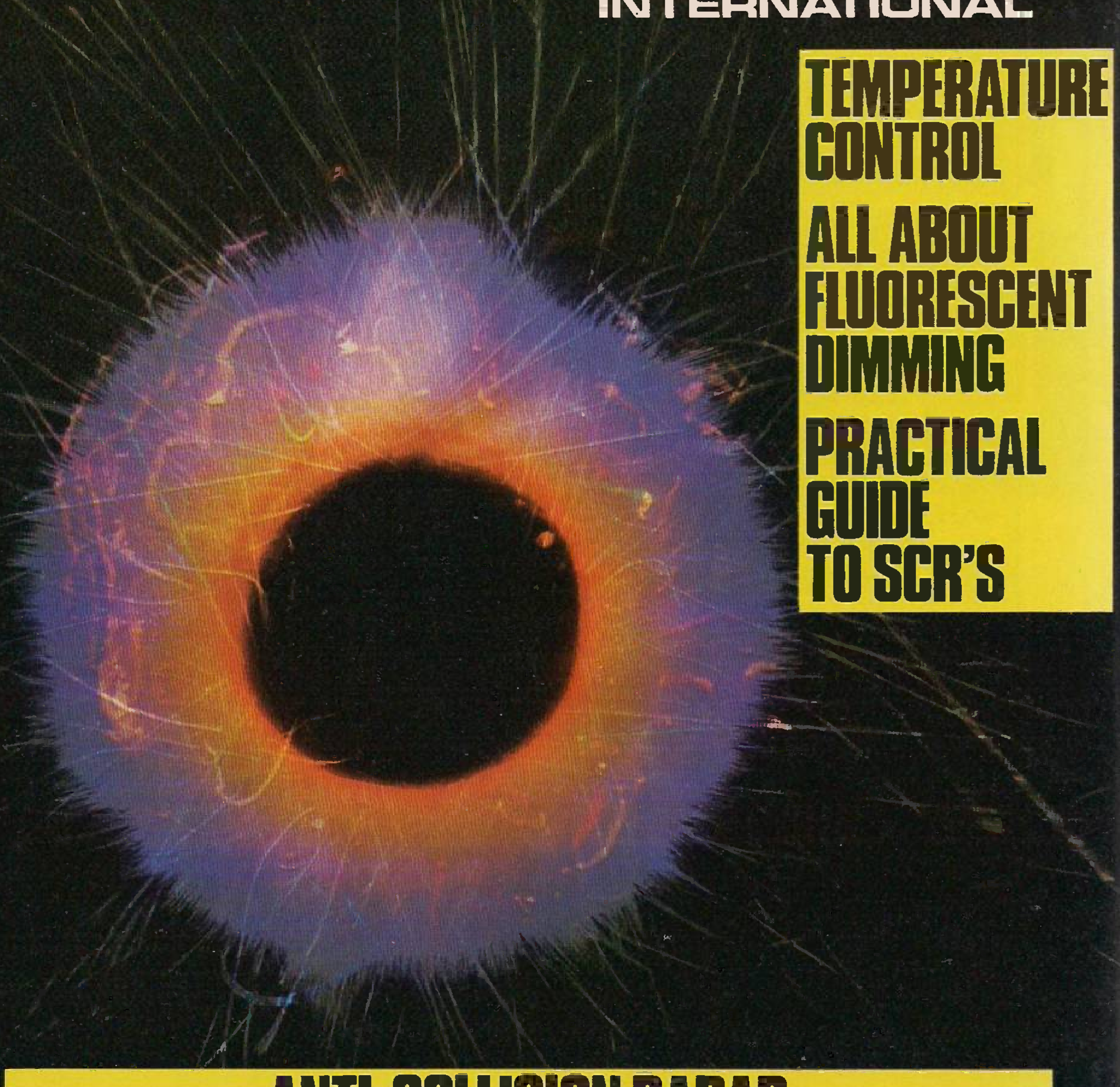
BRITAIN'S DYNAMIC MONTHLY

electronics TODAY INTERNATIONAL

NOVEMBER 1972 20p



TEMPERATURE CONTROL

ALL ABOUT FLUORESCENT DIMMING

PRACTICAL GUIDE TO SCR'S

ANTI-COLLISION RADAR

BRAND NEW GUARANTEED | **LARGEST SELECTION OF SEMICONDUCTORS COMPONENTS** | **RETURN OF POST SERVICE**

TRANSISTORS

2G301	0·15
2G302	0·15
2G303	0·25
2G306	0·30
2G309	0·30
2G371	0·15
2G374	0·15
2G381	0·25
2N404	0·23
2N696	0·15
2N697	0·15
2N698	0·25
2N706	0·10
2N708	0·13
2N709	0·38
2N718	0·21
2N914	0·15
2N916	0·17
2N918	0·30
2N929	0·14
2N930	0·14
2N1090	0·30
2N1091	0·32
2N1131	0·20
2N1132	0·20
2N1184	1·27
2N1302	0·16
2N1303	0·16
2N1304	0·20
2N1305	0·20
2N1306	0·22
2N1307	0·22
2N1308	0·25
2N1309	0·25
2N1507	0·30
2N1613	0·20
2N1631	0·38
2N1637	0·36
2N1638	0·32
2N1711	0·17
2N1893	0·34
2N2147	0·70
2N2148	0·60
2N2193	0·58
2N2193A	0·61
2N2194A	0·30
2N2219	0·20
2N2220	0·20
2N2221	0·20
2N2222	0·20
2N2222A	0·32
2N2368	0·11
2N2369	0·12
2N2369A	0·17
2N2046	0·45
2N2711	0·12
2N2712	0·12
2N2713	0·17
2N2714	0·17
2N2904	0·18
2N2904A	0·23
2N2905	0·26
2N2905A	0·23
2N2906	0·18
2N2906A	0·23
2N2907	0·18
2N2923	0·12
2N2924	0·12
2N2925	0·12
2N2926	
Green	0·10
Yellow	0·10
Orange	0·10
2N3053	0·15
2N3054	0·47
2N3055	0·60
2N3390	0·20
2N3391	0·20
2N3391A	0·22
2N3392	0·13
2N3393	0·12
2N3394	0·12
2N3402	0·17
2N3403	0·19
2N3404	0·24
2N3405	0·27
2N3414	0·10
2N3415	0·10
2N3416	0·15
2N3417	0·21
2N3570	1·25
2N3572	0·97
2N3702	0·11
2N3703	0·10
2N3704	0·11
2N3705	0·10
2N3706	0·90
2N3707	0·11
2N3708	0·70
2N3709	0·90
2N3710	0·90
2N3711	0·90
2N3715	1·28
2N3716	1·30
2N3791	2·06
2N3819	0·26
2N3823	0·62

2N3854	0·16
2N3854A	0·16
2N3855	0·16
2N3855A	0·16
2N3856	0·16
2N3856A	0·16
2N3858	0·16
2N3858A	0·16
2N3859	0·16
2N3859A	0·16
2N3860	0·16
2N3866	0·70
2N3877	0·25
2N3877A	0·26
2N3900	0·20
2N3900A	0·21
2N3901	0·32
2N3903	0·22
2N3904	0·22
2N3905	0·21
2N3906	0·22
2N4058	0·12
2N4059	0·90
2N4060	0·11
2N4061	0·11
2N4062	0·11
2N4303	0·32
2N5172	0·09
2N5174	0·22
2N5175	0·26
2N5176	0·32
2N5245	0·43
2N5459	0·33
3N128	0·63
3N140	0·76
3N141	0·69
3N142	0·54
3N143	0·64
3N152	0·79
40050	0·50
40251	0·53
40309	0·26
40310	0·37
40360	0·35
40361	0·37
40362	0·40
40406	0·40
40407	0·31
40408	0·41
40410	0·53
40467A	0·57
40468A	0·35
AC107	0·35
AC126	0·20
AC127	0·20
AC128	0·20
AC154	0·20
AC176	0·16
ACY17	0·25
ACY18	0·15
ACY19	0·20
ACY20	0·20
ACY21	0·18
ACY22	0·13
ACY28	0·18
ACY40	0·17
ACY41	0·17
AD140	0·55
AD149V	1·23
AD150	0·55
AD161	0·33
AD162	0·36
AD161 } PR AD162 }	0·60
AF106	0·24
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·20
AF118	0·50
AF124	0·24
AF125	0·20
AF126	0·20
AF127	0·20
AF139	0·33
AF178	0·55
AF179	0·65
AF180	0·50
AF211	0·55
AF239	0·36
AF279	0·47
AF280	0·47
ASY26	0·25
ASY27	0·30
ASY28	0·25
ASY29	0·30
ASY50	0·20
ASY55	0·35
ASZ21	0·55
AU103	1·25
BC107	0·12

BC108	0·11
BC109	0·12
BC113	0·18
BC115	0·15
BC116	0·15
BC116A	0·18
BC118	0·11
BC121	0·20
BC125	0·15
BC126	0·20
BC140	0·30
BC147	0·10
BC148	0·09
BC149	0·11
BC157	0·09
BC158	0·10
BC159	0·10
BC160	0·11
BC167B	0·11
BC168B	0·10
BC168C	0·10
BC169B	0·11
BC169C	0·11
BC170	0·11
BC171	0·13
BC172	0·11
BC182	0·10
BC183	0·09
BC184	0·11
BC212L	0·12
BCY30	0·35
BCY31	0·40
BCY32	0·60
BCY33	0·30
BCY34	0·35
BCY38	0·40
BCY39	0·80
BCY40	0·50
BCY42	0·15
BCY43	0·15
BCY58	0·18
BCY59	0·19
BCY70	0·17
BCY71	0·22
BCY72	0·13
BCZ10	0·35
BCZ11	0·50
BD116	0·75
BD121	0·75
BD123	0·82
BD124	0·60
BD131	0·75
BD132	0·75
BDY10	1·25
BDY11	1·50
BDY17	1·50
BDY18	1·75
BDY19	1·97
BDY20	1·00
BDY38	0·65
BDY60	0·90
BDY61	0·85
BDY62	0·75
BF115	0·25
BF117	0·43
BF163	0·20
BF166	0·35
BF167	0·18
BF173	0·19
BF177	0·25
BF178	0·31
BF179	0·38
BF180	0·35
BF181	0·34
BF184	0·17
BF185	0·17
BF194	0·14
BF195	0·15
BF196	0·15
BF197	0·15
BF198	0·18
BF200	0·40
BF224J	0·14
BF255J	0·19
BF237	0·22
BF238	0·22
BF244	0·16
BFX13	0·23
BFX29	0·25
BFX30	0·25
BFX44	0·33
BFX68	0·30
BFX84	0·24
BFX85	0·29
BFX86	0·24
BFX87	0·27
BFX88	0·25
BFX89	0·45
BFY10	0·35
BFY11	0·45
BFY17	0·90
BFY18	0·85
BFY19	0·35
BFY20	0·50
BFY29	0·40
BFY41	0·43
BFY43	0·65

BFY50	0·16
BFY51	0·16
BFY52	0·16
BFY53	0·15
BFY56	0·34
BFY75	0·40
BFY76	0·22
BFY77	0·24
BFY90	0·55
BFY39	0·38
BSX19	0·13
BSX20	0·14
BSX21	0·20
BSX26	0·34
BSX27	0·34
BSX28	0·25
BSX60	0·54
BSX61	0·42
BSX76	0·15
BSX77	0·20
BSX78	0·25
BSW70	0·28
BSY24	0·20
BSY25	0·20
BSY26	0·20
BSY27	0·15
BSY28	0·15
BSY38	0·15
BSY39	0·15
BSV51	0·25
BSY52	0·25
BSY53	0·25
BSY54	0·30
BSY56	0·79
BSY78	0·40
BSY79	0·40
BSY790	0·45
BSY95A	0·09
C111	0·53
C424	0·15
C425	0·36
C426	0·25
C428	0·25
GET113	0·25
GET114	0·20
GET119	0·35
GET120	0·40
GET873	0·15
GET880	0·35
GET887	0·20
GET890	0·35
MJ400	0·78
MJ420	0·86
MJ421	0·88
MJ430	0·75
MJ440	0·71
MJ480	0·75
MJ481	0·85
MJ490	0·94
MJ491	1·10
MJE340	0·47
MJE520	0·59
MPF102	0·25
MPF103	0·33
MPF104	0·33
MPF105	0·33
NKT124	0·42
NKT125	0·40
NKT126	0·38
NKT128	0·48
NKT135	0·26
NKT137	0·32
NKT210	0·25
NKT211	0·25
NKT212	0·25
NKT213	0·25
NKT214	0·15
NKT215	0·21
NKT216	0·46
NKT217	0·50
NKT219	0·25
NKT223	0·17
NKT224	0·25
NKT225	0·21
NKT229	0·29
NKT237	0·31
NKT238	0·18
NKT240	0·19
NKT241	0·20
NKT242	0·15
NKT243	0·63
NKT244	0·17
NKT245	0·18
NKT261	0·21
NKT262	0·19
NKT264	0·21
NKT271	0·18
NKT272	0·18
NKT274	0·18
NKT275	0·23
NKT401	0·70
NKT402	0·76
NKT403	0·65
NKT404	0·61
NKT405	0·80
NKT406	0·63
NKT603F	0·30

NKT613F	0·30
NKT674F	0·24
NKT677F	0·22
NKT713	0·30
NKT717	0·44
NKT781	0·20
NKT10419	0·20
NKT10439	0·27
NKT10519	0·23
NKT20329	0·32
NKT20339	0·36
NKT80111	0·67
NKT80112	0·84
NKT80113	1·00
NKT80211	0·75
NKT80212	0·75
NKT80213	0·75
NKT80214	0·75
NKT80215	0·75
NKT80216	0·75
OC20	0·85
OC22	0·50
OC23	0·50
OC24	0·60
OC25	0·50
OC26	0·25
OC28	0·65
OC29	0·60
OC35	0·50
OC36	0·65
OC41	0·30
OC42	0·35
OC44	0·15
OC45	0·12
OC46	0·27
OC70	0·12
OC71	0·12
OC72	0·12
OC74	0·25
OC75	0·22
OC76	0·22
OC77	0·40
OC81	0·20
OC81D	0·20
OC82D	0·25
OC83	0·20
OC84	0·20
OC139	0·25
OC140	0·30
OC170	0·25
OC171	0·30
OC200	0·40
OC201	0·65
OC202	0·65
OC203	0·42
OC204	0·42
OC205	0·85
P346A	0·18
TIP29A	0·49
TIP30A	0·58
TIP31A	0·62
TIP32A	0·74
TIP33A	1·01
TIP34A	1·51
TIP35A	2·90
TIP36A	3·70
TIS34	0·50
TIS43	0·21
TIS44	0·07
TIS45	0·10
TIS46	0·11
TIS47	0·11
TIS48	0·11
TIS49	0·11
TIS50	0·17
TIS51	0·11
TIS52	0·18
TIS53	0·23

Post & Packing 13p per order. Europe 25p. Commonwealth (Air) 65p (MIN.)
Matching charge (audio transistors only) 15p extra per pair.
Prices subject to alteration without prior notice.

TTL. LOGIC I.C. NEW PRICES

	1–11 £p	12–24 £p		1–11 £p	12–24 £p		1–11 £p	12–24 £p
SN7400	0·20	0·18	SN7433	0·80	0·75	SN7472	0·32	0·30
SN7401	0·20	0·18	SN7437	0·64	0·06	SN7473	0·43	0·41
SN7402	0·20	0·18	SN7438	0·64	0·60	SN7474	0·43	0·41
SN7403	0·20	0·18	SN7440	0·23	0·21	SN7475	0·45	0·44
SN7405	0·20	0·18	SN7441AN	0·87	0·83	SN7476	0·45	0·44
SN7406	0·80	0·75	SN7442	0·85	0·81	SN7480	0·70	0·65
SN7407	0·80	0·75	SN7443	2·86	2·70	SN7481	1·40	1·38
SN7408	0·20	0·18	SN7444	2·86	2·70	SN7482	0·87	0·82
SN7409	0·20	0·18	SN7445	2·50	2·40	SN7483	0·87	0·82
SN7410	0·20	0·18	SN7446	1·00	0·95	SN7484	2·00	1·85
SN7411	0·23	0·21	SN7447	1·00	0·95	SN7485	3·62	3·40
SN7412	0·48	0·46	SN7448	1·00	0·95	SN7486	0·33	0·30
SN7413	0·40	0·38	SN7449	1·00	0·95	SN7490	0·87	0·84
SN7420	0·20	0·18	SN7450	0·20	0·18	SN7491AN	1·21	1·10
SN7423	0·51	0·47	SN7451	0·20	0·18	SN7492	0·87	0·84
SN7427	0·48	0·45	SN7453	0·20	0·18	SN7493	0·87	0·84
SN7428	0·80	0·75	SN7454	0·20	0·18	SN7494	0·87	0·84
SN7430	0·23	0·15	SN7460	0·20	0·18	SN7495	0·87	0·84
SN7432	0·48	0·42	SN7470	0·40	0·38	SN7496	0·87	0·84

SUB-MIN ELECTROLYTIC

range axial lead 6p each
Values: (μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·2/63; 4/10; 4/40; 6·4/6·4; 6·4/25; 10/16; 10/64; 16/40; 20/16; 20/64; 25/6·4; 25/25; 32/10; 32/40; 32/64; 40/16; 50/6·4; 50/25; 50/40; 64/10; 80/16; 80/25; 100/6·4; 125/10; 125/16; 320/6·4.

SILICON RECTIFIERS

PIV	50	100	200	400	600	800	1000	1200
1A	8p	9p	10p	11p	12p	15p	20p	—
3A	15p	17p	20p	22p	25p	27p	30p	35p
6A	—	—	25p	30p	32½p	35p	—	—
10A	30p	35p	40p	47p	58p	66p	75p	—
15A	36p	45p	48p	55p	65p	75p	87p	—
35A	70p	80p	90p	£1·00	£1·40	£1·70	£2·75	—

1 amp and 3 amp are plastic encapsulation.

DIODES & RECTIFIERS

IN34A	10p	AA119	7p	BAX16	12½p	FST3/4	22½p
IN914	7p	AA129	15p	BAY18	17½p	OA5	17p
IN916	7p	AAZ13	12p	BAY31	7p	OA10	20p
IN4007	20p	AAZ15	12p	BAY38	25p	OA9	10p
IS44	7p	AAZ17	10p	BY100	15p	OA47	8p
IS113	15p	BA100	15p	BY103	22p	OA70	7p
IS120	12p	BA102	25p	BY122	47½p	OA73	10p
IS121	14p	BA110	25p	BY124	15p	OA79	7p
IS130	8p	BA114	15p	BY126	15p	OA81	8p
IS131	10p	BA115	7p	BY127	17p	OA85	10p
IS132	12p	BA141	17p	BY164	57p	OA90	7p
IS920	7p	BA142	17p	BYX10	22p	OA91	7p
IS922	8p	BA144	12p	BYZ10	35p	OA95	7p
IS923	12p	BA145	17p	BYZ11	32p	OA200	7p
IS940	5p	BA154	12p	BYZ12	30p	OA202	10p
		BAX13	5p	BYZ13	25p	TIV307	50p

"SCORPIO" CAP DISCHARGE IGNITION SYSTEM
(As printed in P.E. Nov. '71). Complete kit £10·00
P. & P. 50p.

BRIDGE RECTIFIERS

A.	PIV		A.	PIV	
1	100	37p	4	50	60p
1.4	140	57p	4	100	70p
2	50	32p	4	400	80p
2	200	41p	6	50	62p
2	400	46p	6	200	80p
			6	400	£1·10

THYRISTORS (SCR)

PIV	50	100	200	300	400
1A	25p	27½p	37½p	40p	47½p
4A	40p	45p	55p	—	60p
7A	82p	87p	92p	—	£1·12p

TIC47 0.6 amp. 200 PIV 55p.
Also 12 amp. 100 PIV 75p
2N3525 at 85p

VEROBOARD

	0·15 Matrix	0·1 Matrix
2½ × 3¾in	17p	23p
2½ × 5in	23p	26p
3¾ × 3¾in	25p	25p
3¾ × 5in	30p	29p
5 × 17in (Plain)	83p	—

Vero Pins (Bag of 36) 20p
Vero Cutter 43p
Pin Insertion Tools (·1 and ·15 matrix) at 55p.

OPTOELECTRONICS
MINITRON 3015F SEVEN SEGMENT INDICATOR £2·00
TIL 209 LIGHT EMITTING DIODE (RED) 35p.
B9900 PHOTORESISTOR 38p

RESISTORS

Carbon Film
¼ watt 5%, 1p. ⅛W, 1W & 2W E24 Series.
½ watt 5%, 1p.
⅛ watt 5%, 1½p.
⅛ w 2% M/O 4p.
1 watt 10%, 2½p. ¼W & ½W E12 Series.
2 watt 10%, 6p.

MULLARD C280 M/FOIL CAPACITORS

0·01, 0·022, 0·033, 0·047	3p each
0·068, 0·10	4p each
0.15, 0·22, 0·33	5p each
0·47	9p
0·68	11p
1μF	14p
1·5μF	21p
2·2μF	25p

WIRE-WOUND RESISTORS

2·5 watt 5% (up to 270 ohms only). 7p
5 watts 5% (up to 8·2kΩ only). 9p
10 watt 5% (up to 25kΩ only). 10p

POTENTIOMETERS

Carbon:
Log. and Lin., less switch, 16p.
Log. and Lin., with switch, 25p.
Wire-wound Pots (3W). 38p.
Twin Ganged Stereo Pots. Log. and Lin., 40p.

PRESETS (CARBON)

0·1 Watt 6p VERTICAL
0·2 Watt 6p OR
0·3 Watt 7½p HORIZONTAL

THERMISTORS

R53 (STC) £1·20 VA3705 95p
K151 (1k) 12p VA1077 20p
Mullard Thermistors also in stock. Please enquire.

Tel. 01-452 0161/2/3 Telex 21492

A. MARSHALL & SON
28 CRICKLEWOOD BROADWAY, LONDON, N.W.2

CALLERS WELCOME
HRS. 9–5.30 MON.-FRI. 9–5.0 SAT.
(82A)

electronics TODAY INTERNATIONAL

NOVEMBER Vol. 1 No 8

main features

product tests

projects

reviews

news & information

mini-features

COVER: An electronically contrived photo of a fast-moving object entitled 'Nova-2', created by Wennrich and Mead for Fairchild's 'World of Electronics' series

DECEMBER ISSUE ON SALE 17 NOVEMBER 1972

EDITORIAL & ADVERTISEMENT OFFICES
107 Fleet Street, London EC4.
Phone: 01-353 1040

Published by WHITEHALL PRESS LTD.,
29 Palace Street, London SW1.
Phone: 01-834 0423/4

Printed in England by: Alabaster Passmore & Sons Ltd, London & Maidstone.

INTERNATIONAL ASSOCIATES:
Modern Magazines (Holdings) Ltd.,
21-23 Bathurst Street, Sydney 2000.
Phones: 26-2296, 22-6129

A.C.P., Room 401, 1501 Broadway,
New York, USA.

Mr Genzo Uchida, Bancho Media Service,
15 Sanyeicho, Shinjuku-Ku, Tokyo, JAPAN.

Distributed by: Argus Press Ltd.

Subscription rates per year: Home, £3.60. Overseas, £4.00.

Sinclair Project 60

Z.50 & Z.30
Power Amplifiers

Z.50 40 watts RMS into 3 ohms using 40V. 30 watts into 8 ohms using 50V. Distortion 0.02% into 8 ohms.
RRP £5.48

Z.30

Z.30 20 watts RMS into 3 ohms using 30V. 15 watts into 8 ohms 35V. Distortion 0.02% into 8 ohms.
RRP £4.48

Stereo 60

Pre-amp and Control Unit. Accepts Mag and Ceramic P.U.'s. Press button input selection. Tone, balance, vol. controls. Brushed aluminium front.
RRP £9.98

Project 60 Stereo FM Tuner

With unique phase lock loop tuning principle. Squelch and AFC facilities. Fantastic audio quality. IC Decoder.
RRP £25

Power Supply Units

PZ.5 *30 volts unstabilised* **£4.98**
PZ.6 *35 volts stabilised* **£7.98**
PZ.8 *45 volts stabilised (less mains transformer)* **£7.98**
PZ.8 *mains transformer* **£5.98**

Guarantee

If, within 3 months of purchasing any product direct from Sinclair Radionics Ltd., you are dissatisfied with it, your money will be refunded at once. Many Sinclair appointed Stockists also offer this same guarantee in co-operation with Sinclair Radionics Ltd.

sinclair

Please send
I enclose cash/cheque/money order.

Name

Address

E.T.11

Sinclair Radionics Ltd, London Road, St. Ives, Huntingdonshire PE17 4HJ. Tel: St. Ives 64311

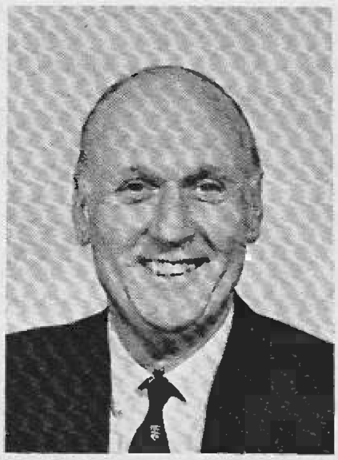
Project 60 offers more advantage to the constructor and user of high fidelity equipment than any other system in the world.
Performance characteristics are so good they hold their own with any other available system irrespective of price or size.
Project 60 modules are more versatile – using them you can have anything from a simple record player or car radio amplifier to a sophisticated and powerful stereo tuner-amplifier. Either power amplifier can be used in a wide variety of applications as well as high fidelity. The Stereo 60 pre-amplifier control unit may also be used with any other power amplifier system as can the AFU filter unit. The stereo FM tuner operates on the unique phase lock loop principle to provide the best ever standards of audio quality. Project 60 modules are very easily connected together by following the 48 page manual supplied free with Project 60 equipment. The modules are great space savers too and are sold individually boxed in distinctive white and black cartons. With all these wonderful advantages, there remains the most attractive of all – price. When you choose Project 60 you know you are going to get the best high fidelity in the world, yet thanks to Sinclair's vast manufacturing resources (the largest in Europe) prices are fantastically low and everything you buy is covered by the famous Sinclair guarantee of reliability and satisfaction.

Typical Project 60 applications

System	The Units to use	together with	Units cost
Simple battery record player	Z.30	Crystal P.U., 12V battery volume control, etc.	£4.48
Mains powered record player	Z.30, PZ.5	Crystal or ceramic P.U. volume control etc.	£9.45
12 W. RMS continuous sine wave stereo amp. for average needs	2 x Z.30s, Stereo 60, PZ.5	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	£23.90
25 W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers	2 x Z.30s, Stereo 60, PZ.6	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	£26.90
80 W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60 W. RMS into 8 ohms)	2 x Z.50s, Stereo 60 PZ.8, mains transformer	As above	£34.88
Indoor P.A.	Z.50, PZ.8, mains transformer	Mic., guitar, speakers, etc., controls	£19.43

F.M. Stereo Tuner (£25) & A.F.U. Filter Unit (£5.98) may be added as required.

(83A)



Sid Gladwin
Production Manager

the rule of the game

HOW an 'Establishment' – be it research, development, engineering, administrative, political or what have you – chooses one out of many courses of action for a specific situation has been a mystery to all of us. Prof Parkinson's, and our own Edsel Murphy's Laws and Dr Laurance Peter's Principle do no more than state the obvious. No one has so far spelt out the Rule for decision-making in an organisation. We believe we have a world scoop here.

The Rule of the Game is the RIS factor. It works like this: LINs (Logical Importance Numbers) are allotted to the various choices; their reciprocals are then squared and the largest resulting number represents the decision to be taken.

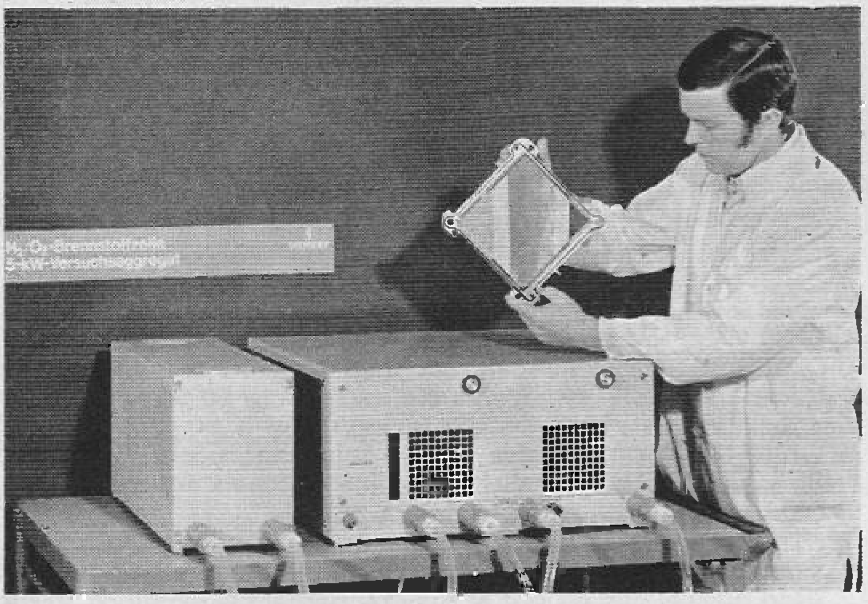
To illustrate: In terms of striking stand-out against an off-white background, LINs for red, blue and yellow are (say) 8, 5 and 2. Reciprocal Importance Squared are then 0.015, 0.04 and 0.025 – hence yellow is chosen.

This – and this alone – can explain Establishment's considered decisions in such spheres as equipment design (oft-used presets can be got at only by partial dismantling), component supply (a manufacturer's own 'direct replacement' for a discontinued line is just too large and has different pin connections) and even in every-day life (a newly laid road soon dug up to lay electric/phone cables or gas/water pipes; crash barriers at roundabouts obscuring road signs).

Take the new colour code for electric cables. 'Earth' is green-yellow because nowhere on earth is the soil any colour except a shade of brown; 'Live' is brown since this is the deadest and truly earthy colour; 'Neutral' is blue since this is, except for green, the most all-pervading colour, in the sky and the ocean, even in the most arid green-less countries.

news digest

FUEL CELLS



At Siemens it is the general opinion that fuel cells will be more widely used commercially, despite the fact that other firms have now ceased to work in this field. Prime considerations are applications such as solitary operation independent of supply systems and emergency power supply in cases where technical and economical reasons or reasons connected with the environment preclude existing solutions.

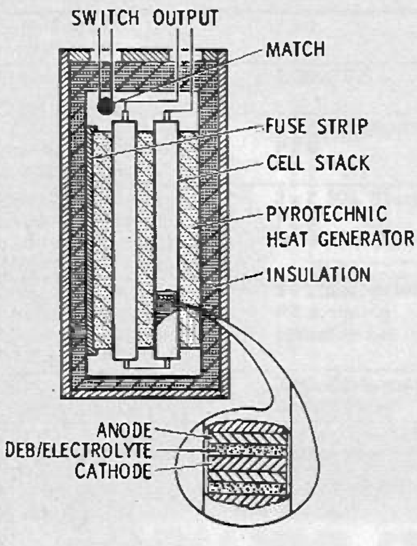
As an example of recent progress, Siemens have developed a compact fuel cell battery with a continuous rating of 5kW at 80V and a current density of 250 mA/cm^2 of electrode surface. The output can be raised to 8kW for a few minutes. The battery consists of two units of fifty fuel cells each and weighs 90kg. The alkaline electrolyte temperature is about 80^{o}C.

The design next envisaged is a weight per unit output of 8.5kg/kW and a volume per unit output of 6000 cm^3/kW, ie half the weight for the same output.

If such batteries are to be employed on a large scale it will be necessary to use cheap liquid primary fuels. Siemens propose to produce the necessary hydrogen from primary fuels, with reforming units or crackers, and to apply new principles to obtain a more compact design for these units. It intends to abandon the use of oxygen cylinders and to extract the oxygen required for the fuel cells from the atmosphere. **(159)**

THERMAL BATTERY

A 1½-ounce battery that will yield 1000V at low current for up to 50 seconds has been invented at Sandia Laboratories. It replaces a 500V battery that measures 6.6 cubic inches and weighs a half pound. Thermal batteries, used in systems where high voltage would be needed only once, after a period of storage, are 'one-shot' devices actuated by a small heat-producing (pyrotechnic) charge. When the heat melts the electrolyte in a series of cells, the electrolyte becomes conductive and the battery produces electricity via an electrochemical reaction.



In previous designs, heat-generating material was included as part of each cell or pair of cells. This presented several problems — the pyrotechnic material would occupy a large portion of the battery volume; its closeness to the electrolyte would sometimes overheat the cells and cause them to malfunction; and there was difficulty in igniting each pyrotechnic element at the same time.

The new design has a radically new configuration with the cells placed in electrically insulating, thermally conducting beryllium oxide tubes. A pyrotechnic material such as iron-potassium perchlorate, located in bulk form outside the tubes, permits a large number of cells per unit area, and protects them from thermal shock. Each cell, typically 0.020" thick and 1/8" in diameter, consists of a depolarizer-electrolyte-binder (DEB) pellet sandwiched between a calcium anode and an iron cathode. The electrolyte is a eutectic lithium chloride mixture; a typical binder is finely divided silica.

In the prototype, an electrical signal ignites — in this order — an electrical 'match', a fuse strip, and the pyrotechnic heat generating material. The 84 cell stack provides two 3mA 500V outputs of 50 seconds duration, from a package measuring less than a cubic inch and weighing less than 0.9 pound. **(160)**

LACATE

Determining the effects of high-flying aircraft — including supersonic transports — on the earth's weather patterns is one aim of a meteorological experiment being planned at Honywell's Aerospace Division here under a $682,000 contract from the NASA Langley Research Centre, Hampton, Virginia. Called the Lower Atmospheric Compositon And Temperature Experiment (LACATE), this is one of about 30 advanced application flight experiments being funded by NASA. The experiment uses an infrared radiometer to look at the earth's atmospheric porfile, or 'limb'. Temperature, ozone, water vapour and various trace constituents, including nitrous oxide, nitric acid, nitrogen dioxide, methane and aerosols, will be measured.

Meteorologists are said to be particularly interested in the experiment because it will provide them with accurate measurements of these atmospheric constituents at the altitudes of 7 to 16 miles where supersonic and other high-flying aircraft will operate. Establishing accurate records in the next few years of ozone, water vapour and other stratospheric constituents, should give scientists a basis for determining any changes caused by increased high-altitude air traffic.

Some scientists have said the aircraft could dump enough water vapour and nitrogen oxides — by-products of jet engine combustion — into the atmosphere to reduce its concentration of ozone, a form of oxygen which filters out the sun's potentially harmful ultraviolet rays. There is also concern that jet exhaust pollutants may tend to build up faster in the upper atmosphere. At lower altitudes, natural turbulence tends to disperse particulate matter before it reaches harmful concentration.

Key element of the experiment is a nine-band infrared radiometer that will be designed to scan the earth's limb to a height of about 62 miles, and across an open area of about 240 square miles from a given position. Carried aloft by a weather satellite like Nimbus, the radiometer could make global measurements of atmospheric constituents. **(156)**

PCB PROTOTYPE SERVICE

Protronic 24 have now brought into operation an entirely new production line geared to the ultra-high speed manufacture of through-hole plated boards.

This new facility is said to enable making a batch of PCBs in as little as five working days from receipt of finished artwork, depending on the quantity involved, allowing customers to build prototype and pre-production equipment quicker than ever before.

The advantage of through hole plating is that it gives perfect electrical continuity between the surfaces of a double-sided board, so that in effect both sides become one circuit. It also gives a much more solid connection when a lead is soldered in. The result is greater freedom for the circuit designer and a more reliable end product.

(157)

BR TRAIN PA SYSTEM

The ENTEL 378 passenger address equipment has already been in operation for some time on inter-city trains of British Rail's Eastern Region, and is now being installed on those of the London Midland Region running between Euston, Manchester, Liverpool and Wolverhampton. Automatic transmission of pre-recorded announcements is made to passengers via loudspeakers in the coaches, from a central transmitting point located in the guards van. Provision is also made for emergency announcements to be made by the Guard from a handset fitted to the transmitting amplifier.

Transmission is at voice frequency and the equipment uses the lighting control wires as the transmission path. In this way, the need for special circuits is avoided and, as the lighting control system is essentially the same on all BR loco-hauled passenger rolling stock, continuity of the transmission path is maintained even when a non-standard coach — not fitted with passenger address — is introduced into the train.

(154)

COLOUR ROMA

The current state of indecision in Italy over which TV colour system to use has, we understand, given rise to certain new definitions to the PAL system originally developed by Germany, the

(Continued on page 8)

news digest

(Continued from page 7)

SECAM system by the French to counter America's NTSC (related to PAL):
NTSC: Never The Same Colour
PAL: Pray And Learn
SECAM: Supreme Effort contre les Americains.

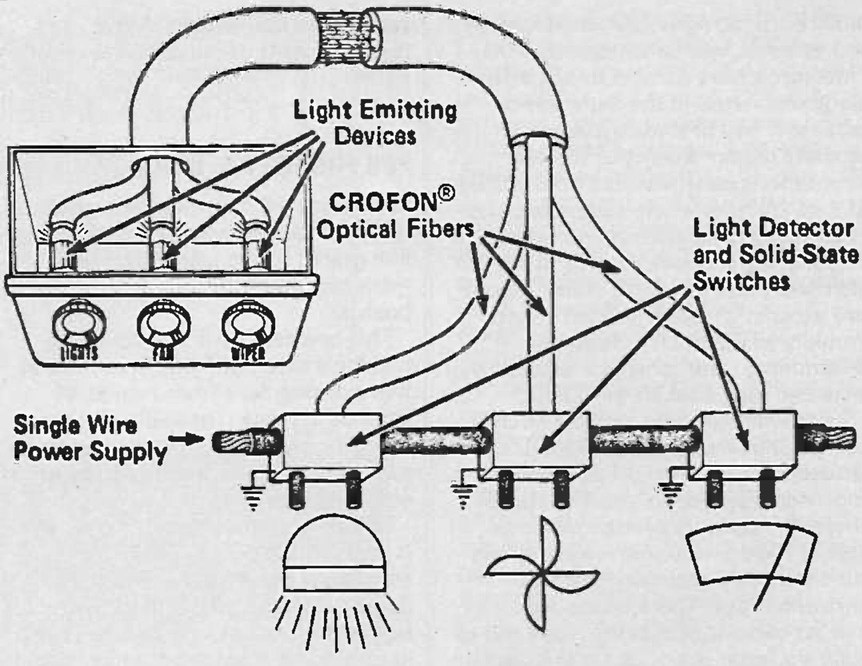
MORE LIBRARY AUTOMATION

36 NCR thermal printer communication terminals have been installed in the Ohio State University library to make 2½ million books more accessible to students. The terminals are linked on line to the university's computer system, from the main library and 22 departmental libraries. Students with enquiries or requests for books contact one of the library's information desks. An attendant then interrogates the computer through the terminal. If the book is available, the attendant enters instructions for the book to be sent to the student or to arrange collection. If it is not available the student can be placed on a waiting list.

Information on books returned is also entered into the computer, thus ensuring that an up-to-date register of all available books is always and immediately available. Programming of the computer allows enquiries to be entered by author, title, number or reader identification. This system is said to have significantly reduced enquiry times — the terminal will print out from the computer at 300 words-per-minute — while the compact size and very low noise level enable the terminals to be located in the library itself without disturbing library users. **(147)**

FIBRE OPTICS

'Crofon' IRX, an optical fibre with improved infra-red transmission properties, particularly at the 9000 Angstom level, is a light transmitting fibre capable of carrying beams at levels required to operate electronic switching devices. This was demonstrated recently by a working model of an automobile dashboard from which Crofon light guides carried electro-optic signals to control several electrical functions. On pressing the horn-button, for example, a light-emitting device sends an infra-red



signal to a receiver at the other end which re-converts the signal to an electrical signal to operate the horn. Flipping a switch causes a second LED to send out a different signal to turn on the headlights. In the illustration, headlight, fan and wind-screen wipers are used as examples. However, such a bundle of fibres can activate every electrical function in the car from tiny LEDs located at the control points. By varying the wave-length of the signal, one cable of fibres can control many operations in the car, either consecutively or simultaneously. Du Pont in USA are now manufacturing pilot quantities of the new material. **(161)**

Zn-AIR BATTERIES FOR MoD

Energy Conversion Limited have been awarded a £120,000 contract by the Ministry of Defence to develop a zinc-air primary battery suitable for the Clansman range of man-portable military communication radios.

Known as METAIR model ZBD1, this battery consists of standard D size cylindrical zinc air cells connected together to provide the required voltage, and contained in a suitable case with interface for the three radios for which it has been designed: the UK/PRC 351 adn UK/PRC 352 sets developed by the British Communications Corporation.

Already in commercial use, zinc air batteries are high power, high capacity power sources, which provide a very stable voltage throughout the discharge period. Characteristics which make METAIR batteries particularly suitable for military applications are their extremely light weight per unit of capacity, and good performance down to -30°C and below. They are ideally suited for use in forward areas, or when charging facilities are not readily available or the tactical situation precludes the use of such charging facilities.

Several other military applications for zinc air batteries are being explored by the Company — for example, their ZBD2 primary battery (24V 2 amp continuous current) is suitable for use with ground surveillance radars and night observation devices. **(158)**

PRESSURE TRANSDUCER

Components which are designed for use in food preparation containers and pipe lines must meet certain stringent requirements in addition to achieving normal high engineering standards regarding accuracy and reliability. Materials employed must not themselves introduce any form of contamination, nor must they absorb or trap minute particles of food which would subsequently decompose.

The SB 19/F transducer employs a stainless steel diaphragm and fits flush with the inside surfaces of the container so that it will not trap or absorb food particles. The stainless steel is type EN58J(316) recommended for use in food processing. Designed for 10 volt ac or dc operation, it is said to have a non-linearity of less than 0.3% with a hysteresis of less than 0.15% over the full rated range.

NO COMMENT

Quote from the General Secretary of the Amalgamated Holeborers' Union: "We will not rest until every man jack of industrial workers is paid more than the average in the industry".

ROBOT FOR SPACE SHUTTLE

A Honeywell electronic 'robot' will govern the throttle of NASA's Space Shuttle orbiter when the reusable manned vehicle begins in 1979 to carry satellites and other payloads into space.

Unlike conventional space engines, which operate either at full power or off, the three main engines of the shuttle will be controllable for variable thrust at launch. The thrust required will be regulated by a digital processor.

Rocketdyne, prime engine contractor to the National Aeronautics and Space Administration, has awarded a contract to Honeywell to design and build the engine control system. For this, the HDC-601 digital computer has been selected as the system's central processor, to be built by the firm's aerospace division under terms of a subcontract expected to total as much as $9 million over the next seven years.

According to Honeywell, the HDC-601 fits NASA's criteria of high reliability, low weight, low power consumption, and real-time processing. It weighs 14 lb, has a one-microsecond memory cycle time, operates on 60 watts of power and features a plated wire nondestructive readout (NDRO) memory. **(151)**

LASER STICK FOR THE BLIND

A stick specially designed for blind persons gives the bearer a loud sonic signal in the event of impediment in his path at wrist height or above. The new device was commissioned by the Swedish Institute forthe Handicapped and work on the project was initially financed by the Swedish Board for Technical Development (STU). The prototype stick comprises a 1.3-metre-long tube made of glassfibre-reinforced plastic. To it is attached a gallium-arsenide laser, a midget transmitter and receiver, and an amplifier. The power source is a tiny nickel-cadium accumulator. The laser beam's trajectory is almost at right-angles to the stick's length, and as such sticks are normally held forward at an angle of about 45 degrees to the ground, the beam is directed both upward and forward. The laser sends about 1000 pulses per second and when one of these meets an object — such as a lorry, car or a road sign — it is reflected back to the stick, where it is electronically transformed into a sonic warning signal to alert the bearer.

The power of the laser beam is small enough to rule out any danger to passers-by. The prototype stick weighs about 0.60 kg or about three times as much as a conventional blind man's stick. Its weight will be reduced still further in the event of its being put into production. **(148)**

DIGITAL TV

An important development in the evolution of digital techniques for processing and transmitting TV signals has been revealed by EMI. In an experimental system, the analog processing normally used in the TV camera video chain is replaced by a digital equivalent. Digital techniques offer the benefit of reduced noise and distortion and improved stability and the use of a digital video signal at every stage from the camera head amplifier to the transmitter should ensure almost error-free signal handling throughout. **(155)**

METAL ANALYSIS IN SITU

ICI Agricultural Division has devised a simple method whereby the analysis of metals used in the construction of chemical plant can be determined 'in situ'. This has been achieved by analysing the spark spectrum, generated by an arc struck on the metal, in a 'Metascop' portable spectroscope and recording it on a modified 'Polaroid' instant picture camera, which develops black and white prints within 30 seconds.

This technique was evolved because of the need to check the construction materials of complex modern chemical plants both at the construction stage and in production. By using this equipment, which can be operated in places difficult of access, the need to dismantle structures is minimised. The wide sensitivity and speed of the 'Polaroid' film make it possible to detect elements which have very sensitive spectral lines in the ultra-violet region, in particular niobium, an important stabilising agent for welding. Silicon, aluminium and lead spectral lines also show up well.

This system of on-site inspection is invaluable wherever the performance of metals is critical in terms of safety or economy, or both. In fact, as it is easy to identify most low alloy steels, high alloy steels, nickel-based alloys and various copper- and aluminium-based alloys, the method, now employed by ICI, could be of great importance in many fields of engineering. **(150)**

FLUORESCENT LAMP DIMMING

When electricity supplanted oil and gas lighting, it brought with it hitherto unavailable levels of illumination. But something was lost, and that was control of brightness. The development of solid-state power controls has once again made brightness control possible, and many people use dimmers to control incandescent globes. Contrary to general belief, fluorescent tubes can also be dimmed — this article tells how.

IN RECENT years the development of solid state devices such as the silicon controlled rectifier (SCR), and more recently the Triac, has made practicable the development of compact, light and inexpensive equipment for dimming both incandescent and fluorescent lamps.

Incandescent lamps are fairly easy to dim and a few simple circuits were shown in the article entitled 'A Practical Guide to Triacs' in the May 1972 issue of ELECTRONICS TODAY INTERNATIONAL.

This present article explains how fluorescent lamps can be dimmed — and our constructional project on page 42 of this issue describes the construction of a dimmer that is suitable for both incandescent *and* fluorescent lighting, (some commercially made light dimmers *can* be used to dim fluorescent lights but far better results will be obtained by using a circuit specifically designed for this purpose).

Apart from the correct choice of dimmer, it is essential that the correct type of fluorescent lamp and auxiliary control equipment is used.

Two types of lamp are generally available nowadays. These are commonly known as "quick-start" and "rapid start". The main difference between the two is the filament voltage. This is 8.0 volts and 3.5 volts respectively.

The 'quick-start lamp' is now going out of fashion, and almost all lamps sold today are 'rapid-start'. Any new dimming installation should be planned around the 'rapid-start' type.

STARTING CIRCUITS

Figs. 1a and 1b show the two most commonly used fluorescent lamp circuits. Figure 1a shows the 'Switch-start' circuit. This is the type most commonly found in existing domestic installations. It is used because it is simple and cheap.

The second circuit (Fig. 1b) shows the 'Starterless' system. This is used in commercial installations because it has several operating advantages that offset the higher initial cost.

The fluorescent lamp is basically a mercury discharge lamp in which short wavelength ultra-violet radiation produced by the discharge, is converted to visible light by a phosphor coating on the inner walls of the tube.

Like most other gas discharge devices, fluorescent tubes have a negative resistance characteristic; that is, unless the current is limited by some means, the lamp will draw all the current available until either the lamp or the supply source fails.

A resistor could, of course, be used to limit this current, but this would result in excessive power losses. Hence an inductance is used, because at least in theory, this will limit the current without in itself dissipating any power. In practice some power is wasted due to copper and iron losses.

In the 'Switch-start' circuit, a thermal starter switch closes for a short time when power is first applied. This allows ac power to heat the filaments. When the switch opens, the ballast choke gives an inductive 'kick' and the lamp starts. This is a brute force method. Each start strips emissive material from the cathodes,

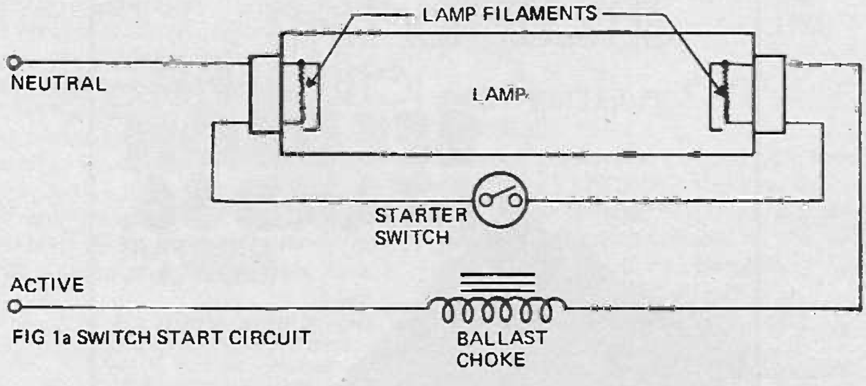


FIG 1a SWITCH START CIRCUIT

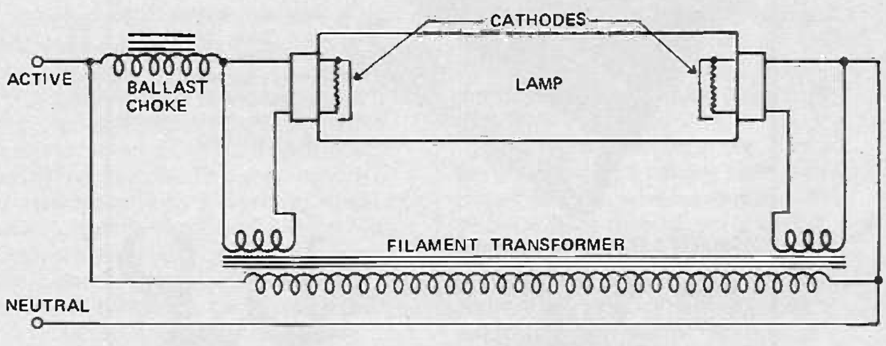


FIG. 1b STARTERLESS CIRCUIT

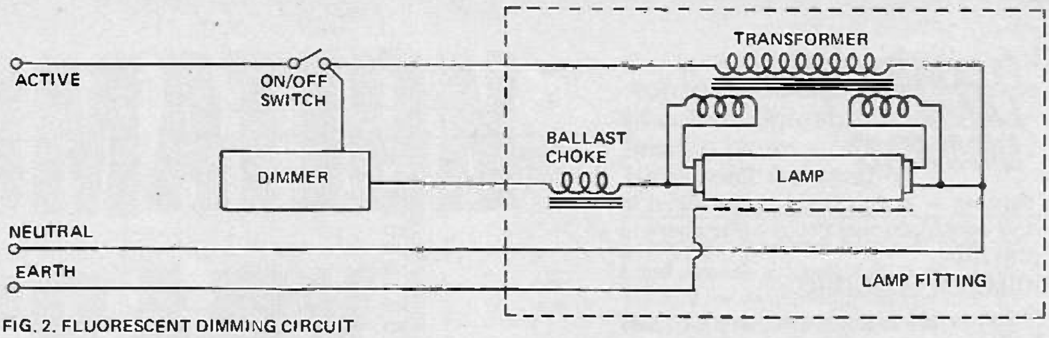


FIG. 2. FLUORESCENT DIMMING CIRCUIT

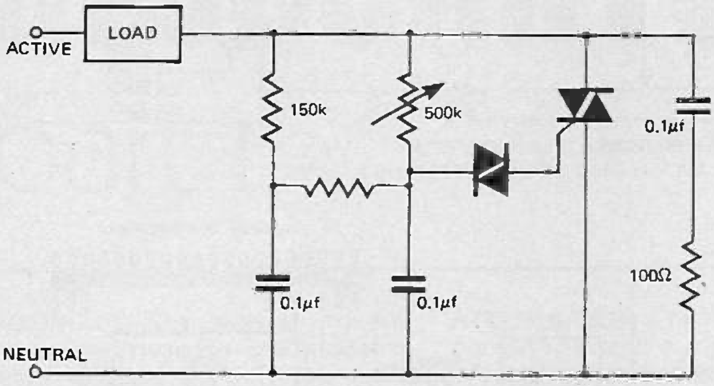


FIG. 3. TYPICAL DIMMER FOR DOMESTIC INSTALLATIONS

until finally the lamp fails to start. The starter switch, nevertheless keeps on trying to start the lamp and the familiar clacking sound is the result.

"The "Starterless' circuit (Fig. 1b) is a better system. Instead of the starter switch, a filament transformer is used to supply continuous heater power, thus the lamp starts noiselessly, without such a drastic stripping of the cathodes. Thus lamps in starterless circuits have a longer life than those in switch-start circuits.

Neither of these circuits can be dimmed satisfactorily without modification. In fact, it would not be possible to dim the lamps by more than 50% without the lamps extinguishing and failing to restart.

THE MODIFICATIONS REQUIRED

Fortunately quite a simple modification to the starterless circuit considerably improves operation. All that is necessary is to supply the filament transformer directly from the mains, whilst the dimmer controls the current through the ballast choke and lamp. (Fig. 2).

Thus to dim existing fluorescent lights the following changes must be made:—

SWITCH-START CIRCUITS

(1) Remove and discard the starter switch.

(2) Install a filament transformer. Make sure that the transformer has the correct filament voltage for the type of tubes being used. Filament transformers for this purpose can be ordered through most electrical wholesalers.

(3) Install an additional active lead from the fitting back to the active side of the dimmer.

(4) Make sure that the fitting is properly earthed. A good earth is essential for reliable starting.

At first it seems a simple matter to convert a starterless circuit to dimming operation.

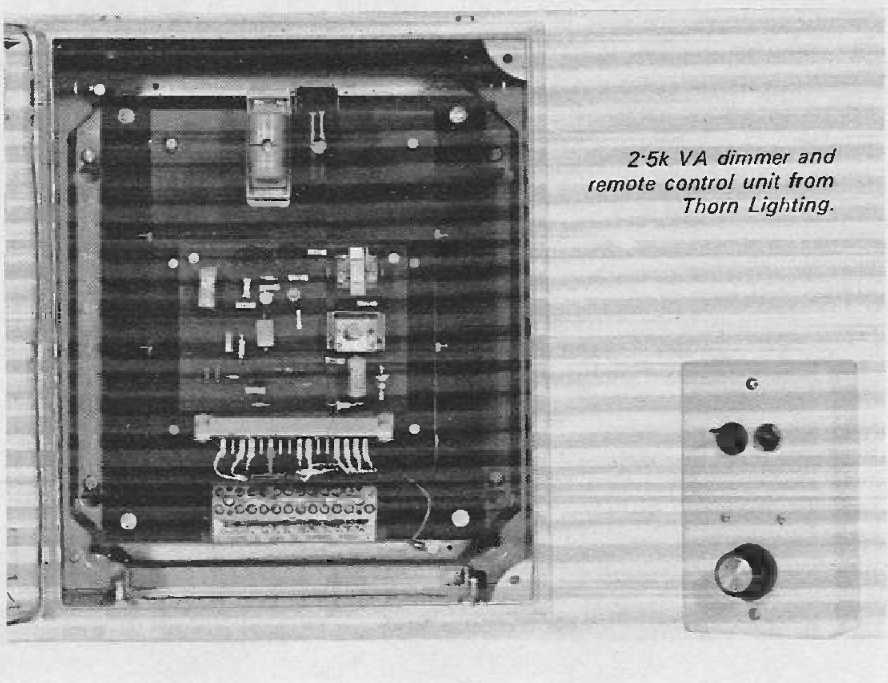
However, there is a snag and that is that the majority of starterless fittings use a "Rapid-Start" or "Quick-Start" ballast. This consists of the limiting choke and filament transformer contained in the one can, and only one active lead is brought out for both.

It is practically impossible to cut open the ballast and separate these leads. The complete assembly must be discarded and a separate switch-start ballast and filament transformer installed. Similar additional wiring is as for the switch-start conversion.

The circuit of a typical commercial dimmer is shown in Fig. 3. Up to a point this circuit is suitable for dimming both incandescent and fluorescent lamps, but at low illumination levels the inductive nature of a fluorescent load will cause this circuit to hunt and the lamp to flicker. This flickering may be reduced by installing a resistance in parallel with the fluorescent load. This can be either a 1500-2500 ohms, 50 Watt resistor, or an incandescent bulb. If an incandescent bulb is used, the size should be related to the VA rating of the fluorescent loading on the dimmer, as shown below:

dimmer loading	incandescent load
100 VA	15 Watts
300 VA	25 Watts
700 VA	40 Watts
1000 VA	60 Watts

Only one resistor or lamp will be required across each dimmer. This will reduce the flickering to some extent, but as most of the low level flickering is caused by assymetrical triggering of the Triac (caused by lack of symmetry in the triggering diode) it is better to use a dimmer that has been specifically designed for use with fluorescent



2·5k VA dimmer and remote control unit from Thorn Lighting.

FLUORESCENT LAMP DIMMING

lighting — as has the one described in the constructional project elsewhere in this issue.

DIMMER LOADINGS

Solid-state dimmers are rugged devices. They can be used continuously at their maximum designed rating but they cannot withstand any appreciable overload. This may be taken into account when calculating dimmer loading

With incandescent lamps, calculating the load is a simple operation. A 100 Watt lamp consumes 100 Watts. Six 100 Watt lamps consume 600 Watts.

But with fluorescent lamps it is not that simple, for the ballast choke causes the fluorescent circuit to have a lagging power factor. Loading must, therefore, be based on the volt/amps (VA) rating of the lamp, *not* the wattage.

The VA ratings of fluorescent tubes are given in Table 1.

Thus, as can be seen, a dimmer rated for a 500 watt load, will in fact be suitable for only five 40 watt fluorescent tubes, and not 12 as might be expected.

A separate ballast and filament transformer must, of course, be used for each lamp.

Preferably all lamps on one dimmer circuit should be of similar wattage. This is because the light output of different lamps does not decrease at the same rate for similar dimmer settings.

The variation in dimming characteristics is proportional to the ratio of lamp volt/amps to lamp wattage. If, for example, a 20 watt lamp must be paralleled with a 40 watt lamp, then a special auto-transformer type of ballast must be used to make the volt/amps:wattage ratio of the 20 watt lamp equal the 40 watt lamp. (Fig. 4).

The use of these special ballasts will improve tracking, but there will be less starting voltage available and flickering at low illumination levels may increase. Multiple dimming of dissimilar lamps should, therefore, be avoided wherever possible.

POWER FACTOR

An undimmed 40 watt lamp has an uncorrected power factor of 0.4 lagging. This may be brought back to about 0.85 lagging by adding a 3.5 uF capacitor in parallel with the lamp circuit.

In areas where frequency injection is used to control off-peak water heaters, a blocking inductor must also be fitted to prevent the capacitor bypassing the injected tone (which is usually within the frequency range 750 — 1050 Hz).

Power factor capacitors must *never* be fitted across the output of the dimmer because the surge current drawn by the capacitor will exceed the rating of the Triac or SCR and destroy it. The capacitor must, therefore be located on the mains side of the dimmer. This can be achieved by wiring the capacitor (and blocking inductor, if used) between the filament transformer active and neutral — as shown in Fig. 5.

A dimming circuit that has been power factor corrected to a factor of, say, 0.8, will only remain at 0.8 at full output. As the dimmer reduces the lamp current, the inductive component of the line current is reduced, but the capacitive component remains the same. The nett result is that the power factor, as the dimmer level is reduced, moves towards unity and eventually becomes leading. Some electricity boards may get very uptight about this, but the power factor becomes leading only at very low power levels, and dimming circuits are very rarely operated at these levels for extended periods.

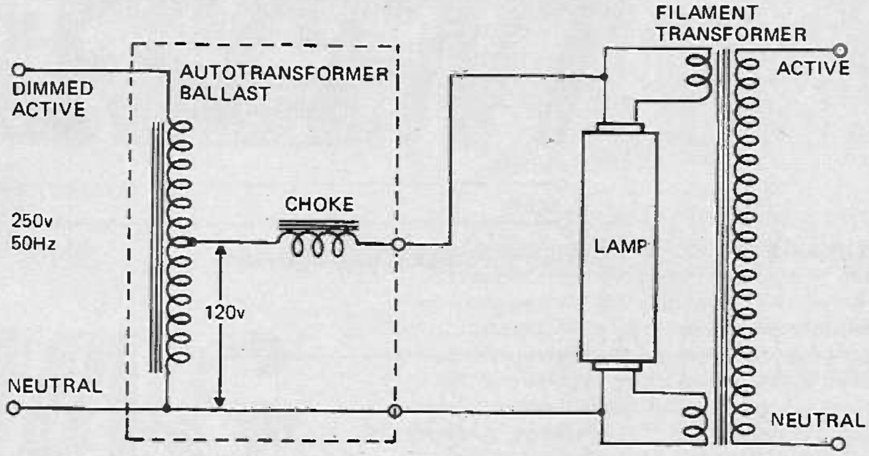


FIG. 4. AUTO TRANSFORMER DIMMING CIRCUIT USED TO MATCH TRACKING OF DIFFERING LAMPS

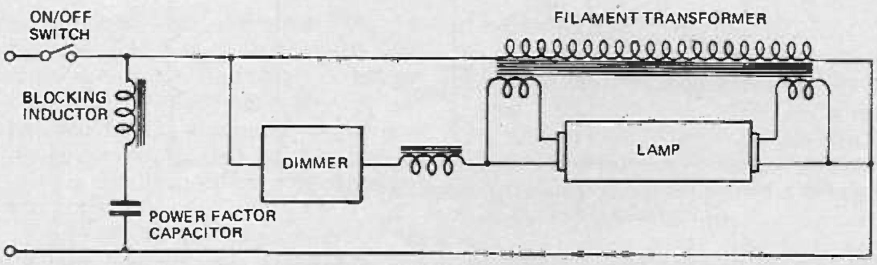


FIG. 5. FITTING OF P.F. CAPACITORS TO DIMMING FITTING

VERY LOW LIGHT LEVELS

Where very low light levels are required, the following points should be noted:—

1. Lamps should be pre-aged for at least 100 hours and then selected for minimum flickering.
2. 'Warmwhite' (low colour temperature) lamps behave very much better at low levels than 'Daylight' or other high colour temperature types.
3. Heaters may need to be used at very low light levels as low wall temperatures will cause unstable arc operation.
4. High loaded lamps, such as the two foot 20 Watt, or five foot 65/80 Watt, operate better at low levels than low loaded lamps such as the four foot 40 Watt types. In extremes the tube should be protected from air currents and, if possible, a heater should be used.
5. Tubes should be operated horizontally.
6. Low loss choke type ballasts should be used, rather than auto-transformer types, for minimum flicker. ●

Tube Indicated Wattage	VA Rating
15, 20 or 30	90
40	100
65	180
80	210

Table I. This table shows the VA rating of various size fluorescent tubes.

AUTOMATION GLOSSARY

part I

A contemporary glossary of words and phrases in the language of automation, abstracted by permission from a compilation by Honeywell Automation

Here we have a term hardly 20 years old and lost in a bramblewood of widely variant connotations. In this Glossary, we deal with terms in analogue control (digital terms will be defined in a later issue) – and we hold to very basic definitions. We hope this Glossary will provide common ground for communications in a field which Webster's Third New International Dictionary defines as: "Automatically controlled operation of an apparatus, process or system by mechanical or electronic devices that take the place of human observation, effort and decision."

ACCURACY The ability of a control device or system to give indicated values that closely approach true values of the quantities being measured. The measure of control system accuracy is often termed 'system deviation', the difference between the actual value of the controlled variable and its ideal value.

ALGORITHM A set of rules, or steps, prescribed for solving a problem. Usually the problem is a mathematical one, and the algorithm prescribes its solution in a finite number of steps.

AMBIENT TEMPERATURE The temperature of the environment surrounding an element of an automation system.

ANALOG The representation of numerical quantities by means of physical variables; eg translation, rotation, voltage or resistance.

ANALOG COMPUTER A computer that handles information that is analogous to some value of a controlled process. For example, the signal to an analog computer could be an electrical voltage that increases or decreases with the rise or fall of a process temperature. The voltage is 'analogous' to the temperature.

ATTENUATION The decrease in the strength of a signal as it passes through a control system. Opposite of 'gain'.

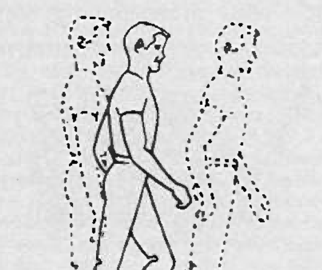
AUTOMATIC CONTROLLER A device or instrument which is capable of measuring and regulating by receiving a signal from a sensing device, comparing this data with a desired value and issuing signals for corrective action.

AUTOMATIC ERROR CORRECTION A technique for detecting and correcting errors that occur in data transmission or occur within the system itself.

AUTOMATIC QUALITY CONTROL Technique for evaluating the quality of a product being processed by checking it against a predetermined standard, and automatically making the proper corrective action if the quality falls below the standard.

AUTOMATION Automatically controlled operation of an apparatus, process or system by mechanical or electronic devices that take the place of human observation, effort and decision.

AUXILIARY FUNCTION In automatic machine tool control, a machine function other than the control of the motion of a work-piece or cutter. Control of machine lubricating and cooling equipment are typical auxiliary functions.



The 'simple' act of walking is actually a demonstration of quite complex automation principles. The walker throws himself continually off balance, and rebalances by moving the lower half of his body back under the centre of gravity. Feedback that makes the process possible comes both from the sensation of the feet touching the earth and from semi-circular-canal 'rebalance pots' in the ears. The entire procedure is so instinctive that we seldom give it a thought.

BACKLASH In a mechanical operation, the 'play' between interacting parts, such as two gears, as a result of tolerance.

BAND Range, or scope of operation. In communications: a range of frequencies, as between two specified limits. In instrumentation, a range of values representing the full control authority of an instrument.

BATCH CONTROL SAMPLE A representative batch (selected either at random or specific intervals) extracted from a process or product for purpose of quality control. Evaluation tests of the batches are averaged out to interpolate quality of the total process.

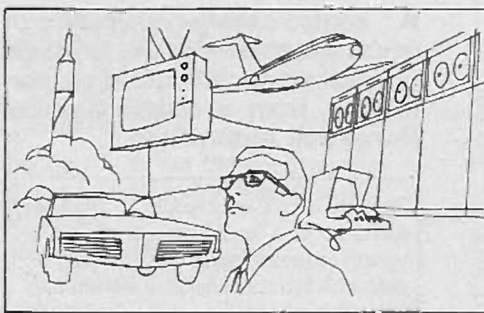
BIONICS The study of living systems, for the purpose of relating their characteristics and functions to the development of mechanical and electronic hardware.

BOOLEAN ALGEBRA Problem solving system based on a series of either/or yes/no (binary) conclusions. Named after George Boole (1815-1864), English mathematician.

CASCADE CONTROL An automatic control system in which the control units are linked chain-fashion, each feeding into (and regulating) the next stage. (Sometimes called 'piggy-back' control).

CHANNEL In *communications,* an electrical transmission path among two or more stations or channel terminations in telephone or telegraph company offices, furnished by wire, radio or a combination of both. Also, in *computer terminology*, a route along which signals can travel; or, that portion of a computer memory to which a particular output station has access.

(Continued on page 14)



One of man's most distinctive characteristics is his hunger for technical knowledge. And he is feeding that hunger at an ever-accelerating rate. For example, while it took 1750 years from the time of Christ to double man's store of technical information, it had doubled again by 1900, just 150 years later; again by 1950, 50 years later, and once again by 1960. Although the 60's had not been evaluated by this printing, the advent of space flights and computer technology leave little doubt that the trend will continue.

(Continued from page 13)

CLOSED LOOP An automatic control system in which feedback is used to link a controlled process back to the original command signal. The feedback mechanism compares the actual controlled value with the desired value, and if there is any difference, an error signal is created that helps correct the variation. In automation, feedback is said to 'close the loop'.

COMPUTER A machine designed to receive data, perform programmed operations on this data, and supply the results. See *analog computer* and *digital computer*.

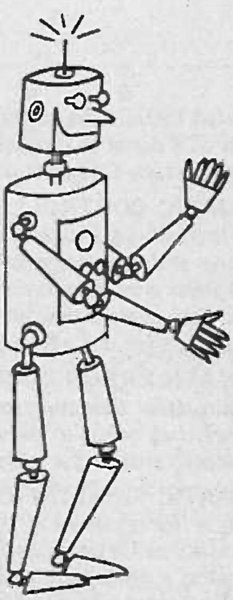
CONTOUR CONTROL SYSTEM In automatic machine tool control, a system in which the tool's cutting path is the result of some control action. It is not necessarily the desired value.

CONTROL POTENTIOMETER Probably the most versatile of all control instruments. It can control any condition that can be measured by a proportionate electric current by comparing the difference between known and unknown electrical potentials.

CONTROL REGISTER Element in a digital computer that controls the proper sequence of information being fed in for processing. The control register keeps the next word always ready for feed-in.

CONTROLLER An instrument that holds a process or condition at a desired value; eg a thermostat that holds room temperature at, say, 70° by sensing the actual room temperature (actual value), comparing it with the thermostat setting (desired value), and causing corrective equipment to eliminate any variation between the two.

CROSS COUPLING An effect in which an output is a result of more than one input. For example, pressure applied to the gimbal of a spinning gyroscope will cause the gyro to tilt in a different direction from the applied pressure. The gimbal's reaction is a resultant of its spin plus the applied pressure.



The word 'robot' was given to us by Karel Capek, a Czech playwright, in 1921. In Capek's play, RUR (Russom's Universal Robots), anthropomorphic machines performed faithfully until an ambitious scientist gave them nerves and sensibilities. Then they overthrew the human race that created them. The robots' final downfall was their inability to reproduce themselves, so that they eventually wore out and broke down.

CROSS TALK Interference in a given transmitting or recording channel which has its origin in another channel.

CYBERNETICS The theory of control and communication in the machine and the animal.

CYCLE In *electricity*, the time for alternating current to change from zero through positive and negative maximums, and then back to zero. In *computer terminology*, a sequence of operations that is repeated regularly, or the time it takes for one such sequence to occur.

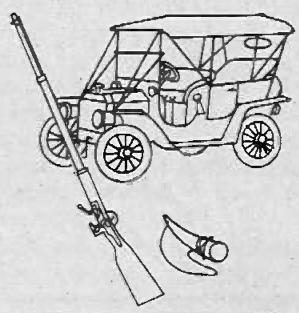
CYCLING A rhythmic change of the factor under control at or near the desired value.

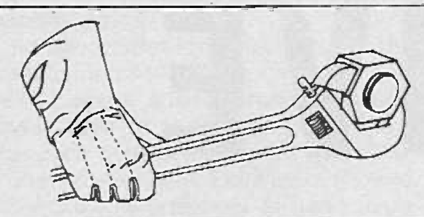
DAMPING A characteristic built into an instrumentation system to reduce over-response, instability, or oscillation by slowing up reaction time. A simple example of damping would be the shock absorbers on an automobile, that damp the reactions of the springs.

DATA In computer terminology, a general term used to denote any or all facts, numbers, letters and symbols, or facts that refer to or describe an object, idea, condition, situation, or other factors. It connotes basic elements of information which can be processed or produced by a computer. Sometimes data is considered to be expressible only in numerical form, but information is not so limited.

DEAD BAND A neutral zone in which a proportioning controller is 'satisfied', and calls for no corrective action. A temperature controller set for 72°, for example, might call for more heat at a room temperature of 71°, thus operating with a central dead band of 2°. The term 'Dead Band' is used in connection with proportioning control;

An interesting thing about technology is the way it accelerates. For example, the first step in mass production (the interchangeability of parts) was first employed in 1789 by Eli Whitney, who used the idea in building muskets for the government. But it was more than a century later when Henry Ford took the second step, installing assembly lines in his Highland Park plant in 1917, to mass-produce Model T Fords at the rate of one every two minutes. Today, computer-supervised, electronically-automated techniques make the assembly lines of only 25 years ago look almost antique.





Did you know that all of the ingenious mechanical devices ever invented — millions of them — are based on just two mechanical principles; the lever and the inclined plane? Of the six basic principles, the pulley and wheel are actually adaptations of the lever, while the wedge and screw are adaptations of the inclined plane. All other mechanical movements employ these two principles, and without them there would be no machines and no automation.

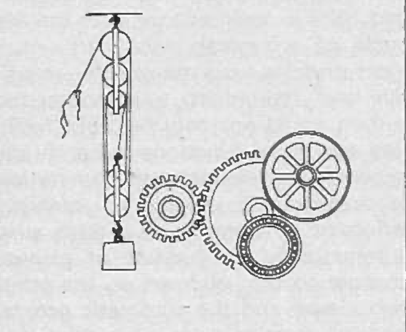
and is equivalent to 'Differential Gap' in on-off control.

DEAD TIME Any definite delay deliberately placed between two related actions in order to avoid overlap that might cause confusion or to permit a particular different event such as a confusion or to permit a particular different event such as a control decision, switching event or similar action to take place.

DELAY LINE A device that can retard the transmission of one unit of information until another unit can synchronize with it. Common forms of delays are mercury acoustic tanks, coaxial cables, magnetic drums, and other such devices.

DEMODULATOR A device (such as a radio, for example) which extracts the modulation information from a modulated carrier (such as an AM or FM radio wave). In most cases it rectifies the incoming modulated carrier frequency and separates the desired modulation signal from the carrier.

DERIVATIVE ACTION Control operation in which the speed of a correction is made according to how fast a condition is deviating from the set point (same as rate action).



Ever since the wheel, our world of technology has been going in circles, so to speak. Today, it's hard to imagine a mechanical device that does not depend in some measure on something that goes 'round and 'round. Yet, no one can prove mathematically that a circle actually exists. The trouble is, you need pi (3.14159 ...) to prove out the circle, and pi never seems to come out even, no matter how far you draw it out. One mathematician worked in his spare time for 15 years, and a computer went even further. No use . . . both agreed that pi just isn't a rational number, so the math model of a circle is really a spiral, and there's no such thing as a 'perfect' circle; at least, not in the mathematical sense.

DIFFERENTIAL ANALYZER A type of analog computer (either electronic or mechanical) that solves differential equations by assigning analogies to mathematical functions.

DIFFERENTIAL GAP In on-off control, the differential gap is the span between the 'on' and 'off' switching points. A room thermostat, for example, that is set to control for 70° might switch the furnace 'on' at 68°, and 'off' when the temperature has risen to 72°, giving it a 4° differential. See 'Dead Band'.

DITHER A small electrical signal deliberately injected into an electromechanical device for the purpose of overcoming static friction in the device. In a recording instrument it keeps the indicator alert.

DOWN TIME The period during which equipment is malfunctioning or not operating correctly due to mechanical or electronic failure. Production-time lost while equipment is being repaired.

END-POINT CONTROL Quality control through continuous, automatic analysis. In highly automatic operations, final product is analyzed; if there are any undesirable variations, the control system automatically brings about the necessary changes.

ERROR 1) The general term referring to any deviation of a computer or a measured quantity from the theoretically correct or true value. 2) The part of the error due to particular identifiable cause; eg a truncation error. Contrasted with 'mistake'. In a restricted sense, that deviation due to unavoidable random disturbances, or to the use of finite approximations to what is defined by an infinite series.

FEEDBACK In a control system, feedback is the signal (or signals) fed back from a controlled process to denote its response to the command signal. Feedback is derived by comparing actual response to desired response, and any variation is fed as an 'error signal' into the original control signal to help enforce proper system operation. Systems employing feedback are termed 'closed loop' systems, with feedback closing the loop.

FEED FUNCTION In automatic machine tool control, the relative motion between the work and the cutting tool. (Does not include that motion provided for removal of material.)

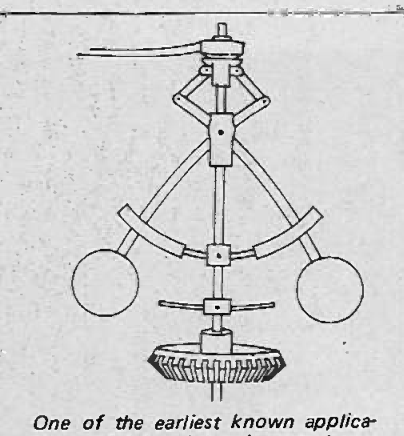
FINAL CONTROL ELEMENT The unit of a control system which directly changes the amount of energy or fuel to the process. In an industrial oven, for instance, the final control element might be a valve which regulates the amount of fuel flowing to the burner.

FIXED POINT ARITHMETIC Calculations in which the computer is not concerned with the decimal place. An example would be a sliderule calculation, since here the human operator must keep track of the decimal place. Also, a type of arithmetic in which all figures must stay within certain fixed limits.

FLOATING POINT ARITHMETIC Calculations in which the computer is responsible for keeping track of the proper decimal place. Also called the 'floating decimal arithmetic'.

FLOW CHART Graphic presentation of the major steps of work in process, with accent on how the work flows through the process rather than on how the steps are done. A 'logical flow chart' is a detailed graphic presentation of work flow in its logic sequence — often, the built-in operations and characteristics of a specific machine, with symbols to indicate types of operations. ●

(Part 2 will define the remaining terms in this Glossary)



One of the earliest known applications of 'closed loop' control was James Watt's flyball governor, devised in 1778 to control the speed of his steam engine. The flyball consisted of a rotating vertical shaft equipped with two weighted balls that could move outward on cantilevered arms. As the shaft was accelerated, the balls were thrown outward by centrifugal force, levering the arms to close down the steam valve.

INTERACTIVE DISPLAY

Part 2

by D. O. Harris, B.Sc. (Eng), Ph.D.,
of Stabletron Ltd.

Some known and some foreseen applications of man's ability to communicate with a machine.

WE will now look at a few of the many graphics applications where communication with the machine has, in a short time, enabled us to attempt projects which a few years ago would have been thought irrational. These users have had direct financial savings, reduced turn-around time, improved product quality or have introduced a new capability which could not have been considered before the visual display unit was installed.

AEROSPACE INDUSTRY

Probably the most sophisticated user of graphics in almost all design activities is the aerospace industry. Lofting or master dimensioning, ie defining the exterior geometry of a part or product in such a way that fabrication and assembly of the whole is facilitated, is carried out by McDonnell Douglas using (since late 1967) a mathematical representation of the graphical techniques used by a loftsman. The system uses an interactive CRT to input curve shapes and parametric date and to visually check the results before creating a hard copy plot on an ORTHOMAT plotter. Interactive aspects of the system are reputed to have saved over 20% in dollar costs over conventional batch computer techniques and about 50% in elapsed time.

Lockheed-Georgia has also had an interactive 2-D structures program since early 1968, used extensively on the G-5 aircraft with a first year cost savings of $250,000. A scope display is used to check the input data for a complex three dimensional structural analysis batch run and is estimated to have avoided 500 hours of aborted computer runs during the analyses of a single aircraft wing.

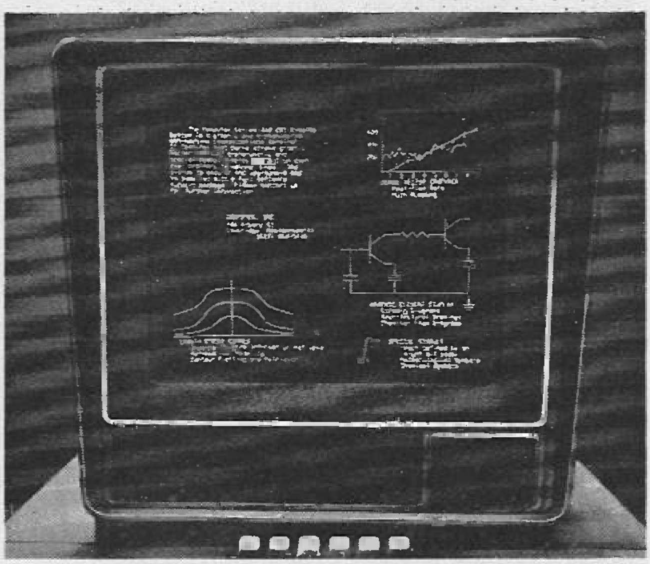
Printed Circuit Board design (Redac Software Ltd).

More controversial are applications in the basic aerospace design and drafting activities. Many people believe that straight forward speeding up of drafting process (with associated cost savings) is not adequate to justify the large software investment and hardware costs for a computer graphics system. The storage cost for maintaining the digital representations or 'models' of the drawing itself, particularly if fast response to retrieval requests is desired, is still high compared with microfilm or even standard hard copy storage costs, although newer optical storage systems and higher density magnetic techniques may soon become cost effective.

In view of the fact that 15% of the cost of a drawing is in its generation and 85% in maintenance over the life cycle of a typical piece part, since most drafting work tends to be repetitive and redundant, a computerized system could not only help but facilitate additional functions to justify the expense. For example, the generation of orthographic projections (manipulation of an element on a third view automatically as a result of manual changes to that element on the other two views) and the automatic generation of isometric views multiplies a draftsman's productivity many times. Another function, known variously as the 'detail' or 'grouping' function, enables a designer to designate a structure as a single entity to be copied, moved about, scaled up or down, rotated etc without any redrawing.

In pursuing other applications, many firms are integrating their computer graphics work with NC (numerical control) tape preparation to produce several hundred parts and templates for production aircraft. Preliminary design of aircraft to evaluate various configurations of landing gear, engine placement etc is also increasing in popularity and sophistication.

At Messerschmidt in Munich, for the simulation of the transition phases of a VTOL plane, a batch process was originally used to control parameters as a function of time before the computer run could be made. Experience showed that this was extremely difficult to do and the results of the run were always subject to doubt whether lack of performance was due to false aircraft conception or unfavourable estimated steering functions. The obvious answer was to be able to intervene in the computation and control the wing flaps and control surfaces during the simulation. This was carried out on an IBM graphic display where, simultaneously, control parameters (such as speed, acceleration, angle of incidence etc) replacing important cockpit instruments, and a history of the steering parameters controlled by the pilot are displayed. When a satisfactory 'flight' has been made, a hard copy of the results can also be obtained.



Various types of Computek local display generation (Transworld Data Systems).

MANAGEMENT INFORMATION

In this general field, the cost benefits of graphics are more difficult to quantify. The quality of a manager's decision, which could be worth substantial sums to a company, is certainly improved by the use of the graphic display. Rapid access to company data files, conversion of numerical information to graphical form for the evaluation of trends, and the ability to ask a variety of 'what if?' questions allow the manager to make a faster and more accurate assessment of a situation.

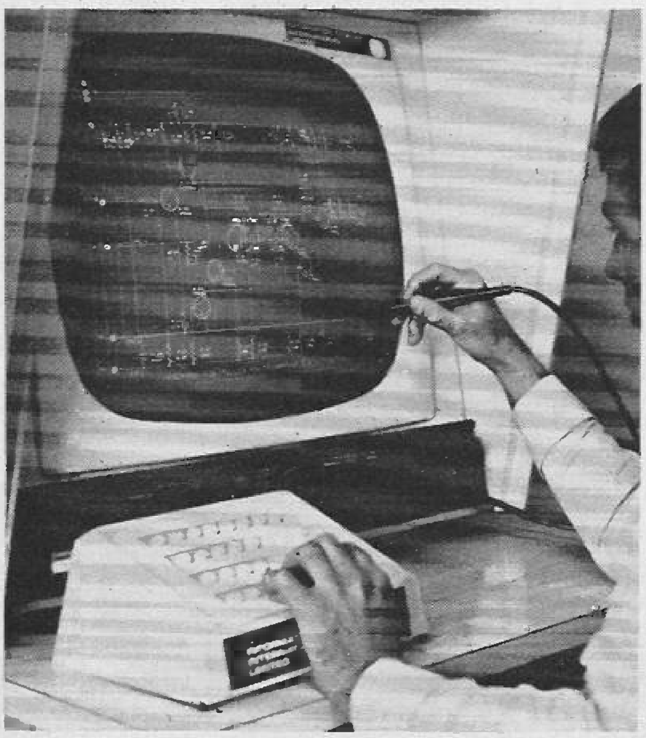
Westinghouse Electric chose to implement a Management Information System in a middle-management area that dealt with large amounts of sales forecasting and production scheduling data and required judgment and computation in decision-making. All parameters of the problem are initially presented to the manager in the form of a light pen menu. By pointing the light pen at the information on a CRT, he can choose the content and form of display of an information. The display data can be manipulated by light pen and keyboard, and he can conveniently move back and forth within the data base, asking 'what if?', and making decisions. Although the data is computer generated, it is presented in a form with which he is intimately familiar; so he need not learn a new language in order to communicate with the computer. And the response from the computer is fast enough so that he does not forget the original 'what if?' question. The plot results include both numeric and graphic data describing the conditions the operator has selected and, to the right of the presentation, are additional light pen functions so that he can continue to interact with his data base and move through approximately 20 presentations in order to complete their monthly schedule, concentrating on making his judgements rather than getting involved with paper work and calculations.

Shell Petroleum Company also chose market planning as the area in which radical advances could be made most easily in the short term; the program sub-system for evaluation of profitability and cash flow analysis of a project was designed specifically to demonstrate how, in a real life situation, interactivity and graphics could assist the manager to understand a project, make cash flow calculations almost instantaneously examine in pictorial form so that trends can be detected. An important facet of this system, however, is that it allows the manager to change the figures in the table and to examine what effect this has on the overall viability of the project.

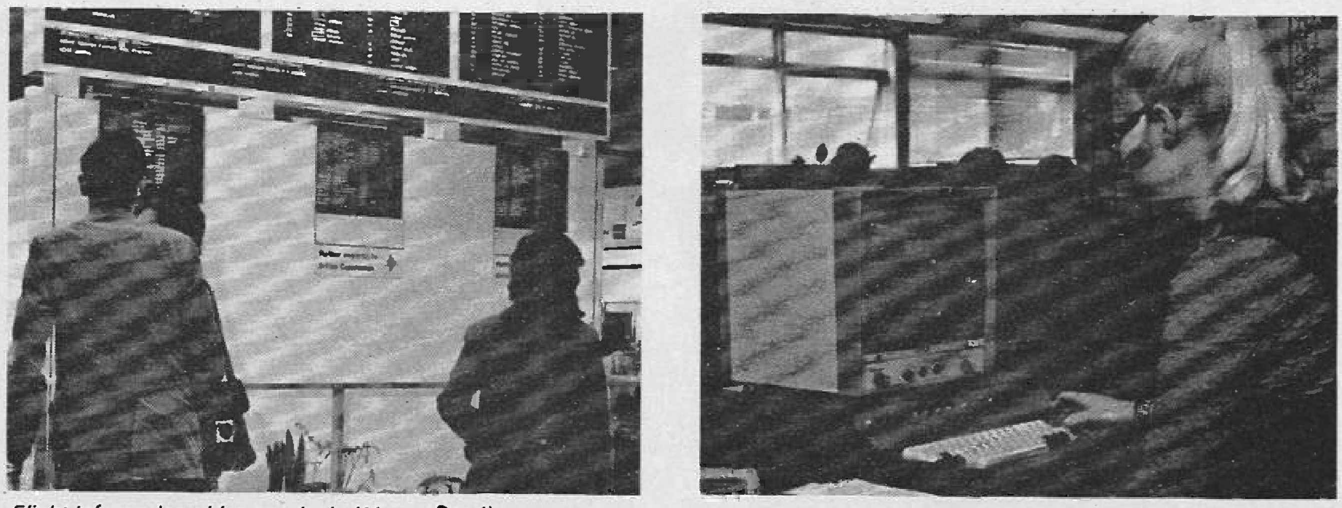
PROCESS CONTROL

In general, these applications can be divided into two groups – open loop processes (eg chemical or oil movement system via pipelines) and closed-loop processes (eg refining units in the oil industry, nuclear reactors, chemical plants, paper making machines, cement kilns and blast furnaces. With a closed-loop it is advantageous to expand the CRT's function to monitor past and future action of several variables.

At this moment, the IDIIOM is being used to control an Esso blending refinery on the island of Aruba, the CRT



IDIIOM in circuit design.



Flight information video terminals (Moore Reed).

INTERACTIVE DISPLAY

display replacing the traditional 'status board'. In such systems the operator can control pumps and valves by pointing the light pen at symbolic representations on the CRT. The computer accepts the commands, sends out appropriate signals to accomplish the operation, and displays the results on the screen. Without the CRT, the status board would usually be a wall mounted panel which, in a very large system, would not show in sufficient detail the status of valves, pumps and switches. The flexibility of the CRT display system permits the operator to use a large or small section of the total process as he desires, the degree of detail increasing as he works in smaller sections.

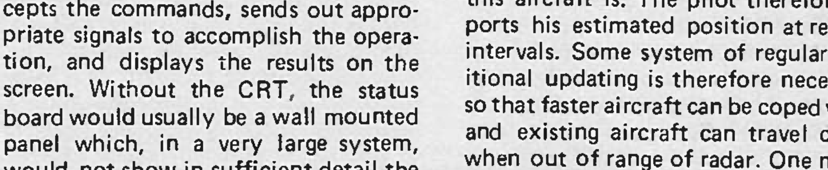
AIR TRAFFIC CONTROL

The modern air traffic controller, with very arduous and responsible tasks and many lives dependent on his decisions, relies on his ability to interpret the passage of dots on a radar screen in conditions of subdued lighting. He also has to listen to verbal messages from the pilot and instructions from the control supervisor, and watch a 'real time' clock separate from the radar display. Flight paths and aircraft identification numbers are presented to him on separate displays.

Once an aircraft goes out of range of the radar system (at about 150 miles distance), there is at present no means by which ground control can tell where this aircraft is. The pilot therefore reports his estimated position at regular intervals. Some system of regular positional updating is therefore necessary so that faster aircraft can be coped with, and existing aircraft can travel closer when out of range of radar. One major airline estimates it would save up to $20 million per year by closing the gap to 10 miles.

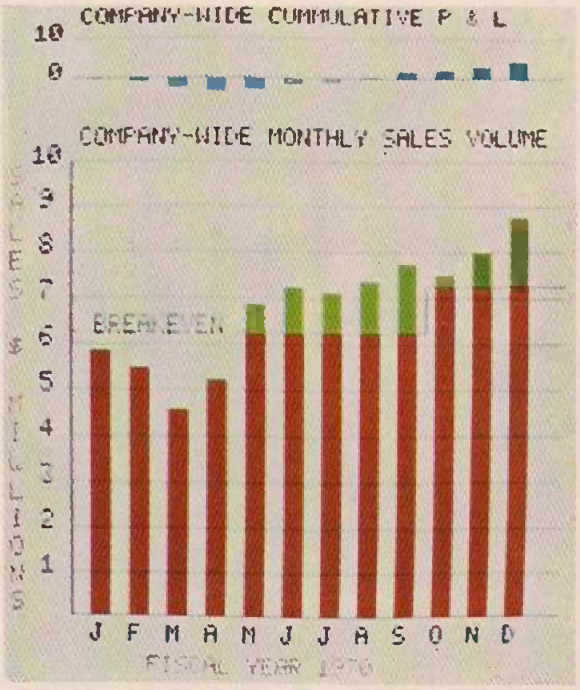
For this reason, an experimental scheme is under way in Oakland, USA, and is due to begin soon at Heathrow Airport, London, involving an interactive display at the controller's desk. On the aircraft itself, a black box computes and transmits latitude, longitude and altitude readings which are transferred to the IDIIOM display. Other aircraft data flight plans, progress reports etc arrive at the control position by telephone from the airline operations office or over the aircraft voice radio. In the prototype system, these telephone messages are fed in by an online teletype. Thus all the information the controller needs is assembled in one data bank and presented in pictorial form on one screen with latitude/longitude grids superimposed on the display and a video map of the region of interest also shown. Oceanic routes within the sector (flight paths) and reporting points are presented at the controller's request and a real-time clock is also presented on the screen. The controller thus has all he needs on one console. The system itself calculates potential collision courses and asks for assistance when an aircraft changes sectors. However, the system does not take and will not take any control decisions. This is the sphere in which the man has been trained and is superior. Calculations and conflict monitoring are performed and presented to the controller for his judgement, decision and action. If he requires flight path or progress details, he just points at the aircraft symbol with the light pen and this information is displayed in tabular form at the foot of the screen.

IDIIOM in, left to right, refinery control, hidden line rotation and public utility system applications.



ELECTRONIC DESIGN

Application of computer graphics to printed circuit board layout, probably one of the best known areas of CRT usage, permits packing of components to a high degree of density very quickly and interconnections to be organised by the computer for minimum branding and optimum routing. Many programs employ an iterative approach, alternatively re-routing and re-packing until an optimum result is achieved. This type of two dimensional layout of rectilinear objects lends itself to easy computerisation.



Management information display (Sintrom Electronics).

A more interesting development at the other end of the scale is circuit design and layout of schematic on the screen from first principles, the operator getting his ideas down in 'writing' and the interconnections and component values being fed into the computer run concurrently. Thus, as the designer gets his circuit organised, the display hardware takes care of his future input requirements so that, when he has completed his work and completed specifying the input to the circuit, analysis to provide the output can proceed immediately.

FUTURE TRENDS

Away from the pressures of a commercial environment, the frontiers of this science have been pushed forward even further and there are exciting prospects of advance in new fields.

IDIIOM in Project Analysis.

Multi-colour displays, where data can be presented in several colours in graphic form to enable quick visual comparison, have now reached the market at a reasonable price and with compatible performance. These have only one electron gun and a special phosphor which shows different colours according to the depth of penetration of the electron beam and involve some high speed switching and dynamic focusing circuitry.

At General Electric, a colour TV system driven by a video disc is being developed for NASA; the interesting (and expensive) hardware part of this system enables the video disc content to be modified in real time to change the colours in up to 56 different plane areas being displayed. Planes and shapes are specified in three dimensions and conversion to a two dimensional display picture is carried out by the hardware. Hidden lines are coped with by building up the picture in the negative Z direction, overwriting blanked portions of the picture on the video disc as the picture is constructed.

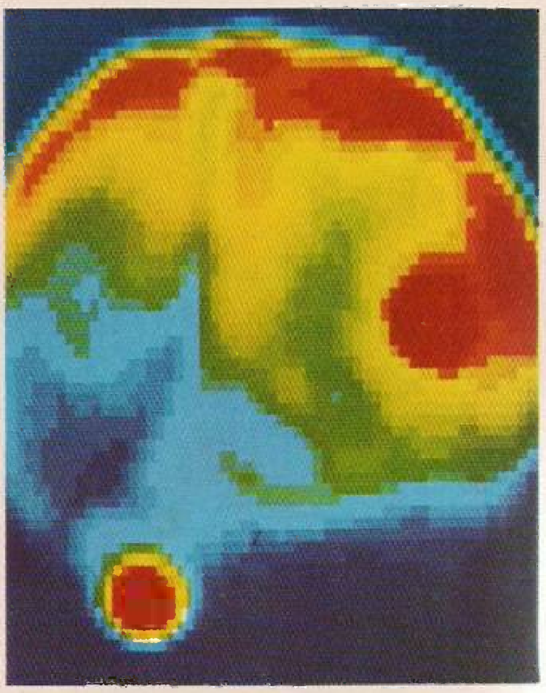
True three dimensional displays are not far off. Work is being done on the generation of two slightly displaced images that constitute a stereo pair. At the Battelle Institute in Germany the idea of using red and green vectors at adjacent positions is being pursued, the user wearing special 3D spectacles.

A pioneer of computer display engineering, Evan Sutherland, is continuing advanced work with the development of a pair of spectacles (rather bulky at present) which comprise two 1" CRTs and a sound device. A lens system converts the images from the CRTs into a stereoscopic environment in which the wearer can live and work.

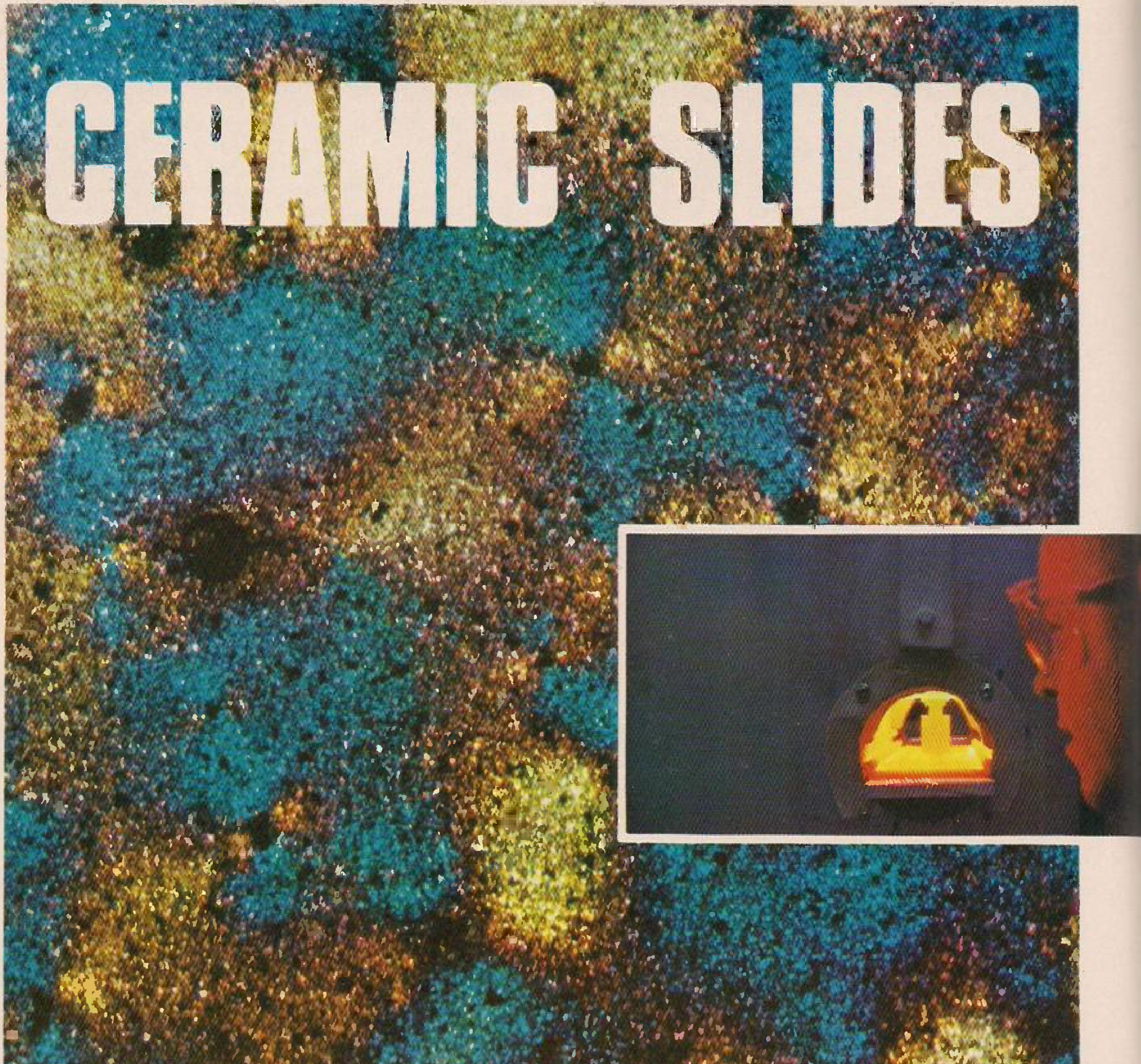
An ambitious project at the Department of Machine Intelligence and Perception, Edinburgh University, sets out to solve the problem of communication with the machine by teaching the computer to learn from its own environment, just as human beings pick up data and experience from birth. The team, who are endeavouring to develop a 'Real World Interface' for their computer, decided that vision (a sense which permits access to a large quantity of data and can function at a distance from an object) is the most important sense to impart to a computer and are investigating ways to communicate with a computer visually by showing it diagrams or objects and 'demonstrating' operations which it must learn to perform.

The prototype, a TV camera with a wide-angle close-up lens, is equipped with wheels which can drive it around a 3' diameter platform which constitutes its 'world'. It is performing the groundwork for object recognition and manipulation. In order to deal with recognition of complex three-dimensional shapes such as kettles or bowls of flowers, it is being taught to see objects as collections of merging areas, rather than a construction of lines. Already the system has been taught to identify cups, wedges, pencils, balls, hammers, cylinders, tubes, doughnuts, and spectacles. A Mark II device is now being planned which will contain a mechanical hand with a sense of touch. It will then be able to distinguish two separate entities from a single solid one and perform such operations as lifting cups from saucers. ●

Computer-generated radiogram of the liver (Sintrom Electronics).



CERAMIC SLIDES



Photomicrograph showing strains and their resultant colour phenomena in polarised light.
Inset: PLZT inventor Haertling viewing specimen in hot press oven

The Image Retaining Panel described in our September issue stored images only so long as a voltage was applied to it. THE 'CERAMPIC' device described here is able to store images as long as desired and without any applied voltage. It was developed by Sandia Laboratories as part of their prime contractor undertaking to the US Atomic Energy Commission to whom patents have been assigned on certain aspects of the invention. The device has some other unusual properties and will, we believe, lead to compact image displays in computer, facsimile, xerographic reproduction, document verification between distant locations and other numerous fields in the near future.

SENDING pictures from point to point on a radio beam has been the subject of much discussion for manufacturers, users and communication specialists. Television is relatively expensive, requires high frequency signals (which, because they propagate in straight lines, need relay stations to circle the curvature of the earth) and expensive storage equipment for long-term display. Other techniques developed specially for sending documents and still photos, for example by using telephone lines, are either slow or suffer from lack of definition (resolution) which limits them to certain types of information only.

A new device, developed by Sandia, stores and displays images at high resolution in a few seconds from signals received by telephone or radio. It is called 'Cerampic' and uses a simple transparent ceramic material. To store an image, the device is simply exposed to the image, just like a photographic film is exposed. However, the ceramic picture needs no processing, may be erased (and the device re-used) at will and may be viewed directly or projected like a transparency.

Previous ceramic imaging devices proved impractical for varied reasons such as requiring polarised and essentially mono-chromatic (of one pure colour) light or mechanical stretching/compressing prior to image storage. The Cerampic is simple to fabricate, has no critical tolerances, is able to use white non-polarised light for storage and/or display, has uniform image quality over its surface and, by use of slightly modified procedures, permits positive-to-positive reproduction as for projection slides. While the device does not yet store pictures of exceptional quality, the inventors believe it is only a question of further materials development.

PLZT CERAMIC

The basic operating medium of Cerampic devices is PLZT 7/65/35 ceramic containing 7% lanthanum, 65% lead zirconate and 35% lead titanate. In the original process, this solid solution was chemically prepared by co-precipitation and hot pressed in an oxygen environment to give the near theoretical density and an average grain size of 4 to 5 microns. The plate is typically 0.0123" thick and 1" in diameter.

Recently Sandia have developed a simplified process for the production of transparent PLZT ceramics. This process involves atmospheric sintering and bypasses the essentially more expensive and less versatile hot-pressing technique — and it is readily adaptable for mass production of large plates of PLZT and fabrication of 'green' (unprocessed) ceramic shapes by traditional techniques such as dry pressing and slip casting. Chemically prepared PLZT powders containing 6% (by weight) excess lead oxide is sintered in an alumina jacket whose double walls are filled with an 'atmosphere powder' consisting of lead zirconate and lead oxide, providing a relatively high pressure of lead oxide vapour in the sintering cavity. Oxygen introduced to the system is allowed to diffuse to the ceramic sample as it is sintered at a nominal 1200°C for 3 hours, resulting in a dark orange coloured PLZT wafer. This colouration is removed in a subsequent heat treatment at 1200°C for a further 30 hours in a controlled 'atmosphere' of lead zirconate.

CERAMPIC DEVICE

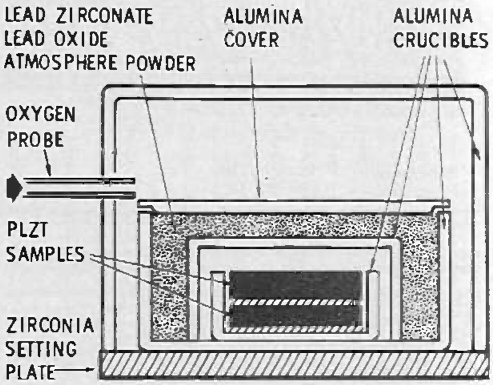
The 1" diameter, 0.013" thick 'Cerampic' device itself is a four-layer sandwich stack consisting of a transparent layer on top of a photo-conductive film (whose electrical conductivity changes with the intensity of light striking its surface), a 0.012" thick PLZT ceramic (which performs the actual image storage and display) and a second transparent electrode. The photo-conductive film is PCK polyvinyl carbozole and the transparent electrodes are of indium oxide doped with tin oxide.

HOW IT WORKS

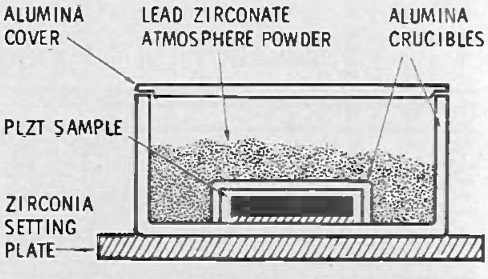
The ceramic material consists of an aggregate of many tiny crystals, each a distorted (rhombic) cube, composed of oxygen and the metals lead, titanium and zirconium. Like many crystalline ferro-electric materials, the ceramic has the ability to organise its physical structure into regular geometric formations. When a strong electric voltage is applied across the two electrodes, the crystals align themselves in the direction which permits light to pass through the ceramic. If a voltage of opposite polarity is applied for a short time, some domains lose their original alignment and block light passage through them.

In the virgin or thermally de-poled state, the ceramic is essentially strain-free and many crystal domains in each

New PLZT Process



Atmosphere Sintering Apparatus



Heat-Treatment Apparatus

CERAMIC SLIDES

Image projected directly from a Cerampic

grain are oriented at 180^{o} with respect to each adjacent crystal domain. Before an image can be stored, the Cerampic is pre-poled by flooding it with incident light and applying a dc voltage of 12kV per cm thickness; this aligns the domains in each grain along one of the crystallite axes, creating internal strain and increasing the light scattering (and hence reducing somewhat the transparency) of the ceramic uniformly over the area of the plate. Pre-poling is used in order to establish a repeatable maximum level of electrically controllable transparency to the device. The pre-poled Cerampic is less transparent than the virgin ceramic; to restore the full transparency would require thermal depoling which is only feasible in slow-switching electro-optic devices.

Principle of Cerampic operation in Negative-to-Positive mode

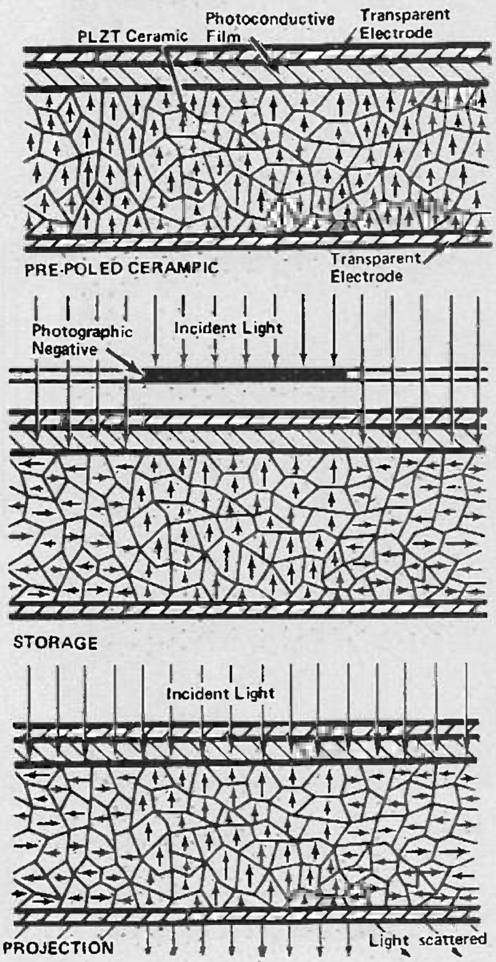


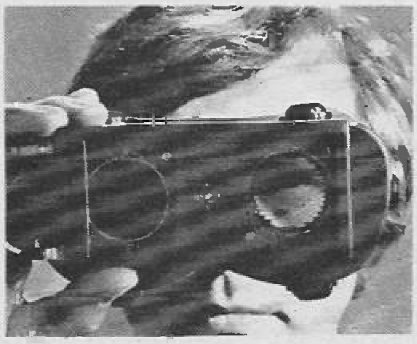
IMAGE STORAGE

An image is stored in the device by projecting it on to the photoconductive film (through a photographic negative or positive medium or by scanning it with an intensity-modulated pin-point light beam) while simultaneously applying a voltage, across the transparent electrodes, of opposite polarity to the pre-poling voltage. In the dark areas of the image (as incident on the Cerampic), the photoconductive film acts as an electrical insulator, permitting only part of the voltage to appear across the ceramic layer, depending on the relative darkness of the area. In the light areas, the film acts as a conductor and more the applied voltage appears across the ceramic layer depending on the relative lightness of these areas. Thus variations of light intensity (determined by the details of the image exposed to the Cerampic) produce, in effect, local (and corresponding) differences in the electrical conductivity of the device which are translated, in the crystal, into corresponding degrees of alignment or misalignment of the ceramic domains. Little or no domain switching occurs in the darker areas where the crystal orientations remain in the strain-relieved mode which results in scattering of incident light away from the field of view. Significantly more domain switching from the pre-poled to the opposite poled state occurs in the lighter areas where crystal orientations are aligned to permit passage of light of corresponding intensities. A stored image thus corresponds to an array of aligned or misaligned areas correlated to the details of the original image.

If the image is exposed on to the Cerampic through a photo 'negative' the resulting stored image, as seen by the unaided eye, is a 'positive' mosaic of shades of grey with a typical resolution of 40 line-pairs per mm (five times the resolving power of the human eye at 10") in a 0.25mm thick plate. Line resolution (definition) of the stored image should decrease with thickness of the ceramic plate due to increased light scattering.

To store 'positive' images from 'positive' originals or 'negative' images from 'negative' originals, an additional step is required, viz, after pre-poling, the Cerampic is switched to the near de-poled state so that the entire PLZT is relatively opaque. Image storage then consists of 'erasing' (rendering transparent) parts of the darkened plate in proportion to the pictorial details of the image.

Prototype Flash-blindness goggles (with one lens 'on' and the other 'off') and System schematic



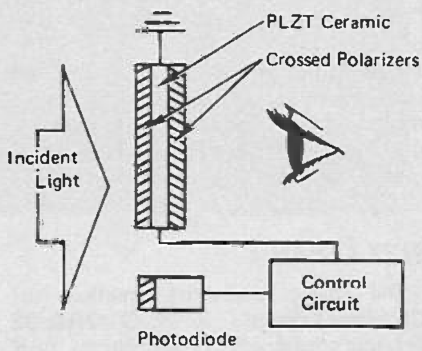


IMAGE STORED BETWEEN THERMALLY DEPOLED AND ELECTRICALLY DEPOLED STATES

IMAGE STORED BETWEEN ELECTRICALLY POLED AND ELECTRICALLY DEPOLED STATES

PRINT FROM ORIGINAL NEGATIVE USED TO STORE THE TWO IMAGES

Whatever storage method is used, image storage is effected by applying a voltage of polarity opposite to that used to establish the initial state, and of at least half the value of the poling voltage.

VIEWING THE IMAGE

Once the image is stored, it remains in the ceramic permanently, until it is intentionally 'erased' (see below). It is viewed simply as one would view a transparency, either by the unaided eye or through an enlarging viewer or projector.

ERASURE

To erase a stored image, the entire surface of the Cerampic is uniformly flooded with incident light while, simultaneously, a poling voltage is applied of polarity opposite to that used to store the image.

APPLICATIONS

Since image formation and storage is by spatial variations of light scattering (instead of by bi-refringence as in other ceramic image storage devices), this simplifies storage, viewing and erasing procedures and eliminates the need for polarisers or analysers. The device has a variety of potential usage in any application involving optical information storage, processing and retrieval including display.

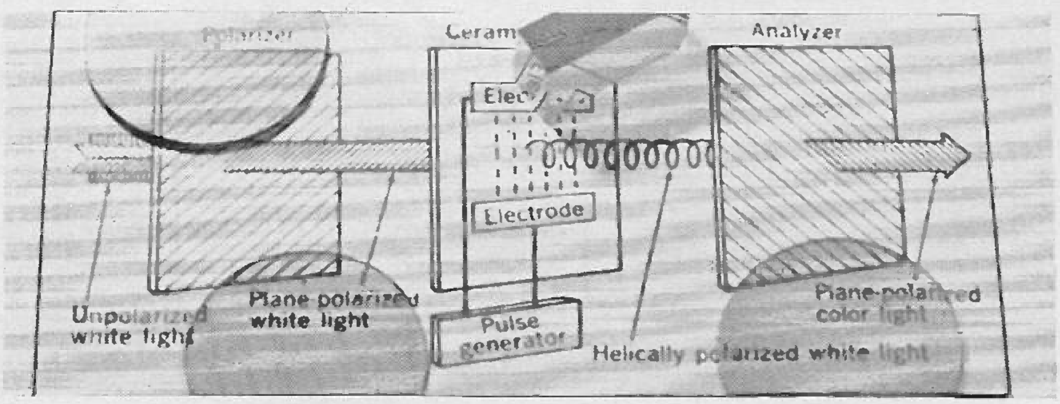
One promising application is the generation of images (of documents, photographs, diagrams etc) from signals received by telephone or radio. Facsimiles can be generated in a few seconds and the user would be able to inspect them at leisure and make permanent paper (or other) copies at will.

When successive lines are swept by an intensity modulated light beam in raster patterns, pictures and data can be reproduced in a manner analagous to TV systems. Sandia researchers believe that raster rates up to 15,000 lines per second are possible, permitting the ceramic to display TV-like images. In adapting the device to TV, the digital and logic technologies developed to store and retrieve bits of data in computer memories can be used along with the new fast-response photo-conductors being developed.

Along with such and other more familiar image storage and display applications, the newly discovered 'longitudinal scattering effect' in the ceramic may also prove useful in such devices as electronic shutters, optical memories and page composers for holographic memories. In such applications, the photo-conductive film in the ceramic sandwich will be replaced by patterns or arrays of transparent electrodes.

One application of the PLZT ceramic itself was mentioned on page 7 of our October issue, viz, electro-optic goggles. In the prototype device, the lenses are a sandwich comprising a polariser, an electroded PLZT ceramic and a second polariser oriented at 90° to the first. The PLZT surface is overlaid with an interdigital electrode array with sputtered copper or vacuum deposited chromium-gold electrodes 2 mils wide separated by 40 mil gaps. In the 'ON' state, light transmission is 21%, ie 6% more than conventional sunglasses, and is essentially colourless. A simple rheostat control can be used to set any 'on' level between 21% and the opaque value of 0.003%. Flash hazard is detected by an array of five photodiodes located between the lenses and forming integral parts of a discriminator circuit which senses the light intensity threshold and switches the goggles to the opaque state; the threshold can be adjusted by a variable resistor in the circuit. Similar filters having areas of 10" sq or more can be controlled by the same pocket-size power pack. The same general principle can be used also in image intensifiers and vidicon tubes to protect sensitive photo detectors, as electronic shutters in photographic applications, as optical switches (light gates) or as variable transmission windows.

At higher voltage levels, the device has also been used as a colour filter. White light passing through a thin sandwich of the ceramic (provided with patterned electrodes) between two polarisers emerges as a mono-coloured light when specific voltage pulses are applied to the various cells in the ceramic. Each pulse aligns the dipoles in the ceramic in the direction of the electric field and across the path of the incoming light. The greater the initial applied field, the greater the dipole alignment. The voltage pulses required are precise (eg, +90, -30 for red; +90, -30, -30 for orange; +90, -30, -30, -30 for yellow; +90, -30, -30, -30, -30 for white) with typical switching times of 100 uS per pulse. Faster switching is possible by using higher voltages. ●



Principle of colour filter application

PIÈCE de RÉSISTANCE

"OHM my God!" wrote one entrant to our resistor cube problem — ETI, August issue — "if that's what you call making a problem a bit harder, I'd hate to attempt one you'd really stiffened up".

However, despite similar comments from many of the 241 entrants, the correct answer of 122 ohms was submitted by a total of 39 readers. The names of the lucky first ten are listed on page 25 and their free one year's subscription will start from the November issue. To the other 29: our apologies for not being able to extend our bounty!

To all the entrants: thank you so much for your response, your efforts and your enthusiastic comments! A breakdown of the entries is given on page 26.

Complete Kirchoff Solution
(Assuming 100 volts applied)

Junction Point	Voltage	Resistor	Current (Amps)	Voltage Drop
A	100	R1	0.342	34.2
B	65.8	R2	0.134	24.1
C	41.7	R3	0.144	17.2
D	58.9	R4	0.274	41.1
E	55.2	R5	0.204	44.8
F	34.6	R6	0.208	31.2
G	0	R7	0.278	41.7
H	43.3	R8	0.130	15.6
		R9	0.137	20.6
		R10	0.197	34.6
		R11	0.346	43.3
		R12	0.066	11.9

Star Delta Transform
Resistance Values

R13	400	R19	553	R15	145	R31	414
R14	333	R20	664	R26	196	R32	812
R15	600	R21	453	R27	110	R33	390
R16	420	R22	205	R28	567	R34	991
R17	420	R23	208	R29	548	R35	496
R18	336	R24	257	R30	401	R36	424

Note: Rounding off all resistor values to nearest ohm gives answer of 122 ohms.

A problem of this nature can only be solved by Ohm's Law if symmetry exists. For example consider the Wheatstone bridge shown in Fig. 1. If all resistors are the same value, and assuming a voltage applied to the bridge, then by symmetry the voltages at points A and B will be equal and hence no current will flow in R5 and it therefore may be disregarded. Thus the network would simplify to that shown in Fig. 2, and the total resistance may be calculated from the series/parallel combinations.

If symmetry does not exist, points A and B would be at different potentials and the above simplification could not be used.

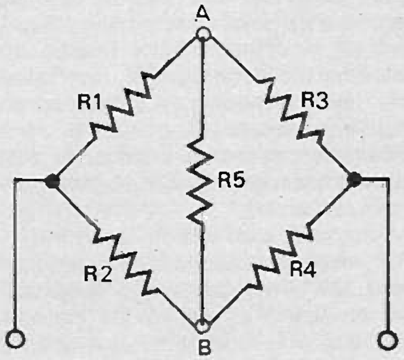


Fig. 1. Wheatstone bridge.

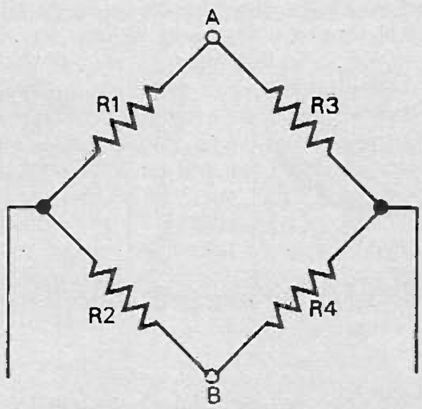


Fig. 2. R5 may be deleted from bridge if symmetry exists.

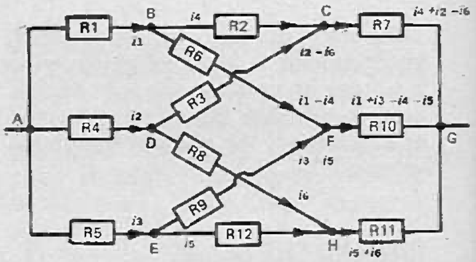


Fig. 3. The resistor cube redrawn in one plane for clarity.

There are several basic methods of solving assymetrical networks such as that in Fig. 1. These include Kirchoff's Laws, and the Star Delta Transformation theorem.

KIRCHOFF'S LAWS

Kirchoff's Laws are:—

1) The sum of the current flowing into and out of any point in a network is zero.

2) The sum of the voltages between any two points in a network is the same regardless of the path traversed.

The resistor cube may be seen to be a three dimensional version of Fig. 1. For clarity we have redrawn it as shown in Fig. 3.

Using Kirchoff's First Law we assume:—

A current
- i_1 flows through R1
- i_2 flows through R4
- i_3 flows through R5
- i_4 flows through R2
- i_5 flows through R12
- i_6 flows through R8

Then

$i_1 - i_4$	flows through R6
$i_2 - i_6$	flows through R3
$i_3 - i_5$	flows through R9
$i_2 + i_4 - i_6$	flows through R7
$i_1 + i_3 - i_4 - i_5$	flows through R10
$i_5 + i_6$	flows through R11

Using Kirchoff's Second Law and assuming 100 volts across the points A to G we may say that where V_D equals voltage drop.

WINNING ENTRIES

	Answer	Method		Answer	Method
W Haywood Mansfield Woodhouse Notts	121.82	Star-Delta Transform	D D Chawthe Birmingham	121.93	Kirchoff and sequential elimination
P Calvert Bangor, Co Down N Ireland	122	Star-Delta Transform	P Robson Harlow Essex	122	Star-Delta Transform
R E Bassett Manchester	121.96	Kirchoff solved by IBM-1130 computer	J A Dardis East Barnet Herts	121.962	Kirchoff and Cramer's Rule
P A O'Connell Basingstoke Hants	121.96	Star-Delta Transform	G L G Jeans Burnham-on-Sea Somerset	122	Star-Delta Transform
R Schragge Darmstadt W Germany	121.962	Network theory, Matrix and determinants	E Tweedly Kirkfieldbank Lanark	122	Star-Delta Transform

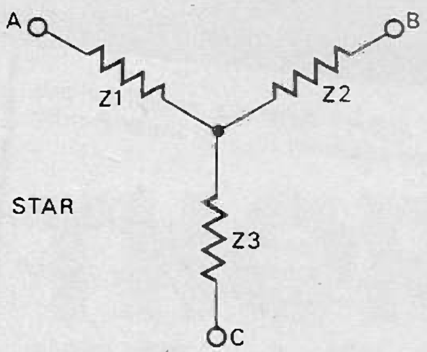


Fig. 4a. Star network.

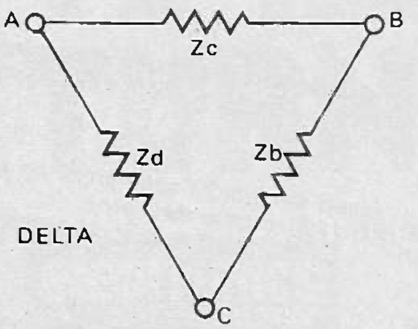


Fig. 4b. Delta network.

$V_D R1 + V_D R2 + V_D R7 = 100$

and since V = IR we get:—

$100i_1 + 180i_4 + (150i_2 + 150i_4 - 150i_6) = 100$

Which simplifies to:—

$100i_1 + 150i_2 + 330i_4 - 150i_6 = 100$ (path R1, R2, R7). Similarly by using all the possible independent paths from A-G, we obtain six equations.

$$100i_1 + 150i_2 + 330i_4 - 150i_6 = 100$$
$$350i_1 + 100i_3 - 250i_4 - 100i_5 = 100$$
$$420i_2 + 150i_4 - 270i_6 = 100$$
$$150i_2 + 220i_5 + 340i_6 = 100$$
$$100i_1 + 470i_3 - 100i_4 - 250i_5 = 100$$
$$220i_3 + 400i_5 + 220i_6 = 100$$

We now have six simultaneous equations in six unknowns which are most easily solved by use of determinants/matrix methods or more laboriously by traditional algebra. We only require to know the total current from A to G and this is the sum of i_1, i_2 and i_3.

These are i_1 = .34217761 amps
i_2 = .27402335 amps
i_3 = .20372400 amps

but adding these and dividing into 100 ($R = \frac{E}{I}$) we get 121.96238 ohms from A-G.

We also checked the result using a programme on our Honeywell computer to solve the six simultaneous equations.

Many readers, when redrawing the network, considered that there was symmetry. However this is not the case. No simplification of the problem by this means is possible.

STAR-DELTA TRANSFORMS

The second method, although still laborious, is perhaps easier to use if you do not understand advanced methods of solving simultaneous equations.

The Star Delta Transformation Theorem may be stated as follows:—

Any Delta (Pye) network may be replaced by an equivalent Star (Wye) network without upsetting operation. And conversely — any Star network may be replaced by an equivalent Delta network. That is, if we have a network between points A, B and C as shown in Fig. 4a, it may be replaced by that in Fig. 4b.

The transformation formulae are:— Star to Delta

$$Zc = \frac{Z1 \times Z2 + Z1 + Z2}{Z3}$$

$$Za = \frac{Z1 \times Z3 + Z1 + Z3}{Z2}$$

$$Zb = \frac{Z2 \times Z3 + Z2 + Z3}{Z1}$$

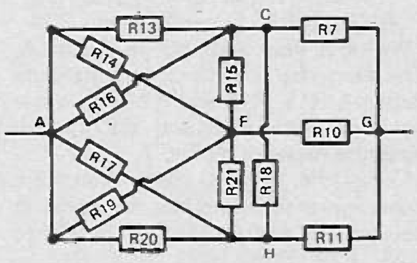


Fig. 5. The network after three star to delta transforms.

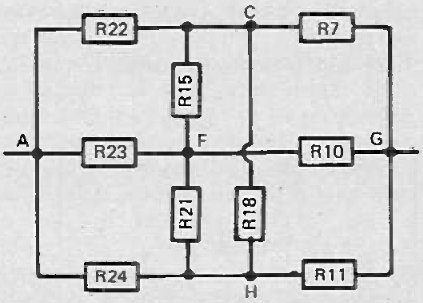


Fig. 6. After eliminating paralleled resistors.

STATISTICS OF ENTRIES

Entries received: 241

Correct answers: 18 to within 0.1%
14 to within 1%
7 without details of method used

Methods Used	Total	Correct
Kirchoff's Laws	31	9
Star-Delta Transforms	86	17
Network theory, matrix equations and determinant analysis	9	2
Sundry — Parelleling, simplification, Thevenin theorem, Unspecified or not detailed	115	11

Correct answer: 121.962 ohms

Most common incorrect answers:
77 (±2) ohms in 9 entries;
118 (±2) ohms in 27 entries;
128 (±3) ohms in 8 entries.

Computer usage in solving matrixes or simultaneous equations:
4 entries; 3 correct.

Lowest answer: 1 ohm

Highest answer: 1055 ohms

Delta to Star

$Z1 = Z_aZ_c/(Z_a+Z_b+Z_c)$

$Z2 = Z_bZ_c/(Z_a+Z_b+Z_c)$

$Z3 = Z_aZ_b/(Z_a+Z_b+Z_c)$

Now referring again to Fig. 3 we may transpose the three networks at points B, D and E from star to delta.

Thus we transpose

R1,R2,R6 to R13,R14 and R15
R3,R4,R8 to R16,R17 and R18
R5,R9,R12 to R19,R20 and R21

and obtain the network of Fig. 5.

Now we find that

R13 and R16 in parallel gives R22
R14 and R19 in parallel gives R23
R17 and R20 in parallel gives R24

We now have reduced to Figure 6. The next step is to transform the delta network R15, R18 and R21 into a star network R25, R26 and R27 which gives the network of Fig. 7.

Using the star to delta transform three more times on the networks at points C, H and F, (R22, R25, R27 to R28, R29, R30) (R23, R26, R10 to R31, R32, R33) (R24, R27, R11 to R34, R35, R36). gives us Fig. 8. which is a simple series parallel network.

Although as said before, the method is cumbersome, it does move step by step and is easier if your mathematics are shaky.

We ran a computer programme for this method also and obtained the same answer as for the Kirchoff method. As a point of interest, the computer running time was 35 seconds for the simultaneous equation programme, and three seconds for the star delta transformation.

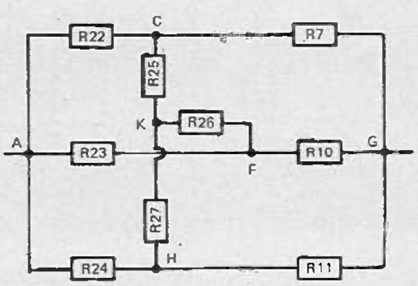


Fig. 7. A delta to star transform gives this result.

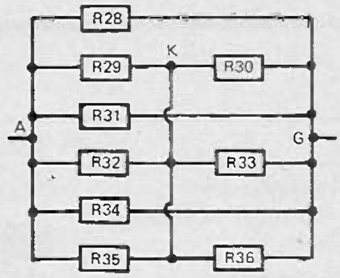


Fig. 8. Three more star to delta transforms give a simple network which can be resolved by Ohm's Law.

THE TEN OHM CUBE

Now to return to the cube with 10 ohm resistors in each leg. Due to symmetry, points B, D and E are at equal potentials, as are points C, F and H. These points may therefore be joined giving R1, R4 and R5 in parallel (3.33Ω), R2, R6, R3, R8, R9 and R12 in parallel giving (1.67Ω) and also R7, R10 and R11 in parallel (3.33Ω). As all these groups are in series, the total resistance is 8.33 ohms. This problem is indeed a simple one — as we said. ●

The numbers involved in using Kirchoff's laws are not easily managed without the use of a calculating machine.
—M P Constantine, Kent

It would be harder if no two resistors had the same value and if the resistance was required between A and any other point.
—P G Faulkner, Herts

How about a regular monthly problem of this nature?
—G E Lewis, Glamorgan

More problems, please — not necessarily with prizes attached!
—J I Lewis, Middlesex

Without a computer, it is an evil thing to solve!
—B Spohr, W Germany

Thanks for the opportunity to test my own knowledge.
—D J Chamberlain, Essex

I am not at all sure it is right but this is how I solved it.
—T G Kearey, Herts

Thank you for an intriguing problem.
—M Ash, Surrey

I suspect there is a general for this type of circuit.
—J Smith, Penrith

Even if I do not win, I shall still get ETI each month.
—E C Wright, Ipswich

I used a manual calculator and took 3 hours.
—K Khoury, Cornwall

You have favoured people with access to a computer.
—M W King, Berks

I used the SIMQX sub-routine on an IBM 1130 to solve the matrix.
—R E Bassett, Manchester

I hope there wasn't a more direct method.
—M P Dyer, London

The answer was the same using 'an AVO adn handful of resistors — I've tried it!
—P O'Connell, Hants

I solved the six equations by Cramer's Rule which has the distinct advantage that each current is calculated independently.
—J A Dardis, Herts

THORENS MODEL TD 125 TURNTABLE

electronics TODAY INTERNATIONAL
product test

This top-quality turntable uses a Wien-bridge oscillator circuit to maintain constant, yet adjustable speed.

THE Thorens model 125 turntable is electronically speed controlled and is manufactured under licence in West Germany. Thorens have been producing studio quality transcription turntables for over two decades and this company's reputation for quality has ensured product sales to both professionals and amateurs alike.

The TD125 is available in UK without the cartridge only. The Mk II model is supplied without, and the A/B model with, the tone-arm, base and cover. The unit tested came complete with base and tone arm, but no cover. The cover, we feel, is necessary as protection from dust fall out is essential, even during a protracted evaluation and testing for review.

The unit supplied was well packed in a partially dissassembled state. Only the head shell needs to be plugged in and the turntable installed, to prepare the unit for immediate use. The signal leads, two metres long, are fitted with a pair of moulded R.C.A. coaxial plugs. The mains lead also two metres long, is terminated by a moulded German two pin plug. A separate

THORENS MODEL TD 125 TURNTABLE

earthing lead is supplied which for safety reasons must be used.

The turntable base has separate vibrational isolation from the operational controls, these controls are located on a brushed aluminium panel 1-5/8" wide extending across the full front width of the polished timber base. The control panel which forms part of the base, is independent of the spring mounted turntable and tone arm base, so that operation of controls does not impart any movement to the turntable tone arm thus providing excellent protection against damage to the record stylus.

The controls are unusual, have an impressive appearance, and consist of three slide bars 2" long by 1" wide by ¼" high, which move parallel to the front panel. Each slide bar is moulded from black plastic with a brushed aluminium top. Speed selection is performed by moving the extreme left hand slide bar to one of three positions:— 16-2/3 rpm on the left, 33-1/3 rpm in the centre, or 45 rpm on the right. The next slide bar, which is located to the right of the strobe light and speed control potentiometer, is the power on-off switch. The third slide bar operates the arm lift, and is mounted to the left of the name plate at the right hand end of the panel.

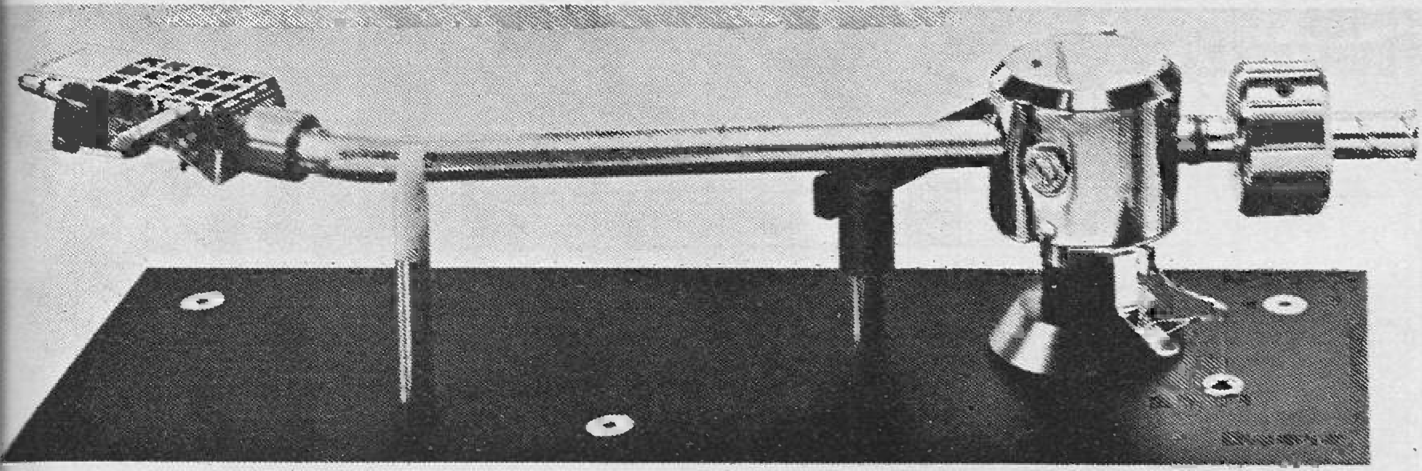
A potentiometer driven by a knurled wheel located on the front panel adjusts turntable speed. This adjustment is performed whilst viewing a stroboscope through a front panel window and prism lens assembly.

The stroboscope has four sets of markings: two for 50Hz operation and two for 60Hz operation. One pair of markings is for the 45 rpm speed, the other pair for both 16-2/3 rpm and 33-1/3 rpm operating speeds. Speed changes are effected by changing the frequency of a Wien bridge oscillator which drives the sixteen pole synchronous motor. The nominal motor drive frequencies are 50Hz, 37Hz and 18.5Hz with resultant motor speeds of 370 rpm, 274 rpm and 137 rpm respectively. Once a speed has been selected, and correctly adjusted by the potentiometer, further adjustments for any other speed are unnecessary due to the accurate switched frequency ratios of the oscillator. In fact, having initially adjusted the speed in the laboratory, it was not found necessary to make further corrections even though the unit was used at various speeds every day for over four weeks.

Adequate power for the motor is provided by a push-pull power amplification stage included between the oscillator and the motor. Another interesting feature is the use of switched phase shift capacitors, which are changed by the speed selector to obtain maximum motor torque at each speed setting.

The drive from the motor is taken via a Delrin pulley and a damped rubber belt to the diecast inner turntable support ring which is spigotted to take the diecast turntable. Both the inner support plate and the turntable are balanced and machined on both the top faces and edges. The turntable and tone arm are mounted on a diecast base supported by three high deflection spring mounts, providing extremely good isolation. Maximum isolation is obtained at the expense of isolator damping and this is most noticeable with this base arrangement. The base can be readily set into oscillation by removing the tone arm from its rest clamp or by any severe movement of the timber base. Once this happens it is necessary to wait till the oscillations die down before a record can be played with safety.

The three isolation springs are housed in knurled plastic retainers, which can be screwed in or out so that the turntable base may be levelled. Thorens recognise the problems which can occur in an environment where



usage is "rough" and offer an alternative rubber grommet isolator, which, whilst not providing good isolation, does allow heavy handed operation of the unit.

The cast base is finished in light grey under the turntable and has a matt black panel under the tone arm.

The printed circuit boards, 16 pole synchronous motor, power transformer, power transistors and fuse boards are all mounted on a heavy 10 gauge chemically treated steel panel mounted below the cast turntable base. This panel also contains the three spring mounts supporting the turntable base and a terminal strip for the tone arm leads.

The printed circuit board, which measures approximately 10" x 5", has been etched with the following information:–

a) reference voltages at selected points in the circuit
b) base, collector, and emitter points
c) output terminals and colour codes
d) positive connections for all electrolytic capacitors.

All switching contacts on the boards are gold plated to provide low noise and trouble free operation. The board contains seven tab potentiometers for frequency and voltage adjustment, five low-power transistors, an encapsulated full-wave bridge rectifier, resistors, two air wound inductors, and numerous electrolytic and polyester capacitors. The two large pnp germanium power transistors, type AD 149, are mounted on the 10 gauge steel panel, which provides more than adequate heat dissipation. Mains voltage selection is effected by changing fuses and is very simple, yet foolproof, due to the different fuse lengths used for 117V and 240V volt supplies.

The tone arm used on the turntable supplied to us was a Thorens TP.25. This is very similar in design to the Thorens tone arms used over the past few years. We, therefore, were interested to find out how good it was by modern standards. Performance was good in terms of anti-skating and transverse friction characteristics even though the anti-skate device is an updated version of the fishing line and sinker principle.

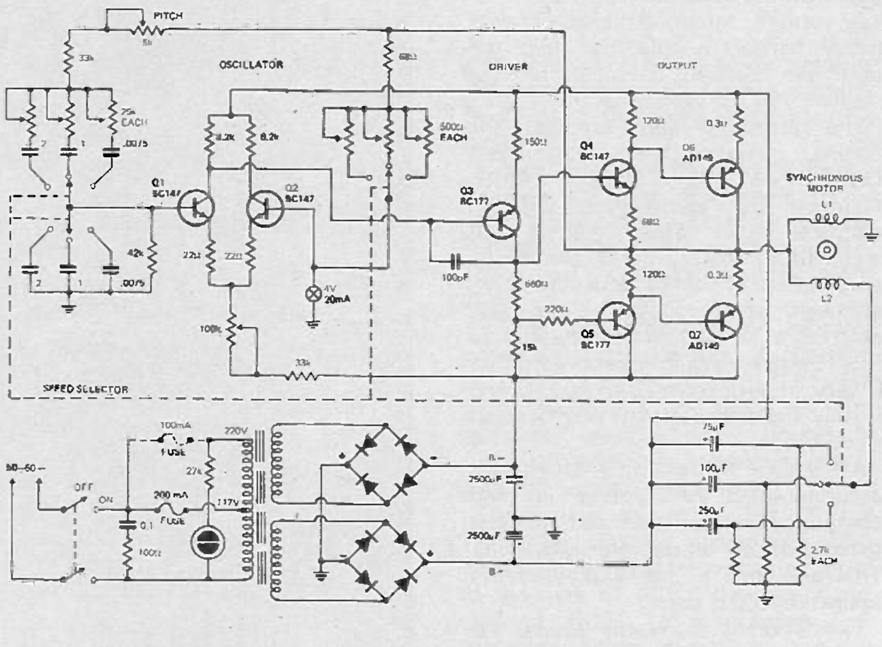
We decided, as a final check, to find out what effect arm resonance had upon performance. To do this we mounted a miniature accelerometer on the arm itself. To excite the arm into resonance a 45 rpm test record was used at 16-2/3 rpm giving a frequency range of 5.3Hz to 5.3kHz (20Hz to 20kHz at normal speed).

The output from the accelerometer and the output from both channels were then monitored to determine performance. The first, and only significant resonance, occurred at 9Hz (as measured by the accelerometer), but its effect was barely noticeable on the output from the cartridge. In all respects the Thorens tone arm was equal to the task and consistent in quality with the system as a whole.

The design of the tone arm is fairly conventional, being a balanced arm with a screw type counter weight, and an anti-skate weight fixed via a nylon thread to a small arm on the side of the tone arm support gimbal. The arm is designed to accept heavy cartridges and therefore may require an additional weight installed in the head shell when using a light cartridge such as the Ortofon MI5E.

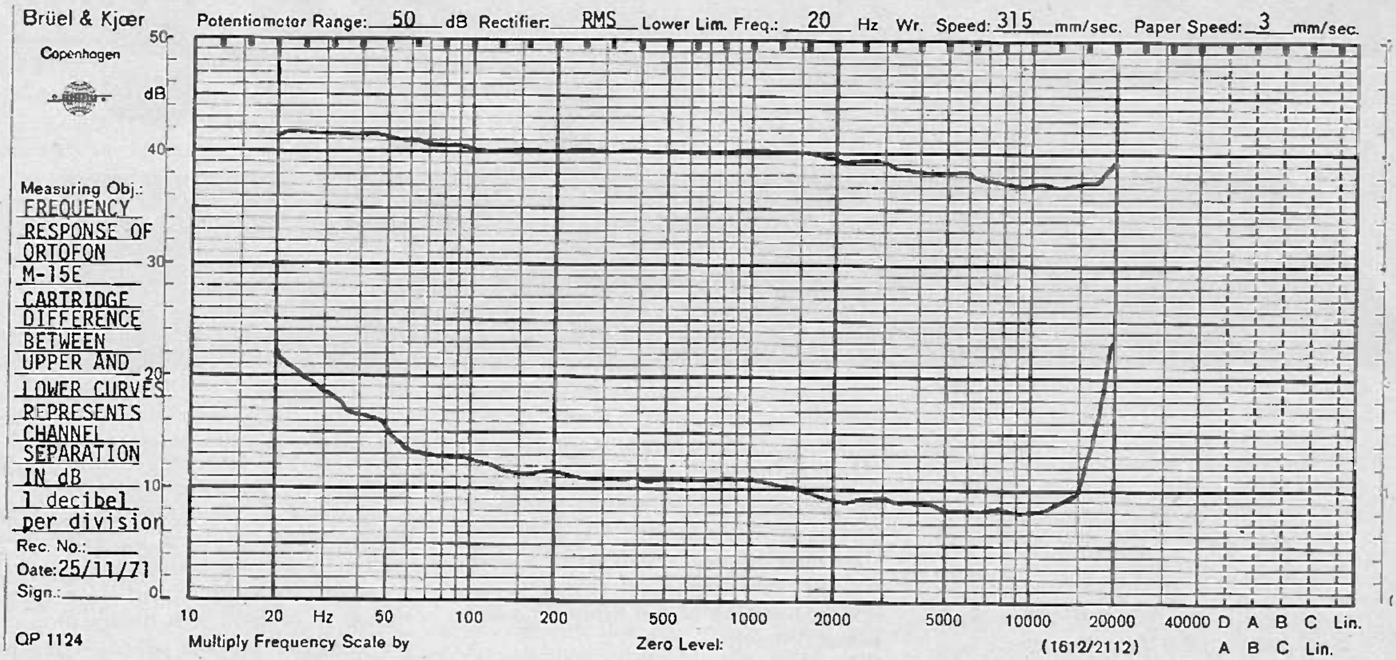
Once the arm has been balanced the desired tracking weight can be selected by moving a small lever on the left hand side of the support head. The lever is calibrated at ½ gram increments and applies the load by tensioning a spring. The arm itself is constructed from a polished aluminium tube, and is fitted with a plug in head shell designed to take most cartridges with standard ½" mounting centre.

Stylus, overhang, and tracking angle



This is the circuit of the Thorens 125 constant speed motor drive.

THORENS MODEL TD 125 TURNTABLE



can be readily adjusted by screws on the head shell which allow the mounting plate to move in or out and to tilt up or down; a necessary feature that is not found on many tone arms.

Another feature is the tone arm lift which not only has a smooth, well damped movement, but is also fitted with a rubber pad on the top edge so that the tone arm will not readily slide across it.

One problem we found was that there is no automatic cut-off and, because the unit is so silent, we usually did not notice for some time that the stylus was in the run-out groove, and with clean records a few hours could pass with the noise undiscerned.

A further, minor criticism, is that heavy handed people may find the unit too delicate because of the resiliency of the mountings.

The turntable was supplied for testing complete with the latest Ortofon M 15E cartridge, which features low compliance and an elliptical stylus. This stylus is well matched to the turntable due to its very good tracking characteristics, although some sibilance was just noticeable on certain records due to slight mistracking. Frequency response is very smooth from 20 to 20 kHz and is only bettered by a few other brands of cartridge.

A 19 page instruction manual gives accurate data for setting up and operating the turntable and includes specific details on cartridge alignment. The unit has a one year warranty against defective parts.

The Thorens Turntable Model TD 125 has a very pleasing and uncluttered external appearance, which is matched by an equally exceptional mechanical performance. The incorporation of an electronic speed control system is a worthwhile addition resulting in a turntable with well balanced performance characteristics. By and large we found this unit was a delight to use and its technical performance was exemplary in every respect.

We consider that this turntable is equal to the best that we have ever seen and should maintain Thorens untarnished reputation for many years to come. ●

MEASURED PERFORMANCE OF THORENS MODEL TD 125 TURNTABLE

Turntable			
Wow and Flutter	–	45 rpm	0.15% rms
	–	33-1/3 rpm	0.15% rms
Hum and Rumble Equalised (unweighted re 1kHz at 5 cm/sec)			–47dB
Speed Adjustment		+2%	–2.5%
Turntable Weight		7.2 lbs	
Pick Up Arm			
Transverse Friction		less than 0.1 gram	
Arm Resonance Frequency			9Hz
Cartridge			
(Ortofon M15E) Frequency Response			20Hz to 20kHz $^{+2}_{-3}$ db
Channel Separation at 1kHz			29dB
Channel Difference at 1kHz			0.4dB
Output re 1kHz at 5 cm/sec			4mV
Cartridge Impedance			1.1kΩ
Signal-to-Noise Ratio of complete system (re 1kHz 5cm/sec)			39dB

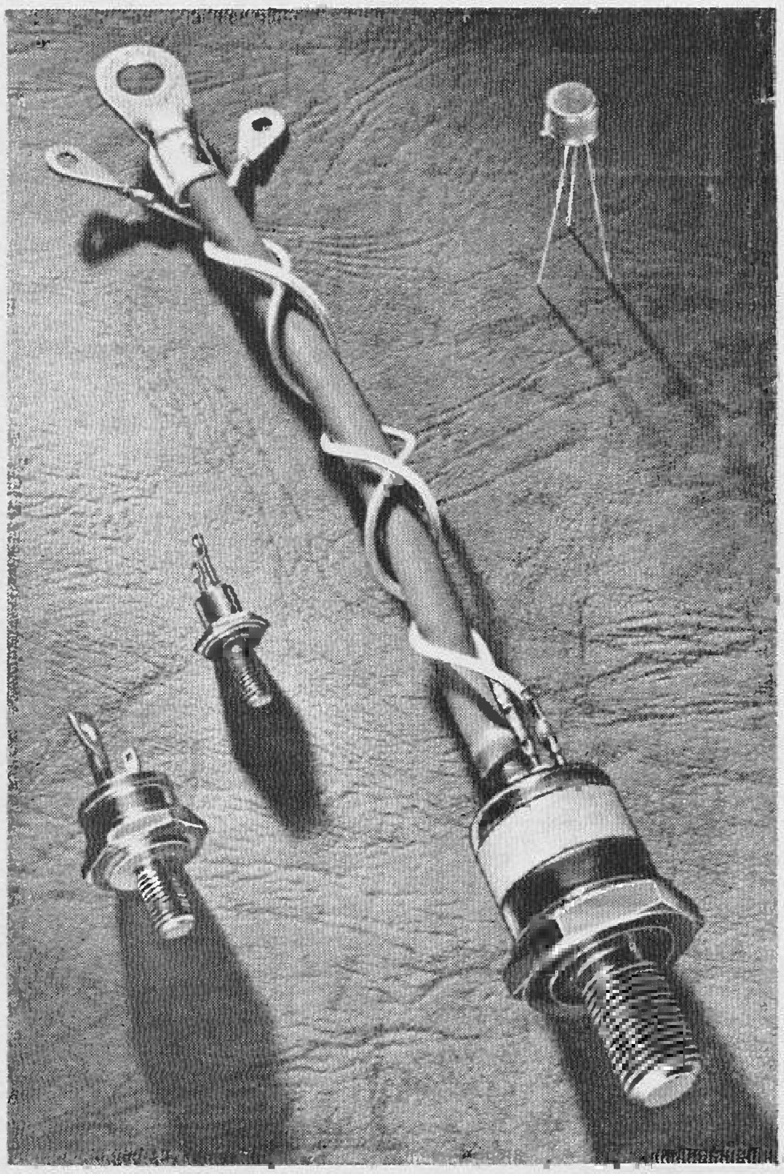
Dimensions, 18-3/8" long x 14-1/4" deep x 5-1/2" high over tone arm.

Price, TD 125A/B around £105 excluding cover and cartridge.

A PRACTICAL GUIDE TO SCR's

PART II

In the second part of the series Collyn Rivers describes how SCR's are used in switching, timing, and logic and phase control circuits.



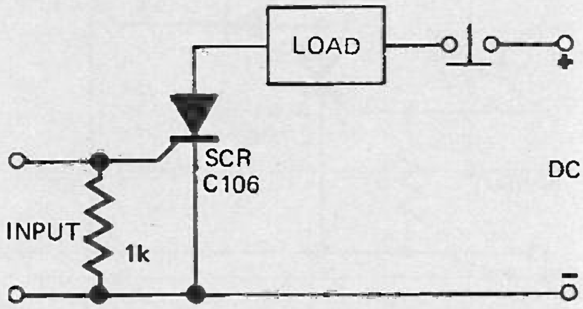


FIG. 1

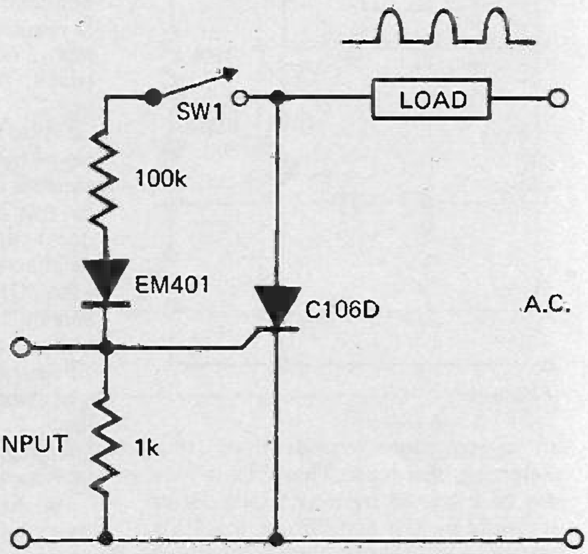


FIG. 2

SCR's may be used to simulate common relay configurations, Figs. 1 through 5 show how this can be done.

Figure 1 shows how an SCR can simulate a single pole single throw latching contact. A positive input to the gate of the SCR activates the load. The circuit is deactivated by the 'reset' switch.

An ac energized version of this circuit is shown in Fig. 2. Here, a positive input (or closure of SW1) will cause the load to be energized with half-wave rectified dc. Reset is automatic when the triggering signal is removed (or SW1 is opened).

The circuit shown in Fig. 3 is a 'normally closed' version of that shown in Fig. 2. Here a positive input to the gate of SCR1 shorts out the gate of SCR2, thus preventing it triggering. When the input signal is removed, SCR1 switches off and SCR2

A PRACTICAL GUIDE TO SCR's

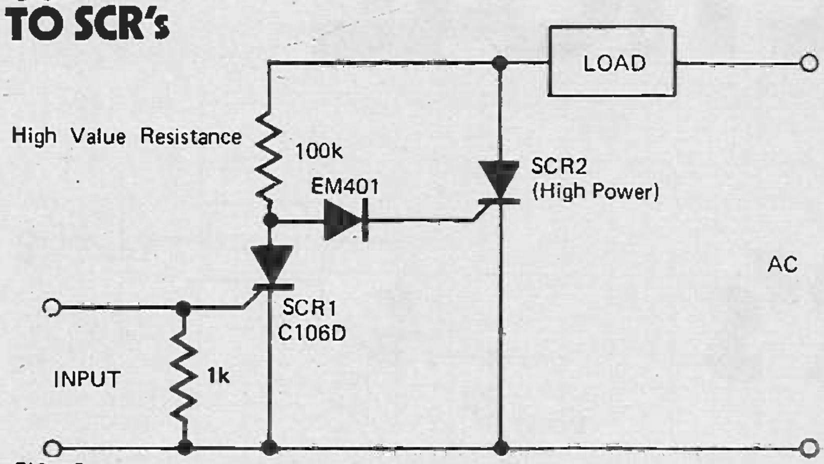


FIG. 3

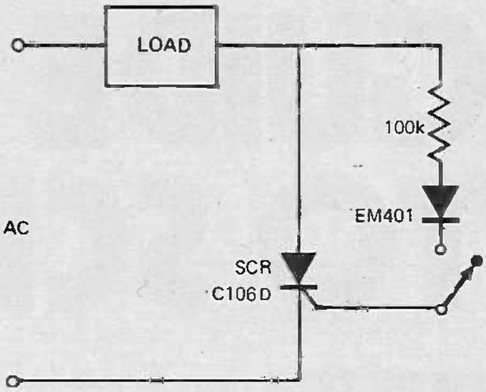


FIG. 4

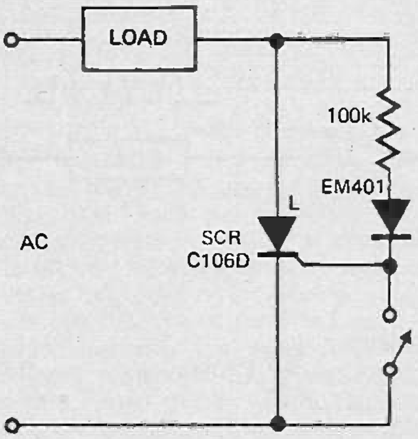


FIG. 5

is biased into conduction thus energizing the load. This circuit may also be triggered by a switching device – simply by the addition of the 100k resistor and EM401 diode shown in Fig. 2.

Figure 4 shows how an SCR may be triggered (via a switch) by energy derived from the ac supply. The circuit shown in Fig. 5 is a variation of Fig. 4, the difference being that the switch shown in Fig. 5 causes the SCR to switch 'off' when closed.

It is important to appreciate that the circuits shown in Figs. 2, 3, 4 and 5 will cause half-wave rectified dc to be supplied to the load.

Full-wave operation may be obtained by connecting the SCR's within a full-wave rectifier bridge as shown in Fig. 6. Both ac and dc loads may be switched using this type of circuit, but unless the circuit is being used to take advantage of the low gate current triggering capabilities of small SCR's, it is generally more satisfactory to use Triacs if full-wave switching is required.

LOGIC OPERATIONS

The 'on-off' (or binary) nature of the SCR makes it an ideal device for low-speed logic circuitry in applications where large power output is required. They may be used to drive high current relays, incandescent lamps, fractional horse-power motors etc.

Figure 7 shows how a pair of C106s may be used as an 'AND' circuit capable of switching up to four amps. In this circuit, unless inputs 1 and 2 occur simultaneously, no voltage can exist across the load.

An 'OR' gate, again using C106s, is shown in Fig. 8. Here, an input to either 1 or 2 will energize the load.

Figure 9 shows a triggered multivibrator – an input to 1 energizes load 1. A subsequent input to 2 energizes load 2, thus turning off SCR1 and de-energizing load 1.

The circuit shown in Fig. 10 is a 'one shot' or pulse generator. Here an incoming signal triggers the SCR and energizes the load. The load voltage energizes the UJT timing circuit. After a time determined by R1/C1, the UJT fires, and a pulse generated across R2 is coupled to the cathode of the SCR through D1 and C2. The SCR's cathode is momentarily lifted above the anode voltage and the SCR turns off.

A pulse generating circuit, suitable for use as a car, boat or warning flasher, is shown in Fig. 11.

This circuit will operate reliably from noisy or fluctuating power supplies – and unlike many multivibrator circuits – is inherently self-starting when power is applied. In this circuit unijunction transistor Q1 is used as a relaxation oscillator supplying a continuous train of pulses to the gates of the SCRs. Assume that SCR2 has been triggered into conduction and that lamp 2 is energized. The next trigger pulse from Q1 triggers SCR1, this discharges C2 and the resultant commutation pulse turns off SCR2. The resistor R2 in the anode of SCR1 is of a value high enough to prevent SCR1 from latching on. SCR2 is retriggered by the next triggering pulse from Q1. Using the component values shown, the flash rate of this circuit is adjustable – by R2 – from 35 to 150 flashes a minute.

TIMING CIRCUITS

The precision time delay circuit shown in Fig. 12 will provide accurate and repeatable time delays adjustable from a few milliseconds to a minute or two. This is a very flexible circuit in which the operating current and voltage depends only on the choice of SCR.

The timing sequence may be initiated either by applying power to the circuit – or by opening a shorting switch

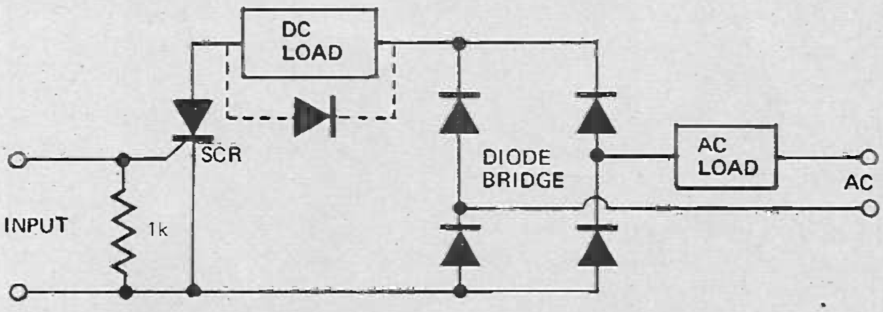


FIG. 6

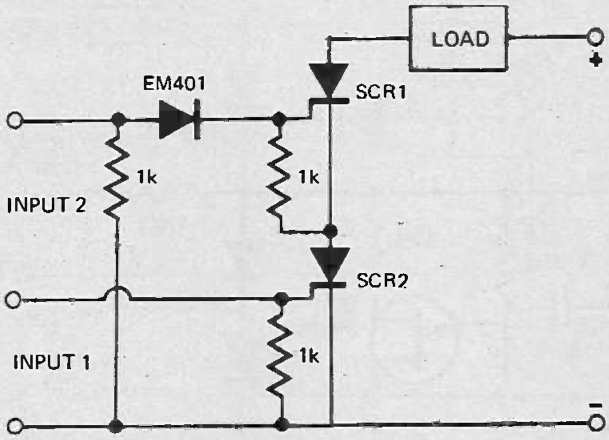


FIG. 7

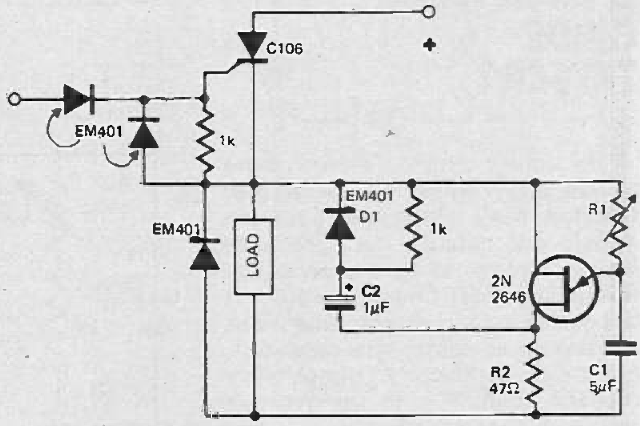


FIG. 10

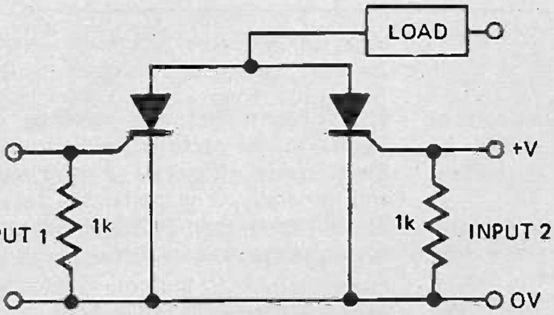


FIG. 8

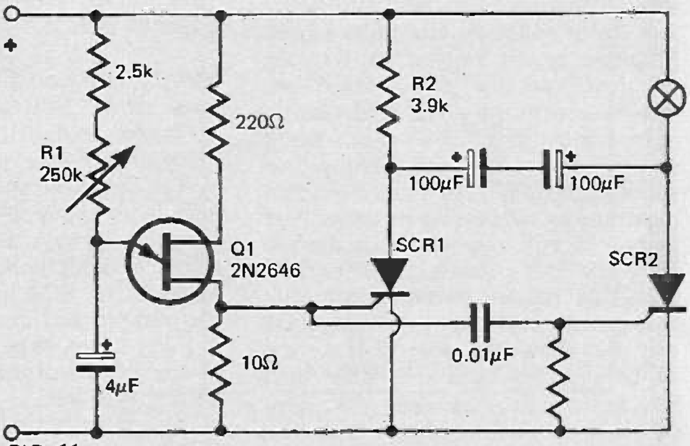


FIG. 11

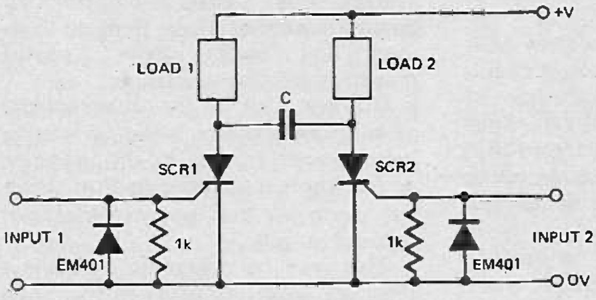


FIG. 9

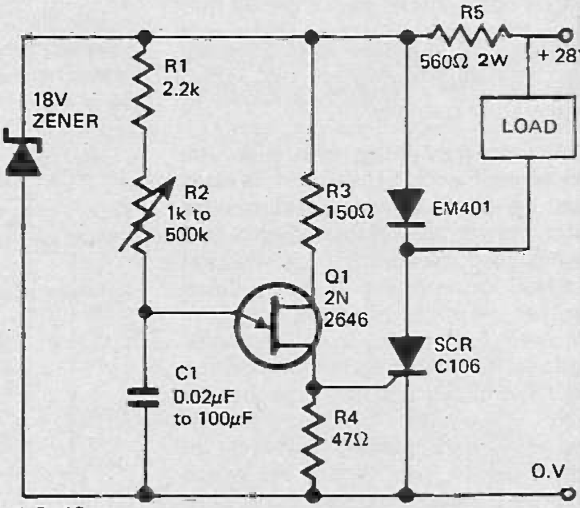


FIG. 12

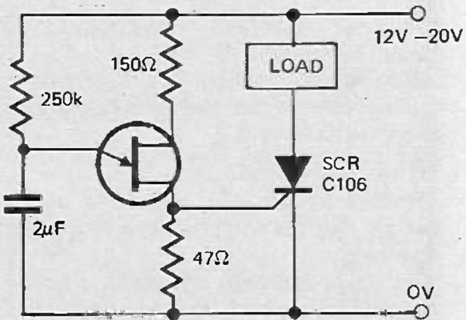


FIG. 13

wired across C1. Timing capacitor C1 is charged via R1 and R2 until the voltage across C1 reaches the peak point voltage of the UJT Q1. When this occurs, Q1 fires, generating a pulse across R4, triggering the SCR, and applying power to the load. Holding current for the SCR is provided via R5 and D1.

The circuit is reset by momentarily removing the supply voltage.

If the circuit is to be used in an application where both rapid cycling and accurate, repeatable timing is required – some provision must be made to ensure that C1 is discharged to zero before each timing sequence. This can most easily be done by interconnecting a pair of switch contacts with the reset system so as to momentarily short out C1 whenever the circuit is reset.

Temperature compensation for this circuit is provided by R3. Increasing the value of this resistor causes the circuit to have a positive temperature coefficient. It is possible to obtain zero coefficient over a small range of ambient temperatures by optimizing R3.

A simpler version of this time delay circuit is shown in Fig. 13. The supply voltage to the timing circuit is not Zener stabilized in this latter version, and because of this, repeatability is not as good.

A PRACTICAL GUIDE TO SCR's

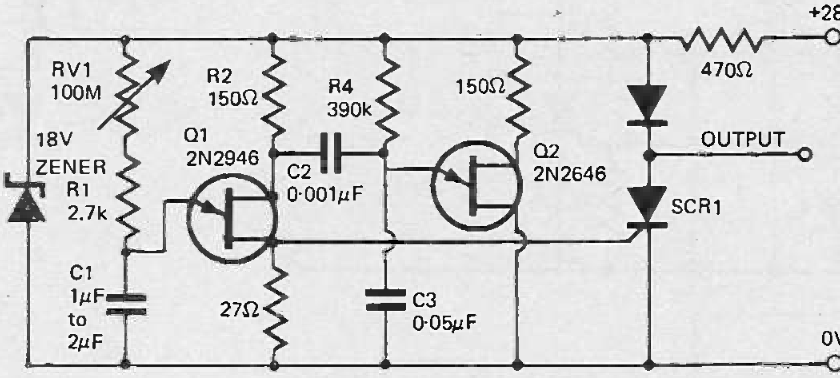


FIG 14

The timing circuits shown above provide delays which may be adjusted from less than a millisecond to approximately one minute. The upper time limit is determined by the amount of leakage in the UJT timing capacitors. It is possible to use special large value low-leakage computer type capacitors, but a more satisfactory (and certainly cheaper) solution is to use a circuit such as that shown in Fig 14.

This circuit will provide precise time delays from about ½ millisecond to several minutes — in fact by using a 2μF mylar capacitor as C1 and a 2000 Megohm timing resistor as R1, the circuit will provide delays of well over one hour with excellent repeatibility.

In operation, the peak point requirement of UJT Q1 is reduced to about 1/1000 of its normal requirement by pulsing its upper base with a ¾ volt negative pulse derived from the free running oscillator UJT Q2. This regular pulse momentarily reduces the peak point voltage of Q1 and thus allows the peak point current to be supplied from C1 rather than R1, as it would be with the more conventional circuits of this type. The pulse rate of oscillator Q2 is not very critical but it should have a period that is less than one fiftieth of the overall time delay. Resistor R2 may be adjusted to provide optimum temperature stability.

An unusual timing circuit is that shown in Fig 15. This circuit is often used in electrically powered stapling machines, impulse hammers etc, and causes load current to flow through the load for one complete half-cycle of the ac supply whenever SW1 is actuated (i.e. moved from its normal position (1) to energise-load position (2)). The circuit is arranged so that the SCR is always triggered at the beginning of a positive half-cycle of the ac supply, even though the switch may be closed randomly at any time during the previous two preceding half-cycles.

Resistor R1 and capacitor C1 should be chosen so that their series combination supplies just sufficient holding current for the SCR for one complete half-cycle.

PHASE CONTROL

Phase control is a technique used for varying the effective power input to a load.

It is a process of rapid on-off switching in which the ac supply is connected to a load for a controlled (but adjustable) fraction of each cycle.

The simplest form of SCR phase control is shown in Fig. 16. This is a very basic circuit and provides control only from SCR full-on (100% of half-wave output) to SCR half-on (50% of half-wave output).

The addition of one capacitor and one more diode **(Fig 17)** extends the range of the basic phase control circuit from SCR full-on (100% half-wave output) to SCR off (0% half-wave output). In this circuit, the values of R1 and C1 must be chosen to suit the characteristics of the particular type of SCR that is used.

By wiring a diode across the SCR **(Fig 18)**, the basic phase control circuit will provide a fixed half-cycle of power plus a variable half-cycle. Thus control can be obtained from full power to half power — but there will be a major dc component which will

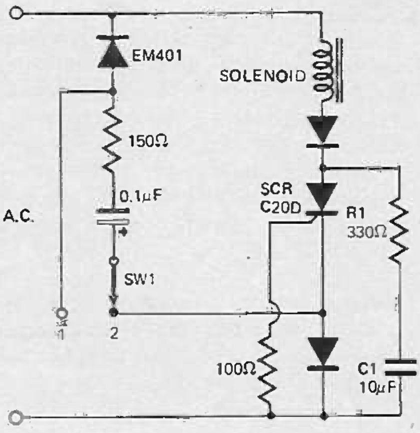


FIG 15

adversely affect many loads — especially inductive loads. In particular a half-wave control circuit should not be used to vary the power input to a transformer, variac, induction motor etc.

Full-wave control, over the full range from zero to maximum, may be obtained by connecting the basic control circuit inside a full-wave diode bridge. **(Fig 19)** This arrangement may be used to provide either controlled ac, or controlled and rectified dc. Losses in the rectifier bridge reduce the electrical efficiency of this circuit, and generally it is preferable to use Triacs rather than SCR's if full-wave control is required.

HALF-WAVE CONTROL FOR UNIVERSAL MOTORS

One of the most common applications for SCR phase control systems is speed control of commutator motors — such as those used for food mixers, sewing machines, pottery wheels etc.

However one of the disadvantages of controlling motor speed by varying input power is that as the effective power input is reduced to slow down the motor — the torque available is reduced as well.

This may be overcome by using a feedback signal to advance the firing

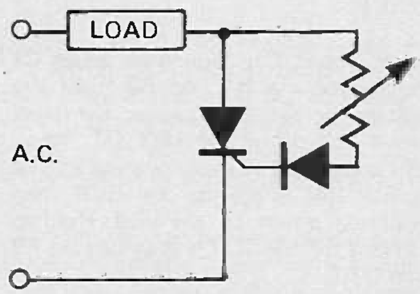


FIG.16

angle in proportion to the load on the motor — thus increasing the power input if more torque is required.

The circuit shown in Fig 20 achieves this load compensating function by deriving a feedback signal from the armature back-emf (produced by the residual field of the motor). In this circuit, the SCR is triggered when the voltage on the wiper arm of potentiometer R2 rises to a high

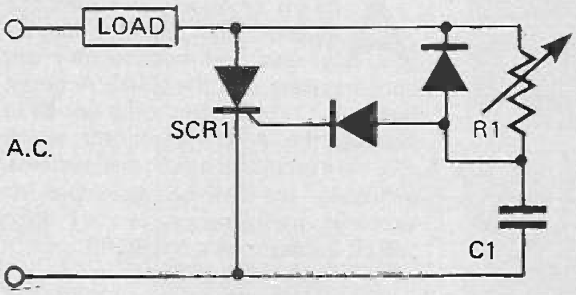


FIG 17

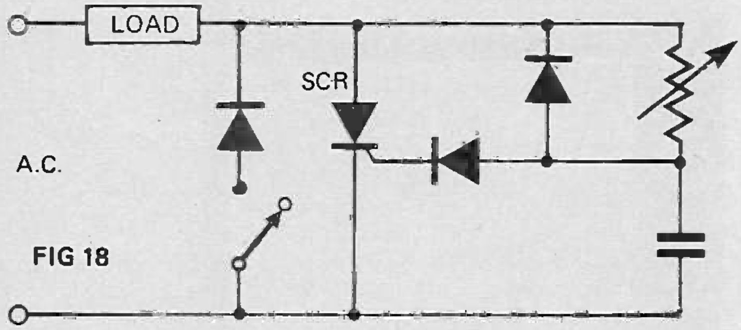


FIG 18

enough value to forward bias diode D2 — thus allowing gate current to flow. As the back emf tends to reverse bias D2, the firing point of the SCR depends largely upon the back emf and this in turn is a function of speed. If the motor is loaded, the speed reduces, thus also reducing the back emf — hence D2 becomes forward biased earlier in the cycle (triggering the SCR earlier in the cycle), and thereby supplying the motor with more power to offset the effect of the loading.

The component values shown in Fig 20 are suitable for most fractional horsepower motors — for optimum results it will be necessary to adjust component values to suit the motor used.

The circuit described above will provide stepless speed control over a wide range of motor speed — but tends to cause jerky operation at low speeds.

This tendency can be almost entirely overcome by using the circuit shown in Fig 21. As may be seen from the circuit diagram, it is necessary to bring out separate connections from the armature and field windings. This is generally a simple operation and providing it can be done the circuit will provide stepless speed control down to virtual standstill. In this circuit the 20V zener diode provides a constant voltage for the discharge of C1. Capacitor C2 and resistor R4 are connected from gate to cathode of the SCR to stabilize the circuit by preventing the SCR from being triggered by extraneous signals.

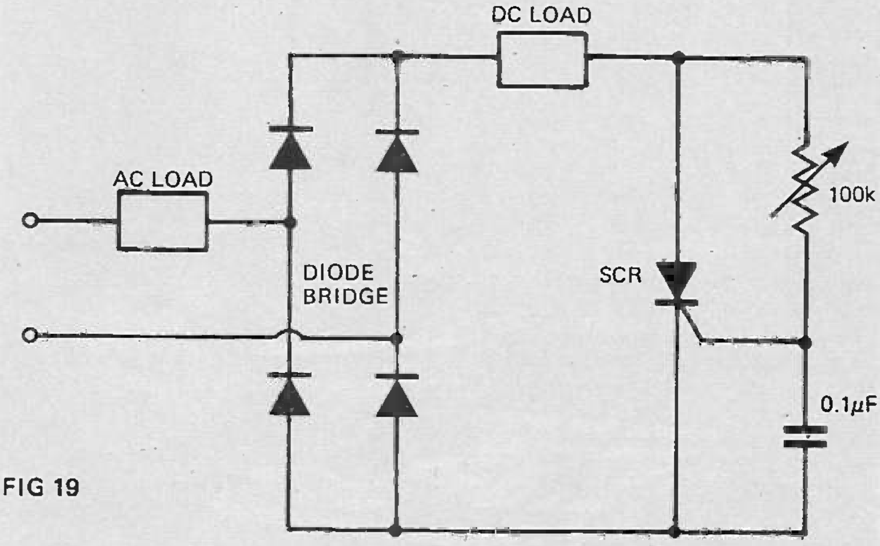


FIG 19

INDUSTRIAL APPLICATIONS

Silicon controlled rectifiers are in common use around the world for the control of very large dc motors — often using tachometer feedback control to provide speed regulation. These control systems are built in surprisingly large sizes and single units exceeding 50,000 h.p. are by no means uncommon.

Another common use for industrial SCR's is in the control of heating loads — and here again very large loads may be steplessly controlled.

These two applications are outside the scope of an article of this nature — however we shall be publishing technical articles describing large scale SCR drive systems and also temperature control systems later this year.

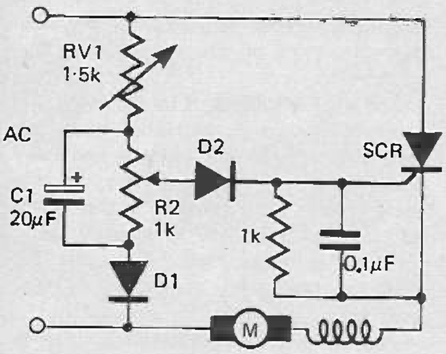


FIG 20

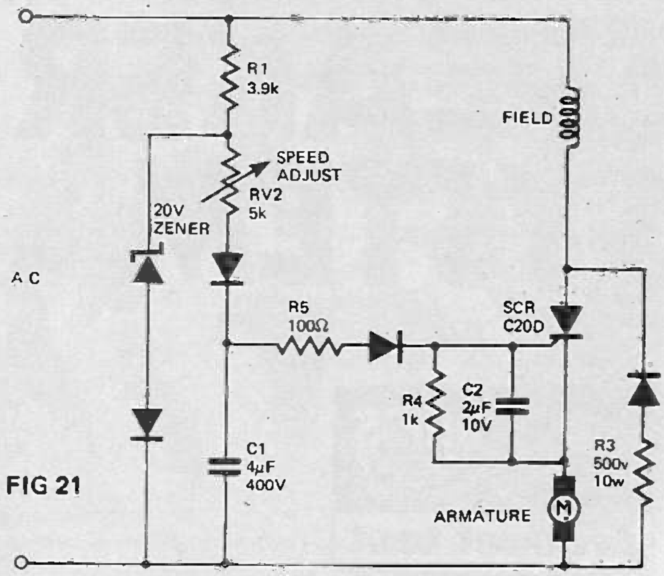
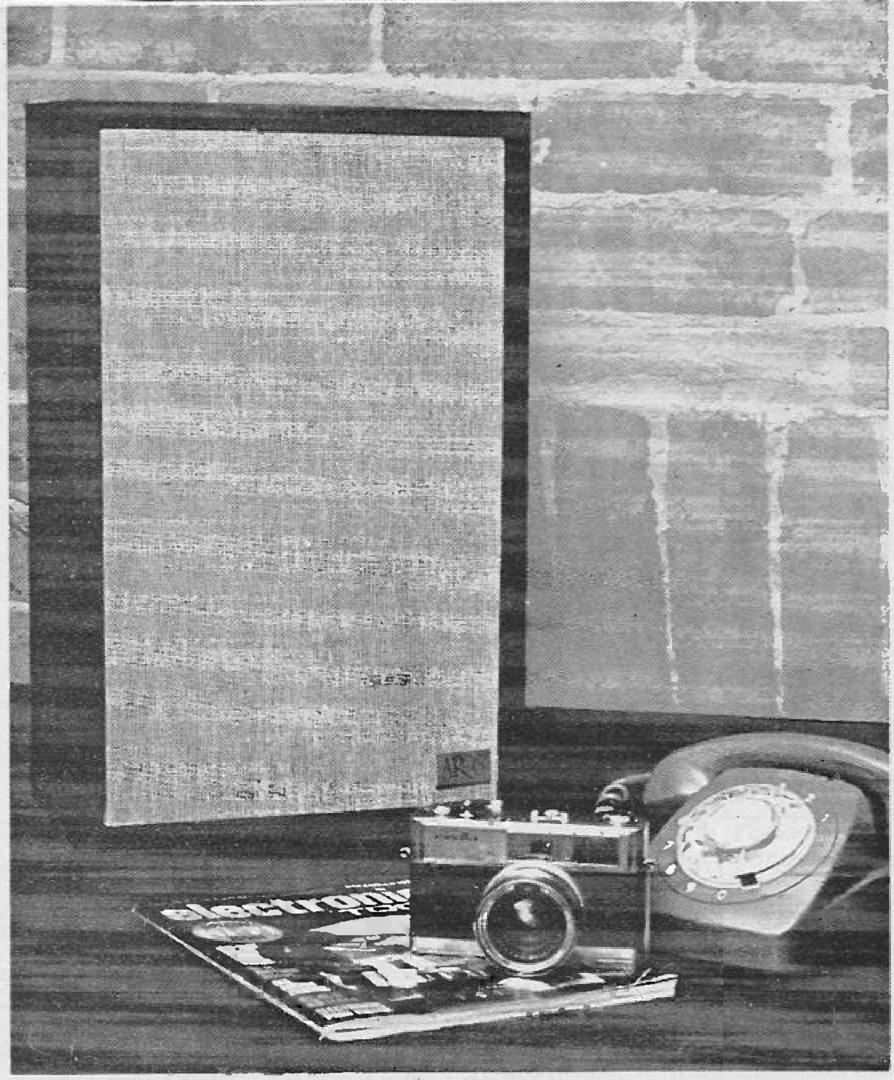


FIG 21



THE AR-6 BOOKSHELF SPEAKER SYSTEM

electronics TODAY INTERNATIONAL **product test**

The AR-6 speakers are the best true 'bookshelf speaker system' that we have yet heard.

AFTER producing in excess of a million high quality speaker systems over two decades it is not surprising that the USA's Acoustic Research Corporation should decide to develop the AR6 system, for whilst AR, have produced other small systems, including the AR-4X, that provide excellent performance, few of these will sit properly on a bookshelf.

For a speaker system to deserve the title "bookshelf" it should not be more than 8" deep and should have sufficient height or width so that its other smallest dimension is 12" or less. The AR-6 has dimensions of 12" x 19½" x 7" deep so it complies with the basic physical constraints to allow it to fit in a bookshelf. (Many speakers will fit *on* a bookshelf, but only a few actually fit *in* a bookshelf.)

All AR speakers are characterised by their unpretentious appearance and the AR-6 is no exception.

The result is an enclosure which, although devoid of any fancy trim and finish, reflects the quality and attention to detail put into the construction of all AR units.

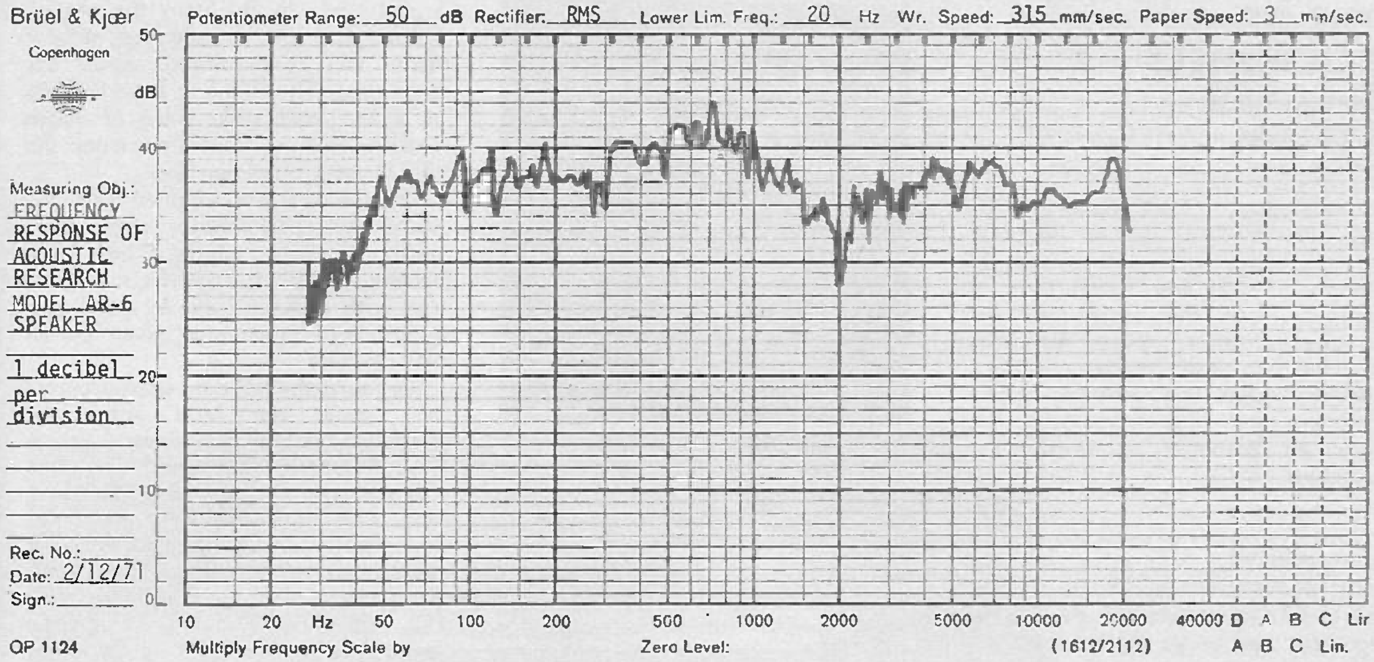
The enclosure has a volume of only 0.65 cubic feet and is constructed from ¾" veneered particle board which is crafted into a solid resonance-free enclosure. The drive units used in the enclosure are a new 8" diameter woofer, with a flexible urethane edge suspension and a stiff cone, and a 1½" diameter wide-dispersion domed tweeter.

The drive units are conventional, at least by AR standards, but intriguing none the less. To obtain a linear travel in a long throw speaker you either need a long linear magnetic field for the air gap and a short voice coil, or, conversely, a short magnetic field air gap and a long voice coil.

Of these two basic approaches the first type, whilst technically refined, is, none the less, expensive. This type results in high efficiency, high linearity speakers of the type which J.B.L., Goodmans, and other top of the line manufacturers produce so well. But most hi-fi enthusiasts care little about speaker efficiency, providing the system has good linearity; and speaker linearity is synonomous with low distortion when the other physical characteristics of the speaker are also good.

Linearity is still maintained with the second design approach, but the electro-acoustic efficiency is generally way down. This, of course, is one reason why AR speaker systems are generally lower in efficiency than some other systems on the market.

The magnet assembly in the woofer uses an open yoke structure, that is sealed on the two sides with tape to keep out dust and dirt. (We did not really expect to find this type of



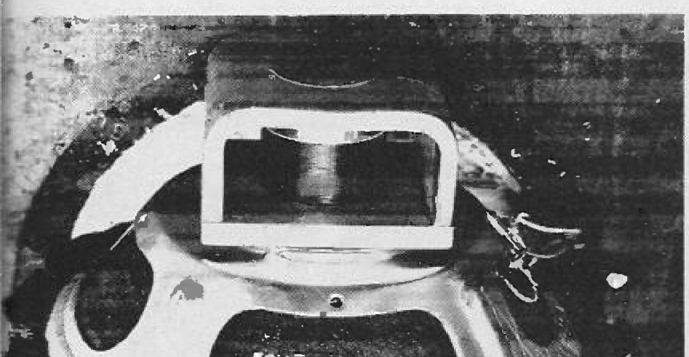
construction, having read the extracted blurb that one well known American reviewer had written on the back of the technical data sheet supplied with the speakers, but we assume that the system he tested was different — or something.) The linear travel of the speaker voice coil exceeds 0.7 inch (or 2 centimetres) which is a good starting point for a low distortion speaker. The visual impressions created by this voice coil and magnet structure belie the quality of the performance which they produce.

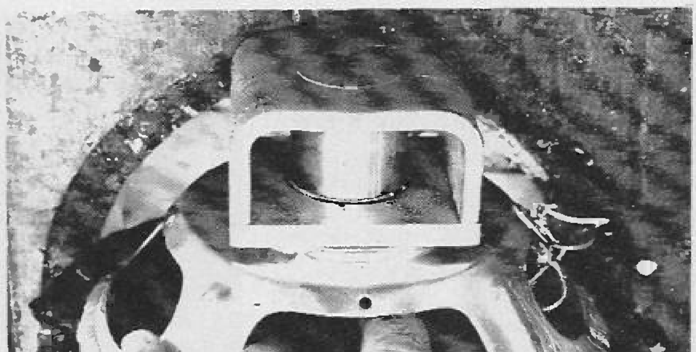
The tweeter is also conventional, but is as good as any tweeter that we have ever seen, with a performance which has to be admired particularly because of its exceptional dispersion. The tweeter is smooth to beyond 20 Kilohertz, for those whose ears have an ultrasonic response. The wiring of the tweeter into the system is unusual, as the wires are taped onto the front panel (with electrical insulation tape), from a pair of feed-through terminals. This is simple, but adequate, as it facilitates easy replacement and insertion of the speaker from the front of the fully sealed enclosure.

Subjective A-B tests were conducted in our laboratory, against our control monitors, and domestically with a number of similar sized bookshelf speakers. When compared against the control monitors the major difference was the lower efficiency of the AR-6. The manufacturers recommend an amplifier rating of 20 watts per channel because of this low efficiency.

Frequency-wise the difference was much less perceptible, with the only real difference being the loss of very low frequency due to the roll off around 40Hz. The only other difference was a slight loss of presence, which had a mellowing effect on the music reproduction. Actually, this lack of presence is synonomous with good frequency linearity, as later evidenced in our laboratory testing.

The manufacturers claim a maximum power handling capability under "normal home use on conventional music" of 200 watts short-term. We took them at their word and drove the speakers with a Pioneer SA1000 amplifier which delivers a nominal 170 watts peak power per channel at full volume. The results with a CBS Jerry Lee Lewis record, although ear shattering, were astounding, with the only noticeable distortion occurring at very high level low-frequency signals. Otherwise the speakers appeared to handle the power with ease, and without intermodulation distortion, particularly on the J.B.L.





These two photographs dramatically illustrate the long voice coil of the AR-6 bass driver. (Note the open yoke construction of the magnet assembly).

THE AR-6 BOOKSHELF SPEAKER SYSTEM

'Contemporary' Test Record PRO 496. We tried a number of other records, including the J.B.L. Classical Record SL672, and found that, in common with the other new AR speakers, this unit provides particularly clean reproduction of classical music. The ability to handle tympany and high frequencies can only be described as bright and effortless.

The measured performance confirmed our subjective appraisal with an effective response of 40Hz to beyond 20kHz. With 6 decibels of amplifier bass boost applied the lower cut-off frequency was reduced to 30 Hertz. With such a small enclosure volume it would be reasonable to expect the bass performance to be mediocre with a low frequency roll-over below 80 Hertz. But, the AR-6 does no such thing and, rather to our surprise, has a performance only slightly inferior to the other considerably larger speaker systems in the AR range. The linearity of the AR-6 is more than adequate for the purist, and only the crossover dip at 2kHz stopped the AR-6 from achieving the smoothest frequency response that we have ever measured between 40Hertz and 20 Kilohertz.

The distortion was particularly hard to determine, because of the recommended upper limit of five Watts continuous power for sine waves and the very low distortion levels generated by the speakers above 100 Hz.

Rear-mounted potentiometer provides 6dB cut or boost.

The cross over network is a simple LC circuit with a wire wound potentiometer in series with the tweeter. The capacitor used is a large block, solid dielectric capacitor mounted on the rear panel whilst the air-wound inductors provide good linearity.

As with all AR speaker systems, three terminals are mounted on a recessed panel in the back of the speaker enclosure. This panel also contains the tweeter level control potentiometer. This rather coarse wire-wound potentiometer provides approximately 6 dB boost or cut centred on the recommended 'normal' position. This control will seldom be used and provides adequate adjustment.

Ther terminals on the control panel are marker 1,2 and T. Terminals 2 and T are bridged by the manufacturer. Normally, connections are made to terminals 1 and 2. Removing the link between terminals 2 and T isolates the tweeter, so that the woofer alone may be driven if required.

The enclosures are very effectively sealed and, to maintain the sealing around the speaker openings, a very dense and tacky fibrous putty has been used. The filling in the enclosure is a long-fibre glass wool of above average quality, separated from the woofer by a tissue barrier.

The speakers are supplied with the usual AR performance data; brief wiring details which stress the recommended fusing requirements, and with each unit comes the 5 year international guarantee given on all AR speakers.

We found the AR data to be accurate and could not fault either the technical content or format

A set of hooks is supplied for mounting the speakers on a wall, for those who neither own or want a bookcase. An ideal wall mounting position is between 4' and 7' above floor level, but, unless properly sound-insulated, this could be annoying for anyone seeking peace and quiet on the other side of the wall, particularly in a home unit. Normally, some form of structural isolation is desirable to minimise low frequency vibrations being transferred to the building structure.

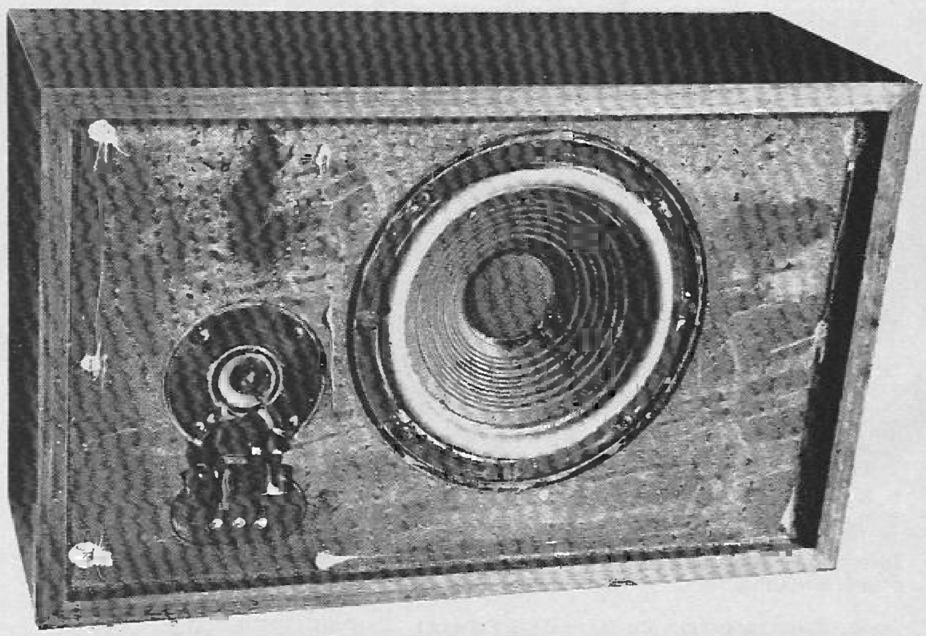
Acoustic Research have other fine speakers, but when we equate cost and size against performance it is clear to us that the AR-6 is most probably the best value for money that AR have ever produced, and the best true "bookshelf speaker system" that we have yet heard.

(We share our consultant's enthusiasm for these very beautiful speakers. We also understand that AR are establishing UK offices with sales, service, production and test facilities, resulting in a big reduction in prices of their equipments. — ED ●

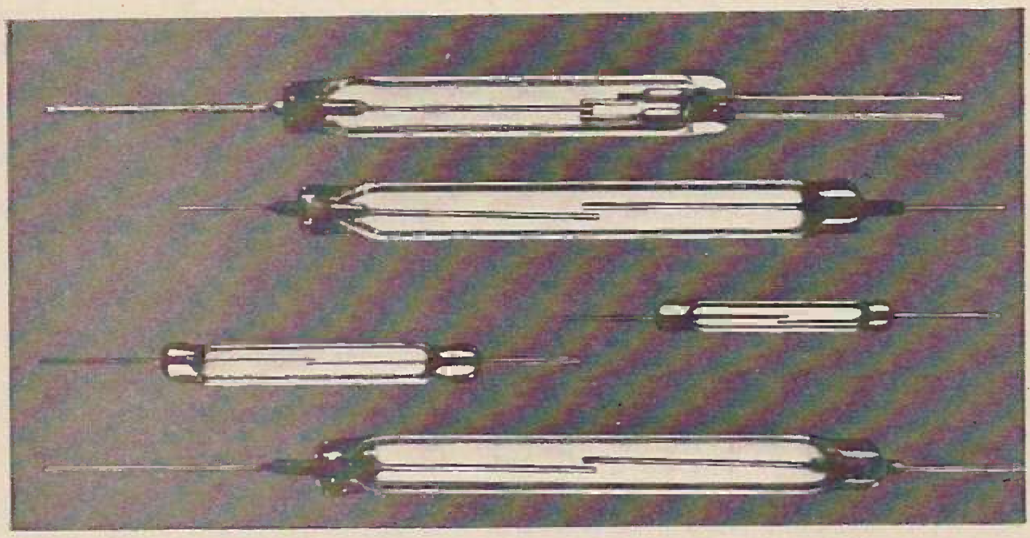
MEASURED PERFORMANCE OF ACOUSTIC RESEARCH SPEAKER

MODEL AR-6 SERIAL NO. HG00 4925

Frequency Response
40Hz to 20kHz ± 6dB
Woofer Resonance in Free Air = 27Hz
in Enclosure = 60Hz
Cross Over Frequency
2kHz
Harmonic Distortion
at a frequency of 100Hz
½ watt .8%
5 watts 1%
Electro-Acoustic Efficiency
0.2%
Dimensions: 19½" x 12" x 7"
Weight: 20 lbs.
Price (recommended retail) each:
£39.90



PRACTICAL GUIDE TO REED SWITCHES



Final article in this three-part series describes reed switch applications.

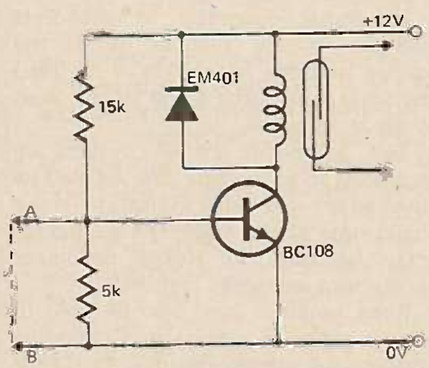


FIG. 23

Reed switches can be combined with solid-state electronic components to provide extremely reliable and maintenance free circuitry.

The low operating current of the actuating coil is well within the collector current rating of practically any transistor (and most linear integrated circuits). Many simple practical circuits can be constructed using a single transistor and a reed switch.

The circuit shown in Fig. 23 is commonly used to open or close a relay when an external circuit is made or broken. It is commonly used in simple burglar alarm installations.

In operation, the transistor is cut off by a short circuit across points 'A' and 'B' (shown as dotted lines). Because the transistor is cut off, the reed relay operating coil in the transistor's collector circuit is not energized, and the relay contacts are open.

If the short circuit is removed from points 'A' and 'B', the transistor is biased on via the 15k resistor, the relay coil is energized and the reed switch is closed. Current consumption of this circuit — whilst the relay is de-energized — is less than one milliamp.

The circuit shown in Fig. 24 has a similar function to that of Fig. 23, except that the relay will close when a short is placed across points 'A' and 'B'.

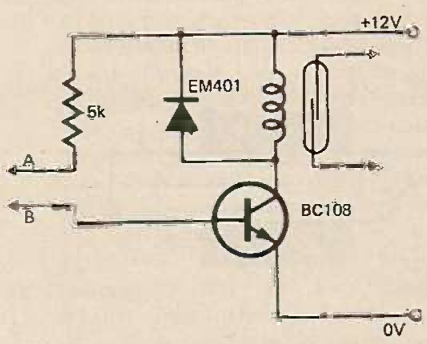


FIG. 24

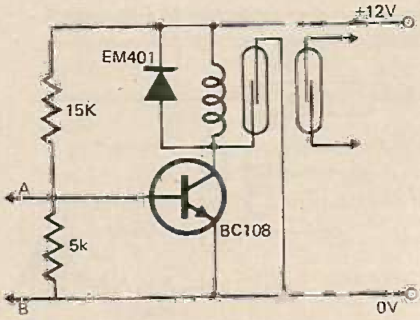


FIG. 25

It is often necessary to arrange for the relay to remain closed even though the actuating signal is only momentary. This can be done by using an actuating coil containing two reed switches, and using one of the reed switches to short out the transistor the moment the coil is actuated — Fig. 25 refers.

A very sensitive circuit that can be used as a moisture sensing switch is shown in Fig. 26. This circuit has a gain of well over 2500.

The relay will close whenever the resistance between points 'A' and 'B' falls below a few hundred thousand ohms. The 100k potentiometer is not

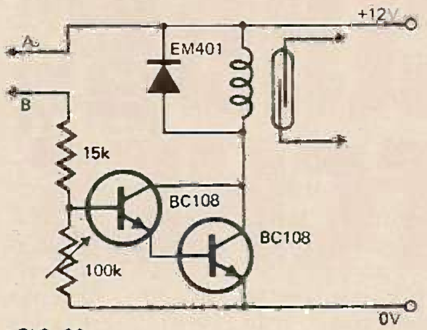


FIG. 26

an essential part of the circuit, but may be included as a 'sensitivity' control. The current consumption of this circuit, when the relay is de-energized, is less than one micro-amp.

Any of these circuits (Figs. 23, 24, 25, 26) may be combined with the Triac actuating circuit shown in Fig. 27 and used to switch very high current loads.

For example the moisture sensing circuit shown in Fig. 26 can be combined with the Triac switching circuit to energize a large motor driven pump. If necessary, three reed switches may be combined in one energizing coil to switch three Triacs in a three phase circuit. Using this principle loads of several hundred Amps may be switched without using a single contactor.

An unusual application for a pair of reed switches is shown in Fig. 28.

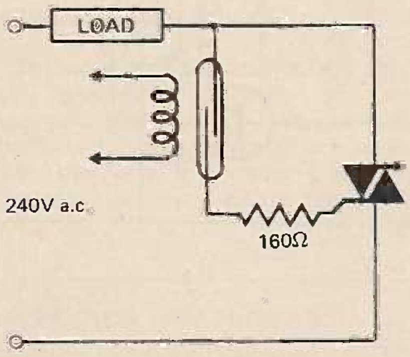


FIG. 27

This circuit can be used to switch a common antenna to either a transmitter or receiver. As the capacity between the contacts on the open reed is less than 0.2 pF, the system may be used at very high frequency.

Time delays of up to 10 seconds can be obtained using the simple circuit shown in Fig. 29. The delay is adjusted by the 50k potentiometer. It is not practicable to obtain longer delays than 10 seconds by increasing the size of the capacitor.

RESONANT REEDS

Resonant reed switches are basically similar in construction to normal reed switches, except that one reed is designed to resonate mechanically when its operating coil is energized at a specific frequency. At all other frequencies the reed will not move to any extent.

As the reed only makes contact for a portion of each cycle, it is usually necessary to arrange for latching action, or for some form of storage or pulse lengthening circuit.

Resonant reed switches are used for a variety of applications where response is required only to one specific frequency — these include communications, selective signalling, data transmission, telemetry, frequency monitoring etc.

Reed switches may also be used in very sophisticated logic circuits, usually in applications where their immunity to noise causes them to be chosen in preference to the generally cheaper solid-state components.

Fig. 30 shows a four-stage shift register which uses reeds as magnetically latched devices in simple magnetic circuits. The information in each stage is stored as closed or open switches, and the condition of each stage is transferred to the next as the shift control is operated. Only a single contact set is used for control purposes in each stage, as the state of a stage is stored as a capacitor charge during the shifting interval. However each stage as auxiliary switching contacts for output purposes.

The basic principle of operation can be considered as a series of latching

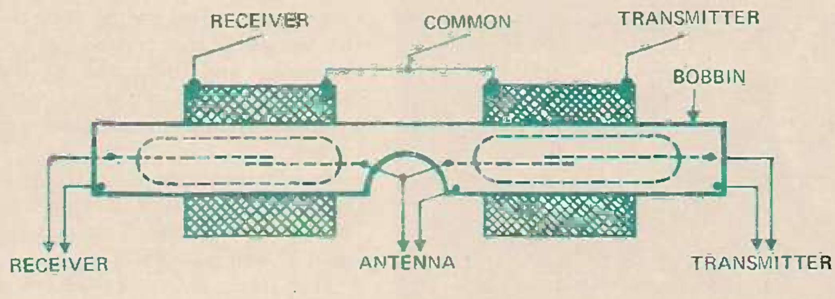


Fig. 28. Here reed relays are used to switch a common antenna to either a receiver or transmitter. As the capacitance between the reeds is less then 0.2pF, the arrangement may be used at very high frequency.

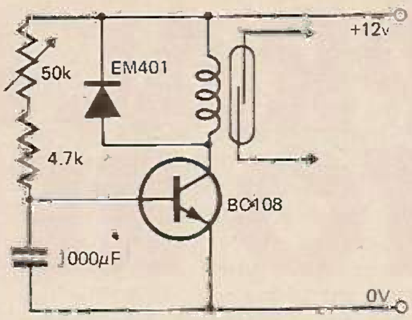


FIG. 29

relays. Momentarily closing the 'set' contact energizes coil S1 and closes reed switches STG1. The associated bias magnet latches these switches closed, thus allowing the 'set' contact to be re-opened. The logic state of the first stage may now be shifted to the second stage by operating the shift contacts in this sequence:

a. Closing contact A, thus charging capacitor C2.
b. Closing B for a few milliseconds and thus unlatching STG1 switches.
c. Opening contacts A and B.
d. Immediately and momentarily closing contact C. Capacitor C2 now discharges through coil 2S via contact C. Switches STG2 now close and are latched by the associated bias magnet. The switches associated with the second stage are now closed and those of the first stage are open.

Sequential operation of the shift circuits in this manner moves the closed or open logic state of the reed switches from each stage to the next stage in sequence.

Two additional sets of contacts are provided in each stage, one set may be used to provide visual indication of the logic state of the stage, the second set may be used to trigger particular operations whenever required.

Reed switches may also be used in many types of coding and decoding systems. A simple decimal to binary encoder is shown in Fig. 31 In this circuit, the input is from a decimal keyboard energizing reed relay coils, while the output is in four-bit binary. Single, double, and triple switch relays are required for this application.

MERCURY WETTED CONTACT RELAYS

The mercury wetted contact relay overcomes the problem of contact bounce that is inherent in the dry reed switch.

The construction of the mercury wetted switch is shown in Fig. 32. It consists of a glass encapsulated reed which has one end immersed in a pool of mercury. The other end of the reed is capable of moving between two sets of stationary contacts. The mercury

PRACTICAL GUIDE TO REED SWITCHES

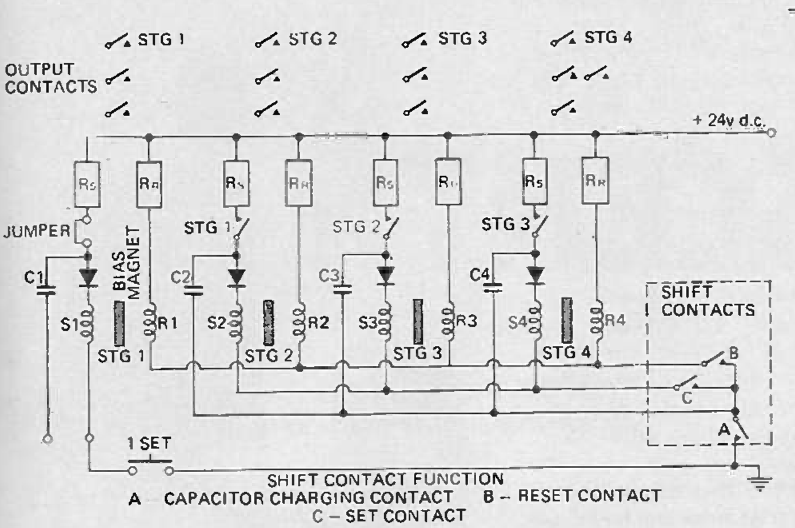


Fig. 30. This four-stage shift register uses reed relays.

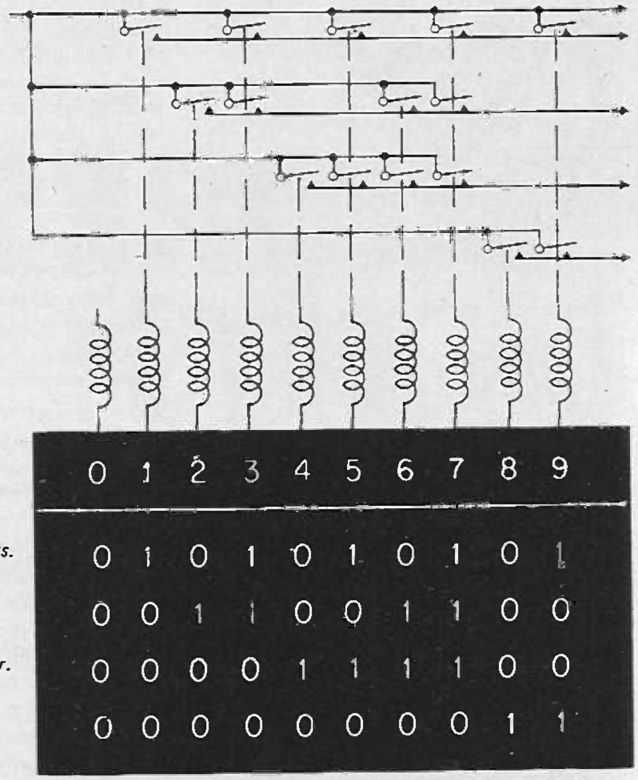


Fig. 31. Reed switch decimal binary encoder.

flows up the reed by capillary action and wets the surface of the fixed and moving contacts. Thus a mercury to mercury contact is maintained whilst the contacts are closed.

The resistance of mercury is very low and contact to contact resistances of mercury wetted switches rarely exceed 50 milliohms. This is somewhat less than if the contacts were permanently soldered together!

The mercury wetted switch may be opened and closed in a similar fashion to its dry reed counterpart. Operating times are typically 10 milliseconds at normal coil current, falling to three milliseconds at twice the normal ampere-turn rating. The release time is typically four milliseconds under any conditions.

Apart from their high current carrying capacity, mercury wetted reeds have extremely long life since contact erosion is eliminated.

The disadvantages of mercury wetted reeds are poor resistance to shock and vibration, and the need to mount the reed vertically.

FUTURE DEVELOPMENTS

A lot of development work is currently being undertaken – particularly toward the use of cladded reed material.

Nickel-iron reeds combine optimum magnetic characteristics with the high internal damping that is required to minimize contact bounce; but the material is by no means an ideal conductor, and because of this, high resistivity losses within the switch are appreciable at high current loadings.

Cladding with gold or copper substantially reduces many of the undesirable characteristics of the nickel-iron reeds. This cladding reduces the effect of skin resistance – which can be appreciable at high frequencies – and if the cladding is continued right to the ends of the external lead-outs – it virtually eliminates the thermal emfs generated when a copper wire is soldered to a nickel-iron reed in a conventional reed switch.

Another problem currently being investigated is that of reed switch contacts failing to separate, especially after they have been held closed for long periods at high temperatures. This is caused by molecular migration and the resultant metallic bond cannot be broken by the low separating force available. This problem has not yet been completely overcome but current development is toward heat treatment to produce a diffusion of gold into the nickel-iron base, and multi-layer diffusion techniques.

Prices of reed switches are still decreasing, and as they become cheaper, new markets are opening up.

The motor industry in particular is using reed switches in fuel injection and ignition systems. The security industry appreciate the reliable maintenance-free service that can be obtained. Machinery manufacturers are beginning to use reed switches in applications in which adverse environments preclude open switch contacts.

For what other type of switch can remain static for twenty years and then work perfectly the first time that it is actuated? ●

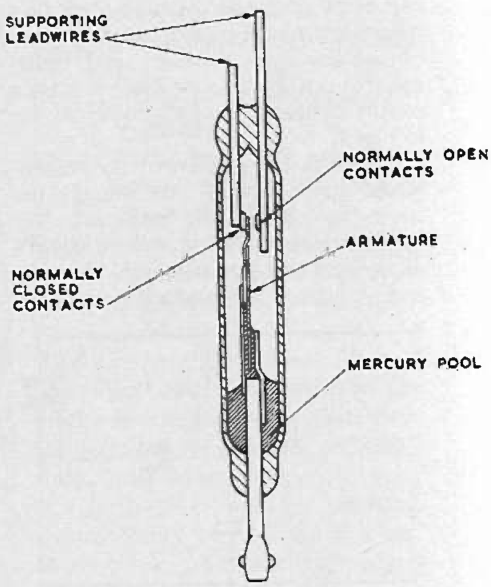


Fig. 32. Construction of a mercury wetted reed switch.

A DIMMER FOR FLUORESCENT LIGHTS

ETI PROJECT 508

This 700VA dimmer ensures smooth and almost flicker-free control of fluorescent lighting

As our article on page 10 explains, it *is* possible to dim fluorescent lights over a limited range using a dimmer that has been designed for incandescent lighting control.

But it is very probable that there will be severe flickering at low light levels.

Although this flickering can be reduced by various techniques, it is primarily caused by asymmetrical current flow in the tube, i.e. current in one half cycle is greater than current in the other half cycle, and unlike the 100 Hz flicker that is present at all times, asymmetry introduces a 50 Hz component that the eye can follow.

The most commonly used method of light dimming today is phase control, (described in detail in our article A Practical Guide to Triacs — May 1972).

In this method the effective power input to the lamp is adjusted by varying the proportion of each half-cycle of the mains wave-form that is supplied to the load.

Most domestic dimmers sold today use this operating principle and have a circuit basically similar to that shown in Fig. 1.

This circuit will control fluorescent loads fairly well providing the triggering diode is selected for symmetrical operation, but triggering diodes are not generally sold this way and 10% asymmetry is not uncommon. What this means is that the diode will trigger on one half-cycle at say, 32 Volts and on the next half-cycle at 29.5 Volts. And so at low light levels the diode may trigger the Triac only on alternate half-cycles. This causes flicker.

The same asymmetrical operation will also occur with incandescent loads, but due to the thermal inertia of the filament, the visual effect is much less noticeable.

The dimmer shown in this project overcomes the problem of asymmetry. It provides as nearly as possible an ideal and symmetrical waveform for fluorescent tubes.

Some flickering may still occur at very low light levels because the fluorescent tubes themselves may not be perfectly symmetrical. (The only way to achieve totally flicker-free operation is to use a variable frequency supply. The cost of this method would be enormous).

The maximum loading that can be placed on the dimmer is 700VA. Table 1 shows how the VA rating is calculated. It is also possible to use a combination of both fluorescent tubes and incandescent lamps and in this case the VA rating of the incandescent lamp is simply its normal wattage ie. 100 Watts equals 100VA.

CONSTRUCTING THE DIMMER

Construction is fairly simple, but remember that this unit is connected to the main 240 Volt supply and follow our instructions carefully — especially those sections concerning insulation.

The circuit diagram of the complete unit is shown in Fig. 2, and the foil pattern of the printed circuit board in Fig. 3. Metalwork drawings are shown in Fig. 4 and the complete assembly drawing in Fig. 5.

1. Mount the potentiometers on the chassis and cut the shafts to the required length. The minimum adjustment potentiometer should be cut short and slotted so that it may be adjusted with a screwdriver.

Insulated wires should now be soldered onto the respective terminals of the potentiometers ready for later attachment to the printed circuit board.

2. Any 6A or 10A rated triac without built-in diac and with PIV of 400V will do. If you use a triac, such as AC10DR, with the case forming the anode, follow the procedure in para 3 to mount the device.

3. Glue a piece of insulating material 0.025" — 0.035" thick and ¾" diameter to the back of the potentiometers.

Before mounting the triac a lead must be soldered onto the top edge (ie nearest the terminals). When doing this, place the triac on a piece of copper or aluminium to act as a heat sink, and use the minimum heat required to make a good joint.

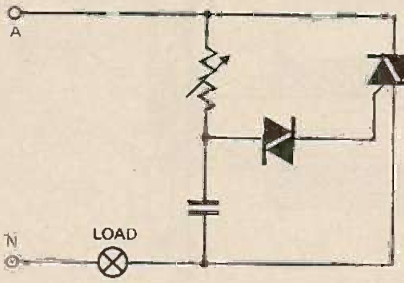
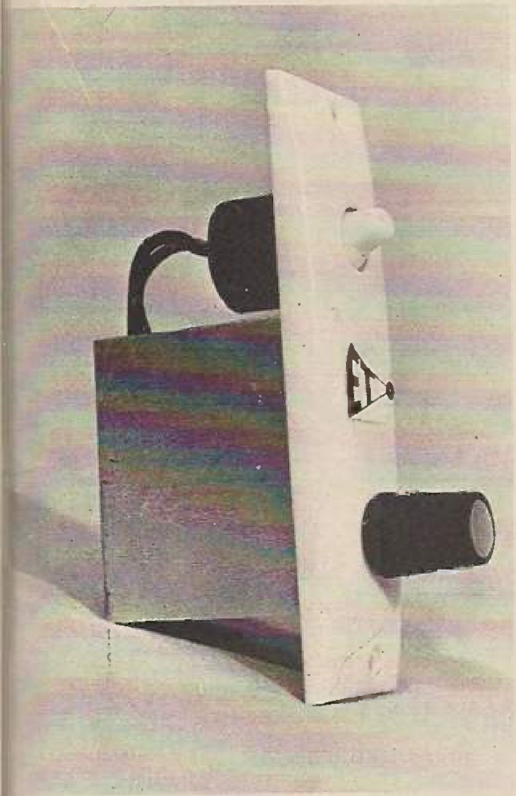


Fig. 1. Many commercially available light dimmers use circuits similar to this.

Tube Indicated Wattage	VA Rating
15, 20 or 30	90
40	100
65	180
80	210



Cut a circle of mica ¾" diameter and 0.002" to 0.005" thick. This may be cut out of a T03 washer if required. Glue this mica washer to the side of the chassis, using epoxy glue. Then glue the Triac to the centre of the mica. The epoxy glue should extend completely over the top surface of the mica to prevent the mica splitting. The new 'five minute' epoxy glue is ideal for this purpose.

4. The rf choke (L1) should now be wound following the details shown in Fig. 6. Then wind the pulse transformer as shown in Fig. 7. Care must be taken with the insulation — there is 240 Volts ac between the primary and secondary winding on this transformer.

5. The components can now be soldered onto the printed circuit board. Locate transistor Q2 so that it is about 3/16" off the board and transformer T1 so that it is about 1/8" off the board. Capacitor C1 is mounted flat on top of the diodes. Fig. 8 shows the location of all components.

6. Glue the choke L1 on top of the 50k potentiometer, and connect one lead to the 'cathode' of the Triac (larger of the two terminals).

7. Connect the lead, which is soldered to the case of the triac, and the second lead from the choke to the appropriate places on the printed circuit board.

8. The printed circuit board should now be mounted on the chassis using 6BA nuts and bolts and 3/16" insulating spacers. Make sure that the board is reasonably level and is not touching the Triac or the chassis.

9. The leads from the secondary of the pulse transformer should now be twisted together. One lead should be connected to the Triac gate and the second lead connected to the Triac 'cathode'.

10. Connect the leads from the potentiometers to their respective locations on the printed circuit board.

11. Insert two short lengths of 23/0076 240 Volt insulated wire through the slot in the chassis and solder one end of each to the appropriate solder lands on the printed circuit board.

12. Place a piece of insulating material over the back of the printed circuit board and fit the cover temporarily in position. When doing this make sure that no bare wires can touch any metal. The dimmer is now ready for testing.

PARTS LIST
FLUORESCENT DIMMER ET 508

- C1 — capacitor 0.033 uF, 630V
- C2 — capacitor 0.047 uF, 100 or 160V
- D1-D4 diodes EM 404
- D5 — diode 1N 914
- ZD1 — zener diode BZY 88 C30 or 1N972B
- Q1 — Triac type AC 10 DR
- Q2 — programmable unijunction transistor type D13T1
- RV1 — miniature potentiometer 50k linear
- RV2 — miniature potentiometer 2 Megohm
- L1 — choke (see text) wound on ferrite plate 7/8" long x 19mm x 3.8mm
- T1 — pulse transformer (see text) wound on Neosid core type 0.159 x 0.375/2 x B6/F14
- R1 — resistor 120k, ½Watt, 5%
- R2 — resistor 22k, ½Watt, 5%

One on/off switch plate with switch mechanism and one spare terminal. Insulation material 0.025" — 0.035" thick, mica sheet, 6BA x ½" bolts and nuts, 3/16" spacers, insulated control knob, wire, epoxy glue etc. Metal work, printed circuit board ET 011.

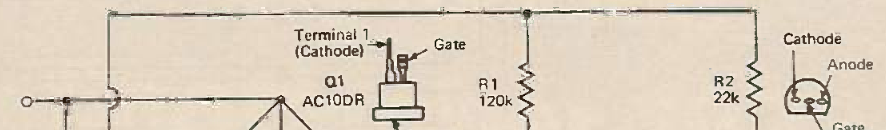


Fig. 2. Complete circuit diagram of the ET 508 light dimmer.

A DIMMER FOR FLUORESCENT LIGHTS

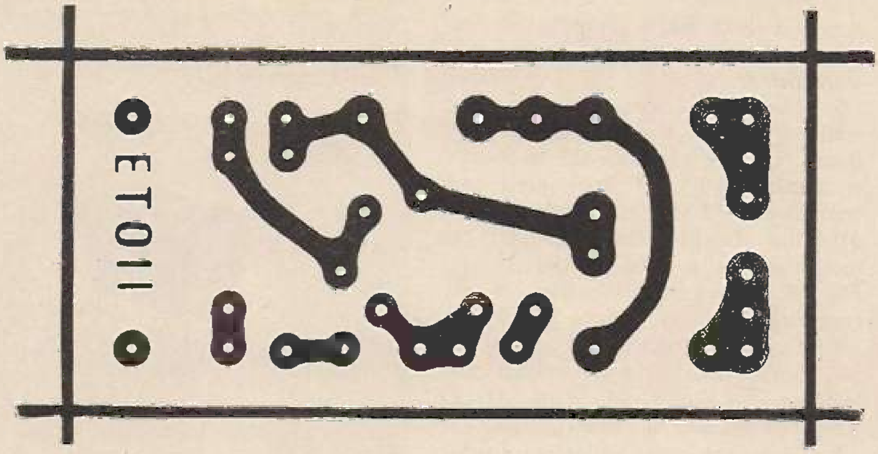
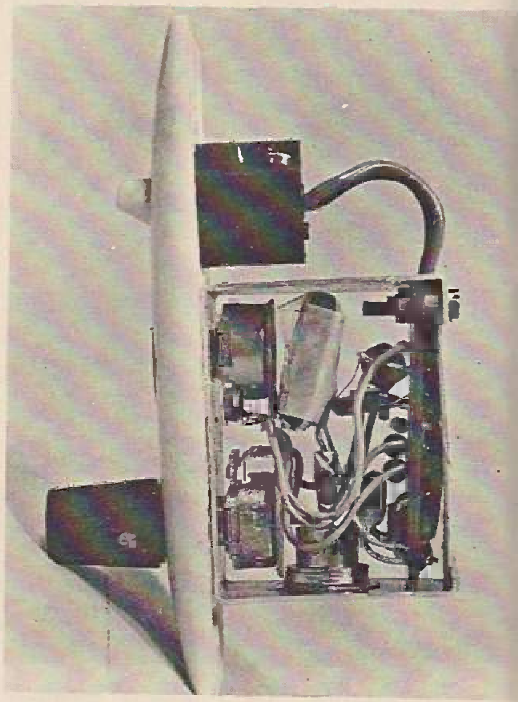


Fig. 3. Foil pattern of the printed circuit board. Note that this is shown here exactly twice full size.



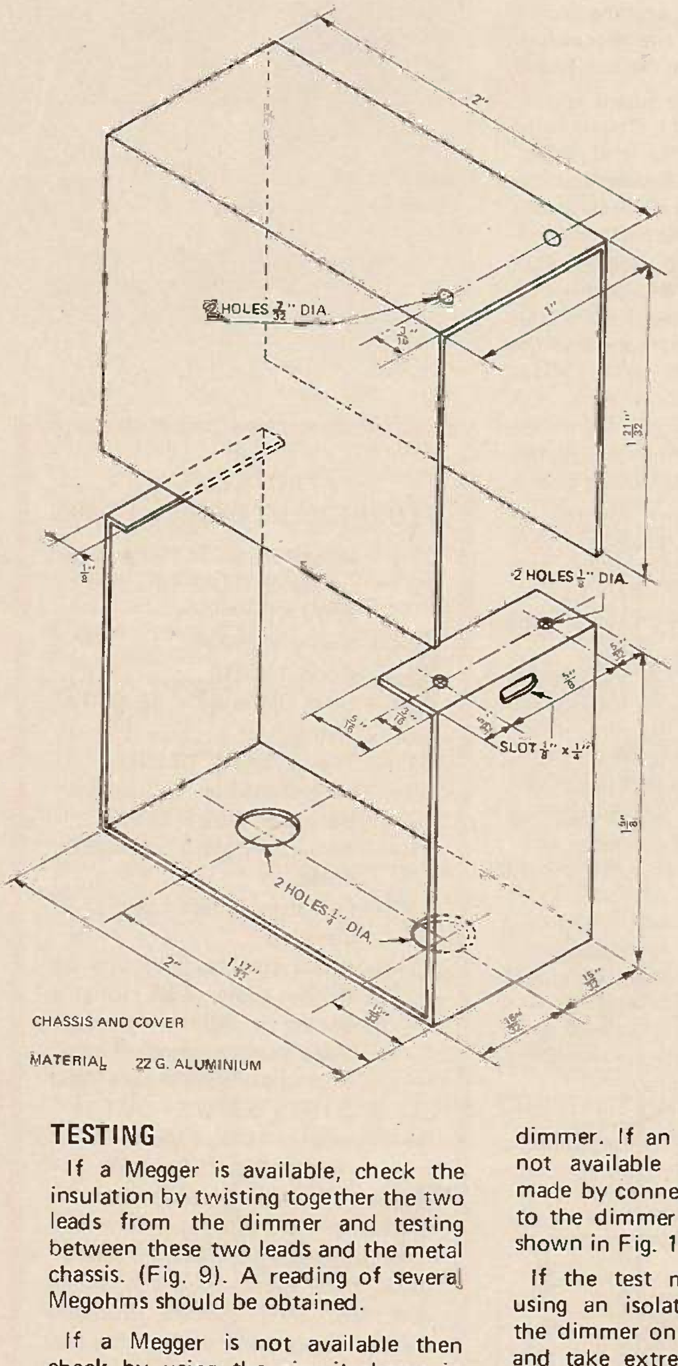
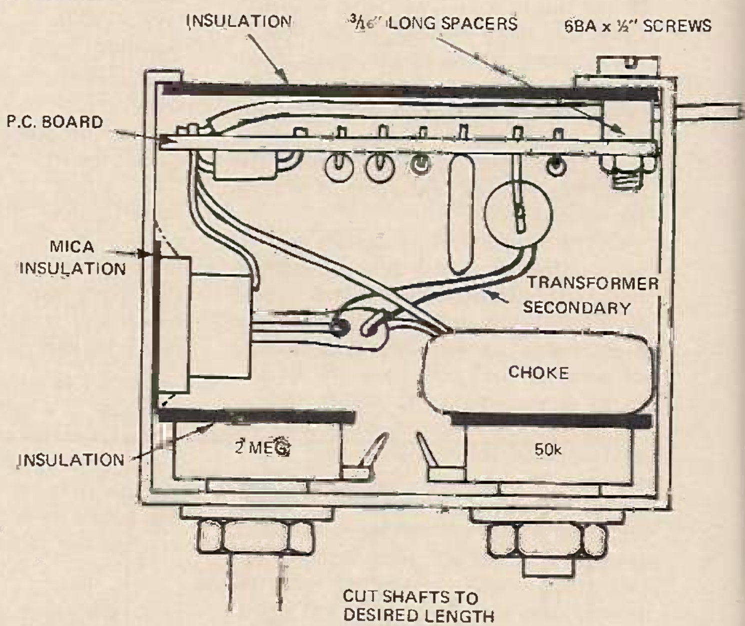


Fig. 4. Details of metalwork.

Fig. 5. How the unit is assembled.



TESTING

If a Megger is available, check the insulation by twisting together the two leads from the dimmer and testing between these two leads and the metal chassis. (Fig. 9). A reading of several Megohms should be obtained.

If a Megger is not available then check by using the circuit shown in Fig. 10. The lights should not glow at all – if they do then there is an insulation breakdown within the dimmer. If an isolating transformer is not available the same test can be made by connecting the mains directly to the dimmer via a 15 Watt globe as shown in Fig. 11.

If the test must be done without using an isolating transformer, place the dimmer on a thick dry newspaper and take extreme care not to touch either the dimmer or the leads whilst power is connected to the circuit.

Having completed the insulation test, connect the dimmer to an incandescent globe as shown in Fig. 12. Turn both potentiometers fully anticlockwise and switch on the power to the dimmer. The light should not be on, now turn up the minimum adjustment potentiometer until the light just glows. The main potentiometer should now control brilliance up to the maximum level.

If flickering is evident, switch off and reverse the connections from the pulse transformer to the Triac.

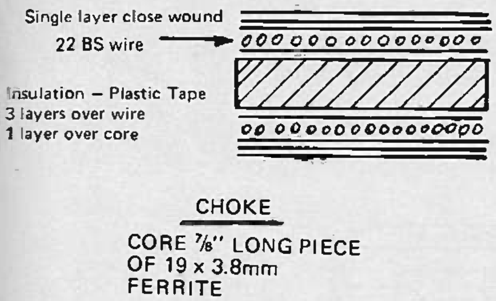


Fig. 6. How to wind the choke.

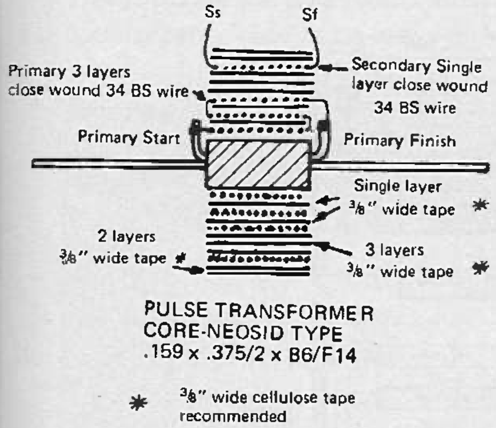


Fig. 7. Details of the pulse transformer – follow the construction exactly as shown.

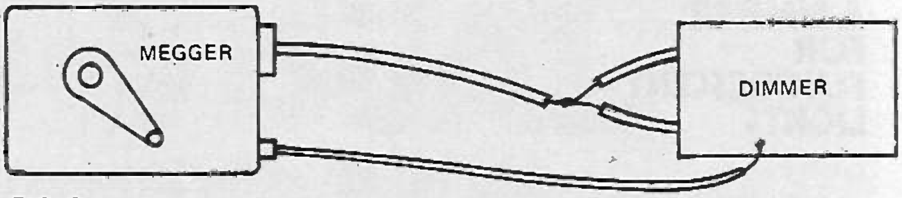


FIG. 9

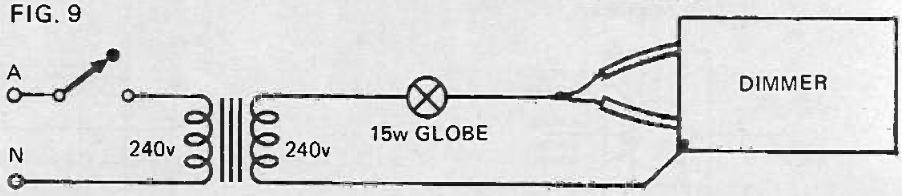


FIG. 10

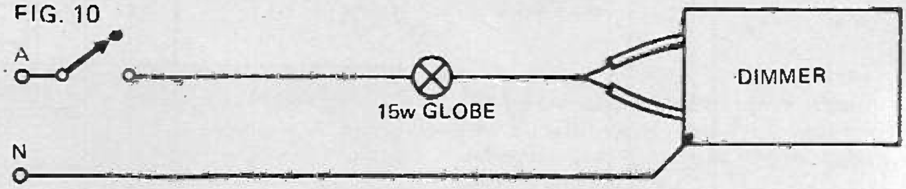


FIG. 11

The unit may now be glued to the front plate and the cover glued onto the chassis (use Araldite or other epoxy glue). Connect the two wires from the dimmer to the switch.

INSTALLATION

Any modifications to the house wiring must preferably be carried out by a licenced electrician and the following notes are intended for guidance only:-

If the dimmer is to be used solely with incandescent loads, all that is necessary is to connect the dimmer in place of the existing wall switch.

If fluorescent lamps are to be used, first read the article on fluorescent lamp dimming (beginning on page 44 of this issue), and then refer to Fig. 13. This is a composite drawing showing the wiring required for various combinations of fluorescent lamps.

A single fluorescent lamp would be connected as shown in Fig. 13a. If twin tubes are used then Fig. 13b would be applicable. If both single and twin fittings are to be paralleled then use Figs. 13a and 13b.

There may be occasions when it is

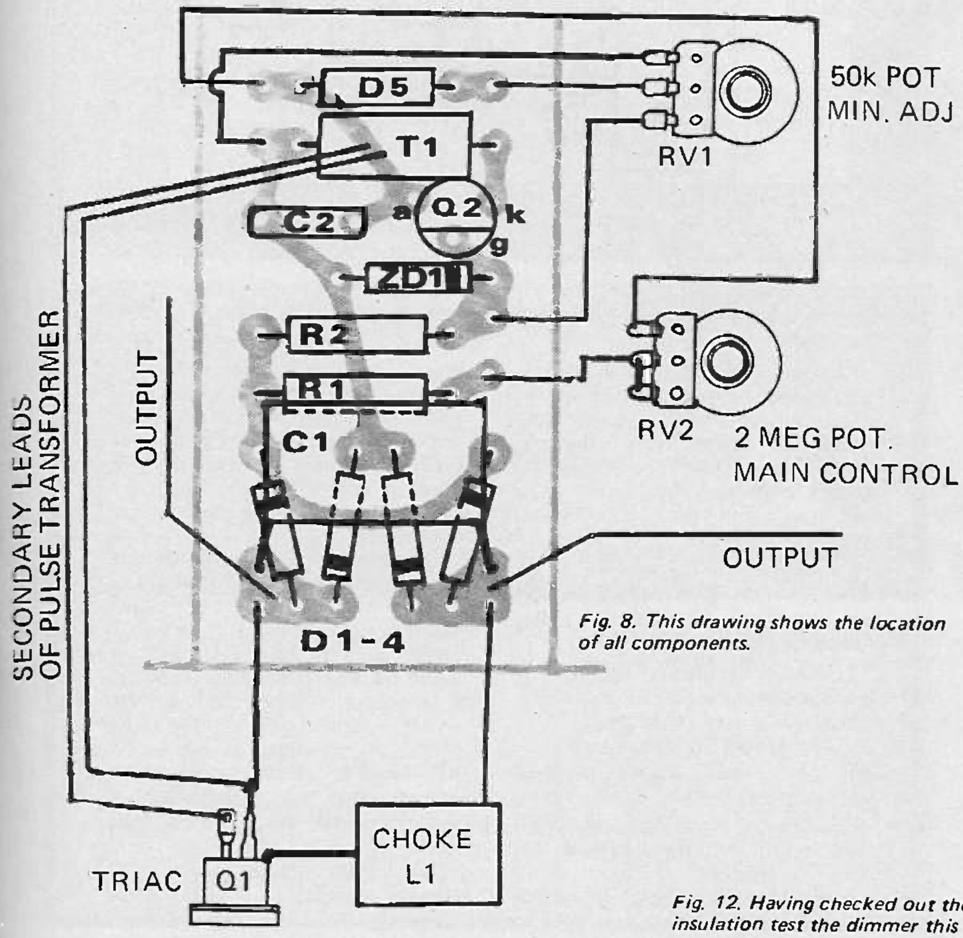


Fig. 8. This drawing shows the location of all components.

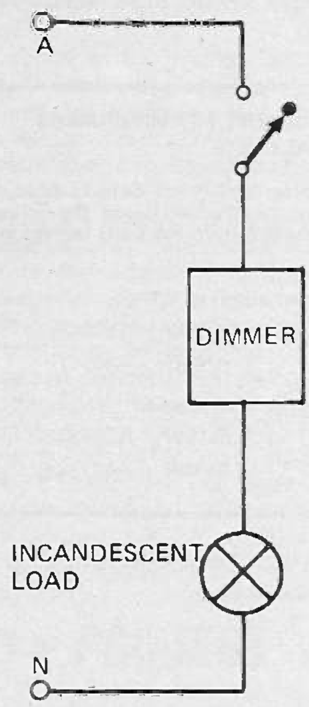


Fig. 12. Having checked out the insulation test the dimmer this way.

A DIMMER FOR FLUORESCENT LIGHTS

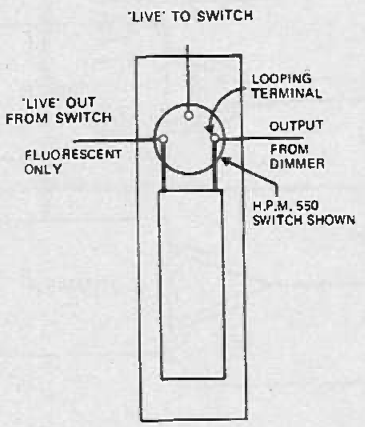
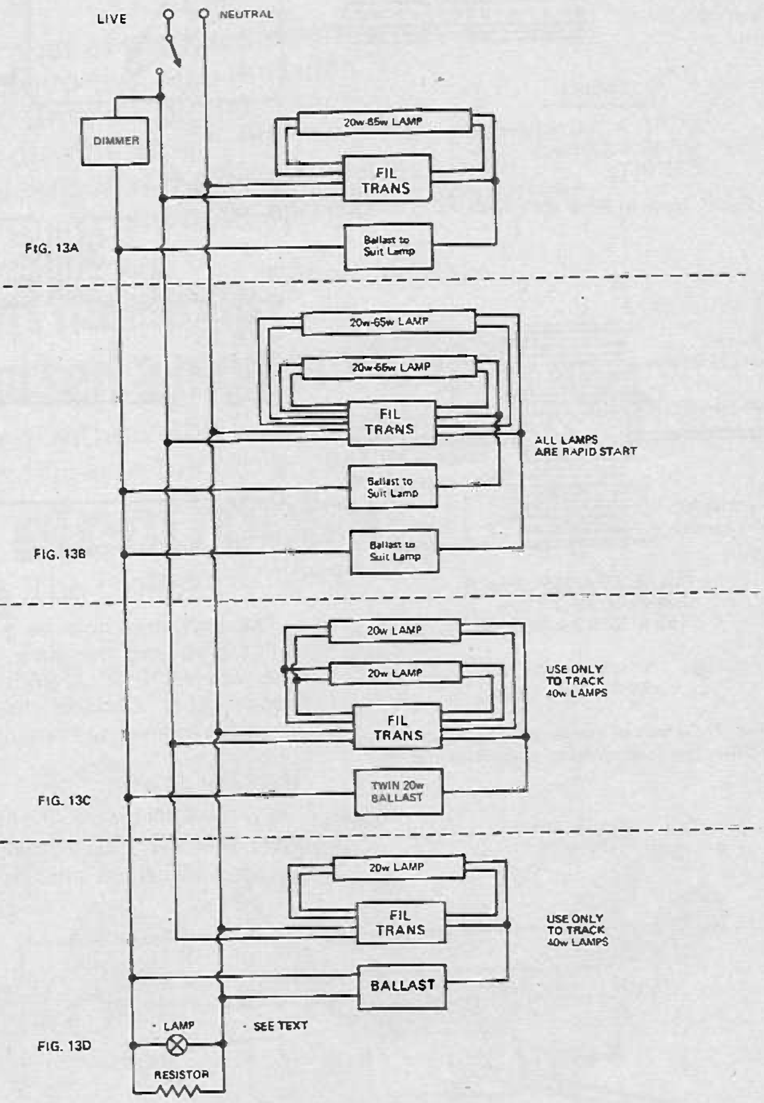


Fig 14. This shows how the dimmer is connected to the lamp switch



necessary to parallel a twin 20 Watt fitting and a single 40 Watt fitting – in this case use Figs. 13a and 13c.

No matter what combination of fluorescent tubes are used it will always be necessary to install the resistor (or incandescent bulb) as shown in Fig. 13 and explained in the fluorescent dimming article.

Again, as explained in the fluorescent dimming article, filament transformers must be used. The correct type of transformer for each application is shown in Table 2.

Filament transformers may be ordered through your parts supplier or through an electrical wholesaler. Our experience is that most companies do not hold them in stock but will willingly obtain them against a firm order. ●

FILIAMENT TRANSFORMERS & BALLASTS

Transtar Ltd, Prince Consort Road, Hebburn, Co Durham stock the following filament transformers and ballasts in one can:

Single rapid-start tubes

20W	:	A20SCR
40W	:	A40SCR

Twin rapid-start tubes

2x20W	:	A20TSCR
2x40W	:	A40TSCR

HOW IT WORKS

The power circuit consists of C1, L1, and Q1. Q1 is a Triac, which when triggered into conduction, remains so until the current through it falls to zero. The Triac is triggered at any required point during each half cycle to give a chopped sine-wave output.

The purpose of C1 and L1 is to slow down the rise time of voltage and current to reduce radio frequency interference.

The diode rectifier bridge (D1 – D4) supplies unsmoothed 240 Volts dc to the control circuit, where R1 and ZD1 supply 30 Volts to the gate of the PUT (Programmable Unijunction Transistor) Q2.

Capacitor C2 is rapidly charged via RV1 and D5 until the voltage set by RV1 is reached. Charging then continues via R2 and RV2. When the voltage across C2 exceeds the gate voltage (nominally 30 Volts) by about half a volt the PUT conducts and discharges C2 into the primary of pulse transformer T1. This causes a pulse of energy to be fed into the gate of the Triac and to trigger it into conduction.

The action of the Triac conducting removes all voltage from the control circuit until the next half cycle of the mains input waveform.

The point in each half cycle at which the PUT (and hence the Triac) is triggered is determined by the setting of RV1 and RV2. The range of the main control potentiometer RV2 may be varied by the preset potentiometer RV1, and so RV1 is used to preset the minimum light level.

This circuit ensures symmetrical firing of each half cycle of the Triac.

AUDIO-VISUAL METRONOME

This simple electronic metronome sounds just like its mechanical counterpart — and has a visual output as well!

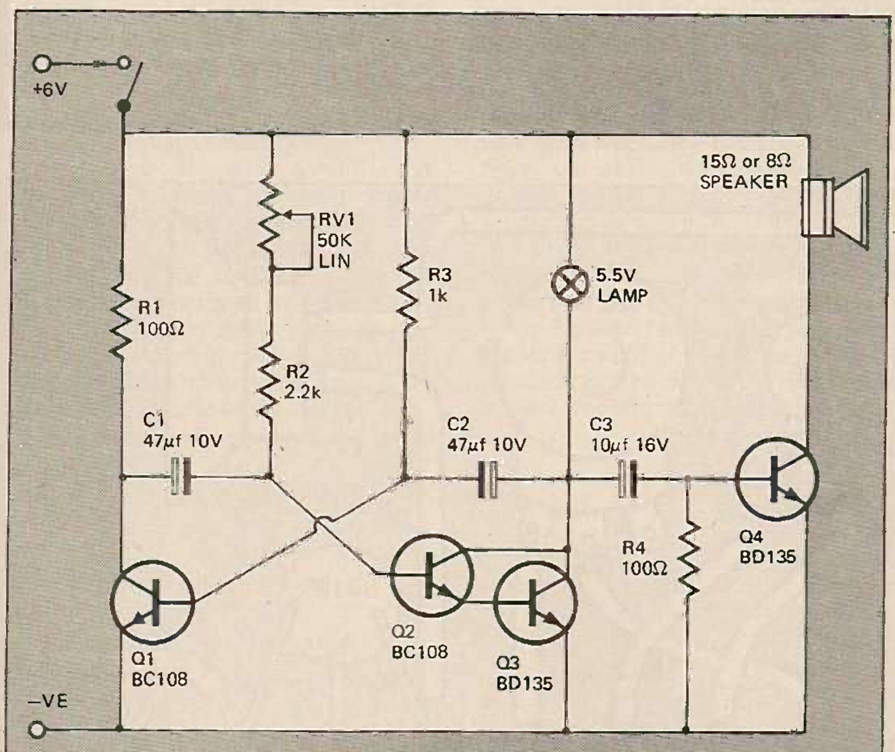


Fig. 1. Circuit diagram of complete unit.

PARTS LIST

R1	—	resistor 100 ohm, ½ watt, 5%
R2	—	" 2.2k, " "
R3	—	" 1.0k, " "
R4	—	" 100 ohm, " "
RV1	—	potentiometer 50k, linear, ½ watt
C1	—	capacitor, electrolytic 47µf, 10 volt
C2	—	" " " " "
C3	—	" " 10µf, 16 volt
Q1	—	transistor BC108 or equivalent.
Q2	—	" " "
Q3	—	" BD135 or equivalent.
Q4	—	" " "
SW1	—	single pole, single throw switch
Speaker	—	8 ohm or 15 ohm speaker 1" — 5" diameter
Lamp	—	5.5 volt, up to 500 mA.

When Maelzel invented the clockwork metronome about 170 years ago, his device indicated the tempi in music both audibly and visually.

Today's electronic counterparts rarely have visual outputs, and even the audio signal is quite unlike the 'tic' sound characteristic of the mechanical instruments.

But here's one with a difference.

The beat rate of this simple electronic metronome may be varied from adagio to allegro as required. The unit realistically simulates the 'tic' of the conventional clockwork units, and also flashes a light in time with the beat. This latter feature is of considerable value especially in school classrooms.

CONSTRUCTING THE UNIT

The circuit diagram of the unit is shown in Fig. 1.

Component layout is not at all critical and the unit may be assembled using tag strips — as shown in Fig. 2 — or on perforated board, or, if a completely professional appearance is required, a printed circuit board may be used.

The choice of loudspeaker, again, is not at all critical, and any eight or 15 ohm unit not exceeding four or five inches in diameter may be used.

The size of the loudspeaker and the choice of battery will probably determine the method of housing the main components. One simple way is to locate the electronic components and batteries inside an extension loudspeaker enclosure. The flashing light may then be mounted on the front face of the completed unit.

An alternative method of using the flashing light is to locate it away from the main unit. This is a valuable feature if the unit is used for instruction in school classrooms (an application we had in mind when building the prototype unit).

(Continued overleaf)

ETI PROJECT

THE UNIT IN USE

Having completed the assembly, check over all connections for wiring errors, and then connect the unit to a six volt battery — an Eveready type 713 will power the unit for several hundred hours.

Turn RV1 fully anticlockwise and switch SW1 to ON. The loudspeaker should now tick at a very slow rate, and the lamp should flash in unison (if it does not do so, switch off and check all connections carefully).

Now turn potentiometer RV1 until the metronome produces the lowest beat rate required (i.e. adagio) and mark this point on a scale attached to the face of the instrument. Further points should be marked on the scale by checking the metronome against a stopwatch or another accurately calibrated metronome.

It is advisable to check the calibration occasionally — this is done simply by setting the unit to the lowest point marked on the scale — i.e. adagio — and checking the rate against a stopwatch.

But, as the beat rate of the circuit is not affected by changes in battery voltage from 6.5 volts down to less than 5.5 volts, it is not necessary to calibrate the unit each time that it is used.

As a matter of interest the word 'metronome' is derived from the Greek metron (measure) and the Greek nomos (law). There is no truth in our London correspondent's theory that the unit was named after a very small man who once worked on the Paris underground railway. ●

HOW IT WORKS

Transistors Q1 and Q2 form a free-running multivibrator, the frequency of which is varied by potentiometer RV1. The output waveform is amplified by Q2 and Q3 which are connected as a Darlington pair.

The flashing light is driven by Q3, the on time of this lamp is approximately equal to $\frac{R3 \times C2}{10^6}$ seconds. the time off is approximately $\frac{(R2 + RV1)\,C1}{10^6}$ seconds.

The output square wave from the multivibrator is differentiated by C3 and R4 and then amplified by Q4. The loudspeaker forms the collector load of Q4.

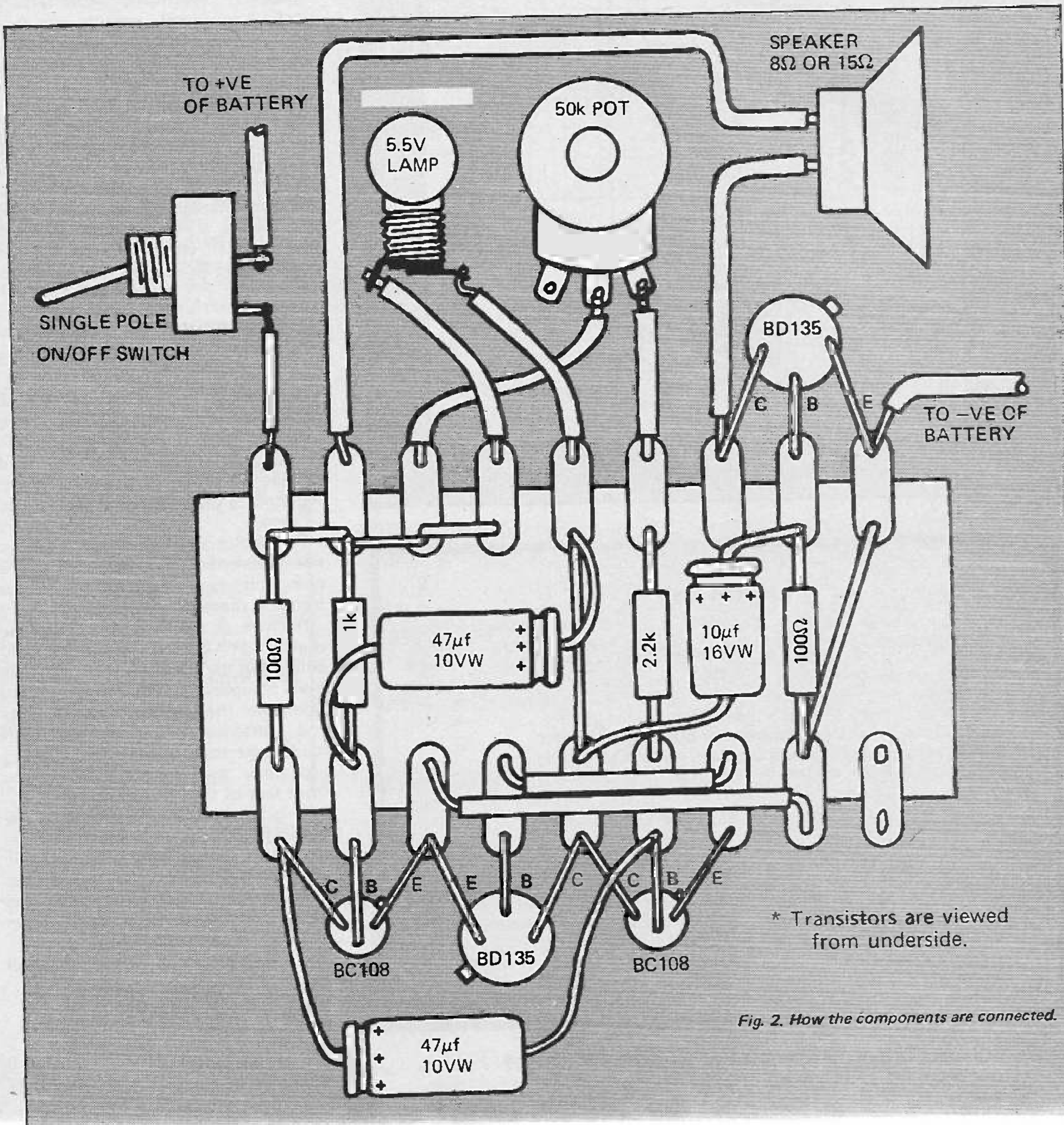


Fig. 2. How the components are connected.

INPUT GATE

LETTERS FROM OUR READERS

DAMPING FACTOR

While I agree entirely with the first part of your Sept feature, I think you have not drawn the correct conclusions from the data you have gathered. For some years I have been experimenting with audio amplifiers using current (instead of) voltage feedback.

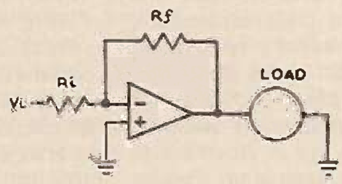
The only portion of an amplifier output which imparts mechanical energy to the speaker cone is the in-phase current in the voice-coil, since the speaker is a current-operated device. Speaker enclosures are designed to acoustically and mechanically damp the cone, thus reducing impedance variations in the coil — and in most cases ruining the transient response of the system.

If this is generally accepted (as it seems to be), then why not compensate electronically for the impedance variations?

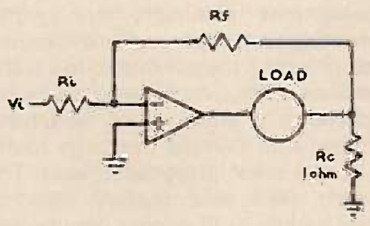
Since cone movement is proportional to current in the speaker coil and a current amplifier gives an output *regardless* of voice coil impedance, one should expect better results with this system. By the way, voice coil impedance varies not only with frequency but also with the magnitude of the input waveform.

Subjective tests in my laboratory on various guinea-pigs including musicians, with an amplifier switched from voltage to current feedback, have yielded the consensus that current amplifiers gave vastly superior results. Any power operational amplifier which has overall all feedback can be converted simply to a current amplifier as shown below:

—R Stewart, Glasgow



Normal Audio Amplifier



Current Amplifier

QUESTIONNAIRE

I have pleasure in assisting by completing the Questionnaire in your Sept issue. Although a new reader to ETI, may I say I find the new approach particularly refreshing and the articles and reports should be of interest to many. Wish you every success in the future. —H P Orange, Warwickshire

Thank you, Mr O — and may I take this opportunity to say the same to the many readers who have responded to our questionnaire with such enthusiasm and a wish to help. Our Research Dept is sifting through the hundreds of replies we have received to date and we hope soon to be able to share the knowledge gained from this with our readers. —Ed

PHONE HANDSET

Mr Shrewsbury (Sept) is quite right. The idea is certainly not new in this country. I filed a Provisional Patent (11338/60) and later a complete specification under 'Improvements Relating To Handsets' but I could not give it away! The unit was battery powered for convenience but the specification allowed mains powered operation and had other advantages like a plug-in unit. Unfortunately, like so many ideas in UK, British manufacturers seemed to prefer to wait till the patent lapses, the inventor goes broke or some other country claims the idea.

—A C Geer, MInstPI, MBHI

AMATEUR ELECTRONICS

Congratulations on a magazine of considerable interest, though I am not interested in the Record Review sections! I hope you will exchange it for a section on Bridge which is my second Hobby!

The British Electronics Club, of which I am Chairman, is also interested in promoting (and helping all those interested in) electronics as a hobby. Your readers may like to contact our Secretary at 17 St Francis Close, Abergavenny, Mon. —C Bogod, Glamorgan

NEVER TOO YOUNG

I am interested in the use of electronics in modern art and theatricals. I read most features and projects. I found Biological Feedback, Wiegand Effect and Of Utmost Gravity specially interesting, so also the Photo timer project and Practical Guide to Triacs. Superlative magazine!

—M G Kiff, Berks (aged 16)

Can we have more introductory articles for beginners in this field? There is not enough suitable done for the younger generation. Who with 50p allowance can construct many of your projects? —K R Gunn, London E15

ETI tries to cater to all age groups and all professions, vocations and hobbies. But, with only so many pages per month, it is not an easy job to choose some items in preference to others. As for the interests of younger readers, may we suggest they get in touch with each other for mutual benefit? ETI will make space available for the younger generation to give their names and addresses and areas of interest. How about it? —Ed

ENERGY

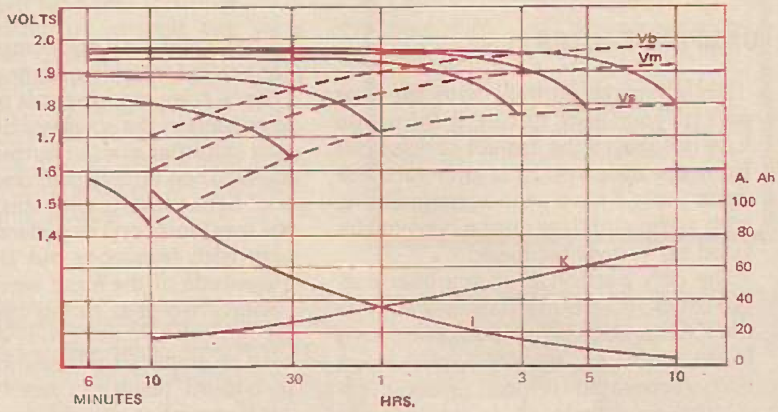


Fig. 1. Discharge curves for lead acid batteries where V_b = Initial cell volts, V_m = mean cell volts, V_s = Final cell volts, I = current in amps per positive plate and K = capacity at current I per positive plate.

ENERGY sources have attracted a great deal of Research and Development effort over the last two decades, and all existing and potential systems have been subjects of most detailed examination.

Early in the 60's, the developments in fuel cell systems caused optimistic forecasts that these devices would replace all other types of batteries for power and traction purposes. At present, however, the implementation of fuel cells in every day systems is still far from a reality.

A large variety of exotic battery couples have been devised and work is still proceeding on their development, but the manufacturers of the well established types have been active in the steady improvement of their products as well. We shall look at some of the specialised developments of each type in turn.

LEAD ACID BATTERIES

The Lead Acid System has been the most successful in terms of aggregate energy storage capacity produced each year, largely due to their use for starting, lighting and ignition in automobiles. Energy and power density have both been increased by 50% during recent years and life performance has increased quite spectacularly. At the same time costs have been held down by increased productivity in the industry.

There is a current demand for transport having low maintenance costs, low running costs and low pollutant emission. The battery electric vehicle fulfills these requirements admirably and world wide interest has led to limited production of these vehicles in several countries. Naturally a factor of major importance is the battery, and here, the lead acid battery has been found to be the most practical to date. The modern lead acid battery matches nickel cadmium in energy density and freedom from mainteinance, while its higher cell voltage (2.0 versus 1.2) means fewer cells for a given voltage. This among other applications has led to an even greater demand for lead acid batteries than ever before.

Knowledge of the mechanism by which the lead acid battery works and fails has enabled electrochemists, metallurgists and engineers to produce lead batteries designed for specific applications whilst maintaining an attractive performance/cost relationship. Performance has been improved by a better understanding of the physical chemistry of the lead/acid reaction. This understanding enables the optimum material porosity or surface area to be developed consistent with the duty cycle expected in use and hence best use of lead materials with regard to the annual cost factor of the installations' capital value.

Corrosion of positive grid structure is a major limiting factor in the life of lead-acid batteries, and new alloys have been developed to reduce this factor. Among these are the lithium and calcium lead alloys which have been used successfully for very long life battery systems. For example, Bell have found that life expectancy in telephone exchange service may be 30 years or more when using these alloys. The use in Australia of pure lead grids for emergency power batteries has shown that a life expectancy of 20 years is reasonable. In Europe batteries with tubular positive plate designs using non-antimonial lead alloys have given similar results.

In the field of emergency power batteries, other developments have been made including explosion proof catalytic recombination stoppers, and third electrodes which allow once-yearly maintenance when the batteries are used in the float or constant potential mode, and are required to supply emergency power for one hour or longer. The very low self discharge rate of these batteries (50% capacity loss per year on open circuit) allows their use in remote low drain installations where they are returned to depots for re-charging on a yearly schedule.

The power available on discharge in any electrochemical device is directly proportional to the surface area available for electrochemical reaction. This is the reason automotive starter

SOURCES

The characteristics of existing and potential battery systems are examined by John C. Howlett, Technical manager, Dunlop Batteries (Australia) Ltd.

batteries are designed with a large number of closely spaced thin plates with low resistance, inter-cell connections. In contrast, a mine-locomotive battery would be made with plates four times as thick with double the spacing between them and have inter-cell connections of cross section adequate for currents at the five hour discharge rate.

The capacity available varies inversely with the rate of discharge as shown in Fig. 1. The end point of discharge is where the voltage time curve starts to develop a definite knee, very little further energy is delivered after this point.

CHARGING SYSTEMS

The success of any battery system depends to a large extent on the design and performance of the associated charging means. With modern solid state control, the characteristics of the charger may be exactly matched to the battery for optimum system performance. Charging system constraints will be laid down in an Australian Standards Associations draft specification being generated by a group of battery technologists and charger manufacturers. These may be summarised as follows:-

The charger should be capable of recharging the battery in the minimum allowable time and the current and voltage regulation should be such that the battery electrolyte temperature does not exceed 50°C at any time. A number of parameters contribute, but the current at any particular state of charge and the percentage ripple in the rectifier output are the prime causes of increased battery temperature.

Various schedules of charging are used, but the three most common are taper charging where the charge is started at about the 5 hour rate of the battery and tapers uniformly over a 12 hour period to the 40 hour rate at finishing, this is known as a "12 Hour Taper Charge".

The most usual schedule for traction battery charging is called "The 2 Step Charge", in which a constant or nearly constant current is passed until the average cell voltage reaches 2.35 to 2.4 volts. When this point is reached, a voltage sensing device changes the charge to a taper system, and starts a 3 to 5 hour timer. This system may be used to charge a fully discharged battery in as little as 6 hours, but an 8 hour period is usually preferrable. When either of these systems is used for rapid recharge, a temperature control of some sort is necessary, the most effective being a fusible link which will open circuit the battery if its temperature exceeds 55°C.

Batteries which are used for "stand-by", or "emergency power" applications frequently have a charger permanently in parallel with the battery; arranged to float the battery at a voltage of 2.15 to 2.2 volts per cell. This cell potential will maintain the battery at 95 to 98% fully charged when a trickle charge rate of 0.4 to 0.5 milliamps per ampere hour of capacity at 10 hour rate is used. The most important feature of the above is that the voltage range is in the area of minimum corrosion rate for lead in an anodic environment and hence a system life expectancy of 15 years or more will be obtained if the rectifier system is suitably controlled. With cell voltages of this order a negligible amount of water is electrolysed from the cell and if a large volume of electrolyte is allowed above the plates, maintenance periods may be decreased to perhaps twice yearly. The addition of catalytic re-combination stoppers will further increase the time between water additions.

The rectifier needs to be of a design which minimises ripple on the dc voltage, higher ripple increases the amount of gas evolved and increases the corrosion rate. A ripple level less than 5% of the dc output voltage is normally acceptable. High ripple content will also increase cell heating

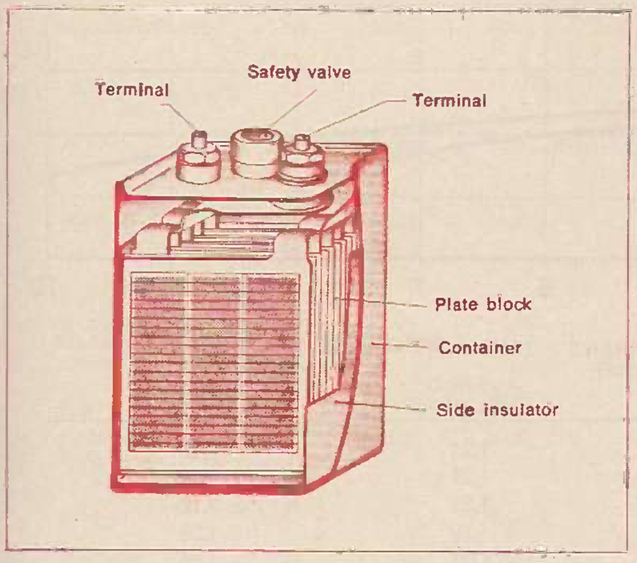


Fig. 2. Construction of typical vented alkaline battery.

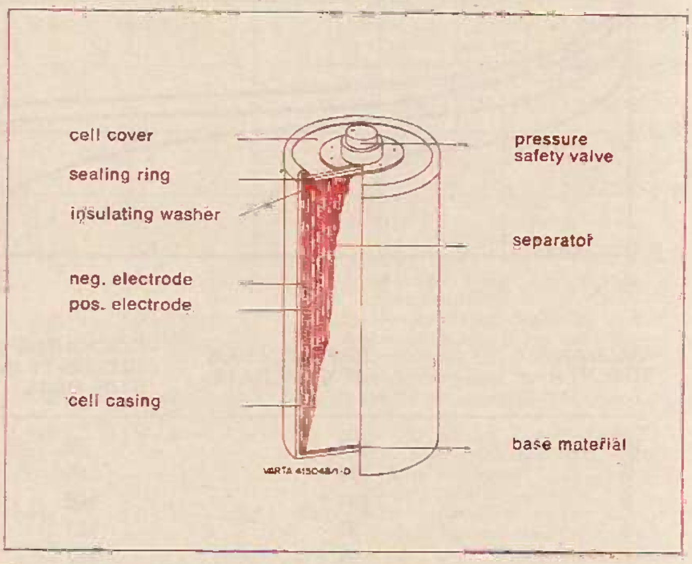


Fig. 3. Construction of sealed alkaline battery.

during re-charge and will limit the charge rate. This factor is therefore very important and should be given consideration in traction battery chargers.

Pulse Cycle Charging

The "Pulse Cycle" charge maintenance system is relatively new, but some success has already been reported with the method in applications using automotive batteries. The system charges at a constant current until a cell voltage of 2.5 volts is reached, this voltage is sensed and the charge ceases until the cell voltage falls to 2.1 volts when the charge cycle recommences. This charging method produces very little electrolysis of water in the electrolyte, maintains the battery in a fully charged condition and reduces the corrosion rate appreciably.

Lead acid battery systems exhibit very small voltage change over their normal operating range. For example:-

A 24 cell battery will float at 2.17 volts per cell or 52.2 volts and on discharge will range from 2.1 volts to 1.85 volts (5 hr. rate) with an average voltage of 1.93 volts per cell or 46.4 volts.

ALKALINE BATTERIES – NICKEL-CADMIUM

There are a number of applications where batteries are required to withstand rough handling, high or low temperatures and/or very high current pulses. Additionally they may have weight constraints and be required to withstand years of float trickle charge without being liable to failure when called upon in an emergency.

Nickel cadmium alkaline batteries are capable of withstanding the above conditions to a much greater extent than lead acid. Initial cost is 3 or 4 times higher than with lead acid but in many instances the cost will be offset by the added reliability.

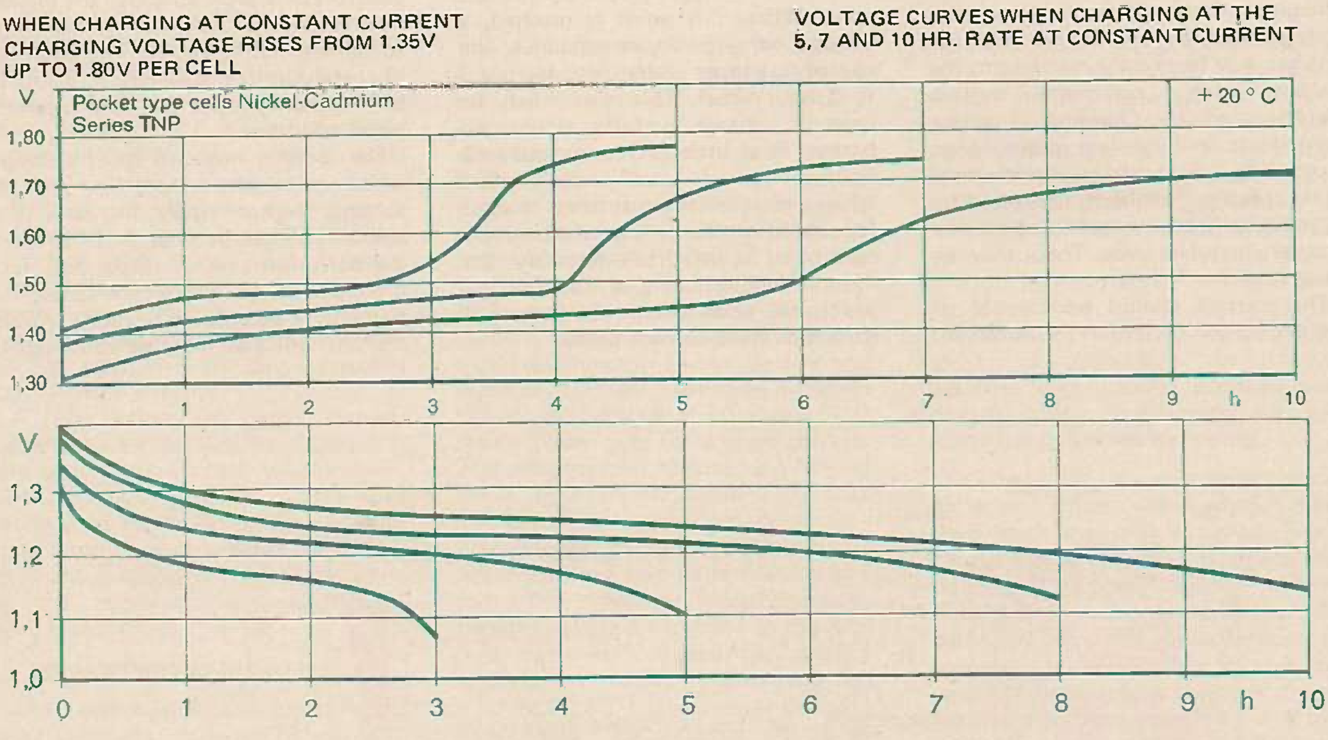
In a nickel cadmium battery the electrolyte functions purely as a low resistance source of ions for the electro-chemical process and part of the electrolyte is therefore not consumed in the reaction. This allows the plates to be assembled with close spacing thus providing a low resistance cell.

The electrolyte is a solution of potassium hydroxide and a small percentage of lithium hydroxide. The specific gravity of the electrolyte is held at 1.17 and thus a resistivity of 2.0 ohms/cm is obtained – the minimum possible for these solutions.

In vented alkaline cells the electrolyte readily absorbs carbon dioxide from the atmosphere thus producing potassium carbonate which interferes with positive plate operation. Vented alkaline cells therefore require maintenance at 3 to 5 yearly intervals. The cell should be emptied, washed with warm de-ionised water, refilled with fresh electrolyte and recharged before return to service.

The voltage time curve for nickel cadmium (Fig. 4) allows the construction of permanently sealed cells which have similar electrical characteristics to the vented types but are completely free from maintenance in operation. Some types are designed for float trickle charge, but of course, are very sensitive to voltage variation and ripple on the dc supply.

Sealed cells operate very satisfactorily in charge discharge cycling and are made in a range of sizes identical with those of



DISCHARGE TIME IN HRS.	CAPACITY IN % OF 5 HR. RATE	DISCHARGE CURRENT INTENSITY IN % OFF 5 HR. RATE	DISCHARGE VOLTAGE AVERAGE VOLTS	DISCHARGE VOLTAGE FINAL VOLTS
10	105	53	1,24	1,13
8	104	65	1,23	1,12
5	**100**	**100**	**1,21**	**1,10**
4	97	121	1,19	1,08
3	94	157	1,17	1,06

Fig. 4. Charge/discharge characteristics of Varta type TNP alkaline cells.

Table 1. Characteristics of Typical Batteries

System	Anode	Cathode	Electrolyte	Open current voltage,	Typical operating voltage,	Capacity Ah/lb[a]	Wh/lb[b]	Remarks
Primary systems Leclanche	Zn(Hg)	MnO_2(C)	NH_4Cl-$ZnCl_2$	1.6	0.9-1.4	23	30	most common form of the dry cell; extensive applications; sloping discharge curve
Alkaline Zn-MnO_2	Zn(Hg)	MnO_2(C)	KOH	1.52	0.9-1.2	30	33	suitable for greater drain rates than Leclanche cells; sloping discharge curve
mercury cell (Rubin)	Zn(Hg)	HgO(C)	KOH-ZnO	1.35	1.30	40	53	constant voltage during discharge; heavier drains and higher capacity than Leclanche cells
Mg—MnO_2	Mg	MnO_2(C)	$MgBr_3$, Li_2CrO_4	2.0	1.6-1.8	30	46	higher capacity and voltage than Leclanche cell; 35—40% of magnesium consumed in hydrogen liberation during discharge
air-depolarised Zn	Zn(Hg)	O_2(C)	KOH	1.36	1.1-1.2	60[b]	70[b]	utilizes oxygen from air; wet type used for railway signals, home radios; dry type available but moisture loss a problem
Zn-AgO	Zn	AgO	KOH	1.8	1.4-1.5	35	53	one-shot, high-drain-rate reserve cell; also available in another form as a secondary battery
Zn-PbO_2	Zn	PbO_2	H_2SO_4	2.5	2.0-2.3	18	26	one-shot, high-drain-rate reserve cell
Zn-CuO	Zn(Hg)	CuO	NaOH	1.06	0.9-1.0			low operating voltage; used principally for railway signals
Zn-Cl_2	Zn	$ZnCl_2$	Cl_2	2.1	1.5-1.9			one-shot, high-drain-rate cell
Pb-PbO_2-$HClO_4$	Pb	PbO_2	$HClO_4$	2.0	1.6-1.8	11	19	one-shot, high-drain reserve types used for military applications
thermal cell	Ca	$PbCrO_4$(Ni)	LiCl, KC1 fused	2.8	2.2			must be heated to melt electrolyte, one-shot, high-drain, military type cell
Mg-Cu_2Cl	Mg	Cu_2Cl	$MgCl_2$	1.4	1.1-1.3	25	30	one-shot, high-drain reserve cell; may be activated with sea water
Mg-AgCl	Mg	AgCl	$MgCl_2$	1.6	1.3-1.5	54	75	one-shot, high-drain reserve cell with very high capacity; may be activated with sea water
Zn-V_2O_3	Zn	V_2O_3	NH_4OH, ethylene glycol, boric acid	1.2	1.2			available commercially as a bias cell providing stable voltage at zero current over long periods
Weston standard	Cd(Hg)	Hg	$HgSO_4$, $CdSO_4$	1.019	1.2			used as a voltage standard
solid electrolyte	Ag	$CuBr_2$	AgBr	0.75				power source for radiation warning devices; charging source for low-leakage capacitors
Fery cell	Zn	O_2(C)	NH_4Cl	1.2	0.7			used extensively in foreign countries for telegraphy and telephone service; performs efficiently at low drains
Zn-AgrO	Zn	Ag_2O	KOH or NuOH	1.6	1.5	33	49	small sealed primary cell for electric wrist watch or hearing aid use; hermetically sealed
In-HgO	In	HgO	KOH	1.15	1.05			electric wrist watch battery; hermetically sealed
Experimental cells (primary) organic cathode	Mg	*m*-dinitro-benzene	$MgBr_2$	1.65	1.15[d]	56	65	one of the more promising of a large number of organic compounds being considered; multistep discharge
solid electrolyte	Ag	V_2O_3	AgI	0.46	0.38-0.46[d]			typical of a variety of similar systems that could be made commercially if applications warranted: thin flat cells providing 100 V/in. of battery length
Al-MnO_2	Al	MnO_2	$AlCl_3$,$(NH_4)_2Cr_2O_7$	1.7	1.3			higher capacity and voltage than Leclanche cell; wasteful corrosion of aluminium remains a major problem
Mg-Bi_2O_3	Mg	Bi_2O_3	$MgBr_2$	1.6	1.0	6		operates 0.2-0.3 V lower potential than HgO-Zn system but otherwise has similar voltage-time discharge characteristics
Secondary cells lead acid	Pb	PbO_2	H_2SO_4	2.2	1.95-2.05	10	20	conventional lead storage cell
Edison	Fe	Ni oxides	KOH	1.6	1.2-1.4	10	13	much longer useful life than lead storage cell but lower capacity and more expensive
	Cd	Ni oxides	KOH	1.35	1.1-1.3	10	12	available as a completely sealed cell
Cd-NiO Zn-AgO	Zn	AgO	KOH, ZnO	1.8	1.4-1.5	35	53	very high capacity and suitable for high discharge rates but smaller number of cycles than Ni-Cd or lead storage cells
Cd-AgO	Cd	AgO	KOH	1.4	1.0-1.1	30	33	greater number of cycles than Zn-AgO secondary cell
MnO-Zn	Zn	MnO_2	KOH	1.5		8	9	available only as a completely sealed cell

a *Based on total weight of commonly available size of commercial cells.*
b *Exclusive of O_2 consumed from air.*
c *Average voltage for light-drain application.*
d *2×10^{-10} A/in.^{2} drain for the first 7 yr of cell life.*

conventional primary cells. The capacity ranges from 10 milliampere hours to over 20 ampere hours at the 10 hour rate. The constant current method of charging is used with time limit facility. The degree of charge required is easily determined by discharging at the 3 hour rate for a few seconds and measuring the cell voltage accurately. When plotted on the 3 hour discharge curve, the percentage charge may be determined. The cell is then charged at the 5, 7, or 10 hour rate, in each case with constant current, for a time which is based on 125% of the calculated charge requirement.

Cell voltage of Nickel Cadmium varies from a maximum of 1.8 volts at end of charge and a nominal 1.3 volts open circuit fully charged to between 1.25 and 1.0 volt average during discharge. The optimum voltage for float trickle charge is 1.44 volts per cell at which rate the charge current should equal the capacity at the 5 hour rate divided by 300.

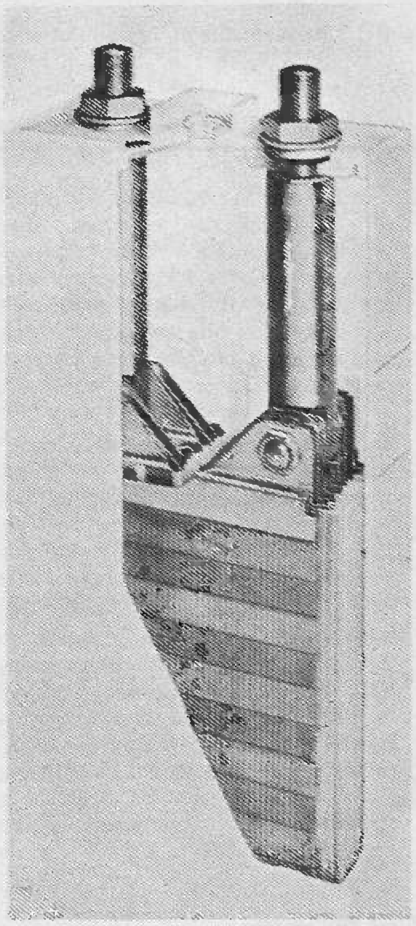
The average discharge voltage at the 3 hour rate is 1.17 volts per cell so that in a nominal 50 volt emergency power supply 38 cells would float at 54.7 volts and average 44.4 volts during a 3 hour discharge, ending at 40.2 volts.

High performance cells made with foil plates are capable of very high currents of the order of 75 times the 5 hour discharge rate and these batteries are applied to engine starting for large emergency power plants. In this application the battery is maintained at full charge by continuous trickle charge and must remain unaffected by this treatment for very long periods.

SPECIAL SYSTEMS

Many other couples have been developed and perhaps the most spectacular is the Silver Zinc system used in Lunar rovers on the moon and the 160 m.p.h. plus battery-powered car. This system delivers very high energy density, but is very costly and has limited life. Another well publicised system is the Sodium Sulphur battery being developed in U.S.A., this also has high energy density and is made from materials which are relatively abundant. The disadvantages are the high operating temperature of 800°C and the difficulty of manufacturing the special β alumina ion-exchange electrolyte.

Other exotic couples include the Lithium Fluorine cell which operates in a non-acqueous electrolyte and produces the highest yet obtainable energy density. The capability is due to the low density of the reagents and the high (3.4 volts on load) voltage of the couple.



A high capacity alkaline cell.

More recently, metal air cells and in particular Zinc Air, have been developed to semi-commercial stages and offer many attractive properties. Many problems in rechargability have to be overcome, however, before these can be considered as viable secondary batteries. The Air Electrode and Separator System has quite a long life expectancy when the cells are operated on a mechanised recharge program, i.e., the discharged zinc in the form of oxide and zincate is removed from the cell, a new zinc electrode and electrolyte added and the spent reagents are reformed to metallic zinc in another cell specially designed for this purpose.

The future of batteries for both stationary, starting and traction use is brighter then ever and developments in the established Lead-Acid and Nickel-Cadmium designs have maintained these two systems as the most reliable and economical for nearly all applications. The significant break-throughs promised for other types have not yet appeared and it is likely that these two systems will find continued use in the future. ●

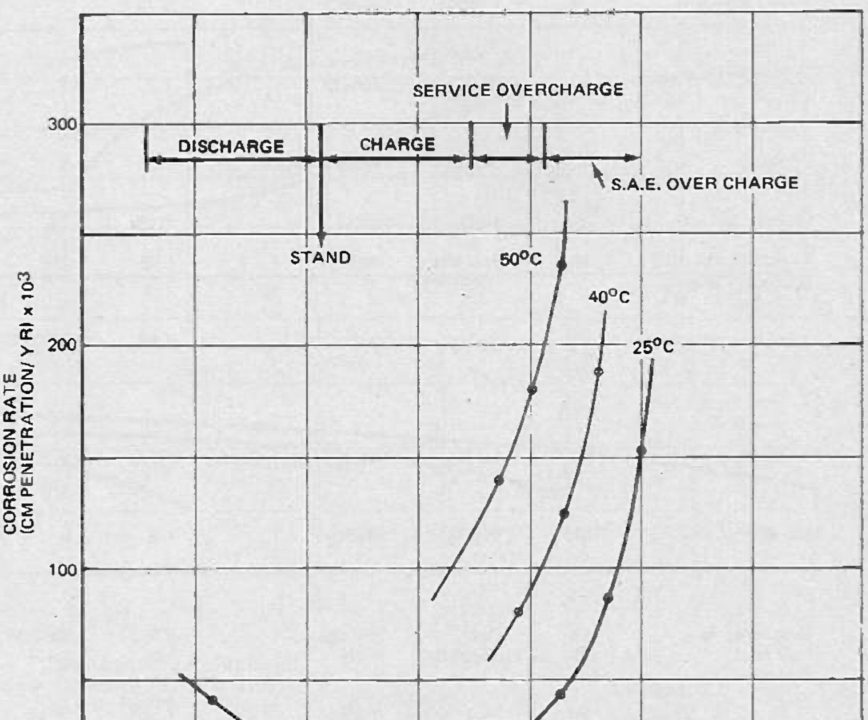


Fig 5. Typical corrosion rate versus plate voltage of lead acid cells. The total cell voltage is the sum of the negative and positive plate voltages.

THIN FILM SPUTTER ETCHING

Philips Research Laboratory in Hamburg have succeeded in substantially reducing the rate of undesired erosion of photolacquer masks in sputter-etching of patterns into thin films — an important part in the manufacture of integrated circuits. To this end the film to be etched is provided photolithographically with a lacquer mask, through the openings of which the film below is removed.

The frequently employed wet-chemical etching method, in which etching baths act upon the exposed areas of the film, possesses certain fundamental disadvantages, such as under-etching and, in certain circumstances, poor compatibility of the etching solution with parts of the substrate to be etched.

For this reason, sputter-etching has lately found increasing application. In this, the masked substrate is placed on the target of a cathode sputtering device and eroded by ion bombardment (see Fig 1). Since the mask as well as the film is eroded in this process, it is desirable that the mask-etching rate is low.

The target material predominantly used hitherto has been copper or stainless steel. With these materials, however, the etching rate of the mask is found to be relatively high, erratic and strongly affected by the pressure of reactive gases (such as oxygen and hydrogen) in the cathode sputtering system.

Research in the above laboratory has shown that a low and well-reproducible mask-etching rate can be obtained in sputter-etching if a target with strong gettering power, preferably titanium, is used as substrate holder. The titanium which is sputtered around the substrate during etching ensures highly intensive gettering of the reactive gases, in consequence of which the gases cannot attack the mask. A condition for the effectiveness of the method is that the target surface is not entirely covered by the substrate to be etched.

The influence of the target material on the etching of a photolacquer mask is represented in Fig 2. This shows the ratio R of the etching rates of a conventional lacquer mask and an underlying SiO_2 film as a function of the oxygen pressure in the discharge chamber adjusted prior to etching. Curve 1 refers to a copper target and curve 2 to a titanium target. Whereas with a copper target, ratio R increases rapidly at increasing oxygen pressure, the effect of a titanium target is that R remains nearly constant at first and increases rapidly only above a specific oxygen pressure, which is determined by the sputtering rate of the titanium. Accordingly, etching results of far better reproducibility can be obtained through use of a titanium target. Research into the effectiveness of other target materials is in course of preparation.

The results described refer to laboratory experiments; they do not necessarily imply a follow-up in production or marketing.

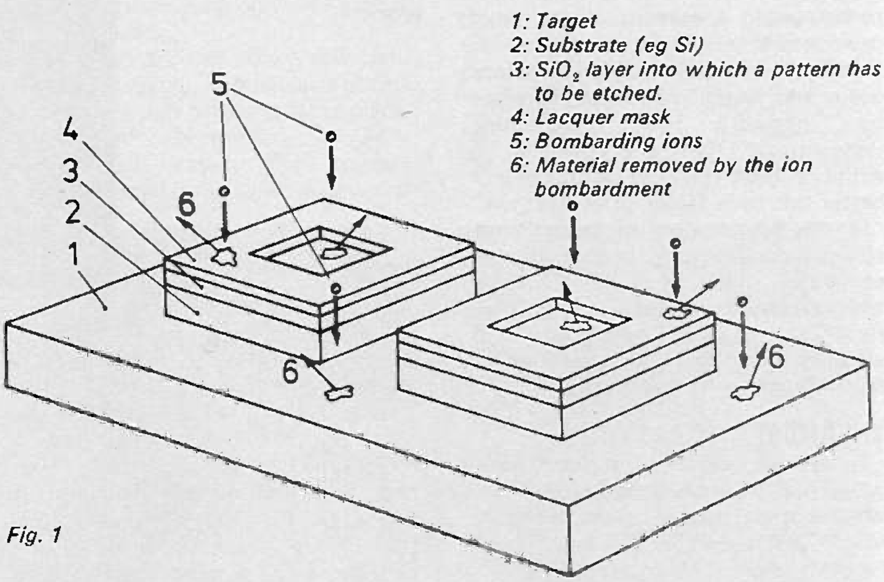


Fig. 1

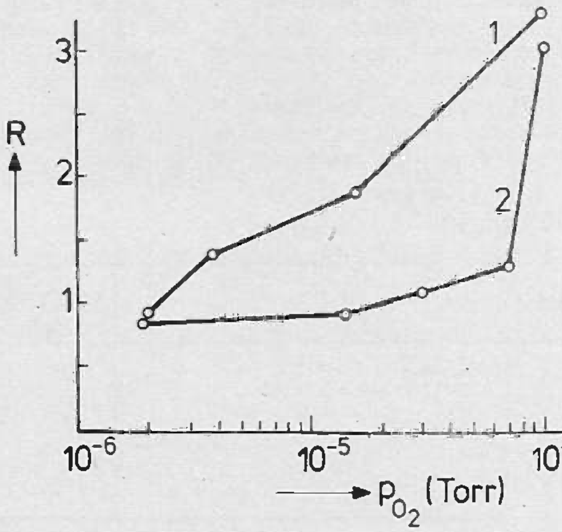
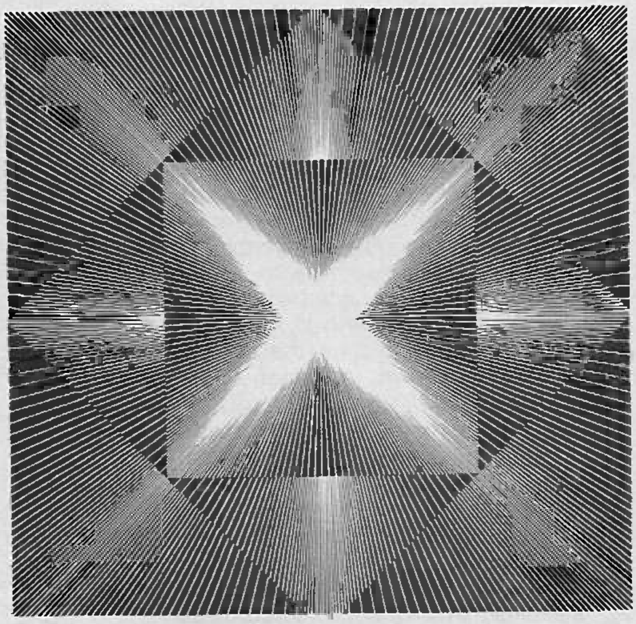


Fig. 2

PRACTICAL GUIDE TO TEMPERATURE CONTROL

PART 1



Temperature controlled systems are used throughout science and industry — in this series of articles Collyn Rivers explains how they work.

Accurate, repeatable temperature measurement and control is an essential requirement in many aspects of science and industry.

Many scientific experiments depend upon the maintenance of a stable temperature — often, as with pathological specimens, over long periods of time.

Even the cheapest usable laboratory ovens and water baths must therefore be capable of maintaining temperatures that are constant to within at least 1°C — in fact many will better this by a factor of at least two.

In the development of colour films on an industrial scale, large quantities of water must be held to close temperature limits, even in industries such as chicken hatching, large volumes of air must be maintained to astonishingly tight specifications.

THERMOSTATIC CONTROL

To various extents, all solids expand when heat is applied to them. Thus, when a metal rod is heated along its length, each unit of its length will become longer. This increase in length (per degree of temperature rise) is called the coefficient of linear expansion and has different values for different materials.

Table II shows the coefficient of expansion for various materials. The Table also shows the coefficient of volumetric expansion — which is roughly equivalent to three times the coefficient of linear expansion.

From Table II it can readily be seen that the volumetric expansion of mercury is over six times that of glass, and that the linear expansion of copper is considerably greater than that of say, invar, (invar is an alloy containing 36 percent nickel and 64 percent steel).

It is this difference between expansion rates that is exploited in devices such as thermometers and thermostats.

The simplest form of thermostat consists of a bimetal strip — usually invar and brass. As temperature rises, the brass expands more than the invar thus causing the strip to bend. This movement is used to open and close a pair of electrical contacts which in turn make and break the electrical energy supplied to the heating (or cooling load. (Fig. I).

The thermostat is located within the area to be controlled — for example, in a laboratory water bath the thermostat will be immersed in the bottom of the bath.

A thermostat of any type is simply an 'on/off' device: it is either open or closed. This effect is shown diagrammatically in Fig. 2. Here the upper line represents the thermostat movement whilst the lower line shows the current flow through the heating element which is controlled by the thermostat. At the lowest temperature the bimetal strip is straight and the contacts are closed — hence current flows through the heating element and temperature begins to rise (T1). For a time, temperature rises and as it does so the bimetal strip begins to bend. At a certain temperature — determined by the characteristics of the bimetal strip

TABLE I

SCALE	MELTING POINT	BOILING POINT	SYMBOL
Celsius (Centigrade)	0	100	C
Fahrenheit	32	212	F
Reaumur	0	80	R
Absolute Celsius	273	373	K
Absolute Fahrenheit	492	672	—

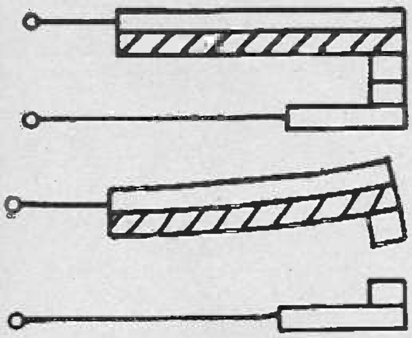


Fig. 1. Basic thermostat: when heated, brass (shaded) portion expands more than invar thus causing strip to bend and contact to open.

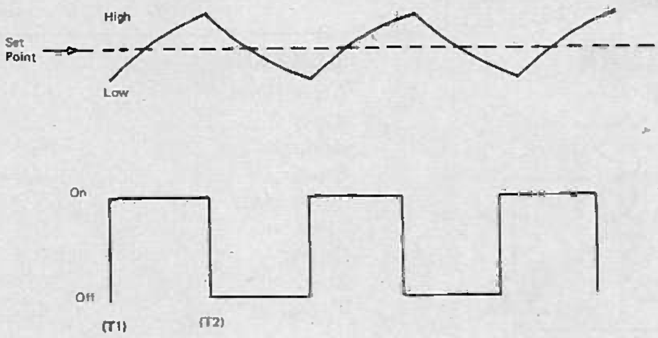


Fig. 2. Operation of thermostat above and below set point, upper curve shows temperature of load, lower curve shows heater being turned on and off.

and the spacing of the electrical contacts — the bimetal strip bends sufficiently to open the contacts (T2) and the heating stops.

Thus the thermostat oscillates between maximum temperature (contacts open) and minimum temperature (contacts closed). This variation is known as the 'differential' of the thermostat, and in top quality units may be as little as ½°C.

It should however be clearly understood that the temperature differential described above is that achieved once the heated system has reached a state of equilibrium. During the initial process of coming up to the desired temperature, the system may well 'overshoot' by quite a substantial amount. This action may then be followed by several swings of temperature — diminishing in amplitude — above and below the required set point.

The amount of initial overshoot is a function of the design of the complete heating system — including the electrical size of heating elements, time taken for the thermostat to respond to temperature change etc. It may be reduced by careful design but can rarely be eliminated conpletely. Hence on/off control systems must only be used where these initial characteristics can be tolerated.

A further article in this series will describe various types of proportional controllers — which do not exhibit this overshoot characteristic.

Precision thermostats, such as those used for laboratory applications, whilst still exploiting the basic principle of different coefficients of linear expansion — do not use bending bimetal strips. Generally they use long rods of brass or copper located within an invar framework. One end of the rod is rigidly clamped to the invar frame and the other end is linked to electrical contacts via a lever mechanism that magnifies the relative movement between the two brass rod and the invar framework.

This type of precision thermostat is necessarily large and is therefore only suitable for large ovens and water baths — or other applications where space is not at a premium. Nevertheless they can be very effective devices indeed and differentials of 0.1% have been achieved.

A major disadvantage of nearly all electric thermostats is that the contacts are used to interrupt the heating load current, which, in large ovens or water baths may be at least ten to fifteen amps.

This results in two problems — with a common cause.

Thermostat contact points open and close fairly slowly, and because of this a certain amount of arcing takes place. Unless the thermostat is very conservatively rated, the contact points become burnt and pitted and must be replaced at frequent intervals. Failure to do so may well result in the points welding together and thus supplying power continuously to the heating element. If the element is used to heat a pathological oven, months of research can literally be burnt up in less than half an hour. Many a thankful of tropical fish has perished for the same reason.

The second effect of point arcing is that the heat generated in the arc disorts or expands some parts of the thermostat, thus affecting its operating accuracy.

To overcome these problems, a few top quality ovens use the thermostat merely as a switching device to control a main power contactor.

Practically throughout science and industry, and shortly to become common useage elsewhere, temperature measurements are quoted in degrees Celsius.

Earlier, a centigrade scale was proposed by Celsius, a Swedish astronomer. This term was used extensively until 1948 when, at an international conference, the word 'Celsius' was adopted in place of 'centigrade' — a term which is also used to define one hundredth part of a grade (part of a European scale in which a circle is divided into 400 grades).

The Celsius scale has now been adopted by Standards Institutes worldwide for use in scientific work. Units are expressed in degrees Celsius — often abbreviated to °C.

An absolute Celsius scale (Kelvin scale) is also used in scientific calculations. In this system, zero degrees represents the total absence of heat. Units are expressed as degrees Kelvin — or °K.

The Fahrenheit scale is still used in some parts of the world in medicine, engineering, meterology, and for domestic purposes.

All conventional temperature measurements are based on two fixed reference points which are both stable and easily reproducible.

The lower of these two points, 0°C (273°K) is defined by the temperature of melting ice. This is measured at an external pressure of 760mm of mercury at sea level on latitude 45°.

The second point defines 100°C (373°K) and is based on the boiling point of water — measured under the same conditions.

Two further reference points are sometimes used. These are the boiling point of sulphur (444.6°C), and the melting point of gold (1063°C).

Relationships between these three scales are shown in Table I — which also includes the Reaumur scale. This latter scale is still used in parts of Europe for domestic temperature measurement.

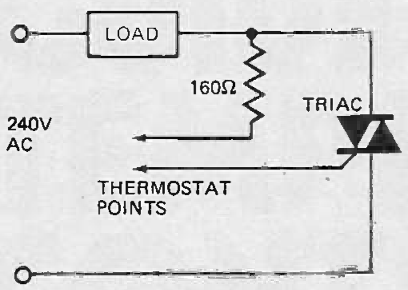


Fig. 3

This method is effective, but expensive and clumsy.

A far simpler method of overcoming the problem is to use the thermostat contacts in the gate circuit of a suitably rated Triac which in turn switches the heating load. This overcomes all the problems in one go and is both cheap and effective.

The writer of this article has modified several hundred laboratory heating systems in this way over the past eight years — and without exception none has since required any further attention to contact points. A further bonus is that the temperature regulation of the device is frequently improved — by as much as 50 to 75 percent.

Figure 3 shows how the modification is made. If installing this modification, bear in mind that the Triac assembly must be mounted in the coolest possible location and not within the heated part of the oven!

CONTACT THERMOMETERS

The construction and use of the mercury-in-glass thermometer is familiar to us all. The contact thermometer is in essence a standard thermometer of this type but modified to incorporate electrical contacts.

In its simplest form the contact thermometer is made to switch at a specified temperature. A typical example of this type of thermometer is shown in Fig. 4. Here, one wire is in permanent contact with the mercury pool in the thermometer bulb — a second wire is attached to the inner face of the tube and this is contacted by the mercury at the predetermined temperature.

An adjustable form of contact thermometer is shown in Fig. 5. In this device the leads enter the glass tube via a plastic cap. A magnet mounted on this cap is used to rotate an internal armature; this is attached to a fine threaded spindle terminating in a platinum contact, the operating temperature of which is read from a calibrated scale.

TABLE II
Coefficients of expansion (per $^{o}C \times 10^{-6}$)

SUBSTANCE	LINEAR	VOLUMETRIC
Aluminium	23	69
Brass	18.9	56.7
Copper	16.8	50.4
Glass	8.6	26.4
Pyrex glass	3.2	9.6
Invar	0.9	2.7
Quartz	9.4	1.2
Steel	10.7	32.1
Tungsten	4.5	13.5

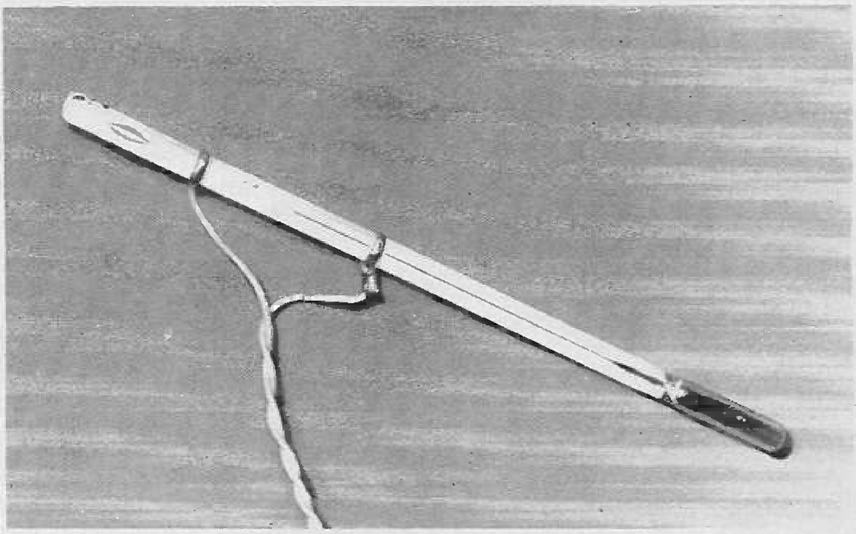


Fig. 4. Basic contact thermometer — designed to switch at 40°C. At that temperature, the expanding mercury touches the second contact point.

Although far more fragile than electro-mechanical thermostats, contact thermometers are simple devices capable of accurate, repeatable switching for millions of operations. The switching differential is largely a function of the range that must be covered — but accuracies of 0.1% and better are quite common; and thermometers with a differential of as low as 0.001% (over limited ranges) can be obtained.

Contact thermometers are less commonly used than they deserve to be — probably because they were developed many years before the introduction and commercial acceptance of cheap simple circuitry that was capable of exploiting their switching capabilities: for contact thermometers have what was at one time a major drawback — that is that they can only switch very low currents and voltages. This switching capability is limited to preferably less than five to ten volts — the lower the better within reason — and the current flow should be less than a few milliamps. If these limits are exceeded, changes within the mercury will shorten the unit's life quite drastically — and apart from this the heating effect of the current (which must inevitably pass through the mercury cloumn) will grossly affect the switching accuracy.

Originally, complex valve amplifiers were used to magnify the low acceptable switching currents to a level which could be used to drive a load contactor — these were clumsy and expensive — although incredibly enough, several companies still have such anachronisms in series production.

Unlike thermostats in which the contact points close as the temperature falls — and thus reapply power to the heating load — contact thermometers switch 'on' as the set point is reached. This is of course an ideal characteristic for refrigeration loads but is the opposite to that normally required for heating loads.

Nevertheless a Triac switching circuit may be used — switching the Triac 'off' as the desired temperature is achieved. One method of achieving this is shown in Fig. 6.

In operation, when the contact thermometer is 'open', the capacitor is charged via the 150k resistor until the breakover voltage of the trigger diode if reached — usually around 30 volts — the diode then breaks down triggering the triac into conduction.

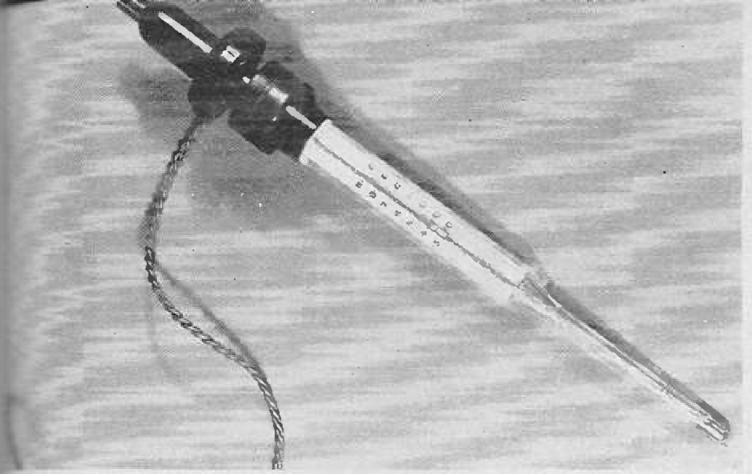


Fig. 5. Adjustable contact thermometer. Rotating upper magnet assembly (in top hat fitting) is used to adjust switching temperature – here set at 35°C.

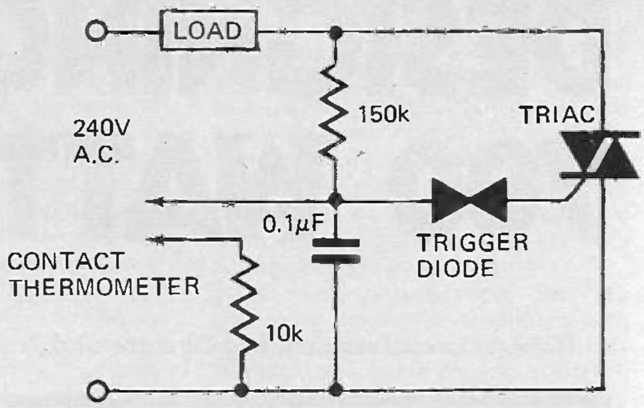


Fig. 6

The power loss caused by the minor phase shift is negligible).

Subsequently, when the contact thermometer 'closes', the capacitor is prevented from reaching the trigger diode breakover voltage and the triac is prevented from conducting.

In practice this circuit works very well indeed, although it may occasionally be necessary to select triacs capable of switching reliably at low trigger energy levels. The voltage applied across the contact thermometer is higher than desirable but in practice problems are rarely experienced.

A more elegant (but also more costly) version of this circuit is shown in Fig. 7. This latter circuit should preferably be used in critical applications. Both switching voltage and current is much lower than in the version shown in Fig. 6. In this circuit the contact thermometer is wired across the capacitor in a UJT firing circuit. When the contact thermometer is 'closed', the capacitor is prevented from reaching the UJT valley point (or 'firing') voltage and thus the triac is not triggered.

This is an excellent circuit for controlling laboratory water baths and ovens for applications where the characteristics inherent in 'on/off' control systems are acceptable.

Yet another method – originally developed by General Electric in the USA – uses an SCR connected within a full-wave bridge. (Fig. 8).

With the contact thermometer 'open', the SCR will trigger on each half cycle and deliver power to the heater load. When the contact thermometer 'closes', the gate of the SCR is effectively held at SCR cathode potential and is therefore prevented from triggering. Thus power is removed from the heating load. In this circuit the maximum current through the contact thermometer is about 250 uA.

This circuit (Fig. 8), whilst limited to switching loads of less than 150 watts or so, is reliable, cheap and simple. It is an excellent temperature control system for small fish tanks, or other similar applications where only low energy heating elements are used.

As with electro-mechanical thermostats, contact thermometers are strictly 'on/off' devices, and because of this the heating element that they control (and hence the controlled volume) will continuously cycle above and below the 'set point'.

This characteristic in inherent in this – and other – types of control systems, but in a well designed system the variations may be well within the permissible limits. In fact using these techniques the writer has successfully designed laboratory water baths and ovens with an overall temperature differtential of less than 0.1%. One small water bath was produced with a differential of less than 0.05%.

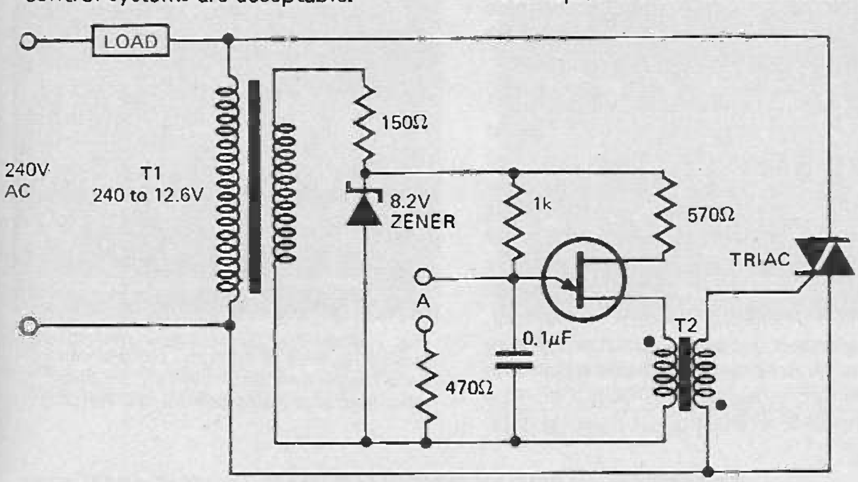
The following points should be noted by experimenters seeking to obtain optimum accuracy and long term stability when using contact thermometers.

a) The exposed glass column may be at a different temperature from the bulb. This may cause non-uniformity in the temperature of the mercury column. Where possible ensure that the whole thermometer is at the same temperature. If the thermometer is immersed in liquid, ensure that as much as the cc column as possible in immersed. If an immersion level is specified, ensure that is is maintained.

b) Glass is slightly plastic, and if the contact thermometer is changed from a high temperature to a low temperature there may be errors of up to 0.5°C until the galss returns to its original dimensions. This may take several weeks.

c) As the glass ages, there will be a slight decrease in the volume of the bulb. This may cause an error of up to 0.2% over a period of five to ten years.

The next article in this series will describe the operation of thermistors – and includes a number of practical circuits. ●



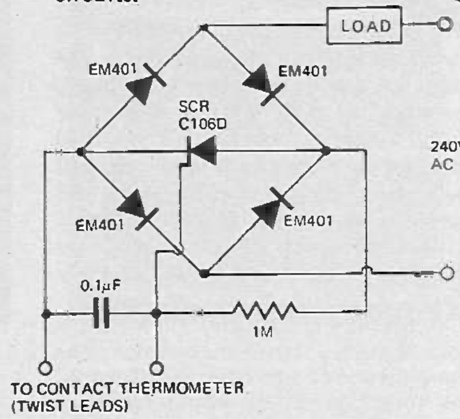
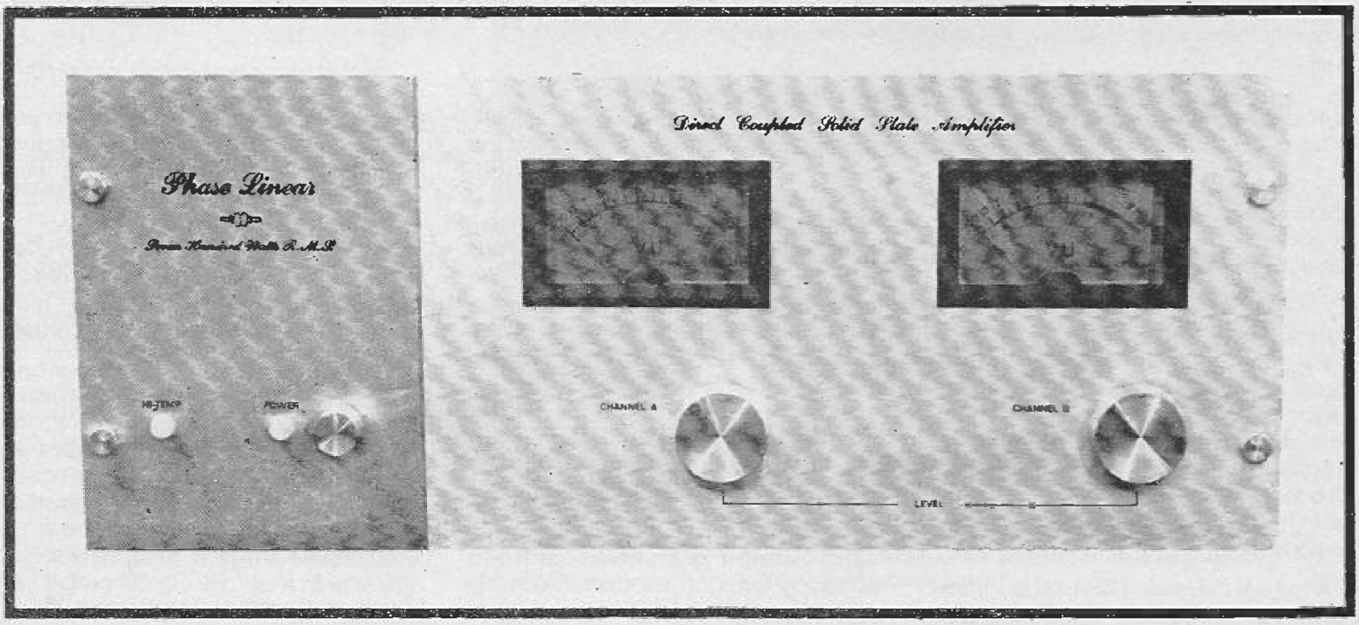


Fig. 8

DESIGNING A 700 WATT AMPLIFIER

by Robert Carver, President and Director of Advanced Projects, Phase Linear Corporation.



In our review of the Phase Linear 700 Watt Amplifier, published in our September 1972 issue, we questioned the need for such a high power output for domestic listening. Here, Robert Carver presents his side of the argument.

A look at the best available power amplifiers shows that bandwidth, distortion, and noise figures extend far beyond the limits of audibility, and in some cases, even the limits of accurate laboratory measurement. It might be concluded that power amplifiers have reached such levels of perfection that further advances could not possibly provide any audible improvements and would be simply "gilding the lily". In any event, it would seem, for example, that decreasing distortion from 0.5% to 0.05% or increasing the signal-to-noise ratio from 90 dB to 93 dB (twice as quiet) would not have any audible effect.

This conclusion might be justified because the deviations from perfection introduced by the rest of the signal-processing chain (speakers, cartridges, and record surfaces) are several orders of magnitude greater than those introduced by the virtually perfect (by comparison) power amplifier. Further, it would seem reasonable to assume that two different amplifiers whose specifications in terms of power, distortion, frequency response, crosstalk, etc., are almost identical should be audibly indistinguishable from one another when compared in listening tests.

However, high fidelity enthusiasts have long observed that different amplifiers do, in fact, sound different and that some amplifiers seem to deliver a more robust low end along with sweeter, silkier highs. Yet their specifications, together with extensive laboratory testing and analysis can reveal no logical reason. A mystery. An engineer recognizes that a mystery is really only a lack of understanding born of insufficient data or the incomplete evaluation of existing data. In the case of the high fidelity power amplifier, it is simply that the human ear is capable of hearing and resolving on-going musical detail that has somehow eluded vast arsenals of laboratory test equipment.

SUBJECTIVE DIFFERENCES

Our own experiences are illustrated in the following experiments and examples. First, certain high quality

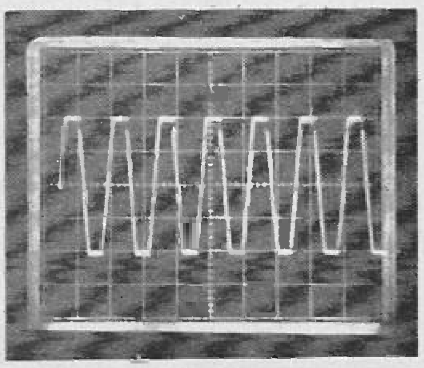


Fig. 1. Amplifier (1) with regulated power supply, is rated at 60 Watts per channel. Unit is seen here operating into an eight ohm load at clipping point of 60 Watts.

transistor amplifiers "sounded better" by a small margin than other high quality transistor amplifiers of identical power rating, in spite of the fact that the latter amplifiers had far "better" electrical specifications in terms of distortion, damping, bandwidth, etc. This difference in subjective sound quality was particularly dramatic when listening to high quality speaker systems using electrostatic components. Particularly, the high end was much airier and open, with much less apparent sibilance during high energy transients.

Let me digress a bit at this point and mention that particular care had been taken to eliminate the last vestige of crossover distortion in the inferior amplifier. At that point, we were virtually certain that crossover distortion was not the culprit. As shall be shown, this assumption proved to be valid.

The second observation was that two different high power, rather expensive transistor amplifiers introduced a mild "snapping" sound into the music when used with some acoustic suspension speaker systems. The "snapping" occurred primarily during low frequency high level passages and on some solo drum instrumentals. Interestingly, the snapping sound was not at all objectional during the drum solos — it tended to give each individual drum beat an added impulse and the illusion of tremendous transient response. However, on sustained low frequency notes, for example, the pedal notes of a pipe organ, the snapping was extremely annoying and clearly an indication of amplifier misbehavior.

In the third observation, in which a valve amplifier rated at 60 watts 'rms' per channel was compared with a transistor amplifier also rated at 60 watts 'rms' per channel, it was observed that the amplifier sounded somewhat more powerful. We discovered that we were able to increase the sound level significantly before objectionable distortion occurred when using the amplifier. In fact, the 60 watt/channel amplifier sounded the same, exactly the same, as a fine transistor amplifier rated at slightly over 100 watts/channel. Two valve amplifiers were used, both vintage models, a Citation II and a Marantz Model 9. The transistor amplifier was of modern design and is very highly regarded.

When all the transistor amplifiers included in our listening test were compared, an interesting pattern emerged — which was two-fold. First — relatively low power transistor amplifiers, those under 60 watts, and those built into receivers and integrated amplifiers did not exhibit *any* form of overt or obvious misbehaviour. The only real "fault" was their low power and consequent inability to produce satisfying music levels without severe overloading. On the other hand, two of the high power units exhibited the "snapping" phenomena and this we considered to be overt misbehaviour and a grevious fault. (As we shall see later, the trouble was due to the protection circuits.)

POWER SUPPLIES

The second part of the emerging pattern was that, given two transistor amplifiers of similar power ratings, it was found that units with a regulated power supply sounded the least powerful; that units with separate power supplies (two power transformers) sounded subjectively more powerful; and, interestingly, units with a single, common power supply sounded the most powerful.

Without exception, the units that appeared "most powerful" sounded significantly "cleaner" and more "open" compared with the other units. All amplifiers were operated at identical listening levels, and each was operating just below the point of audible overload using the "most powerful" sounding unit as the reference. All of these units had similar 'rms' power ratings. (As a matter of course, the ac power line voltage was adjusted slightly to give each amplifier identical continuous sine-wave power output.)

At this point, the task at hand is to identify the reasons for the subjective differences, on a rigorous, scientific level, and approach the problems from an engineering viewpoint.

The first investigation was to determine why some amplifiers with identical power ratings did not (subjectively) sound equally powerful. For our tests we used a commercially available 60 watt/channel amplifier with a regulated power supply and compared it with a unit specially built and designed for the experiment. It was designed to deliver 60 watts/channel with both channels in operation and it used a single unregulated power supply. An oscilloscope was installed across the speaker terminals and the test was arranged in the familiar A-B fashion. It was possible to switch from one amplifier to another instantly while simultaneously listening to music and observing the output of each amplifier on the 'scope.

It became immediately obvious why the second unit sounded more powerful. We observed that the second unit's output voltage would rise considerably higher prior to clipping than the unit with the regulated supply. It sounded more powerful because, in fact, it was more powerful when operated with music into a high fidelity speaker system.

To understand this, it is necessary to make a detailed examination of how the power supply of an amplifier affects the available output voltage swing.

The absolute value of the power supply voltage is what determines the maximum output voltage swing. If the power supply voltage is, for example, 63 volts, then the amplifier can deliver at its output terminals, up to 63 volts

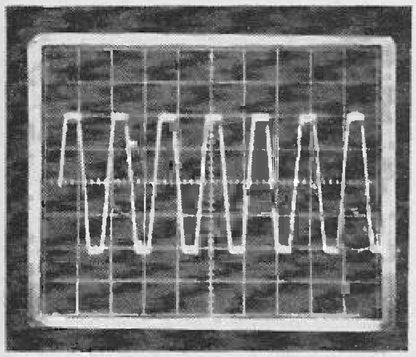


Fig. 2. Amplifier (2) is similar to unit (1) but has a dual power supply. Load and clipping point is the same as Fig. 1.

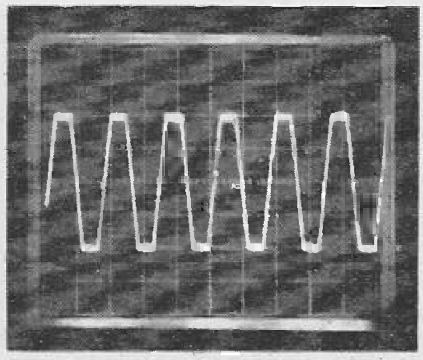


Fig. 3. This shows a specially built 60 Watt/channel amplifier with a single unregulated power supply. Load and clipping point is the same as for the amplifiers shown in Figs. 1 and 2.

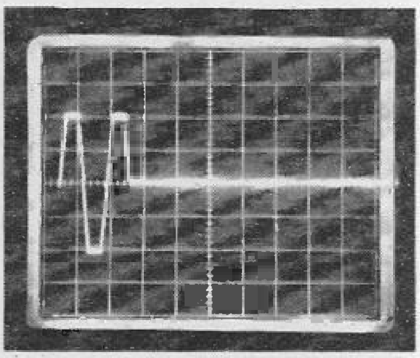


Fig. 4. Here, amplifier (1) is seen handling a low frequency tone burst (simulating a drum beat). Clipping is occurring at 60 Watts. Load is an infinite baffle 8 ohm speaker.

DESIGNING A 700 WATT AMPLIFIER

peak to peak. Once current begins to flow, as the amplifier is delivering power to the load, internal losses cause this voltage to plummet downward. In the case of a 60 watt/channel amplifier whose power supply is unregulated, the supply must be able to maintain 63 volts under full load with both channels operating into 8 ohm load resistors. Since the supply is unregulated, and yet it must somehow supply 63 volts, it must necessarily be designed to deliver a substantially higher voltage during no-load or higher impedance load conditions in order to compensate for internal losses. In the case of a typical transistor amplifier, voltage losses in the power supply are approximately 30%. Hence the power supply voltage must be an unloaded 95 volts.

A regulated power supply can be thought of as, "loss free" because its output voltage remains constant and does not vary from a no-load condition to a full load condition. In the case of the 60 watt/channel amplifier, it is regulated to 63 volts with only very minor variations.

And therein lies the reason that the amplifier with the unregulated supply sounds more powerful. Speaker systems are not of constant impedance; they vary over a wide range over their operating frequency from below 8 ohms to 30 ohms or more.

At resonance, the speaker impedance is at a maximum and if substantial power is to be delivered, the amplifier must have substantial output voltage capabilities. The expression for power if $P = V^2 R$. From this it is readily seen that if the impedance R increases, the voltage must increase or the power delivered will decrease. If the power supply is regulated, it cannot increase, and the available power under dynamic conditions is severely curtailed.

Oscilloscope photographs in Figs. 1 through 6 graphically illustrate these effects. Referring to Fig. 1, the 60 watt/channel amplifier with the regulated supply is being driven to the clipping point (point of overload) with a continous sine wave signal. Both channels are operating. Only one channel is shown in the photo. In Fig. 2, the unit with two power transformers in this power supply is being similarly driven to the clipping point. Figure 3 shows the amplifier with the unregulated power supply similarly driven. Notice that the clipping point is the same for all three units, 63 volts peak to peak. In Figs. 4, 5 and 6, a low frequency tone burst is used to simulate a drum beat. The load is an eight ohm acoustic suspension loudspeaker. The unit with the regulated supply (Fig. 4) clips at its previous voltage level, 63 volts. However, the units with the unregulated supplies (Figs. 5 and 6) are able to deliver a higher voltage prior to clipping. The unit with the single unregulated power supply is clipping at a voltage level approximately 30% higher than its sine-wave continuous clipping level. Thirty percent is almost a one third increase, and since power is proportional to the square of the voltage, the power increase is approximately $1.3 \times 1.3 = 1.69$. Almost seven-tenths more effective power is available from this amplifier.

From another point of view, for any given average power level the second amplifier will be clipping significantly less during musical peaks, and is thereby generating significantly less distortion. This is why the second amplifier sounded "sweeter and airier."

We repeated these experiments with our valve amplifier and compared results. We found that the unit behaved in a manner similar to the amplifier with the unregulated supply, with an interesting exception. When the valve amplifier was very lightly loaded (with a load of around 30 ohms or higher), its voltage swing could go extremely high, producing almost 50% more than the fully loaded condition. This high impedance load is the load condition that an electrostatic midrange or tweeter unit imposes. The power demands are rather moderate because the load impedance under dynamic conditions is relatively high, and therefore the voltage requirements of the electrostatic screens are high. Present day electrostatic middle and high-range screens require their power at high voltage levels, precisely where a valve amplifier excels.

These findings are summarized in graph form in Fig. 7. Notice that the "best sounding" amplifier (7C) can use additional operating area that is not available to the amplifier with the regulated power supply (7A). Figure 7B shows the operating area of an amplifier with two power transformers, and Fig. 7D depicts a 60 watt amplifier idealized to represent a "perfect" 60 watt/channel amplifier. Notice that the available operating area is almost twice that of the unit with the regulated supply. The "perfect" 60 watt/channel amplifier

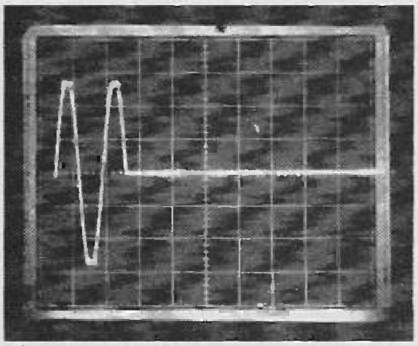


Fig. 5. Amplifier (2) handling the same tone burst – and with the same speaker load – delivers about 20% more voltage than amplifier (1) under dynamic music conditions. Clipping is occurring at just under 90 Watts.

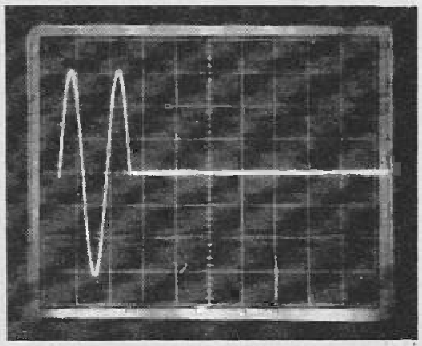


Fig. 6. Here, amplifier (3) – again with the same tone burst signal and speaker load – delivers about 30% more voltage than amplifier (1) under dynamic music conditions. Clipping occurrs at a level exceeding 100 Watts.

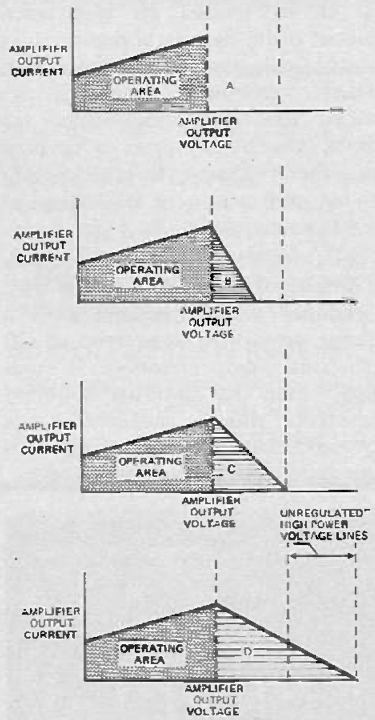


Fig. 7. These drawings illustrate why four different amplifiers – each rated at 60 Watts/channel – sound subjectively different.

- *A. this area cannot be used because of the tight power supply regulation*
- *B. this area is available to an amplifier with dual power supplies.*
- *C. this area is available to an amplifier with an unregulated power supply.*
- *D. this area is available to an amplifier with an 'idealized' design.*

would have, as a design goal, a very high voltage power supply. It would sound very clean and very powerful. The high voltage design approach produces the very best possible "sounding" amplifier, but, as is often the case, there is a tradeoff against other desirable characteristics.

The liability assumed with the high voltage amplifier is that the normal operating temperature of the amplifier must be higher than with the conventional design. If the designer is willing to accept this drawback and is willing to design into his unit an extra margin of thermal stability, an amplifier using this approach would be without peer.

A detailed examination of high powered amplifiers in the 100 to 150 watt/channel range reveals shortcomings and problems unique to these units.

PROTECTION CIRCUITS

A severe design problem that must be undertaken when building a high power amplifier is to design an adequate protection device for the unit. All high power amplifiers must incorporate some form of protection circuit to prevent their destruction in the event of an accidental overload. The protection circuit must limit the output of an amplifier if it is operated into an improper load, but it must not *in any way* limit the output of the amplifier when operated into a proper, normal, or loudspeaker load. These two conditions represent conflicting requirements imposed on a protection circuit, in many instances these conflicting requirements have resulted in protection circuits that do not completely protect the amplifier, or worse, often limit the output in some manner that results in an audible degradation of the musical signal. In the most severe cases, outright amplifier misbehaviour results. Figure 8 is a 40 Hz output signal delivered into an 8 ohm resistive load. The power level is 150 watts. Note that the signal is perfect. Fig. 9 is the same amplifier operated into a complex load whose impedance is also 8 ohms. The load is an 8 ohm acoustic suspension loudspeaker. Notice the large spikes that are occuring on the downward slope of the sine wave. These spikes are caused by false trigger action of the protective circuitry built into the amplifier and cause the "snapping" sound sound mentioned previously. The spikes are called "flyback" pulses and are generated as follows. As the sine wave reaches its peak value and begins to decrease, the energy that has been stored in the magnetic field associated with the inductive component of the loudspeaker impedance is forced to flow back into the amplifier. The protective circuit senses this reverse energy flow as an overload and commands the amplifier output stage to shut down. This happens instantly, and when the output stage turns off, the energy is prevented from flowing back into the amplifier. The result is a large voltage spike due to the collapsing magnetic field in the loudspeaker.

An easily understood analogy is an automobile spark coil and a set of points. When the points interrupt the flow of current, the collapsing magnetic field inside the coil generates a high energy spark. In an analogous manner, the voltage at the loudspeaker terminals rises until clamping diodes (built into all large amplifier output stages) conduct and prevent any further increase. The audible effect is the "snapping" misbehaviour and occurs during heavy low frequency demands. (Fig. 10 is the same amplifier but with the protection circuits disconnected and operated into the loudspeaker load. Observe that the sine wave is again perfect.

Figures 11, 12 and 13 show the output of an amplifier rated at over 100 watts operated into a loudspeaker system. In Fig. 11, the signal consists of a 15 kHz tone butst whose ON and OFF times are equal. Here the amplifier output response is perfect.

Figure 12 consists of the same 15 kHz tone burst but with the following characteristics. The OFF time is very long compared to the ON time. The repetition rate of the tone burst is very low, (in this instance, 500 Hz). This particular tone bursts simulates the simultaneous output of a low frequency musical note (the repetition rate) and a high frequency musical note (the internal tone burst frequency). This would, in a musical sense, correspond to the simultaneous reproduction of a low frequency woodwind note and, say, a harp. Notice that the first few cycles of the tone burst are limited and distorted. This is because the protection circuits in the amplifier confuse the simultaneous low and high frequencies with an overload and because of this they falsely trigger, and limit the amplifier output.

Figure 13 shows the same output as Fig. 12, but with the protection circuits removed. Again, note that the response is perfect.

The audible effect of this particular amplifier misbehavior is much more subtle than the previous example. The effects range from a slight "edginess" and "stridency" to outright breakup associated with the highs, as for example when an opera singer hits her high C at the end of an aria.

A general review of all of these photographs clearly indicates the need for improvement in power amplifier performance.

A perfect amplifier should be powerful enough never to overload, even during low frequency passages or musical peaks. The protection circuits should never falsely trip and generate distortion or amplifier misbehavior, yet must safeguard the amplifier against accidental short circuits or from any other form of abuse. An amplifier must also protect the loudspeaker from accidently dropped

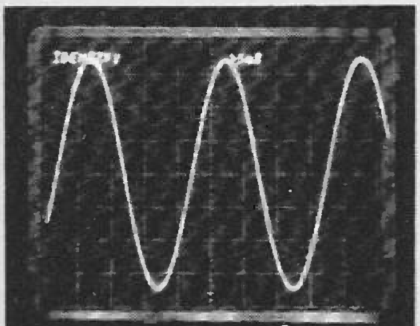


Fig. 8. Output of high power amplifier operating at 40 Hz into an ohm resistive load – power level is 150 Watts.

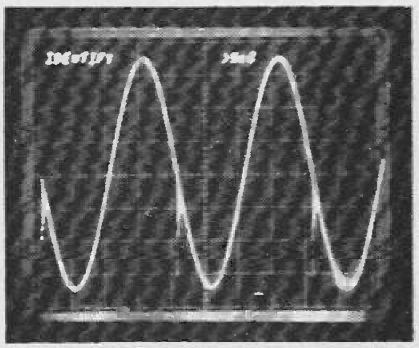


Fig. 9. Here the same 150 Watt amplifier as in Fig. 8 is operating at 40 Hz but this time into an 8 ohm loudspeaker. Power level again is 150 Watts. Tearing at the centre of the wave form is due to false triggering of protective circuits.

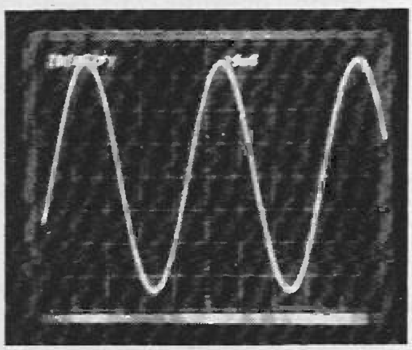
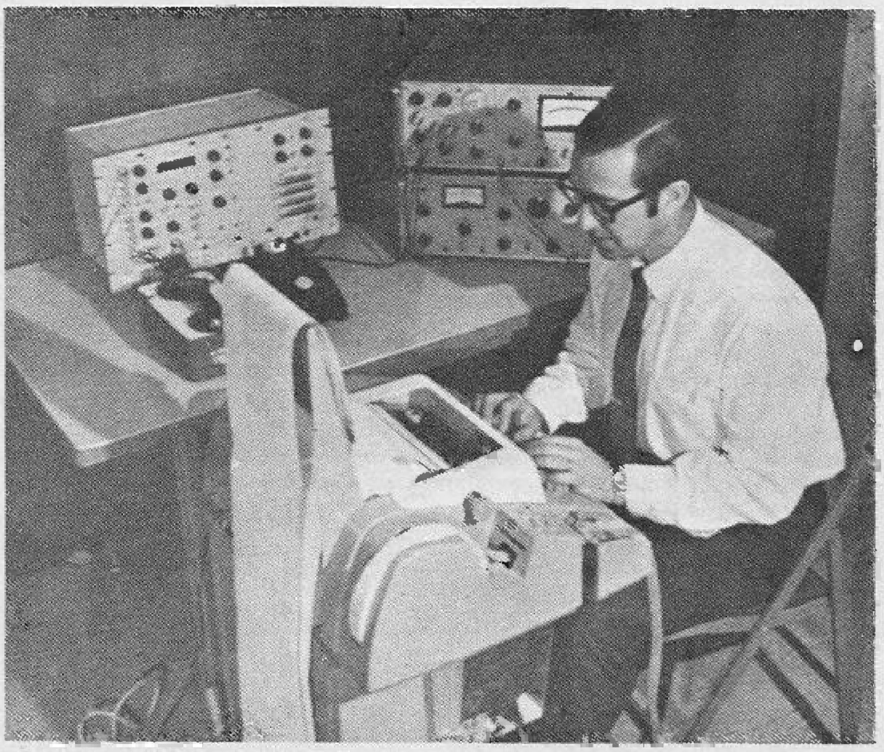


Fig. 10. In this illustration, all conditions are as in Fig. 9 except that here the protection circuits have been made inoperative.

(continued on page 71)

Computer-Interfaced Instrumentation in the Development Laboratory

BY GEORGE KEATS, DIGITAL DATA INSTRUMENTATION PRODUCT GROUP MANAGER, PRINCETON APPLIED RESEARCH CORPORATION.



• *Researcher analyzing data from an in-process experiment employing computer-aided instrumentation.*

Although it generally agreed that a small, "dedicated" computer is usually best suited to production/quality control/ quality analysis applications, the requirements of computer-interfaced instrumentation in the measurement and development laboratory differ significantly from those of computer-interfaced production-test instrumentation. Practical, standard equipment by means of which laboratory instruments may be interfaced with a time-shared, general-purpose digital computer is described, and several examples of computer-aided laboratory measurement systems are presented.

THE benefits of computer-interfaced instrumentation for production-test and quality control/quality analysis applications have been recognized for many years, and are almost universally acknowledged. Similarly, computer-interfaced instrumentation can be equally beneficial in the development laboratory.

However, the requirements for the two applications differ significantly.

Currently, there is considerable difference of opinion concerning the appropriate computer system to be used with instrumentation in the experimental and development laboratory. The spectrum of learned opinion ranges from the "mini-computer concept" to the "maxi-computer complex." In applying the "mini-computer concept", a small, "dedicated" computer is programmed to fulfill the requirements of one specific measurement (or, at most, a few measurements), and to provide the necessary data reduction according to a fixed programme. A system of this type is well suited to typical production-test requirements.

LABORATORY MEASUREMENTS

The requirements of typical laboratory measurements differ from those of production-line and quality control/quality analysis applications in many ways. Among the principal differences are:

- The need to evaluate and analyze – not just to measure and record.
- The greater range of mathematical operations that are typically interposed between the observations (readings) and the results.
- The greater diversity of measurement modes, ranges, and formats (configurations) encountered during the course of a single problem – hence, the frequent need for operator intervention in the original setup, to override the original pattern of tests . . . and also the greater need for "midstream" interpolation,

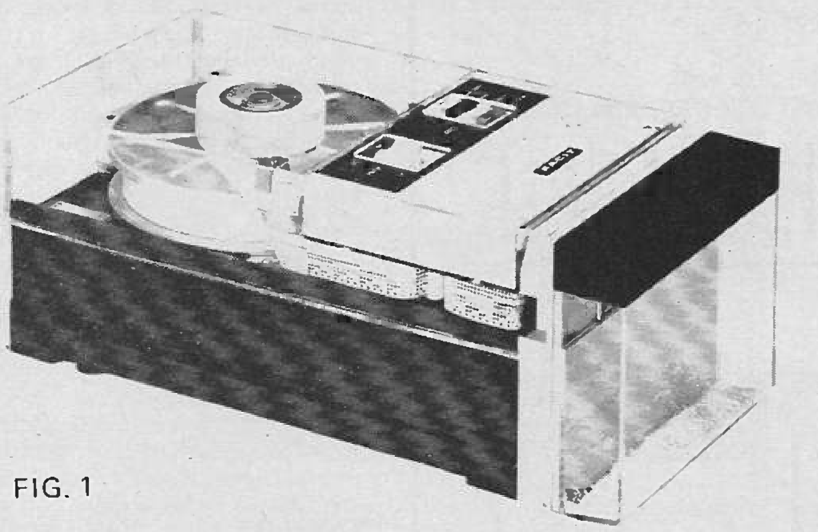
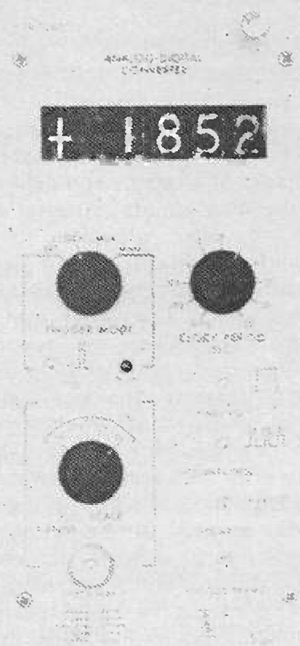
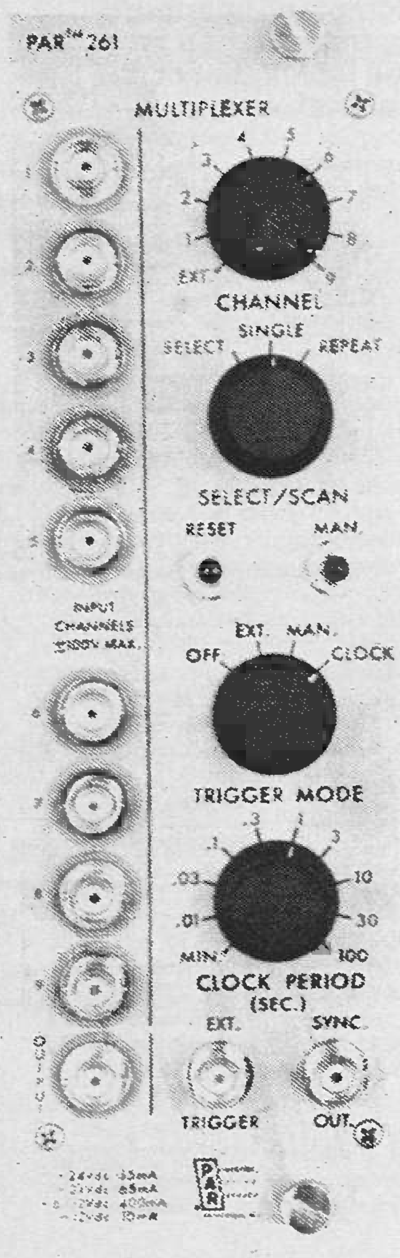


FIG. 1

This FACIT tape punch is used extensively in ELECTRONIC TODAY INTERNATIONAL'S own laboratories as an interface between our laboratory instrumentation and Honeywell time-sharing computer terminal.



This PAR Model 260 A/D convertor is specifically designed to operate as part of an instrument/computer interface system.



Princeton Research's analogue multiplexer samples one to nine analogue channels sequentially, and/or repetitively and provides the resulting signal at an output connector. It also provides a two digit BCD output identifying the channel under observation.

modification, and interpretation.

- The greater need to transfer the burden of computation to the computer — but (generally), with much shorter runs, fewer readings, and more data manipulation per reading.
- The less-restrictive time-vs-accuracy tradeoffs (eg, less need for fast settling time) — hence, more emphasis on the ability to accommodate more signal conditioning and greater range, and less emphasis on data rate.

By providing access to powerful numerical techniques for the solution of empirical and analytical problems, the high-speed, general-purpose digital computer has wrought far-reaching changes in both the scope and intensity of "experimental attack" that is used in laboratories throughout the scientific and engineering communities. Until quite recently, such computers were within the reach of only those few laboratories that enjoyed generous budgets. Only the largest and most complex problems could justify the expense associated with their use.

However, once a large general-purpose computer became available to a laboratory, it was discovered that its speed was so great that it became difficult to keep it busy. To make better use of the capacity and capability of such computers, time-sharing systems, in which many (often, one hundred or more) subscribers can use the computer on a virtually "simultaneous" basis have been developed to the point where they can make available the computational power of a large computer system to the requirements of the average laboratory engineer at relatively low cost. Indeed, the individual scientist or engineer can now enjoy liaison with a million dollar computer for an average charge of the order of $12.00 per hour.

A major obstacle that has hampered the more extensive application of time-shared computer systems in the development laboratory has been the

Computer-Interfaced Instrumentation in the Development Laboratory

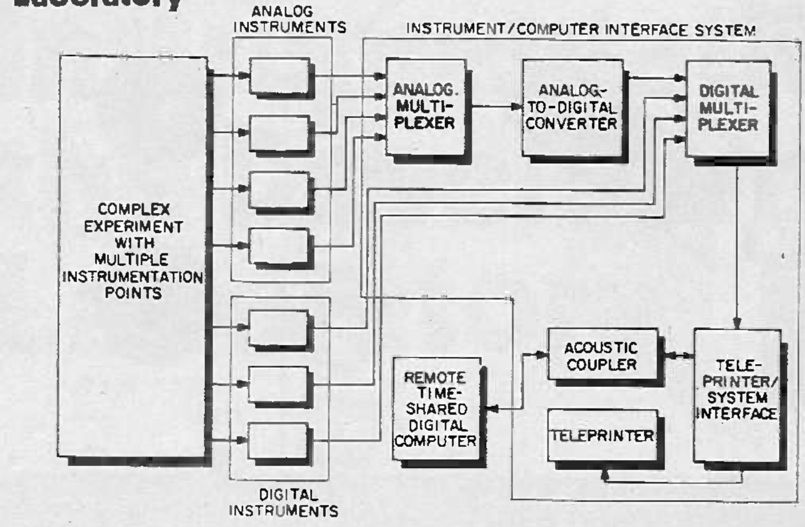


FIG. 2

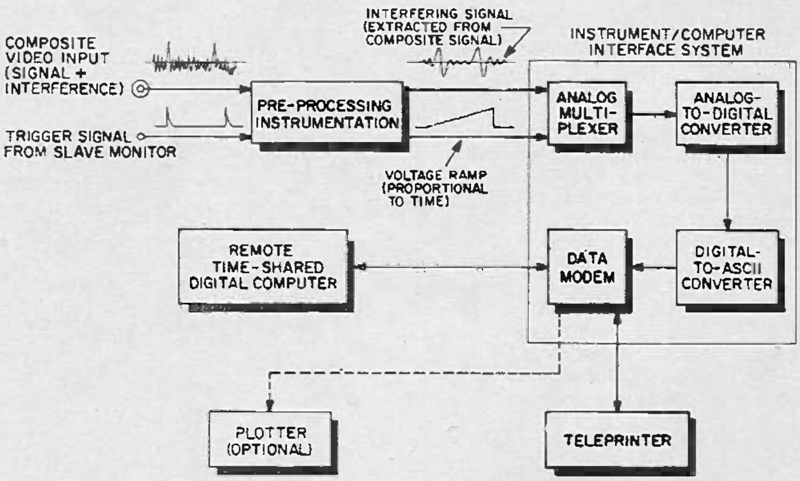


FIG. 3

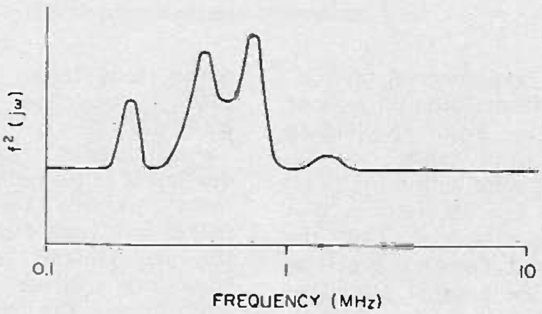


FIG. 4

Fig. 2. Simplified block diagram of a computer interface system. Fig. 3. Computer-aided instrumentation system that pre-processes information prior to its introduction into the computer. The particular setup shown is intended to determine the spectral characteristics of interference in the output of a video amplifier. Fig. 4. Typical Fourier transform of the interfering waveform, produced from data provided by the test setup of Fig. 3.

problem of transferring data between laboratory instrumentation and the computer. For this purpose, if the maximum benefits of the computer-laboratory liaison are to be realized, it is essential to avoid the slow and tedious task of measuring, recording, and entering data by means of which the effectiveness of ordinary laboratory instruments may be enhanced by literally "hanging a computer" on their inputs and outputs.

INSTRUMENT/COMPUTER INTERFACE

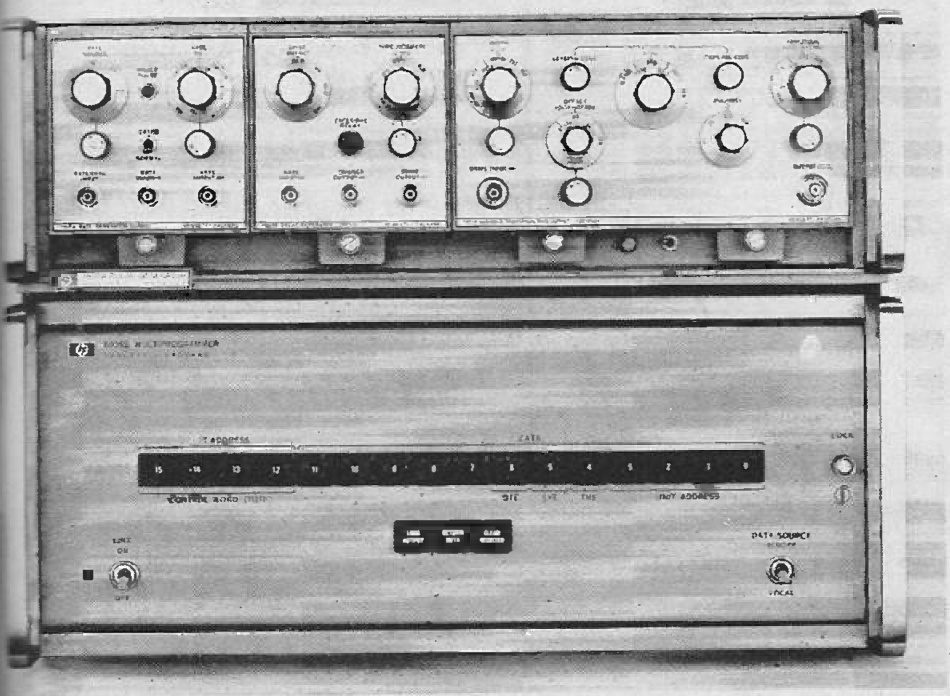
Instrument/computer interface systems, that are intended specifically to facilitate the efficient transfer of data between laboratory measurement instruments and a remote, time-shared computer, are now available commercially. A group of instruments, that comprise a typical instrument/computer interface system, intended specifically to accommodate the special requirements of the development laboratory, are shown in Fig. 1. This system facilitates the conversion of analogue and digital data into the now almost universal ASCII code. It also provides for the automatic sequencing and/or external addressing of each signal which may be in either analogue or digital form.

Figure 2 shows how the instruments are organized into the computer interface system. Analogue data are sampled by the analogue multiplexer, which employs nine double-switched reed-relay channels that are expandable in increments of nine. This module accepts as many as nine analogue inputs, samples each channel sequentially or selectively, and provides channel-number identification. Several modules may be connected in parallel to accommodate as many analogue channels as are required.

The analogue multiplexer output proceeds to an analogue-to-digital converter, that employs the dual-slope technique to produce a four-digit BCD output. The operator can select either 200-ms sampling with 0.01% accuracy, or 20-ms sampling with 0.1% accuracy.

The digital multiplexer accepts up to eight digital inputs, each of which may provide 5-digit BCD data. Several digital multiplexer modules may be operated in series to accommodate an unlimited number of digital inputs.

Either the digital multiplexer or the A-to-D converter may serve as inputs to the teleprinter/system interface. This module converts parallel input words (comprised of 5 BCD digits, exponent, polarity sign, and 2-digit channel-identification number) into serial form that may be fed to either a teleprinter, or to an acoustic coupler



Hewlett-Packard Model 1900A/6936S Programmable Pulse Generator interfaces easily to computer.

or data set for interconnection to a remote computer.

To illustrate how computer-aided measurements can be employed in the development laboratory, three examples of typical applications are described, and three additional applications are suggested.

ANALYSIS OF AN ARBITRARY WAVEFORM

Assume, for example, that in testing a video amplifier, which drives a display system under development, a "glitch" is observed in the amplifier's output waveform, and it is determined that the glitch is somehow correlated with the raster generator of a nearby TV monitor. The glitch is found to produce a characteristic series of "picket-fence" images on the screen of the primary monitor. Clearly, the interference is caused by the second slave monitor. However, before a good engineering solution can be devised to eliminate the interference, it is necessary to know the spectral characteristics of the interfering waveform.

The instrumentation to provide this information is shown in Fig. 3. The basic scheme consists of averaging the video signal over many repetitions, using the classic box-car-integration or gated-integrator technique. In this manner, a particular signal may be extracted from a composite waveform, since all non-coherent signals (i.e., not correlated with the interfering waveform) will average to zero. To recover the entire waveform, the observation point (aperture) is moved in time with respect to an arbitrary – but consistent – synchronizing trigger. This is the essential operating principle of many signal averagers and sampling oscilloscopes.

Note that the use of an instrument such as the boxcar integrator, which is the "pre-processing instrumentation" in Fig. 3, performs a great amount of pre-processing of the signal prior to its introduction into the computer system, thus obviating the requirement for ultra-high-speed multiplexers and A-to-D converters.

The "philosophy" involved in obtaining the desired spectral characteristics of the interfering waveform is simple. Two outputs are available from the pre-processing instrumentation: a voltage proportional to time, and a voltage proportional to the amplitude of the interfering signal. These voltages are sampled alternately (multiplexed), encoded into BCD, re-encoded into ASCII, and transmitted to the remote time-shared computer by means of a conventional teleprinter, modem, or terminal. The data are stored automatically in a file, and later recalled (in this example) by a Fortran programme which computes and plots the Fourier transform (power spectral density) of the interfering waveform, as shown in Fig. 4.

Once the spectral characteristics of the offending waveform have been defined, the solution to the problem in terms of the provision of effective shielding, circuit redesign, etc., may be approached in a rational manner.

TRANSISTOR PARAMETER MEASUREMENTS

It is sometimes necessary to characterize, in some detail, the behaviour of semiconductor devices under actual operating conditions. Frequently, however, the circuit designer must abandon the manufacturer's typical specifications, and determine his own design parameters, based upon a measurement scheme that approximates these conditions. Figure 5 illustrates a method whereby the testing of RF transistors may be

FIG. 5

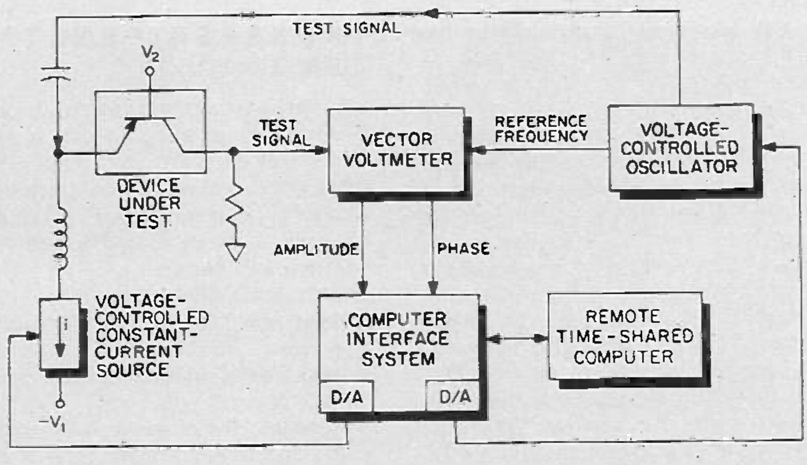


Fig. 5. Block diagram of a computer-aided system for the determination of transistor characteristics under actual operating conditions.

Computer-Interfaced Instrumentation in the Development Laboratory

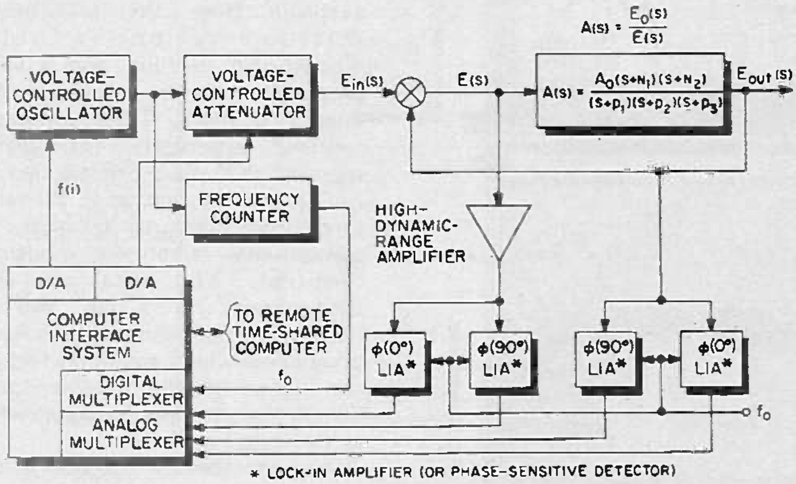


FIG. 6

Fig. 6. Block diagram of a system for the computer-aided determination of a linear circuit's transfer function.

automated by means of a time-shared computer to control the test frequency, temperature, bias levels, etc. The experimental requirements call for the measurement of gain, phase shift, and spot noise as functions of frequency, temperature and collector current. From these measurements, the device can be characterized in terms of the usual hybrid or scattering-matrix parameters, for use in a software programme involving computer-aided design.

A CW test signal is supplied to the transistor under test by a voltage-controlled oscillator, while collector current is controlled by means of a voltage-controlled current generator. Both test conditions are responsive to the analogue outputs of two D-to-A converters, located in the computer interface system. The D-to-A converters are special hardware-software-orientated subsystems that decode the serial information from the remote computer into digital data words. The software that controls these words is relatively simple, resembling those driver routines that are employed with conventional peripheral plotters.

The example presented here is simple, and may assume a variety of physical configurations. It should be noted, however, that the control is essentially open-loop. Although it is easy to construct a system in which the output of each controlled instrument is measured and verified, it is far simpler and faster to control instrumentation that provides the necessary inherent accuracy, thus obviating the need for careful feedback verification. Philosophically, this concept is somewhat analogous to the argument for pre-processing of measured data.

TRANSFER-FUNCTION APPROXIMATION

A classic circuit and systems problem is the characterization of a linear circuit or system in terms of its transfer function. The approach is usually semi-analytical, and the engineer is often forced to employ a graphical technique in which straight-line asymptotes are drawn, revised, etc. It is not unreasonable, therefore, to employ a remote, time-shared computer as the modern "graph paper."

Consider, for example, the problem of determining the open-loop transfer function of an amplifier or servo system that must operate in a closed-loop mode. For this purpose, one might devise a programme to perform a "survey" of amplitude and phase as functions of frequency, and then return to search for intermediate points, based on the strategy of finding those critical phase-shift changes that signal entry into a higher-frequency time constant, or into more interesting phase-change phenomena.

In the computer-aided system shown in Fig. 6, several lock-in amplifiers (phase-sensitive detectors) serve as excellent data pre-processors to produce in-phase and quadrature signals (converted to DC voltages) that can be read directly into the file system of the remote computer.

As in the previous example, D-to-A converters (alternatively, digital-to-digital converters) provide the means for varying the input frequency and amplitude to the instrument system. However, unlike the previous example, the reference frequency is monitored (by the frequency counter), and is therefore verified in order to close the loop completely.

OTHER APPLICATIONS

The significant applications of the time-shared computer in the R & D or measurement laboratory are virtually unlimited. Additional examples of such applications include:

- *Multiple Decay Products.* A multi-exponential decay phenomenon is associated with the various lifetimes and relaxation effects of fluorescent systems. Assuming that each relaxation effect is a true exponential, one can calculate the logarithm of each time-correlated data point, and then let the computer find the resulting straightline asymptotes.

- *Low-Frequency Correlation Studies.* Many electromechanical devices, such as gyros and accelerometers, suffer not only from long-term drift, but also from internal noise arising in bearings, etc. One can record (off line) long-term stability measurements, and then calculate, by means of simple programmes, the statistical fluctuations and spectral characteristics of the recorded data.

- *Extended Measurements.* One can use the counters, scalers, sampling oscilloscopes, lock-in amplifiers, boxcar integrators, etc., that are available in his own or his neighbour's laboratory to increase the precision and accuracy of other basic instruments by determining their inherent errors, and storing the data. The time-shared computer can then take these systematic errors into account when performing calculations based upon data derived from these instruments.

Fluke problem solvers

Introducing the only 3½ Digit Multimeter with specs guaranteed for one full year.

MODEL 8000A

£99

★ **The most complete 3½ DMM on the market.**

Now you can have the unmatched quality of Fluke instrumentation at the price of an ordinary multimeter.

Here is the DMM with more functions! It has 26 ranges, including five ranges of AC and DC volts, five ranges of AC and DC current, and six ranges of resistance. Push button control gives you the most reliable, error-free operation possible. The A/D converter has automatic self-zeroing which eliminates offsets.

There are more details on the next page for your review.

Complete the coupon overleaf and send to

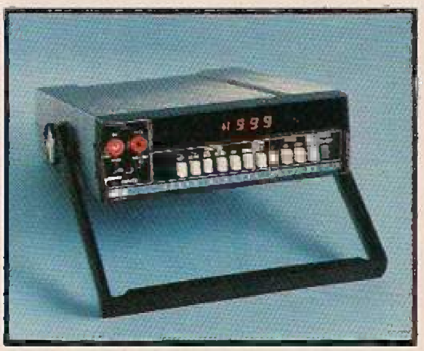
FLUKE INTERNATIONAL CORPORATION
GARNETT CLOSE
WATFORD WD2 4TT

Telephone: WATFORD 33066

Now you get performance, reliability, and low cost with only 110 parts.

★ There is no better $3\frac{1}{2}$ digit multimeter at this price.

DESIGN
Look inside! The 8000A has only one-third the number of components used in the typical $3\frac{1}{2}$ DMMs on the market today. Fluke makes this possible by being the only manufacturer to use both analog and digital LSI chips of proven reliability.

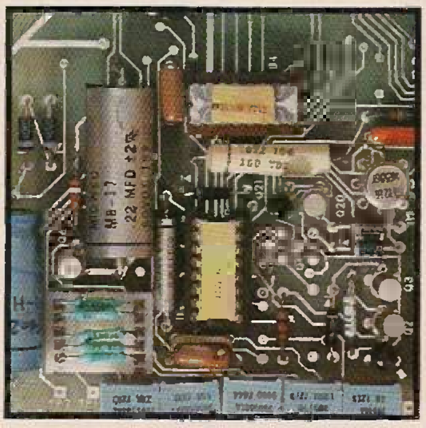


GUARANTEE
The Fluke guarantee is easy to understand. If anything should happen to your 8000A during the first 12 months, we will provide 48 hour service.

SPECIFICATIONS
The 8000A has DC accuracy of **0.1% when you buy it.** Fluke guarantees it will still be within **0.1% a year later.**

MEASUREMENTS
Measurement flexibility is broad enough to meet all the situations you'll ever encounter. The Fluke 8000A features 26 ranges to measure AC and DC voltages from 100 microvolts to 1200 volts, AC and DC currents from 100 nanoamps to 2 amperes, with resistance from 100 milliohms to 20 megohms.

OPTIONS
For a little more money, you can add rechargeable battery operation to give you completely portable operation for over eight hours. The batteries are automatically recharged when the 8000A is connected to the mains power. Other options include digital printer output, high voltage probe, rf probe, and clamp-on ac current probes, universal test leads, dust cover, rack mounting kits, and fitted carrying case.



A COMPLETE DIGITAL MULTIMETER
But with or without options, the Fluke 8000A comes complete with test probes. It all adds up to an instrument you can rely on day after day, year after year. Isn't this what you want in a digital multimeter at any price? Fluke thinks so.

** Please fill in the reply card and see the 8000A for yourself*

- ☐ Please send me the complete details of the Model 8000A.
- ☐ I would like to have demonstration of the Model 8000A.
- ☐ I would like to have 10 day free trial of the Model 8000A.
- ☐ I would like to purchase the Model 8000A. Please have Field Engineer contact me.

- ☐ Rechargeable Battery Pack
- ☐ 30kV H.V. Probe
- ☐ AC High Current Probe
- ☐ RF Probe
- ☐ BCD Data Output
- ☐ Fitted Carrying Case
- ☐ Deluxe Test Leads
- ☐ Front Panel Dust Cover
- ☐ Rack Mounting Kit - Center
- ☐ Rack Mounting Kit - Side

Name ....
Title ....
Department ....
Telephone ....
Company ....
Address ....
City ....
Country ....

FLUKE®

DESIGNING A 700 WATT AMPLIFIER

(Continued from page 63)

tonearms or amplifier failures, and all of these qualities must be built in.

HOW POWERFUL

Simply stated, an amplifier should be powerful enough to prevent overload and clipping when operated at a satisfying listening level. Instant overload recovery is not enough.

The best speaker systems today obtain their smooth, wide range low distortion performance by significantly sacrificing efficiency. The best speakers are excellent, but require large peak power (and thus – output voltage capability) of an amplifier. Figure 14 shows a 120 watt amplifier reproducing the opening allegro piano note from Part III, of Beethoven's *Emperor* concerto performed by Rudolf Serkin. The volume level has been adjusted so the piano volume level approximates a live piano. The speaker is a Bose 901 which of course uses active equalisation. Observe that piano note peaks are being clipped. This leads to harshness and may cause listening fatique. Figure 15 is the same passage but with a 350 watt amplifier. Note that clipping does not occur. The sound is smooth, sweet, and open. The subjective volume level is identical in both cases. The average power level in both cases is approximately 38 watts.

If the goal is to eliminate the severe amplifier distortion that occurs on musical peaks and during low frequency passages, and if the best wide range speakers available today are utilized, a minimum of 200 watts/channel is required. A maximum of over 500 watts/channel is required when using some of the very latest, highly inefficient speakers. The important point to remember when dealing with these high power levels is that the peak to average power ratio of musical material is approximately 10:1. This means that when a 200 watt/channel amplifier is operating full tilt into a set of loudspeakers, the long time average power delivered to the loudspeaker is only 20 watts. In addition, these loudspeakers are designed safely to sustain extremely high impulsive power levels. For example, the new Acoustic Research LST loudspeaker system can safely sustain 1000 watts for brief time periods. It is this capability that will allow a high level drum beat, a low frequency pedal note, or an opera singer hitting her high C at the end of an aria to be safely accommodated by the loudspeaker system.

700 WATT AMPLIFIER

The first step in designing our Phase Linear 700 watt amplifier was to evaluate existing design approaches to high power. Primarily, the problem is one of obtaining the required high output voltage. Three hundred fifty watts at eight ohms (two channels), requires an unregulated power supply capability of over 200 volts. Until very recently, the very best existing transistors had sustaining voltages of only 120 volts, and, at that, a designer was pushing the state of the art to build an amplifier with a 120 volt supply (150 watts). The standard solution to higher voltages is to use low voltage transistors and use a step-up transformer or autotransformer at the output of the amplifier. The disadvantages of this approach are many. Excessive phase shifts through the transformer generate stability problems, increase distortion, reduce the bandwidth, and transformers are excessively heavy and expensive. We computed that an amplifier using step-up transformers or auto-transformers would weigh over 130 pounds!

A second design approach consists of connecting two (or several) low power amplifiers together in series to obtain the required high output voltage. Amplifiers connected in this fashion are said to be "in bridge" and their separate output voltages add together or double. Since power increases as the square of the output voltage, doubling the voltage would quadruple the power. For example, two 150 watt units in bridge would yield four times 150 or 600 watts.

This design approach is a fairly workable one, but it too suffers severe and fundamental drawbacks. The input and the output grounds are not common. Rather, they are "floating"

(Continued overleaf)

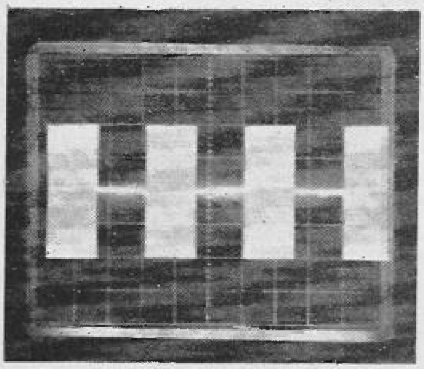


Fig. 11. This shows a 15 kHz tone burst from a high powered amplifier into an 8 ohm loudspeaker, the response is perfect.

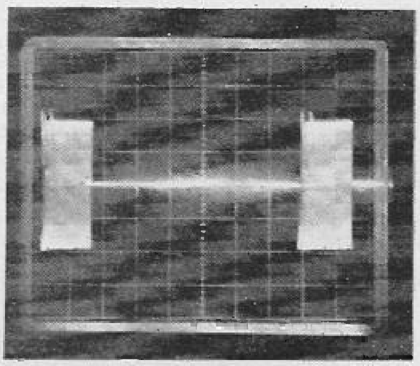


Fig. 12. Here the same 15 kHz tone burst (Fig. 11) is being repeated at 500 Hz. Limiting and distortion may be clearly seen on the leading edge of each burst. This is due to the protection circuits.

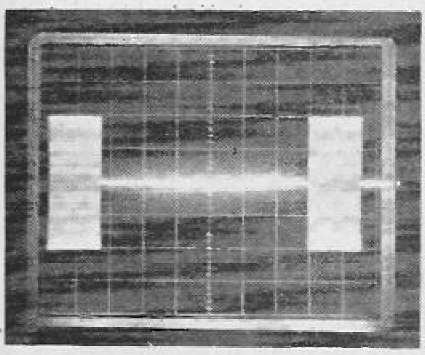


Fig. 13. Conditions here are the same as in Fig. 12 except that the protection circuits have been removed.

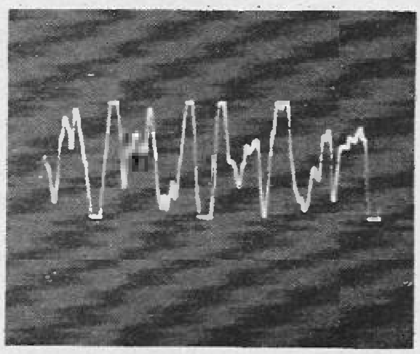


Fig. 14. Opening piano allegro from third movement of Emperor concerto. Clipping is occurring on peaks as amplifier overloads. Average power is 38 Watts. Amplifier is rated at 120 Watts/channel.

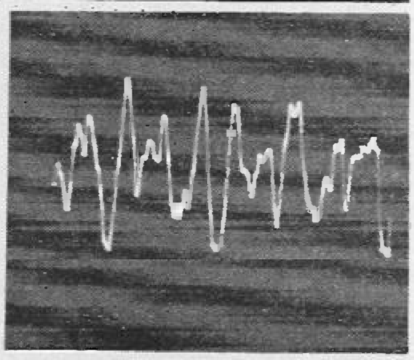


Fig. 15. Same musical passage as shown in Fig. 14 – but here the amplifier is a 350 Watt/channel unit. Note that no clipping occurrs.

DESIGNING A 700 WATT AMPLIFIER

(continued from page 71)

above chassis ground and any attempt to use such an amplifier in a multiple unit installation would raise havoc with the grounding system. Another drawback is that a stereo amplifier would require four separate amplifiers connected internally to obtain two channels; this plus the required double power supply would even further add to the complexity, weight and cost.

Solving the primary problem of transistor voltage breakdown required close work with a major transistor manufacturer. The basic power transistor used in the 700 watt amplifier design is a 600 volt television horizontal sweep transistor. This basic power transistor was modified extensively in order to obtain the best suitability for high power amplifier application. Energy breakdown levels, current gain, pulse safe operating area, and other transistor parameters were carefully adjusted in order to optimize their use.

Another of the many problems associated with transistor amplifier design is the problem of crossover or "notch" distortion. Historically, this was a severe drawback in early transistor amplifiers. It was successfully solved by allowing the output transistors to operate in a mode which was somewhat less efficient than ideal and represented one of many engineering compromises. In order to eliminate crossover distortion, it was necessary to allow a small amount of idling current to flow at all times. This idling current would generate a small amount of heat but was perfectly acceptable for small, low voltage amplifiers that had at most two pair of output transistors. For a large 700 watt amplifier, the amount of heat that would be generated by idling current flowing in 24 output transistors would be excessive. It was necessary to incorporate a novel biasing circuit that would allow the output stages to operate without idling current (pure class B) and simultaneously and completely to eliminate crossover distortion. This biasing circuit is used in integrated circuit "op-amps" but had previously never been applied to power amplifiers. The success of this approach depends on the careful attention to specific power transistor parameters in the low current region. Crossover distortion appears as high intermodulation distortion at low levels. The best transistor amplifiers have attained IM figures of well below 0.05%. Our production 700 watts units attain IM figures at 750 milliwatts of between 0.01% and 0.02%.

Speaker protection is accomplished by a "crow bar" circuit in which heavy fault-current (for example, caused by accidently dropping a tone arm, or an output transistor failure) is forced to flow through a pair of fuses rather than through the loudspeaker. Since the "crow bar" forces heavy fault-current to flow through the fuses and not through the loudspeaker, they open immediately and prevent any possibility of damage.

The problem of amplifier misbehavior caused by false triggering of protective circuits was solved by incorporating a totally new protection circuit design which monitors, from microsecond to microsecond, the *energy** that is being absorbed by the output transistors during normal operation. All previous protection circuits have monitored the *current*, or in the case of large amplifiers, the *power*.

The energy limiting approach results in an amplifier that can provide approximately three times as much power as an amplifier equipped with current limiting or power limiting circuits.

Whenever a loudspeaker engineer makes an attempt to extend or smooth the frequency response of his design, or to lower the distortion, the laws of physics demand that the loudspeaker become ever less efficient.

These two facts of life, the conflicting requirements of sonic perfection versus loudspeaker efficiency has always set an upper practical limit on loudspeaker performance. The recent availability of truly high power amplifiers has allowed speaker designers a new freedom and without question, the best speaker systems of tomorrow will be capable of truly awesome performance. ●

*(*Energy is the time integral of power. Expressed mathematically, Energy, $E = \int VI\ dt$, where V = voltage, I = current, and with the limits of integration chosen, to be over one half cycle of the waveform.)*

NEW LITERATURE

● Updated brochure 41-759 with complete application, characteristics and operation information on types AR and ARS auxiliary relays for high-speed circuit breaker tripping. Similar brochures 33-252 and 43-270 respectively on outdoor oil-type circuit breakers for 14.4-69kV transmission systems and resistance thermometers of the taut-band suspension type. Westinghouse Electric Corporation, Pittsburgh, PA 15222.

● A new sample card with details of availability and applications of self-adhesive sealing strip, gasket, disc and gasket materials in rubber and synthetic substances. Vito Self Adhesives Ltd, Hardwick Trading Estate, King's Lynn, Norfolk.

● Abridged Data catalogue including Lucas semi-conductor product range and factored products manufactured by Centralab and Quantrol of USA. Joseph Lucas (Electrical) Ltd, Mere Green Road, Sutton Coldfield, Warwicks.

● Informative leaflet on a new air-leak detector for component testing in factory or laboratory, using differential pressure techniques. Also a concise leaflet on a new Gelometer (viscosity monitor). IDM Electronics Limited, Arkwright Road, Reading RG2 0LH.

● Leaflet on the 'AC' series of low-cost solid state timers for switching ac power, including operation from control pulses as short as 6mS. Tempatron Ltd, 5 Loverock Road, Reading.

● Bulletin E2547 on a new range of 250A fast-switching SCRs designed specially for inverter, ac motor drive, hf induction heating and similar applications. International Rectifier, Hurst Green, Oxted, Surrey.

● 12-page application and selection guide (B-232) for copper-clad circuit laminates. Westinghouse Electric, Industrial Plastics Divison, 41 Avenue Gerges V, Paris 8e.

● Leaflet describing DAV (Annemasse, France) switches, terminal blocks, lamps and other components. Magnetic Devices Ltd, Exning Road, Newmarket, Suffolk.

TECH TIPS

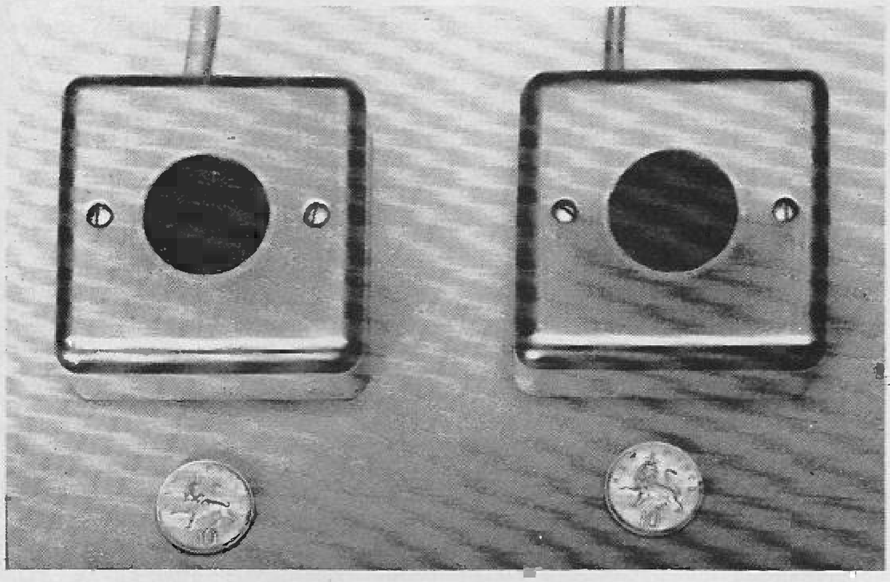
Circuits described and illustrated in this section are derived from manufacturers' application notes, readers' letters etc. They have not necessarily been tested by this magazine.

The section is intended primarily as a source of ideas for electronic engineers.

Because of the nature of the information we cannot enter into any correspondence concerning any of these circuits, nor can we provide any constructional details.

EQUIPMENT NEWS

MINIATURE INFRA-RED ALARMS



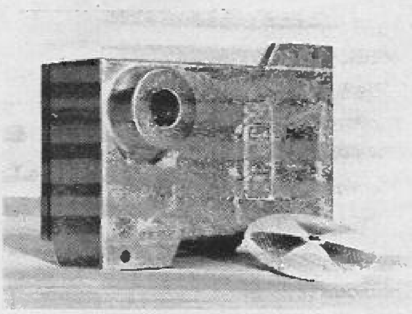
Infra-Red Beams as burglar alarm detectors have not usually been fitted in private houses due to the size of the transmitter and receiver units; the housewife has not been prepared to have "that ugly thing" upsetting the decor of her home.

However, with the introduction of miniaturized components and integrated circuits, the sizes of these units can be considerably reduced and Photain have now produced a unit specially for domestic use. They have chosen for their housing the standard lighting switch box to be found in every home. The whole circuitry is contained within these housings which can be fitted as a projecting unit or mounted flush in the wall, as required. The complete housing, $3\frac{3}{8}'' \times 3\frac{3}{8}'' \times \frac{11}{16}''$, is available with either a bronze or satin chrome front plate.

Each beam consists of two such housings, one with the solid state infra-red emitter and the other with a photo-detector, amplifier and switch circuits. The units can be connected into any type of burglar alarm system and operate from a 12V dc supply and are said to have an effective beam length of 45′ – enough to provide coverage for even the largest room. **(145)**

SUN-PROOF PHOTO SWITCH

The Opcon 1400A comprises a solid state pulsed light source and detector combined in a single unit for maximum reliability and ease of installation. A standard retro-reflector is used to return the light beam to the detector. It is said to operate reliably in full sunlight, dust, rain or snow from −5° to +65°C. Used with a 3″ reflector, it can be located up to 15′ away. Under less severe conditions, the unit works up to 30′. Housed in a gasket sealed rugged aluminium case, the 1400A is suitable for both factory and outdoor applications. It is completely solid state with exception of the output



relay and unaffected by severe shock and vibration.

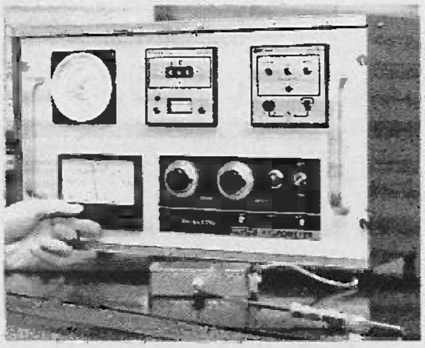
Options such as variable Delay-on and/or Delay-off and contact closure for an adjustable period of time after an object is detected render it especially useful in various types of material handling applications. **(146)**

HYGROMETER

A new hygrometer which not only monitors moisture levels, but also incorporates all the facilities necessary for controlling ancillary equipment, such as pumps and motorised valves, to maintain a pre-set level, as well as automatically giving an alarm in the event of process failure, has been introduced by Moisture Control and Measurement Ltd.

Said to be the first instrument of its kind to provide such versatility, it was originally developed to meet a specific need of the North Eastern Gas Board. The concept of a self-contained unit, at less than half the cost of any comparable hybrid system, is believed to have other fields of application also where accurate measurement and control of relative humidities or dewpoint is required, eg, dewpoint or humidity control on various storage applications – steel, vegetables, grain and on cargo vessels; control of various drying processes, on foodstuffs, in foundries, paper tissues, textiles, and in a wide range of manufacturing operations, etc.

Measurement is by means of a sensitive probe which is effectively a variable capacitor connected to a high-frequency



bridge circuit in the instrument. A direct moisture reading is displayed on a Sifam Meter Relay which also has upper and lower set-pointers which will initiate an alarm if the moisture level rises or falls outside an acceptable bandwidth. **(134)**

FREQUENCY DIFFERENCE METER

The Tracor Model 527A Frequency Difference Meter is designed for instant determination of the fractional frequency difference between two stable oscillators instantly to an accuracy of one part in 10^{11} or better. The fractional frequency difference is displayed on a front-panel, centre-zero meter, with a front-panel oscilloscope indicating the phase relationship of the two input signals. Observation of the oscilloscope over a period of few minutes, and using time averaging techniques, can extend the 527A's accuracy to one part in 10^{12}.

An external recorder output connector provides a dc voltage proportional to the frequency difference for presentation on a chart recorder, enabling the frequency

EQUIPMENT NEWS

change rate and long-term stability between two oscillators to be determined by recording the dc output against time. The Frequency Difference Meter has many applications including the adjustment of oscillators to the same frequency, frequency difference measurement, offsetting of one oscillator from another by a specified amount, and the analysis and measurement of short and long-term oscillator stability. **(144)**

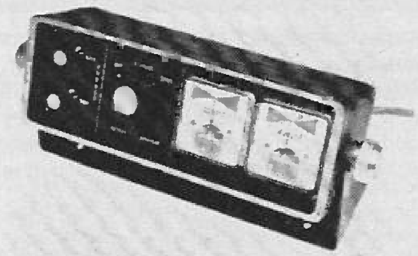
CRIME FINDER

The CF-2P Intruder Alarm consists basically of a simple vertical aerial that detects objects by interference with its field. The system is said to work up to a third of a mile from its electronic control box. When an intruder approaches within a 15 metres radius from the aerial, or within four metres above or below its centre, an indicator lamp flashes, followed by an audible warning. If mounted on a ceiling it therefore protects roof area. If the coaxial connecting lead is cut, or disconnected, an alarm is also given.

The Electronic Unit is equipped with a standby battery which operates a buzzer, should the mains supply fail. More than one antenna can be used, and sensitivity controls are provided. It is also suitable for triggering existing alarm circuits, and is ideal for use in factories, garages, warehouses, schools and shops, etc. **(142)**

AUTO-PILOT FOR SEACRAFT

A new slimline auto-pilot control, type 701/SL, is designed to meet modern standards of solid state miniaturisation whilst retaining reliability and comprehensive functional aspects. Meters indicate



rudder position and course holding.

Two units are available, catering for vessels up to 65 feet. Motor switching is also solid state to avoid use of mechanical relays subject to wear and failure. CETREK systems are suitable for any form of steering including hand or power-assisted hydraulics and, as rudder reference techniques are used, play in the steering linkage is not claimed to affect the auto-pilot operation. **(143)**

DUAL FUNCTION INTERCOM

An entirely new type of dual-function intercom station can be used at will either for loudspeaking or normal-tone conversations. The instrument was conceived following a survey which showed that many users of intercom stations found them cumbersome, space-consuming, and lacking in privacy.

When the new Ericom 30001 station is placed on the desk or in a wall bracket, it functions exactly like a conventional intercom; the user speaks into the microphone at the top and hears replies through the

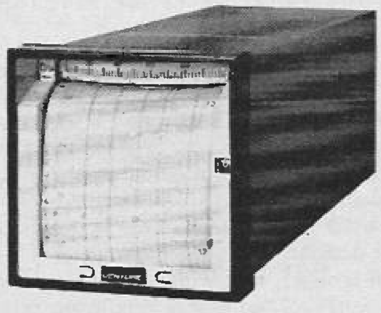
powerful loudspeaker in the base.

When he chooses, however, he can simply lift the apparatus to actuate a mechanism which causes the microphone and loudspeaker to switch functions; the user now speaks into the loudspeaker and listens at the microphone and the conversation of the other party cannot be overheard by any other person or persons in the room at the time. **(131)**

6-COLOUR RECORDER

Miniscript Model 6D six-colour dotted-line recorder is believed to be the smallest ever of its type. Either two, three or six channels may be ordered, each with one to six ranges of measurement; the recorder size is constant at 96 mm square by 265 mm deep.

A wide range of current and voltage



measurement can be accommodated, and in some cases these may be combined in a single instrument. The Model 6D incorporates its own constant-voltage source for resistance measurement. Chopping rate is switchable between 10-second and 20-second cycles, and chart speeds may be altered by variable gear from 10 to 20 to 30 or 60 mm/h (for a chopper speed of 10/sec.) or from 5 to 10 to 15 or 30 mm/h (for 20 imprints/sec.). Recording accuracy is said to be ±1.5% of reading. Applications will include temperature recording with resistance thermometers (also thermocouples with and without cold junction compensation), and recording relative and absolute humidity. **(132)**

CAMERA LINE

A particularly versatile new camera line, the **TXK**, has been introduced to the British market by Bosch. The basic circuitry of the TXK camera line can be modified for a wide variety of applications, and is virtually a modular system. Using the basic camera for this line, a variable number of video outputs together with an RF-output can be provided.

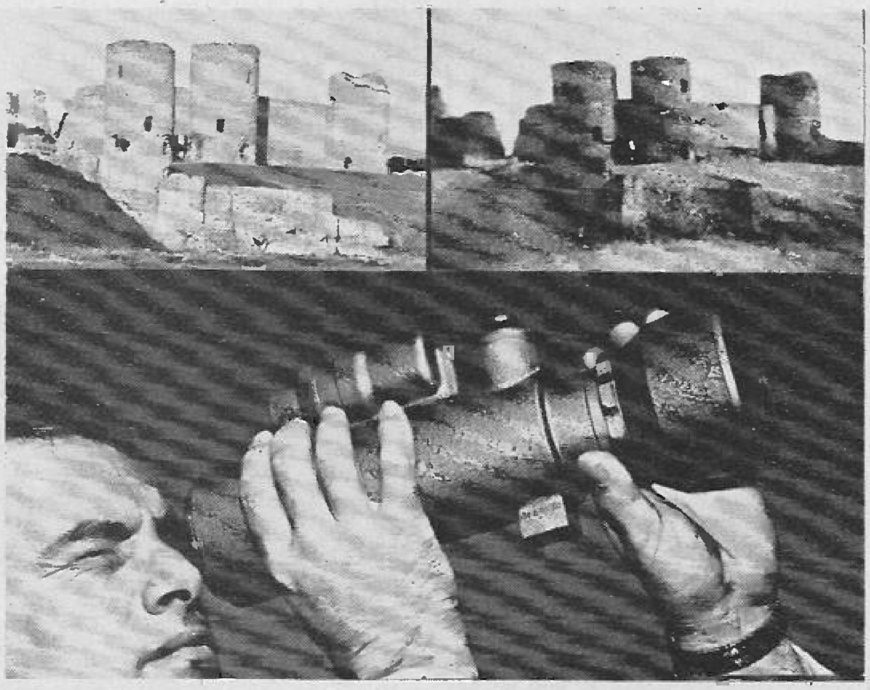
A particular advantage is that all cameras of the TXK line can be equipped with either Vidicon, Plumbicon or Silicon tubes without modification of the circuit. The power supply built into the camera is laid out to enable either ac mains or battery voltage to be used.

All the TV standards are said to be possible and some versions of the camera can be remotely synchronised by an external SPG and it is also possible to control functions like gain, black level and aperture correction from a remote control unit. Talk back facilities are also provided. **(137)**

NIGHT SIGHTS

A new family of high performance portable night vision sights with a "see without being seen" range of several kilometres incorporates an image intensifier device which amplifies natural light available up to 50,000 times. Artificial illumination by infra-red beam – which could be pin-pointed – is unnecessary and complete undetectability is therefore assured.

Custom-built units are believed to have applications in police and commercial security work, marine surveillance, air sea rescue and nocturnal animal observation.



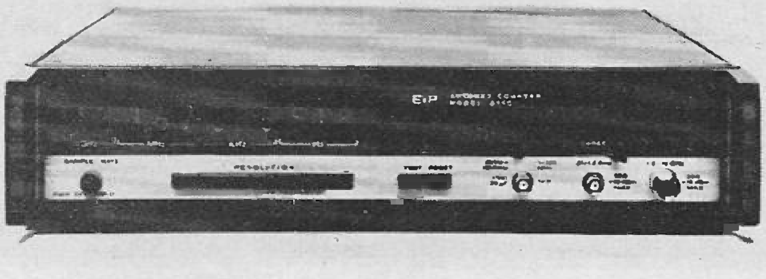
The equipment can be fitted to single lens reflex, cine and TV cameras to allow photographs to be taken in conditions normally dark to the naked eye.

The illustrations show the Lolite and, on the left, Rhuddlan Castle in bright sunlight and, on the right, as photographed at 1 am with quarter moonlight as the only light source. **(140)**

AUTO-HET COUNTER

Autohet counter Model 351C offers, as standard, completely automatic counting from 20Hz to 18GHz, 1Hz resolution in one second, an 11-digit sectionalised display with blanking control of the six least significant digits, and high fm tolerance.

Where other high-frequency heterodyne counters generate a comb of reference frequencies and need a manually-tuned cavity or filter to select the required reference frequency, the Model 351C uses automatic electronically tuned filters. Due to the Autohet technique being used, once the signal has been acquired it can be counted directly, without prescaling, giving the greatest possible resolution in the shortest time. With a gate time of one second, resolution is 1Hz; with a gate time of 100 mS, it is 10Hz. The sweep search time is about 25 mS/GHz, but once lock is achieved readings are made continuously at up to ten a second. **(141)**



VOLTAGE SENSOR

The checking and testing of electrical apparatus, installations and machinery of all types is facilitated with the introduction of a new magnetic field detector called the DOKA. This handy, pocket-size tool gives instant information about the presence and location of a magnetic field (voltage), without the need for dismantling the equipment concerned or having to resort to additional tools.

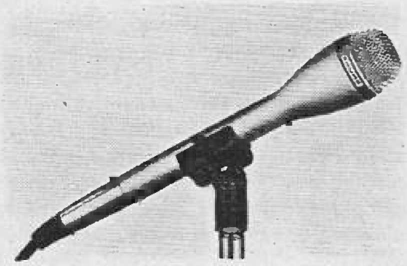
It works on the principle that a stray magnetic field creates a voltage change in a coil. This change-signal is amplified by a transistor-amplifier, located in the body of the detector, causing a signal lamp to light and thus reveal the presence of a voltage. No direct contacts have to be made between the detector and the item to be tested; the DOKA is simply held over the equipment.

Applications envisaged are in the heating, ventilating and air conditioning fields, as well as in refrigeration and the general electronics industry, to check electrically operated valves, magnetic valves or a complete series of contactors, and for checking phase loading. **(136)**

AUDIO NEWS

STUDIO MICROPHONE

The new Model SM61 Professional Omnidirectional Microphone is designed to overcome the problem of mechanically transmitted noise with a hand-held microphone in professional applications. Exceptionally low handling stand and cable noise is said to result from a special, built-in mechanical isolation system between the microphone and the case, and breath, wind and 'pop' noises are effectively controlled by an incorporated filter. These unusual features, coupled with a smooth, wide range frequency response and an extremely natural colouration-free sound should make the SM61 ideal for speech, vocal music and instrumental pickup. **(130)**



LH SM CASSETTES

LH (low noise, high output) ferric oxide compact cassettes from BASF will be available in the autumn with the patented Special Mechanics (SM) developed by BASF in West Germany. The Special Mechanics are a combination of two plastic tusks and a roller system which together guide the tape smoothly on and off the spools. They are said to ensure constant free running of the tape and improved performance of the cassette by eliminating jerking caused by static.

Improvement in tape running is most noticeable with C120 cassettes which, because of their extreme tape length (over 56 feet) and thinness, are prone to running difficulties.

Special Mechanics are already available on BASF Chromium Dioxide cassettes where they have been thoroughly proven. By incorporating them in their LH cassettes, BASF claim to give the range a reliability unrivalled in similar tapes. **(103)**

AR1214 Tuner/Amplifier

HI-FI KITS

Heathkit have released their new Model 1214 Series of Amplifier, Tuner and Tuner/Amplifier with the following comprehensive specifications:

Tuning range: 88-108MHz (FM); 535-1620kHz (AM)
Sensitivity: less than 2uV (FM); less than 100mV (AM)
Capture ratio: 2dB (FM)
Amplifier: 15W rms into 8 ohms per channel, ±1dB from 20-15000Hz; less than 0.5% harmonic distortion from 20-20kHz.

Also announced are their new model speaker kits (AS 9530/9520/9515) incorporating KEF speakers. **(107)**

MODULAR TURNTABLE UNITS

Garrard has introduced three new modular versions of its successful Zero-100S, AP76 and SP25 Mk III high quality record-playing units. All three turntable units will now be available ready-wired and mounted on newly-designed attractive bases with tinted transparent plastic covers and fitted Shure cartridges.

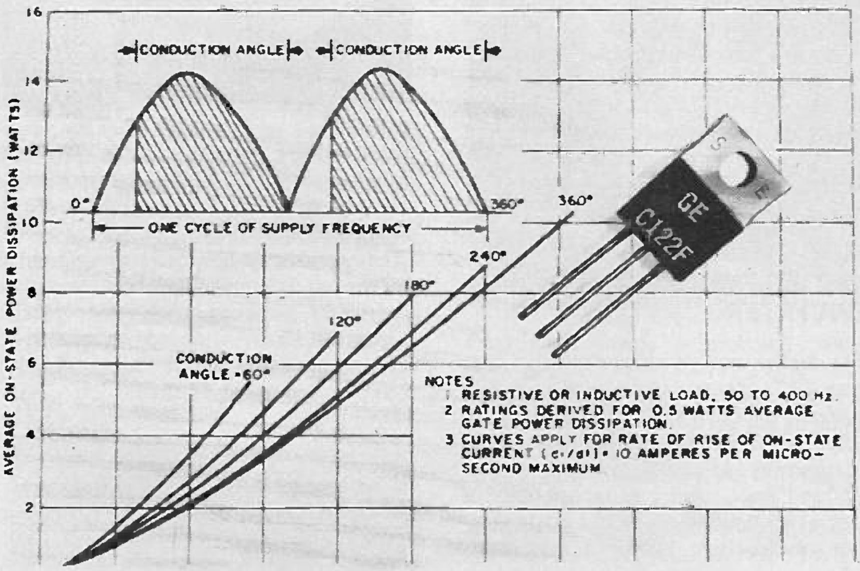
The bases introduced for the Zero-100S and AP76 are structural plastic foam mouldings designed to be non-resonant, rigid and strong. An elegant brushed aluminium trim embellishes the Zero-100S module and a simulated teak trim completes the AP76 base. A teak effect is also used on the moulded base for the SP25 Mk III which, in common with the other two models, will be supplied ready-wired for easy connection to hi-fi systems. The hinged plastic cover fitted to the three models is automatically supported when raised by a spring-loaded stay and can be removed quickly and easily.

All three units are single-play record transcription turntables with the Zero-100S and its tangential tracking pick-up arm representing the top of the range, followed by the AP76 and SP25 Mk III models. **(106)**

AP76

COMPONENT NEWS

8A THYRISTOR



Jermyn announce availability of a low-cost 8A power thyristor from General Electric. The C122 is made with a plastic thermotab package to the low profile TO-220 AB outline and is immediately available for 50V to 500V operation, and is said to have improved performance and reliability.

Peak one-cycle surge rating is 82A at 50Hz, a peak off-state reverse current is 0.1mA maximum at 25°C case temperature, a typical dv/dt is 50 V/µsec with an open circuit gate, and the operating temperature range, T_J, is −40°C to 100°C. Typical applications include motor and temperature control, relay and solenoid drive, power regulation, capacitor discharge circuits, etc. **(109)**

REGULATOR MODULE

Designed for original equipment manufacture applications in equipment using TTL devices, this module delivers a 5V dc output fully stabilized for currents up to 3 amps with less than 7V dc input. Constructed for direct mounting on a printed circuit board, the module carries its own integral heat sink, which is said to give fully adequate cooling under continuous maximum load conditions. **(123)**

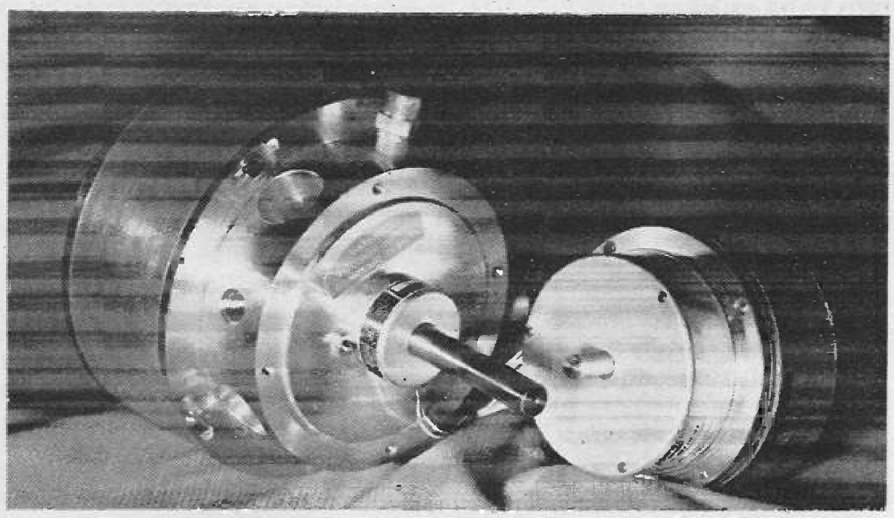
DIGITAL TACHOMETERS

Two digital tachometers for use with high-performance dc servomotors are now being offered by Honeywell. They are said to be suitable for high- and medium-speed tape drive systems. With optical increment encoders the motors can be used in digital phase-locked velocity-controlled servo systems.

The 500-line low-inertia model is suitable for high-speed tape drive systems (150-250 ips). The 2,000-line digital encoder is used in low-to-medium speed (45-75 ips) tape drives and precision N/C positioning systems.

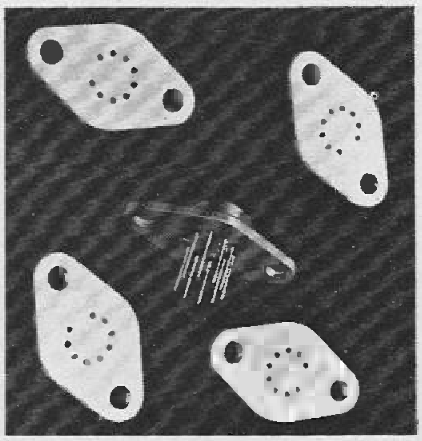
Both tachometers are offered with single or double track outputs (sine or square wave) and are compatible with TTL/DTL electronics. Light source for the encoders may be an incandescent lamp, with a life expectancy of more than 20,000 hours, or an LED.

The illustration shows the 500-line encoder on the left. **(128)**



HEAT TRANSFER WASHERS

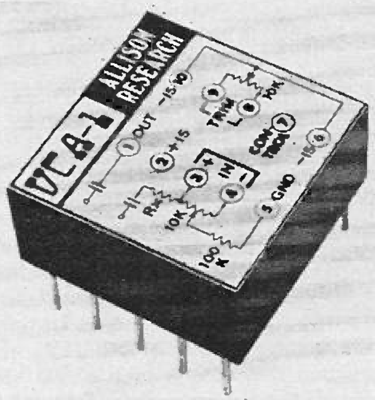
The A26–3029 heat transfer washer introduced by Jermyn has been designed specifically for TO-66 9-lead packages, such as Motorola's type R. Made of high purity (97.6%) aluminium oxide, the device has a thermal resistance of 0.6°C per W when used with "Thermaflow" grease. Its breakdown voltage is greater than 1kV, while insulation resistance is over 10,000 Megohms. The capacitance between a device used with this washer and the heat sink on which it is mounted is approximately 15pF at 1 kHz. **(110)**



COMPONENT NEWS

VOLTAGE CONTROLLED AMPLIFIER

Designed primarily for professional audio applications, the Allison Research VCA-1 voltage controlled amplifier module is said to overcome the frequently occurring problems of poor signal to noise ratio and severe harmonic distortion. It provides an extremely wide range of linear gain control through the application of 0 to 1V dc control

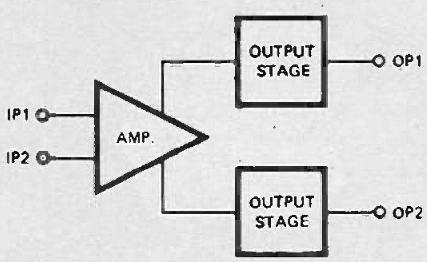


signal. Any number of VCA-1s may be fed from a control voltage source, without loading effects, and will track each other within ± 1dB over at least a 60dB range.

A typical application is as the gain control element in a sound mixing console. When operating in the −15 to −20dB region necessary to allow the mixing engineer freedom to raise or lower each input in the mix, the VCA-1 is said to be capable of maintaining a 70dB signal noise ratio at 20dB attenuation, when operated on a ± 4dBm equivalent input level. The distortion characteristics of the VCA-1 are said to be a function of the equivalent input signal and are not dependent on output or control voltage levels. **(113)**

VOLTAGE COMPARATOR

The new μA 760 high speed differential voltage comparator, unlike the μA 710 comparator, has two identical output stages, driven from a single differential amplifier. The complementary outputs are TTL compatible, providing adequate current sourcing and sinking capability with a

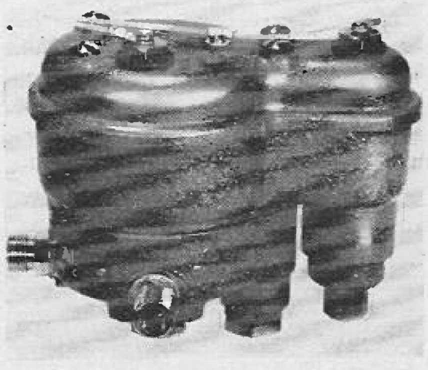


minimum fanout capability of two TTL gate loads.

The maximum delay difference between outputs is guaranteed, as is the total response time for each channel. The matched outputs are said to make the μA 760 ideal for use as a zero-crossing detector in phase encoding applications. Operating from symmetrical supplies of ± 4.5 to ± 6.5V, it has a common mode input voltage range of ± 4 Volts with ± 6V supplies and is available in ceramic dual in line and metal can. **(112)**

ELECTRO-PNEUMATIC CONVERTER

The sealed unit electro-pneumatic converter EP72 incorporates a high-coercivity magnetic material said to contribute to higher rebalance forces and consequent improvement in accuracy (linearity of 0.25% of scale range and repeatability of 0.1% of scale range). A special grade polyurethane diaphragm is used for high resist-



ance to abrasion combined with immunity to ozone.

The unit includes a single bleed valve to prevent ingress of grit in dirty environments. It converts a 0–10 mA or 4–20 mA input signal to a 3–15 lbf/in^2 air signal. All connections are made to a flying lead whilst zero and span calibrations are made via two slotted adjustments accessible through the top. The small size of the unit allows it to be mounted directly onto a control valve. **(116)**

5GHz TRANSISTOR

The low-power BFR14A silicon planar microwave transistor can be used for frequencies up to 5GHz. It is characterized by a low noise figure, high gain and low distortion and is thus suitable for use in low-noise prestages, wideband-, IF-, and radar amplifiers. As a result of the flat noise-figure response over the collector-current range, complete freedom of choice exists for setting the optimum operating point with respect to a low receiver noise

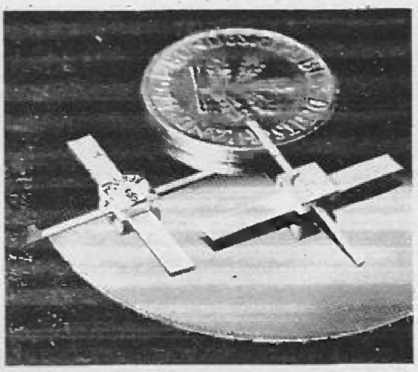


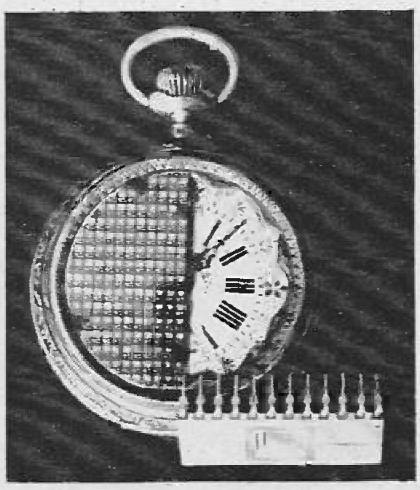
figure and low distortion during wideband operation. Since it can be driven to 20 mA, this transistor is also suitable for low-power oscillator circuits.

The ceramic strip-line metal casing (approx 3.5 mm x 3.5 mm) has been designed for use in microwave integrated circuits. Connector straps arranged on one level on the underside of the casing simplify incorporation in hybrid circuits. **(121)**

RETAINS STORED INFORMATION

Module G 192 is a re-programmable semiconductor store with non-volatile storage facilities, i.e. information is retained even after disconnection of the supply voltage, a characteristic which, up to now, could only be obtained with toroidal-core stores. Storage times of several months have been measured in tests.

The principle is based on the storing of charges on the insulator of an MOS FET. The insulation layer consists of a silicon oxide layer and an adjacent nitride layer, the charge carriers being stored on the interface between the two layers. These charges shift the threshold voltage of the transistor without, however, altering the structure of the semiconductor. Hence information can be written-in and erased as often as required. Retrieval is by applying a voltage of appropriate value to a gate; the transistor is then either conducting or cut-off, depending on the stored information. Pulses of +35V and −35V with a

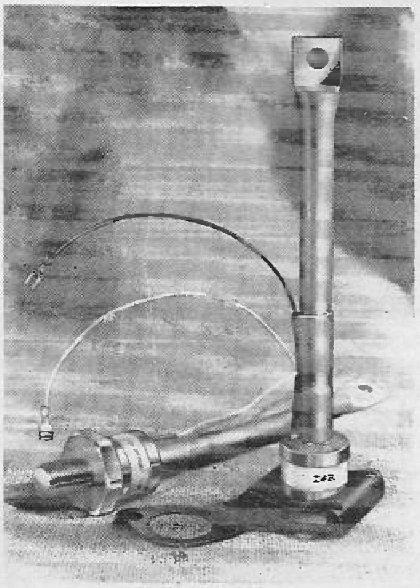


length of approx 50 to 100uS are required to write-in and erase information. The read-out speed is approximately that of normal MOS stores.

The module is organised on a word basis, in the form of eight words each of four bits. Information is fed-in and read out in parallel and the inputs and outputs are not decoded. **(119)**

HIGH POWER THYRISTORS

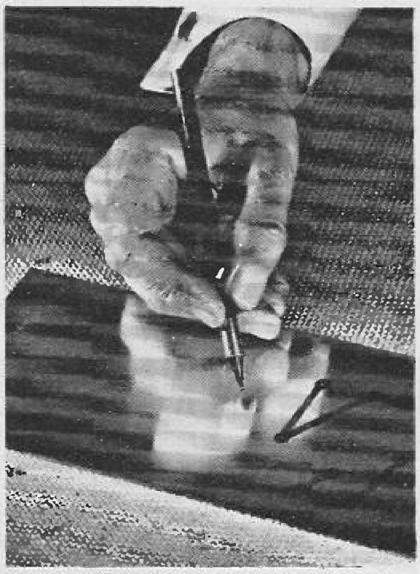
High power sophisticated inverter equipment manufacturers will be interested to hear that a new range of 250A (average) rated Accelerated Cathode Excitation (ACE) fast switching SCRs are available across a V(DRM)/V(RRM) range of 600 to 1200V. The new 250RM series offer a minimum di/dt rating of 800A per µS under low gate drive conditions. A guaranteed dv/dt capability of 200 V/uS and a turn-off time of less than 40 uS is also standard specification.



The devices are available in several case and fixing styles, including stud mounted and flat based configurations, with either two-hole or four-hole fixing clamps to meet JEDEC, DIN and other European standards, and are designed for applications such as inverters, ac motor drives, hf induction heating. **(115)**

PCB MARKING PENS

Now available in half-dozens and single units, making them ideal for the smaller engineering department and laboratory engaged in small-scale and prototype pcb production and for the home amateur, model 33 PC is a nylon-tipped marker pen that applies an etch-resist ink to copper laminated board, in line thicknesses down to $\frac{1}{32}$in. A spare nylon tip in the body of the pen can be trimmed for even finer work. The attractive point about this method of working is the time and trouble it saves – no



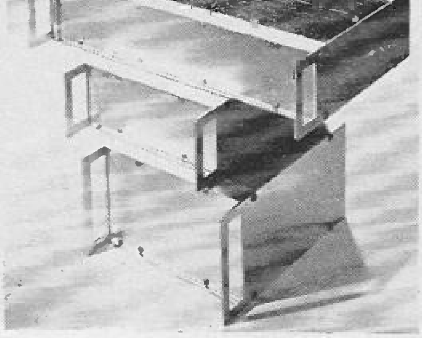
masking or taping is necessary. Simply draw the desired circuit and, after a few minutes drying time, the ink tracks are impervious to ferric chloride and all normal etchant solutions.

The spring-valve-controlled tip minimises evaporation when the marker is laid aside with the cap off. The body shell is completely filled with the special ink, not simply an ink-soaked wick. **(122)**

RACK-SIZE CASES

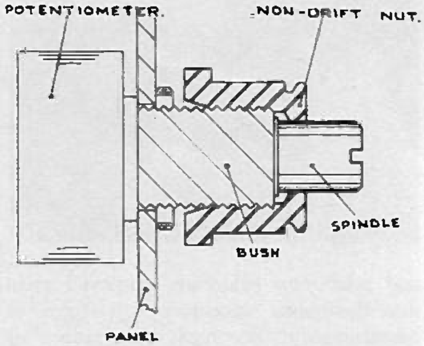
The Brightcase is now being offered in a range of four sizes, providing two heights and two widths. These are 19" rack and half rack, either 3.5" or 5.25" high, with a smart professional look of anodised aluminium and black, an integral design of combined side plates and handles and black PVC-covered steel top and bottom panels. In addition the upper and lower panels are also available with louvres as an alternative when extra heat dissipation is required.

All the cases are delivered complete with front and rear panels and fully assembled. Brackets are available for rack mounting. The internal chassis in quarter, half and full rack sizes enables power supplies and other bulky components to be easily mounted. Fixing screws are of stainless steel. Prices are from £6.80 each. **(114)**



POT LOCK NUTS

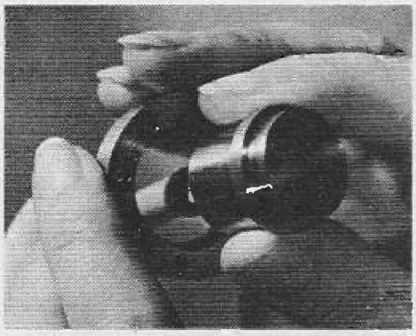
Girdlestone have announced several additions to their range of Potentiometer Non-Drift Nuts. Designed to prevent accidental alterations to potentiometer settings, the new nuts are now available for metric as well as Imperial sized spindles and can also be used on panel thicknesses of up to 0.125 in. In addition, a flame retardant type has been introduced. The nuts, which offer considerable savings of both cost and weight compared with earlier metal types, are approved for service and NATO use. **(120)**



COMPONENT NEWS

PRESSURE TRANSDUCER

Components which are designed for use in food preparation containers and pipe lines must meet certain stringent requirements in addition to achieving normal high engineering standards regarding accuracy



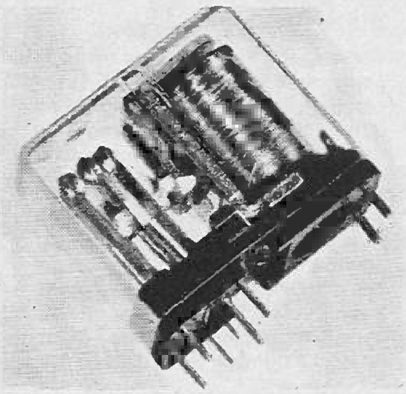
and reliability. Materials employed must not themselves introduce any form of contamination, nor must they absorb or trap minute particles of food which would subsequently decompose.

The SB 19/F transducer employs a stainless steel diaphragm and fits flush with the inside surfaces of the container so that it will not trap or absorb food particles. The stainless steel used is type EN58J(316) recommended for use in food processing. Designed for 10 volt ac or dc operation, it is said to have a non-linearity of less than 0.3% with a hysteresis of less than 0.15% over the full rated range.

Models are available with ranges from 0 – 50, to 0 – 1,000 pounds/inch². Permanent zero shift will not occur with applied pressures up to 1.5 times rated pressure and the diaphragm will not rupture at up to 3 times rated pressure. **(126)**

MINIATURE RELAY

The Series 265 miniature printed-circuit relay with single or double pole changeover contacts complying with the requirements of BS 3955 and CEE10 is capable of switching 5A at 30V dc or 250V (non-inductive) ac.



Coil operating voltages up to 110V dc are catered for. Dimensions are 30 × 28.8 × 12.1 mm. **(117)**

DUAL COMPARATORS

The LM219 and LM319 dual-voltage comparators feature high gain and low input current and are designed to operate over a wide range of supply voltages down to a single 5V logic supply and ground. The uncommitted collector of the output stage makes the devices compatible with RTL, DTL and TTL as well as capable of driving lamps and relays at currents up to 25 mA.

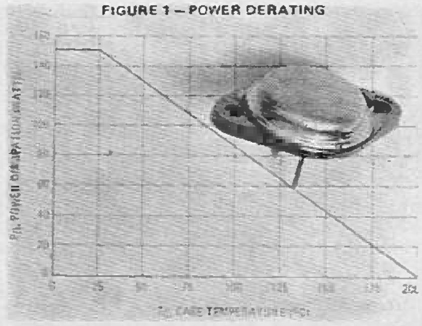
Outstanding features include 80 ns typical response time at ±15V, minimum fan-out of 2 on each side and high common mode slew rate. Inputs and outputs can be isolated from system ground. **(125)**

PNP POWER TRANSISTOR

The Distribution Division of Jermyn Industries has just announced off-the-shelf availability of Motorola type MJ2955 pnp silicon power transistor, rated at 15A maximum continuous collector current, is a true complement to the type 2N3055 npn silicon power transistor, facilitating high-power, low cost complementary amplifier design. The device is rated for a maximum collector-emitter voltage of 60V and can dissipate up to 150W at 25°C.

When used in complementary pairs with 2N3055, the MJ2955 has applications in dual (+/−) power supply series regulators and in most types of industrial control equipment. Complementary pairs

FIGURE 1 – POWER DERATING



with matched values of h_{FE} to specific customer requirements can also be supplied. The small-signal current gain is 15 minimum, with cut-off frequency at 10kHz. The current-gain bandwidth product is 4 MHz. **(118)**

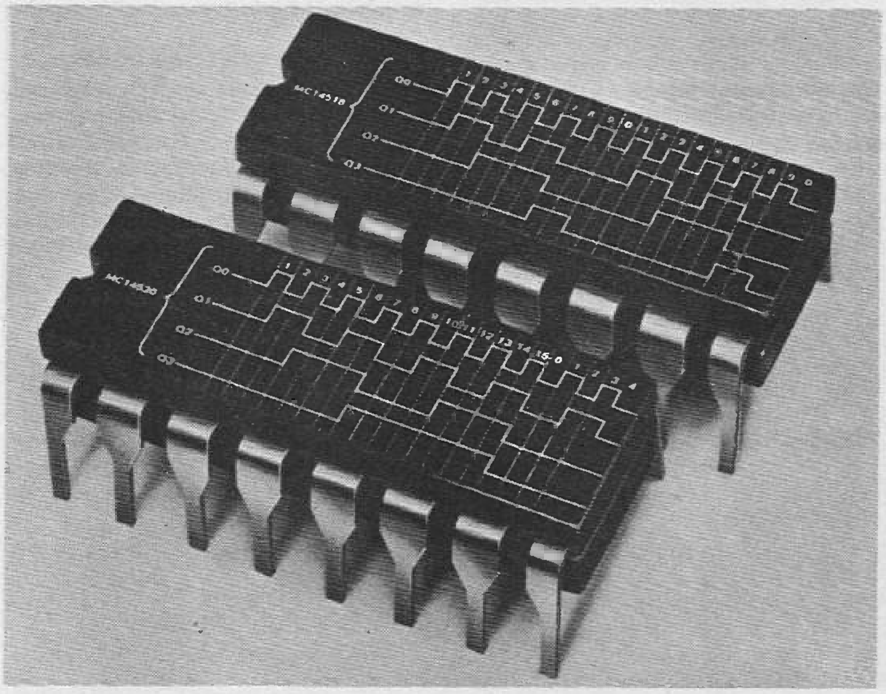
MOS COUNTERS

Dual BCD decode counter MC 14518 and dual 4-bit binary counter MC 14520 are internally sychronous and will operate at clock rates of up to 6MHz. Power consumption is 1μW (per package) when both counters are in their quiescent state, rising to 6mW when both counters are operating at 6MHz (V_{DD} = 5V).

The enable and clock input lines are interchangeable, allowing the counters to be incremented on either the negative or the positive clock transition depending on which input is used for the clock.

The AL version operates with power supply voltages from 3V to 18V over the temperature range −55 to +125°C. The CL device requires a V_{DD} of between 3 and 16V and is intended to be used within the temperature range −40 to +85°C.

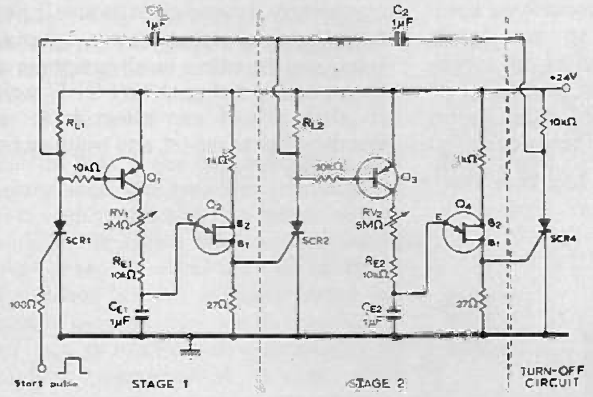
Noise pulses as large as 45% of V_{DD} are said to have no effect on the counters. The guaranteed noise immunity is 30% of V_{DD} or better. **(127)**



TECH-TIPS

SEQUENTIAL TIMER

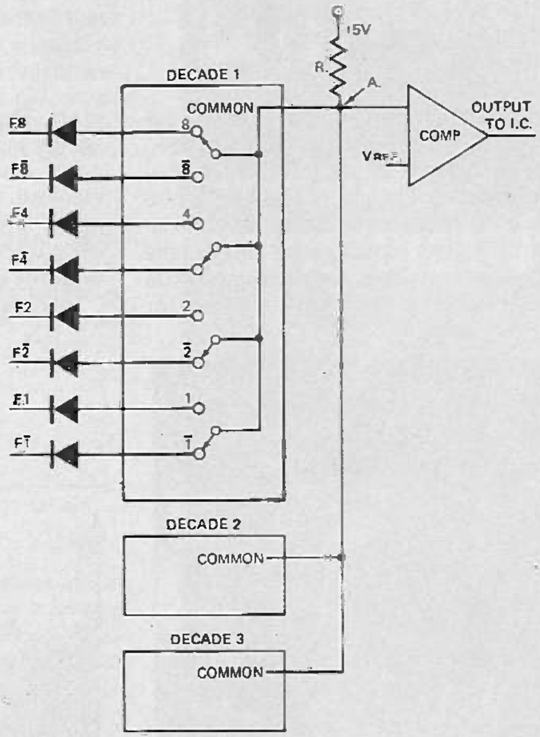
This circuit automatically switches from one time delay to another. The delays are independently adjustable. Although only 2 stages are shown, any number can be used. The starting pulse to SCR 1 gate can be taken from the last UJT for automatic recycling. (UJT: 2N4871, Motorola)



LOW COST DIGITAL COMPARATOR

A simple thumbwheel-switch/digital-counter comparator may be constructed by using the thumbwheel switch and diodes to form an AND gate, and driving this combination with the output of the counter. The output will be high only when the outputs of the counter and the switch coincide, and low for all other conditions.

Use of a voltage comparator will considerably reduce the possibility of erroneous operation. As many other decade counter-switch combinations as desired may be paralleled to the input of the comparator which should have a reference voltage of at least 2 or 3 volts.



ANTI-COLLISION RADAR

Apprentices at BAC have built a device which could be fitted to an ordinary family saloon car or to lorries to prevent the serious nose-to-tail collisions on motorways. Using a radar signal to detect obstructions ahead, the automatic device can close the throttle if this is sufficient to avoid collision, or can apply gentle or hard braking as necessary.

A battered old family saloon has already been equipped, as a prototype vehicle, with two radar horn antennae carried on a roof rack but a developed production version of the device would use a micro-wave strip which could be hidden in, for instance, the front bumper. The cost of fitting the developed device would, it is said, add an estimated £60-70 to the cost of a new car.

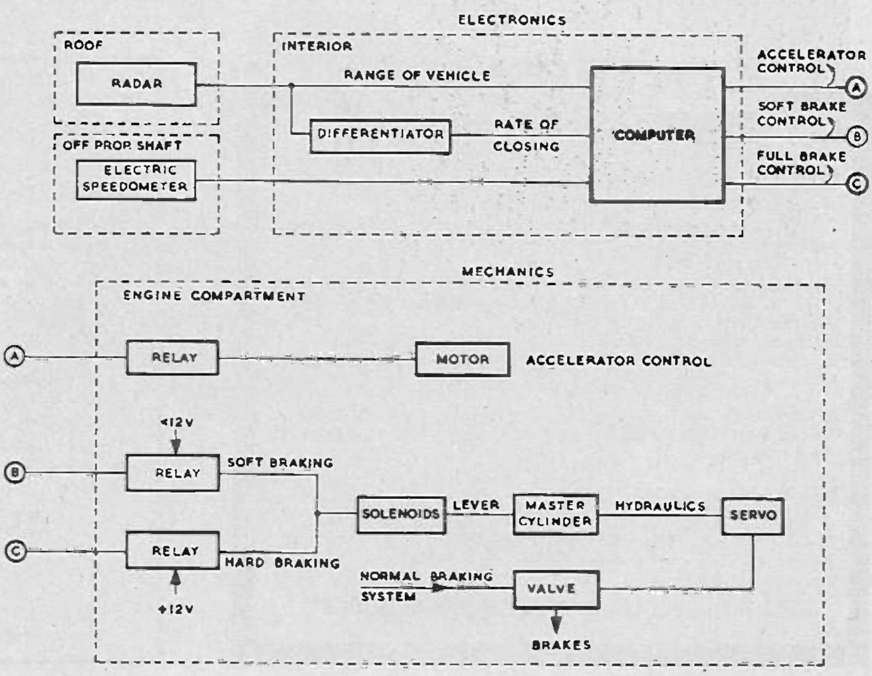
The device works by measuring three parameters — the distance from the obstruction and the closing (or opening) speed, which are measured by the radar transmitting and receiving aerials, and the car's own speed which is measured electro-mechanically from the prop-shaft. These measurements are continuously fed into a pre-programmed computer and, according to the signals received, the computer takes the appropriate decision of action or closure of the throttle for sufficient deceleration or gentle braking or emergency braking.

Throttle closure is via a small electric motor operating a modified linkage system which overrides the normal accelerator pedal. Braking, however, is via relays to a solenoid operating a lever which puts pressure into a servo-assisted hydraulic system. A special valve is provided to isolate the automatic braking system from the manual system while still allowing the normal footbrake to be used if necessary.

The whole system works entirely off the car's standard electricity supply, is completely independent in that it needs no reflector or transmitter in other vehicles, can function in all weathers and incorporates a simple 'ON-OFF' switch so that drivers can select it at will. Warning lights report any malfunctioning of the system. ●

David Scott-James and Lawrence Anderson with the computer

Fig 1 Prototype device on experimental car



SOLVE A PROBLEM

Do you have a problem — in locating a device with special characteristics, in achieving a design or usage function, in applying electronic and (associated) techniques or merely as a challenge to ingenuity? Write and tell us — and, through this column, your fellow-readers in all engineering disciplines — about it. Here are two more problems:

Problem 008: A one-shot switch for a 3kW heating load. The switch to remain closed from supply switch-on to a certain temperature of the heated substance and, having then opened, to remain open till the supply is switched off *and* the temperature falls again to a preset value. The Maclaren Company used to market such a thermostat but this is no longer available. We want a simple device or circuit, not one as expensive as a 15A contactor.

Problem 009: The second resistor in a potential divider is followed by another divider and so on *ad infinitum*, see Fig 3. Given that each resistor in such a chain is the same value, what is the resistance measured across A and B?

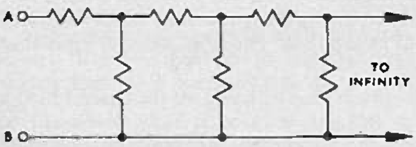


Fig. 3

Solution to 001: Place the dc line in the form of a coil with a 'dry' reed switch inside it. The amount of turns could be worked out so that the switch contacts close for the lowest current value required. The switch contacts could be used to close an alarm circuit.

—C J Jones, Gibralter

Solution to 002: Attach a permanent magnet (small and perhaps of the magnetised rubber variety) to the handset and a change-over contact dry reed switch to the telephone case such that lifting the handset operates the switch. The contacts can be wired to

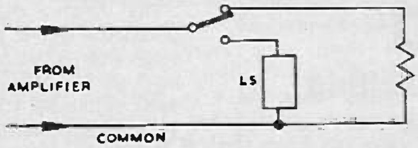


Fig. 4

switch a resistance load in place of the speaker (Fig 4) or, in the case of more than one speaker, to operate a second multi-contact relay. Note that this solution may be feasible only where short wire-runs to the speaker is involved.

—R Dobson, Dorset

To readers with solutions: please help our mail department by writing the problem number prominently on the bottom left of the envelope. Since almost every problem has more than one solution, do not give up seeking or sending your solution to a problem even if one solution to it has been published in these columns.

—Ed

READERS ARE REQUESTED TO USE THE ENQUIRY SERVICE OFFERED ON PAGE 86 FOR FURTHER DETAILS OF EQUIPMENT AND MATERIALS MENTIONED IN THIS ISSUE.

BOOK REVIEWS

REVIEWER: Brian Chapman

PULSE, DIGITAL AND SWITCHING WAVEFORMS – By Millman and Taub. McGraw Hill International Student Edition, published 1965. Hard covers, 985 pages 8¼ x 5¾. Review copy supplied by Modern Books and Plans. Price £4·50.

This book was planned originally as a second edition of the authors' "Pulse and Digital Circuits". However so much new material has been added and so extensive and thorough have been the additions, that the authors decided to give it a new title.

Thorough is definitely the word to use in connection with this book, which treats the subject to a degree that would be more than adequate for undergraduate electronics courses.

The opening chapter of the book reviews such things as the notational system used, networks, small signal equivalent circuits of tubes and transistors, elementary feedback amplifiers and graphical methods of analysis. The book then gives a complete study of how pulse signals are transmitted, shaped, or amplified by linear circuits. This is followed by a detailed study of wideband transistor amplifiers and the analysis of transistors at cutoff and in saturation. Clipping, clamping, comparator and switching circuits utilising non-linear elements are analysed in chapters 7 and 8 before moving onto digital circuitry in chapters 9 to 11.

Further chapters follow on negative resistance devices and switching circuitry incorporating them, timebase circuits, sampling gates and counting, timing and frequency-division circuitry. The final chapter deals with the transient switching characteristics of diodes and transistors.

Both transistor and valve circuitry are analysed side-by-side throughout the book with the emphasis, naturally, on semiconductors. The mathematical treatment is adequate for a first course in electronic engineering requiring a level of maths sufficient for the understanding of solution of linear differential equations with constant coefficients.

Examples are provided in each chapter based on the characteristics of practical components, and the working is fully developed to exemplify the limitations and parameter variations due to these characteristics. In addition to the large number of examples there are over 700 problems provided in a section at the rear of the book. Problems are keyed to the relevent chapters and have been designed to give maximum insight into real circuit parameters with practical devices. This feature makes the text most suitable for use in conjunction with a suitable electronics course.

Excellent value for the student or engineer and must be considered as one of the better standard texts – B.C.

RECORDINGS... CLASSICAL

REVIEWERS: John Clare, John Araneta, C.M. Wagstaff.

MOZART – Piano Concertos, no.19 K.459, no. 23 K.488. Brendel, Marriner, Academy of St. Martin-in-the-Fields. Philips 6500 283.

Let us hope this disc is the start of a series that will ultimately comprise the whole cycle of the piano concertos. Brendel's renditions of six of the concertos have long been justifiably well known, but notable as those recordings were for their pianism, the orchestral support and engineering on these records left much to be desired.

Brendel and Marriner? The combination seems too good to be true. I must confess the results on this record are not quite what I would have expected, although to be quite objective about this I hasten to remember that neither Brendel nor Marriner have recorded either of these concertos before. On first hearing, I felt that Brendel's previous recordings were not so poised, and doubtless Marriner's collaboration enforces that feeling. I rather expected Marriner to sound more lush, or even at times as precious as his other Mozart can be. What we have in these performances is hardly the Mozart one often hears these days. These performances are certainly poised but by that I do not mean they are artificial in any way, rather there is a remarkable balance between sponaneity and calculation, always a seemingly unattainable ideal in any Mozart. I cannot hesitate to say that the playing here does come very close to that ideal.

Of the two concertos here, K.459 seems to impress me more, perhaps because so many other renditions unduly emphasize the "coronation" aspects performers usually imagine in this music. One can hardly help remarking the unusually fine orchestral playing: the opening tutti is brilliant but not overpowering and certainly precise.

While Marriner is suitably light-hearted, and melancholy accents are also made to seem not just in the foreground of this music (note those oboes). How preferable it is then to have a smaller orchestral ensemble for this music. From his entry on, Brendel sings, and just as important his rhythms are crisp and almost danceable. Speaking of singing, I have seldom been more forcibly reminded of the operatic qualities of these concertoes as here.

Brendel goes into the cadenza in the first movement naturally; one is simply not treated to virtuosity but a graceful flourish. The final trill here (and in K.488) is beautifully calculated and phrased. The tone of Brendel's playing begins not too loudly and builds up, but I was amazed how nothing ever seems to just happen in this performance, control is never lost sight of. Much the same things can be said of the K.488 here and I find myself once more pointing out the cadenza just because Brendel integrates the section so well with the rest.

Perhaps the most strikingly played section in this concerto is the second movement. Both Brendel and Marriner deliver a true opera scene of great beauty: I can almost hear some of the piano passages as vocal ornamentation, but note, not the least trace of show. A beautiful record.

The engineers have also done well – the piano, for once, does not sound swamped or too formidable. Justice must make me record some slight pitch changes in the second movement of K.459 and I do not think the musicians had anything to do with it. But the damage is slight and I can easily overlook it. – J.A.A.

MOZART – Symphony no. 25 in G minor, K.183 – Symphony no.29 in A major, K.201 – Marriner, Academy of St. Martin-in-the-Fields – ARGO ZRG 706.

Mozart's first two remarkable essays in symphonic form receive from the Academy typical performances, which is to say that one cannot help but remark immediately on the precise delivery and the splendid tone which seems to suit Mozart so well. Phrasing is always obviously well considered (note the excellent opening of K.201 always a difficult moment). Rhythms are energetic – nothing static here. At the same time nothing just pretty, but rather fiery playing without seeming overly romanticized.

In the G minor, the Academy is especially bent on pointing out the work's affinities with K.550, a valid veiwpoint since Mozart did have the earlier work in mind while composing the latter. The Minuets are particularly striking moments in these interpretations. One senses in the melancholy the evolution from dance to pure statement.

If you do want these symphonies (you should) I feel this record will do very well indeed. Recording is clear with good separation but there is some distortion from the horns in the tuttis, on my copy. – J.A.A.

G.F. HANDEL – Music for the Royal Fireworks – Water Music – Academy of the St. Martin-in-the-Fields, directed by Neville Marriner – Argo ZRG 697.

Well it's about time that someone has had the sense to put both the "Royal fireworks Music" and the "Water Music" onto a single disc. And it's about time that the Academy of St. Martin-in-the-fields recorded these two works, undoubtedly two of Handel's greatest compositions, for after hearing most of its other performances of Handel I was just waiting for the day. Did the record fulfil my expectations? Well, yes and no. As regards performance, the playing is simply first class (one should really to careful about being Marrinated) but interpretation is another matter – particularly with regard to the Fireworks Music.

Apparently Marriner takes the view that Handel recruited strings to build up the numbers for a particular performance of the Fireworks and also that he undoubtedly used strings for a later concert version (is this version supposed to be an improvement?). This might well be the case but it does not dispell the fact that it was primarily music to precede the fireworks display and used wind, brass and percussion. In any case Marriner has changed the original orchestration quite extensively so that now the strings are the central focus. Whether you prefer your Fireworks Music this way depends, of course, on taste. Personally I prefer the original orchestration with all those antiphonal batteries of fiery trumpets and horns, and the rows of percussion (for this type of performance listen to Piallard: Erato, W.R.C.). Sometimes the current performance seems a little too precious, a little too lush, particularly when the strings alone are playing. But enough of this. Let me now speak of performance.

The Acedemy's playing is exactly what one would expect from this orchestra – very rhythmic, beautifully phrased (perhaps sometimes a little too overphrased for Handel) cleanly articulated, incredibly precise and radiantly warm. Some very fine trumpet playing here – listen to how it soars with apparent ease in the Fireworks Music eg. the small cadential cadenza of slow sections (rather unusual for trumpet). Mention should also be made of Colin Tilney's imaginative harpsichord playing with his funfilled interplay of themes. The harpsichord used (Goble) sounds on the whole rather subdued (although is sounds well balanced in the Air of the F major – Water Music suite) – perhaps it could be brought into the fore very slightly.

Ornamentation is plentiful and generally tasteful (even though it seems rather carefully premeditated). Some of the quavers have been dotted effectively and this could perhaps be even more developed in say the last movement of the Royal Fireworks Music. The double dotting at the opening of the Fireworks music is interesting but not all that convincing. Some of the cadential elaborations at the end of slow movements (in Water Music) are simply gorgeous.

Very clear and well spread sound. If one listens hard the sound of someone saying "right" may be heard at the beginning of the Air of the F major Water Music Surto.

Superb musicianship and probably the finest recording of the Water Music available. – C.M.W.

READER ENQUIRY SERVICE

Both advertisement and editorial matter are allocated code numbers, in bold type in brackets, accompanying the item.

Enter the relevant numbers in the list provided on a card, cut it out and mail it to us. Your enquiries will be passed on to the manufacturers or companies concerned, and you can expect to hear from them directly.

If you did not see this copy first-hand or if you are way down on the circulation list, you may not be getting the best benefit from this enquiry service.

May we suggest that you have your own copy? Place an order with your newsagent at 20p per copy delivered to your door.

Subscription rates: UK, £3.60 a year. Overseas, £4.00 a year, postage by surface mail.

ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....

ELECTRONICS TODAY INTERNATIONAL

ENQUIRY SERVICE

Please arrange for me to receive further information on the items listed, the code numbers of which are entered in the space provided.

(BLOCK LETTERS, PLEASE)

Name: ....

Position in the company: ....

Name of company: ....

Address: ....

....

....

Signed: ....

ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....

ELECTRONICS TODAY INTERNATIONAL

ENQUIRY SERVICE

Please arrange for me to receive further information on the items listed, the code numbers of which are entered in the space provided.

(BLOCK LETTERS, PLEASE)

Name: ....

Position in the company: ....

Name of company: ....

Address: ....

....

....

Signed: ....

ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....
ETI....	ETI....	ETI....

ELECTRONICS TODAY INTERNATIONAL

ENQUIRY SERVICE

Please arrange for me to receive further information on the items listed, the code numbers of which are entered in the space provided.

(BLOCK LETTERS, PLEASE)

Name: ....

Position in the company: ....

Name of company: ....

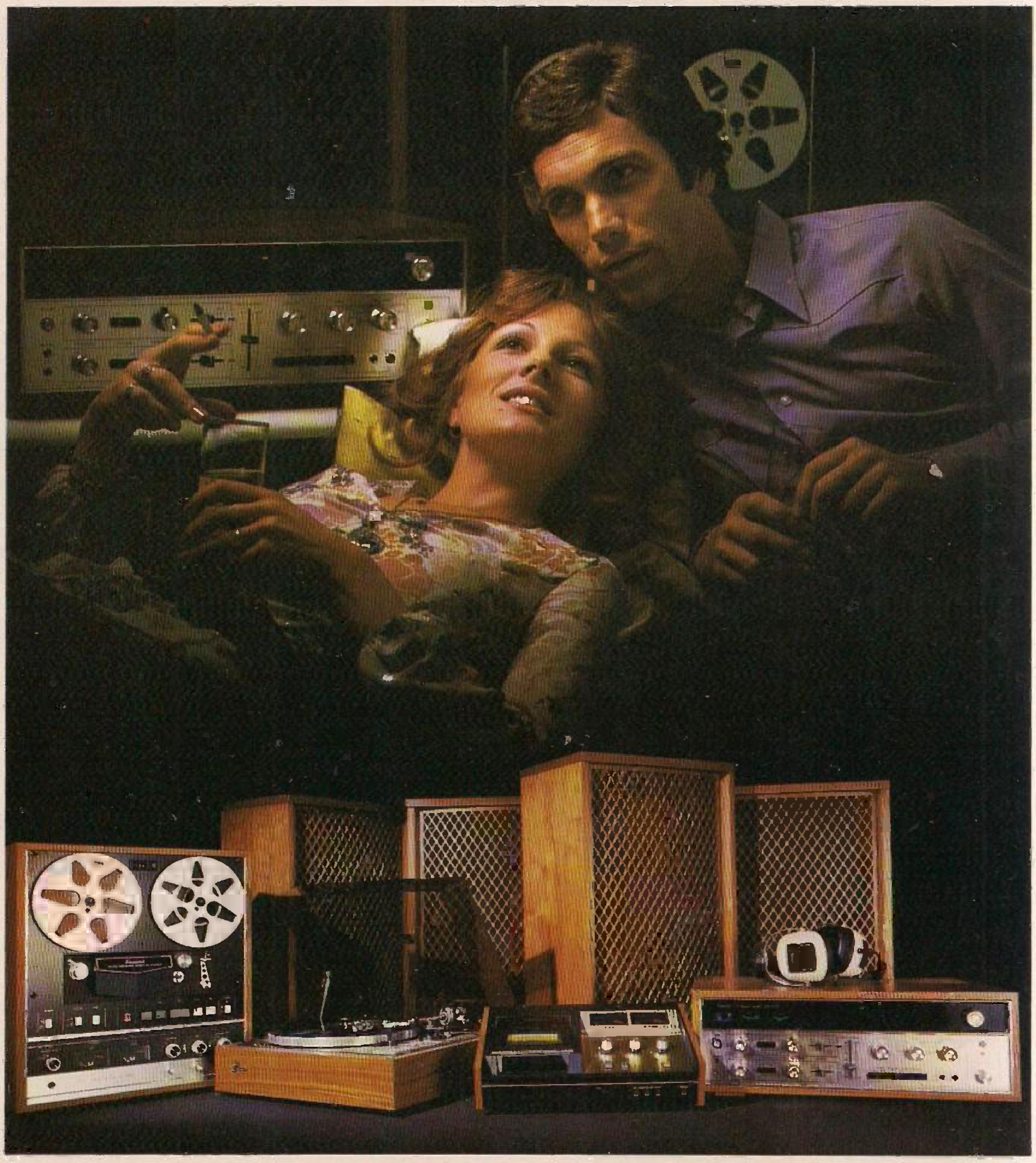
Address: ....

....

....

Signed: ....

The entrancing world of SANSUI's quadrasonic 4-channel stereo.



The complete range of Sansui's sophisticated 4-channel equipment at your dealer's now!

Sansui 4-CHANNEL STEREO

England : VERNITRON(UK)LTD. Thornhill Southampton S09 5QF Tel : Southampton 44811

SANSUI AUDIO EUROPE S.A. Diacem Bldg., Vestingstraat 53-55, 2000 Antwerp, Belgium SANSUI ELECTRONICS CORPORATION 32-17 61st Street, Woodside, New York 11377, U.S.A.
SANSUI ELECTRIC CO., LTD. 14-1, 2-chome, Izumi, Suginami-ku, Tokyo, Japan