of parts to be made to good dimensional tolerance at reasonable price, once the tool costs have been paid for. Spinning and turning are operations requiring human skill; their expense makes them less suitable for parts needed in large numbers, but they are still widely used. The reason is that, since industrial valves are made for specific tasks, a large number of types is needed with comparatively small numbers of each type, and the selling price is high enough to justify one-at-a-time methods like turning.

A disadvantage of all these traditional methods of forming metal is that the metal has to be lubricated during the operation and every trace of the lubricating material must be removed before the valve is assembled. Some lubricants are almost impossible to remove completely, and valve manufacturers must specify materials which are known to work satisfactorily if they are "farming out" metal forming work. Newer methods of forming metal such as explosive forming, spark machining and powder sintering are much cleaner and therefore being increasingly used.

JOINING

When the raw materials have been shaped and cleaned the next problem is of joining them together. Spot welding, as on car bodies, is a favourite method, since the weld can be closely controlled, but it has the disadvantage of leaving traces of copper behind which may have to be removed in an acid-wash. In addition, high conducting metals such as copper cannot be spot welded, and spot welding on the commonly used molybdenum causes brittleness. Of the commonly used materials suitable for valves, nickel is most easily spot welded, and so nickel and its alloys, many of which were originally developed for jet-engine turbine blades, are extensively used.

Argonarc welding is also a much used process, as it produces a clean unoxidised finish of high strength, and is a fairly trouble free process. Many commonly used soldering, brazing and welding materials cannot be used in valve construction because they contain metals which evaporate too easily at the temperature and vacuum used. For example, any solder or brass containing zinc is unusable, for the zinc will evaporate over the whole interior of the valve, making the insulators break down.

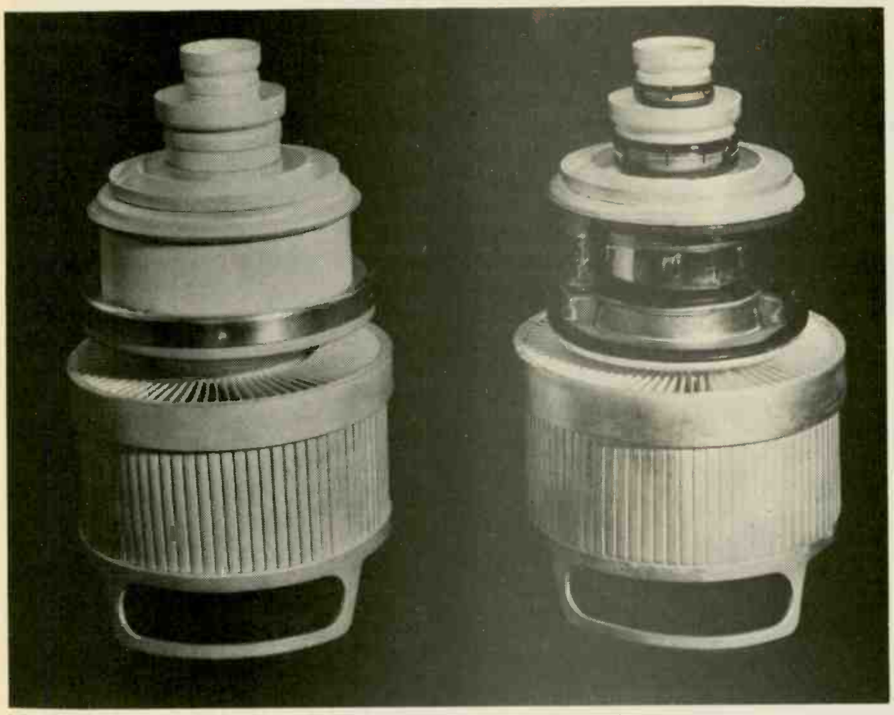
Brazing with copper, gold or a silver-copper alloy is a useful process, but must be carried out either in a vacuum or with the work totally immersed in hydrogen gas to avoid oxidation. Oxidation of metal means that elaborate cleaning is needed, because an oxidised surface will give off oxygen under vacuum conditions, leading to rapid failure of the valve.

The use of nuts and bolts is avoided as far as possible, because air is trapped in the threads inside the nut and can be very difficult to remove. In addition, the heating and cooling of the valve during processing and in use tends to cause bolts to slacken. If they are used at all, they are turned from stainless steel.

CLEANING

Before a valve can be finally assembled and pumped free of air, each component must be cleaned to a high standard. Cleaning in this case does not imply mere surface cleanliness, the metal must be free of absorbed materials which could evaporate during processing, and it must also contain the

KILOVOLTS AND MEGAWATTS



Glasses and Pots. Industrial heating triodes in ceramic-metal or glass envelopes. Filament 5V, 78A; Anode 6kV max., 2A max.

minimum of dissolved gases which would cause the pumping time for the valve to be longer than necessary. Grease remaining from forming operations, and volatile metals rubbed off from tools are the most common sources of contamination of parts and the most harmful. During pumping at high temperatures, grease breaks down chemically releasing large amounts of gases and leaving carbon behind. Volatile metals, zinc in particular, evaporate and coat insulators as mentioned earlier. Brass, which contains zinc, is the usual source of this contamination; the parts may have to be placed over a brass jig or filed with a file used on brass. The ease with which this contamination may occur leads manufacturers to carry out most critical forming operations themselves so that brass can be completely excluded.

The gases absorbed by valve components include all of the gases of the atmosphere, and of these water vapour and carbon dioxide give the most trouble. Water vapour is particularly troublesome when glass parts are used, as it is particularly strongly absorbed by glass and only prolonged high temperature treatment will remove it. It is essential to remove the water vapour, as bombardment of surface films of water by electrons causes hydrogen and oxygen (the elements making up water) to be released, and the oxygen is particularly harmful. The problem associated with carbon dioxide is that it is a dense gas, and therefore can be pumped away only very slowly.

Cleaning processes must therefore be aimed at removing surface films of grease and other solids, and also at making the job of gas removal as easy as possible. All cleaning therefore starts with washing, using pure water for ceramics and glass and degreasing solvents for metals. The remaining cleaning operations are carried out at high temperature, air baking for glass and ceramics, and hydrogen furnacing for most metal components. Hydrogen furnacing consists of heating to red-hot temperature in an atmosphere of hydrogen, and has two particular merits. Firstly, the hydrogen will combine with any traces of oxygen present; secondly the denser gases present tend to be replaced by hydrogen, which, as it is the least dense gas known will be most easily pumped away during the final processing of the valve. In a few cases, components for very specialised tubes may be heated in a vacuum and then stored in a vacuum until assembled, but hydrogen furnacing is by far the most widely used treatment; the main exceptions being the important metals molybdenum, tungsten and tantalum which become brittle when heated in hydrogen.

Other heat treatments may also be applied at this stage. Where metals are to be sealed to glass, a thin film of metal oxide is needed on the metal surface to bond to the glass, and the thickness and composition of the oxide is critical to the seal, affecting its strength and vacuum-holding. The mild oxidation is usually carried out in a hydrogen furnace into which water vapour is blown; the small amount of oxygen obtained from the breakup of the water vapour is enough to give a good uniform oxide film on the metal. Some components require a particularly spongy metal surface to help retain a surface coating, and this is generally achieved by furnacing alternately in wet hydrogen and dry hydrogen, so that oxide films are produced and turned back to metal again.

COATING

Coating of materials applied to surfaces within a valve account for only a tiny fraction of a valve's weight but often for a large part of its performance. To take an obvious example, in the smallest industrial valves and microwave tubes the electron emission is from a cathode coating. The cathode material is nickel, but no electrons are obtainable from hot nickel unless it has been coated with a mixture of the oxides of calcium, barium and strontium and these materials have to be applied to the cathode at some stage in its manufacture. The time chosen is after cleaning and hydrogen furnacing, when a mixture of the carbonates of these metals is sprayed on, in the form of a paint, to the cathodes. The spraying technique is critical, much more so than in the case of normal painting. During the valve processing, as the valve is pumped, the heater is activated and the carbonates release carbon dioxide, turning to oxides. This rather indirect method is needed because the oxide surface exposed to air absorbs water vapour, destroying the efficiency of the cathode.

Carbon is another material much used for coatings, this time to destroy electron emission. Desirable as electron emission is for cathodes, it is undesirable from grids or anodes, and carbon coating of the grid wire or anode cylinder is carried out to minimise electron emission from these surfaces. In the case of small radiation-cooled valves, carbon coating is also used on the outside of the anode to increase the efficiency of radiating away heat since blackened surfaces are more efficient radiators. The longer valves use blackening on the fins (when air cooled), but the need is less important.

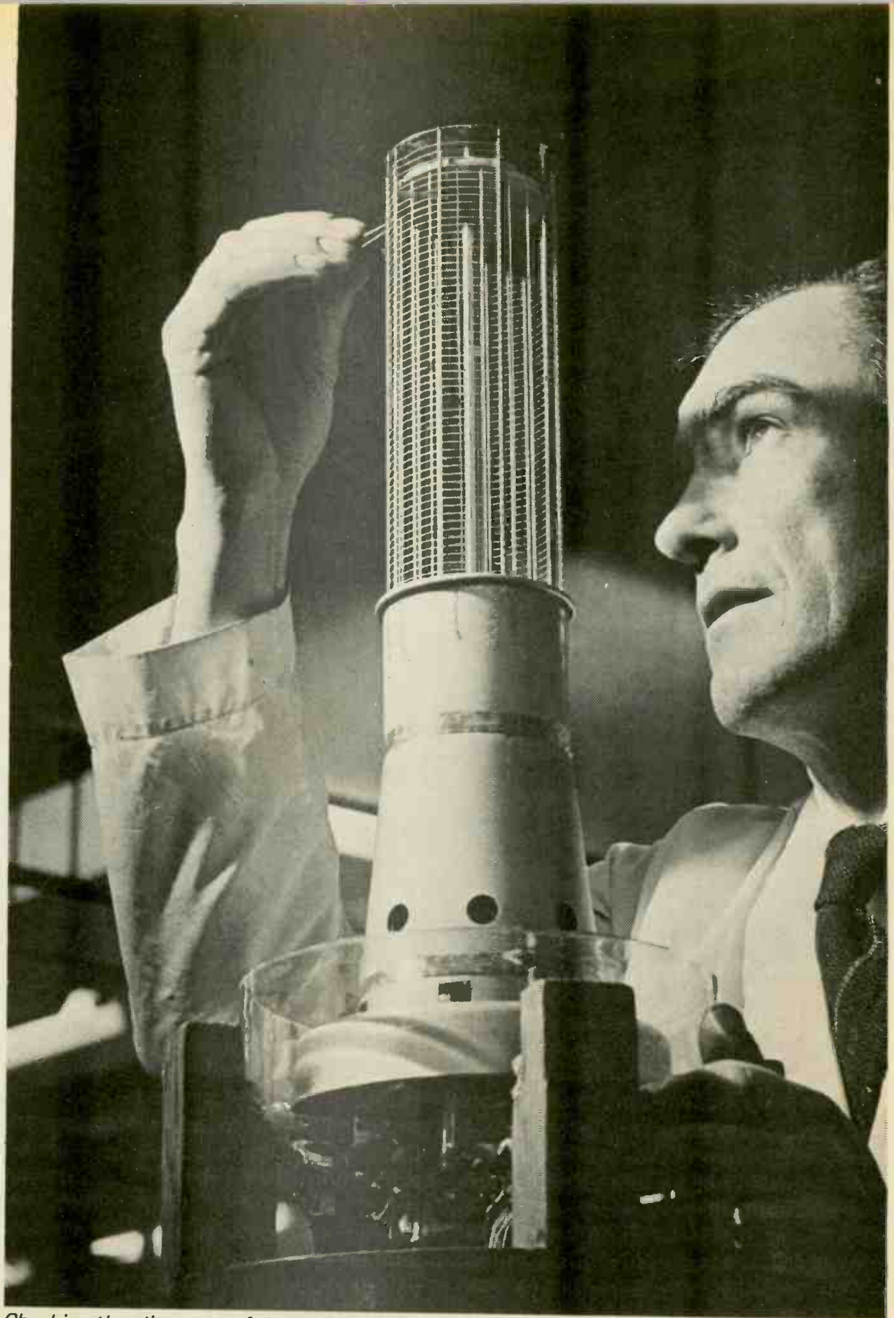
A third and most important type of coating is the gettering agent. Conventional vacuum pumping can remove a fair proportion of the gases inside a valve, but there comes a stage when no more is being removed. At this point, or just before it, the valve is sealed and taken from the pump, but pumping cannot stop at this point. For long life even more gas must still be removed and there must be some way of soaking up the gas which will inevitably be given off during the life of a valve. A few hours of pumping time cannot remove the gas which will be emitted by hot components over several thousand hours of active life. A material is therefore placed inside the valve to 'get' this last trace of gas; logically enough, it is called a getter. Smaller valves use barium alloy getters. Because the material is so intensely gas absorbing, it cannot be exposed to air and is therefore produced inside the valve when needed. The chemicals needed to produce the getter film are mixed, packed in a nickel tube and the assembly mounted in a part of the valve where there is little chance of material being evaporated on to insulators. In smaller valves this is usually on top of the anode insulators or well below the main assembly. When the nickel tubes are heated from outside (by induction heaters), the chemicals react, evaporating a thin film of barium metal to form the familiar shiny coating which will then clean up the remaining gas throughout the life of the valve.

Large valves work at such high internal temperatures that barium getters would re-evaporate, causing insulation problems, so other materials must be used. A favourite metal is zirconium which, again, cannot be used directly. Anodes and grids of large valves are coated with zirconium hydride, often mixed with carbon, and this emits hydrogen during valve pumping to leave a coating of pure zirconium as the gettering material. Unlike barium, zirconium works better hot and so the coating can be formed while the valve is on the pump.

PUMPING

Assembly ends with the sections of the valve being sealed together ready for pumping. A large triode would consist of an anode, with glass or ceramic insulator as one unit, and a filament and grid mounted on a base unit with glass or ceramic seals. The final operation is therefore a glass or ceramic seal. In other cases there may be several seals, or the final operation may be that of argonarc welding metal flanges. Once this is carried out, the valve is ready to be pumped.

Pumping is never merely an operation of removing air from a valve; many of the activation processes are carried out at this stage. During pumping, the valve must be heated to a temperature higher than it will normally attain in use, and this temperature must be held until most of the absorbed gases have been pumped away. In addition, the valve will usually be operated; so supply voltages need to be laid on ready for connection to the filament, grid and anode.



Checking the alignment of the grid assembly for a power triode.

The schedule of operations for pumping a valve will vary from one type to another, but the principles are roughly similar. Two pumps are used, a mechanical pump which provides a 'backing' vacuum, removing about 99.9999% of the air (this is a poor vacuum!), and providing conditions good enough for the second pump to take over. The second pump uses the principle of diffusion - that a stream of rapidly moving dense gas such as mercury vapour or silicone oil will carry along with it molecules of less dense gases and so move them from one place to another. In the diffusion pumps used for valve pumping, the stream of vapour carries gas from the valve to the backing pump, and the backing pump then carries it away.

In action, the valve is sealed to the vacuum system. Rubber or similar joints are unusable, as they can stand neither the vacuum nor the temperature. The backing pump is started up and a vacuum gauge switched on. When the pressure of gas in the valve is low enough (about 1/100,000 of normal air pressure) the diffusion pump is switched on. As the diffusion pump takes over, the pressure falls rapidly and an oven is drawn down over the valve and switched on. As the oven heats up, the gas absorbed in the valve components is released and pumped away by the diffusion pump.

After a few hours or so, depending on the size of the valve and the speed of the pumps, the pressure will be low enough to start the activation of the valve. The smaller valves are the most difficult to deal with at this point, because the operation of the heater releases very large quantities of carbon dioxide from the cathode and this has to be pumped away before electrons can be drawn from the cathode. The larger valves have the emitting wire (tungsten or thoriated tungsten) run at a higher temperature than will be used in practice. Then current is taken to the anode, often using the valve as a rectifier.

For the large valves this may require substantial power supplies at the pump; for example it is not unusual for a large transmitting valve to need 115V at 400A on the filament, and 30-50kV on the anode at currents of 1A or so.

Photoelectric devices such as TV camera tubes and photo multipliers require very specialised pumping schedules at this point, since the photosensitive and multiplier stages are formed inside the tube during pumping. Microwave valves also require specialist treatment as they can seldom be operated normally while on the pump.

When activation is complete and the valve is behaving normally, cooling starts, and this should be accompanied by a steady drop in pressure as gas ceases to be emitted from the internal components. Once the valve is cool enough, it is removed from the pump. Where a glass seal has been used this is carefully heated until the glass tubing collapses and can be drawn out into the familiar tip so sealing off the valve. For the metal pipe seals, more common in the large valves, the pipe is simply squeezed flat and then cut. Using a soft copper pipe, this is sufficient to ensure a vacuum seal owing to the 'cold welding' which takes place between clean copper surfaces when pressed together at high pressures. At this stage, the small valves, phototubes and smaller microwave tubes will have their barium getters activated.

High power transmitting triode being prepared for high voltage testing.

CHECKING AND TESTING

An industrial valve is a high cost item, and its packing and transport is expensive; it is important that each valve sent out should have been properly checked and tested. The first checks are for electrical leakages between electrodes. since the valve is to be used at high voltages, a high voltage tester is used with the valve cold. Traces of conducting films on insulators can be sparked away until the insulation is of a satisfactory standard. This cannot be measured with a conventional megohmeter, as its test voltages would be too low. For example, a gap of 1mm between conducting films would register as open circuit on a megohmeter, but would spark furiously at anywhere near operating voltage. The valves are then slowly run up to normal operating conditions, during which time the getters are working hard and the electron emission is building up. Testing the valve during this period is useless, as the characteristics will alter continually until the valve has settled. This period, the ageing period, can often be speeded up by operating the valve at rather more than its normal ratings.

Testing follows when ageing is complete, and can vary from a simple test in an oscillator to the complete measurement of every parameter of the valve, depending on the price and the application. In some cases, a valve which fails to meet one specification may meet another one, and will be stamped accordingly, but usually the uses of large valves are so specialised that there is no outlet for a 'near-pass'. The successful valves are booked into stores for sales, the failures are broken up and the most valuable components salvaged.

This, then, is one of the bright spots of our Electronics industry, the region of megowatts and kilovolts, phototubes and microwaves. The design of some of these devices has hardly changed in 40 years; others are novel both in concept and engineering. Lumped together they form a formidable part of the electronics components industry which is hardly known outside professional engineering circles. It seems likely that the achievements of this sector of electronic engineering will continue to grow and yet will continue to be unnoticed.

(The author is grateful to STC Valve Division for the provision of the photographs illustrating this article).

eti INPUT GATE

LETTERS FROM OUR READERS

THE LADIES REPLY

Having only recently discovered your magazine, I was intrigued by the plea in the 'News Digest' section for any ladies who are interested in electronics to write to you. My interest in electronics is fairly recent (within the last couple of years) since it was so badly taught at university (London, Westfield College) that the word transistor made me shudder. I decided that this was a very bad situation in view of the increasing influence of electronics on everyday life, and ended up at the local college doing a City and Guilds evening course.

At present I am employed by a local firm, Erie Electronics Ltd., as a 'Filter and Suppressor Design Engineer' (albeit a rather fledgeling engineer).

I hope this letter is of interest to you, if only to convince you that there are members of the gentler sex who show an interest in electronics.

Joyce A. Farnese,
Gt. Yarmouth, Norfolk.

Mrs. Farnese was the first lady reader to write to us and has been given a free three months subscription.

With reference to your appeal in ETI for lady electronics enthusiasts to write to you, I felt that you may be interested to hear of my involvement in the electronics field.

I am 21 years of age, recently married, and employed by the Ministry of Defence (Air) as a radio technician. I received my training for this position at the Royal Air Force Maintenance Command Civilian Technical Training School at R.A.F. Sealand, Deeside, Flintshire. It is at Sealand that I work now doing all the same jobs as my male counterparts. I have obtained my final certificate in the City and Guilds of London Institute Telecommunications course and, although I am extremely happy at my work, my only regret is that should my husband (who is a serving member of the Air Force) be posted it may prove very difficult, as a woman, to get another technical position in the electronics field.

Mrs. J. Sayce, Mold, Flintshire.

As one of your female readership I was full of good intentions about answering your "C.Q. Ladies" call in May. As usual, a second call was necessary to kick me into action, and I hope you will receive a goodly number of replies this time. I look forward to reading about my contemporaries in other places.

I must confess it is my hubby who buys the magazine but I enjoy "second read".

My entry into electronics was fairly accidental - first job being as a technical trainee in PYE's Radio and TV design lab at Waihi, New Zealand. I eventually gained a New Zealand Certificate of Science (Chemistry) - had a spell on radio and TV alignment and did a radio apprentice's correspondence course.

After four years with PYE, then two years testing milk, cheese and water with the makers of "Anchor" products, I joined the staff of the Technical Institute in Hamilton, NZ. I found myself doing a wide variety of things; drilling holes to put up shelving, sexing fruit flies, building electronic test gear and even a bit of teaching.

When we came to England two years ago I decided, if possible, I wanted to work for someone who made scientific instruments. I started as a junior electronic engineer with Vacuum Generators who produce vacuum chambers, associated control and measuring instruments and systems such as electron spectrometers.

By the way, I'm not a "Women's Libber". I haven't yet met sex discrimination that isn't to my advantage.

Mrs. M. Donald, Lingfield, Surrey.

BOOM! BOOM! BOOM!

I was watching colour television in the Tokyo YMCA in November 1964, which is more than "about six years ago". Even a remote farm in Nikko Province had colour television when I stayed there in February 1968, which is more than "two years ago".

One can but wonder where we would be today if the development contract for Concorde had been placed with Japanese industry!

R. G. Simmons, Pinner, Middx.

ELECTRONICS TOMORROW

May I congratulate you on your new series electronics tomorrow. This is the kind of article we want to keep us in touch with the latest products, and of equal importance where to get data and (we hope) applications sheets. Where to buy one-off components is also very helpful.

D.G., Stanmore, Middx.

LIQUID GAS?

The enjoyment of the article on 'Cryogenics and Superconductivity' was considerably lessened for me by the repeated references to 'liquid gas'. One expects technical publications to do better than this especially as there are references in the article to liquefied gas.

If you or your contributor can show me some liquid gas I will present him with an empty box of matches!!

J.R.T., Colwyn Bay.

The Editor does not necessarily agree with the views expressed on this page.
Letters intended for publication should be addressed to:
Input Gate
Electronics Today International
36 Ebury Street
London SW1W 0LW

eti

WHAT TO LOOK FOR IN NOVEMBER

SPECIAL SUPPLEMENT: DIRECTORY of Hi-Fi AMPLIFIERS

In the next issue we shall be listing the specifications of about 100 of the most commonly available Hi-Fi amplifiers available in the UK. Where possible the specifications will all be shown in the same form to enable instant comparison of performance.

EXCLUSIVE OFFER TO ETI READERS

THE ADVANCE INTERNATIONAL PORTABLE CALCULATOR KIT (as described in this issue)

FOR ONLY £26.95

(Only by using the special coupon in the November issue)

HI-FI–The state of the art

Things are happening in Hi-Fi with entirely new approaches being taken by some manufacturers. The Quadrophonic War is only one of the items discussed.

Unreasoning radiation

It took some years to appreciate the dangers of radioactivity and now a similar danger is seen for microwaves. ETI reports on disturbing new evidence.

Product test: Beogram 4000

This revolutionary turntable is now becoming available. It uses completely new techniques and these are tested by ETI's audio consultants.

Automatic battery charger

An ETI project which enables you to connect the battery charger and forget it. The unit will even operate into a short circuit and is regulated for both voltage and current.

ON SALE MID-OCTOBER–20p

ETI TAKES A PRIDE IN BEING REALLY UP-TO-DATE, SO WE OURSELVES DO NOT ALWAYS KNOW WHAT WILL BE IN THE NEXT ISSUE SO THE FEATURES MENTIONED ON THIS PAGE ARE ONLY SOME OF THOSE THAT WILL BE INCLUDED.

electronics today INTERNATIONAL

EXCLUSIVE KIT PREVIEW

The ADVANCE International Portable Calculator

"A KIT FROM ADVANCE?.... surely they're test and laboratory gear people?'

Correct Sir, but they're also pretty big in calculators; the Advance Executive is one of the best sellers in this country and also this company have quite a bit of experience in calculator kits. They produced some time back the first calculator kit known to us (featured in *Wireless World*) and for some time now they have been exporting the Executive in virtually kit form for assembly overseas.

Our calculator competition in the July issue which had three of the Executives as prizes attracted over 2000 entries - an exceptionally high response and so when we heard that Advance were thinking of introducing the Executive as a kit we were on to them like a shot.

Your Editor already had one of the built versions and was very pleased with it. Now, for most mechanically or electronically minded chaps the guts of a machine of this type have an overpowering fascination, even if it is just a few components. With the maker's agreement, this was opened to see what a kit would involve. The inside can be seen in one of the photographs.

THE INTERNATIONAL

Advance will be launching this kit known as the International on October 19th but we were supplied with a prototype kit and a set of basic instructions and allowed to get on with it.

Now we have all heard about the danger of soldering CMOS I.C.'s and we mentioned this to Advance. This is more critical in this kit than most as the main chip is soldered in direct: there is no room for a socket. Advance say, and they should know, that if reasonable precautions are taken troubles are most unlikely. These precautions include leaving the chip on its conductive foam until the last minute, avoid handling the pins, use a small bit soldering iron and make certain it is earthed. There are one or two other simple rules but they are clearly described in the instructions. If these rules are followed, Advance will replace the chip free of charge and they can tell what has caused the thing to blow!

BUILDING THE KIT

At the time we received the kit the instructions were not completed and so we were provided with the instructions for the overseas assemblers which were far more basic. Even so, after reading them carefully, we checked that the earth on our mains socket was connected (they aren't always) and plugged in the soldering iron (which must have a bit of 1mm or 2mm).

The kit has been well thought out. The correct solder is included and the fifteen or so wires from the keyboard to the main circuit board are all cut to length, stripped and tinned.

Component siting is printed on the p.c. board and is virtually foolproof. The p.c. board has plated through holes and only requires soldering on the underside.

After about 2½ hours we were ready to switch on but not before a thorough check had been made to ensure that there were no solder bridges and that everything was the right way round.

Success! On came the little LED zero and we were underway.

We have since seen the instructions which will accompany the kit and they are excellent. It would have saved us some time if we had them available. The instruction books which accompany calculators have always seemed to us to be rather poor but that which comes with the International is pretty good and shows how best use can be made of your calculator.

There is a Mains Unit which also acts as a desk stand and recharger (rechargeable batteries come with this); this is extra. We also built up

As the photograph shows, there are relatively few components to the Advance International Calculator kit. It can be built in under three hours.

this with no problems.

Both kits are beautifully thought out - there is even a plug with the mains unit!

CALCULATOR FEATURES

The Advance International is identical to the Executive except that you build it up yourself and so naturally it has the same features.

In addition to the usual functions of addition, subtraction, multiplication and division, the calculator will perform chain operation, a series of consecutive instruction and constant operation in the multiply or divide mode. A useful fixed or floating decimal point function is included, the fixed decimal point being very useful for monetary calculations.

The 'International' is based on a Texas chip and incorporates a nine digit, LED, seven segment display. It has one of the best keyboards that we have come across - having a pleasant, positive 'click' action making it almost impossible to enter incorrect data.

NEXT MONTH'S OFFER

The regular selling price of the kit will be £29.95 including VAT and postage, making it one of the best calculators available at about the cheapest price. However, ETI have made arrangements for an even lower price to our readers - £26.95 including VAT and postage. Please note, however, that the International will not be available until October 19th and the low price only applies to those using the special coupon which will appear in the next issue.

The main circuit board, the key board and the battery holder of the kit built by ETI.

CALCULATOR COMPETITION WINNERS

Over 2000 entries were received for the Advance Calculator Competition in our July issue. Surprisingly only about one third were correct. The first three drawn were from

G. W. Horrocks,
Nantwich, Cheshire.

F. Birchall,
Levens, Westmorland.

S. McLuckie,
Coatbridge, Lanarkshire.

A number of readers pointed out that question 5 was ambiguous. For this reason we accepted both answers: 53.17581 and 30.14279 although very few entries were received with the former figures.

The correct answers were:

1. At present a man is earning £1,875 per annum. If his salary increases by 8.5% each year for five years and 7.6% per year for a further five years, what will his salary be after 10 years? The rises are compound; give your answer to the nearest 1p.

   £ 4066-41p

2. Calculate to two decimal places:

   $\left(\frac{187.632}{7.531} \times \frac{7856.42}{8.437}\right) + 50.485 = 23250.64$

3. What is the square root of 789 (to five decimal places)

   = 28.08914

4. If we take the population of England, Scotland and Wales as 54,022,410 and the total area as 88,763 square miles, what is the population density per acre? Give your answer to five decimal places.

   = 0.95096

5. What is 1.76413 to the power of six (multiplied by itself six times)? Give your answer to five decimal places.

   = 30.14279

6. The resonance of a tuned circuit is given by the formula:

   $f = \frac{10^6}{2\pi\sqrt{LC}}$ kHz

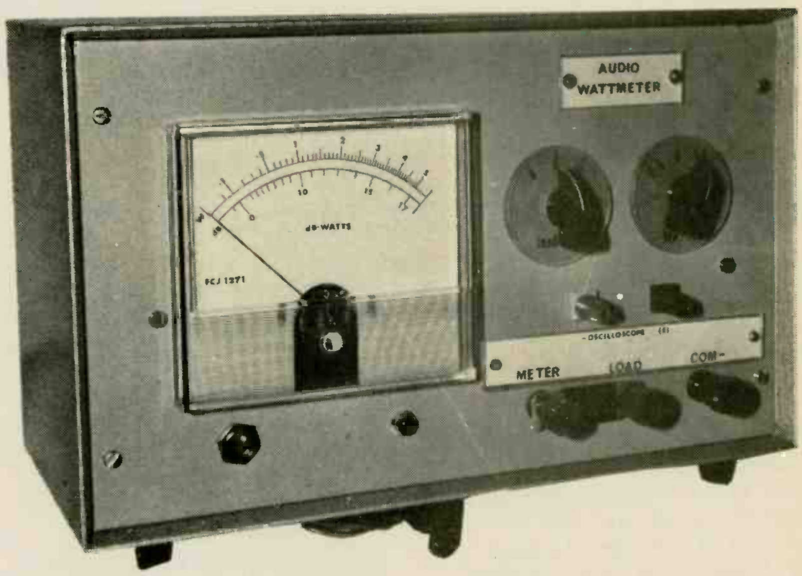
   Where L is in microhenries and C in picofarads; take π as $\frac{22}{7}$

   If L is 97μH and C is 109pF, what is f? Give your answer to four decimal places.

   f = 1547.1993

AUDIO WATTMETER

eti PROJECT



BY B. GRAVES.

THE MOST COMMON method used for checking audio power levels is first to measure the r.m.s. voltage (V) across a given load resistance (R) connected to the amplifier output and from V^2/R obtain the r.m.s. power in watts. Test gear requirements are an audio signal voltmeter that will operate over a frequency range of at least 10 to 100,000 Hz (+1dB), a load resistance of accurately known value and an oscilloscope for monitoring the signal output. The latter is essential for (a) checking that the signal output is not distorted by overloading at the amplifier input stages and (b) for verifying the onset of clipping when measuring maximum r.m.s. output power. If power level differences are to be expressed in decibels, when plotting power bandwidth for example, then the ratios must be connected by 10 log10 P2/P1 (or by a decibel coversion table or chart).

The advantage of a direct reading audio wattmeter is that instant power readings in watts (r.m.s.) and level differences in decibels can be obtained at any frequency within the normal audio range. This facility is particularly useful for example, when carrying out total harmonic distortion checks at different power levels and frequencies. An instrument of this nature could be particularly advantageous in a busy service department dealing mainly with amplifiers of various kinds and to those who like the writer, are frequently engaged in testing hi-fi amplifiers and the like for performance to manufacturer's specifications.

The audio wattmeter described here was designed and constructed expressly for checking the r.m.s. power output of amplifiers operating into standard loudspeaker loads of 4, 8 and 15 ohms. Three power ranges are provided, 0 to 0.5W, 0 to 5W and 0 to 50W with minimum levels on each range of 0.01 0.1 and 1W respectively. The lowest level that the meter is capable of indicating with reasonable accuracy is 0.01W (10 milliwatts). Absolute maximum on the 0 - 50W range is 56 watts for the meter f.s.d. The audio frequency range of the meter is 10 to 200,000Hz ± 1dB. The 4, 8 and 15 ohm load resistors are incorporated within the meter but note that the meter will not indicate true wattage readings with loads of values other than 4, 8 or 15 ohms.

THE CIRCUIT

The meter circuit is shown in Fig. 1 and consists simply of the dummy load resistors R1, R2 and R3, the attenuation and correction networks RV1 to RV6 and the two stage audio voltmeter Q1-Q2. The input impedance to the meter circuit is never less than 100k ohms, the value of R4, and imposes no load on the dummy load resistors R1, R2 and R3. From R4 signals are fed via RV1, RV2 or RV3 which provide signal level correction according to the dummy load in use. For instance 20W into 8 ohms will produce a lower r.m.s. voltage than 20W into 15 ohms, so correction must be provided in order that one wattage scale only can be used on the meter itself.

The pre-sets RV4, RV5 and RV6 set the wattage ranges to either 0 to 0.5, 0 to 5 or 0 to 50W, the signals across these being taken to the meter amplifier Q1-Q2. The meter operates from a bridge rectifier D1 to D4 with negative feedback applied via RV7 to ensure a uniform frequency response, from 10 to 200,000Hz, and also to set the initial sensitivity of the meter amplifier. The meter circuit is powered from a 24V stabilised supply, the circuit of which is shown in Fig. 2.

CONSTRUCTION

The prototype, as shown in the photos was housed in a mild steel case with louvres in the base and rear (Home Radio type BX5 12¼ x 7½ x 5½ins). If any other, ready made or home made, case is used it must have holes or louvres in the base and rear to allow air circulation around the dummy load

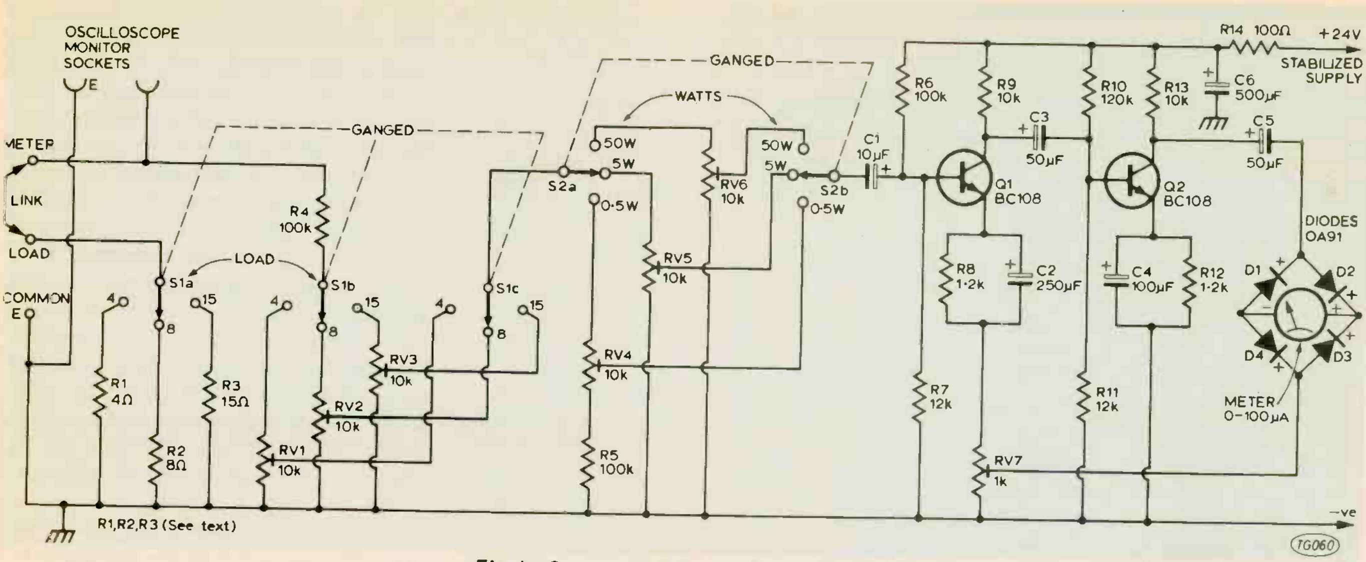


Fig. 1. Complete circuit of the Audio Wattmeter.

resistors. Details for the panel layout are given in Fig. 3a and for the chassis in Fig. 4. The chassis is attached to the front panel as in Fig. 3b.

There are four circuit boards, one for the power supply, one for the meter amplifier, one for the meter rectifier and one for the pre-sets RV1 to RV6. Details for these are given in Figs. 5, 6 7 and 8. The two larger boards, meter amplifier and power supply, are mounted on the chassis on stand-off pillars in the positions shown in Fig. 9. The presets board is mounted upright on a piece of aluminium angle and the meter rectifier board is secured under the meter terminals (see also Fig.5).

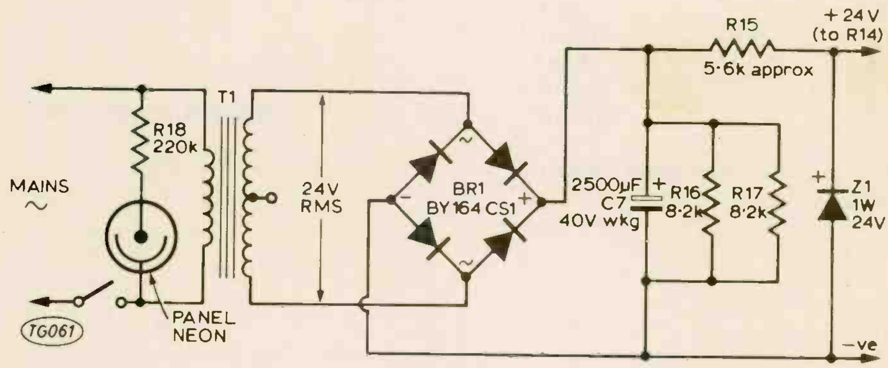


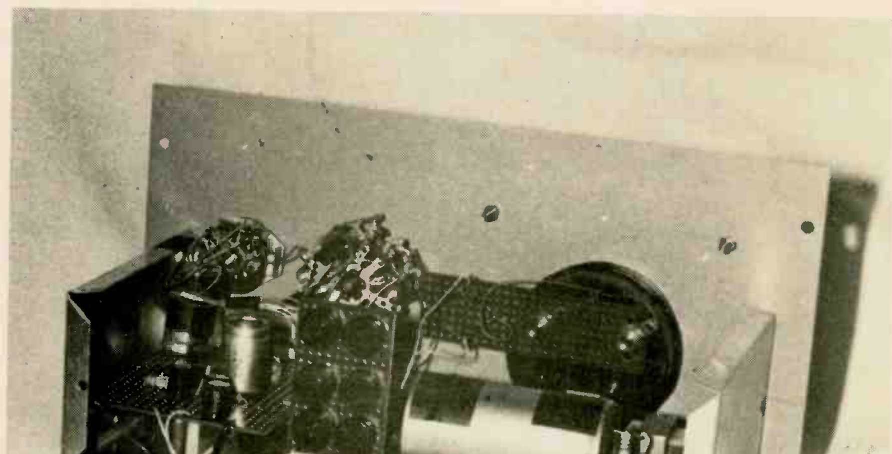
Fig. 2. Power supply circuit.

THE DUMMY LOADS

These must be accurate to within about one tenth of an ohm, if the meter itself is to give accurate readings. The load resistors are made from spiral electric fire elements rated for 1,000 watts and which can be purchased readily from electrical goods retailers. The frame for the resistors is made from paxolin (not less than 1/16th in. thick) as shown in Fig. 10a. The 4 ohm load is made from three lengths of spiral element connected in parallel as in Fig. 10b.

Each length is approximately 11 ohms but the best way of being sure to obtain the right amount in each piece and then arrive at the final 4 ohms, is to cut three pieces each of say 12 ohms. Join them in parallel on the frame as in Fig. 10c and trim each piece by a turn or two of the spiral at a time until exactly 4 ohms is obtained. The preliminary cutting can be done with the ohms range on an ordinary multimeter but the final adjustment must be done by measuring voltage and current with accurate meters.

A supply voltage can be obtained from a transformer capable of delivering say 6V at 1A or by tapping a car battery. The test set up is as shown in



Rear view of the prototype. Various sub-assemblies can be seen though the load resistors are hidden underneath.

PARTS LIST

R1	Resistor	made from 1000W electric		
R2	''	fire spiral element (2 required)		
R3	''	See text		
R4	''	100k	5%	¼W
R5	''	100k	''	''
R6	''	100k	''	''
R7	''	12k	''	''
R8	''	1.2k	''	''
R9	''	10k	''	''
R10	''	120k	''	''
R11	''	12k	''	''
R12	''	1.2k	''	''
R13	''	10k	''	''
R14	''	100ohms	''	''
R15	''	5.6k	''	''
R16	''	8.2k	''	''
R17	''	8.2k	''	''
R18	''	220k		
C1	Capacitor	10uF	25V min. electrolytic	
C2	''	250uF	''	
C3	''	50uF	''	
C4	''	100uF	''	
C5	''	50uF	''	
C6	''	500uF	''	
C7	''	2,500uF	40V min. electrolytic	
RV1	Miniature Pre-sets		10k	
RV2	''		''	
RV3	''		''	
RV4	''		''	
RV5	''		''	
RV6	''		''	
RV7	''		1k	
D1	Diode		OA91	
D2	''		''	
D3	''		''	
D4	''		''	
Z1	Zener Diode		24V, 1W	
Q1	Transistor		BC 108	
Q2	''		BC 108	
S1	Switches		3 pole 3 way	
S2	''		2 pole 3 way	
BR1	Rectifier		BY164	
T1	Transformer		Primary 230V; Secondary 12V + 12V, 50mA (Eagle MT12)	

Meter 0 - 100uA f.s.d.; Anders KM118

Case 12¼ x 7½ x 5½ ins. (BX5, Home Radio)

On/off Swtich; mains panel neon; 2 pointer knobs; 3 insulated panel terminals; 2 insulated sockets; four 0.15 in. matrix circuit boards (1 x 3¾ in., 3 x 1½ in., 5 x 3¼ in., 4 x 3 in.); Aluminium sheet (16 s.w.g.), 16¼ x 4¾ in. for chassis, 2 x ½ in. for link; Aluminium angle, 3/8 x 3/8 in. (2 pieces, 3 in. long and one 1½ in.); Paxolin sheet 5 x 3 3/4 x 1/16 in; 4 stand-off pillars.

Needed in setting up

For load resistors: 6V, 1A supply; meters for 1A and 6V; 20 ohm, 1A variable resistor (see text)

For Calibration: Signal Generator; Audio millivoltmeter.

Fig. 11 and requires a heavy duty variable resistor in addition to the voltage supply and meters. The 4 ohm load resistor (R1) can be adjusted for true value with a current of say 0.5A at 2V. Do not use higher voltage and hence higher current, as the resistor will heat and give a false value. Even at 0.5A some heat will be produced but not enough to effect the readings. If a heavy duty variable resistor is not available a temporary one can be made from about 6 inches of spiral element (as used for the loads) and a couple of crocodile clips. The 8 ohm load (R2) is adjusted the same way but this time with 0.25A (250mA) at 2V and the 15 ohm load (R3) with say 0.2A (200mA) at 3V.

Considerable care must be taken over this operation as the accuracy of the meter depends on it. The resistors are arranged on the frame as in Fig. 10c and the frame is finally mounted spaced off by about half inch on the underside of the chassis as shown in Fig. 12. Note that leads from the load resistors con-

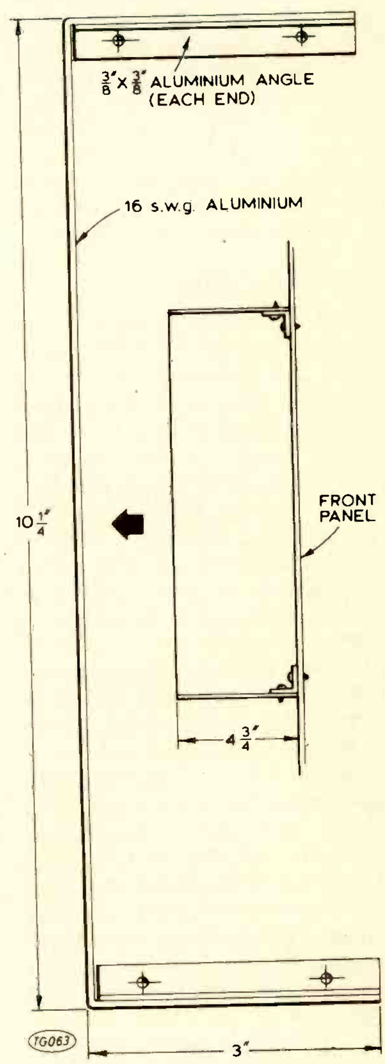
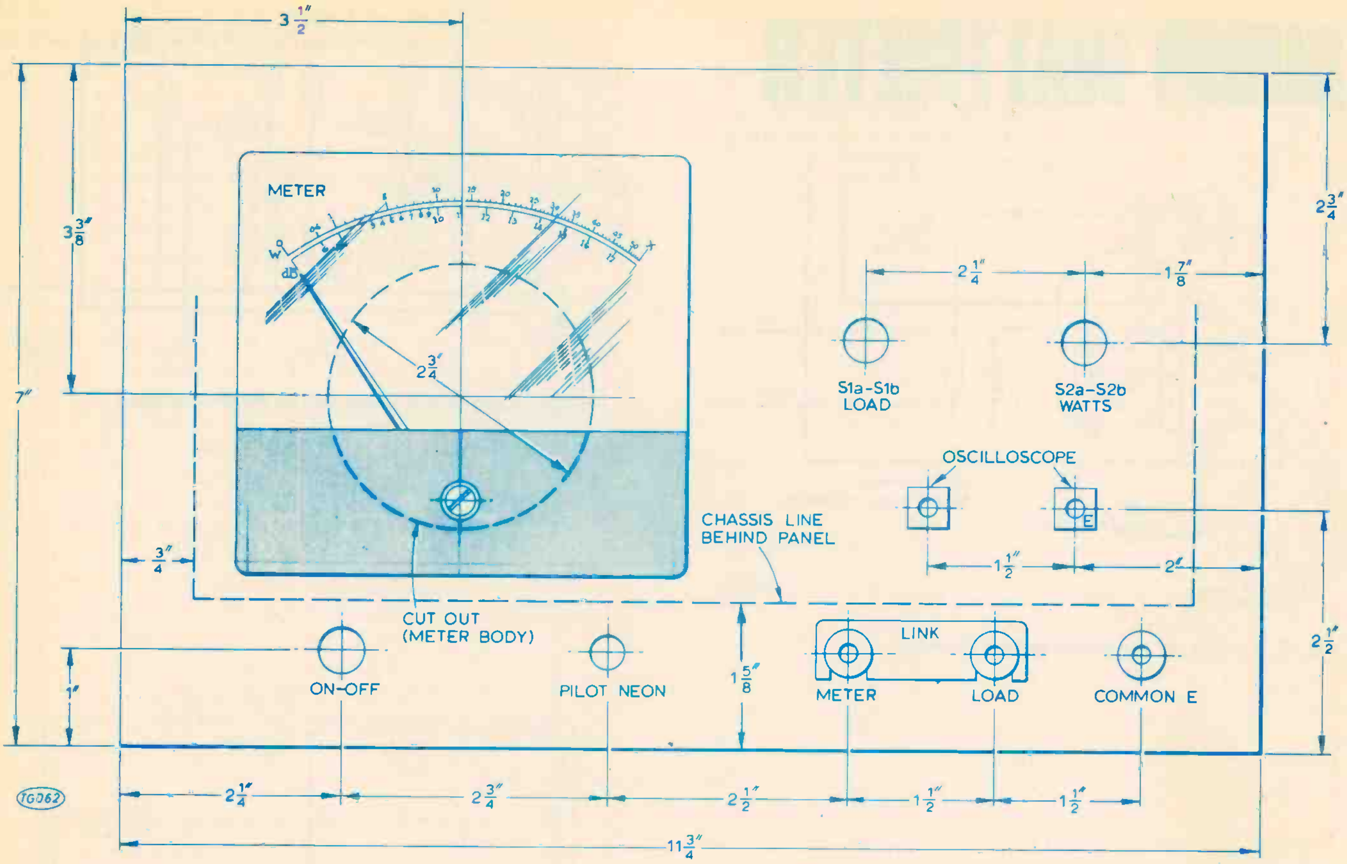


Fig. 4a) Details of the chassis.
b) How the chassis is bolted to the front panel.



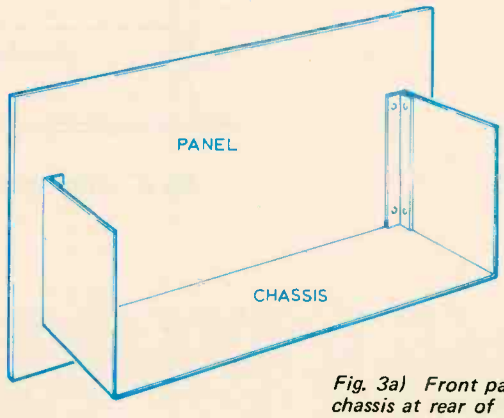


Fig. 3a) Front panel layout and drilling details. b) Position of chassis at rear of front panel.

necting to the load input terminal and to S1A should be heavy flex or 18 s.w.g. covered wire.

THE METER

The meter used for the prototype shown in the photos was an Anders type KM118 0-100uA f.s.d. The meter scale can easily be removed for re-calibration in watts and decibels to the scale given in Fig. 12. The figures on the meter scale will come off with an ordinary India rubber leaving a plain white surface. The new scale, which is suitable only for the meter specified, can be drawn on with Indian ink and the figures transferred from Letraset. Again accuracy is important and great care must be taken to avoid damage to the meter movement and the pointer.

CALIBRATION

The new meter scale must be drawn on and the meter itself connected in cir-

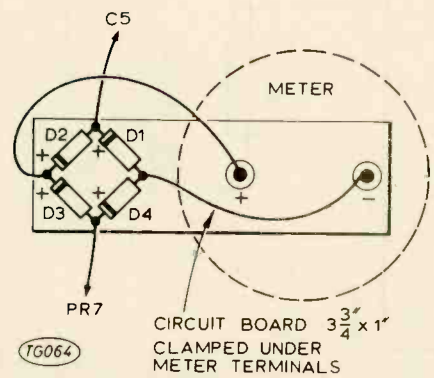


Fig. 5 (above). D1-D4 are fitted to a board which mounts on the meter terminals.

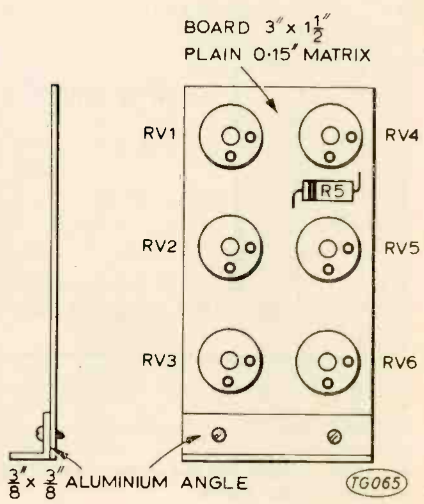


Fig. 6 (right). Circuit board for the presets.

AUDIO WATTMETER

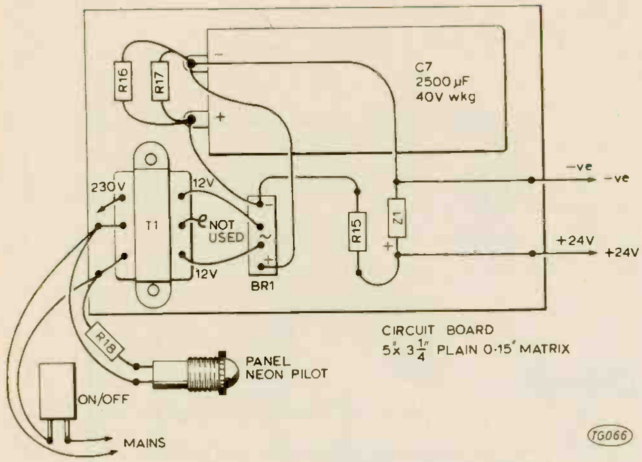


Fig. 7. Layout of the power supply board.

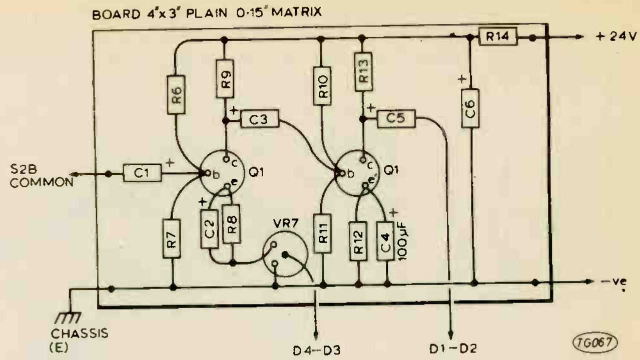


Fig. 8. Layout and wiring of the meter amplifier.

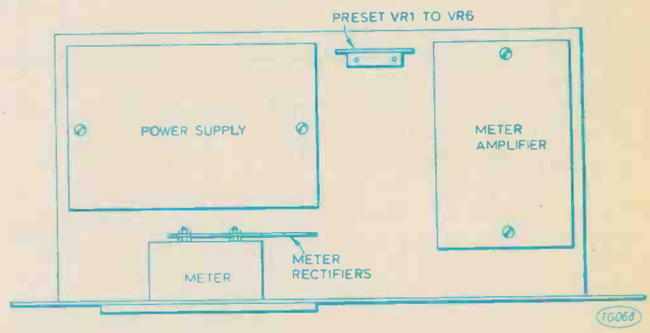


Fig. 9. Layout of circuit boards on the chassis.

cuit. A signal generator (sine-wave) capable of 10V r.m.s. output and an audio millivolt meter are required for the adjustment of the attenuator presets RV1 to RV6 and the feedback control RV7.

The signal generator is used at 1,000 Hz and is connected to the input of the meter amplifier at C1 and with the lead between C1 and S2b common disconnected. The audio millivolt meter is

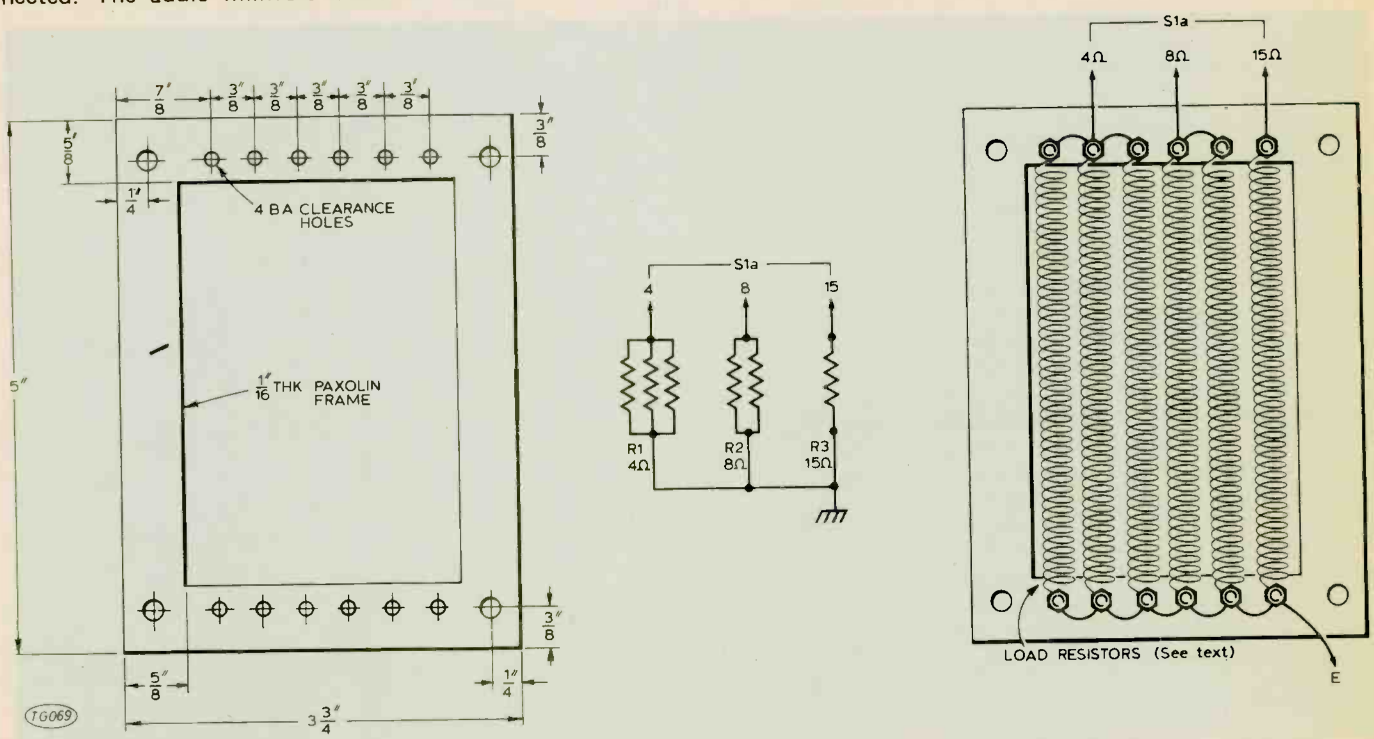


Fig. 10a). Frame for the dummy loads R1, R2, R3. b). The circuit of the dummy loads. c). Assembly of dummy load resistors on the frame.

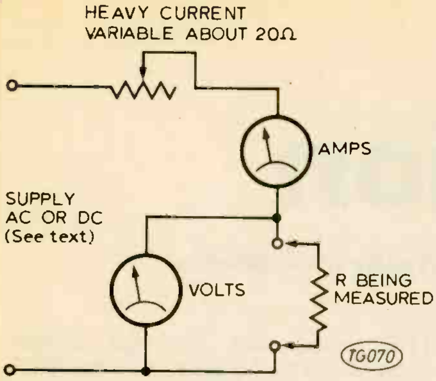


Fig. 11. Measuring set up for determining values of the dummy load resistors.

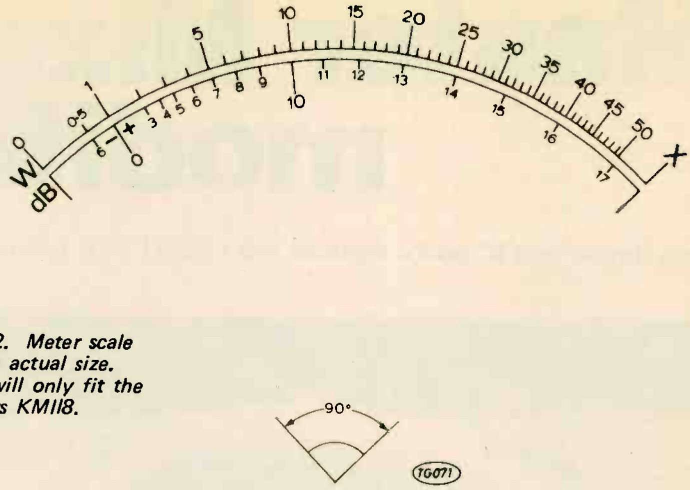


Fig. 12. Meter scale shown actual size. This will only fit the Anders KM118.

connected across the output from the generator, i.e. between C1 and earth. Set the generator to provide exactly 50 millivolts output and adjust RV7 to obtain full scale reading on the power level meter, that is to point X, Fig.12. At this stage the meter amplifier can be checked for frequency response by keeping the generator output constant at 50mV and running through the frequency range from about 10 or 20Hz to at least 10,000Hz.

Now reconnect C1 to S2b common and disconnect the common of S2a from S1c. Couple the audio generator, with the audio millivolt meter in parallel, to the common of S2a. Set S2a to the 50W range and adjust RV6 to obtain meter f.s.d. (to point X) from a 600mV signal from the generator (all these tests are at 1000Hz). Now set S2a to the 5W range and adjust RV5 to obtain meter f.s.d. (to point X) from 180mV signal from the generator. Finally, set S2a to the 0.5W range and adjust RV4 to obtain meter f.s.d. (to point X) from 68mV input. Again accuracy is important.

Reconnect the common of S2a with S1c. Couple the audio generator with the audio millivolt meter in parallel between the main input terminal marked 'METER' and the common E terminal. The "link" to the loads must be disconnected. Set S2 to the 5W range and S1 to 15 ohms. Adjust RV3 to obtain a meter reading of 5W with a signal input (at 1,000Hz) of 8.66V. Check with S2 on the 50 watt range to obtain meter reading of 5W.

Reset S2 to the 5W range and S1 to 8 ohms. Adjust RV2 to obtain meter reading of 5W with a signal input of 6.32V. Check with S2 on the 50W range to obtain reading of 5W.

Reset S2 to the 5W range and S1 to 4 ohms. Adjust RV1 obtain meter reading of 5W with 4.47V input signal. Check with S2 on the 50W range to obtain a meter reading of 5W.

Continued on page 80

TABLES FOR CHECKING CALIBRATION

Range 1, 0 to 0.5W $V = \sqrt{P_O \times R}$

Power level watts	4 ohms (volts)	8 ohms (volts)	15 ohms (volts)
0.5	1.414	2.00	2.739
0.4	1.265	1.789	2.449
0.3	1.095	1.599	2.121
0.2	0.894	1.265	1.732
0.1	0.632	0.894	1.224
0.05	0.447	0.632	0.866
0.01 (0dB)	0.200	0.282	0.383

Range 2, 0 to 5W $V = \sqrt{P_O \times R}$

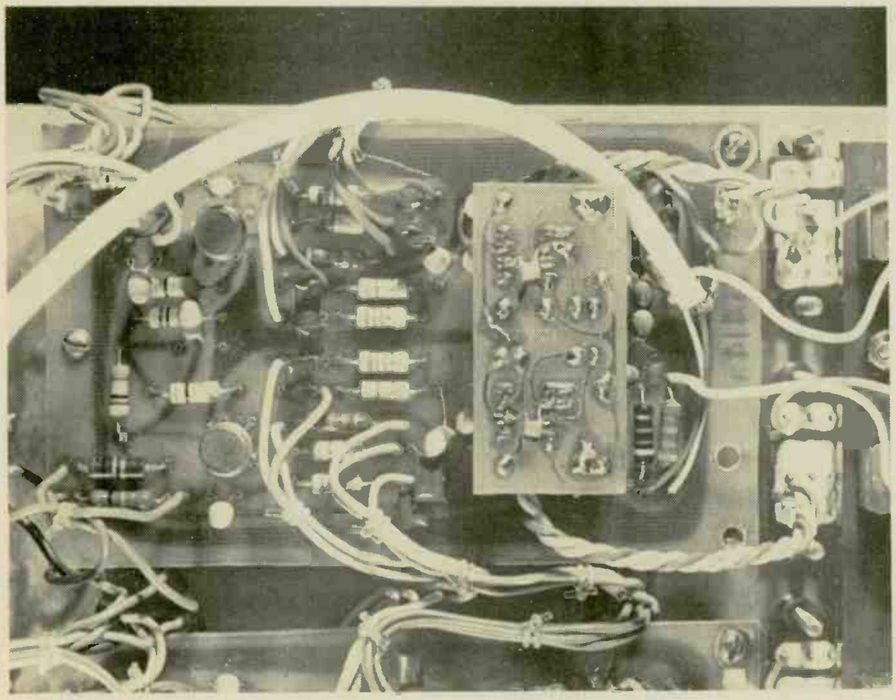
Power level watts	4 ohms (volts)	8 ohms (volts)	15 ohms (volts)
5	4.472	6.325	8.660
4	4.00	5.657	7.746
3	3.464	4.899	6.708
2	2.828	4.00	5.477
1	2.00	2.828	3.873
0.5	1.414	2.00	2.739
0.1 (0dB)	0.632	0.894	1.224

Range 3, 0 to 50W $V = \sqrt{P_O \times R}$

Power level watts	4 ohms (volts)	8 ohms (volts)	15 ohms (volts)
50	14.142	20	27.386
40	12.649	17.889	24.495
30	10.954	15.492	21.213
20	8.944	12.649	17.321
10	6.325	8.944	12.247
5	4.472	6.325	8.660
1 (0dB)	2.00	2.828	3.837

Master Mixer modification

This simple two IC board replaces the LM381 dual preamplifier which is currently unobtainable.



The replacement board is mounted, component side down, as shown. A small wooden block spaces this board from the main board. Note that C1 and C3 mounted on the copper side of the board.

THE component shortage strikes again! After being assured by National Semiconductor that they had plenty of LM381s for our Master Mixer project, stocks dried up completely and efforts to find fresh stocks here and overseas have been unsuccessful — to both National's and our embarrassment. Even worse, deliveries of LM381's cannot be reasonably expected until the end of 1973!

The LM381 was chosen for the Master Mixer because it has excellent low noise characteristics, and unfortunately, there is no direct replacement.

Partially to overcome this problem we have designed a small printed circuit board conversion carrying two LM301's (and associated components) that may be substituted for the LM381's on the main preamplifier board.

Due to the wide gain variations required in the mixer, most available low-noise ICs will either not remain stable, or will not have the required frequency response (—50 dB to +55

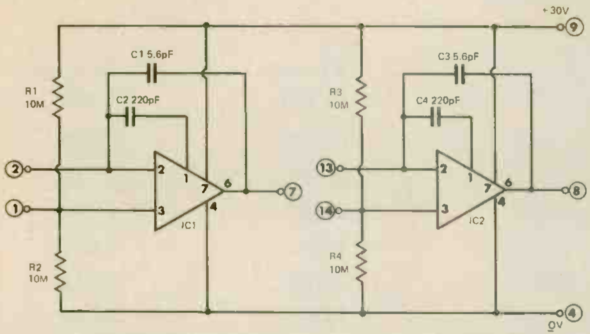


Fig. 1. Circuit diagram of the replacement unit. The ICs are National LM301.

HOW IT WORKS

Except for biasing, the operation of the LM301 is identical to one half of the LM381 (LM381 is a dual amplifier).

The LM381 is designed for operation from a single-ended power supply whereas the LM301 requires a dual power supply. The LM301 therefore requires resistors to split the power rail by providing an artificial centre tap (R, R2 and R3, R4).

The 390 kohm biasing resistors for the LM381, R7 and R8, are therefore no longer used and must be removed from the main board.

A 5.6 pF capacitor is connected across pin 6 to pin 2 of each IC, as feedback, to reduce the high frequency gain beyond 20kHz, thus reducing high frequency noise. With this capacitor in use the gain when set to maximum drops 3 dB at 20 kHz. At lower gain levels the response is flat to well beyond 20 kHz.

Frequency compensation is applied to each amplifier by means of the 220 pF capacitor connected between pins 1 and 2. This mode of compensation is known as "Feed forward" and is used to extend the frequency response of the LM301 which would otherwise be 3 dB at 1 kHz and maximum gain.

PARTS LIST

IC1 Integrated circuit LM301 (mini-DIP pack preferred)
IC2 Integrated circuit LM301 (mini-DIP pack preferred)
R1 resistor 10M ¼ or ½ watt 5%.
R2 resistor 10M ¼ or ½ watt 5%.
R3 resistor 10M ¼ or ½ watt 5%.
R4 resistor 10M ¼ or ½ watt 5%.
C1 capacitor 5.6pF ceramic
C2 capacitor 220pF ceramic
C3 capacitor 5.6pF ceramic
C4 capacitor 220pF ceramic
PC board ETI 414d

The LM301 is available from Electrokit, 8 Cullen Way, London N.W.10 at 49p plus 10p postage.

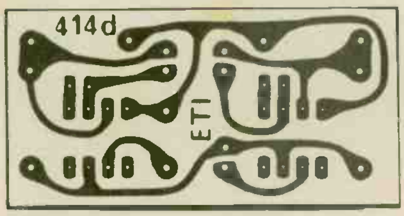


Fig. 2. Foil pattern of printed circuit board shown full size.

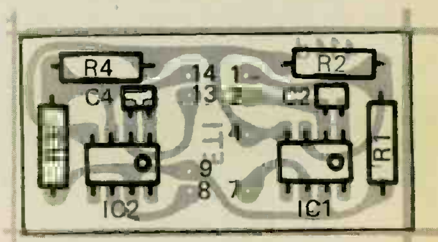


Fig. 3. Component overlay

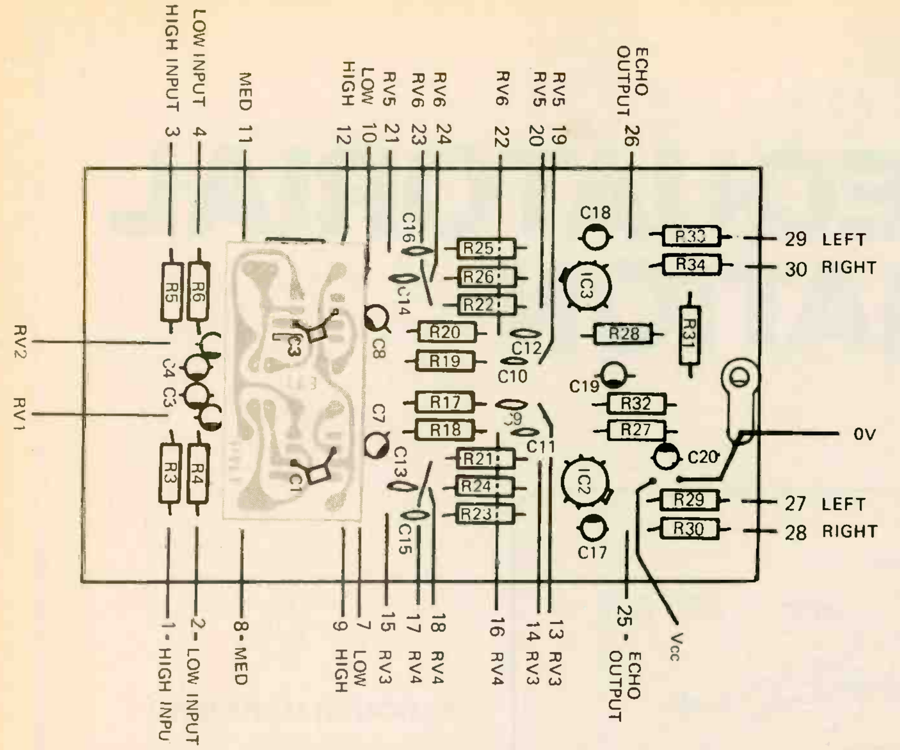


Fig. 4. Position of the printed circuit board with respect to the preamplifier board. Note the positioning of C1 and C3.

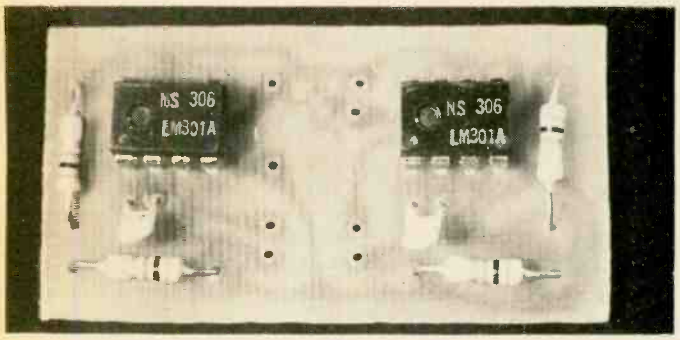


Fig. 5. The completed PC board is connected by means of wire links from the remaining holes to the LM381 socket on the preamplifier board.

dB gain at 10 kHz). We have established however that the LM301, when used with feed-forward compensation, does provide the necessary stability and frequency response over the required gain range.

The LM301 is not primarily a low-noise amplifier however, and the noise level of the mixer will be 10 to 15 dB worse than with the LM381. This however will not be a problem for normal live work. It may however, (but not necessarily) be a problem when the unit is used for recording.

As the noise performance of the original unit was very good indeed, 10 to 15 dB degrading is not as serious as it might at first seem, and for normal live work, will cause no problems. The increased noise level may (but not necessarily) be a problem when the unit is used for recording purposes in studios with low ambient levels.

Apart from the noise increase, this modification will not degrade the performance in any way. Both gain and frequency response will remain as specified, and the mixer will operate satisfactorily for all but the most exacting applications.

CONSTRUCTION

Mount the components onto the printed circuit board as shown in Figs. 3 and 5. Ensure that the IC's are correctly orientated. The dot or notch on the IC should be to the left when the board is orientated as shown in the photograph. Note that capacitors C1 and C3 are mounted on the copper side of the board as shown in Fig. 4 and the photograph.

Remove existing R7 and R8 from the preamplifier board (390 kohm) and using a small wooden block as a spacer (1/2" x 1/4" x 3/4") position the small board over the LM381 socket in the preamplifier board as shown in the photograph and in Fig. 4.

Small straight pieces of tinned-copper may be used (eg,. ends of resistors previously cut off) to join the two boards together. Note that the small printed circuit board is designed as a pin-for-pin replacement for the LM381 but pins 3, 5, 6, 10, 11 and 12 are not used. Thus the pieces of wire are passed through the holes in the small board to the corresponding hole in the LM381 position. Solder the wire to the copper pads on both boards and trim the excess wire. ●

VHF TRANS-EQUATORIAL PROPAGATION

By ROGER HARRISON

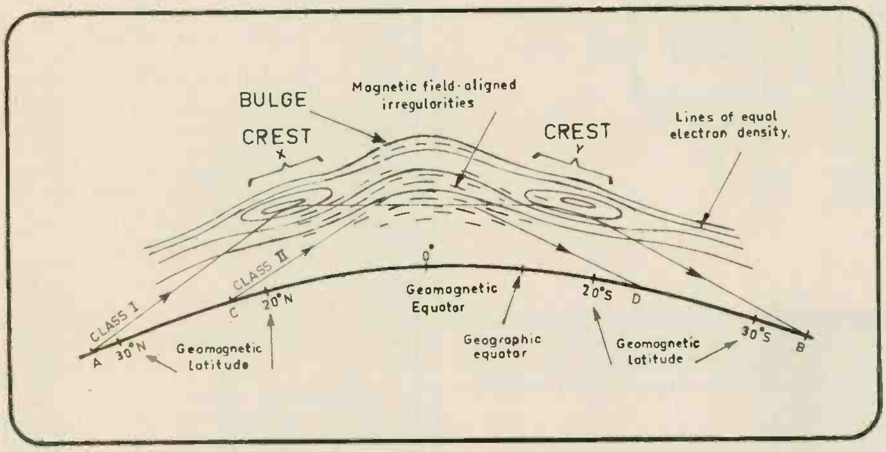


Fig. 1. The propagation modes of class I and class II TEP.

RECEPTION of VHF signals over very long paths that cross more-or-less transversely to the equatorial zone have been frequently reported in the last 25 years. The frequencies involved are generally far in excess of the predicted maximum useable frequency, and signal strengths sometimes approach free-space values. Path lengths reported are usually greater than 5,000km – with a few up to 18,000km. These signals are generally regarded as having arrived by "anomalous" transequatorial propagation.

Throughout the remainder of this article the letters TEP are used to denote this form of propagation.

A SHORT HISTORY

The first intercontinental VHF contacts were reported in QST by Ed Tilton in "The World Above 50 Mc", May and October 1947 but the discovery of TEP by radio amateurs did not receive a great deal of attention in the scientific world until the late 1950's (and the IGY in 1957/58).

Contacts between Australia and Hawaii, Mexico and Argentina, and the U.S.A. and Peru were fairly common between 1947 and 1951. There was then a sharp decline during the sunspot minimum but new reports began to appear again in 1955, reaching a maximum during 1957 – 1960, and again during 1968 – 1971. Some contacts were reported over extremely long paths, ranging from 9,860km to 18,760km.

The first scientific paper to appear on TEP was by Ed Tilton, published in the Proceedings of the Second Meeting of the Mixed Commission on the Ionosphere, in Brussels 1951.

Observations made between 1950 and 1966 of the characteristics and propagation modes of TEP along with research into the equatorial ionosphere, brought to light a lot of very interesting information. In addition to collecting amateur observations, a number of experiments were set up involving HF and VHF scatter soundings, oblique incidence ionosondes, observation of beacons and TV and FM stations in Korea, Japan and Russia, and topside ionospheric sounding by satellites. This led to a better understanding of the structure of the equatorial ionosphere and to suggestions regarding the various modes that support TEP.

GENERAL CHARACTERISTICS OF VHF TEP SIGNALS

There appears to be two distinct types of TEP, distinguished by times of peak occurrence, fading characteristics, path lengths, and principal mode of propagation.

One mode, designated Class I, exhibits the following characteristics:—

(a) a peak occurrence around mid-to-late afternoon (1200 to 1900 local mean time, measured at the point where the path crosses the magnetic equator).
(b) normally strong, steady signals with a low fading rate and, more specifically, a small Doppler spread (around ± 2 to 4 Hz).
(c) path lengths of 6,000km to 9000 km and sometimes longer.

The proposed propagation mode for Class I TEP is generally termed the "super-mode" or FF mode. As can be seen from Fig. 1, the ray, transmitted from A, "skips" from the crest in the equatorial ionosphere at X, across the crest at Y and is refracted down to earth at B. These "crests" are a feature of the equatorial ionosphere (about which I shall have more to say later).

The other mode, designated Class II, shows the following characteristics:—

(a) a peak occurrence around 2000 hours to 2300 hours local mean time
(b) high signal strengths but with deep, rapid fading (typical rates are 5 Hz to 15 Hz) accompanied by a Doppler

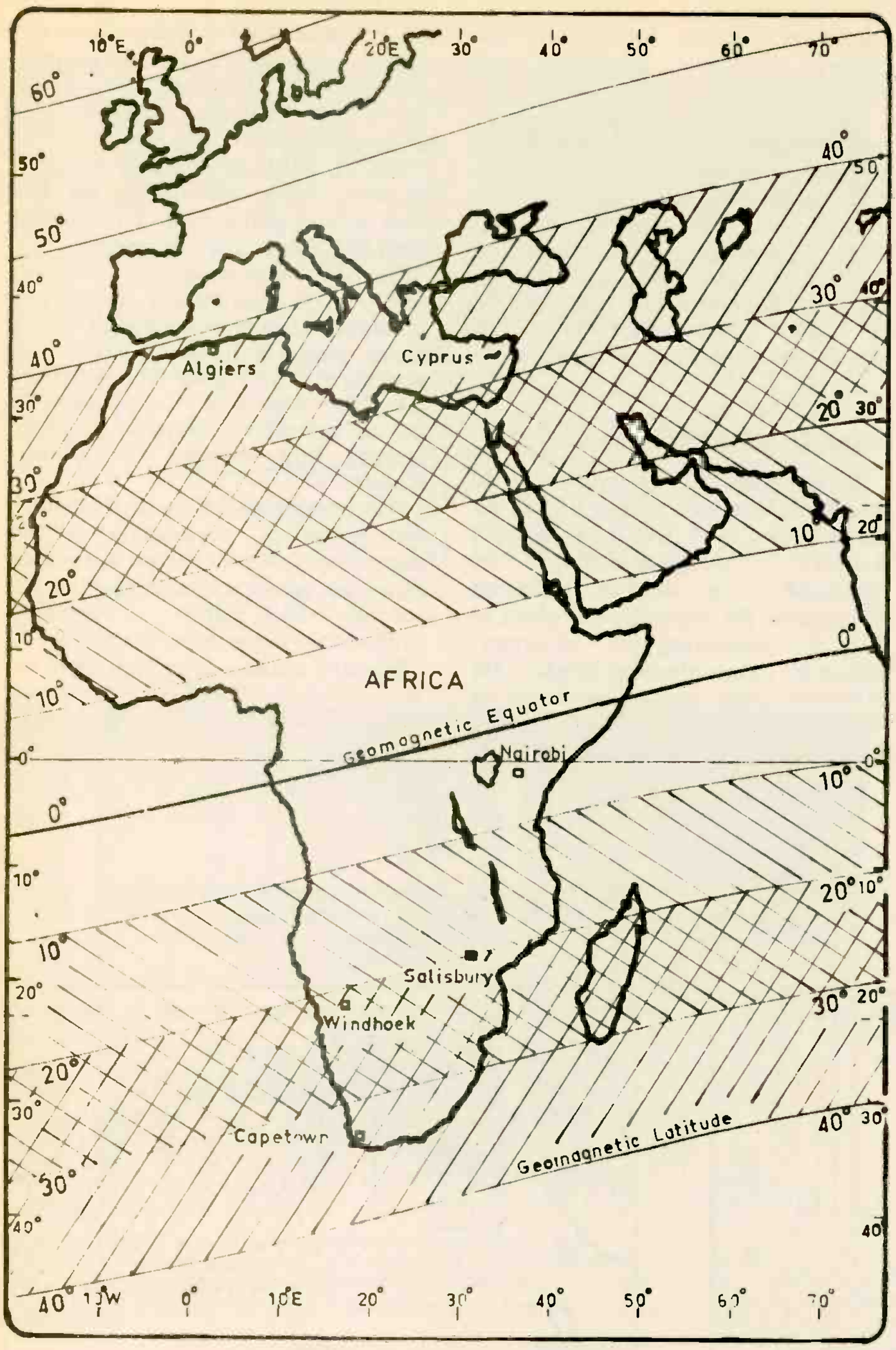


Fig. 2. The African-Mediterranean Sector of the world showing terminal zones for class 1 TEP (20° to 40° geomagnetic latitude) and class 11 TEP (10° to 30° geomagnetic latitude).

spread much greater than for Class I, generally in the order of ± 20 to 40Hz (i.e. ten times that for Class I).

(c) path lengths are usually shorter than for Class I, being around 3,000km to 6,000km.

The propagation mode or mechanism for this class of TEP is not fully understood, but it is believed that irregularities (dense "clouds" of electrons having a certain specific shape) in the equatorial ionosphere – aligned with the earth's magnetic field – are responsible for "ducting" or efficiently "scattering" the signal such that the path geometry looks like that in Fig. 1. (from C to D).

Additionally, Class II will support much higher frequencies than Class I, signals have been observed up to 102 MHz.

THE EQUATORIAL ANOMALY

The equatorial ionosphere does not have an even distribution of electron density. As can be seen from Fig. 1., the F-region iso-electronic contour lines (lines of equal electron density) show a depletion of electrons, together with a rise of the F-region height, above the magnetic equator. Roughly symmetric, north and south of the geomagnetic equator, are two "crests" that represent an increased electron density in the F-region. These crests are located between 10° and 20° (geomagnetic latitude) north and south of the geomagnetic equator. The location of these regions are shown in Figs. 2, 3 and 4.

This region of the ionosphere (within approximately ± 20° geomagnetic latitude) is generally referred to as the equatorial *anomaly* region. It is a regular feature and not a transient phenomena.

If the electron density within the crests increases sufficiently, it will be possible for a signal, incident upon one crest at a very small angle, to be refracted across the geomagnetic and geographic equators to the opposite crest and hence to earth as illustrated in Fig. 1.

DIURNAL VARIATION OF THE EQUATORIAL ANOMALY

From what little data is available, it appears that the equatorial anomaly starts to develop between 0800 and 1000 LMT, the crests moving away from the magnetic equator between 0900 and 1500 LMT.

When the sun sets on the base of the equatorial ionosphere (about 1½ hours later than ground sunset, i.e. 1930 hours LMT, the base of the layer generally rises and the equatorial anomaly begins to break up into large "blobs". This does not always happen, the base of the layer may not necessarily rise and, on occasion, is found to fall or remain at the pre-sunset height. Sometimes the anomaly does not break up into distinct blobs and the electrons appear to diffuse back over the magnetic equator. The ionosphere is generally like this during early morning and late evening. The detailed behaviour of the decay phase of the equatorial anomaly has not yet been fully established.

SEASONAL VARIATIONS OF THE EQUATORIAL ANOMALY

The crests lie very nearly symmetrically either side of the magnetic equator at equinox and asymmetrically at solstice. The electron densities of the bulges are greater at equinox than at solstice and this, combined with the anomaly symmetry at equinox, favours Class I TEP at the equinoxes. The separation and overall width of the crests varies seasonally also, being greatest at equinox.

"Tilts" in the base of the F-layer are known to be associated with the crests and are most pronounced between 1200 and 2000 LMT and at equinox. These tilts which are departures of the

VHF TRANS-EQUATORIAL PROPAGATION

somewhere within these limits. The peak occurrence times coincide with the stable phase of the equatorial anomaly which is generally well developed after 1100 LMT and begins to decay around 1900 LMT. Occasionally it remains stable after this time, particularly at equinox at sunspot maximum and observations bear this out, signals remaining stable for several hours after 1900 LMT before experiencing the flutter fading of Class II TEP.

Paths that are normal (or nearly so) to the geomagnetic equator and symmetrically located either side are favoured, experiencing earlier start times, longer durations and a greater number of occurrences — especially at sunspot minimum.

I might add that TEP can occur at any time of the night or day but it is most infrequent between 0400 and 0800 LMT for either Class I or Class II TEP.

Occurrence times are generally dependent on:—

(a) Suitable path geometry, including tilts which allow supermode propagation.

(b) Build up of sufficient ionisation density in the crests of the equatorial anomaly such that foF2 of each crest is sufficiently high to increase the maximum usable frequency above that normally expected.

(c) Sunspot number — (b) is obviously dependent on sunspot number but this is not the only factor involved. This dependence is not as great as one would imagine and is much less than for Class II.

(d) Season.

PATH CHARACTERISTICS

As class I TEP is propagated via a supermode (Fig. 1.) the path geometry can be determined for the maximum and minimum range possible for the observed parameters of the bulges of the equatorial anomaly. The parameters affecting the path geometry are the height and location of the virtual reflection points, foF2 for these points and incidence angles to those points. Knowing these, it becomes possible to predict the maximum and minimum ranges. These work out to be between 5000 and 9000 km. This was calculated assuming that the path and equatorial anomaly were symmetrical about the geomagnetic equator.

The 'best' paths are those which are located symmetrically about and normal (or nearly so) to the geomagnetic equator and the terminals of which lie in areas between 20° and 40° geomagnetic latitude north and south of the geomagnetic equator. These areas are marked in Figs. 2, 3 and 4 (cross hatched to the right). These paths tend to experience Class I TEP more often than oblique or asymmetrical paths.

Very long paths (greater than 10 000 km) are always oblique and some other form of propagation appears necessary to assist the signal in being favourably incident on the bulges of the equatorial anomaly. Sporadic E (Es) is the most likely cause but this has yet to be confirmed.

TEP over paths which are fairly oblique to the geomagnetic equator (65° or less) tend to be reasonably long (greater than 8000 km), rare, short lived and tend to occur mainly some weeks after the equinoxes. Many of them are asymmetrically situated with regard to the geomagnetic equator but this bias is probably due to observer station distribution. Very long range TEP is generally observed one to two years after a sunspot maximum and rarely, if ever, during the sunspot minimum.

RAY TRACING

If a series of rays from a transmitter in one hemisphere is traced, using computer simulation through a model of the equatorial ionosphere, it is found that much of the low angle radiation travels via the supermode of propagation and experiences a large degree of focussing at the receiver.

In Fig. 7., a computer printout illustrates this ray-focussing effect. The inset shows the variation of foF2 with geomagnetic latitude assumed for the particular circuit. The printout is reproduced by kind permission of Mr. B.C. Gibson-Wilde of the James Cook University of North Queensland.

Ray focussing is a very important characteristic of Class I TEP as it provides the strong signals and "area selectivity" (signals being heard in one narrowly defined area and not in others) that is often noticed as being associated with afternoon type TEP.

SEASONAL CHARACTERISTICS

There is a maximum number of occurrences around the equinoxes for all sectors of the world. This is due to the more favourable conditions that exist in the equatorial anomaly at the equinoxes.

It is well known that the sunspot number affects the maximum useable frequencies of the F-layer and peak electron density for the crests of the equatorial anomaly follow a similar pattern. However, the greatest number of occurrences of Class I TEP lags behind the sunspot maximum by one to two years. The reason for this is, as yet, unknown.

SIGNAL CHARACTERISTICS

Apart from the frequencies involved, the most extraordinary characteristics of Class I TEP signals are their strength and steadiness (absence of fade). Signal strength can sometimes approach free space values, and the fading rate is normally quite low and not very deep. This is explained by the fact that rays strike the tilts associated with the crests of the equatorial anomaly very near to tangency and are efficiently refracted; this, combined with ray focussing, and the same absorption for a one-hop path, leads to very little signal loss.

Many amateurs report good results running only medium to low power (under 20 watts) and small antennas.

The frequencies involved in Class I TEP will always be above the predicted maximum useable frequency, for the path involved, by a considerable factor. Thus Class I TEP affects the HF region as well as the lower VHF region. Contacts on the HF bands via Class I TEP have been reported, but are not often recognised by amateurs.

The MUF for oblique paths is generally lower, owing to unfavourable "look" angles on the equatorial anomaly, and consequently the MUF for these paths exceeds 50 MHz less often than for paths which are more nearly normal to the magnetic equator.

Although Class I TEP provides fairly stable signals, wideband system will suffer distortion due to multipath effects (see Fig. 7). Voice transmissions will not appreciably suffer, especially narrow band FM, but television picture signals will be of very poor quality.

It must be understood that Class I TEP is not a "normal" F2 mode of propagation as many VHF amateurs seem to think, but it is certainly not "anomalous" within the definition of the word. The maximum useable frequency of the F-layer for 1F or 2F modes in general rarely exceeds 50 MHz so that Class I TEP cannot be classed as "normal" F2 skip on these grounds alone. Secondly Class I TEP travels via a two-hop ionospheric mode *without intermediate ground reflection.* This supermode or FF-mode is sometimes referred to as "chordal-hop" propagation.

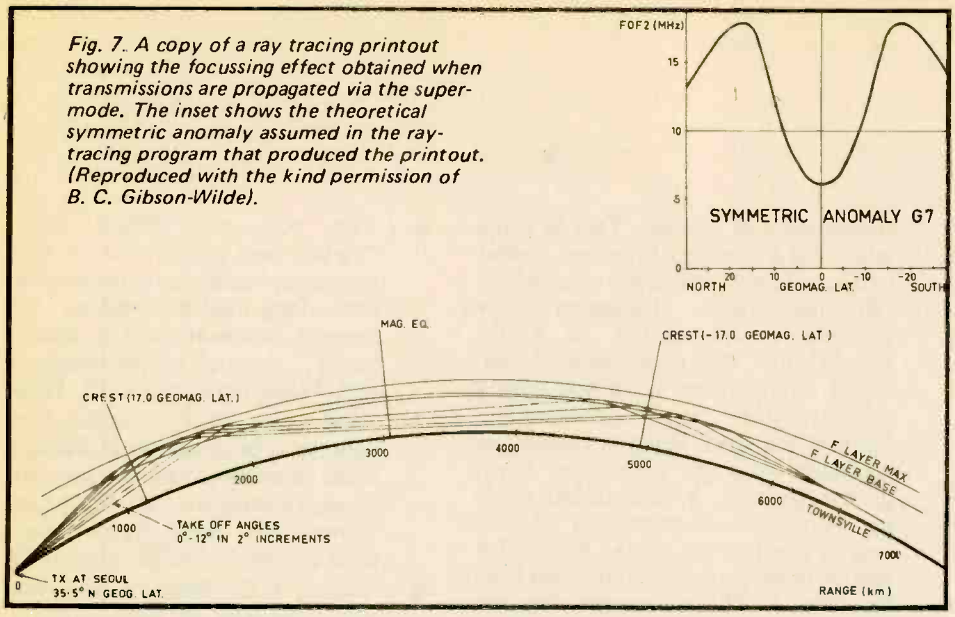


Fig. 7. A copy of a ray tracing printout showing the focussing effect obtained when transmissions are propagated via the supermode. The inset shows the theoretical symmetric anomaly assumed in the ray-tracing program that produced the printout. (Reproduced with the kind permission of B. C. Gibson-Wilde).

CLASS II TEP – CAUSES AND CHARACTERISTICS

The characteristics of Class II, or evening-type TEP, are generally well known but the mode of propagation is not yet known or completely defined. Several different explanations have been put forward, based on the correlation observed between night-time TEP observations and the occurrence of equatorial spread-F. Experimental results, when applied to the various theories, have shown them to be incorrect, but it is well established that there is some definite connection between spread-F along the paths considered and the occurrences of Class II TEP.

The higher frequencies propagated by Class II TEP offer some interesting possibilities to the communicator. There is a maximum occurrence between 2000 and 2300 LMT with a pronounced peak somewhere in this range for different seasons and particular paths. This means that just about every circuit has an individual peak occurrence time for different seasons but it will be somewhere between 2000 and 2300 LMT. This coincides well with the occurrence of equatorial spread-F, but the duration of TEP signals is usually less than the duration of spread-F. This is probably due to the reduction of peak electron density in the F-layer after midnight.

Class II TEP has been observed to last until the early hours of the morning, but only on lower VHF. The occurrence of Class II TEP openings is greatest during the equinoxes as is spread-F — this is more pronounced than in the case of Class I TEP. These openings are fewest during the winter solstice over the magnetic equator. This occurs during December – January for the Asian and African sectors and June – July for the Americas (7).

Start times for openings via Class II TEP are less dependant on path geometry than for Class I TEP as also are the times of duration. Class II is much more tolerant of asymmetrical path geometry than Class I.

Usually contacts are dependent on

(a) Appearance of equatorial spread-F at an appropriate geomagnetic latitude.
(b) Season of the year, i.e. proximity to the equinoxes.
(c) Sunspot number.

PATH CHARACTERISTICS

Path lengths for Class I TEP are generally from 3000 km to 6000 km and terminals are quite often asymmetrically and obliquely situated with regard to the magnetic equator. Some very long night-time paths have been observed but these can be explained by the occasional continuance of the Class I TEP mode after sunset, or another mode of propagation assisting in extending the range of signals. Again, sporadic-E is likely to be the reflector at the lower end of the VHF range. Tropospheric ducting could extend the range in a similar fashion at the higher frequencies but little work has been reported in this direction. Nielson mentions Es in this regard in his paper.

There is a zone where stations (or circuits) will experience both modes, and zones where stations will only experience one or the other. The area between 20° and 30° geomagnetic latitudes (Figs. 2, 3, 4) is common ground for both Class I and II TEP. Stations located in these areas will encounter both modes from time to time with perhaps a gradual transition from Class I to Class II (evidenced by an increase in flutter fading after 2000 hours) or a signal dropout of up to an hour's duration.

Stations north and south of about 30° geomagnetic latitude will tend to see only afternoon-type TEP while those stations closer than about 20° to the geomagnetic equator will tend to see only evening-type TEP.

The westward movement of contacts via Class II TEP is not generally noted as it is for Class I TEP. The irregularities that occur in the base of the F-layer, are certainly known to move westward but their longitudinal "spread" is usually considerably wider than for the equatorial anomaly. As Class II TEP appears to depend to a large extent on these irregularities, the westward movement may be masked by their longitudinal width and the tolerance to asymmetrical paths that is noted.

SEASONAL CHARACTERISTICS

There is a marked dependence of Class II TEP on the equinoxes and sunspot number. The same dependence is noted for equatorial spread-F.

Class II TEP has a maximum number of occurrances which lags the sunspot maximum by a year or so — as is noted for Class I. The reasons for this are not yet clear but further research should elucidate the causal mechanisms.

Similarly to Class I, contacts can be had almost every night around the equinoxes during peak occurrence

VHF TRANS-EQUATORIAL PROPAGATION

years. There is a rapid drop off in the number of occurrences after this time, few contacts being noted during the solstices and the years spanning the sunspot minima. Observations carried out using oblique sounders and beacon transmitters also bear this out.

SIGNAL CHARACTERISTICS

The most surprising aspect of Class II TEP signals are the high frequencies that it will support and the high signal strengths that are recorded.

Beacon transmissions on 102 MHz from Darwin have been recorded in southern Japan on many occasions, but, as yet, there have been no reports of higher frequency signals. No upper frequency limit has been proposed for Class II TEP as the mechanism by which it is reflected or refracted in the ionosphere is not yet known.

Here is an opportunity for enterprising amateurs who would like to try for some exotic DX on 144 MHz — and make a contribution to a body of scientific knowledge on a phenomenon about which we know little. Unfortunately 144MHz contacts might have to wait till the next sunspot maximum. But don't let me discourage anyone from trying.

Generally speaking, high signal strengths are experienced having a considerable amount of flutter. The flutter rate is mostly between 5 and 15Hz and Doppler shift is mainly between ± 40Hz. This means that, at times, A3 (DSB or SSB) signals will be seriously degraded. The effect on wideband systems (FM or PM) would be much less but TV would suffer owing to the spread of time delays experienced.

Paths whose terminals are magnetic conjugates (have the same angle of magnetic dip but the opposite sense i.e. 25°N and 25°S) experience the higher frequencies more often and with greater reliability. The signal strength for these paths is higher than for the less favourable asymmetric paths and path lengths are generally shorter.

As Class II TEP is probably supported in some way by field guided ionization, the closer a ray can be launched to tangency with the magnetic field, the more favourable are its characteristics, i.e. higher frequencies will be supported, higher signal strengths will be guaranteed and greater reliability will be obtained than for less favourable rays.

Many people refer to class II TEP as transequatorial scatter. This is quite wrong for a number of reasons. Scatter propagation involves incoherent reflection from tropospheric or ionospheric irregularities of a size smaller than the wavelength in use. Signal strengths are weak and have a considerable flutter component. Transmitted and received angles of elevation from the ground are much greater than for a field guided mode and signals are not necessarily received over a great circle route. Ranges for scatter propagation are much less than for Class II TEP. It appears that the considerable flutter component often observed on evening-type TEP leads to a confusion involving the modes of propagation. Class II TEP is dependent on many factors (season, sunspots, geomagnetic latitude, etc.) that seem to have no bearing on true scatter modes.

CURRENT RESEARCH

The Ionospheric Prediction Service (Australia) is currently conducting research into TEP, particularly the evening-type or Class II. Equipment has been set up to examine the signal characteristics of VHF beacons located in Japan (JA1IGY) as part of this research which is aimed at elucidating the propagation mechanism of the evening type TEP and eventually predicting its occurrence. The ionosonde located at Vanimo, New Guinea, is almost ideally situated to study the equatorial ionosphere. It has been equipped with an interferometer system to assist in studying the irregularities that cause spread-F.

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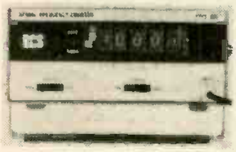

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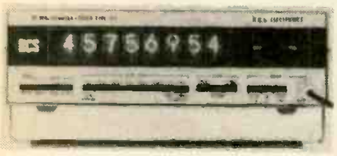

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NUMBERS

by Ronald Froom

"God made the integers: all else is the work of man" – Leopold Kronecker

THE concept of number belongs to societies which have reached a certain level of sophistication. Certain very primitive and illiterate societies – the early Australian aboriginals or the Kalahari bushmen for example, go no further than – ONE, the individual (me) – TWO, the two sexes (us) – and MANY. Even the ancient Greeks, with their insatiable curiosity about the world around them, stopped their numbering system at 10,000, all greater numbers being considered infinite!

It is probable that the evolution of highly organized societies, where taxes and revenue (in terms of corn, animals, gold, etc.) made necessary some form of accountancy, and man began to be aware of numbers and of the necessity of recording them. The ancient Egyptians, the Babylonians, the Maya and other such civilizations evolved, at a very early state in their evolution, a satisfactory system of recording the number of things, but did not evolve a system of recording that was adaptable to arithmetical operations on the numbers thus recorded.

An important step forward was made when it was realized that numbers could be used not only to record but also to calculate. Since the systems of recording numbers did not permit direct arithmetical operations, it was necessary to invent a calculating device. This gave rise to the first computer – the abacus. Invented independently in Rome, China and Japan, in slightly differing forms, this simple device of beads on wires permitted the operations of addition, subtraction, multiplication and division. Even today a skilled abacus operator can add up a column of figures more rapidly than can be done on an electric desk calculator, and if one considers the time taken in punching cards and preparing an appropriate program, much more rapidly than an electronic computer!

The Roman abacus merits closer study as it demonstrates several principles common to all methods of calculation.

The Romans had no numerical symbols, but used letters of the alphabet to represent numbers: I, V, X, L, C, D, M, Ɔ. It will be seen that each symbol is alternately five times as large and twice as large as the one preceding it: 1, 5, 10, 100, 500, 1000, 5000. This apparently clumsy system becomes clear if it is realized that the letter symbols represent the position of the beads on the abacus, as shown in Figure 1.

A feature of Roman numbers that has puzzled many is the use of the combinations IV, IX, XL, XC, CD, CM, etc. to represent 4, 9, 40, 90, 400, 900, etc. This is because in carrying out additions and subtractions on the abacus, it is simpler to add, say 4, by adding 5 and subtracting 1, than by the direct operation.

The Roman system of numerals therefore is well adapted to *recording* the results of calculations performed on a computer (the abacus) but does not, of itself, permit any arithmetical operations upon the numbers thus recorded.

The ancient Chinese numerals are similar in concept; they represent the result of operations on the Chinese abacus, which differs from the Roman in certain details. The numerals are:

一	二	三	四	五	六	
1	2	3	4	5	6	
七	八	九	十	百	千	萬
7	8	9	10	100	1000	10000

To write any given number, combinations of these signs are used, for example, the date 1973 would be written:

一千九百七十三

or (1 x 1000) + (9 x 100) + (7 x 10) +3

Here again direct arithmetical manipulation of these numbers is impossible.

The great breakthrough in numbers was achieved by the ancient Hindus, who realized two fundamental parameters of any numbering system:

– the use of a sign to indicate zero – a radically new conception that none of the earlier systems had considered;
– the concept of positional notation, that is to say, that one can express any number by a very small number of signs (in fact 10) the signs being given a significant value by their *position*.

The original Hindu signs were:

१	२	३	४	५	६	७	८	९	०
1	2	3	4	5	6	7	8	9	0

which are sufficiently close to our own figures that several of them can be recognized at once. Here, the year 1973 would be written

१९७३

exactly as we do.

From India these numerals were taken over by the Arabs, who wrote them:

١	٢	٣	٤	٥	٦	٧	٨	٩	٠
1	2	3	4	5	6	7	8	9	0

and it is from these characters that our "arabic" figures that we use today were derived.

With the invention of the arabic (or Hindu) numerals, man was enabled to carry out arithmetical operations directly on numbers as written, without the intervention of any mechanical assistance.

This state of affairs continued right into the seventeenth century, when, evolving scientific knowledge required calculations of greater complexity to be performed than were practicable (though still possible) without the assistance of some device – hence the evolution of logarithms, the slide-rule, mechanical calculators, and now the electronic computer.

Inherent in any numerical system using positional notation is that of a "base".

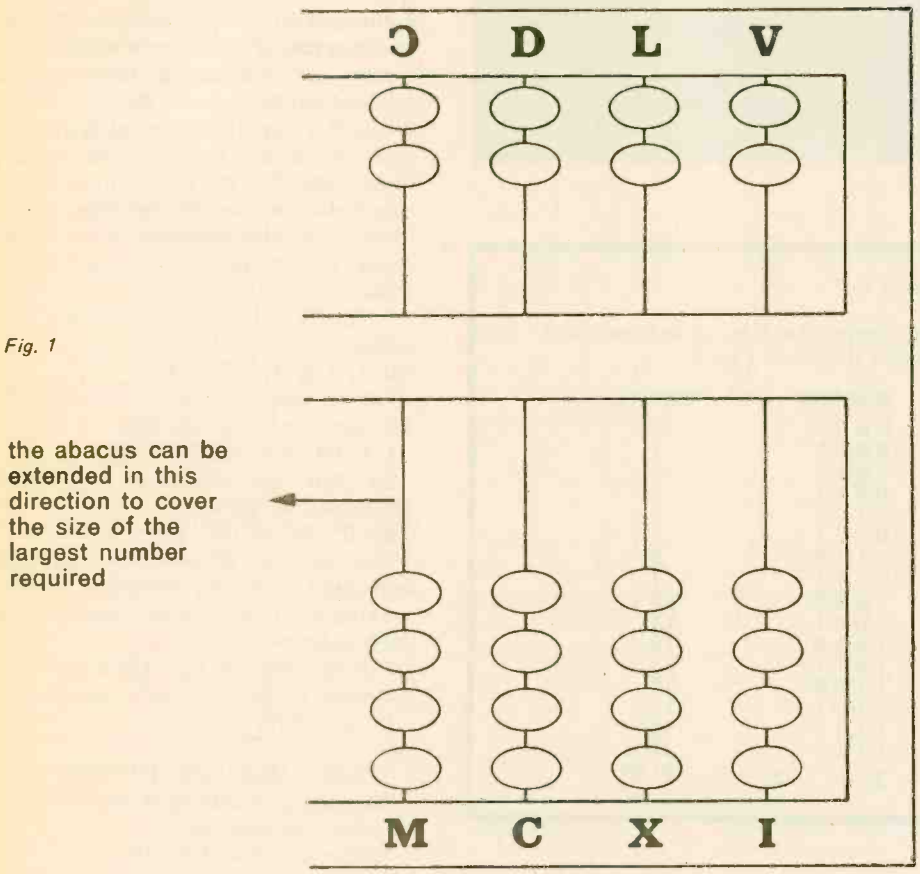


Fig. 1

This is the number that corresponds to the number of different numerical signs used. Since man has ten fingers and ten toes, it has been usual to use the number ten as a base, since counting on the fingers is one of the most primitive and fundamental ways of expressing numbers.

As we have previously shown (using as a base the number 10) the digits in any number beyond 10 are given a significant value by their *position* in the number.

Thus by using the nine numeric signs, 1, 2, 3, 4, 5, 6, 7, 8 and 9, together with the zero, we can express any number we like. For example 1973 = (1 x 1000) + (9 x 100) + (7 x 10) + (3 x 1); we know that the 1 represents 1000 solely because it has three whole digits to its right.

With this principle established, we can carry out any desired arithmetical operation upon our numbers. It must, however, be borne in mind that basically *there are only two arithmetical operations possible — addition and subtraction.* Multiplication, division and the extraction of roots are all, in the ultimate, dependent on addition and subtraction. We cannot multiply two numbers together without having first committed to memory a "multiplication table" which gives the results of all possible combinations of multiplication from 1 x 1 to 10 x 10. The expression 5 x 7 = 35 is merely a convenient shorthand version of

5+5+5+5+5+5+5 = 35

or

7+7+7+7+7 = 35

Note here the principle of commutation, it does not matter whether we write 5 x 7 or 7 x 5, the result is the same. For some types of calculation, however, this law is not valid and care must be taken to perform the operations in the correct order. This aspect, however, is outside the scope of this article and may be ignored.

The smallest base that can be used is 2. Here only two symbols, 1 and 0, are used. But with just these two symbols we can express any number no matter how big.

In this system, known as 'binary notation', each successive symbol to the left of the first digit — which can only be a '1' or a '0' — is increased by a factor of two.

Thus the binary number 1011 is represented by 11 in decimal notation. Starting from the left, the first digit represents 1, the second 2, the third 0, and the fourth 8, hence binary 1011 equals decimal 1 + 2 + 0 + 8).

Were the binary number to be 1110 then the decimal equivalent would be 14, (0 + 2 + 4 + 8).

Table 1 shows binary/decimal equivalents from decimal 0 to decimal 15. The table can be extended indefinitely. Just remember that each digit to the left has twice the weighting of its neighbour to the right. Thus the weighting of succeeding digits are from the right to left, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024 etc — the number 1024 would in binary notation appear as 10000000000, 1025 would be 10000000001.

The date 1973 becomes 11110110101 in binary notation (1x1) + (0x2) + (1x4) + (0x8) + (1x16) + (1x32) + (0x64) + (1x128) + (1x256) + (1x512) + (1x1028).

There is no absolute reason why 10 (or 2) must be chosen as the base for our numbering system. For certain purposes, a system based on 8 (octal system) has distinct advantages. Such a system would give us the number sequence shown in the octal column of Table 1. (The octal system is described in greater detail later in this article).

It is important to realize that although the *number recorded* may appear strange, *the number of objects it represents* remains the same.

At this point, many readers will be asking why anybody in their right mind would willingly forgo the conciseness of decimal notation for the apparant obscurity of the binary system.

NUMBERS

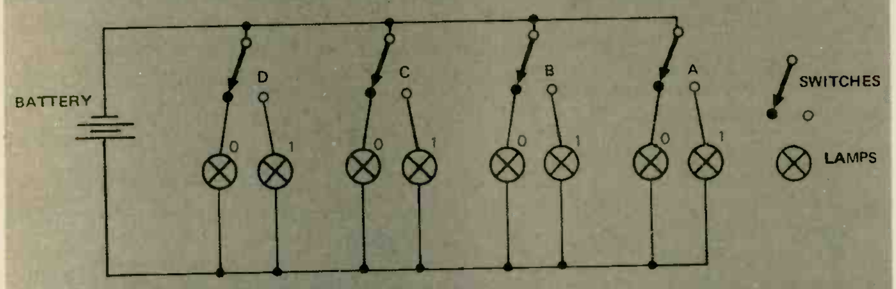


Fig. 2. This arrangement of four switches may be used to represent the decimal numbers 0 to 15 in binary notation.

TABLE 1

Table 1. Comparison of decimal numbers from 0 to 15 in binary and octal. Letters A to D refer to switches shown in Fig. 2

	DECIMAL	BINARY	OCTAL
One switch	0	0 0 0 0	0
	1	0 0 0 1	1
Two switches	2	0 0 1 0	2
	3	0 0 1 1	3
	4	0 1 0 0	4
Three switches	5	0 1 0 1	5
	6	0 1 1 0	6
	7	0 1 1 1	7
	8	1 0 0 0	10
	9	1 0 0 1	11
	10	1 0 1 0	12
Four switches	11	1 0 1 1	13
	12	1 1 0 0	14
	13	1 1 0 1	15
	14	1 1 1 0	16
	15	1 1 1 1	17
Weight	10^1 10^0	2^3 2^2 2^1 2^0	8^1 8^0

The answer to this lies in the capabilities and limitations of electronics to perform mathematical operations.

At present the simplest and least ambiguous device that is suitable for our requirements is a basic on/off switch. It has two stable states — it is either 'on' or it is 'off'.

A device such as this fits in perfectly with the binary system, the 'on' state representing a '1', the off state '0'.

Four switches, interconnected as shown in Fig. 2 may be used to represent the (decimal) numbers 0-15 in binary form.

Each switch represents one binary digit — thus decimal '0' would be represented by all switches being in the 'off' (0) positions. Decimal 5 would have switch D at 'O', C at '1', B at 'O', and A at '1'. (note that the '0' lamps shown in the circuit are only necessary to avoid possible ambiguity — i.e. the '1' light need only be off to represent a '0' — but there is always the possibility that absence of light is due to a blown bulb rather than an intentional '0')

The number of switches may be increased as desired to cover any range of numbers. Thus five switches will cover 0-31, six switches 0-63. In other words, where 'n' equals the number of switches the range of numbers covered equals 2^n-1

For example when n = 8

$$2^n = 2^8 = 256$$

i.e. eight switches will represent numbers from zero to 255.

In a computer these switches are replaced by transistors which perform the same function electronically. Transistor switches may be packed into an amazingly small area (5000 per square millimetre), they require very little power and are very fast acting.

The computer may therefore be constructed to handle vast quanties of data in a very short space of time.

The binary numbering system is essential to electronic computation because at present there are no known devices or circuits which exhibit more than two stable states and are as simple and unambiguous in operation as the transistor switch.

Although it is possible to construct a computer working strictly in binary notation, such a device would be unnecessarily complex and occupy too much space. What is more suitable is a system of numbering based on a number which is an integral power of 2. Such a system is the octenary. Its base, 8, is sufficiently close to our usual base 10, to give numbers of a reasonably concise format and, at the same time, the numbers 0 to 8 can easily be expressed in binary form, thus:

0, 1, 10, 11, 100, 101, 110, 111, 1000

0, 1, 2, 3, 4, 5, 6, 7, 8

For an octal number, the weighting for successive positions are:

1, 8, 64, 512, 4096, 32768, . . .

So that we can have a number composed of, say:

$8^0, 8^1, 8^2, 8^3, 8^4, 8^5 \ldots$

Each position of which can easily be expressed in binary notation using a maximum of three binary numbers for each position.

Taking the date, 1973 as our example, we get, in octal notation:

1973 = 3665

or

$(3\times8^3)+(6\times8^2)+(6\times8^1)+(5\times8^0)$

which can be transcribed into binary — octenary notation as:

1973 = 011 110 110 101.

It may be thought that such a system is cumbersome, but although for relatively small numbers it is more complex than other forms of notation, when dealing with very large or very small numbers, such as are frequently met with in computer calculations, a considerable economy in memory cells results.

The foregoing analysis shows that the representation of a physical number may differ according to the system of numeration employed, however it is the number itself that is fixed and not the group of numerical signs by which it is represented.

So far we have considered numbers in the abstract as being the numerical representation of physical magnitudes. However, as will be seen below, numbers have an independent existence of their own with some odd and surprising properties. Henceforward in this article we shall only consider numbers written in our normal decimal notation.

Let us first of all consider whole numbers (integers) only and see what *kinds* of numbers may exist. The first category is that of *odd* and *even* numbers. Starting from unity the numbers are alternatively *odd* (that is, cannot be divided exactly by 2, but always leave a remainder of 1) and *even* (which can be divided exactly by 2). Simple manipulation of those numbers show the following properties.

- the sum of two odd numbers is an even number, e.g. 9+5 = 14;
- the sum of two even numbers is an even number, e.g. 8+6 = 14;
- the sum of an odd and an even number is an odd number, e.g. 9+4 = 13;
- the product of two odd numbers is an odd number, e.g. 7x9 = 63;
- the product of two even numbers is an even number, e.g. 8x6 = 48;
- the product of an odd and an even number is an even number, e.g. 9x8 = 72;
- the division of two odd numbers, if an exact solution exists, will be an odd number, e.g. 63/9 = 7;
- the division of two even numbers, if an exact solution exists, may be either an odd or an even number, e.g. 48/6 = 8; 72/8 = 9;
- division of an odd number by an even number, will not give an exact solution.

It can thus be seen that straight away we have found some regular patterns in the relationship between the odd and the even numbers.

A second division of numbers is that of *prime* and *factorial* numbers. A prime number is a number which cannot be divided exactly by any other number except unity. Thus 1,2,3,5,7,11,13,17,19,23,29,31........... are all prime number.

Since the prime numbers cannot by definition be divided exactly by 2 they are all, with the exception of 2 itself, odd numbers, but all odd numbers are *not* primes, e.g. 9 = 3x3; 15 = 5x3; 21 = 7x3, etc.

Since Leibnitz in the seventeenth century mathematicians have tried to establish two formulae:

- a formula permitting one to determine whether a given large number is a prime or not;
- a formula permitting the calculation of the series of prime numbers up to any desired value.

So far neither of these goals have been reached and the problem, which appears so simple at first sight, has resisted all attempts at solution.

The series of numbers, 0, 1, 2 . . . extends up to infinity, since no matter how large a number we may choose, there is always the possibility of augmenting its value by 1 and thus obtaining a new and larger number.

If we now consider numbers such as $\frac{1}{10}$ $\frac{1}{100}$ $\frac{1}{1000}$ etc a whole infinity of such numbers can be inserted between any two integers in the series 0, 1, 2, 3, . . . These numbers also have their peculiar properties and may be divided into two main categories:

- decimal fractions which have a definite and exact value. Thus 10/4 = 2.50000 . . . with no doubt as to its exact equivalence;
- recurring decimals, which, no matter how far the process is extended a final and exact result is never reached:

e.g. 10/3 = 3.33333 . . .
10/9 = 1.11111 . . .
10/7 = 1.42857142857142857 . . .
and so on for ever.

It must be realized that between any two consecutive whole numbers there are a whole infinity of numbers which can be represented exactly, and equally a whole infinity of recurring decimals.

Finally, in our classification of numbers there come the real "wild men". These are called "irrational numbers" or "surds" and are represented by decimals that *neither come to a final result* nor *recur*. This means that we can approach the value of the number to any desired degree or precision by taking into account an appropriate number of decimal points, but can never reach a final result. To complicate the issue, many of these numbers represent physical magnitudes which have a real existence.

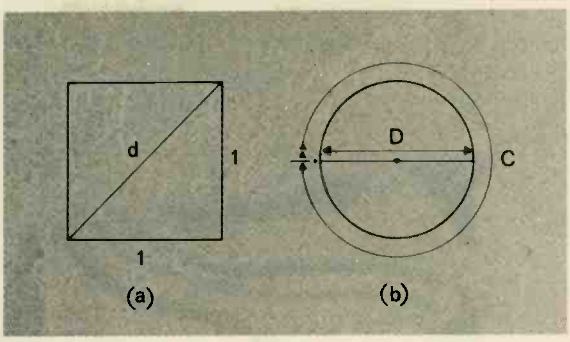


Fig. 3

Figure 3 shows two examples of these numbers. Figure 3(a) shows a square, the side of which is 1 unit, with its diagonal. Now, according to the theorem of Pythagoras concerning right-angled triangles, the length of this diagonal is given by $d = 1^2 + 1^2 = 2$. But although the diagonal of this square has a physical existence, there is no finite number capable of representing 2, the best we can do is to write 2 = 1.4142 . . . out to infinity.

This means that although the length *d* on the figure is a definite physical magnitude it is not possible to express its value *exactly* in our system of numeration.

Again, in figure 3(b) we have a circle and its radius. The length of the diameter *D*. is known, and the circumference *C* of the circle is a physical magnitude which has a real existence. However, if we wish to express the ratio of the circumference *C* to the diameter *D*. we obtain the well known relationship:

$C = \pi D$

where π = 3.14159 . . . and to infinity.

This number can never be expressed exactly in our numerical notation but can only be expressed to a desired degree of accuracy by taking into account the appropriate number of decimal points in the expression for π.

It will now hardly come as a surprise to know that between any two subsequent numbers in the series 0, 1, 2, . . . there can exist a whole infinity of such surds, none of which is capable of exact representation using our numbers.

Other categories of numbers exist: negative numbers, imaginary numbers, complex numbers, vectorial numbers, which are not dealt with in this simple exposition. Nevertheless, it is hoped that it has been made clear that a series of conventional signs, designed initially to represent simple physical magnitudes have come to have a curious life of their own, divorced from their primitive functions, the study of which provides a fascinating field to the inquiring mind. ●

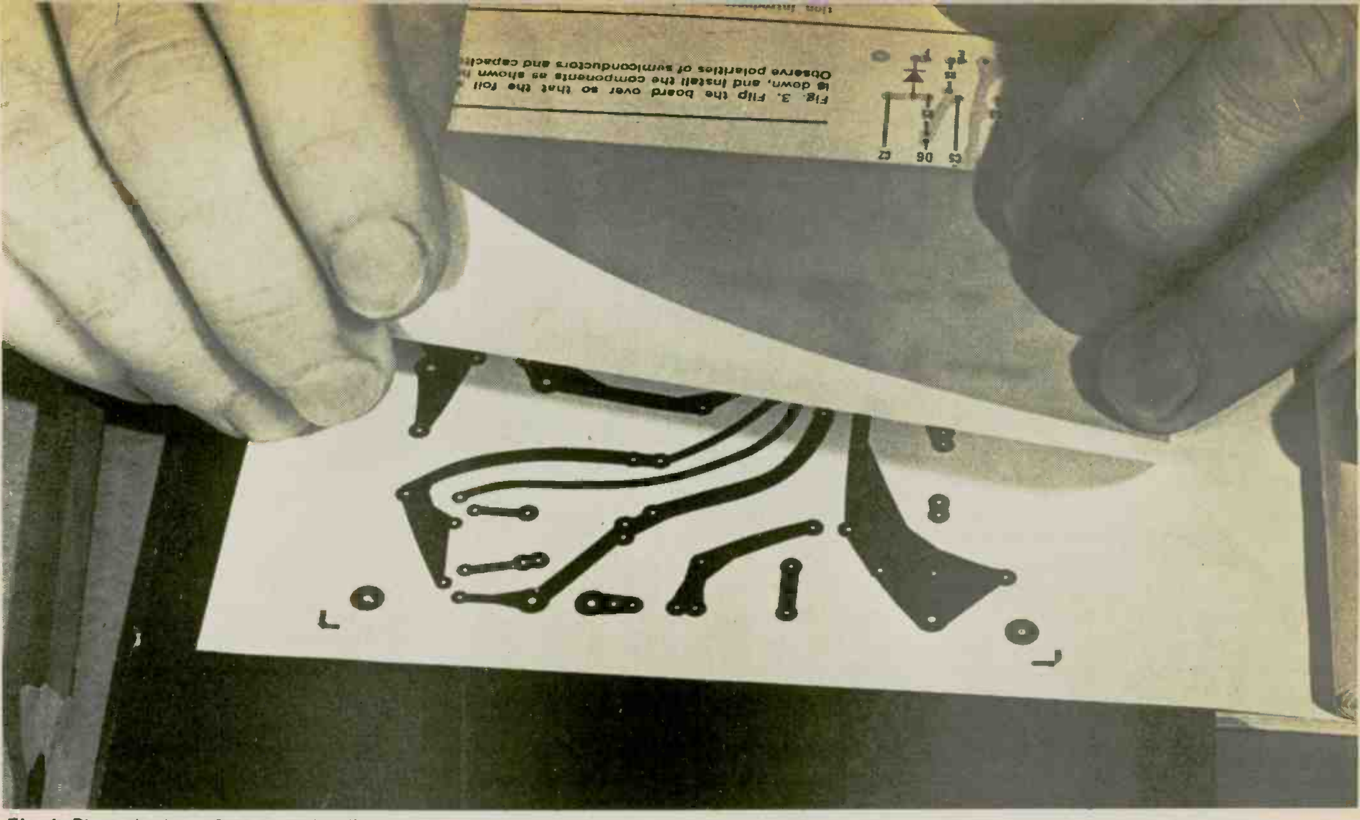
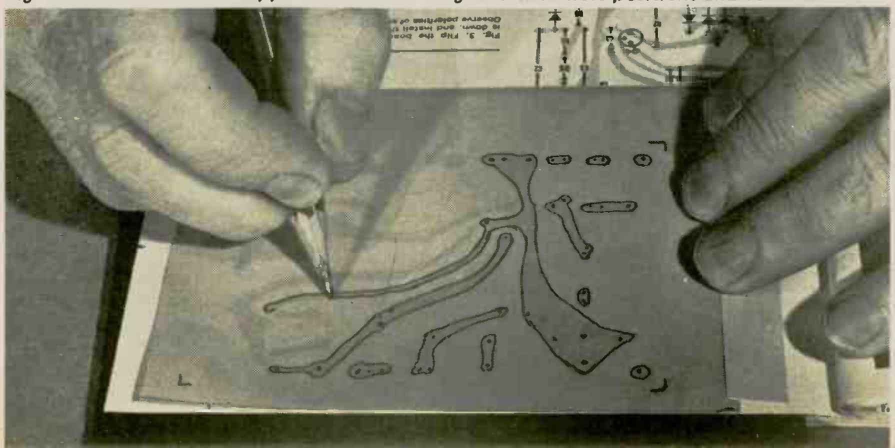


Fig. 1. Place the Letrafilm over the diagram.

Easier way to make your own P.C. boards

Now you can do away with all the fuss and bother of conventional printed circuit preparation, says A. J. Lowe

Fig. 2. Trace around the copper areas on the diagram. Mark hole positions and corners also.



At last! Here's a quick, clean method of preparing printed circuit boards for etching — and it's for the home constructor.

Photographic methods are fine if you want to produce a large number of identical boards, but far too slow, expensive and involved for the 'one-off' man who simply wants to make one board — usually from a diagram in a magazine.

The standard method, for the experimenter, involves the use of tracing paper, carbon paper, and a resist paint. Sure, it works — but those who have used it know how hard it is to get narrow clean-edged lines with paint. Sometimes the paint is thin and porous and lets the etchant through, and sometimes it runs across narrow gaps, leaving short circuits to be cleaned up later. Sometimes the paint is thick and hard to manage. Besides, it takes ages for the paint to dry.

This new method requires no tracing paper, no carbon paper, no paint, no brushes, no solvents — and you can have a printed circuit board ready in an hour or so.

It depends on the use of a cut-out colour film used in the graphic arts field, called LETRAFILM. Made by the manufacturers of the widely-used Letraset stick-on letters, it is obtainable from artists' shops and drawing office supply houses.

Letrafilm is a thin sheet of film available in a range of 50 colours, tacky on one side and 'toothed' on the other. The tacky side is backed with a translucent paper support. The toothed side can be written or drawn on with ease. The film is quite impervious to etchants and so makes

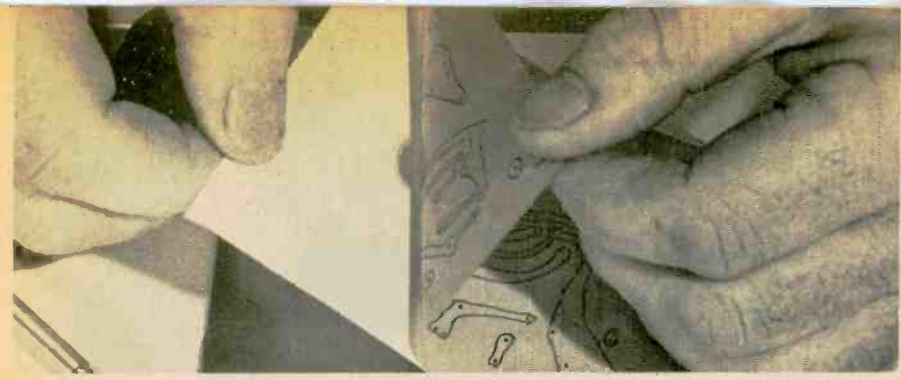


Fig. 3. Separate the Letrafilm from its backing support.

Fig. 4. Place the film down on the copper side of the p.c. board.

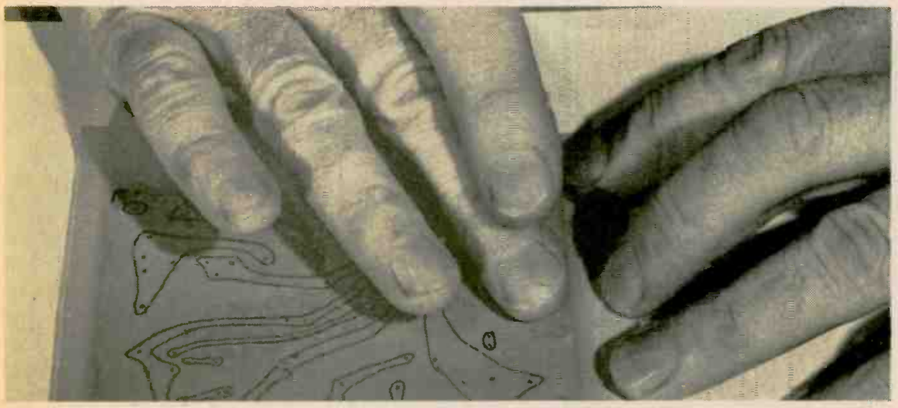


Fig. 5. Press the film down gently.

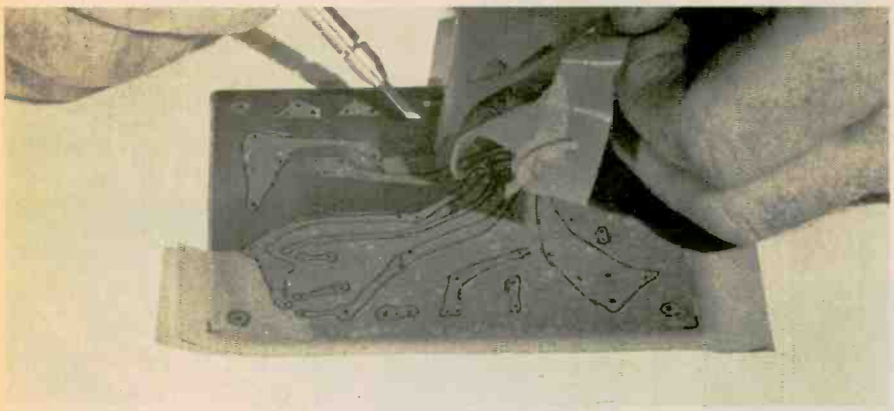


Fig. 6. Cut around the copper areas with a sharp craft knife.

Fig. 7. Remove the unwanted film, leaving film over the areas where copper is to remain.

an ideal resist. It is available in sheets 10" x 15" and is quite inexpensive. Only a few pence worth will cover the typical printed circuit board. A light colour, such as pale yellow, is ideal for this application.

Here's how to use it:

1) Cut a piece of Letrafilm, complete with its backing, about 3/8" or so larger all round than the printed circuit board.

2) Place a sheet of aluminium, or phenolic board, or even printed circuit board, below the diagram of the printed circuit. This gives a hard support for the next few operations.

3) Lay the Letrafilm over the diagram (see Fig. 1) and hold it down at one side with sticky tape. It will be found that the diagram can be seen quite clearly through the Letrafilm.

4) Trace around the copper (i.e. black) areas in the diagram with a pencil. (Fig. 2), making sure that the corners of the board are marked as well. The position of holes for the component leads should be marked with a pencil dot. This is another advantage of this method over the paint method, in which hole positions have to be gauged later.

Many diagrams prepared professionally, using stick-down circles and lines, have lots of fine curves and indentations where none is really required. There's no need to follow unnecessary detail and it may be eliminated as tracing proceeds.

5) Remove the Letrafilm from the diagram and carefully separate the film from its backing sheet (Fig. 3).

6) Lay the film, tacky side down, on to the thoroughly cleaned copper surface of the printed circuit board, using the corner marks as a guide (Fig. 4).

7) Press the Letrafilm gently down on to the printed circuit board. (Fig. 5). Do not press too hard, as this will make later removal of the unwanted film portions unnecessarily difficult. Small air bubbles need not be squeezed out.

8) Cut around the pencilled outlines of the copper areas with a sharp craft knife (Fig. 6). This process is much easier than painting, and quicker – and clean sharp lines are automatic.

Do not, at this stage, do anything about the dots marking component lead hole positions.

9) When cutting is complete, carefully peel away the *unwanted* film

from the board — that is, the film which does not cover areas where copper is required. This is done by gently lifting the film at one corner and easing it back. It will break as you progress, but that's no disadvantage (Fig. 7). Watch that none of the 'islands' lifts, due to bad cutting along the pencil lines. If one does lift, press it back and cut around it once again.

10) When all the unwanted film has been lifted, lay a sheet of paper over the board and press down firmly all over it. This bonds the film to the wanted copper so that it acts as an effective resist (Fig. 8). Make sure that no air bubbles are near the edge of an island. In the middle they don't matter.

11) Etch the board. This can be done in your usual etching bath. For those who have never made a printed circuit board before, an effective etching solution is 4oz. of ferric chloride dissolved in 10oz. of hot water. This will etch a typical board in 20 to 30 minutes. Protect your eyes and hands — the solution is corrosive.

12) When etching is complete, remove the board from the etching bath and wash it clear of etching solution under running water. Dry the board by dabbing it with a rag.

13) With a scriber, mark the positions of the holes for component leads by pressing through the film into the copper (Fig. 9). The pencil dots already made (see introduction 4 above) give the positions.

14) Remove the remaining Letrafilm. This can be peeled and rubbed off (Fig. 10).

15) Clean away any residual adhesive from the film by cleaning the board with an abrasive domestic cleaning powder and, if needed, some steel wool. The board is now clean and ready marked for drilling (Fig. 11).

16) To prevent the copper oxidising, it should be sprayed with a special printed circuit board lacquer. Alternatively — and much more cheaply — it can be brushed with a rosin solution (one lump of rosin dissolved in a little methylated spirit). This makes a first-class flux and maintains the shiny look of the board.

Well, there it is — a simple, clean, efficient and quick method of doing-it-yourself and, at the same time, saving money. ●

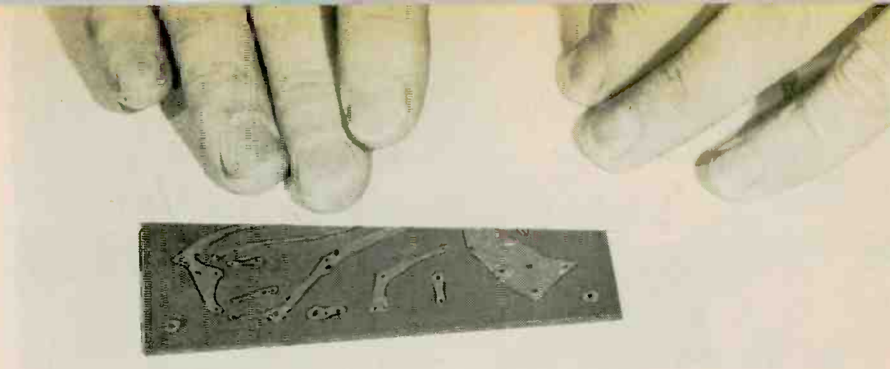


Fig. 8. Press down hard, to bond the remaining film to the board.

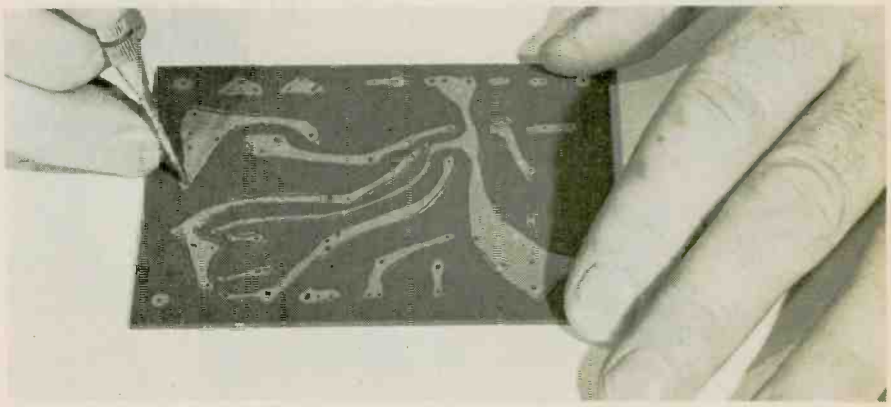


Fig. 9. After etching away all unwanted copper, mark hole positions with a scriber.

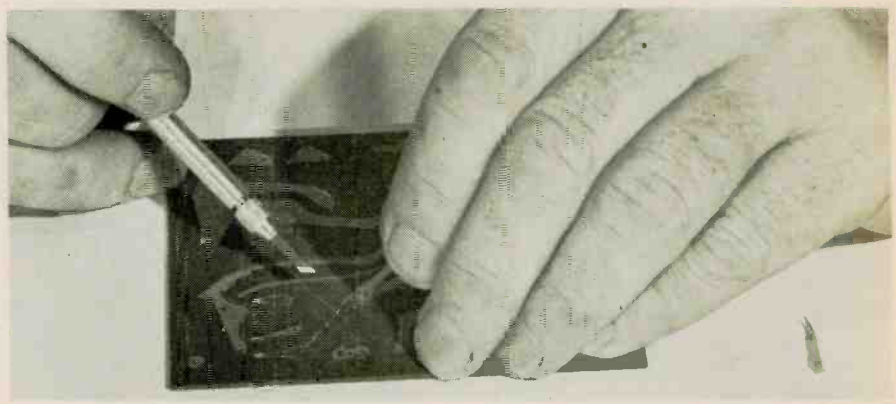


Fig. 10. Remove remaining film from the board.

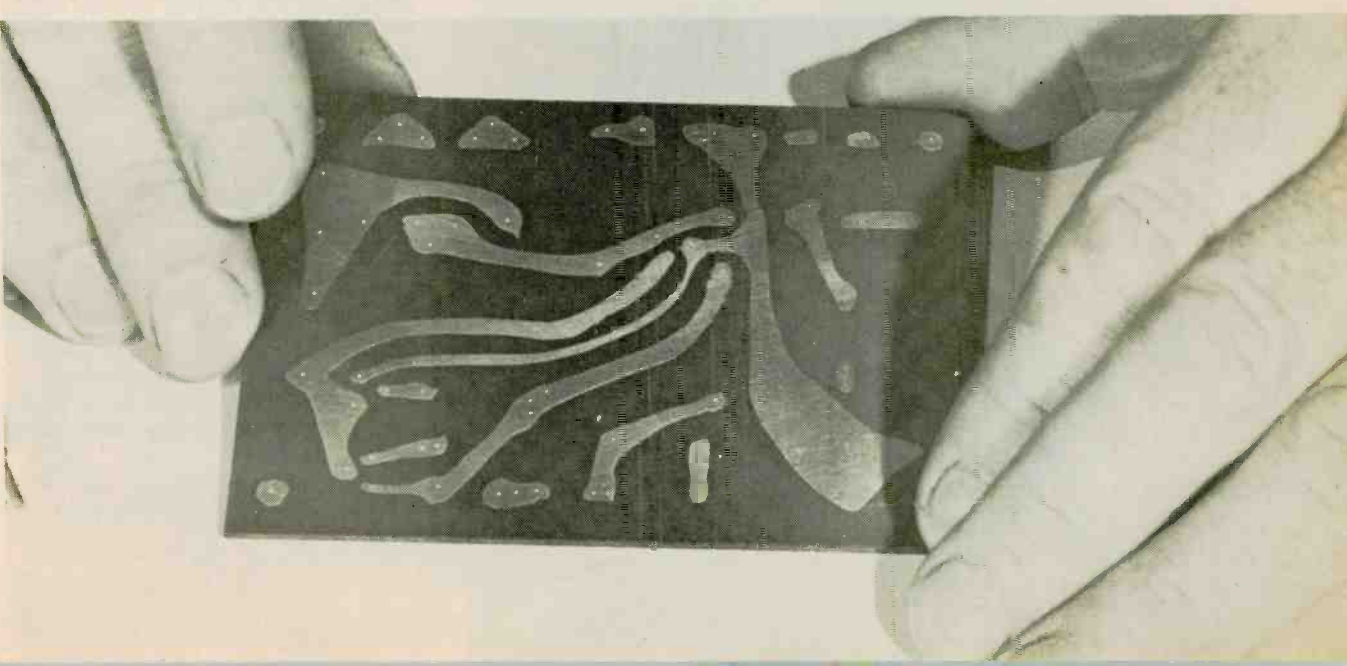


Fig. 11. The board, cleaned and ready for drilling.

J. T. EDEN ELECTRONICS

TRANSISTORS

AC 107	£0·20
AC 113	0·20
AC 115	0·20
AC 117	0·20
AC 117K	0·20
AC 121	0·15
AC 122	0·15
AC 125	0·18
AC 126	0·15
AC 127	0·15
AC 128	0·15
AC 132	0·15
AC 141K	0·25
AC 142K	0·25
AC 151	0·20
AC 154	0·20
AC 155	0·20
AC 156	0·20
AC 176	0·18
AC 187	0·20
AC 187K	0·20
AC 188	0·20
AC 188K	0·22
ACY 17	0·25
ACY 18	0·20
ACY 19	0·20
ACY 20	0·20
ACY 21	0·20
ACY 22	0·15
ACY 28	0·20
ACY 39	0·50
ACY 40	0·20
ACY 41	0·20
ACY 44	0·30
AD 140	0·50
AD 142	0·45
AD 143	0·45
AD 149	0·40
AD 150	0·65
AD 160	0·35
AD 161	0·35
AD 161/2	0·55
AD 162	0·35
AD M/PR	0·55
AF 114	0·20
AF 115	0·20
AF 116	0·20
AF 117	0·20
AF 118	0·45
AF 124	0·25
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AF 126	0·20
AF 127	0·20
AF 139	0·40
AF 178	0·45
AF 179	0·55
AF 180	0·50
AF 181	0·42
AF 186	0·45
AF 239	0·43
AL 102	0·65
AL 103	0·60
ASY 26	0·30
ASY 27	0·30
ASY 28	0·30
ASY 29	0·30
ASY 50	0·20
ASY 56	0·25
ASY 57	0·25
ASY 58	0·25
BC 107	0·10
BC 107B	0·10
BC 108	0·10
BC 108B	0·10
BC 109	0·10
BC 109B	0·10
BC 113	0·15
BC 114	0·15
BC 115	0·15
BC 116	0·15
BC 117	0·15
BC 118	0·10
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BC 132	0·25
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BC 142	0·25
BC 143	0·20
BC 144	0·25
BC 145	0·20
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BC 148	0·10
BC 149	0·12
BC 153	0·20
BC 154	0·20
BC 157	0·13
BC 158	0·13
BC 159	0·13
BC 160	0·12
BC 167	0·12

BC 168	£0·12
BC 169	0·12
BC 169L	0·13
BC 170	0·12
BC 171	0·12
BC 172	0·12
BC 173	0·20
BC 175	0·23
BC 177	0·17
BC 178	0·20
BC 179	0·20
BC 182	0·10
BC 182L	0·10
BC 183	0·10
BC 183L	0·10
BC 184	0·10
BC 184L	0·10
BC 186	0·25
BC 187	0·25
BC 207	0·10
BC 208	0·1[illegible]
BC 209	0·10
BC 212L	0·12
BC 213L	0·12
BC 214L	0·14
BC 258	0·10
BC 259	0·13
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BCY 32	0·50
BCY 33	0·25
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BCY 39	0·65
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BCY 70	0·16
BCY 71	0·20
BCY 72	0·15
BCZ 11	0·40
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BD 121	0·65
BD 123	0·80
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BD 130	0·50
BD 131	0·75
BD 132	0·75
BD 133	0·65
BD 135	0·40
BD 136	0·45
BD 137	0·45
BD 138	0·55
BD 139	0·60
BD 140	0·75
BDY 20	1·00
BF 115	0·25
BF 117	0·45
BF 119	0·58
BF 121	0·25
BF 123	0·27
BF 125	0·25
BF 127	0·27
BF 152	0·21
BF 153	0·30
BF 154	0·16
BF 158	0·15
BF 159	0·30
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BF 180	0·30
BF 181	0·32
BF 182	0·35
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BF 195	0·15
BF 196	0·15
BF 197	0·15
BF 200	0·35
BF 224	0·35
BF 244	0·18
BF 257	0·40
BF 258	0·45
BF 259	0·50
BF 270	0·25
BF 271	0·20
BF 272	0·50
BF 273	0·25
BF 274	0·29
BFS 61	0·27
BFS 98	0·25
BFW 10	0·25
BFX 13	0·25
BFX 29	0·25
BFX 30	0·60
BFX 34	0·70

BFX 37	£0·30
BFX 84	0·25
BFX 85	0·30
BFX 86	0·25
BFX 87	0·25
BFY 50	0·20
BFY 51	0·20
BFY 52	0·20
BFY 53	0·15
BFY 64	0·40
BFY 90	0·60
BRY 39	0·30
BSX 19	0·15
BSX 20	0·15
BSY 27	0·15
BSY 28	0·15
BSY 38	0·15
BSY 39	0·15
BSY 52	0·25
BSY 95A	0·10
BU 105	2·25
BU 105/2	1·75
C 111	0·50
C 407	0·20
C 424	0·20
C 425	0·35
C 426	0·25
C 428	0·25
C 449	0·30
C 450	0·20
OC 16	0·60
OC 19	0·40
OC 20	0·65
OC 22	0·40
OC 23	0·40
OC 24	0·60
OC 25	0·35
OC 26	0·30
OC 28	0·40
OC 29	0·40
OC 35	0·42
OC 36	0·50
OC 41	0·20
OC 42	0·25
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OC 45	0·15
OC 57	0·50
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OC 72	0·20
OC 74	0·30
OC 75	0·25
OC 76	0·15
OC 77	0·40
OC 81	0·20
OC 81D	0·20
OC 82	0·25
OC 82D	0·20
OC 83	0·23
OC 84	0·25
OC 139	0·25
OC 140	0·55
OC 169	0·25
OC 170	0·25
OC 171	0·30
OC 200	0·40
OC 201	0·75
OC 202	0·80
OC 203	0·50
OC 204	0·40
OC 205	0·75
OCP 71	1·00
ORP 12	0·50
ORP 60	0·40
ORP 61	0·40
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2G 302	0·20
2G 303	0·20
2G 306	0·35
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2G 371	0·15
2G 374	0·15
2G 381	0·20
2G 417	0·20
2N 404	0·20
2N 696	0·15
2N 697	0·15
2N 698	0·25
2N 699	0·30
2N 706	0·10
2N 706A	0·12
2N 708	0·13
2N 709	0·40
2N 718	0·20
2N 718A	0·30
2N 916	0·18
2N 918	0·30
2N 929	0·15
2N 930	0·15
2N 1131	0·20
2N 1132	0·20
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2N 1303	0·16
2N 1304	0·20
2N 1305	0·20
2N 1306	0·22
2N 1307	0·22
2N 1308	0·25
2N 1309	0·35

2N 1613	£0·20
2N 1631	0·25
2N 1711	0·20
2N 1893	0·35
2N 2147	0·75
2N 2148	0·60
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2N 2646	0·45
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2N 2712	0·13
2N 2714	0·20
2N 2894	0·35
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2N 2905A	0·25
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2N 2907A	0·12
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2N 2924	0·12
2N 2925	0·12
2N 2926R	0·10
2N 2926G	0·10
2N 29260	0·10
2N 2926Y	0·10
2N 29206B	0·10
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2N 3054	0·50
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2N 3393	0·15
2N 3394	0·12
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2N 3405	0·25
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2N 3415	0·10
2N 3416	0·15
2N 3417	0·20
2N 3440	0·85
2N-3563	0·15
2N 3564	0·18
2N 3565	0·13
2N 3566	0·20
2N 3572	0·95
2N 3692	0·17
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2N 3709	0·10
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2N 3711	0·10
2N 3714	0·10
2N 3773	3·00
2N 3790	2·00
2N 3794	0·15
2N 3819	0·25
2N 3820	0·50
2N 3866	0·65
2N 3903	0·20
2N 3904	0·18
2N 3905	0·20
2N 3906	0·20
2N 4033	0·75
2N 4058	0·12
2N 4059	0·12
2N 4060	0·12
2N 4061	0·12
2N 4062	0·12
2N 4143	0·25
2N 4236	1·35
2N 4248	0·10
2N 5172	0·10
2N 5457	0·30
2N 5458	0·33
2N 5459	0·35
2S 301	0·50
2S 302	0·42
2S 303	0·55
2S 322	0·50
2S 324	0·95
2S 502	0·35
40360	0·45
40361	0·50
40362	0·45
40408	0·50
40636	1·10

DIODES AND RECTIFIERS

IN 34	£0·08	BA 154	£0·15
IN 34A	0·08	BA 155	0·16
IN 914	0·08	BA 156	0·16
IN 916	0·08	BAY 18	0·20
IN 4001	0·06	BAY 31	0·10
IN 4002	0·06	BAY 38	0·30
IN 4003	0·07	BAX 13	0·10
IN 4004	0·07	BAX 16	0·15
IN 4005	0·12	BY 100	0·15
IN 4006	0·13	BY 101	0·15
IN 4007	0·15	BY 103	0·25
IN 4148	0·05	BY 105	0·20
IS 021		BY 114	0·15
IS 44	0·15	BY 124	0·15
IS 113	0·15	BY 126	0·15
IS 120	0·15	BY 127	0·20
IS 121	0·11	BY 164	0·65
IS 130	0·11	BYX 10	0·35
IS 131	0·11	BYX 38/30	0·45
IS 132	0·13	BYZ 10	0·35
IS 414B	0·07	BYZ 11	0·35
IS 920	0·10	BYZ 12	0·35
IS 922	0·10	BYZ 13	0·30
IS 923	0·15	BYZ 16	0·45
IS 940	0·06	BYZ 17	0·40
IS 951	0·06	BYZ 18	0·40
AA 119	0·10	BYZ 19	0·30
AA 120	0·10	BZY 78	1·00
AA129	0·10	OA 5	0·25
AAY 30	0·12	OA 9	0·12
AAY 42	0·15	OA 10	0·20
AAZ 13	0·12	OA 47	0·10
AAZ 15	0·15	OA 70	0·08
AAZ 17	0·15	OA 79	0·08
BA 100	0·15	OA 81	0·10
BA 102	0·25	OA 85	0·10
BA 110	0·25	OA 90	0·08
BA 115	0·08	OA 91	0·08
BA 116	0·25	OA 95	0·08
BA 126	0·25	OA 200	0·10
BA 141	0·35	OA 202	0·10
BA 142	0·35	SO 10	0·06
BA 144	0·15	SO 19	0·06
BA 145	0·25	T1V 307	0·25
BA 148	0·15		

ZENER DIODES

All preferred voltages from 2·0 to 33·0. 5% Tolerance 400 MW (DO-7) 12p.; 1·5 W (SO-16) 20p; 10 W (SO-10) 30p.

RESISTORS

Cracked carbon. Metal oxide. 5% Tolerance. ½ watt all values 1p. each.

INTEGRATED CIRCUITS

7400	£0·18	7488	£12·50
7401	0·18	7489	5·50
7402	0·18	7490	0·70
7403	0·18	7491	1·10
7404	0·18	7492	0·70
7405	0·18	7493	0·70
7406	0·35	7494	0·80
7407	0·35	7495	0·80
7408	0·20	7496	0·90
7409	0·20	7497	6·50
7410	0·18	74100	1·80
7411	0·25	74104	1·00
7412	0·40	74105	1·00
7413	0·30	74107	0·45
7416	0·40	74110	0·60
7417	0·40	74111	1·30
7420	0·18	74118	1·10
7421	0·25	74119	1·40
7422	0·50	74121	0·45
7423	0·50	74122	1·50
7425	0·50	74123	2·85
7426	0·35	74141	0·80
7427	0·45	74145	1·60
7428	0·60	74150	3·50
7430	0·18	74151	1·10
7432	0·45	74153	1·30
7433	0·80	74154	2·00
7437	0·60	74156	1·50
7438	0·60	74157	1·50
7439	0·60	74160	2·00
7440	0·18	74161	2·00
7441	0·70	74162	3·75
7442	0·70	74163	3·75
7443	1·20	74164	2·50
7444	1·20	74165	2·50
7445	2·00	74166	4·00
7446	1·20	74167	7·00
7447	1·20	74170	5·00
7448	1·20	74174	2·50
7450	0·18	74175	1·50
7451	0·18	74176	2·00
7452	0·23	74177	2·00
7453	0·18	74180	1·80
7454	0·18	74181	6·00
7460	0·18	74182	2·25
7470	0·30	74184	3·00
7472	0·30	74185A	3·00
7473	0·40	74190	2·20
7474	0·40	74191	2·20
7475	0·50	74192	2·20
7476	0·44	74193	2·25
7480	0·70	74194	2·75
7481	1·30	74195	2·00
7482	1·00	74196	1·75
7483	1·10	74197	1·75
7484	1·00	74198	5·00
7485	3·00	74199	5·00
7486	0·35		

I. C. SOCKETS

14 pin, 14p.
16 pin, 16p.

Please send your remittance with order: cheques, P.O.'s, M.O.'s should be made payable to J. T. EDEN ELECTRONICS and crossed. Cash should be sent by registered post. Add 12p. for post and packing charge; orders are despatched by first class post. If an item is temporarily out of stock and is not expected in from our supplier for more than a week, a credit note is issued for the value and should be included with your next order. We can also despatch the item to you when it arrives and not charge you for the post and packing. If you would prefer, we can also refund the amount to you. Please let us know what you would like us to do.

As V.A.T. is chargeable, please add 10% of the total value (that includes the 12p. post and packing charge). In order to try and keep prices down we have decided to charge only 5% to orders of £5 and over, so if you just include 5p. in the pound, we will pay the rest in the form of a discount to you.

Finally, if you think there are any significant omissions or lines you like us to stock, we will try to include them in our new catalogue which will include capacitors, potentiometers, meters, kits and more semi-conductors.

ORDERS TO

J. T. EDEN ELECTRONICS, P.O. Box 5, LANCASTER LA1 3HZ.

SIMPLE LOUDHAILER

eti PROJECT

This cheap and simple loudhailer can be built in a few hours

HERE's a simple device to save your voice at sports meetings, large picnics or any other occasion that requires you to raise your voice above the surrounding noise.

It needs a minimum of components, all of which are easily obtainable; it is cheap and can be built in a very short space of time.

THE CIRCUIT

The circuit is shown in Fig. 1. A single transistor (Q1) is arranged as an amplifier with resistor R2 providing the necessary bias. The resistance of the carbon microphone will vary as sound is impressed upon the diaphragm, thus varying the voltage across R1.

Resistor R1 is ac coupled to the base of the transistor Q1. This transistor amplifies the signal and drives the speaker.

CONSTRUCTION

All the minor components are easily mounted on a single tagstrip (as shown in Fig. 2). This tagstrip may be bolted to one wall of the loudhailer enclosure and wiring taken to the microphone, speaker, pushbutton and battery.

Any suitably enclosed box of the right dimensions, may be used to house all the components including the battery and the speaker.

Generally, the larger the speaker the better, but remember this is a loudhailer not a public address system!

The back of the carbon must be enclosed to prevent feedback from the loudspeaker — if this is not done the system will oscillate. *(See over)*

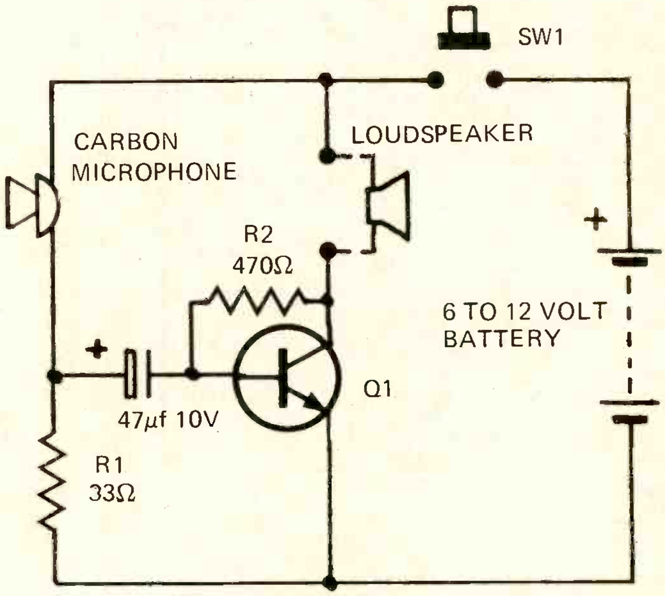


FIG. 1 CIRCUIT DIAGRAM

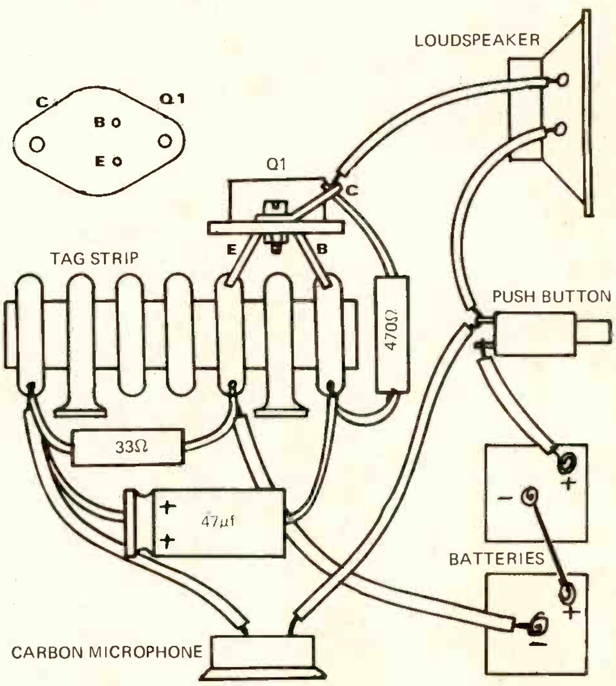
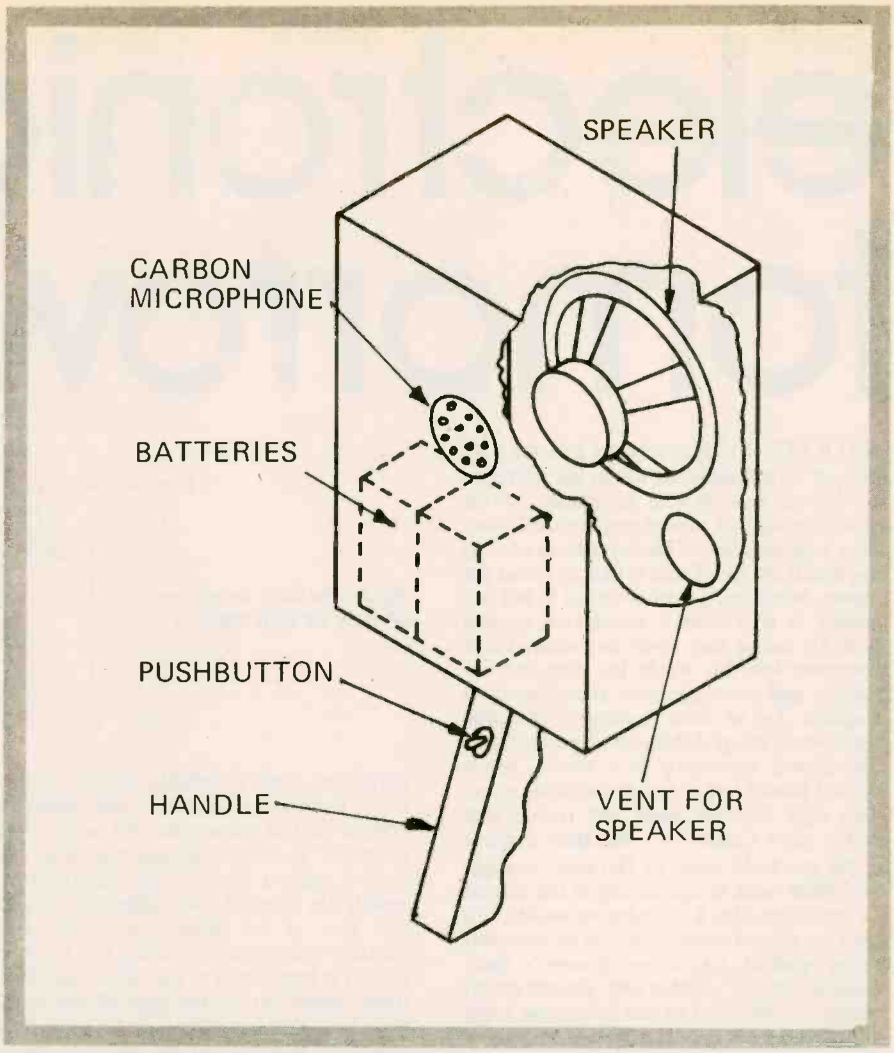


FIG. 2
COMPONENT CONNECTIONS

SIMPLE LOUDHAILER

A sketch, showing one suggested arrangement for mounting the components, is shown in Fig. 3. The layout is not critical however. Practically any arrangement that is convenient to you will work satisfactorily.

The unit is surprisingly effective — and quality is excellent — despite the bias caused by some dc energization of the loudspeaker voice coil. ●



PARTS LIST

R1 resistor, 33 ohm, ½ watt, 5%
R2 resistor, 470 ohm, ½ watt, 5%
SW1 small push-to-make switch
C1 capacitor 47 μF, 10 Volt electrolytic
Q1 transistor type 2N 3055, 40250, 2N 3054, SE 7010 or suitable equivalents.

Loudspeaker — 3" to 8" diameter, 4 ohm to 15 ohm impedance.

Batteries — two type 509 lantern batteries.

Carbon microphone.

One seven lug tagstrip, connecting wire, box, etc.

electronics tomorrow

HAVE YOU EVER wondered how the BBC manage to get sub-titles up on the television screens so quickly and accurately during sports events and similar programmes? Next time you see one of their captions coming up, watch the speed that it flashes across the screen, much too fast to be typed in but not instant as if it were a pre-printed caption card. Of course they could be prepared on a computer but this would be extremely expensive and would involve recording on a magnetic disc or drum as paper or magnetic tapes would not give fast enough access times. The answer apparently is a record, not a normal record but a disc of magnetic recording tape material layed out (oxide face down) on a Garrard 401 turntable rotating at the good old speed of 78 r.p.m. A single read-write head is carried across the disc on an arm controlled by a stepping motor, this head has sixteen positions across the disc thus giving sixteen tracks or 'grooves'. Each track is logically divided into sixteen spaces which are identified by the equipment using a LED-photocell system activated by sixteen equally spaced holes drilled around the turntable. Thus, by activating one control to select the track and another to select the segment of that track one can assess the data in that storage space in less than one second.

Each of these segments holds about 400 bits (a bit is a logical 1 or logical 0) if each character is defined by eight bits, as in standard ASCII or EBCDIC codes, this gives enough for start and finish codes, line-return, etc codes and 32 characters per line, thus each disc segment defines one display line. All of the required data is prepared before the event and consists of players names, times, placings, countries, etc.

For anybody interested in building mini-computers or suchlike and requiring 100K bits (12K bytes) of slow random access this sort of system seems to be ideal but check with the BBC first as the system (called *Anchor* by the way) is probably patented.

SHIFT REGISTERS

If you don't require 100K bit data storage, you could always try using a shift register. A shift register is a small storage device which can be likened to a conveyor belt with *n* positions on the belt, *n* is the number of bits in the register. When the clock controlling the shifting of the belt is pulsed, the belt moves along one position allowing the acceptance of a new one or zero bit at the input and producing an old one or zero at the output. One obvious use of a shift register is a divide by *n* counter; if we are using an 8 bit register we use the signal we wish to divide as the clock and press the start switch. This switch causes a logical 1 to be entered at the input during one clock period, the switch will then revert to entering a logical 0. Our logical 1 is now in bit 1 of the register and, as the clock pulses, it is shifted through the other bits until it reaches bit 8, in the meantime our switch has ensured that logical 0s follow it and thus at any stage our register only contains one logical one. When the 1 reaches bit 8 it is transferred to the output and from there passed on to the rest of the count chain and also passed back into the register at bit 1. The layout of the register is shown as Fig. 1. If the output is only inverted once then a 0 output will produce a 1 input and vice-versa, this means that our output will be low for 8 clock pulses and then high for the next 8 and so on, this means that we now have a divide by 2*n* counter.

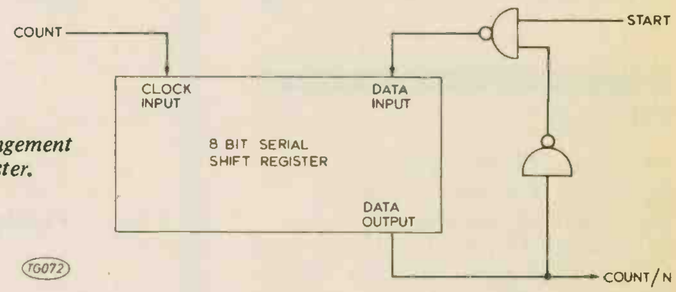


Fig.1. The basic arrangement of the 8 bit shift register.

Next question – why are we telling you all about shift registers? Answer – because they are our special offer this month, what better reason. We have discussed an 8 bit register above such as the 7491, our special offer is for a triple 66 bit register the EMIHUS EDSR3166, three 66 bit registers, 2 clocks, TTL compatible, wire-OR capability with speeds from 10Hz to 10MHz. All this in a TO-92 ten pin package, but be warned, this is one of those devices which dies if the pins are mishandled as do a lot of MOS devices so use a socket.

This special offer to ETI readers is being made by BI-PAK components of Ware, Herts who normally sell this device at £3.50 the special offer price is £2.00 inclusive of VAT, post, etc. The offer is limited to 2000 devices and each order must be accompanied by the coupon.

AUDIO CHIP

One problem with the available audio amp ICs such as the IC12 and SL403 types is the number of additional components required resulting in an amplifier a lot larger than the IC used and thus losing one of the main benefits of using an IC. Also the power available from these ICs is wasted in most applications such as radio output stages, intercoms, etc, the smaller audio ICs being not quite powerful enough. National Semiconductors have an amp designated the LM380 designed to give 2.5W r.m.s. into an 8 ohm load. Supply voltage range is 8-22V at a max of 1.3A, input voltage for maximum output is 500mV although the LM380 produces a good output from only a 50mV input, the quiescent current is only 7mA and the input impedance is 150k. Package is 14 pin D.I.L.

All very well, but what about the external components? Fig. 2 shows the LM380 in two typical applications, count the components for yourself! Data from (2), LM380 from (3) price £1.50 plus VAT.

DIY PCB'S

That stands for Do-It-Yourself Printed Circuit Boards. Quite a few kits are available to enable you to draw and etch your own PCB's but most of these kits work on the one-off principle, that is you have to draw each board required, one mistake and back to square one. Professionally boards are drawn up on drawing paper or film, photographed, exposed on photosensitive boards and etched, any mistake can be rectified on the master

Continued on page 85

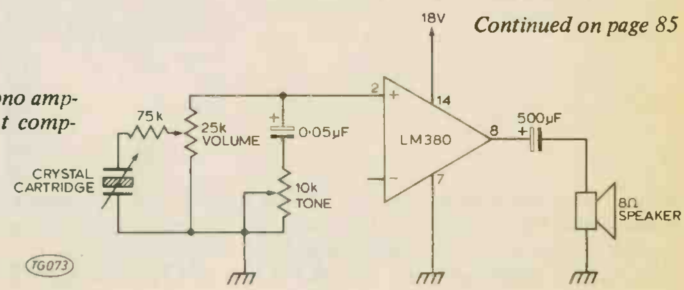
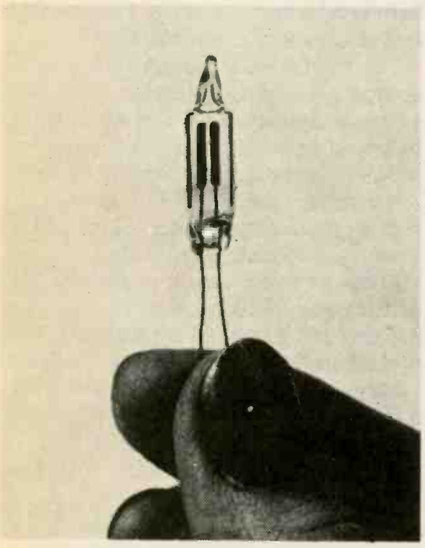


Fig.2a. A simple phono amplifier using only eight components.

eti component news

SURGE ARRESTER

A special surge voltage arrester has been designed by Vitality to protect Post Office lines from high voltage transients generated in equipment connected to the lines. This protective device, type XSA 2, is the only protector approved and specified by the Post Office for use where signals exceed ±6V.



The two principal applications for the surge arrester, which is a miniature gas-filled tube, are in the Post Office's mandatory general purpose barrier for speech band circuits (for signals up to 80V a.c. or 120V d.c.) and the barrier for wide band circuits (for use on wide-band and coaxial circuits up to 5.5MHz.)

The gas-filled tube, 6mm diameter and 23mm long, has a breakdown voltage of 150V and is designed to blow a 200mA fuse within 20mS when a transient voltage in excess of its breakdown voltage appears on the line.

Vitality Ltd, Beetons Way, Bury St Edmunds, Suffolk.

LOW INPUT CURRENT OP AMP

The SSS112 series are precision monolithic operational amplifiers featuring extremely low input offset and bias currents, made possible through use of 'Super β' input transistor circuitry.

This unit from Precision Monolithics Inc. is suitable for battery operated and other low power applications due to the low supply current drain and ability to operate at extremely low supply voltages, while the low offset and input bias current provide excellent performance in high impedance circuits such as long period integrators, sample-and-holds, low frequency active filters, logarithmic amplifiers and with piezoelectric and capacitive transducers.

Features include: Low Offset Current, 200pA max; Low Bias Current, 2nA max; Low Power Consumption, 18mW max. Supply Voltage can be plus or minus 20V. The unit also has internal frequency compensation, compensation overvoltage protection and balanced offset nulling.

Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx.

AUDIO WARNING DEVICE

When lamps are used for warnings they are only useful if the right person happens to be looking the right way at the right time. A range of warning devices based on audible alarm signals is now available. They vary in size and in the volume of the alarm signal.

A.P. Besson Ltd., St. Joseph's Close, Hove, Sussex, BN3 7EZ.

MICROCIRCUIT FOR ELECTRONIC ORGAN

Manufacturers of low cost electronic organs and electronic music enthusiasts can now obtain, in a single microcircuit package, all the circuitry needed to generate from one frequency source a full 12 note chromatic music scale.

The new AY-1-0212 microcircuit, manufactured by General Instrument Microelectronics, significantly reduces the number of components needed in the manufacture of an electronic organ. Today, most mass produced electronic organs employ 12 separate master tone generators, normally manufactured in discrete components, to generate every keyboard note.

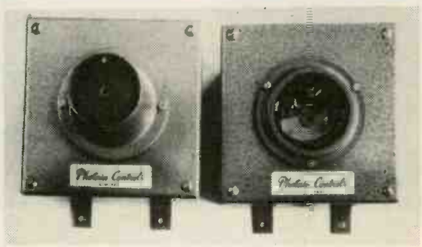
GIM's master tone generator can be used with a quartz crystal oscillator or with a high stability electronic oscillator as the master tone generator. From its 12-note chromatic scale output all other keyboard notes can be generated by simple frequency division using MOS dividers. This means that the entire keyboard can be tuned by a single adjustment to the master oscillator during manufacture and will not drift out of tune with time or temperature.

The cost of the AX-1-0212 is £4 and for a six stage binary divider to interface with the master tone generator (the AY-1-6721/6) the cost is £1.10 (both in 100-up quantities).

General Instrument Microelectronics, 57/61 Mortimer Street, London W1N 7TD.

LONG DISTANCE PHOTOCELL RELAY

This is a new self contained, long distance photocell relay from Photain Controls. The units are contained in weatherproof housings suitable for all outdoor operating conditions and can be used for a wide variety of applications (Conveyor Control, Paper Breakage Alarm, Machine Guard, Automatic Spraying, Automatic Door Opening, Level Control, Height Gauge, Burglar Alarm etc.)



Each set of equipment consists of a Projector Unit and a Receiver Unit. The Projector Unit is complete with its own power supply, low voltage lamp and optical system which provides a concentrated light beam over any distance up to 30 metres. The Receiver Unit has its own power supply, photocell and optical system and is complete with an operational relay with two sets of changeover contacts (5A mains).

If the power supply fails or a component fails then the relay is immediately de-energised, providing a "fail safe" operation.

The price is £30.00 per set plus V.A.T.

Photain Controls Limited, Randalls Road, Leatherhead, Surrey.

METAL CAN BC107/BC108

Despite the enormous shortage of metal can BC107 and BC108 transistors, Gothic Electronic Components announce that they are able to source supplies and maintain deliveries. Buyers experiencing difficulties in obtaining regular supplies of these devices are requested to contact them.

Gothic Electronic Components, Beacon House, Hampton Street, Birmingham 19.

news digest

Continued from page 11.

(Development chemical engineers get £4,303, electrical engineers £4,270 and mechanical engineers £4,221.)

At the bottom two rungs of the professional ladder (for engineers in their first four years of experience) the salaries are: electronic engineers £1,800 & £2,066; chemical engineers £1,808 & £2,175; electrical engineers £2,054 & £2,373; mechanical engineers £1,784 & £2,273.

NEW ELECTRONIC IGNITION

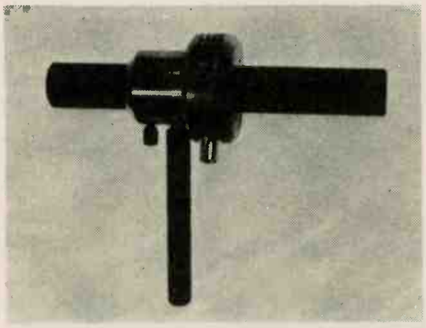
From the makers of Gunton Electronic Ignition, comes a new product called Sparkrite. This highly developed electronic ignition system incorporates a short circuit proof inverter to prevent SCR lock on, improved radio interference suppression filter and

a trigger circuit with a positive feedback clamp circuit from output of the unit, as well as the usual benefits of electronic ignition, which when fitted (can be done in 15 mins) produces a higher energy spark and thereby creates more efficient combustion giving faster acceleration, higher top speed, continual peak performance, reduced fuel consumption, longer spark plug and contact breaker life etc. Designed for all petrol engines, the unit costs £11.55 incl. VAT and carriage and is guaranteed for 5 years, or £9.35 including VAT and carriage in kit form.

For further details on Sparkrite Electronic Ignition contact: Electronics Design Associates, 82, Bath Street, Walsall, WS1 3DE.

TRANSVERSE PHOTON DRAG DETECTOR

Having developed a range of detectors and monitors based on the 'conventional' Photon Drag principle in which the momentum from the photons in the beam of light is transferred to free carriers in a doped crystal, further research has now resulted in the development of a new instrument which takes advantage of the transverse component of the energy transfer and enables a voltage gradient to be measured across the crystal instead of at both ends.



The result of this development permits the manufacture of detectors containing crystals of very large aperture but very short length. The light passes through what looks effectively like a window and creates a voltage gradient across the crystal and this can be fitted to an output socket. In the new Model 7412 Transverse Photon Drag Monitor, attenuation of light passing through the crystal is between 3% and 5% and this permits output measurements to be made from pulsed CO_2 lasers during normal operation. As the faces of the monitor crystal are very flat, virtually no distortion is introduced to the beam and the detector can be said to give little more effect on the laser beam than that of a window. With responsivity of 10mV/MW an aperture of 1" the monitor has a rise time of approximately 1ns, operating at room temperature and will withstand very high peak powers.

INTEGRATED CIRCUITS FOR TELEPHONE COMMUNICATIONS

Plessey Semiconductors have announced a new family of bipolar integrated circuits (designated SL1000 series) primarily designed to enable Post Office contractors to offer a more compact Channel Translation Equipment. However, these devices will also appeal to wider markets and already several other applications have been evaluated within the telephone communication system.

Basically, there are two devices in this new family, which has been developed in co-operation with the British Post Office. The channel amplifier SL1020 is designed to meet requirements of the Post Office for an audio amplifier with a gain which may be varied from a remote point via a single wire. The device is a complex monolithic circuit which has to meet many of the constraints placed upon the translation equipment in which it is used. The modulator/demodulator (SL1001A/B) is designed to require the addition of only three external components to couple into a normal balanced line system.

Both of these devices are applicable to overseas equipment and Plessey Semiconductors expect to see considerable sales into these markets.

The SL1001A/B modulator/demodulator is designed for a minimum external component count when using balanced signal and balanced carrier inputs. Two coupling capacitors and a resistor are sufficient to realise an F.D.M. modulator/demodulator. The integrated circuits exhibit signal and carrier suppressions at the output of typically 40dB without any adjustment, a conversion gain of 1, and a bandwidth up to 1MHz. Noise, weighted in the speech band and with a 600 ohms load is typically -112dBmOp. The package is a 10 lead TO74, and quiescent current is 6mA (SL1001A) or 4mA (SL1001B).

The SL1020 channel amplifier includes a d.c. controlled attenuator. Hence the overall gain of the amplifier may be varied from a remote point. The control system is unaffected by the reactive components of the control wires and by noise and cross talk induced into them. The distance over which the remote control system may be operated is limited only by the d.c. resistance of the control wires and exceeds 320 metres for 0.4mm copper conductor. A typical application of the circuit gives a gain of 26dB variable over a range of 7.4dB, Class A operation up to +13dBm output and non-interactive adjustment of absolute gain, gain range and return loss. Noise into 600 ohms is typically -81dBmOp.

ANTI-SKID CONTROL

The first standard i.c.'s designed specifically for the automotive market have been announced by Fairchild. Both are complex linear circuits developed over the past two years as 'custom' circuits before being added to the standard product line.

Typical applications include the control of anti-skid systems, fuel metering and the generation of either digital or analogue tachometer displays. Both are subsystems that will be used as components of larger automotive electronic systems.

The UA 7350 includes a tachometer pulse generator, an operational amplifier and two comparators on a single chip, in a 16-pin dual-in-line package. The tachometer section produces fixed-width pulses at the zero crossings of a ground-referenced alternating current input signal. This section is a common emitter NPN transistor with an uncommitted collector. The output stages of the op-amp and comparators are Class-A PNP amplifiers with uncommitted collectors. This allows the system to be used with a variety of loads for general applications. It will operate with either single or dual power supplies and includes built-in short circuit protection.

The UA 7350 has a variety of non-automotive applications, including motor speed control, frequency-to-voltage conversion and tone decoding. The on-chip op amp can be used as an integrator to provide a dc output proportional to speed (input frequency) or to amplify digital pulses.

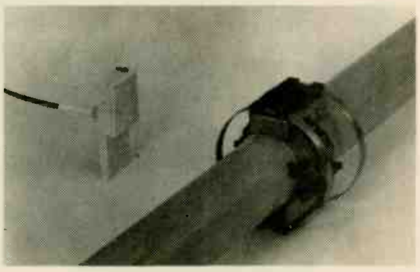
The UA 735I is a triple operational amplifier, a general purpose circuit also specifically designed for automotive operation, with single 4 to 16V or dual 2 to 8V power supplies. The circuit contains three identical op amps on a single circuit chip in a 16-pin DIL package. Each two stage amplifier has a Class-A PNP common emitter output stage with an uncommitted collector, enabling the circuit to be used with a variety of loads. The op amps can be connected in the 'wired-or' mode for logic blocks, such as dual or tri-level comparators. Slew rate is one millivolt a microsecond.

Typical applications for the UA 735I include tri-level sensors, biquad state variable filters (low pass, high pass or band pass), voltage to frequency conversion and peak detection without an external diode.

IMPROVED SHORT RANGE TELEMETRY SYSTEM

An improved version of their general purpose short-range telemetry system is now available from I.E.C. Limited. The modifications result from applications knowledge gained since 1966 when I.E.C. Limited, who pioneered this type of equipment, first introduced the system.

The well proven principle of operation - transferring transducer information from moving components by the use of capacitive transmission and an F.M. pulse carrier has been retained but the transmitter circuit is now housed in a stainless steel casing. Together with its battery supply it is fixed to a shaft (measurements from rotating shafts being the major requirement) using a special clamping bracelet. The bracelet, which is made up from standard transmission chain links interspaced with special carriers and tensioners, combines great strength with easy adjustment over a wide range of shaft sizes. This technique of mounting the transmitter assembly does away with the need for special clamps and is the subject of world wide patents.



Further improvements in the system specifications include a differential operational-amplifier input stage in the transmitter. This permits adjustments of the input characteristics to suit a wide range of transducers and input levels. Typical applications of the equipment include torque and strain measurement in drive shafts and temperature monitoring from rotating kilns and dryers.

BOMB ALERT

When Castle Associates introduced their new Falling Ball Calibrator they did not bargain for the problems recently encountered. Production problems, staff problems, component problems, test problems are normal day to day occurrences for most companies but a product mistaken for a bomb is unusual. This is exactly what happened to Castle on two recent occasions. The PSQ 101A Falling Ball Calibrator is manufactured by Castle Associates for the calibration of their range of sound level meters. It is a mechanical device which operates rather like an egg-timer. When turned upside down 6,000 tiny steel balls fall onto a mica diaphragm creating a fixed random noise of 96 dB which is used as a reference level.

Even in a well designed postal pack the loud noise escapes and has given several postmen quite a shock.

A recent delivery to a well known city insurance company resulted in the bomb squad being called out. As a result all future deliveries to this company have to be by special arrangement...a rather unwelcome additional overhead cost on a unit selling at only £19.

The latest problem was with a large shipment of PSQ 101A's to Boston, U.S.A. Castle Associates' Air Shippers declined to handle the package for fear of a bomb scare at Logan airport, so once again special arrangements had to be made.

If a scared customer receiving a PSQ 101 throws it into water thinking it is a bomb, Castle could well end up with another problem - RUSTY BALLS.

JAPAN'S ELECTRONIC PARTS INDUSTRY

A recent report by the Fuji Bank Bulletin contains a summary of the results of a survey on the present conditions in Japanese industry and the prospects for April-September 1973.

Despite the large upvaluation of the yen in December 1971, Japan's industry made a satisfactory recovery from the 1970 recession in the latter half of 1972.

The comments on the electronic parts industry are as follows:

Present situation and outlook

Production of TV sets and radio receivers will decrease but stronger demand for electronic equipment for industrial use and larger exports will expand production by almost 10%. The low inventories may push unit prices up by 10%-15%.

Exports and imports

Overseas demand is brisk and no significant slowdown in the expansion of exports of parts is expected.

Equipment investment

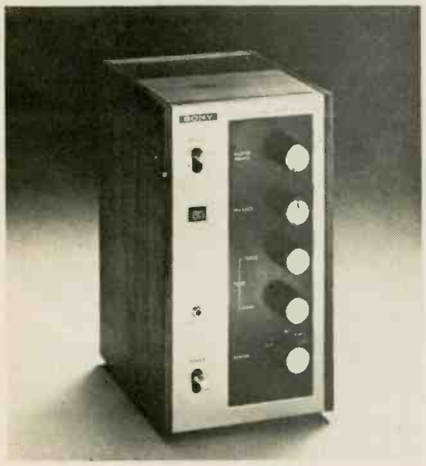
The main emphasis is on investment for strengthening the production of integrated circuits; investment is also large for rationalisation and the installation of labour-saving machinery.

Remarks

The quantitative increase in the production of circuits and semiconductors has lessened the impact of the change to integrated circuits but in 1974, the effects will be rather pronounced. ●

eti AUDIO NEWS

QUADRAPHONIC DECODER/AMPLIFIER



Designed specifically to complement the Sony '8' family, the Sony SQA 100 Decoder/Amplifier is compatible with any Sony system or in fact most amplifiers with a tape/monitor selector switch. The amplifier section is designed to provide the rear speakers of the system with 6W r.m.s. Recommended resale price is £40 plus VAT.

Sony (U.K.) Ltd., Pyrene House, Sunbury Cross, Sunbury-on-Thames, Middx.

PROFESSIONAL TAPE

Users of machines which accept large reels sometimes get trouble from the uneven winding of tapes, causing overlapping and possible consequent damage. We have news of two new tapes with anti-static matt backing a feature which ensures uniform winding to overcome these problems (even when using sideless tape hubs or single-sided spools).

BASF have announced a double play version, DPR 26LH, of this tape, previously available only in long play. Prices start for the double play tape, at £5.60 for a 7in. spool.

EMI's new range is called Emitape 817, and is available in four widths. This tape is low in bias and modulation noise and EMI claim it can be used on multi-track machines without need for any noise reduction system.

BASF U.K. Ltd., P.O. Box 473, 197 Knightsbridge, London SW7 1SA.

EMI Electronics & Industrial Operations, Blyth Road, Hayes, Middlesex.

TUNER AMPLIFIERS

Latest additions to the Eagle range of audio equipment are two new tuner amplifiers, AA.28 and AA.30. Both units are said to be compatible with transcription turntables and cartridges and high quality or monitor type speakers.

AA28

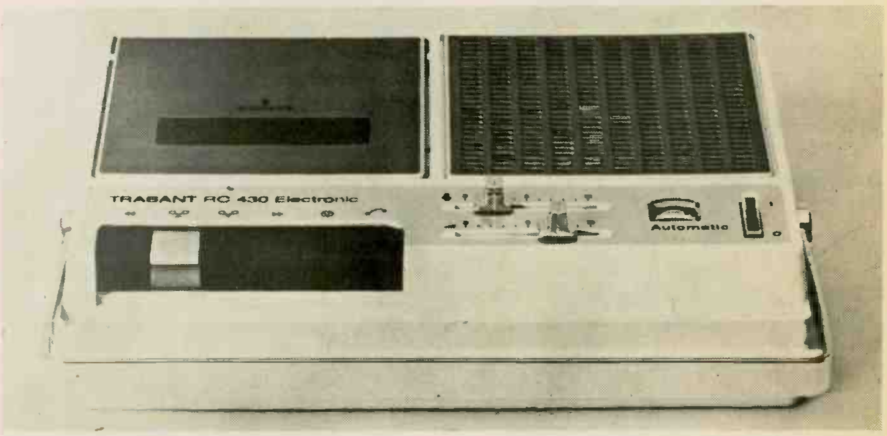
AA 30

Standard features on both amplifiers include main/remote speaker switching, loudness control, and normal bass, treble, volume and balance controls. In addition to these the AA.30 incorporates a Sound Effect Control system.

The tuner section on both units uses a FET front end together with a tuning meter and switching for AFC and interstation muting. Output power is 30W per channel.

Eagle International, Precision Centre, Heather Park Drive, Wembley, Middlesex, HAO 1SU.

RC 430 CASSETTE RECORDER/PLAYER



The new Siemens RC 430 cassette recorder is for recording and playback with C60 or C90 compact cassettes. It includes many advanced technical features; automatic switch-off and automatic volume control guarantee fault-free tape recordings. For manual control the automatic volume control system can be disconnected. A V.U. meter indicates the recording level and can also be used to check battery voltage during playback. The normal functions are controlled by press-buttons. Insertion of the cassette is facilitated by guide bars in the cassette compartment cover.

The reproduction from the loudspeakers is good. There is a 20 cm speaker and a high frequency tweeter, 4 cm in diameter.

The frequency range 80 - 9000Hz and the output is 700 mW.

The recommended retail price is £41.09 (inc. VAT).

Interconti Electronics Ltd., Albany House, Petty France, London, S.W.1.

EQUIPMENT NEWS

MORE CHARGE CURRENT

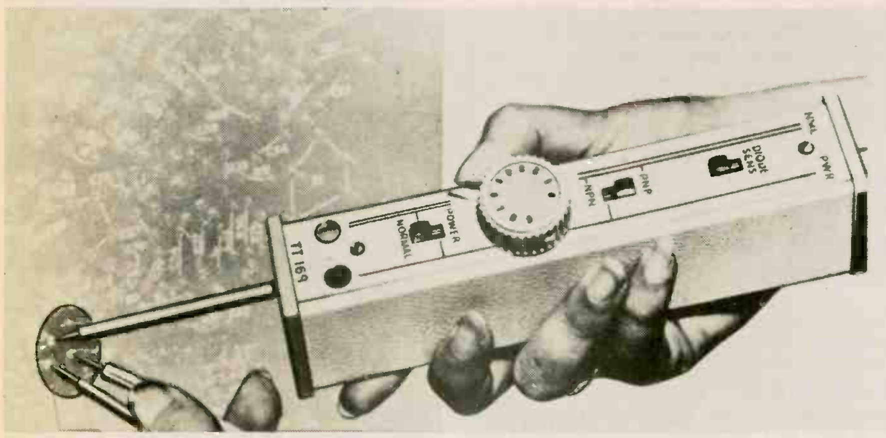
The Electroplan automatic constant current charger now has a maximum charge current of 750mA. The charger provides a transistor regulated constant charge current and is specially designed for rapid re-charging of nickel cadmium batteries and cells.

A 'Set Current' control allows the charge current to be varied up to the 750mA maximum. A 'Set Hours' control gives quick setting of the required charge period. The charger has a useful power output of approximately 17 watts which allows the charging of up to 15 cells in series at the maximum rate of 750mA.

This newly designed charger costs £25.00

Electroplan Limited, PO Box 19, Orchard Road, Royston, Herts SG8 5HH

SIMPLIFIED TRANSISTOR TESTER



The TT169 Transistor Tester offers simple "go/no go" testing of p-n-p and n-p-n signal or power transistors without having to unsolder them from circuit. Good or bad devices are indicated by lights on the front panel working in conjunction with a calibrated control; intermittent illumination giving immediate indication of 'good' devices.

The instrument is hand held, and supplied with insulated colour-coded probes for collector/emitter/base connections. It operates from three internal 1.5V cells, which are sufficient to provide 90 minutes continuous operation. Where bench testing over extended periods is required, an external 4.5V source can be applied.

Diodes and thyristors can also be tested by suitably connecting the probes and watching the lights. Made by AVO Ltd., it is supplied with all necessary leads and connectors in a compact plastic case. Price is £15 plus VAT.

Gothic Electronic Components, Beacon House, Hampton Street, Birmingham 19.

SPECTRUM ANALYZER

Model 8558B, a new 0.1 - 1500MHz Spectrum Analyzer from Hewlett-Packard, comes as a plug-in module for their oscilloscopes. Although simple to operate, the instrument's performance is lab grade, with ±1dB frequency response and greater than 70dB distortion-free dynamic display range.

Ease of operation has been emphasized in the design. For most measurements only three controls need be used; TUNING sets either the centre-frequency or the start-frequency of the display, which is indicated on a 3½ digit LED readout. FREQUENCY SPAN sets the width of the frequency window to be viewed. Span range is 1000MHz to 50kHz. REFERENCE LEVEL (amplitude) directly calibrates the display in absolute power units. The range is -115dBm to +30dBm.

When the FREQUENCY SPAN control is set, the analyzer automatically selects the optimum resolution bandwidth and sweep time. If the operator chooses to override the automatic selections, resolution bandwidths from 1kHz to 3MHz can be chosen. The analyzer also indicates optimum and maximum input level for the chosen amplitude control setting, which minimises the possibility of overloads that could cause erroneous measurements or even equipment damage.

It was interesting to use this equipment to see what radio signals could be picked up by a small aerial. Using just a door key held to the input socket, ETI staff could see at a glance what frequencies were being used by local radio and TV stations. The whole of the LW, MW, SW, VHF and UHF bands were monitored in one picture and then we analysed the bands one by one.

The equipment is beyond the pocket of the amateur, however, at £1,675 (£2,133 with oscilloscope).

Hewlett-Packard Limited, 224 Bath Road, Slough, Bucks. SL1 4DS

EQUIPMENT NEWS

NEW CLAMP AMMETER

Electronic Brokers Limited have introduced a new clamp type ammeter having 6 current ranges plus 2 voltage ranges for use on 50 to 60Hz alternating current supplies. Known as the AMPERTEST 690, the new instrument is manufactured in Italy by Industria Construgioni Ellectro-meccaniche.

The Ampertest 690 uses the familiar clamp or 'pincer' system to measure the current flowing in a conductor without breaking the circuit. The meter, has 6 current ranges from 3 to 600 amps f.s.d. with the first division at 100mA. The current ranges may be extended by use of a 10 to 1 current transformer which is supplied with the instrument providing ranges from 300mA to 60A f.s.d. with the first division at 10mA. In addition there are two a.c. voltage ranges, 250V and 600V f.s.d. The connections for voltage measurements are made by two leads and probes which plug into the base of the instrument.

The Ampertest 690 is supplied with voltage measuring leads and probes and combined twin wire adaptor/current transformer in a solid leather carrying case.

The Ampertest 690 is available at a price of £37.50 complete.
Electronic Brokers Ltd., 49/53 Pancras Road London NW1 2QB

PRINTING CALCULATOR

The Meritronic is the latest addition to the Diehl range of advanced printing calculators, and is designed to fill the need for a robust, reliable office machine for day-in, day-out commercial calculations.

One of the features of the Meritronic is the simple, functional keyboard, equipped with full-size colour-grouped keys. Office machines must be designed to standards that allow the inexperienced operator every facility clearly. Thus the numerics are centrally grouped, and electronically buffered so that it is practically impossible for an operator to

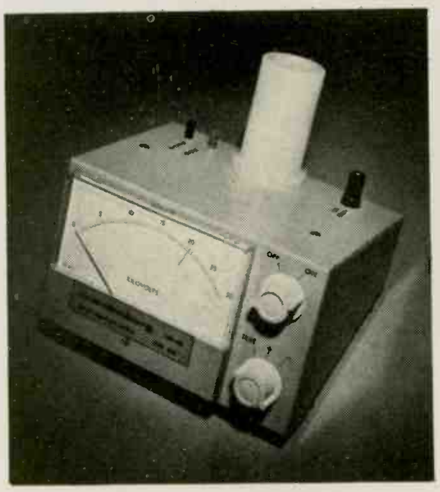
key too fast. The function keys include the four basic rules of arithmetic, and allow chain operations, automatic constants, automatic decimals, and accumulation of products and quotients. A useful feature is the ability to accept a floating decimal input to give a fixed decimal output.

Every keyboard action prints out as it is made, giving a ready check that figures have been correctly entered and the appropriate function performed. Provisional figures can be readily re-checked, or final calculations filed for future reference - of special value to VAT bearing services. Cost is £168 complete.
Calculating Systems Limited, 956 High Road Finchley, London N12.

DIRECT READING 30kV METER

Complementing their range of power supplies this direct reading 30kV d.c. meter designed and developed by Brandenburg Ltd., provides an highly accurate tool for both field or laboratory use.

It is the only one of its type currently available. It is compact and portable and is housed in a lightweight rigid new style case incorporating an easy-to-read 4.5in. scale meter.



Operated by internal 9V battery, linked with a built-in checking facility, the instrument is flashover and transient proof and provides an accuracy of 1% fsd over the complete range of 0-30kV d.c. High input impedance of 30,000MΩ ensures that current drain is negligible at less than 1μA and positive or negative ground is easily selected by a switch mounted in the front panel.

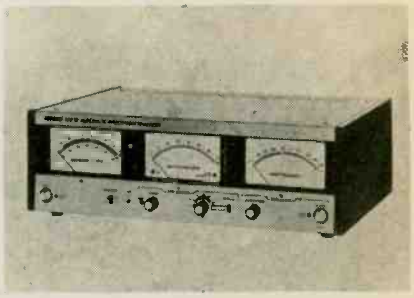
The meter, only 178 x 114 x 127mm is suitable for a temperature range of 5-35°C and has a battery life of 800 hours.

AUTOMATIC DISTORTION ANALYZER

Radiometer A/S of Copenhagen have just announced a new fully automatic programmable Distortion Analyser, known as the Model BKF 10. This instrument can be connected to any signal source and will instantly and automatically indicate its frequency and the percentage distortion without balancing or any further adjustment. Furthermore the BKF 10 has a built-in low distortion sweep generator and an amplitude input/output response ratio meter, the combination of which can be used to obtain complete and fully automatic frequency response and distortion analysis of amplifiers, tape recorders and similar Low Frequency equipment.

A voltage proportional to the logarithm of the frequency is available as a recorder output and can be used as the X input for X-Y recordings.

The fundamental frequency range is from 20Hz to 20kHz and the harmonics range from 10Hz to 150kHz. For distortion measurement the fundamental frequency is automatically



suppressed by a band-stop filter circuit but an automatic level control circuit enables either the fundamental input or the output from the apparatus under test to be held constant and thus it is possible to measure distortion as a function of frequency at a constant output power. The signal-to-noise ratio can be automatically shown on the meter by merely pressing a front panel button, and if the signal should include a high hum content, this can either be suppressed or measured by using the high-pass or low-pass filters which are built-in the instrument. The distortion range of the BKF 10 is from 0.02% to 10% and the accuracy ± 1dB.

Radiometer A/S market their equipment in the UK through *International Instruments Ltd., Cross Lances Road, Hounslow, Middx.*

SYNTHESIZED SIGNAL GENERATOR

The Farnell Modular Signal Generator range has now been extended to include synthesized versions of two existing AM/FM signal generators, M1/ACM and M2/ACM, which cover the frequency ranges 100KHz to 12MHz and 10MHz to 108MHz respectively.

In the new systems the frequency is controlled by a six decade bank of thumbwheel switches with an accuracy of ±5PPM and a resolution of 1KHz.

Although the oscillator module uses several frequency bands to cover the range, the digital control selects the correct range automatically so that the only adjustment necessary is to set the thumbwheel switches to the required frequency. The correct range is automatically selected and a search lamp extinguishes to indicate that the correct frequency has been reached.
Farnell Instruments Limited, Sandbeck Way, Wetherby LS22 4DH, Yorkshire.

AUDIO WATTMETER

Continued from page 51

Some further checks can be made as follows:—
Set S2 to 0.5W range and S1 to 15 ohms. With the audio generator at 2.73V output the power level meter should read 0.5W. Now set S1 to 8 ohms and the audio generator to 2.0V in which case the power level meter should again read 0.5W.

Providing all the pre-sets have been adjusted as already described the calibration for different power levels and for the three load ranges of 4, 8 and 15 ohms can be checked simply by coupling known audio signals into the meter circuit via the 'METER' terminal on the front panel and common E. The load link must be disconnected. The tables provide a number of spot checks for various power levels and for each of the three load values.

It will be seen that the tables have been worked out from $V=\sqrt{P_0 x R}$ to three decimal places. In practice, meter readings to this accuracy are almost impossible but if readings to one decimal place only can be achieved, then providing everything else has been adjusted to the same degree, the audio wattmeter will be accurate enough for all practical purposes. The interior of the finished prototype is shown in the photograph.

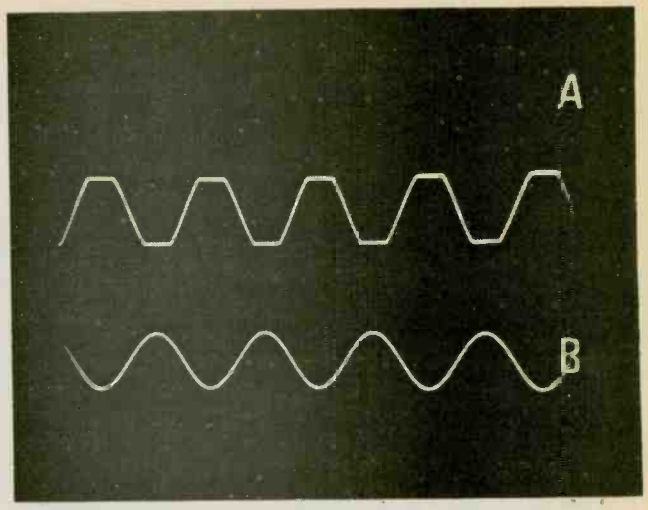
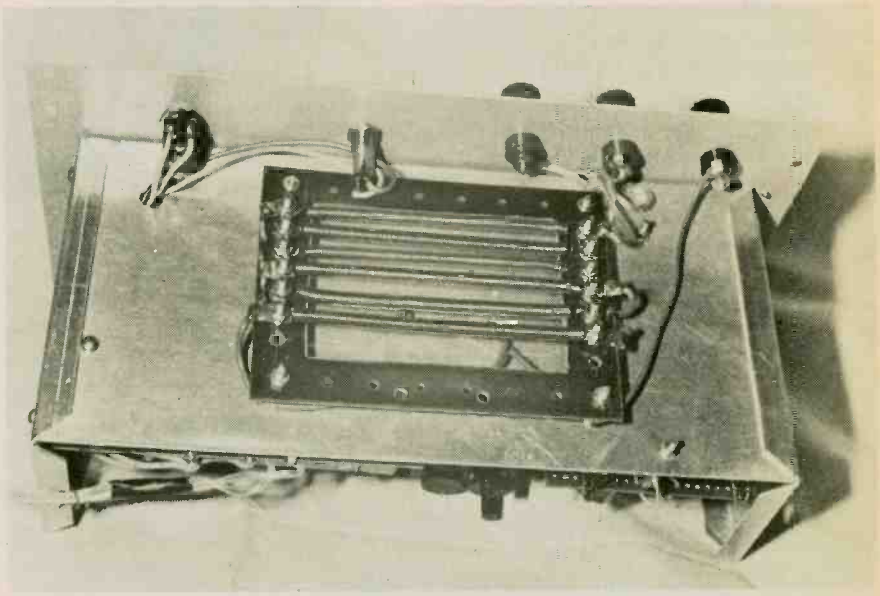


Fig. 13. A) Clipped output B) Sine wave at maximum power, just before clipping.



The dummy load resistors mounted under the chassis.

IN OPERATION

The prototype was finally checked against laboratory standard instruments and found to have a high degree of accuracy. The loads of 4, 8 and 15 ohms were chosen because these are more or less standard. The load ranges and even the power ranges could be extended with additional attenuators and correction networks. In operation the load resistors will run warm at high power levels but these should not be sustained for longer than is necessary to take a reading. The loads have no inductive effects and the material used for them was chosen because it is readily available and fairly cheap. High wattage load resistors of precise values are difficult to obtain and the one or two firms who do manufacture them were not prepared to supply other than *bona-fide* trade users. In any case they were very expensive.

When a meter of this nature is used it is essential to know when the maximum output of an amplifier has been reached, i.e. at the point just before clipping occurs. It is for this reason that an oscilloscope monitoring point has been included to check the waveform across the load. Maximum power output must always be checked with an oscilloscope monitor and the usual procedure is to set the amplifier gain control at maximum and then bring up the input signal (sine wave) to the point at which clipping occurs as on the upper trace in Fig. 13a. The input signal is then reduced until clipping just ceases and the amplifier output signal resolves into a sine-wave as in the lower trace Fig. 13b. Even at lower power levels, i.e. well below maximum power output,a check should always be made on the amplifier output waveform as clipping can occur at amplifier input stages if the input signal is too high. *Do not connect the power meter to an amplifier unless the load link is connected between the 'METER' terminal and the "LOAD" terminal.* This link may be a piece of wire or a thin plate with slots to fit under the terminals as shown in Fig. 3b. Finally please note that the decibel scale is for power dB related to 10 $Log_{10}P2/P1$. ●

DX MONITOR

Compiled by Alan Thompson

No reader of this feature will need me to point out that the days of summer are past for another year, and that in just a few weeks we shall be huddling together at the bus-stop or on the station (why, oh why, are they *always* located in the windiest spots in the region?) sheltering from the icy blasts — or else, joy of joys, turning the starter of the car for the umpteenth time when we know darn well that the so-and-so battery is as flat as the proverbial pancake. There's no problem in recognising the DXer amongst the winter-battlers: he's the one with an inner warmth and a smug, complacent smile! DXers, of course, are somewhat schizophrenic about the seasons; as others long for the warm summer days, so DXers long for those endless winter nights when the DX is coming in thick and fast, there's a healthy (?) fug in the shack and there's always the chance of another new country going into the logbook. Truly, DXers are something of a strange breed of men (and women, because there are a few YLs in the fraternity too) and their ways must seem rather strange to the rest of the world!

The approaching winter gives promise of being one of the more absorbing for DXing for quite a few years. Currently we are on the downward side of Sunspot Cycle No. 20 which means that the number of sunspots is getting steadily less and less and the minimum ought to be reached about 1975. Fewer sunspots means less atmospheric noise and that means that there will be a better chance of hearing some of the weak stations that the real DXer is always searching for. However, there are a few minuses in all this — firstly, it is likely that the signal strength of stations will, generally, be lower than it has been whilst the sunspot cycle was nearer the maximum; next, there will certainly be added congestion in the international broadcast bands between 49 and 19 metres as numerous stations are forced by propagational factors to give up transmitting in the 16, 13 and 11 metre bands and will be forced to look for some clear spot in the already over-crowded lower frequency bands; lastly, there has certainly been a great increase in the amount of man-made interference since the last time we were at this point in a sunspot cycle (11 years ago) and that isn't going to make hearing the rarer stuff any easier!

Whenever one goes into print, or on the air, on any subject, there is always a quiet little man lurking somewhere who is going to read what you have said and who will then carefully demolish your arguments just because he is THE authority on that subject. So, my dear Sir, please don't take issue with my statement that winter is *the* time for hearing Australasia and the Pacific Islands — I *do* know that it is (just) possible to hear some of them at other times of the year when propagation windows are open for brief periods, but explaining the whys and wherefores of those openings is rather beyond the scope of "DX Monitor". Right - if Australasia and the Pacific Islands are the targets for your DXing this winter, a good place to start will be with **Radio New Zealand.** RNZ is never the easiest of catches in the U.K. since it uses transmitters of only 7.5W and non-directional aerial arrays (for most of the time). Best reception is usually noted in the 31 metre band around 0800-0930 GMT and once you've heard the very distinctive interval signal of the New Zealand Bell Bird you'll be surprised just how often you'll hear it on other channels throughout the years ahead. As this is being written, precise details of RNZ's winter sked are not to hand, but it is a fair bet that either 9520 or 9540kHz will be the 31-metre band frequency used.

Another nice Pacific catch is ORTF's station in Tahiti: the channel that usually gives the best reception in the U.K. is 15170kHz, where ORTF uses a 20kW transmitter and it is frequently a really good signal at sign-on at 0300 GMT, although a couple of times a week it begins at 0230 GMT with educational broadcasts. At that time of day, the language used is Tahitian changing into French at 0500 if the signal is still audible, as it often is. One that has not been reported over here for a few years is Noumea, in **New Caledonia**: the frequency for this 20kW transmitter is 7170kHz where it is on the air from 2200 until 0600 GMT each day.

Radio Australia's Overseas Service is one of the easiest long-haul DX stations to hear with its characteristic *Waltzing Matilda* interval signal at the start of each transmission. If you want to try for this part of the world in a more difficult way, why not try 4920kHz where ABC's Domestic Service station in **Brisbane** often puts in remarkable strength signals around 0800-0900 GMT on a cold winter's morning. Radio Australia, too, operates a number of stations in **Papua and New Guinea** with most of these Domestic Services being of low-power in the 90 metre band: a couple of outlets worth a try are 3925 and 4890kHz where you stand a fair chance of making your catch either at 2000 GMT sign-on (not on Saturday evening UK time!) or just before sign-off which comes shortly after 1400 - with irregular later operation on Saturday afternoons our time when it may be heard carrying sports features. The transmitters are located at **Port Moresby**, by the way.

Moving over towards the Far East, **Laos** is a country that many DXers find difficulty in logging - best channel to try is 6130kHz where the Domestic Service outlet is often quite fair until sign-off at 1430 GMT. One of the more difficult countries in this general area of the world is **Burma** with Rangoon transmitting two Home Services on 5040 and 4725kHz until around 1500 GMT: even when you have managed to log this one your problems are not over if you are a QSL collector — QSL's from the Burma Broadcasting Service are anything but easy to get. My own was the result of some dozen reports and something like another dozen follow-ups before the required card was added to the collection.

Last station to be mentioned in this round-up of some of the goodies that should be available through the winter is **Azad Kashmir Radio**, the official voice of the Pakistani-controlled portion of Kashmir. This station operates on a somewhat irregular schedule signing-off around 1800 to 1900 GMT at the end of it's day's programmes, with a once-heard, never-forgotten, vocal 'anthem' in which the words *"Azad Kashmir"* are repeated over and over again. Frequencies, too, are somewhat variable but a favourite outlet is around 4730kHz, and in the 90 metre band it can often be heard on or about 3390kHz. Recently, QSL's have started to come from this station after years in which it refused to answer any reports and I was delighted to obtain the very first in the world for this station - the address is simply Azad Kashmir Radio, Muzzafarabad, Azad Kashmir, Pakistan.

A few general words on DXing the Far East may not be out of place. The stations mentioned above should all be audible at some time between now and the beginning of March but it is very unlikely that all will be heard on any particular day. Especially

DX MONITOR

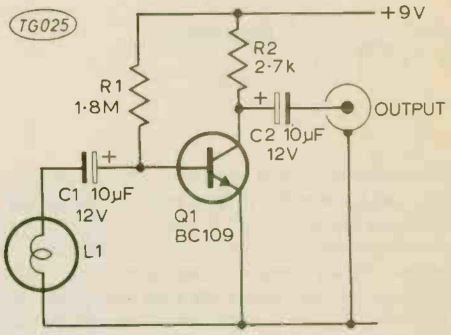
on the lower frequencies, afternoon reception will normally not start until the days are very much shortened, and the peak period for reception of stations like ABC Port Moresby and Laos in the afternoon 'slot' therefore tends to be between the end of October and mid-February. Similarly, ABC Brisbane isn't likely to appear on the 60 metre band until the same part of the year. However, it is worth keeping a sharp look-out for these stations as they may well show up at times when they are not normally to be expected.

Far Eastern languages are not easy for European ears to comprehend since many of them are of the 'tonal' variety. If one is interested in getting to grips with them, a lot of progress can be made by tuning to either the B.B.C. or the Voice of America's services to the Far East, as both these broadcasts start their transmissions with an English announcement that "the following programme is in Chinese" (or whatever). However, reporting isn't too difficult since the vast majority of stations will accept English reports, although French is to be preferred in the case of both Laos and Cambodia.

I hope that this short introduction to some of the delights of Far Eastern and Australasian DXing will have fired some of our readers with a wish to get in on the band wagon. If anyone has any questions I shall be very glad to do what I can to assist and you can write direct to me at 16, Ena Avenue, Neath, Glamorgan SA11 3AD: if you want a personal reply I am afraid that a self-addressed, stamped envelope is a must. If you feel that there are any aspects of DXing that you would like to see given the treatment in this feature I shall be very pleased to hear what they are and I shall try and include them in future articles in this series. "Feedback" letters should, if possible, reach me by about the 10th of the month for inclusion in this page. Until we meet again in a month's time, all good wishes for a very successful autumn and winter of DXing — I'm just off to bring my list of wanted countries up-to-date and I'm hoping to add a few more to the list of those I've heard before 1974 arrives. My fingers are crossed!

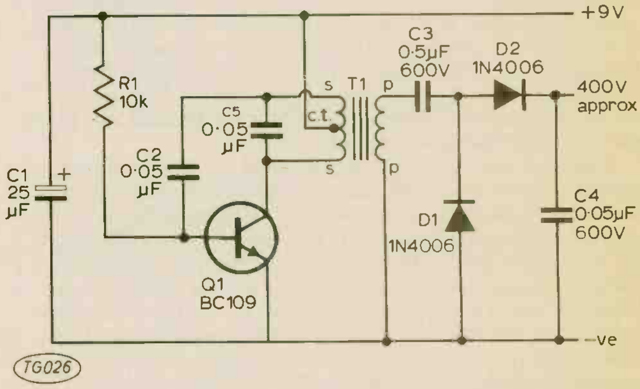
eti TECH-TIPS

RECORDING PICKUP



It is often inconvenient to interfere with a circuit to take an audio tap off for recording etc. However by using a telephone pickup coil and placing this near the coil of almost any loudspeaker, excellent quality may be obtained with no direct electrical connection. The varying magnetic flux in the loudspeaker is induced directly into the coil. As the output may be low for some uses the very simple amplifier shown in the circuit will raise the level. This may not work well with some TV sets due to high frame pulses from the transformer which may cause a low frequency buzz though this depends on the proximity to the loudspeaker.

HIGH VOLTAGE FROM A BATTERY



It is a simple matter to obtain up to 400V from the smallest 9V battery using the circuit shown. The transformer is widely available — it is a 250V to 9-0-9V (or similar) type. The 9-0-9V connections are connected to the transistors in a Hartley oscillator configuration. The 250V connection is taken to a voltage doubler which will give about 400V, albeit at very high impedance and is not all that dangerous. The secondary voltage can be varied by inserting a potentiometer (5k) in the supply line.

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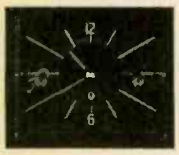

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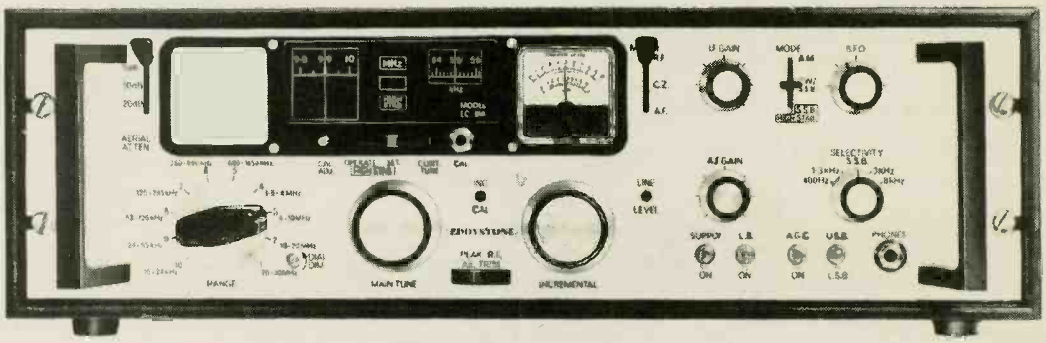

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ELECTRONICS TOMORROW

Continued from page 72

drawing, rephotographed, etc. Not much saving, you might comment, except that the drawing stage is the most time consuming and expensive part of the system. The cost of getting one prototype board say 3 x 4in containing 60 components or 10 TTL ICs is about £80, board £3, photographic charges £3, ancillaries £4 (each twice allowing for one set of corrections) design and layout £45, corrections to design and layout £15. These figures as a matter of interest were based roughly on the board produced for the clock in the September issue, a simpler or rougher board may be a lot cheaper. The point is that a large proportion of the cost is in something which the average amateur could tackle himself with the right equipment.

The equipment required is drawing film and 0.1 inch graph paper from a drawing or art show, layout tapes (1x size for contact exposure), photosensitive boards (positive sensitivity, the developer will wash off the clear areas of the original and leave the black areas), developer, Ferric Chloride etchant, drill.

Layout tapes – Mecanorma Electronic (press on tapes).

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Positive-20 from Electrovalue.

Ferric Chloride – Electrovalue or some chemists.

Drill – Mini Drill and bits from Model Shops.

Ideally you will also require an ultra-violet lamp for exposure. The Kodak chemicals cost about £15 but these will do hundreds of boards. Positive-20 costs 50p and covers about 10 boards, a good range of tapes will cost another £15. Your first board will cost you about £80 but the boards after the first will cost less than 10p each and you end up with artwork suitable for small production runs. The boards produced may not be up to professional standards but they will be better than etch-resist pen or paint boards and more customised than matrix type breadboards.

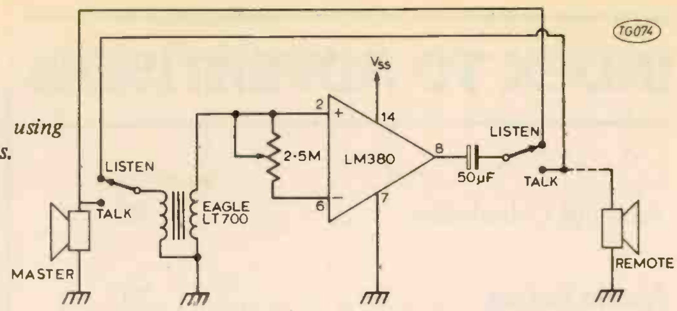

Fig.2b. An intercom using only seven components.

REFERENCES

1 Bi-Pak Components, P.O. Box 5, Ware, Herts.
2 National Semiconductors, The Precinct, Broxbourne, Herts.
3 Bywood Electronics, 181 Ebberns Road, Hemel Hempstead, Herts. 0442-62757
4 Mecanorma Electronics, 49-51 Central Street, London EC1. 01- 253 1102
5 Electrovalue Ltd., 28 St. Judes Road, Englefield Green, Egham, Surrey. Egham 3603.
6 Kodak Ltd., Resists Dept., Swallowdale Lane, Hemel Hempstead, Herts.

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