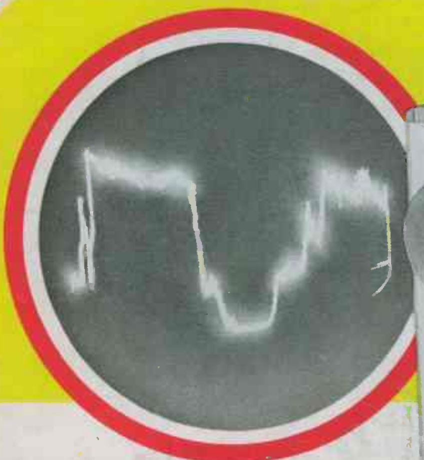
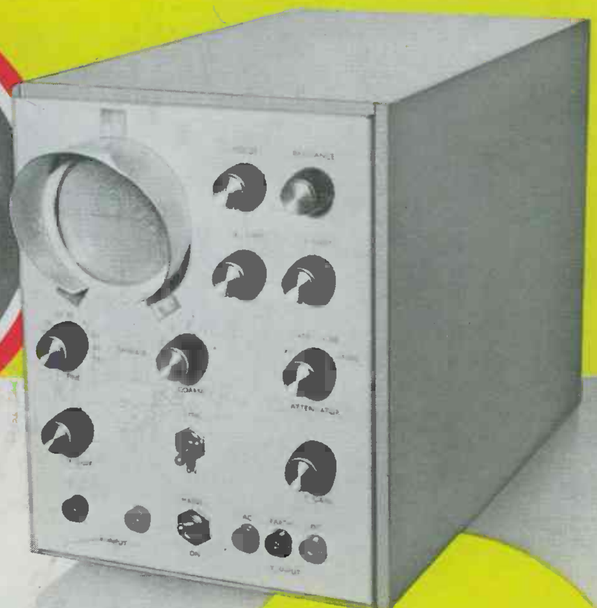
RADIO & ELECTRONICS CONSTRUCTOR

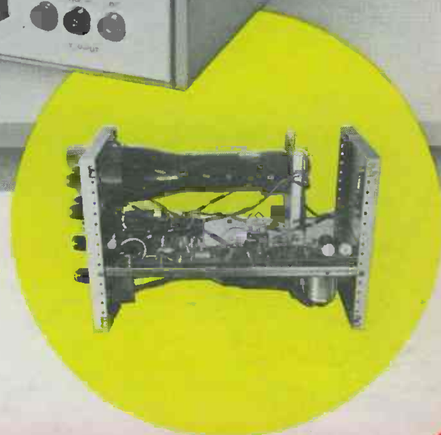
SEPTEMBER 1975

30p





NEW



Transistorised Oscilloscope

PART ONE (Three parts)

ALSO FEATURED

PARALLEL S.C.R. COMBINATION LOCK

CA3048 AND CA3052 AMPLIFIER ARRAYS

Each £3 unit of Home Unit Insurance gives you protection up to the limit shown

This is the simplified insurance you have been waiting for. Not just cover on the contents of your home but a package of personal protection you and your family need. And it's how we save you so much money: just ONE policy to issue instead of nine! You can build up to the cover you need by additional units (or ½ units after the first) up to a maximum of five. So simple. So easy. Apply to your Broker, Agent or local office of a General Accident company. The Home Unit Policy can replace your existing insurances And remember – as you buy more possessions just add more Home Units at any time. *Quote Ref. 20/9468*

THE GENERAL ACCIDENT FIRE & LIFE ASSURANCE CORPORATION LTD

Metropolitan House, 35 Victoria Avenue,
Southend-on-Sea, Essex, SS2 6BT

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Please send me further particulars of the Home Unit Insurance.

Name..

Address...

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20/9468

BI-PAK

SEMICONDUCTORS

COMPONENTS

CARBON RESISTOR PAKS
These Paks contain a range of Carbon Resistors, assorted into the following groups:

R1. 50 Mixed
100 ohms–820 ohms 1/8 W. 0.60
R2. 50 Mixed
1K ohms– 8.2K ohms 1/8 W. 0.60
R3. 50 Mixed
10K ohms– 82K ohms 1/8 W. 0.60
R4. 50 Mixed
100K ohms–820K ohms 1/8 W. 0.60
R5. 30 Mixed
100 ohms–820 ohms 1/2 W. 0.60
R6. 30 Mixed
1K ohms– 8.2K ohms 1/2 W. 0.60
R7. 30 Mixed
10K ohms– 82K ohms 1/2 W. 0.60
R8. 30 Mixed
100K ohms–820K ohms 1/2 W. 0.60
These are unrepeatable prices

LOW COST CAPACITORS
500 uF 50V Elect 0.09 each
.01 uF 400 V 0.03 each

REPANCO CHOKES & COILS
RF Chokes
CH1 2.5mH 0.27 CH2 5.0mH 0.28
CH3 7.5mH 0.29 CH4 10mH 0.31
CH5 1.5mH 0.26
Coils
DRX1 Crystal set 0.29
DRR2 Dual range 0.42

CARBON POTENTIOMETERS
Log and Lin
4.7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M.

VC 1	Single Less Switch	0.14
VC 2	Single D.P. Switch	0.26
VC 3	Tandem Less Switch	0.43
VC 4	1K Lin Less Switch	0.14
VC 5	100K Log anti-Log	0.43

HORIZONTAL CARBON PRESETS
0.1 Watt 0.06 each
100, 220, 470, 1K, 2.2K, 4.7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M, 4.7M.

REPANCO TRANSFORMERS
240v. Primary. Secondary voltages available from selected tappings 4v, 7v, 8v, 10v, 40v; 50v and 25v-0-25v.

Type	Amps	Price	P & P
MT50/½	½	£1.79	45p
MT50/1	1	£2.24	48p
MT50/2	2	£3.06	60p

COIL FORMERS & CORES
NORMAN ¼" Cores & Formers 7p
⅜" Cores & Formers 9p

SWITCHES
DP/DT Toggle 28p
SP/ST Toggle 22p

FUSES
1¼" and 20mm, 100mA, 200mA, 250mA, 500mA, 1A, 1.5A, 2A
QUICK BLOW *5p each
Anti-Surge 20mm only *8p each

VEROBOARDS
VB1 containing approx. 50 sq.ins. various sizes all 0.1 matrix. *60p
VB2 containing approx. 50 sq.ins. various sizes all 0.15 matrix. *60p

DECON-DALO 33PC MARKER
Etch resistant printed circuit marker pen. Full instructions supplied with each pen *92p

BATTERY HOLDERS
Takes 6 H.P. 7s complete with terminal clip and lead *31p each

CABLES Per Metre

CP 1	Single lapped screen	* 8p
CP 2	Twin Common Screen	*11p
CP 3	Stereo Screened	*12p
CP 4	Four Core Common Screen	*21p
CP 5	Four Core individually screened	*28p
CP 6	Microphone Fully Braided Cable	*11p
CP 7	Three Core Mains Cable	*11p
CP 8	Twin Oval Mains Cable*	8p
CP 9	Speaker Cable	*6p
CP10	Low Loss Co-Axial	*14p

INSTRUMENT CASES

(In 2 sections, Black Vinyl covered top and sides and bezel)

No.	Length	Width	Height	Price
BV1	8"	x 5¼"	x 2"	*£1.25
BV2	11"	x 6"	x 3"	*£1.62
BV3	6"	x 4¾"	x 1¾"	*92p
BV4	9"	x 5¼"	x 2½"	*£1.39

ALUMINIUM BOXES

No.	Length	Width	Height	Price
BA1	5¼"	x 2¼"	x 1½"	*45p
BA2	4"	x 4"	x 1½"	*45p
BA3	4"	x 2¼"	x 1½"	*45p
BA4	5¼"	x 4"	x 1½"	*54p
BA5	4"	x 2½"	x 2"	*45p
BA6	3"	x 2"	x 1"	*39p
BA7	7"	x 5"	x 2½"	*79p
BA8	8"	x 6"	x 3"	*£1.02
BA9	6"	x 4"	x 2"	*65p

(Each complete with ½" deep lid and screws)
Please add 20p p & p for each box

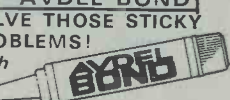
COMPONENT PAKS

Pak No.	Qty.	Description	Price
C 1	200	Resistors mixed values approx. count by weight	60p
C 2	150	Capacitors mixed values approx. count by weight	60p
C 3	50	Precision Resistors mixed values	60p
C 4	75	⅛ width Resistors mixed preferred values	60p
C 5	5	Pieces assorted Ferrite Rods	60p
C 6	2	Tuning Gangs, MW/LW VHF	60p
C 7	1	Pak Wire 50 metres assorted colours	*60p
C 8	10	Reed Switches	*60p
C 9	3	Micro Switches	60p
C10	15	Assorted Pots & Pre-Sets	60p
C11	5	Jack Sockets 3 x 3.5m, 2 x standard Switch Type	60p
C12	30	Paper Condensers preferred types mixed values	60p
C13	20	Electrolytics Trans. types	60p
C14	1	Pack assorted Hardware Nuts/Bolts, Grommets etc.	*60p
C15	5	Mains Slide Switches, 2 Amp	60p
C16	20	Assorted Tag Strips and Panels	*60p
C17	10	Assorted Control Knobs	60p
C18	4	Rotssy Wave Change Switches	60p
C19	2	Relays 6-24v Operating	60p
C20		Sheets Copper Laminate approx. 200 sq.ins.	*60p

Please add 20p p & p on all component packs, plus a further 10p on pack nos. C1, C2, C19 & C20.

* AVDEL BOND

SOLVE THOSE STICKY PROBLEMS!
with



CYANOACRYLATE C2 ADHESIVE
The wonder bond which works in seconds—bond plastic, rubber transistors, components permanently, immediately!

OUR PRICE ONLY 60p
for 2gm phial

BIB HI-FI ACCESSORIES

Ref.		Price
B	Stylus and turntable cleaning kit	*31p
J	Tape head cleaning kit	*68p
P	Hi-Fi cleaner	*30p
9	Wire stripper/Cutter	*94p
31	Cassette head cleaner	*58p
32	Tape editing kit	*£1.64
32A	Stylus balance	*£1.24
36A	Record stylus cleaning kit	*32p
42	De Luxe Groov-Kleen	*£1.84
43	Record care kit	*£2.68
45	Auto changer groove cleaner	*98p
46	Spirit level	*68p
56	Hi-Fi stereo hints & tips	*38p
60	Chrome finish as above	*£1.72

ANTEX EQUIPMENT

SOLDERING IRONS

X25. 25 watt	*£2.45
Model G. 18 watt	*£2.70
CCN 240. 15 watt	*£2.90
SK2. Soldering Kit	*£3.90

BITS AND ELEMENTS

102 for model CN240 ..."	*42p
104 for model CN240 3/16"	*42p
106 for model CN240 3/32"	*42p
1100 for model CCN240 .."	*42p
1101 for model CCN240 ⅛"	*42p
1102 for model CCN240 ¼"	*42p
1020 for model G240 .."	*42p
1021 for model G240 ⅛"	*42p
1022 for model G240 3/16"	*42p
50 for model X25 .."	*44p
51 for model X25 ⅛"	*44p
52 for model X25 3/16"	*44p

ELEMENTS

Model ECN 240	*£1.10
Model EG 240	*£1.35
Model ECCN 240	*£1.55
Model EX 25	*£1.20

SOLDERING IRON STAND
ST3 Suitable for all models *£1.10
Antex heat shunt *10p

PLUGS

		Price
PS 1	D.I.N. 2 Pin (Speaker)	10p
PS 2	D.I.N. 3 Pin	11p
PS 3	D.I.N. 4 Pin	14p
PS 4	D.I.N. 5 Pin 180°	15p
PS 5	D.I.N. 5 Pin 240°	15p
PS 6	D.I.N. 6 Pin	16p
PS 7	D.I.N. 7 Pin	17p
PS 8	Jack 2.5mm Screened	17p
PS 9	Jack 3.5mm Plastic	11p
PS 10	Jack 3.5mm Screened	17p
PS 11	Jack ¼" Plastic	14p
PS 12	Jack ¼" Screened	20p
PS 13	Jack Stereo Screened	33p
PS 14	Phono	9p
PS 15	Car Aerial	14p
PS 16	CO-Axial	14p

INLINE SOCKETS

PS 21	D.I.N. 2 Pin (Speaker)	13p
PS 22	D.I.N. 3 Pin	19p
PS 23	D.I.N. 5 Pin 180°	19p
PS 24	D.I.N. 5 Pin 240°	19p
PS 25	Jack 2.5mm Plastic	15p
PS 26	Jack 3.5mm Plastic	15p
PS 27	Jack ¼" Plastic	28p
PS 28	Jack ¼" Screened	32p
PS 29	Jack Stereo Plastic	28p
PS 30	Jack Stereo Screened	35p
PS 31	Phono Screened	17p
PS 32	Car Aerial	20p
PS 33	Co-Axial	20p

SOCKETS

PS 35	D.I.N. 2 Pin (Speaker)	7p
PS 36	D.I.N. 3 Pin	9p
PS 37	D.I.N. 5 Pin 180°	9p
PS 38	D.I.N. 5 Pin 240°	10p
PS 39	Jack 2.5mm Switched	11p
PS 40	Jack 3.5mm Switched	11p
PS 41	Jack ¼" Switched	19p
PS 42	Jack Stereo Switched	28p
PS 43	Phono Single	7p
PS 44	Phono Double	9p
PS 46	Co-Axial Surface	9p
PS 47	Co-Axial Flush	19p

P.C.B. KITS & PENS

PROFESSIONAL D.I.Y. PRINTED CIRCUIT KIT
Containing 6 sheets of 6" x 4" single sided laminate, a generous supply of etching powder, etching dish, etchant measure, tweezers, etch resistant marking pen, high quality pump drill with spares, cutting knife with spare blades, 6" metal ruler, plus full easy to follow instructions. *£7.80 per kit
Spare container of etchant for above *60p
PCB Pens 2 x Quality marker pens specifically designed for drawing fine line etch resistant circuits on copper laminate. Complete with full instructions *£1.53 per pair

LOW-NOISE CASSETTES

C60 *33p; C90 *44p; C120 *56p

AUDIO LEADS

S221 5 pin DIN plug to 4 phono plugs length 1.5m £1.08
S222 5 pin DIN plug to 5 pin DIN socket length 1.5m 68p
S237 5 pin DIN plug to 5 pin DIN plug mirror image length 1.5m £1.20
S238 2 pin DIN plug to 2 pin DIN socket length 5m 68p
S268 5 pin DIN plug to 3 pin DIN plug 1 & 4 and 3 & 5 length 1.5m £1.00
S270 2 pin DIN plug to 2 pin DIN socket length 10m
S271 5 pin DIN plug to 2 phono plugs connected to pins 3 & 5 length 1.5m
S275 5 pin DIN plug to 2 phono sockets connected to pins 3 & 5 length 23cm.
S318 5 pin DIN socket to 2 phono plugs connected to pins 3 & 5 length 23cm.
S404 Coiled stereo headphones extension cord extends to 7m £1
S217 3 pin DIN plug to 3 pin DIN plug length 1.5m
S219 5 pin DIN plug to 5 pin DIN plug length 1.5m
S474 3.5mm Jack to 3.5mm Jack length 1.5m
S600 5 pin DIN plug to 3.5mm Jack connected to pins 3 & 5 length 1.5m
S700 5 pin DIN plug to 3.5 jack connected to pins 1 & 4 length 1.5m

CROSSOVER NETWORK

K4007 (2-way) 1/P Impedance 8 ohms. Insertion Loss 3dB. Crossover Frequency 3 KHz. PRICE £1

H/PHONE JUNCTION BO

H1012 (3-way-stereo) Enables change-over fr loudspeaker to head-phone listening. Also h a centre position for bo outputs PRICE £1

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227 Pages packed with inform tion on European Transistor Full specification including ou lines. Price # £2.95 ea

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Now complete Data book of series TTL (7400-74132). Coverin 13 main manufacturers in th U.S.A. and Europe, this boo gives full data as well as equiv lents. Price # £3.

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An up to the minute guide fo those interested in DX-ing. Co tains all the world's broadcaster on SW, MW and LW, as well a European FM/TV stations. Price # £3.

A full range of technical book available on request.

PO BOX 6 WARE HERTS

AL 60
50w. PEAK (25w. R.M.S.)

ONLY £3.95

● Max Heat Sink temp. 90°C. ● Frequency Response 20Hz to 100K Hz ● Distortion better than 0.1 at 1KHz. ● Supply voltage 15-50 volts. ● Thermal Feedback. ● Latest Design Improvements. ● Load – 3, 4, 5 or 16 ohms. ● Signal to noise ratio 80dB. ● Overall size 63mm x 105mm x 13mm.

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A. F. enthusiast.

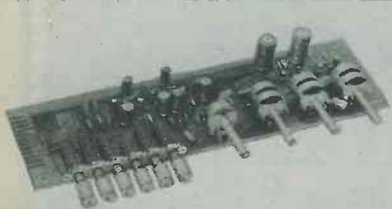
STABILISED POWER MODULE SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BMT80, the unit will provide outputs of up to 1.5 amps at 35 volts. Size: 63mm x 105mm x 30mm.

These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address Intercom Units, etc. Handbook available ≠ 10p

TRANSFORMER BMT80 £2.60

PRICE £3.00



STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques.

Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100 which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

PRICE £13.20

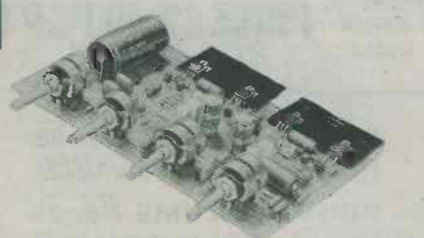
DE V.A.T.
25% TO ALL
ADD 8%
NO V.A.T.
p overseas
m order 75p.

MK 60 AUDIO KIT Comprising: 2 x AL60, 1 x SPM80, 1 x BTM80, 1 x PA100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets.

COMPLETE PRICE: £27.55 plus 45p postage

TEAK 60 AUDIO KIT Comprising: Teak veneered cabinet size 16¾" x 11½" x 3½", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets etc.

KIT PRICE: £9.20 plus 45p postage.



STEREO 30 COMPLETE AUDIO CHASSIS
7+7 WATTS R.M.S.

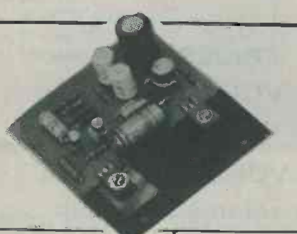
The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind, will produce a high quality audio unit suitable for use with a wide range of inputs, i.e. high quality ceramic pickup, stereo tuner, stereo tape desk, etc.

Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel, knobs, mains switch, fuse and fuse holder and universal mounting bracket, enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available.

Ideal for the beginner or advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty. Can be installed in 30 mins.

PRICE **£15.75** P & P 45p

TRANSFORMER **£2.45** P & P 45p TEAK CASE **£3.65** P & P 45p



AL10/AL20/AL30

The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S. The versatilty of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

AL10 £2.30 AL20 £2.65 AL30 £2.95

M.P.A. 30

Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new Bi-Pak M.P.A. 30 which is a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.

Used in the construction are 4 low noise, high gain, silicon transistors. It is provided with a standard DIN input socket for ease of connection.

Supplied with full, easy to follow instructions. Price £2.65

STORAGE/CARRY CASES

RECORD CASES
7 in. E.P. 18½ in. x 7 in. x 8 in. (50 records) *£2.48
12 in. L.P. 13¾ in. x 7¾ in. x 12¾ in. (50 records) *£3.30

CASSETTE CASES
Holds 15. 10 in. x 3¾ in. x 5 in. Lock and handle. *£1.50

8-Track CARTRIDGE CASES
Holds 14. 13 in. x 5 in. x 6 in. Lock and handle. *£2.20
Holds 24. 13⅝ in. x 8 in. x 5⅜ in. Lock and handle. *£3.20

CARTRIDGES

ACOS

GP91-1SC	200mV at 1.2cms/sec	£1.11
GP93-1	280mV at 1cm/sec	£1.43
GP96-1	100mV at 1 cm/sec	£2.31

TTC

J-2005	Crystal/Hi Output	97p
J-2010C	Crystal/Hi Output Compatible	£1.11
J-2006S	Stereo/Hi Output	£1.52
J-2105	Ceramic/Med Output	£1.81
J-2203	Magnetic 5mV/5cm/sec. including stylus	£4.78
J-22038	Replacement stylus for above	£2.88
AT-55	Audio-technica magnetic cartridge 4mV/5cm/sec.	£3.06

DYNAMIC MICROPHONES

TYPE B1223 200 ohms impedance. Complete with stand, on/off switch and 2.5mm and 3.5mm plugs. Suitable for cassette tape recorders. PRICE £1.67

JUST OUT!

STEREO FM TUNER

WRITE *NOW* FOR FULL DETAILS

WILMSLOW AUDIO

THE Firm for speakers!

SPEAKERS

Baker Group 25, 3, 8 or 15 ohm	£8.64
Baker Group 35, 3, 8 or 15 ohm	£10.25
Baker Group 50/12, 8 or 15 ohm	£14.00
Baker Deluxe 12", 8 or 15 ohm	£13.75
Baker Major 3, 8 or 15 ohm	£11.87
Baker Superb 8 or 15 ohm	£18.12
Baker Regent 8 or 15 ohm	£10.00
Baker Auditorium 12"	£16.25
Celestion PST8 (for Unilex)	£3.75
Celestion G12H 8 or 15 ohm	£15.00
Celestion G12M 8 or 15 ohm	£12.00
Celestion G15C 8 or 15 ohm	£24.00
Celestion G18C 8 or 15 ohm	£33.00
Celestion MF1000 8 or 15 ohm	£10.95
EMI 13 x 8, 150 d/cone, 8 ohm	£2.94
EMI 13 x 8 type 350, 8 or 15 ohm	£9.56
EMI 13 x 8 20 watt bass	£7.69
EMI 5" 14A/730 mid-range 8 ohm	£3.50
EMI 6½" 93850 4 or 8 ohm	£2.90
EMI 8 x 5, cer. mag. 8 ohm	£1.87
EMI 8 x 5, 10 watt, d/c roll/s 8 ohm	£3.44
EMI 10 x 6 93870 8 ohm	£2.69
EMI 2½" tweeter 8 ohm	.77
Elac 9 x 5, 59RM109 15 ohm, 59RM114 8 ohm	£3.64
Elac 6½" d/cone, roll surr. 8 ohm	£4.06
Elac 6½" d/cone 8 ohm	£3.12
Elac TW4 4" tweeter	£1.75
Elac 10" 10RM239 d/c 8 ohm	£3.12
Elac 8" 3 ohm	£2.87
Eagle Crossover 3, 8 or 16 ohm	£1.75
Eagle CT5 cone tweeter 8 ohm	£2.06
Eagle CT10 tweeter 8 or 16 ohm	£3.00
Eagle DT33 dome tweeter 8 ohm	£6.31
Eagle FF5 3 way crossover	£3.62
Eagle SN75 crossover with tw. control	£4.69
Eagle FF28 multicell, horn	£9.00
Eagle HT15 horn tw. 16 ohm	£4.40
Eagle HT21 horn tw. 8 ohm	£6.81
Eagle MHT10 horn tw. 8 ohm	£4.44
Eagle FR4 4" full range	£6.12
Eagle FR65 6½" full range	£9.62
Eagle FR8 8" full range	£12.31
Fane Pop 15 watt 12"	£5.25
Fane Pop 25T 30 watt 12"	£7.50
Fane Pop watt 12"	£12.00
Fane Pop 55 12" 60 watt	£13.95
Fane Pop 60 watt 15"	£14.75
Fane Pop 100 watt 18"	£25.95

SPEAKERS

Fane Crescendo 12A 8 or 15 ohm	£34.50
Fane Crescendo 12B 8 or 15 ohm	£36.50
Fane Crescendo 15, 8 or 15 ohm	£47.50
Fane Crescendo 18, 8 or 15 ohm	£62.95
Fane 910 horn	£14.95
Fane 920 horn	£33.95
Fane 152/12a 15" 15 ohm	£16.00
Fane 801T 8" d/cone roll surr.	£8.12
Fane 808T 8" d/cone	£3.44
Fane 807T 8" d/cone roll surr.	£5.75
Goodmans 8P 8 or 15 ohm	£5.50
Goodsmans 10P 8 or 15 ohm	£5.80
Goodmans 12P 8 or 15 ohm	£13.95
Goodmans 12P–D 8 or 15 ohm	£16.95
Goodmans 12P–G 8 or 15 ohm	£15.95
Goodman 12AX 100 watt 8 or 15 ohm	£36.50
Goodsmans 15AX 100 watt 8 or 15 ohm	£40.25
Goodmans 15P 8 or 15 ohm	£21.00
Goodmans 18P 8 or 15 ohm	£36.00
Goodmans Hifax 750	£16.00
Goodmans Axent 100 tweeter & crossover	£7.44
Goodmans Audiom 100, 8 or 15 ohm	£13.90
Goodmans Axiom 401, 8 or 15 ohm	£20.00
Goodsmans Twinaxiom 8" 8 or 15 ohm	£10.14
Goodsmans Twinaxiom 10" 8 or 15 ohm	£10.75
Gauss 12" full range 8 ohm	£69.50
Gauss 12" Bass 8 ohm	£69.50
Gauss 15" full range 8 ohm	£75.00
Gauss 15" Bass 8 ohm	£75.00
Gauss 18" full range 8 ohm	£80.00
Gauss 18" Bass 8 ohm	£80.00

All the above Gauss (American) speakers are fitted with 4¼" voice coils and can handle 200 watts RMS.

Kef T27	£6.06
Kef T15	£6.94
Kef B110	£8.37
Kef B200	£9.50
Kef B139	£16.50
Kef DN8	£2.31
Kef DN12	£5.75
Kef DN13	£3.87
Richard Allan CG8T 8" d/c roll rurr. 8 ohms	£7.37
STC 4001G super tweeter	£6.56
2½" 64 ohm, 70mm 8 ohm, 70mm 80 ohm	.77
2½" 75 ohm	.55
7" x 4" 3, 8 or 15 ohm	£1.63
8" x 5" 3, 8 or 15 ohm	£1.75
10" x 6" 6, 8 or 15 ohm	£2.69

SPEAKER KITS (Carr. 75p each. £1.50 pair)

Baker Major Module 3, 8 or 15 ohm	each	£13.44
Goodmans Mezzo Twinkit	pair	£47.19
Goodsmans DIN 20 4 ohm	each	£13.44
Helme XLK25	pair	£25.44
Helme XLK30	pair	£17.19
Helme XLK50	pair	£46.25
Kefkit 1	pair	£48.44
Kefkit 3	each	£42.50
Peerless 3–15 (3 sp. system	each	£17.19
Peerless 20/2	each	£17.44
Peerless 30/2	each	£24.38
Peerless 20/3	each	£26.56
Peerless 50/4	each	£40.50
Richard Allan Twinkit	each	£10.37
Richard Allan Triple 8	each	£15.94
Richard Allan Triple	each	£23.12
Richard Allan Super Triple	each	£27.50
Wharfedale Linton 2 kit	pair	£23.12
Wharfedale Glendale 3 kit	pair	£40.61
Wharfedale Dovedale 3 kit	pair	£63.12

PA/DISCO AMPLIFIERS (Carr. and ins. £1)

Baker Major 100 watt	£57.25
Linear 30/40	£30.00
Linear 40/60	£35.00
Linear 80/100	£58.95
Linear 100 watt slave	£44.00
Eagle PRO A120, 120 watts RMS	£129.00
Eagle PRO A65, 65 watts RMS	£98.50
Eagle PRO A35, 35 watts RMS	£77.00
Eagles TPA40 mains/12v mobile	£50.00
Eagle HHS 36 watts. mobile 12v.	£37.50
Eagle TPA20 paging amplifier	£45.00
Eagle RA859 Reverb (p. & p. 75p)	£18.25
Eagle RA856 Reverb (p. & p. 75p)	£12.50

MICROPHO[illegible] (p. & p. 50p)

Shure 515 SB Low Impedance	£17.31
Shure 515 SA High Impedance	£18.25
Shure 545 Dual Impedance	£34.69
Shure 588 SB Low Impedance	£23.12
Shure 588 SA High Impedance	£23.75

FREE with loudspeaker orders over £7 – "HiFi Loudspeaker Enclosures" book

All items guaranteed new and perfect

Prompt despatch

Carriage: 38p per speaker 12" and up 50p each, 25p per tweeter, crossover or 2½"/70mm speaker kits 75p each (£1.50 pair)

Including VAT – 25% on Hi Fi and 8% on PRO and PA.

Send stamp for free booklet 'Choosing a speaker'

Big discounts on Grundig, ITT, Koyo, etc. Send stamp for list

WILMSLOW AUDIO

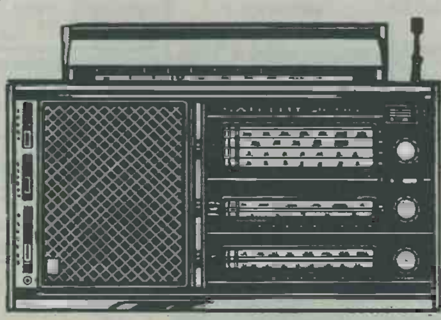
DEPT RC

LOUDSPEAKERS: SWAN WORKS BANK SQUARE, WILMSLOW, CHESHIRE

AMPLIFIERS, RADIO ETC. 10 SWAN ST., WILMSLOW, CHESHIRE

The Ultimate Radio!

GRUNDIG SATELLIT 2000



You've got your yacht, private aircraft, Rolls Comiche? — then all you need for a full set of status symbols is this latest model Grundig Satellit, Germany's top radio! Radio performance, appearance and sound quality are all superb. VHF/FM, MW, LW 10 SW bands plus bandspread, 27 transistors and 22 diodes, Battery/Mains (110/240v.), 2 speakers, 57" telescopic aerial.

Our Price £149.95 inc. VAT, carr. & ins.

Big discounts on Grundig, ITT, Koyo, etc. Send stamp for list.

WILMSLOW AUDIO, 10 SWAN STREET, WILMSLOW, CHESHIRE

COMPONENTS

HOBBYIST - PROFESSIONAL - DOMESTIC - SURPLUS - INDUSTRIAL
JUST A FEW OF OUR BARGAINS ARE LISTED BELOW - SEND STAMPED ADDRESSED ENVELOPE FOR A QUOTE ON OTHER REQUIREMENTS. PAY US A VISIT. OVER 90% OF STOCK BELOW QUANTITY WHOLESALE PRICE. RETURN POSTAL SERVICE UNLESS CHEQUE.

Goods sent at customer's risk, unless sufficient payment for insurance included (2p per £1 Min 5p) U.K. only.

VALVE BASES
Printed circuit B9A – B7G 2p
Chassis B7 – B9G – B7G 4p
Shrouded chassis B7G – B9A .. 6p
B8A – B9A chassis – B12A tube .. 6p

TO3 or TO66
Mica Washer .. 2p
18 volt 4 amp charger, bridge rectifier 50p
GC10/4B £3.00

Speaker, 6″ x 4″, 5 ohm, ideal for car radio etc. £1

Telescopic aerial
Closed $9\frac{1}{2}$″, open $38\frac{1}{2}$″ Fitted right angle TV plug, 50p

TAG STRIP – 6 way 3p
9 way 5p Single 1p

VHF Radio Tuner Head
Takes ECC 85 80p

$1\frac{1}{4}$ glass fuses— 250 m/a or 3 amp (box of 12) 18p
3″ tape spools 8p   1 Terryclips chrome finish 4p
Brand new Boxed 6K7G 25p   1.5m, log edge pot .. 8p
PVC or metal clip on M.E.S. bulb holder 5p
Geared Knob, Inner to Outer Ratio 8:1 .. .. .. 60p
Bulgin, 5mm Jack plug and switched socket (pair) 30p
12 volt solenoid and plunger 30p
250 RPM 50 c/s locked frequency miniature mains motor .. 50p
200 OHM coil, $2\frac{1}{4}$″ long, hollow centre 10p
Belling Lee white plastic surface coax outlet Box 30p
R.S. 12 way standard plug and shell 20p

SWITCHES

Pole	Way	Type	
4	2	Sub. Min. Slide	18p
6	2	Slide	20p
4	2	Lever Slide	15p
2	2	Slide	10p
1	3	+ off Sub. min. edge	10p
1	3	13 amp small rotary	12p
2	2	Locking with 2 to 3 keys	£1.50
2	1	2 Amp 250V A.C. rotary	24p
1	2	Toggle	10p

Wafer Rotary, all types 30p
S.P.S.T. 10 amp 240v. white rocker switch with neon. 1″ square flush panel fitting 30p

RESISTORS
$\frac{1}{8}$–$\frac{1}{4}$–$\frac{1}{2}$ watt .. 1p
1 watt 2p
Up to 5 watt wire 10p
10 watt wire wound 12p
15 watt 14p

Philips transformer, safety fused. In 200-220-240v. Out 240v 60ma + 6.3v 1a approx 2″ x $2\frac{1}{4}$″ x $2\frac{1}{2}$″ £1.50

PIANOKEY SWITCH UNIT
5 lever, interlocking 2 pole mains + 3 pole 2 way + 3 of 6 pole 2 way 15p

POTS
Log or Lin carbon 13p
Switched 25p
Dual Pots 38p
Dual & switch 50p
Lin wirewound 25p
Slider Pot 25p
Dual Slider 35p

COMPUTER AND AUDIO BOARDS
VARYING PANELS WITH ZENER, GOLD BOND, SILICON, GERMANIUM, LOW AND HIGH POWER TRANSISTORS AND DIODES, HI STAB RESISTORS, CAPACITORS, ELECTROLYTICS, TRIMPOTS, POT CORES, CHOKES ETC.
3lb for 85p + 60p post and packing
7lb for £1.75 + 80p post and packing

THERMISTORS
VA1008, VA1034, VA1039, VA1040, VA1055, VA1066, VA1082, VA1100 } 10p
VA1077, VA1005, VA1026 } 15p

Skeleton Presets
Slider, horizontal or vertical standard or submin. 5p

Clear Plastic Boxes
For component storage or projects, sliding lid. $1\frac{3}{4}$″ x $1\frac{1}{2}$″ x 1″ 10p

KNOBS
SILVER METAL PUSH ON WITH POINTER, OR WHITE PLASTIC, GRUB SCREW WITH POINTER AND SILVER CENTRE 8p EACH.
1″ DIAM. WITH $1\frac{1}{2}$″ SKIRT SPUN ALUMINIUM GRUB SCREW FIXING, $\frac{1}{4}$″ 30p EACH.

RELAYS
12 volt S.P.C.O octal mercury wetted high speed 75p
P.O. 3000 type, 1,000 OHM coil, 4 pole c/o 60p
12 volt d.p.c.o. heavy duty octal 60p

ZM1162A INDICATOR TUBE
0-9 Inline End View. Rectangular Envelope 170V 2·5M/A £1.50

RESETTABLE COUNTER
English Numbering Machines LTD.
MODEL 4436-159-989
6-14 volt, 6 digit, illuminated, fully enclosed. £2.50

Boxed GEC KT88 valve £2

Ferric Chloride, Anhydrous mil. spec. 1lb. bag 50p

JAP 4 gang miniature sealed tuning condensers 25p

ELECTROLYTICS MFD/VOLT. Many others in stock

MFD	Up to 10V	25V	50V	70–75V	100V	200–250V	300–350V	450–500V
10	4p	5p	6p	8p	8p	12p	16p	20p
25	4p	5p	6p	8p	8p	15p	18p	20p
50	4p	5p	6p	9p	13p	18p	25p	—
100	5p	6p	10p	12p	19p	20p	—	—
250	9p	10p	11p	17p	28p	—	85p	£1
500	10p	11p	17p	24p	45p	—	—	—
1000	13p	17p	40p	75p	—	£1.50	—	—
2000	23p	37p	45p	—	—	—	—	—

As total number of values are too numerous to list, use this price guide to work out cost of your actual value requirements, i.e. 2MFD, 30V would be 5p, or 330MFD, 50V would be 14p, etc. etc.
8/20, 10/20, 12/20 **Tubular tantalum 15p each**
16–32/275, 32–32/275, 100–100/150, 100–100/275 50–50/300 .. .. **20p each**
50/50–385 .. .. .. **30p**
12,000/12, 32–32–50/300, 700/200 100–100–100–150–150/320 .. .. **50p each**
20–20–20/350 .. .. **40p each**

INDICATORS
Bulgin D676 red, takes M.E.S. bulb 20p
12 volt red, small pushfit 20p
Mains neon, red, pushfit 20p

CAPACITOR GUIDE – maximum 500V
Up to .01 ceramic **2p.** Up to .01 poly **3p.** Up to 1000PF silver mica **5p.** 1,200PF up to .01 silver mica **10p.** .013 up to .25 poly etc. **4p.** .27 up to .68 poly etc. **6p**
Over 500 volt order from above guide and few others listed below.
6p. .1/600: **10p.** .01/1000, 1/350, 8/20, .1/900, .22/900, 4/16. .25/250 AC (600vDC) .1/1500 **40p.** 5/150, 9/275AC, 10/150, 15/150, 40/150.

TRIMMERS, 20p each
100PF Ceramic, 30PF Beehive, 12PF PTFE 2500PF 750 volt, 33PF MIN. AIR SPACED 5PF, MIN. AIR SPACED, 50PF CERAMIC.

CONNECTOR STRIP
Belling Lee L1469, 4 way polythene. **3p each**

Strong grey plastic box same design as die cast ali $4\frac{3}{8}$″ x $2\frac{3}{8}$″ x $1\frac{1}{4}$″ 40p

1″ or $1\frac{3}{8}$″ or $\frac{3}{4}$″ **CAN CLIPS** .. 2p

MAINS DROPPERS
36+79 ohm 15p
66+66+158 ohm, 66+66+137 ohm
17+14+6 ohm, 266+14+193 ohm 20p
50+40+1k5 ohm
285+575+148+35 ohm } 30p
25+35+97+59+30 ohm

$5\frac{1}{4}$″ x $2\frac{3}{4}$″ Speaker, ex-equipment 3 ohm 30p
2 Amp Suppression Choke 5p
3 x $2\frac{1}{2}$ x $\frac{1}{16}$″ } **PAXOLINE** .. 2p
$4\frac{3}{8}$ x $\frac{1}{2}$ x $\frac{1}{8}$″, ... 2 for 1p
220K & 100 ohm 3 watt resistors .. 4p
VALVE RETAINER CLIP, adjustable 2p

OUTPUT TRANSFORMERS
Sub-miniature Transistor Type .. 25p
Valve type, centre tapped or straight 40p

THE RADIO SHACK

61 ST. JOHNS HILL, BATTERSEA, LONDON S.W.11
Open 9.30 a.m. till 8 p.m. Monday to Saturday also Sunday afternoons   Phone 01-223 5016

3 pin din to open end, $1\frac{1}{2}$yd twin screened lead 35p
Whiteley Stentorian 3 ohm constant impedance volume control way below trade at 80p
Drive Cord 1p per yd.

SEMICONDUCTORS

Full spec. marked by Mullard, etc. Many other types in stock

AC107	12p	BC179B	11p	BF180/1/2/3	20p
AC127/128/176	10p	BC184C	9p	BF184/5	15p
ACY28	18p	BC186/7	13p	BF194/5/6/7	5p
AD149	40p	BC213L/214B	9p	BF194A/195C	12p
AD161/2 matched pr.	69p	BC261B	10p	BF200	10p
AF116/7	12p	BC327	15p	BF258	28p
AF124/6/7	20p	BC328	10p	BF262/3	23p
AF139/178	30p	BC337/8	14p	BF336	25p
AF180/1	30p	BC547/558A	7p	BFS28 Dual Mosfet	92p
AF239	20p	BC548	9p	BFW10/11 F.E.T.	26p
ASY27/73	25p	BCX32/36	12p	BFW30	£1.35
BC107A or B	9p	BCY40	60p	BFW57/58	20p
BC107/8/9	7p	BCY70/1/2	9p	BFX12	20p
BC108A/B/109B/C	10p	BD112/3/5/6	40p	BFX29/30/84/88	16p
BC147/8/9	6p	BD131/2/3/5	30p	BFY50/1/2	12p
BC147A/B	8p	BD201/2/3/4	£1.00	BFY90	50p
BC148A/B, 9B/C/S	8p	BD232/4/5	46p	BR101 } Programmable	30p
BC157/8/9	6p	BDX77	£1.40	BRY39 } Unj Junction	31p
BC158A/B	11p	BF115	12p	BRY56 }	34p
BC159B/C, 157A	11p	BF167/173	15p	BSV64	40p
BC178A/B	12p	BF178/9	20p	BSV79/80 F.E.T.s	£1

BSV81 Mosfet	90p
BSX20/21	13p
BSY40	28p
BU105-01	93p
CV7042 (OC41 OC44, ASY63)	7p
GET111	40p
OC35	$32\frac{1}{2}$p
ON222	30p
TIP30	52p
TIP3055	50p
TIS88A FET	23p
ZTX300	8p
2N393/MA393	30p
2N706	10p
2N929	14p
2N987	35p
2N1507/2219	18p
2N2401/2412/2483	25p
2N2904/5/6/7	13p
2N2907A	15p
2N3053	13p
2N3054/3055 (or equiv)	35p
2N3704	10p
2N3133	18p
2N4037	35p
2N5036	60p
2SA141/2/360	31p
2SB135/6/457	20p
40250	60p

OTHER DIODES

IN916	6p
IN4148	2.5p
BA145/148	12p
Centercel	10p
BZY61	10p
BB103/110 Varicap	18p
BA182	24p
OA5/7/10	10p
BZY88 Up to 33 volt	6p
BZX61 11 volt	16p
BR100 Diac.	19p

INTEGRATED CIRCUITS

741 8 pin d.i.l. op. Amp	22p
TAD100 AMRF	£1.00
CA3001 R. F. Amp	£1.00
TAA300 1 wt Amp	£1.25
NE555v Timer	42p
TAA550 Y or G	31p
TAA263 Amp	65p
ZN414 RX	95p
7483	80p
7400/2/10/20/30	13p
7404	14p
7414	60p
7438/74/86	27p
LM300, 2-20 volt	50p
74154	£1.50

BRIDGE RECTIFIERS

Amp	Volt			Amp	Volt		
½	1,600	BYX10	30p	2	30	LT120 type	30p
1	140	OSH01-200	30p	0.6	110	EC433	15p
1.4	42	BY164	35p	5	400	Texas	75p

RECTIFIERS

	Amp	Volt	
IN4004	1	400 }	4p
IN4005	1	600 }	
IN4006	1	800 }	
IN4007	1	1,000 }	
BY103	1	1,500	15p
SR100	1.5	100	7p
SR400	1.5	400	8p
REC53A	1.5	1,250	14p
LT102	2	30	10p
BYX38-600	2.5	600	40p
BYX38-300R	2.5	300	36p
BYX38-900	2.5	900	45p
BYX38-1200	2.5	1,200	50p
BYX49-600	2.5	600	34p
BYX49-300	2.5	300	26p
BYX49-900	2.5	900	40p
BYX49-1200	2.5	1,200	52p
BYX48-300	6	300	40p
BYX48-600	6	600	50p
BYX48-900	6	900	60p
BYX48-1200	6	1,200	80p
BYX72-150R	10	150	35p
BYX72-300R	10	300	45p
BYX72-500R	10	500	55p
BYX42-300	10	300	30p
BYX42-600	10	600	65p
BYX42-900	10	900	80p
BYX42-1200	10	1,200	95p
BYX46-300*	15	300	£1.00
BYX46-400*	15	400	£1.50
BYX46-500*	15	500	£1.75
BYX46-600*	15	600	£2.00
BYX20-200	25	200	60p
BYX52-300	40	300	£1.75
BYX52-1200	40	1,200	£2.50

*Avalanche type

TRIACS

Amp	Volt		
6	400	Plastic	74p
25	900	BTX94-900	£4.00
25	1200	BTX94-1200	£6.00

12-0-12 50M/A Min. Txfmr. 90p

Pair of LA2407 Ferrox cores with adjuster 25p

Chrome Car Radio facia 15p
Rubber Car Radio gasket 5p

DLI Pal Delayline 50p

Relay socket 10p
Take miniature 2PCO relay

B7G or B9A valve can 2p

0-30, or 0-15, black pvc, 360° dial, silver digits, self adhesive, $4\frac{1}{2}$" dia. 10p

OPTO ELECTRONICS

ORP12	44p
BPX40	65p
BPX42	£1.00
BPY10 (VOLTIAC)	£1.00
BPY68 } BPY69 } BPY77 } Diodes	£1.00

Photo transistor

BPX29	£1.00
OCP71	30p

BIG L.E.D. 0.2" 2v 50m/A max.
RED 14p
ORANGE } GREEN } YELLOW } 16p

PHOTO SILICON CONTROLLED SWITCH BPX66 PNPN 10 amp £1.00

THYRISTORS

Amp	Volt		
1	240	BTX18-200	50p
1	400	BTX18-300	65p
1	240	BTX30-200	40p
6.5	500	BT102-500R	75p
15	500	BT107	£1.00
6.5	500	BT101-500R	90p
6.5	500	BT109-500R	75p
20	600	BTW92-600RM	£3.00
15	800	BTX95-800R Pulse Modulated	£8.00
30	1000	28T10 (Less Nut)	£3.00

.3" red 7 segment L.E.D. 14 D.I.L. 0-9 + D.P. display 1.9v, 10m/a segment 65p

CQY11B L.E.D.
Infra red transmitter £1
One fifth of trade

Wire ended glass neons 5p

Plastic, Transistor or Diode Holder 1p
Transistor or Diode Pad 1p
Holdersorpads 50pper100

PAPER BLOCK CONDENSER

0.25MFD	800 volt	30p
1MFD	250 volt	15p
2MFD	250 volt	20p
10MFD	500 volt	80p
4MFD	250 volt	20p
15MFD	150 volt	50p

METAL CHASSIS SOCKETS

Car Aerial }
Coax }
5 or 6 pin 240° din } 9p
Speaker din switched }
3.5mm Switched Socket }

SOLDER

Multicore - $2\frac{1}{2}$p foot

ENAM. COPPER WIRE

SWG.	PER YD.
18	3p
20-24	2p
26-42	1p

GARRARD

GCS23T Crystal Stereo Cartridge £1.00

HANDLES

Rigid light blue nylon $6\frac{1}{4}$" with secret fitting screws 5p

14 D.I.L. socket, gold plated contacts, NOT cheap type 13p

Miniature Axial Lead Ferrite Choke formers 2p

DEE PLUG

McMurdo DA15P 15 way chassis plug 10p

Fairway 18009 Coax. socket 3p

TIE CLIPS

Nylon self locking 7" or $3\frac{1}{2}$" 2p

CINCH 150

12 way edge socket 10p

1lb Mixed nuts, bolts, washers etc. 35p

Philips Iron Thermostat 15p
Bulgin 2-pin flat plug and socket 10p
McMurdo PP108 8 way edge plug 10p

TO3 HEATSINK

Europlec HP1 TO3B individual 'curly' power transistor type. Ready drilled 20p

Tested unmarked, or marked ample lead ex new equipment

ACY17-20	8p	OC71/2	5p
ASZ20	8p	OC200-5	10p
ASZ21	15p	TIC44	24p
BC186	11p	2G240	2-50
BCY30-34	10p	2G302	6p
BCY70/1/2	8p	2G401	10p
BF115	10p	2N711	25p
BY127	7p	2N2926	7p
BZY88 series	5p	2N598/9	6p
HG1005	2p	2N1091	8p
HG5009	2p	2N1302	8p
HG5079	2p	2N1907	2-50
L78/9	2p	Germ. diode	1p
M3	10p	GET120 (AC128 in 1" sq. heat sink)	20p
OA81	2p		
OA47	2p		
OA200-2	3p	GET872	12p
OC23	20p	2S3230	30p

8 way Cinch standard 0.15 pitch edge socket 20p

U.E.C.L. 10 way pin connector 2B6000 OA1P10 10p

U.E.C.L. 20 way pin connector 2A60000A1P20 20p

U.E.C.L. 10 way pin socket 2B606001R10 10p

U.E.C.L. 20 way pin socketB260800A1R20 20p

BELLING LEE L1354 TV Aerial diplexer 10p

Philips electronic engineer kits add on series E1004 £1.00 each

RG4-1250 Mercury vapour rectifier £5.00

SMALL ORDERS, ENCLOSE SUITABLE STAMPED ADDRESSED ENVELOPE
LARGE ORDERS, ADD SUFFICIENT FOR POSTAGE, INSURANCE, ETC.
TOTAL GOODS PLUS CARRIAGE, ADD V.A.T.

MAIL ORDER CUSTOMERS ONLY ADD 8% V.A.T.

DIRECT SUPPLY SERVICE TO READERS . . .

TOWERS INTERNATIONAL TRANSISTOR SELECTOR

This is dead!

If it takes you longer than 1 minute to find out all about these transistors then you need a copy of TOWER'S INTERNATIONAL TRANSISTOR SELECTOR. Its one of the most useful working books you will be offered this year. And probably the cheapest!

Would this replace it?

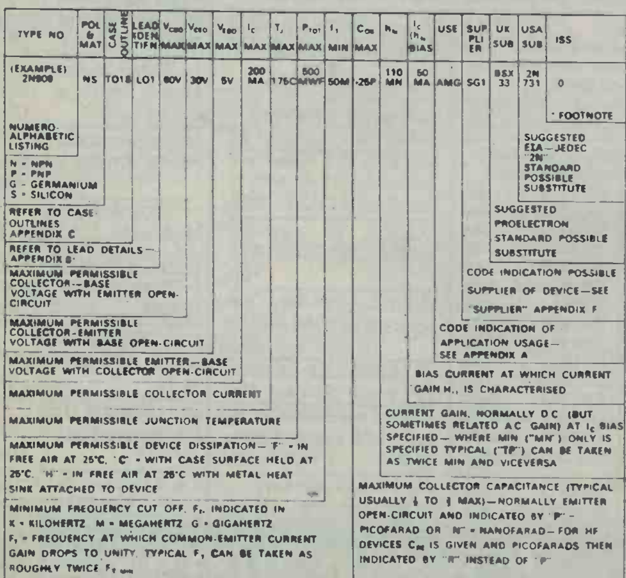
In it you will find a really international selection of 10,000 transistor types – British, Continental European, American and Japanese. And we think that they will solve 90% of your transistor enquiries.

Current and widely used obsolete types were carefully selected and arranged in Numero-Alphabetical order by an author who was uniquely qualified to do the job. With his compendium, all you need to know is the type number and you can learn all about a transistor's specification; who made it and where to contact them; or what to use to replace it.

Look at the entry for 2N909

TRANSISTOR NUMBER	PM OA LT	PACK-AGE	LEAD INFO	VCB MAX	VCE MAX	VEB MAX	I C MAX	T J MAX	P TOT	F T MIN	C OB MAX	H FE	H FE BIAS	USE	MFR	EURO EQVT	USA EQVT	ISS
2N909	NS	TO18	LO1	60V	30V	5V	200MA	175C	500MWF	50M	25P	110MN	50MA	AMG	SGI	BSX 33	2N731	0

This is what you will learn from it



*ISS COLUMN INDICATES ISSUE NO. OF DATA LINE ENTRY

Tower's International Transistor Selector

by T. D. TOWERS
MBE, MA, BSc, C Eng, MIERE

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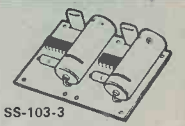

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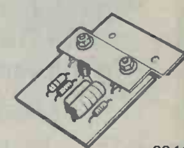

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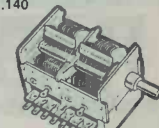

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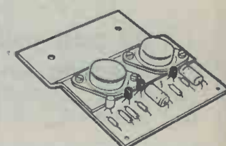

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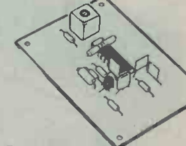

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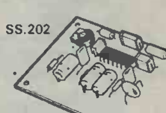

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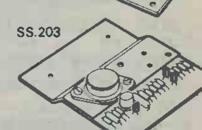

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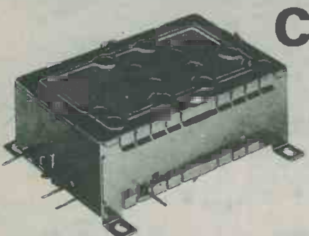

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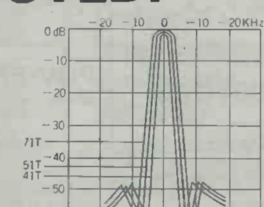

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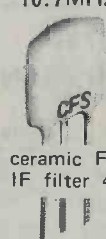

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RADIO & ELECTRONICS CONSTRUCTOR

SEPTEMBER 1975
Volume 29 No. 2

Published Monthly (1st of Month)
First Published 1947

Incorporating The Radio Amateur

Editorial and Advertising Offices
57 MAIDA VALE LONDON W9 1SN

Telephone 01-286 6141
Telegrams Databux, London

Annual Subscription: £4.00 (U.S.A. and Canada $10.00) including postage. Remittances should be made payable to "Data Publications Ltd". Overseas readers please pay by cheque or International Money Order.

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Production.—Web Offset.

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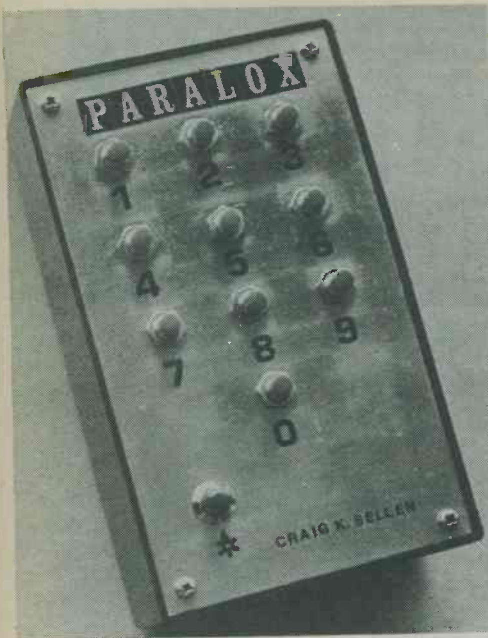
Published in Great Britain by the Proprietors and Publishers, Data Publications Ltd, 57 Maida Vale, London, W9 1SN

The *Radio & Electronics Constructor* is printed by Carlisle Web Offset.

OCTOBER ISSUE WILL BE PUBLISHED ON 1st OCTOBER



The author's prototype push-button unit. He has coined the term 'Paralox' to identify the system.

PARALLEL S.C.R. COMBINATION LOCK

By Craig K. Sellen

An ingenious electronic lock which incorporates a 555 timer and four silicon controlled rectifiers, or thyristors, and which can only be opened by pressing five buttons in correct sequence.

THIS ELECTRONIC LOCK WILL OPEN ONLY AFTER A correct pre-set combination of operations involving five push-buttons has been carried out. A master button must first be pressed, and this actuates a 15 second timing period in which the remaining four buttons must be pressed in the correct order. There are a further five buttons in the lock which, if pressed, automatically cancel any circuit which may have been completed by the last four buttons of the correct sequence.

555 TIMER

As may be seen from the circuit of Fig. 1, the heart of the combination lock is a timer i.c. type 555. The master push-button is S1. When this is pressed the timer is triggered and C2 commences to charge up to the positive 12 volt supply via R3. At the same time, the output at pin 3 goes high. When C2 has charged to ⅔ of the supply voltage the timing period comes to an end, whereupon C2 is rapidly discharged and the output at pin 3 goes low again. Thus, if S1 is pressed and no other push-buttons are touched, an output of slightly less than 12 volts positive appears at pin 3 for the length of the timing period. With the values shown for C2 and R3, this period is of the order of 15 seconds.

The 555 output is connected to the base of TR1, with the result that a positive supply voltage is available at the emitter of this transistor, during the timing period, for the thyristors TH1 to TH4. It is next necessary to press S2, whereupon a triggering current flows through the gate and cathode of TH1, and then through R5, allowing TH1 to become conductive. TH1 remains in this state after S2 is released. A positive voltage is now available at the cathode of TH1, with the result that it becomes possible to turn on TH2 by pressing S3. The cathode of TH2 also becomes positive, and it is possible to turn on TH3, in turn, by closing S4. If, finally, S5 is pressed, TH4 is made conductive and causes a relatively high base current to flow in power transistor TR2. The collector current of this transistor then energises the solenoid, which removes the bolt securing the protected area.

As can be seen, it is necessary to first press S1 to set off the timer, and then press S2, S3, S4 and S5 in that order to open the lock. Also, these four buttons must all be pressed within the 15 second timing period. A pilot lamp, PL1, is employed to indicate when the correct sequence of push-button operations has been carried out. Diode D1 is included in circuit merely to protect TR2 from high back-e.m.f. voltages from the solenoid coil when the latter releases.

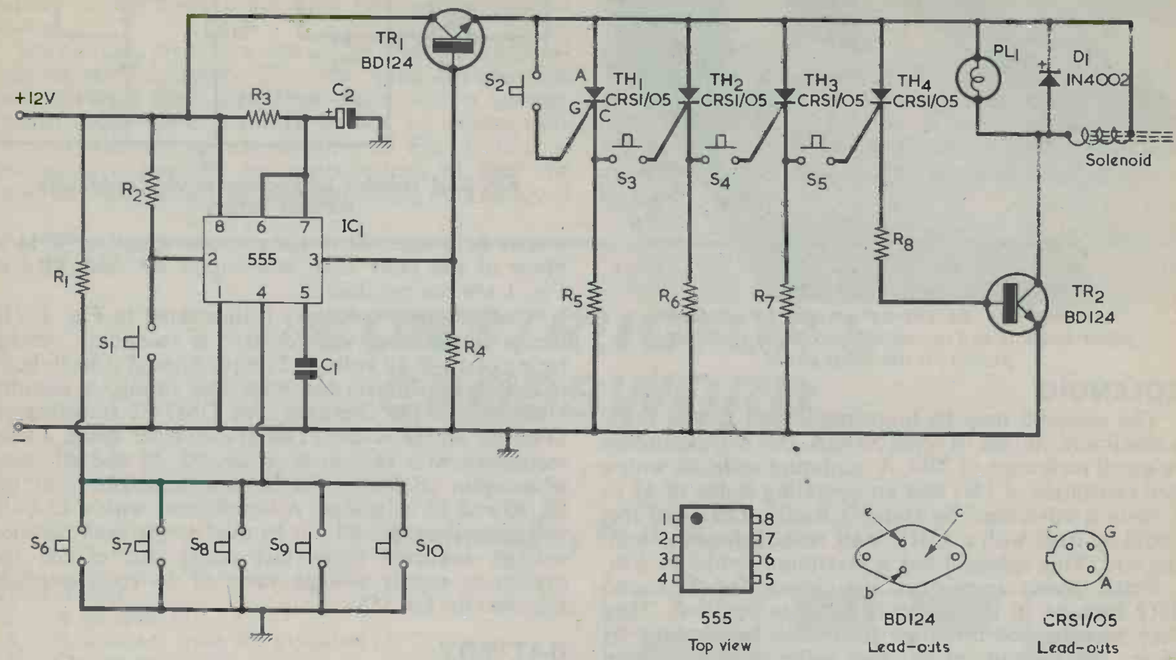


Fig. 1. The circuit of the electronic lock. S1 to S5 have to be closed successively to operate the solenoid

There are a further five push-buttons, S6 to S10, whose function is to cancel any correct push-button sequences which may already be set up. If any of these last five push-buttons is pressed the timer is reset, causing C2 to be discharged and the output at pin 3 to go low. Any thyristors which have been made conductive are therefore automatically turned off. The timer will start another 15 second timing period when the cancelling push-button is released, but it will still be necessary to find the correct sequence in S2 to S5, without inadvertently pressing any button in the S6 to S10 group.

COMPONENTS

Resistors
(All ½ watt 10%)
R1 3.9kΩ
R2 3.9kΩ
R3 1MΩ
R4 6.8kΩ
R5 680Ω
R6 680Ω
R7 680Ω
R8 560Ω
R9 see text

Capacitors
C1 0.01μF
C2 10μF electrolytic, 16 V. Wkg.
C3 1,000μF electrolytic, 16 V. Wkg.

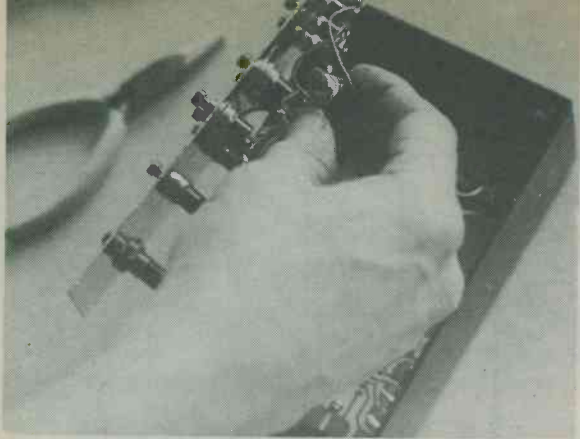
Transformer
T1 Mains transformer, secondary 10–0–10V at 2A

Semiconductors
IC1 555
TR1 BD124
TR2 BD124
TH1–TH4 CRS1/05
D1 1N4002
D2–D4 silicon rectifiers, 50 p.i.v. 2A

Lamp
PL1 pilot lamp, 12V 0.1A

Switches
S1–S10 push-buttons, press to make
S11 s.p.s.t., toggle

Miscellaneous
Solenoid (see text)
Pilot lamp holder



The code can be altered at will by removing push-buttons and re-positioning them at different points on the front panel

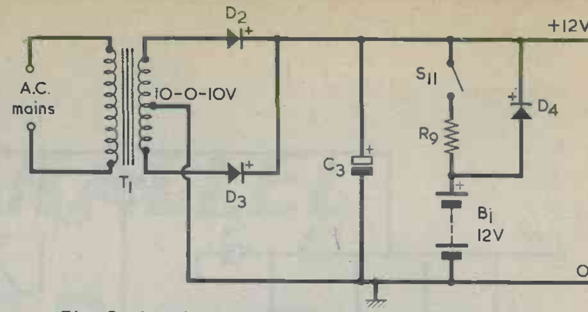


Fig. 3. A suitable power supply with automatic standby battery

SOLENOID

The solenoid may be home-made and should draw a maximum current of some 500mA, this corresponding to a coil resistance of 24Ω. A miniature solenoid with a coil resistance of 15Ω and an operating range of 4½ to 9 volts is advertised by Henry's Radio, Ltd., and this could be used with a 15Ω 3 watt resistor in series with the coil. This solenoid has a maximum stroke of ⅜ in.

Small power transistors are chosen for TR1 and TR2 because of the collector currents involved. They may be mounted on small heat sinks of about 1 by 1½ in., although in practice they suffer little dissipation and should run quite cool.

If the solenoid requires a different operating voltage than the 12 volts available in the present circuit, or a higher current than that just mentioned, R8 and TR2 may be replaced by a relay, as shown in Fig. 2. The relay contacts now complete the solenoid circuit. The relay should be capable of energising reliably at a little less than 12 volts and its coil resistance should be between 700 and 200Ω. If a 12 volt solenoid whose coil falls in the same resistance range is to be employed, it may be connected in the cathode circuit of TH4 in place of the relay coil, whereupon R8 and TR2 of Fig. 1 are not required.

A suitable power supply is illustrated in Fig. 3. The mains transformer should have a secondary voltage rating of 10–0–10 volts at 2 amps. Should it be difficult to obtain a transformer with this rating, a possible alternative is the Osmabet type OMT4/2 transformer, listed by Home Radio. This transformer has a 2 amp secondary with taps at 0, 5, 20, 30, 40 and 60 volts, whereupon 10–0–10 volts become available from the 20, 30 and 40 volts taps. A transformer with a 12–0–12 volt secondary should not be used as the peak rectified voltage available from this could just exceed the maximum supply voltage value of 16 volts which is specified for the 555.

BATTERY

B1 is a 12 volt re-chargeable battery which comes into operation in the event of mains failure. Normally, rectifier D4 is reverse biased, but in the event of a power cut the voltage at the positive rail falls below 12 volts and D4 conducts, coupling the positive terminal of the battery to the positive rail.

Resistor R9 and switch S11 are optional. When S11 is closed a small trickle charge current flows into the battery via R9. The value of this resistor depends upon the type of battery employed, and care should be

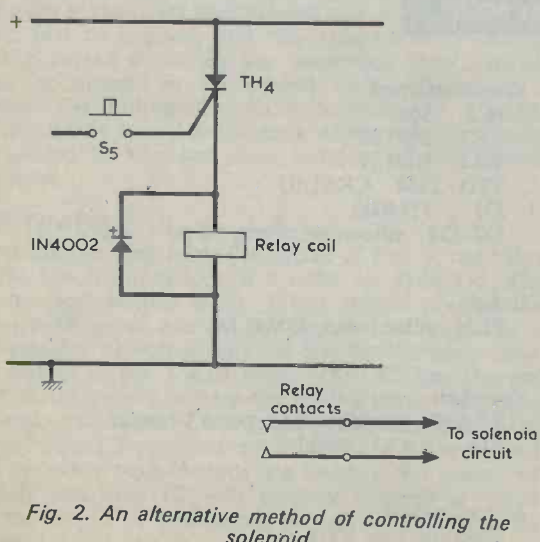
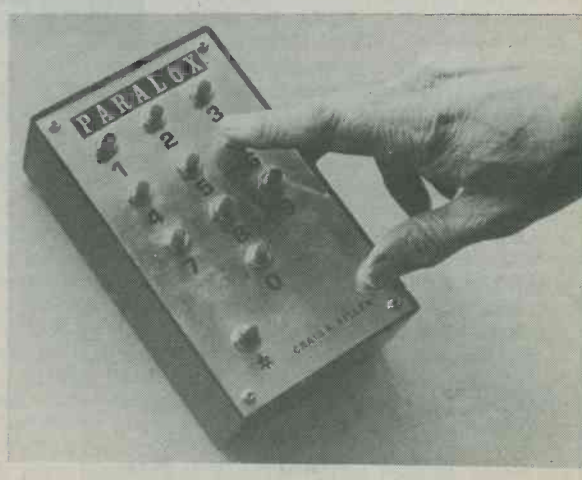


Fig. 2. An alternative method of controlling the solenoid



The push-button unit in use. The lock will not release unless the buttons are pressed in the correct sequence taken to ensure that there is no risk of over-charging. The charging current will, of course, cease if the battery voltage rises to the same level as the rectified voltage.

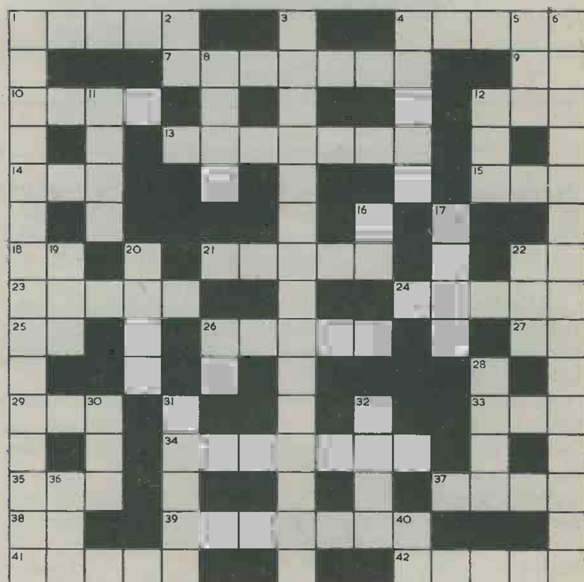
The author's prototype unit can be seen in the accompanying photographs. The ten push-buttons are mounted on a thick aluminium panel, with a number against each. These numbers do not, of course, correspond with the switch numbers in Fig. 1. If it is desired to re-position any push-buttons to alter the code, they may have their bush-mounting nuts removed and then be fitted in alternative holes. This process is simpler than that of unsoldering and re-soldering the connecting wires to the push-buttons. ■

EDITOR'S NOTE

The author is resident in America, and his original circuit incorporated sensitive thyristors which are not easily obtainable in the U.K. In consequence, we have slightly modified the thyristor section of the circuit to allow the use of more readily available components. – Editor.

CONSTRUCTOR'S CROSSWORD

Compiled by D. P. Newton



Clues Across

1. A bit testy (5)
4. A constant from the alphabet (5)
7. Charge for it (7)
9. You can hear it before noon (2)
10. Definitely not imaginary (4)
12. I'm perhaps Maxwell's demon (3)
13. Do they rub the tapes? (7)
14. Just a mho while I reciprocate (3) (Anag.)
15. Ron had to turn about at this gate (3) (Anag.)
18. Neither he nor she (2)
21. Old King Coil (5)
22. A short, transistorised dope (2) (Chemical symbol)
23. What power, James! (5)
24. A mathematician with a strong magnetic field (5)
25. A small part of an inductor (2)
26. Crops up with painful frequency in radio (5)
27. Land – (2)
29. What a shocking creature! (3)
33. Anger (3)
34. A.C. measure at the bank (7)
35. A bit more than the usual voltage (3)
37. A short 1–2 (4)
38. Stitch in the Stationery Office? (2)
39. Tune in for the trains (7)
41. Gone to make a bridge now that Wheat is no more (5)
42. Another slippery oldie mixed up (5) (Anag.)

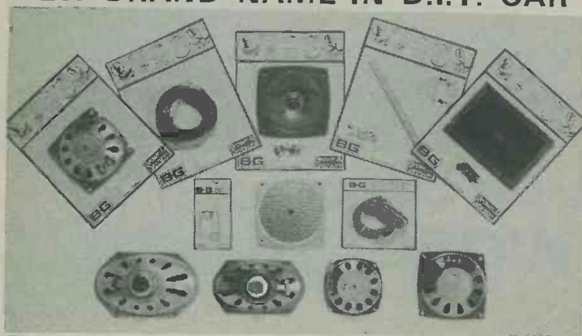
Clues Down

1. Italian radio (7, 8)
2. A capacity for religious resistance to coupling (2)
3. We have him to thank for piles (10. 5)
4. How low can a transistor get? (5)
5. Not another radio-mad meat-eater? (3)
6. Currently his coil (7, 8)
8. Boat propellers (4)
11. A root mean square found in an arsenal (4)
12. The electrified wanderer through gases and liquids (3)
16. Never nay (2)
17. A bird who made a light bulb (4)
19. Circle toucher but no gent (3)
20. Did you see rats about through that telescope? (4) (Anag.)
22. Burnt out (3)
26. Not she (2)
28. Wine about a bridge (4) (Anag.)
30. Rented (3)
31. An uplift in pay (5)
32. Inwards inside Badminton (4)
36. Increase the amps and feel it (3)
40. Definitely not (2)

(Solution on page 119)

NEWS . . . AND .

NEW BRAND NAME IN D.I.Y. CAR ENTERTAINMENT



Brown and Geeson, a company known internationally both as a manufacturer of specialised car accessories and equipment, and as one of the UK's leading lights in the export of these products, now announces a new range. B–G 'Inca' Fit-Kits.

Comments Brown and Geeson Managing Director Ray Brown, 'We have watched the growth of the DIY market for in-car entertainment ancilliary equipment with great interest. Our new Inca range is a comprehensive selection of equipment, carefully selected and priced to meet market demand, and attractively carded in our characteristic yellow and black livery to give maximum point of sale impact, and easy display! We are convinced that the INCA FIT-KIT range from B&G will prove as successful with retailers as have our other products'.

The B–G Inca Fit-Kit range includes speakers, grilles and grille spacers, fascias and mounting kits, balance controls, aerial extension and speaker leads and other items.

Full details and prices may be obtained direct from Brown and Geeson Ltd., 1–23 Queens Road West London E13 0PA.

DRY ANTISEPTIC FIRST AID SPRAY

Now you can buy an antiseptic in an aerosol which soothes and protects cuts, grazes, minor burns and scalds without stinging.

'Disphex' contains povidone iodine in a dry powder form, which uniquely gives the outstanding antiseptic properties of iodine, but is non-greasy, non-staining and non-irritant.

With 'Disphex' there is no need to touch sore broken skin, the protective antiseptic film that forms over the wound will prevent infection and assist healing, and can be easily removed by water when required.

With 'Disphex' in your car or home first aid kit, you are ready for most everyday emergencies, it is particularly convenient for family holidays and outings to the beach.

'Disphex' is formulated and produced by Avlex Limited, a subsidiary of Imperial Chemical Industries Limited, and is available from chemists at 69p for a 55gm aerosol.

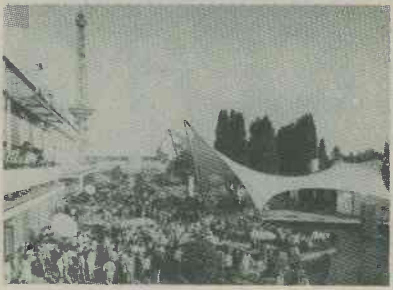
COMPACT SWEEP/FUNCTION GENERATOR

The newest Exact sweep/function generator, Model 121, from Dana Electronics of Collingdon Street, Luton is easy to carry and is one of their most compact generators to date. It offers a dynamic frequency range from 0.002 Hz to 2 MHz, with sine, square, triangle and variable time symmetry of all waveforms for ramp and pulse operation. An internal ramp generator is provided to sweep the main generator over an adjustable sweep width from zero to 1000:1. The rate of this ramp (sweep) generator is continuously adjustable from 1 ms to 10 s.

The Model 121's miniature size, high-impact-resistance case and versatile performance should make it attractive to schools, radio amateurs, and service repair-men, as well as the more obviously interested sophisticated laboratories. Price £155.00. A model with a built-in 20 dB step attenuator (Exact 121A) is available at £195.00.

. . . COMMENT

PICTURES FROM AN EXHIBITION



The above heading does not refer to the well known musical suite by Mussorgsky, but to the *International Radio and TV Exhibition 1975 Berlin*.

The photo above shows a hostess at the exhibition officiating at one of the stands. The top right hand photo shows another typical scene inside the exhibition hall, and the one below it, is of the crowds at the outside part of the exhibition – the Radio Tower can be clearly seen.

EVENING CLASSES

At the De Beauvoir Evening Institute, Tottenham Road, Balls Pond Road, London, N.1., a booster course for those who have unsuccessfully taken the RAE examination and do not want to start from scratch again, is to be held.

The tutor is Fred Barns, G3AGP, enrolment commences on the 15th September, but it is possible to enrol at any time during the term.

At the Headquarters of the Bury and Rossendale Radio Society, Cecil Square, Bury, Lancs, courses will be held for the Radio Amateur Examination, commencing in the Autumn.

Details regarding fees, enrolment, dates of classes etc., can be obtained from J. Marrow, 12 Halcombe Road, Tollington, Nr. Bury, Lancs.

SLOW-SCAN TV CONVENTION

This Convention, organised by the British Amateur Television Club, will take place at Aston University, Birmingham, on Saturday, 11th October, from 1000 to 1800 hrs.

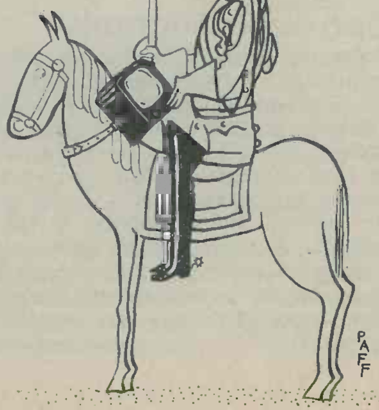
The Convention is open to all who are interested in this fascinating topic whether they belong to the B.A.T.C., or not. There will be lectures and displays of equipment and plenty of opportunity for the exchange of ideas. There is a charge of 50p to cover expenses, and tickets may be obtained from Mike Champion, G8DLX, 16 Percival Road, Rugby, CV22 5JS.

SPECIAL ISSUE–FREE VEROBOARD

We are pleased to announce that our next issue, to be published on 1st October, will be a Special Issue in which will be included FREE with each copy a piece of Veroboard of 0.15 in. matrix having 7 strips by 16 holes.

Two very attractive projects which can be built using the Veroboard, have been especially designed by our Technical Editor – J. R. Davies, and are fully described in the issue. Project One is a VERSATILE LIGHT ALARM and Project Two is a BROADCAST BAND RECEIVER. There will also be many other interesting articles plus all the usual features.

As the issue will sell very quickly, readers who have not placed a regular order with their newsagent are advised to order NOW.



'NOTES FOR NEWCOMERS'

STEREO DISC REPRODUCTION

By P. R. Arthur

Some basic facts on the recording of two stereo channels,

THERE IS NOW PROBABLY A STEREO RECORD PLAYER of some sort in most British households, and designs for stereo record players or amplifiers for use in such equipment appear frequently in the electronics constructional press. However, quite a few constructors, including newcomers to the hobby, are not too clear about the manner in which a stereo signal is recorded on a disc.

This article gives a brief and non-technical description of reproduction from a stereo record.

MONO REPRODUCTION

Before describing the method of stereo recording and reproduction, a brief look at mono recording is in order. The waveform of the recorded signal is cut into the original disc and, after a number of manufacturing processes, reproduced on the subsequent copies in the form of a small groove. During playback the stylus is placed in this groove and is caused to move in sympathy as the record rotates. Stylus vibrations are changed to electrical signals in the pick-up cartridge, either by an electromagnetic process in a magnetic cartridge or by a piezoelectric effect in a crystal or ceramic type. The signals are amplified and fed to a loudspeaker, which then reproduces the original sound.

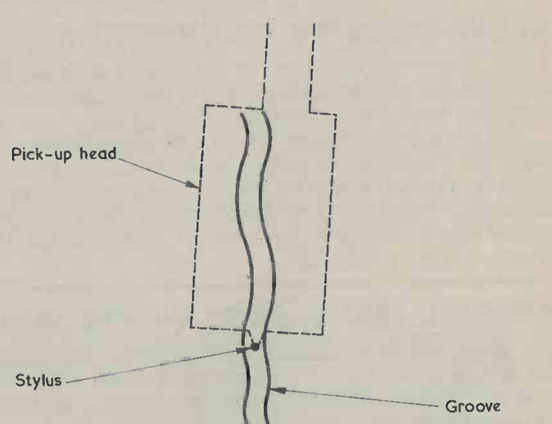


Fig. 1. On a mono recording the groove modulation is lateral only

As can be seen from Fig. 1 the disc groove modulation is lateral, i.e. from side to side. There is no vertical modulation of the groove, which has a virtually constant width.

STEREO SYSTEM

There is more than one possible method of producing a stereo recording on a disc, but the single method in universal use today is the 45/45 system. In this system the stylus can be moved in both the lateral and vertical directions.

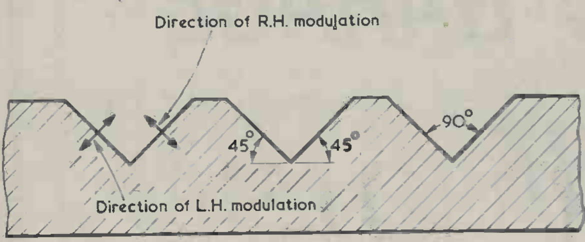


Fig. 2. A cross-sectional view of a stereo record, showing the modulation directions of the two walls

A cross-section of a 45/45 disc is shown in Fig. 2, and it will be seen that the walls of the groove are at right angles to each other, and are each at 45° to the horizontal. Hence the name of the system. One channel of the stereo signal modulates each wall of the groove and the diagram shows the directions of modulation. The wall carrying the left-hand channel is that nearer the centre of the record.

Obviously, the movement of the stylus will be of a complicated nature even when a fairly simple stereo recording is being played. The diagrams in Fig. 3 show theoretical groove outlines for particular examples of modulation and a study of these can give an insight into stylus movement. Fig. 3(a) shows groove outline with no modulation on either wall. As is to be expected, groove width is constant. In Fig. 3(b) the right-hand channel only is modulated, and the right-hand wall will rise and fall along the direction of the right-hand modulation arrows shown in Fig. 2. The stylus will be similarly moved, 45° to the horizontal, along this direction. Fig. 3(c) shows the effect where only the left-hand channel is modulated.

In Fig. 3(d) both channels are modulated by identical signals which are exactly out of phase. The wall outlines on either side are symmetrical, with the result that the stylus will suffer no lateral displacement but will be moved up and down vertically. Fig. 3(e) shows groove outlines when the channels are independently modulated, as would occur during a practical stereo recording. There are combinations of movement along both the left and right hand modulation directions. In Fig. 3(f) both channels carry identical signals which are in phase. Here, one wall goes down as the other goes up, whereupon the groove bottom remains at the same depth and the stylus is moved laterally from side to side. This groove is the same as would be given in a mono recording system.

A stereo cartridge has two transducers, one for each channel, and it is mechanically constructed so that each transducer is sensitive to only one of the two modulation directions. Since these are at right angles to each other, quite good channel separation can be obtained. This is not as high as with other pieces of stereo equipment, being typically in the region of 20 to 30dB, but it is still quite adequate in practice.

COMPATABILITY

When stereo discs were first introduced it was the aim that they should be compatible with mono record players, and that mono discs would be compatible with stereo record players. This was one of the main reasons for the adoption of the 45/45 system.

If a mono record is played on a stereo record player, the same signal level is applied to both channels. This is because, as was shown in Fig. 3(f), the groove on a mono record is equivalent to that given on a stereo record when both channels are identical and are in phase. Thus, playing a mono record on a stereo player gives the same effect as a single speaker placed centrally between the two stereo speakers.

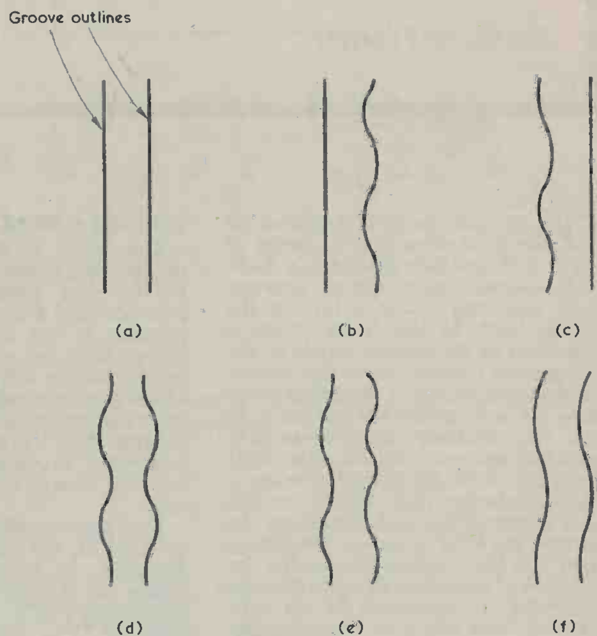


Fig. 3. The outlines of a stereo groove handling different signals. (a). No modulation. (b) Right-hand modulation only. (c). Left-hand modulation only. (d). Both channels identical and out of phase. (e). Both channels independently modulated. (f) Both channels identical and in phase.

Unfortunately there is less compatibility between a stereo disc and a mono record player if the latter has a cartridge whose stylus is intended for lateral movement only. Since the stylus has relatively low compliance in the vertical direction some loss of quality is inevitable. Of more importance is the fact that a mono cartridge of this type may damage the grooves of the stereo record.

Mono-stereo compatible cartridges are of course available, and give improved performance. A more common approach in modern mono record players is simply to use a stereo cartridge with its two outputs suitably paralleled. ■

AUTOMATIC GARAGE LIGHT

By G. A. French

Suggested Circuit 298

One of the minor irritations of life is to drive into a garage at night time and then fumble in a darkness relieved only by the car courtesy lamp until one is able to turn on the garage light. In the device which is described in the present article in the "Suggested Circuit" series this annoyance is overcome in a somewhat novel way. As soon as the car has come to rest the headlamps are momentarily switched on and then off. The light from one of the headlamps activates a photoconductive cell affixed to the wall of the garage and this causes the garage light to be turned on. The garage light will then remain illuminated for a period of some two to seven minutes according to the choice of the constructor, and will then automatically switch off again. This provides enough time to leave the garage. If desired, a switch in the garage can be turned on during the period when the light is illuminated. This switch over-rides the timing circuit and enables the garage light to stay on after the timing period has come to an end.

The photoconductive cell is mounted so that it is in the centre of one of the headlight beams when the car is in its normal parked position. Obviously, the circuit cannot be employed if it is possible for ambient light of equal intensity to the headlight beam to fall on the photoconductive cell, since the ambient light will then also cause the garage light to be turned on. Because of this, the photoconductive cell needs to be mounted in a relatively shaded position and this should be available in most enclosed garages. It is, in any case, possible to carry out some simple ohmmeter checks with the photoconductive cell only, before embarking on construction of the unit, to determine whether the system is viable in any particular location.

CIRCUIT OPERATION

The circuit of the automatic light unit appears in Fig. 1. The unit incorporates two integrated circuits, a transistor and a number of other components. It was decided to turn the garage light on and off by a relay rather than by a triac, since the relay offers a simple way of keeping the low voltage section of the circuit isolated from the mains supply. As it transpired, two relays were required, and the reason for this is discussed later.

The photoconductive cell, PC1, is an ORP12, the resistance of which decreases as the intensity of light falling on it increases. When highly illuminated it offers a resistance of the order of 75 to 300Ω. It is connected across the supply rails in series with R1 and R2, and the potential on its upper terminal goes negative as its resistance decreases. This upper terminal is connected to the inverting input of IC1, a 741 op-amp employed here as a comparator. The non-inverting input of IC1 is returned to the slider of pre-set potentiometer VR1. VR1 is set up such that the inverting input goes negative of the non-inverting input when the resistance of the ORP12 falls below a certain level. R2 is inserted between the lower terminal of the ORP12 and chassis to enable VR1 to be set up for any level of photoconductive cell illumination.

When the inverting input of IC1 is positive of the non-inverting input, the i.c. output, at pin 10, is low. If the illumination of the ORP12 increases sufficiently to take the inverting input negative of the non-inverting input, the i.c. output swings high, causing C1 to be rapidly charged via diode D1 to a voltage slightly lower than that on the positive rail. As soon as the illumination on the ORP12 reduces to its previous level, the i.c. output swings low again, but the presence of D1 ensures that C1 cannot discharge into the i.c. output. There is no necessity to insert a series resistor to limit the charging current when the i.c. output goes high, as the 741 employed for IC1 has its own internal current limiting.

After it has been charged, C1 commences to discharge slowly via R3. The voltage on its positive terminal is coupled to pin 2 of IC2 which functions as a second comparator. This i.c. is a 555 but it is employed here purely as a comparator, no use being made of its capabilities as a timer. When pin 6 of the 555 is taken to the positive rail it is possible to use the internal comparator coupled to pin 2 to respond to voltages around one-third of the supply potential. This method of employing the 555 has been described earlier, in the article 'Two More Uses For The 555' by J. Lewis in the January 1975 issue of *Radio & Electronics Constructor*. Before C1 was charged by IC1, pin 2 of the 555 was negative of the reference voltage of one-third of supply potential, and the output at pin 3 was high. When C1 becomes charged, pin 2 of the 555 is taken positive of the reference voltage and pin 3 then goes low, falling to a voltage only slightly higher than the negative rail. Emitter follower TR1 is able, in consequence, to energise relay RLA, whose coil is identified by the legend A/1.

The energising of relay RLA causes its normally open contacts, A1, to close, whereupon relay RLB becomes energised in turn. The normally open contacts, B1, of this second relay then complete the mains supply circuit to the garage light, LP1, which lights up.

As C1 discharges, the voltage at pin 2 of the i.c. goes more and more

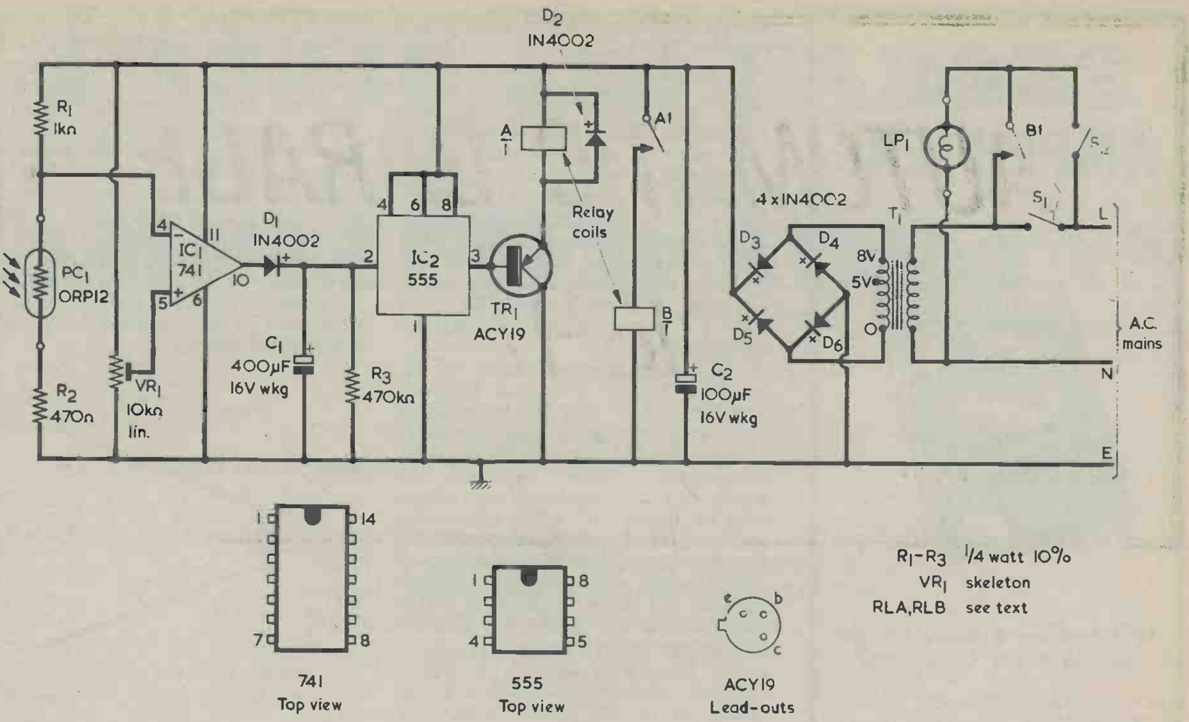


Fig. 1. The complete circuit of the automatic garage light unit. This turns on the garage light when the photoconductive cell is illuminated by a car headlamp

negative until, eventually, it reaches one-third of the supply voltage. The output at pin 3 of the i.c. goes high, relay RLA de-energises, followed by relay RLB. Contacts B1 open, the garage light is turned off and the timing cycle is over.

To sum up the process just described, capacitor C1 is initially discharged and both relays RLA and RLB are de-energised. A momentary illumination of PC1 by the car headlamp causes the output of IC1 to swing high, capacitor C1 to charge, the output of IC2 to swing low, and the two relays to energise, thereby turning on the garage lamp. This situation then continues whilst C1 discharges. When C1 has discharged sufficiently the output of IC2 goes high, the two relays de-energise and the light is turned off.

555 OPERATION

We may next look in greater detail at the circuitry around IC2. When pin 6 of this i.c. is taken to the positive rail, as it is in the present application, the internal flip-flop is disabled and the i.c. acts as a very high gain amplifier. The output at pin 3 remains low until the voltage at pin 2 is very close to the reference voltage of one-third supply voltage. The voltage at pin 3 does not then rise immediately to the high state, but instead, goes positive at a rate dictated by the i.c. internal gain. Thus, whilst the voltage at pin 2 goes very slowly negative, that at pin 3 goes gradually positive although at a comparatively much higher rate. The current in the coil of relay RLA does not in consequence cease abruptly but reduces at a slow rate. To protect the semiconductor device driving the relay it is necessary to connect the protective diode D2 across the coil and this, combined with the property of an inductor to oppose the reducing current, results in a series of coil current fluctuations which are damped by the diode. The author has encountered this effect in other circuits in which a relay is supplied by a very high gain semiconductor amplifier, and the current fluctuations cause no difficulties in practice if the relay is a relatively slow-acting type such as the P.O.3000. When the relay is a fast-acting type it is possible for the current fluctuations to cause armature chatter with, even, momentary opening of the contacts. In the present circuit the fluctuating current effect appears only during the last 10% of the timing period, and transistor TR1 is employed as a buffer amplifier to keep output current fluctuations in the i.c. at a low level.

The relay employed for RLA in the author's circuit was a P.O. 3000 type with a 500Ω coil. Other relays of similar type and having coil resistances between 400Ω and 1kΩ, together with an energising voltage of 8 volts or less, should be equally suitable. P.O. 3000 relays assembled to customer's specification are available from L. Wilkinson (Croydon) Ltd., Longley House, Longley Road, West Croydon. Relay RLB was a 'Miniature Open P.C. Relay' with a 410Ω coil retailed by Doram Electronics Ltd., and it has a changeover contact set rated at 250 volts a.c. and 5 amps. The framework of this relay is common with the moving contact, and care must be taken not to touch it accidentally when it is wired into circuit with the mains supply applied.

For constructors prepared to experiment, a slow-acting relay with contacts and insulation suitable for mains voltage and current could be used in the RLA position. Relay RLB would not then be required.

To complete a description of the circuit, the length of the timing period with C1 at 400μF is approximately 2¾ minutes. The length of the period varies directly with the value of C1. Alternative values up to a maximum of 1,000μF can be employed if desired. With C1 at 1,000μF the timing period is of the order of 7 minutes. Some fairly wide variations on these figures will be given with some capacitors due to the large tolerance on nominal value which is common with electrolytic components.

The power supply consists of T1, rectifiers D3 to D6, and reservoir capacitor C2. T1 is a bell transformer with an 8 volt secondary, tapped at 5 volts, of the type available from Woolworth's stores. However, the supply is not critical and any supply offering about 10 volts reasonably well smoothed may be employed for the circuit. Switch S1 is the on-off switch for the unit, whilst S2 over-rides both S1 and relay contacts B1 if it is required that the light be turned on independently.

The lamp LP1 can be a normal domestic filament bulb with a power rating up to 100 watts. A lamp of higher power should not be used. This is because the cold resistance of a 100 watt bulb is of the order of 50Ω only, which means that the current passed by relay contacts B1 can reach their full rated 5 amps at the instant of closing.

CONSTRUCTION

The circuit may be assembled in any convenient manner. Layout is not important and all the components run cool. The pin numbers shown for IC1 in Fig. 1 apply to this i.c. in the 14 pin d.i.l. package. No connections are made to the pins of either i.c. whose numbers do not appear in the diagram. It will be helpful to initially fit a capacitor with a value of 20 to 50μF in the C1 position. This will enable circuit operation to be checked without long time delays. When it is found that the circuit is functioning satisfactorily the larger value capacitor may then be wired in. Lamp LP1 will, of course, be remote from the unit. The photoconductive cell may either be mounted on the surface of the housing for the unit, or may be positioned separately at the end of a 2-way cable. The cell must be positioned so that it is in the centre of the headlight beam both in the horizontal and the vertical sense. The effect of ambient light can be reduced by fitting a cone-shaped shade to the cell, as illustrated in Fig. 2.

To set up VR1, a voltmeter switched to read 10 volts f.s.d. is connected between the negative supply rail and pin 10 of IC1. The slider of VR1 is then taken to the negative end of its track and the photoconductive cell is illuminated by the headlamp. The voltmeter should give a reading of about 2 volts. The slider of VR1 is then slowly advanced from the negative end of its track, whereupon a point will be reached where the voltmeter reading suddenly rises to approximately 8 volts. The slider is taken slightly beyond this point, after which the headlamp is turned off. If all is well, the voltage at the i.c. output should then drop back to 2 volts. If this adjustment is carried out at a time of high ambient light level, say during the middle of a sunny day, the adjustment in VR1 will be adequate for all future requirements.

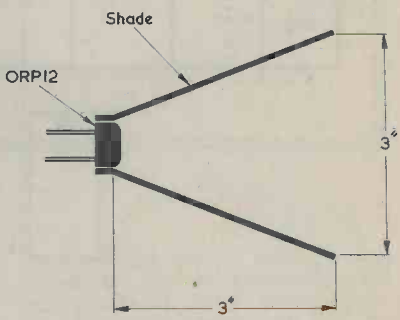


Fig. 2. A simple shade may be fitted to the photoconductive cell to reduce the incidence of ambient light. The interior surface of the shade is painted matt black

Should it be desired to check the viability of the system in an area of fairly high ambient light level before making up the unit, a check can be carried out using the ORP12 on its own. A testmeter switched to an ohms range is connected to the two lead-outs of the ORP12, and its resistance is measured when it is illuminated by ambient light and then by the headlamp. If the ratio between the two resistances is adequately high, says 5:1 or better, then the situation should be suitable for the installation of the unit. For robust positive operation it is best to site and shade the photoconductive cell so that the ratio between the two resistances is as high as is reasonably possible.

A final very important point has to do with safety. The unit must be connected to a reliable mains earth and all care taken to ensure that there is no access whatsoever to any live mains connections. Full precautions against accidental shock must be observed, and it must also be remembered that the concrete floor normally found in garages can be looked upon as offering a very low resistance to earth so far as electric shock is concerned. ■

CA3048 and CA3052 AMPLIFIER ARRAYS

By A. Foord

Each incorporating four separate a.c. amplifiers, the CA3048 and CA3052 have many useful applications in the audio amplifier field

THE RCA CA3048 AND CA3052 AMPLIFIER ARRAYS ARE silicon monolithic integrated circuits consisting of four independent a.c. amplifiers. They include internal d.c. bias and feedback to provide temperature stabilized operation. Each amplifier has a high impedance non-inverting input for the signal, with a lower impedance inverting input for the feedback.

APPLICATIONS

The CA3048 is characterised for low noise general a.c. applications while the CA3052 is specified using R.I.A.A. (audio) methods. With four amplifiers in one dual-in-line package it is possible to conveniently construct stereo pre-amplifiers, mixing amplifiers, tone generators, etc., at an economical price.

The basic parameters for each amplifier are shown in Table 1, whilst Fig. 1 gives the pin connections. The noise figure quoted applies to the CA3048 only because the CA3052 data sheets give noise voltages for specific audio circuits. However, the two integrated circuits are basically identical.

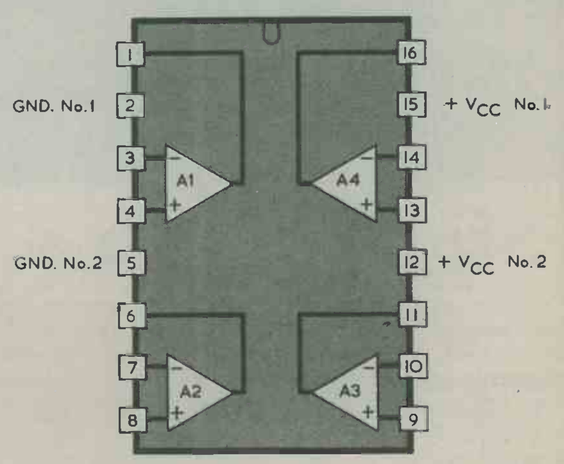


Fig. 1. Pin connections for the CA3048 and CA3052 are as shown here

TABLE 1
CA3048 and CA3052 characteristics
(*Figures are typical unless otherwise stated*)

Noise figure at 1kHz	2dB (CA3048)
Voltage gain without feedback	53dB minimum
Input resistance	90kΩ
Output voltage swing	2.5V r.m.s.
Output resistance	1kΩ
Open loop bandwidth	300kHz
Power supply voltage	16V maximum

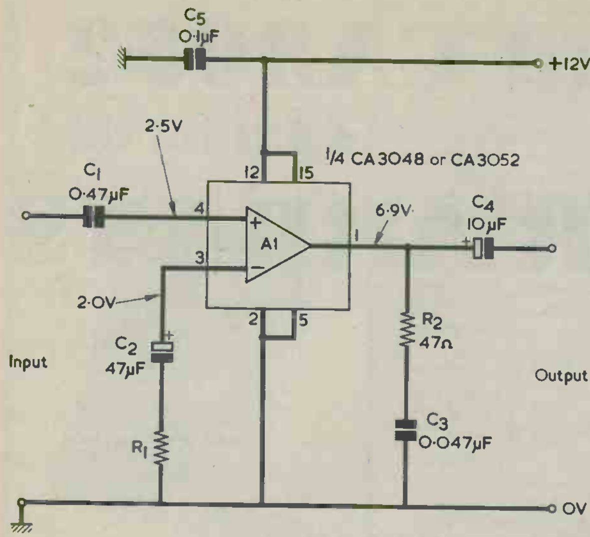


Fig. 2. A simple circuit incorporating one of the i.c. amplifiers. Typical d.c. voltages at the inputs and output are indicated

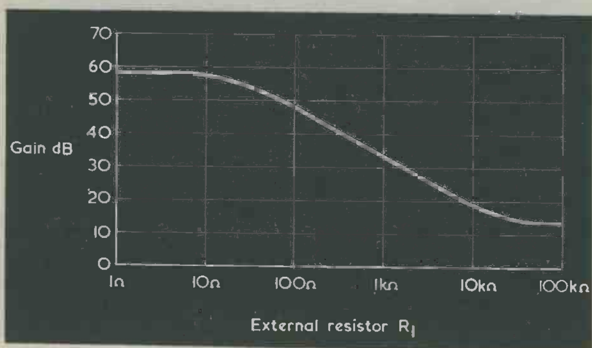


Fig. 3. The gain of the amplifier of Fig. 2 varies according to the value of external resistor R1

SIMPLE AMPLIFIER

A simple amplifier circuit employing one quarter of a CA3048 or CA3052 is shown in Fig. 2. Here, the internal resistive feedback of the integrated circuit is used in conjunction with an external resistor, R1, to set the overall gain. Typical values of gain are plotted against the corresponding external resistance values in Fig. 3.

In order to provide some negative feedback around the circuit it is suggested that overall gains greater than 40dB are not used. This gives at least 13dB of negative feedback even if the open loop voltage gain of the amplifier is at its minimum value of 53dB.

The input capacitor can be a low value because the input resistance of the circuit is 90kΩ.

The method of gain control employed relies on the absolute accuracy of the internal feedback resistor, and the measured gain of various amplifiers will not be uniform for a fixed value of R1. It would seem reasonable to expect that variations between one amplifier and the next on the same chip would be less than the variations between one package and the next.

The circuit of Fig. 2 was set to a gain of 30dB and five other packages tried in the holder without re-setting R1. Out of the total of six packages the gain with five was within 0.5dB, while one package was within 1.2dB of 30dB.

From these findings it may be assumed that R1 could be made a fixed resistor for normal audio work, with package-to-package variations ignored.

STABILITY

Since these amplifiers have a high-gain bandwidth product, normal attention must be paid to layout, construction and frequency compensation to avoid instability. Some i.c. amplifiers shape their frequency response by internal components or external components added to points within the circuit. If the amplifier outputs are unterminated then socket capacitance may provide enough feedback to cause oscillations. With four amplifiers in one package, as occurs with the CA3048 and CA3052, no connections are available to internal points, and any necessary compensating components must be connected at the output terminals.

R2 and C3 of Fig. 2 should be added if no other load exists. The values shown for these two components are suitable under all conditions.

For applications where the output is loaded R2 and C3 may not be required depending on the amplifier gain setting. The suitability of each design must be checked, when the requisite test equipment is available, by observing the step response of the circuit for instability or overshoot.

MAGNETIC PICK-UP PRE-AMPLIFIER

Where required, a.c. feedback can be applied around the amplifier by connecting external components from the output to the inverting input, as shown in Fig. 4. This particular circuit is for a magnetic pick-up

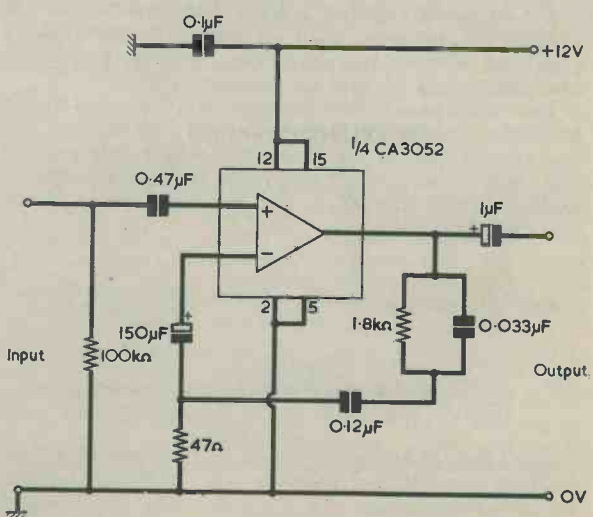


Fig. 4. One of the amplifiers in a CA3052 is used here as a pre-amplifier for a magnetic pick-up

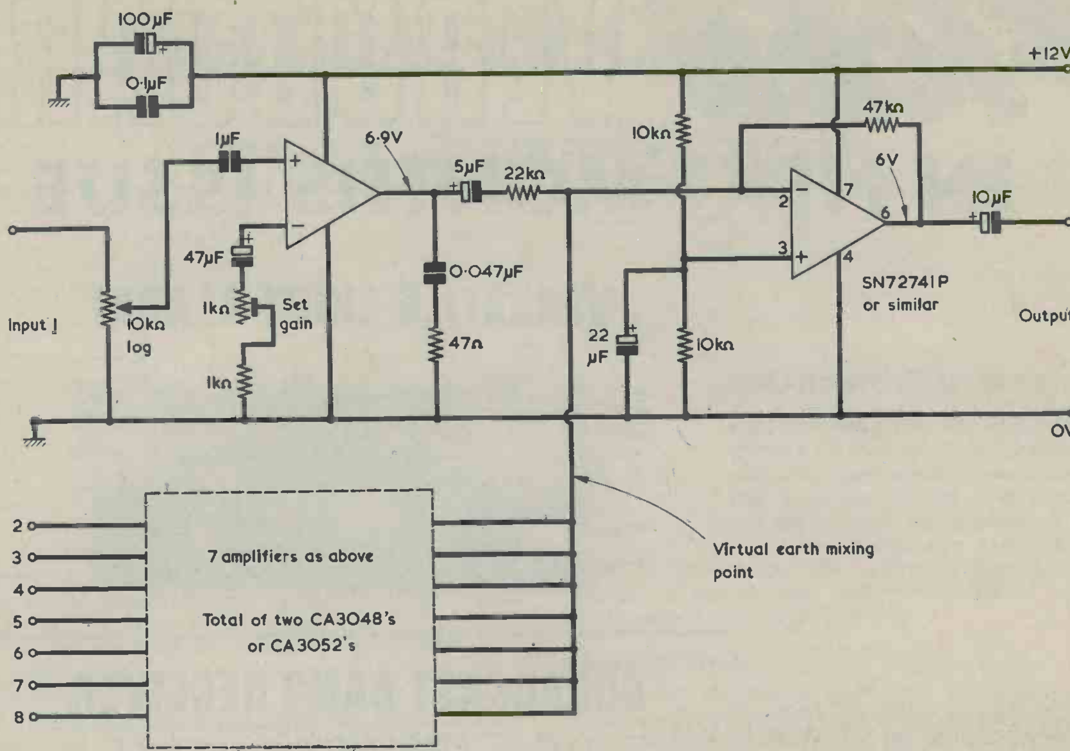


Fig. 5. An 8 channel mixing unit. Connections to the pre-amplifiers are at the pins indicated in Fig. 1. Pin numbering for the 741 i.c. applies to the 8 pin version

pre-amplifier and the equalisation will be within ±2dB of the R.I.A.A. curve.

The 47Ω resistor would normally set the gain to about 50dB, and this must be taken into account when designing such external networks.

8 CHANNEL MIXING CIRCUIT

As an exercise two CA3048 integrated circuits were used with a 741 to provide an 8 channel audio mixing unit. The complete circuit is shown in Fig. 5, with its performance in Table 2. It consists of 8 pre-amplifiers, each of 28.5dB gain, and a virtual earth mixing circuit. The mixing circuit uses a 741 to give an added gain of 6.5dB for each input. This gives an overall gain of 35dB.

TABLE 2
8 channel mixing circuit performance

Frequency response	–3dB at 5Hz and 30kHz
Overall gain	35dB
Output noise level	1.5mV r.m.s.
Input impedance	9kΩ
Maximum output	8V peak-to-peak

The 741 can work with a total supply of 12 volts, and is biased so that its d.c. input (and output) level is at half the supply voltage, i.e. 6 volts. Since, with a 12 volt supply, the d.c. voltage at the output of the pre-amplifier is a minimum of 6.1 with a typical value of 6.9 volts, there should be no difficulty in determining the polarity of the electrolytic coupling capacitors!

The frequency response was measured for one input with the stabilizing components on the pre-amplifier output. It was found that these components could be removed (for the gain value used and the 22kΩ load) with an improvement in bandwidth. However, for audio applications the increased bandwidth is of no advantage, and the stabilizing components may be retained as an extra precaution against instability.

The noise was measured as less than 1.5mV r.m.s. at the output with all the inputs short-circuited. The output level must be kept much greater than this in order to maintain an adequate signal-to-noise ratio.

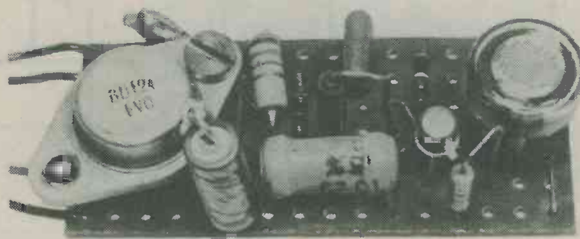
An attempt was made to measure the harmonic distortion of the circuit. However, at a final output level of 1 volt r.m.s. the measurement was limited by the distortion of the rather poor signal generator used as an audio source. Total harmonic distortion was found to be better than 50dB down at the 1 volt r.m.s. output level. ■

FREE VEROBOARD IN NEXT MONTHS ISSUE

VERSATILE LIGHT ALARM

Veroboard Project One

This versatile light alarm can readily be assembled and can be used for a variety of purposes. It turns itself on automatically at a certain light level and then produces an a.f. tone whose frequency varies with light intensity.



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Veroboard Project Two

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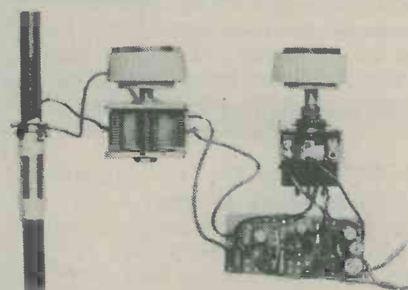

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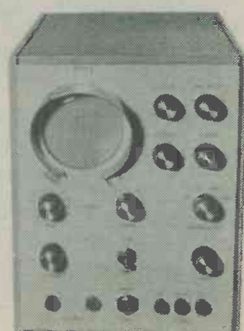
NEW TRANSISTORISED OSCILLOSCOPE

Part 2 (3 parts)

Continuing the constructional work on this popular oscilloscope started last month, including the assembly of the X and Y amplifiers, and the timebase and sync amplifier.



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INTEGRATED CIRCUIT SIGNAL GENERATOR

Part 2

This concluding article deals with the testing of the completed signal generator, then describes two methods of calibrating its output frequency.

By John Lewis

IN LAST MONTH'S ISSUE THE CIRCUIT FUNCTIONING OF the signal generator was discussed, after which details were given of construction. Next to be dealt with are the processes of testing and calibration.

TESTING

Before the unit can be switched on it is necessary for VR3 and VR4 to be adjusted. These are set up, with the aid of an ohmmeter, to give a resistance of 9.09kΩ as accurately as is possible. This is best done before the potentiometers are fitted into the circuit. After having been adjusted they may then be soldered to the Veroboard.

The adjustments of VR1 and VR2 for minimum sine wave distortion are best carried out with the aid of an oscilloscope. If an oscilloscope is not available it is difficult to make meaningful adjustments to VR1 and VR2 and these two potentiometers may, in consequence, simply be omitted from the circuit. Pin 12 of the i.c. should then be coupled to the negative supply rail via an 82kΩ resistor, and no connection made to pin 1. Operation in this manner will still ensure that sine wave distortion up to some 10kHz is of the order of 1%, and this should be an acceptable level for most applications. When VR1 and VR2 are in circuit it is possible to bring the distortion at frequencies below 10kHz to about 0.5%.

When all connections have been finally made, a check should be carried out to see that there are no solder whiskers across the Veroboard copper strips. The author always runs the blade of a small screwdriver down the spaces between the strips to be on the safe side. If VR1 and VR2 are retained they should be set to a central position.

The unit may next be switched on, whereupon the requisite outputs should be obtained. If an oscilloscope is being used, VR1 and VR2 are adjusted, one at a time, for best appearance of the sine wave. These adjustments should be made on one of the lower frequency ranges as they are more difficult to carry out at the higher frequencies.

If for any reason the unit does not produce an output, the obvious faults, such as short-circuits between Veroboard copper strips, dry joints, components inserted wrong way round and the like, should be looked for. The author has found that the 8038 i.c. is quite robust and that it should not give any trouble if due care is taken.

CALIBRATION

Frequency calibration need only be carried out on one range. Provided that close tolerance capacitors have been employed for C4 to C8, the calibration will then hold for the other ranges.

When an oscilloscope can be used this may be employed to obtain Lissajous figures with the 50Hz mains frequency. The signal generator output, switched to sine wave, is applied to the X input of the oscilloscope and the 50Hz mains signal to the Y input. In many cases a mains signal can conveniently be obtained by connecting a wire to the non-earthy Y input terminal and positioning this alongside an unscreened mains lead.

Idealised Lissajous figures for 25Hz, 50Hz, 100Hz and 150Hz under these conditions are shown in Fig. 9. These assume correct phase relationships and require some care in the setting up of oscillator frequency. These four frequencies may be marked up on the scale with the 10 to 150Hz range switched in. The 10Hz point on this range may be marked up by extending the scale in linear fashion below the 25Hz point. Intermediate subdivisions may then be added.

Alternatively, the scale can be marked up in terms of the voltage on pin 8 of the i.c. The values of VR3, VR4 and C4 to C8 have already been selected so that

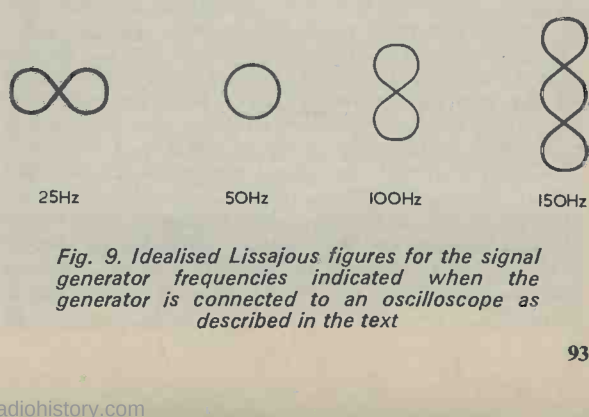


Fig. 9. Idealised Lissajous figures for the signal generator frequencies indicated when the generator is connected to an oscilloscope as described in the text

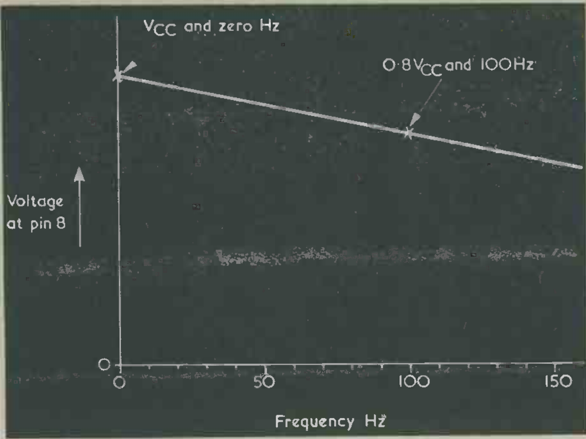


Fig. 10. The signal generator may be calibrated by drawing a straight line graph through the two plotting points shown here

a frequency of 100Hz, 1kHz, etc., according to the range selected, is given when pin 8 of the i.c. is at 0.8Vcc. Frequency reduces as the voltage on pin 8 increases and the frequency can be assumed to be zero Hz when pin 8 is at its highest level, which is equal to Vcc. There are, therefore, two points for a straight line graph, as indicated in Fig. 10.

First measure the value of Vcc between pin 6 (positive) and pin 11 (negative) of the 8038. Plot a point corresponding to this voltage and zero Hz on the graph. Next calculate the voltage corresponding to 0.8Vcc. Plot a second point corresponding to this voltage and 100Hz on the graph. Draw a straight line between these two points. This is the curve relating voltage on pin 8 to output frequency.

Next, connect a voltmeter between pin 11 (negative) and pin 8 (positive), rotate VR5 to produce voltages corresponding to different frequencies on the graph and mark up the scale accordingly. If, to take a simple example, Vcc happened to be 20 volts, then 0.8Vcc, corresponding to 100Hz, will be 16 volts. The scale can then be marked 100 when the voltmeter reads 16 volts, 75 when the voltmeter reads 17 volts, 50 when it reads 18 volts, and so on. In practice the value of Vcc will be a figure lying between some 21 and 24 volts according to tolerance in the power supply zener diodes. The straight line graph may also be employed for marking frequencies up to 150Hz.

This method of calibration is quite satisfactory, although the extremes of the scale will be in some error due to slight non-linearity of the sweep. The voltmeter employed for measuring the voltage at pin 8 should have a high resistance and should be at least 20,000Ω per volt.

The output potentiometer can be calibrated directly using an oscilloscope or alternatively by realising that an emitter follower gives nearly unity voltage gain. The quoted peak-to-peak output from the i.c. for the square wave is 0.9Vcc, for the sine wave 0.22Vcc and for the triangular wave 0.33Vcc. With the prototype the output was calibrated only for the sine wave and is reasonably accurate up to about 50kHz.

When completed, the signal generator can be used for all those jobs which require a stable, well calibrated signal source such as the testing of hi-fi equipment, alignment of tape heads, checking of power outputs and fault location. Within a short space of time the constructor will wonder how he ever managed without it. ■

TEN

This short article concludes our series on 28MHz amateur band equipment.

THE DIMENSIONS AND OTHER DETAILS GIVEN IN THIS article should prove of aid to anyone wishing to set up a 10 metre aerial, for use with the 28MHz band equipment described in the preceding articles, or for any other transmitters or receivers operating in this band.

HALF-WAVE AERIAL

A half-wave aerial, suitably fed, will give much better results than a short telescopic or similar aerial. The length required for 10 metres is quite small, so that it will usually be possible to set up a half-wave aerial without difficulty.

A half-wave dipole has an overall length of 16 ft. 6 in., as shown in Fig. 1. Single wire around 14 s.w.g.

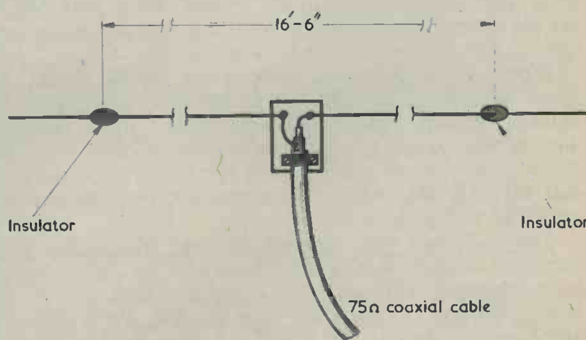


Fig. 1. Suitable dimensions for a 10 metre half-wave dipole

METRE BAND — AERIALS

By F. G. Rayer

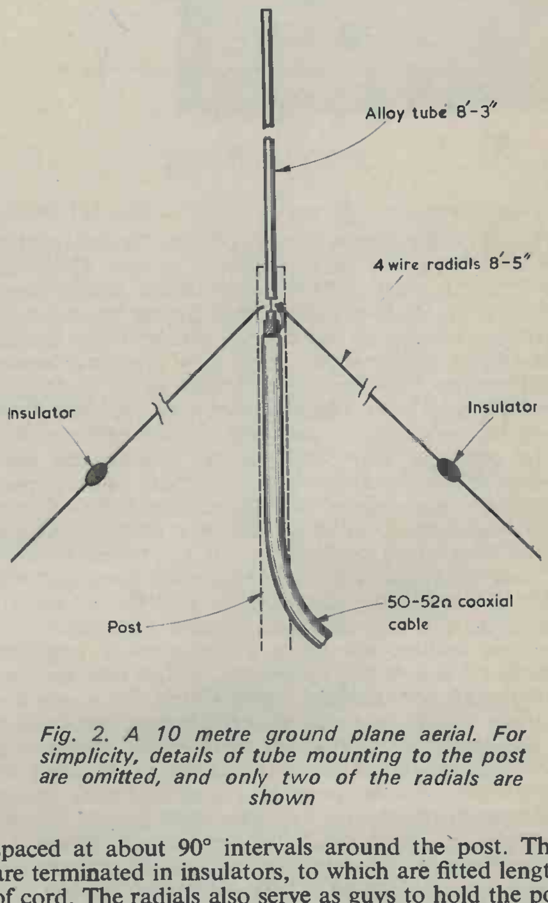


Fig. 2. A 10 metre ground plane aerial. For simplicity, details of tube mounting to the post are omitted, and only two of the radials are shown

can be used, or stranded bare or insulated aerial wire. The wire should be cut a few inches longer than 16 ft. 6 in., as these inches will be taken up when the wire ends are fastened to the insulators. Small porcelain 'egg' insulators are suitable, these being fitted with cords which enable the aerial to be suspended between any supports that are available when using equipment away from the home. As the aerial need not be horizontal, one end may be supported at a high level and the other fastened, if necessary, to a peg or stake at ground level.

The feeder, which can be 75Ω coaxial cable, couples into the centre of the aerial. A suitable support to secure the inside aerial wire ends and the feeder may be made up from insulating material. The inside conductor of the coaxial cable connects to one of the aerial wires and the braiding to the other aerial wire (preferably the lower if the aerial is tilted). The feeder can be of any convenient length and is terminated in a coaxial plug for fitting to the transmitter or receiver aerial socket. The aerial dimensions given are particularly intended for a frequency around 28.5MHz.

The aerial can be of considerable advantage with portable or transportable equipment when an increased range is required. It can be easily set up or taken down, and it may be readily rolled up for carrying.

GROUND PLANE

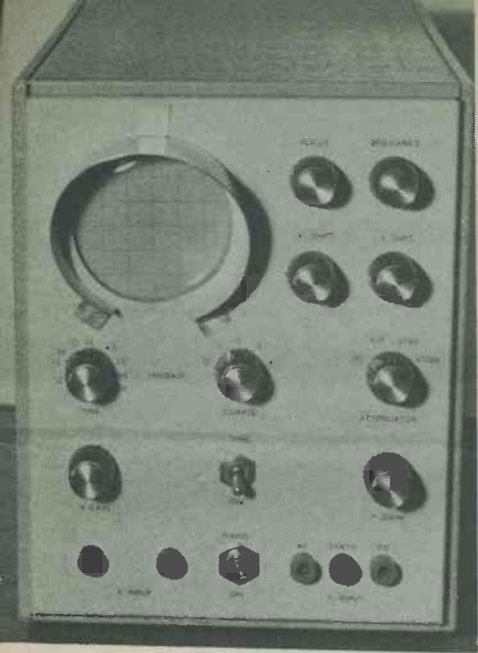
The ground plane is a simple type of low-angle long distance transmitting aerial, but it also performs well at short range. Suitable dimensions for a 10 metre ground plane aerial are given in Fig. 2.

The vertical tube is aluminium alloy and is 8 ft. 3 in. long, with a diameter of around ½ in. It is fixed to the upper end of a post or stake by an insulated mounting. The inner conductor of the coaxial feeder, which in this instance should be 50 to 52Ω, connects to the lower end of the tube.

Four radial wires are used, each 8 ft. 5 in. overall. These slope at roughly 45° to the horizontal, and are spaced at about 90° intervals around the post. They are terminated in insulators, to which are fitted lengths of cord. The radials also serve as guys to hold the post upright, and the length of cord required will depend upon the height to which the aerial is to be raised.

All four radials are connected together at their apex and to the outer braiding of the coaxial cable. The feeder runs down the post and can be any length. The upper end of the coaxial cable and its connections need to be sealed to keep out rain.

The ground plane aerial can be taken down quickly and, if some means of transport is available, can be carried with the alloy tubing detached from the post. It is independent of the need for any support other than the post, and it can be put up easily on any reasonably flat ground. ■



NE TRANSIS OSCILL

Par

By R. A

Regular readers will recall the orised oscilloscope design we and January 1973 issues. Our more modern and up-dated versi ates many important improve introduced in this issue, and co metal-work and the power supp and further details will be give

THE PREVIOUS DESIGN BY THE AUTHOR, "TRANSISTORISED Oscilloscope", was published in the December 1972 and January 1973 issues of *Radio & Electronics Constructor*. This present 3-part article describes an up-dated version of the unit in which all the circuits have been improved in some way. The mechanical construction has also been improved to provide a stronger and more rigid assembly. In fact this latest design is only fairly loosely based on the earlier one.

In common with the original version the main design requirements were for a simple but complete circuit having a good basic sensitivity rather than a wide bandwidth, as most amateur constructors are likely to need an oscilloscope for a.f. rather than for r.f. and TV applications. The bandwidth does, however, include the popular i.f.'s around 465kHz, which is a useful feature. An additional design requirement for the new version was for a d.c. coupled Y amplifier, and a very simple but reliable circuit has been evolved.

Although the design is fairly simple for an oscilloscope it should be borne in mind that an oscilloscope is necessarily a complicated instrument, and a considerable amount of work is involved in building the present unit. Some twenty-five semiconductor devices are used in the circuit, including three f.e.t.'s, thirteen bipolar transistors and one integrated circuit. A testmeter with a sensitivity of 20,000Ω per volt or better on its voltage ranges is needed during construction for setting-up purposes.

BLOCK DIAGRAM

A block diagram showing the various circuits employed in the oscilloscope is given in Fig. 1. As can be seen from this, the instrument has all the usual facilities, these including internal sync, flyback blanking, an i.c. timebase and an internal mains power supply unit. An X input is available for Lissajous figure work when the timebase is switched out, and this also serves as a timebase output when the timebase is switched in.

A brief specification of the prototype instrument is shown in the accompanying table.

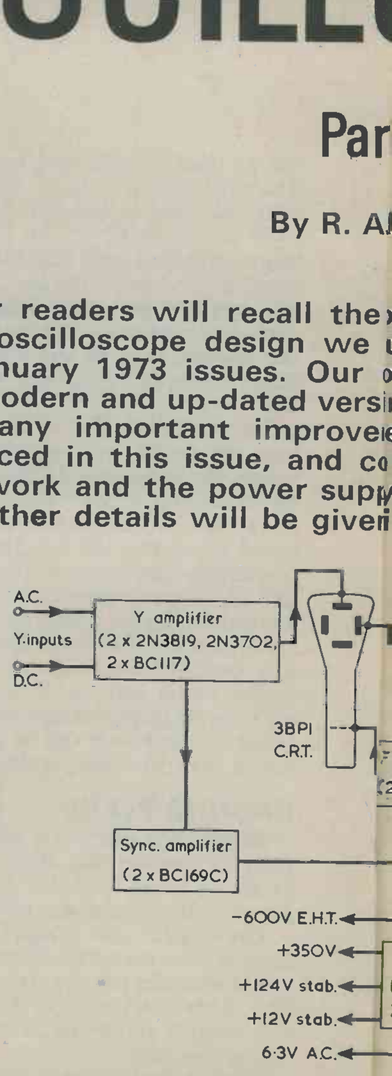


Fig. 1. Block diagram illustrating the semicondu

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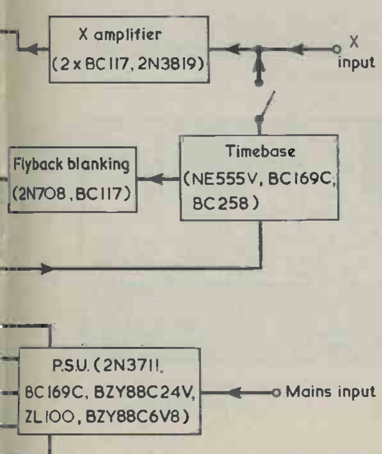

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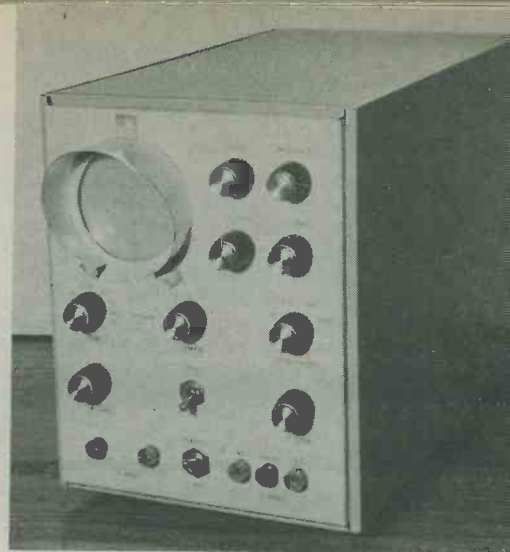


TABLE 1

SPECIFICATION

Cathode ray tube:	3BP1 giving $2\frac{1}{2}$ in. diameter viewing area.
Timebase:	5-position switch plus fine frequency control. Range 0, timebase off; Range 1, 5 – 70Hz; Range 2, 50 – 700Hz; Range 3, 500Hz – 7kHz; Range 4, 5 – 70kHz
X Amplifier:	Input impedance, 500kΩ shunted by approx. 20pF. Sensitivity, 50mV/cm. Bandwidth, less than 5Hz to 500kHz at –3dB. X input provided.
Y Amplifier:	Input impedance, 1.7MΩ shunted by approx. 30pF. Sensitivity, approx. 10mV/cm. Bandwidth, d.c. to 500kHz at –3dB. A.C. input provided. 4-position attenuator, X1, X10, X100, X1,000.
Sync:	Switchable internal sync.

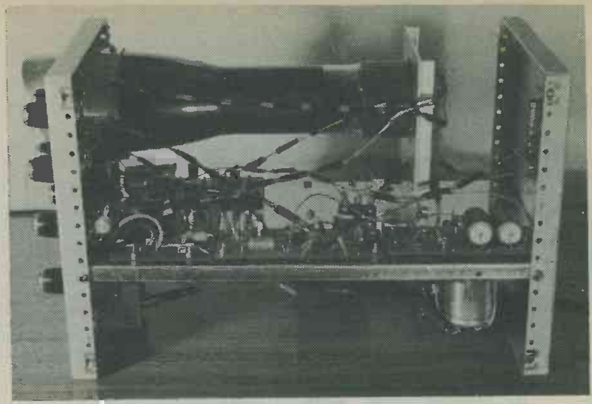
TABLE 2

CONTROL FUNCTIONS

S1	Mains on-off.
S2	Y attenuator.
S3	Timebase range.
S4	Sync on-off.
VR1	X gain.
VR2	X shift.
VR3	Y gain.
VR4	Y shift.
VR5	Timebase fine frequency
VR6	Focus.
VR7	Brilliance.
VR8	Astigmatism.

FRONT PANEL

A ready-made instrument case and chassis form the mechanical basis on which the oscilloscope is constructed. The case is a Contil Mod 2, size Q, and it is supplied complete with an aluminium chassis. It can be obtained from Doram Electronics, Ltd. The case has outside dimensions of approximately 9 by 7 by 13 in., and so a quite compact design is achieved. A similar home-constructed case could of course be used instead, if preferred. The chassis is mounted 6 holes up on the front and rear panels in the manner illustrated in the photograph giving a side view of the assembly.



Side view of the oscilloscope. This gives a useful guide towards general chassis assembly

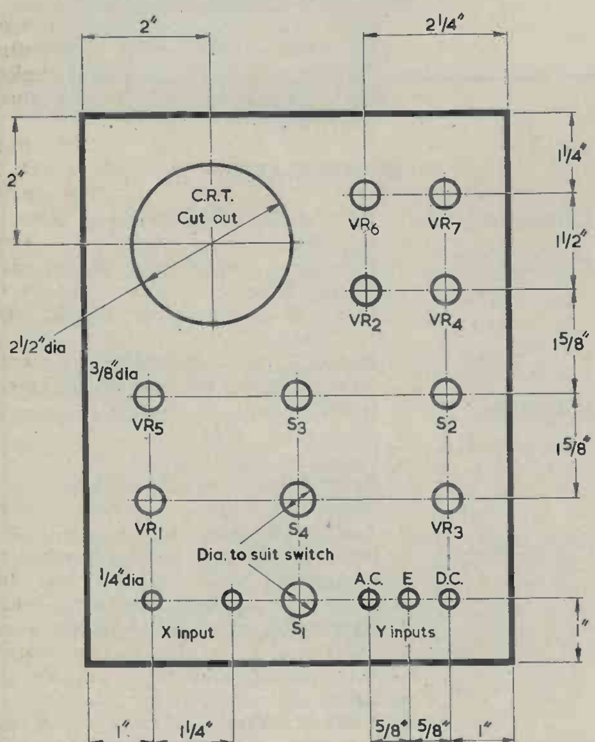


Fig. 2. Control layout and hole positoning on the front panel

Fig. 2 shows the drilling and cutting out that is needed on the front panel. Requirements here are mainly very straightforward, the only likely difficulty being the $2\frac{1}{2}$ in. diameter cut-out for the cathode ray tube. The front panel is made of fairly soft aluminium and an ordinary fret saw can be used to make the cut-out. It is best to cut carefully just on the inside of the perimeter of the required hole, and then use a large half-round file to enlarge the hole to precisely the correct size.

C.R.T. MOUNTING

The layout of the larger components and the component panels on the chassis is shown in Fig. 3. The positions of the mounting holes for these various items are located by using the components and panels as templates. In the cases of the component panels and c.r.t. mounting brackets, marking out must of course wait until these have been completed.

Also shown in Fig. 3 are two $\frac{3}{16}$in. diameter holes and three $\frac{3}{8}$ in. diameter holes. These are fitted with grommets and allow the passage of wires through the chassis. Their precise positioning is not critical, but they should be located so that they are not obstructed by any components.

Details of the three parts forming the c.r.t. mounting are shown in Fig. 4.

The part $11\frac{1}{2}$ in. long is made from a fairly thin gauge of aluminium, about 22 s.w.g., and it is carefully bent round to form a circular band with a diameter of about $3\frac{1}{2}$ in. Two short 6BA bolts are used to secure the two ends of the band together, the nuts being on the outside. This forms a cradle for the front of the tube.

A heavier gauge of aluminium is employed for the U-bracket, 18 s.w.g. material being used in the prototype. The $\frac{3}{4}$ in. flange on the bracket is bolted to the vacant hole in the cradle. The inside of the front of the cradle is coated with a layer of self-adhesive foam rubber. This is sold in D.I.Y. shops as draught excluder.

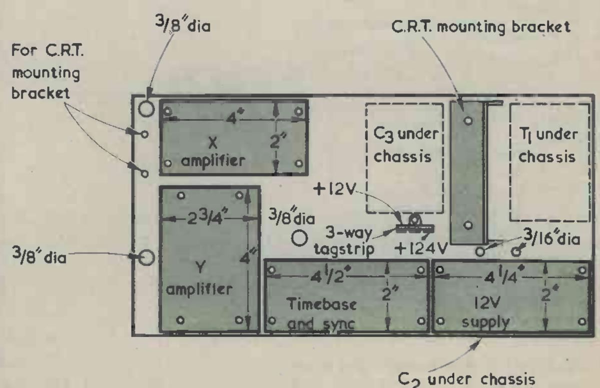


Fig. 3. Chassis layout, illustrating the positions taken up by the oscilloscope sections

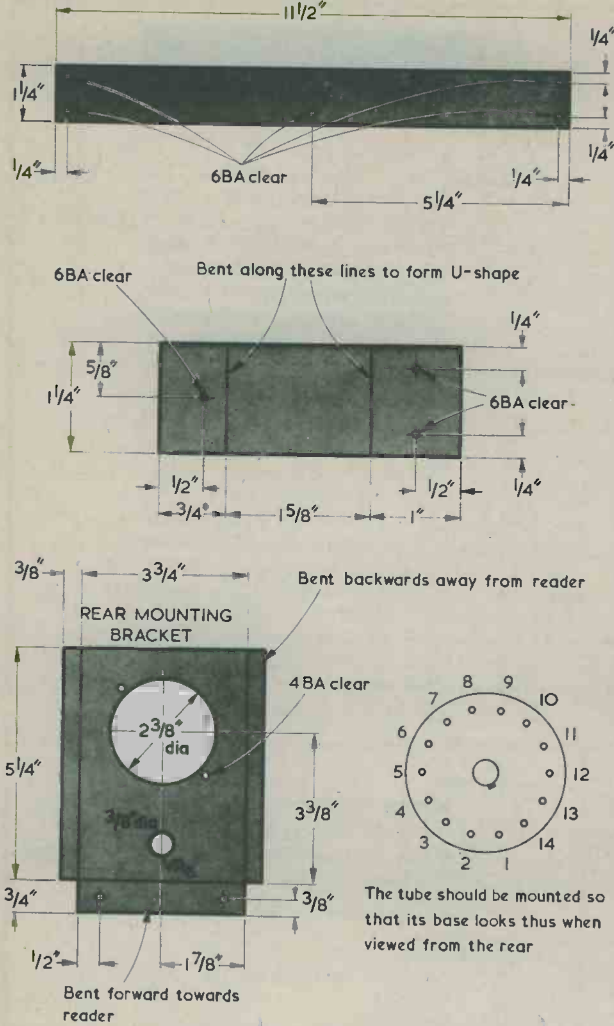


Fig. 4. Details of the front and rear mounting brackets for the cathode ray tube

Next, the 1 in. flange of the bracket is taken under the chassis, and bolted to the chassis such that the cradle is positioned centrally behind the c.r.t. cut-out.

The rear bracket for the c.r.t. must provide a very firm mounting, as the front mounting does little more than support the front of the tube. The rear bracket should be made from 16 s.w.g. aluminium.

It is advisable to make the two small mounting holes for the c.r.t. holder slightly oval by enlarging them with a miniature round file. Then when the oscilloscope is completed the tube can be rotated if necessary to bring the X axis exactly horizontal.

To find the position in which the rear bracket fits on the chassis, temporarily fit the tube into the holder (which is bolted onto the bracket) and put the tube and bracket in position on the chassis. Then use the bracket as a template to mark out the positions of the mounting holes.

The tube must be removed when any drilling work on the chassis is being carried out, as it could easily be damaged if it were left in position.

VISOR AND GRATICULE

Even though quite a bright trace is obtained, it is advantageous to add a visor to shield the screen from external light sources. A visor is readily constructed from a thin piece of aluminium, and the dimensions are shown in Fig. 5. A suitable thickness is 22 s.w.g.

Although it may seem rather difficult to remove the two sections of aluminium between the three lugs in Fig. 5, this process can easily be carried out by first making the four ½ in. cuts down the sides of the lugs with a hacksaw. The metal can then be deeply scored with a sharp modelling knife along the two lines where the two longer cuts are required. The two pieces of metal which are to be removed are then repeatedly bent up and down until the material exhibits fatigue along the scored lines, and the pieces then break off. Any roughness can be removed by gentle filing.

After the aluminium has been cut out it is bent round to form an incomplete circle with a diameter of 3 in. The three lugs are then bent up at right angles, and the visor is glued to the front panel with a good general purpose adhesive.

A graticule can be made from a piece of fairly thin Perspex, about 3 in. square. This is marked with a grid of 1 cm. squares which are made by deeply scribing the Perspex with a sharp pointed instrument. The X and Y axes would normally be calibrated at 1 mm. intervals, but this would be difficult to achieve and 2 mm. divisions are about the smallest which it is practical to mark by hand. In the prototype, the graticule had 1 cm. rulings only.

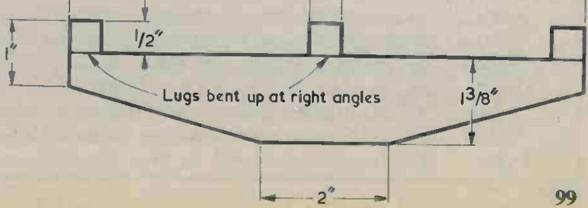
The graticule is glued to the inside of the front panel behind the c.r.t. cut-out using any good general purpose adhesive, such as Bostik No. 1.

MOUNTING T1

The tube is not fitted with magnetic screen and it is important that it should not be affected by the magnetic field from the mains transformer. In consequence it is necessary that the specified mains transformer be employed and that it be mounted in the correct position. The transformer specified is available from R.S.C. Hi-Fi Centres, Ltd., Audio House, Henconner Lane, Leeds, LS13 4LQ, or from any branch of R.S.C. Hi-Fi Centres.

The transformer must be mounted as far towards the rear of the case as possible, and on the extreme left hand side (behind the tube). It must also be mounted on its side, and so cannot be directly fitted to the chassis by its mounting lugs. An L-shaped mounting bracket is made from 16 s.w.g. aluminium, and this provides a firm mounting for the transformer. The laminations are vertical.

Fig. 5. The dimensions of the visor before this is bent into shape



COMPONENTS

Resistors
(All fixed values ¼ watt 10% unless otherwise stated).

R1	1.5MΩ
R2	1.5MΩ
R3	15kΩ 5 watt
R4	3.3kΩ
R5	1.2kΩ
R6	5kΩ pre-set potentiometer, horizontal miniature skeleton
R7	2.2kΩ
R8	2.7kΩ
R9	330kΩ
R10	330kΩ
R11	10MΩ
R12	3.9kΩ
R13	130kΩ 2%
R14	4.7kΩ 2%
R15	33kΩ ½ watt 2%
R16	1kΩ 2%
R17	33kΩ ½ watt 2%
R18	560kΩ
R19	8.2kΩ
R20	10MΩ 5% hi-stab
R21	1MΩ 2% hi-stab
R22	100kΩ 2% hi-stab
R23	11kΩ 2% hi-stab
R24	110Ω 5% hi-stab
R25	220Ω
R26	3.9kΩ
R27	2.5kΩ pre-set potentiometer, horizontal miniature skeleton
R28	27kΩ ½ watt 2%
R29	6.8kΩ
R30	2.2kΩ
R31	1.5kΩ 2%
R32	27kΩ ½ watt 2%
R33	3.9kΩ
R34	2.5kΩ pre-set potentiometer, horizontal miniature skeleton
R35	10kΩ
R36	5.6kΩ
R37	5.6kΩ 2%
R38	1.2kΩ 2%
R39	12kΩ 2%
R40	47kΩ or 50kΩ pre-set potentiometer, horizontal skeleton (see text)
R41	4.7kΩ
R42	2.7MΩ
R43	4.7kΩ
R44	2.7MΩ
R45	470Ω
R46	390kΩ
R47	6.8kΩ
R48	2.2kΩ
R49	3.9MΩ
R50	56kΩ
R51	120kΩ
R52	220kΩ
R53	39kΩ
R54	1MΩ
VR1	500kΩ potentiometer, carbon linear
VR2	25kΩ potentiometer, carbon linear
VR3	2MΩ potentiometer, carbon linear
VR4	1kΩ potentiometer, carbon linear
VR5	5kΩ potentiometer, carbon linear
VR6	250kΩ potentiometer, carbon linear
VR7	10kΩ potentiometer, carbon linear
VR8	500kΩ potentiometer, carbon linear

Capacitors

C1	1,000μF electrolytic, 16 V. Wkg.
C2(a) (b)	32 + 32μF electrolytic, 350 V. Wkg.
C3	4μF block paper, 600 V. Wkg.
C4	1,000μF electrolytic, 16 V. Wkg.
C5	50μF electrolytic, 10 V. Wkg.
C6	0.1μF type C280 (Mullard)
C7	100μF electrolytic, 10 V. Wkg.
C8	1,000pF ceramic or silvered mica (see text)
C9	0.1μF plastic foil
C10	6,800pF plastic foil (see text)
C11	100μF electrolytic, 16 V. Wkg.
C12	100μF electrolytic, 16 V. Wkg.
C13	10μF electrolytic, 16 V. Wkg.
C14	100μF electrolytic, 16 V. Wkg.
C15	2.2μF plastic foil 5% (see text)
C16	0.22μF plastic foil 5% (see text)
C17	0.022μF plastic foil 5% (see text)
C18	2,200pF plastic foil 5% (see text)
C19	10μF electrolytic, 16 V. Wkg.
C20	10μF electrolytic, 16 V. Wkg.
C21	10μF electrolytic, 16 V. Wkg.
C22	10μF electrolytic, 16 V. Wkg.
C23	2,000pF or 2,200pF paper or plastic foil, 750 V. Wkg.

Transformer

T1	Mains transformer, secondaries 250–0–250 V at 60mA, 6.3V at 2A, 0–5–6.3V at 2A, fully shrouded, upright mounting. Northern Transformers, Ltd., type FSM.256. (see text)

Semiconductors

IC1	NE555V or equivalent
TR1	2N3711
TR2	BC169C
TR3	2N3819
TR4	BC117
TR5	BC117
TR6	2N3819
TR7	BC117
TR8	2N3702
TR9	BC117
TR10	2N3819
TR11	BC169C
TR12	BC258
TR13	BC169C
TR14	BC169C
TR15	2N708
TR16	BC117
D1	1N4002
D2	1N4002
D3	1N4007
D4	1N4007
D5	1N4006
D6	BZY88C24
D7	ZL100 (see text)
D8	BZY88C6V8

Cathode Ray Tube
C.R.T. type 3BP1

COMPONENTS

continued

Switches

S1	d.p.s.t. toggle
S2	3-pole 4-way miniature rotary
S3	2-pole 6-way, adjustable end stop (see text)
S4	s.p.s.t. toggle

Miscellaneous

Case, Contil Mod 2, size Q (see text)
10 control knobs
B14A c.r.t. base
3-way tagstrip, centre tag earthed
Capacitor clip (for C2)
5-off 3mm. insulated sockets
Perspex for graticule
Printed circuit board
Sundry tagstrips, connectors for under-chassis wiring
Screened lead
Aluminium sheet for c.r.t. mounting, etc.
Connecting, wire, solder, etc.

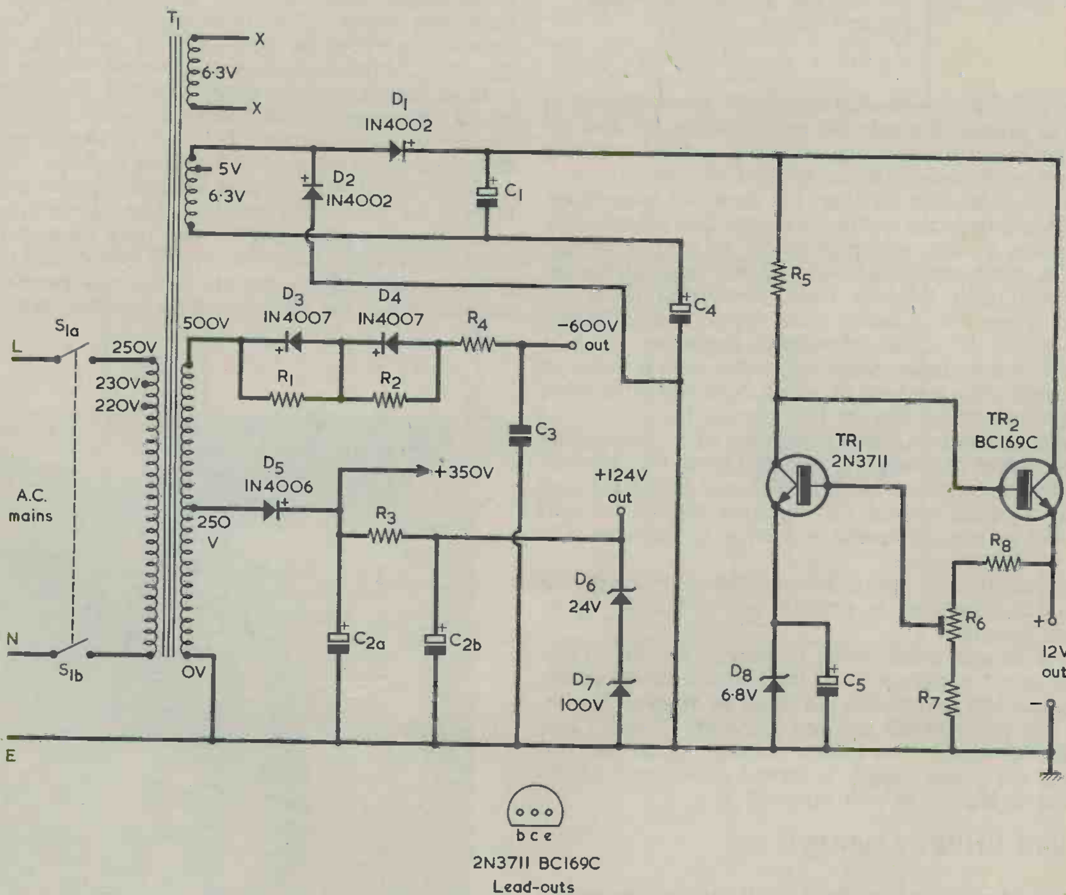


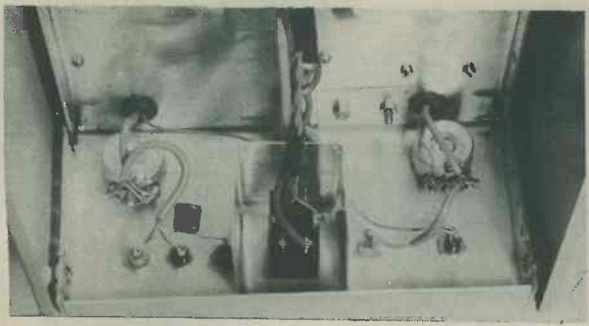
Fig. 6. The circuit of the power supply

POWER SUPPLY

The circuit diagram of the power supply section of the oscilloscope is shown in Fig. 6. This provides d.c. voltages of –600, +350, +124, and +12 together with an a.c. voltage of 6.3.

One of the two 6.3 volt secondary windings is used to power the c.r.t. heater, and the other is coupled to a voltage doubler circuit consisting of D1, D2, C1 and C4. This arrangement is an improvement over the previous design as the c.r.t. heater is fed from a separate winding. The high voltage that appeared between the c.r.t. heater and cathode in the earlier oscilloscope is absent in the present circuit.

The output of the voltage doubling rectifier is fed to a regulator circuit. This has a zener voltage reference source, D8, an amplifier, TR1, and an emitter follower output stage, TR2. A negative feedback loop is provided via R8, R6 and R7, R6 being adjusted to give an output voltage of 12. This is a well-known circuit configuration and, even though very few components are required, gives a well smoothed and regulated output.



Internal view illustrating the wiring to the X and Y inputs, and the screens around the mains on-off switch

The 250–0–250 volt windings of T1 are employed in series to provide a single 500 volt winding. D3 and D4 give half-wave rectification, with R1 and R2 ensuring that approximately half the applied reverse voltage is present across each rectifier. C3 provides smoothing, and R4 controls the output voltage. This resistor has been given a value which produces an output voltage of −600, 100 volts greater than in the original design. The result is a brighter trace. Note that the e.h.t. output is negative of earth, while the other d.c. outputs are positive of earth. Smoothing capacitor C3 is a non-electrolytic paper block capacitor with a value of 4μF at 600 volts working. A block capacitor with these ratings is listed by Doram Electronics, Ltd.

The centre-tap on the h.t. winding of T1 is coupled to a half-wave rectifier, D5, and then to an RC smoothing network consisting of C2(a), R3 and C2(b). R3 also acts as the load resistor for the zener diodes, D6 and D7, which are connected in series to provide 124 volts at the output.

The potential of approximately 350 volts appearing across C2(a) is used to provide power for the astigmatism control.

The 100 volt zener diode employed for D7 is the ZL100, rated at 10 watts. If this cannot be obtained, alternative 100 volt diodes, all listed by Henry's Radio, Ltd., are Z5D1000BF (10 watt), ZS100 (7 watt) and 3VR100 (3 watt). The lowest wattage diode may run warm if the power supply is turned on without a load coupled to the +124 volt output.

POWER SUPPLY WIRING

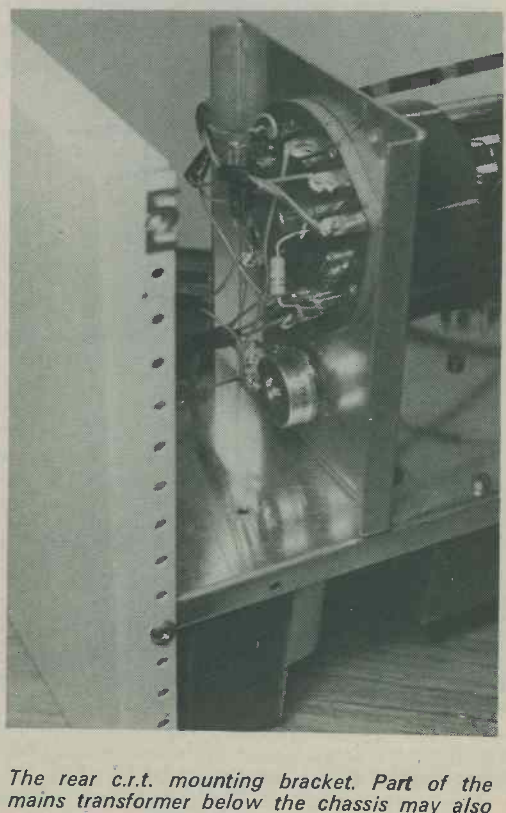
With the exception of the 12 volt section, the power supply wiring is carried out using a point to point wiring system under the chassis. Tagstrips and connector blocks are employed where necessary. The +12 volt and +124 volt outputs are taken one each to the non-earthed tags of a 3-way tagstrip mounted above the chassis. See Fig. 3. From here the supplies are distributed to the X and Y amplifiers, etc.

A printed circuit board is used as the basis for the 12 volt supply. Fig. 7 shows the copper pattern and component layout of this panel. The board measures 4¼ by 2 in., and the diagram is reproduced actual size, as are all the other printed circuit board etching diagrams in the following parts of this article. This permits the designs to be easily traced. The letters X-X in Fig. 7 indicate the same edge in both views.

The component panel is mounted by four ¾ in. 6BA bolts in the position shown in Fig. 3, the bolt heads being below the chassis. One or two extra nuts are placed over the bolts between the chassis and the panel to space the board a little way clear of the chassis. Shake-proof washers can be placed over these nuts at edge X-X to ensure that a good connection is made between the chassis and the copper backing round the board mounting holes. This connection carries the negative supply between the chassis and the panel.

The other four component panels, which are described later, are all mounted in the same manner.

It is necessary to provide a small screen behind the front panel to shield on-off switch S1 from the X and Y inputs on either side, and from the sync switch, S4, immediately above it. The screening extends backwards for about 1¾ in. Shielding from the X and Y inputs is achieved by bending a 1⅜ by 4½ in. strip of 22 s.w.g. aluminium into a U-shape with a central hole so that it may be secured on the mounting bush of S1. Screening from the sync switch is given by bending a second strip of 22 s.w.g. aluminium, this time measuring 1½ by 3 in. into an L-shape. This has a hole which enables it to be mounted on the mounting bush of S4. Both these screens can be seen in one of the accompanying photographs, and their dimensions are not critical. The 3-core mains input lead passes through a hole fitted with a grommet in the rear panel, and is secured under the chassis with a suitable clamp.



The rear c.r.t. mounting bracket. Part of the mains transformer below the chassis may also be seen

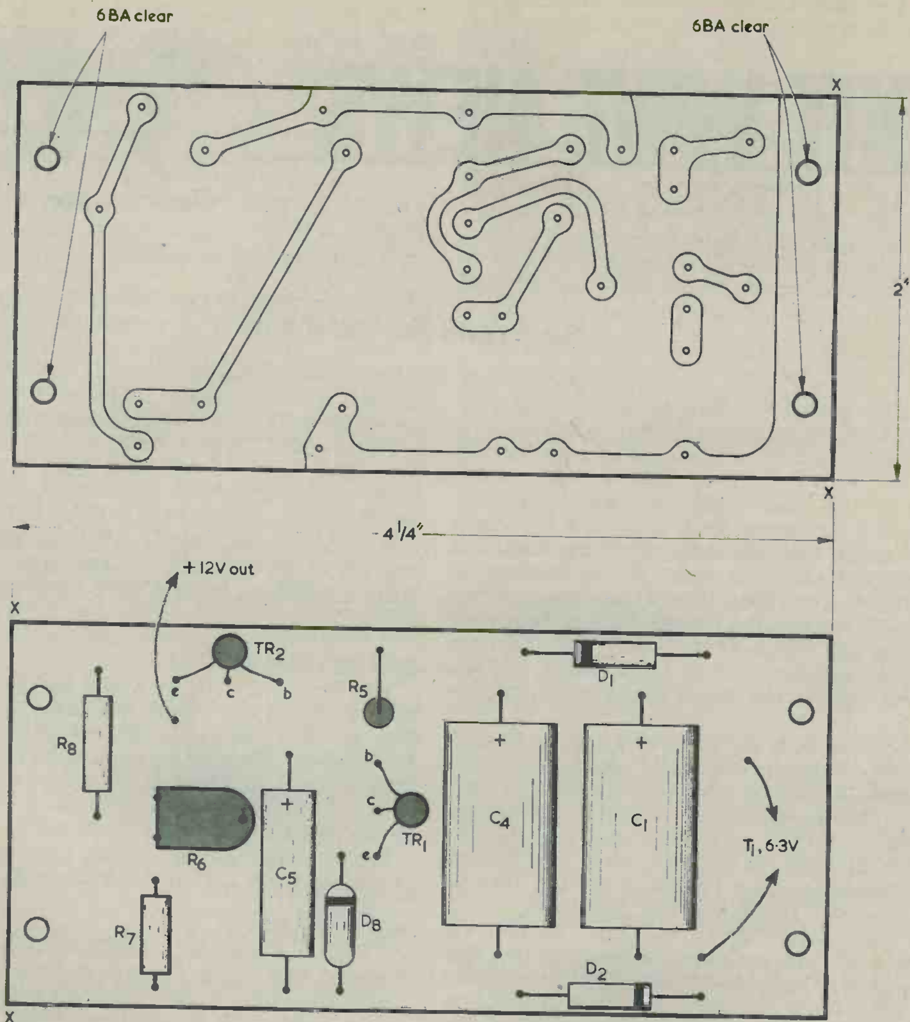


Fig. 7. The copper and component sides of the board on which is assembled the 12 volt section of the supply

The completed power supply should be carefully checked for wiring mistakes. It may then be switched on and the various output voltages measured to ensure that they are all approximately correct. As the 124 volt supply is zener controlled it should be within some 5% of the specified voltage, but as the e.h.t. supply is unloaded at this stage it will probably be a little greater than 600 volts. R6 is then adjusted to provide an output of precisely 12 volts from the low voltage component panel. The power supply should not be turned on for a long period when no loads are connected to its outputs.

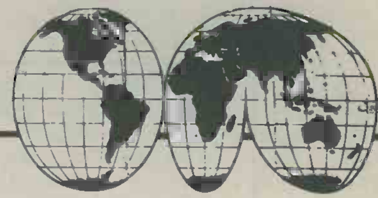
COMPONENTS

For completeness the full Components List is published in this issue but it will, of course, be evident that textual references to some of the components will appear in the succeeding parts of this article. The cathode ray tube is a 3BP1, and this is available together with the tube holder from Henry's Radio, Ltd. The 3BP1 is a surplus tube which has been out of manufacture for a number of years but we are assured that good stocks are still available. Nevertheless, readers are advised to make certain that they have the tube before obtaining any other components.

In next month's issue further constructional details will be given, these including descriptions of the display section, the X and Y amplifiers, and the timebase and sync circuits.

(*To be continued*).

SHORT WAVE NEWS
FOR DX LISTENERS



By Frank A. Baldwin

Times = GMT *Frequencies* = kHz

Rather interesting transmissions are being made via the facilities of Radio Tanzania, Dar-es-Salaam, in the External Service on **15435**. One of these programmes, the Zimbabwe "Voice of the Revolution", is mentioned under our heading "Around the Dial", but there are other transmissions which may be of some interest, all being sent out on the above frequency from Dar-es-Salaam.

Our log book records the entry of a talk in English at 1915 in the "Voice of Namibia" programme, this being presented by the South West African People's Organization. The programme is in English, Afrikaans and vernaculars and the schedule of this transmission is from 1915 to 1930 on Sundays, 1915 to 1945 on Mondays, Wednesdays and Fridays and from 1945 to 2015 on Tuesdays, Thursdays and Saturdays.

There is also, according to the BBC Monitoring Service, the PAC programme presented by the Pan African Congress in English, Afrikaans and vernaculars from 1930 to 1945 on Sundays, Tuesdays, Thursdays and Saturdays; the ANC programme presented by the African National Congress in English, Afrikaans and vernaculars from 2000 to 2015 on Sundays, Mondays, Wednesdays and Fridays; the Molinaco programme presented by the Movement for the Liberation of the Comoro Islands in French and vernaculars daily from 1815 to 1830, also in parallel on **4785** (Molinaco programme only).

CURRENT SCHEDULES

● AUSTRIA

"Radio Austria", Vienna, radiates in English to Europe from 0830 to 0900 on **6115**, **11835**, **15410**, **17850** and on **21675**; from 1230 to 1300 on **6155**, **9770**, **11970** and on **17740**; from 1830 to 1900 on **6155**, **9690**, **15335** and on **17770**.

● GERMANY (WEST)

"Deutsche Welle – The Voice of Germany", Cologne, does not operate in English to Europe or the U.K. but may be heard in English to Asia and Australasia from 0930 to 1030 on **9650**, **11850**, **11925**, **15275** and on **17800** (also relayed from Kigali, Rwanda on **17780** and **21540**); to Central and East Africa from 1045 to 1115 on **17765**, **17875**, **21500** and on **21600** (also relayed from Kigali on **11785** and **15410**); to West Africa from 1200 to 1245 on **17875** and **21600** (relayed from Kigali on **15410** and **17765**); also to West Africa from 1930 to 2000 on **9765**, **11785** and on **15150**.

● NORTH VIETNAM

The First Network of Radio Hanoi, in Vietnamese to both North and South Vietnam, is scheduled from 0756 to 1700 and from 2055 to 0630 on **4932**, **6450**, **7373** and on **10056**. Also from 0756 to 1525 and from 2200 to 0630 on **4706**.

● SOMALI REPUBLIC

Radio Mogadishu has a daily news and commentary in English from 1215 to 1230 on **6095**, **7120** and **9585**.

● TANZANIA

"Radio Tanzania", Dar-es-Salaam, operates an External Service in English and vernaculars to East Africa from 0330 to 0430 and to Central and Southern Africa from 0430 to 0530 on **6105**. To East Africa from 0930 to 1030 on **9750**; to East Central and South Africa from 1600 to 1830 on **4785** and on **15435**; to Central and Southern Africa from 1830 to 2015 on **4785** (until 1915) and on **15435**.

● U.S.S.R.

"Radio Moscow" has an External Service to the U.K. and Eire from 1130 to 1230 on **9450**, **11705**, **11745**, **11830**, **11900** and on **11950**; from 1900 to 1930 on **6045**, **7205**, **7310**, **7390**, **9550** and on **9710**; from 2000 to 2030 on **6045**, **7205**, **7310**, **7390**, **9550**, **9610**, **9640** and on **9710**; from 2100 to 2200 on **6045**, **7310**, **7390**, **9550**, **9610**, **9710** and on **11805**; from 2200 to 2230 on **6045**, **7390**, **9610** and on **9710**.

Some other transmissions from the U.S.S.R. that may possibly be of interest to readers, even if it's just simply to claim that you have heard them, are –

Relay of the Moscow Second Programme "Mayak", in Russian, from 1800 to 1830 on **5935**, **7100**, **7390**, **9560**, **9670**, **11750**, **11755**, **11790**, **11800**, **11880**, **15150**, **15440**, **15450** and on **15455**.

The Fifth Programme "Atlantika" (for Russian ships crews in the Atlantic) from 1630 to 1730 on **9560**, **11705**, **15150**, **15440** and on **15455**.

"Radio Station Peace and Progress", in English to Asia from 1530 to 1600 on **12035**, **15200**, **15295**, **17805** and **17870**.

"Voice of the Soviet Homeland", in U.S.S.R. languages to Europe from 1400 to 1500 on **7330**, **9450**, **11830**, **12010**, **12015**, **12020**, **12025**, **15150**, **15305**, **15425**, **15455**, **15460** (from 1430) and on **17775**.

● U.S.S.R. (REGIONAL RADIO CENTRES)

External Services are also radiated from various regional centres –

"Radio Baku" from 1300 to 1950 in Persian, Azerbaijani, Turkish and Arabic on **6110** and **9840**. Listen, for instance, to the programme in Arabic from 1630 to 1700.

"Radio Dushanbe" from 1400 to 1830 on **7300** in Persian and Tadzhik. Listen for one of the Persian programmes from 1800 to 1830.

"Radio Kiev" from 1530 to 0400 in English, German, Moldavian and Ukrainian. Listen for the English programme to Europe on Mondays, Thursdays and Saturdays from 1930 to 2000 on **6045**, **7205**, **7330** and on **7390**. Also in English to the Americas from 0030 to 0100 on **6020**, **7195**, **7220**, **7295**, **9500**, **9540**, **9600**, **9635**, **9665**, **9690**, **11690**, **11720**, **11735**, **12000**, **12040**, **12050**, **15210**, **15245**, **17720**, **17900**.

"Radio Leningrad" from 2230 to 2330, in Russian for Soviet Fishermen (Fridays only) on **7250**.

"Radio Minsk" from 1800 to 1830 and from 2130 to 2200, in Belorussian for Europe. From 1800 to 1830 on **7310**, **9710**, **9785**; from 2130 to 2200 on **5960**, **7160** and on **7340**.

"Radio Riga" from 0800 to 0915, from 1200 to 1300 and from 1930 to 2200 on **5935**. Listen for the programme in Swedish to Europe from 2020 to 2050.

"Radio Tallin" from 0800 to 1000, from 1600 to 2200 on **6085** in Finnish, Swedish and Estonian. Listen for the programme in Swedish from 2105 to 2135.

"Radio Tashkent" from 1200 to 1800 on several channels. Listen for the programme in English to South Asia from 1400 to 1430 on **11730**, **11925**, **15115** and on **15460**.

"Radio Tbilisi" from 1900 to 2100 in Georgian to Europe and the Middle East on **5930** on Tuesdays, Fridays and Sundays.

"Radio Vilnius" from 2200 to 0100 in Lithuanian and English. Listen for the programme in English to Europe and North America from 2230 to 2300 on Saturdays and Sundays only on **9685**, **9735**, **9745** and on **11770**.

"Pacific Ocean Radio Station", Vladivostok, in various time periods and on many channels. Listen for the English language lesson from 1930 to 2000.

"The Voice of Armenia", Yerevan, from 0300 to 2200, listen for the programme in French to Europe from 0850 to 0900 on **12030**, **15190**, and on **15260**, also for the programme in Arabic to the Arabic world from 1830 to 1900 on **4990** and on **6120**.

AROUND THE DIAL

● NORTH KOREA

Pyong yang at 2000 on **6576** with station identification and programme in English.

● GHANA–1

Tema at 1450 on **21545**, songs in a local dialect, African music, drums at 1500 then identification and the news in English.

● KUWAIT

Radio Kuwait at 1930 on **11940**, pop record programme with announcements in English, identification at 2000.

● AUSTRALIA–1

Brisbane at 1958 on **4920**, organ music, 6 pips at 2000 then newscast of world and local events.

● ZAMBIA

Lusaka at 1910 on **3295**, lengthy discussion in vernacular which lasted until 1930 then into programme of local music and songs. The evening schedule is from 1600 to 2105 weekdays and to 2005 on Sundays, all programmes are in local dialects and the power is 10kW.

● GHANA–2

Ejura at 1934 on **3366**, OM with talk in English, African drums then programme of local pops. This is the Commercial Service, the evening schedule of which is from 1600 to 2300, 10kW.

Ejura at 2005 on **4980**. OM with a newscast in English. This is also the Commercial Service, schedule daily is from 0530 to 2300, 20kW.

● UPPER VOLTA

Ouagadougou at 1915 on a measured **4816**, OM with identification in French, drums, local music then YL with a talk in French. The evening schedule is from 1700 to 2300 and the power is 20kW.

● TANZANIA

Dar-es-Salaam at 1940 on **15435**, OM in vernacular with the Zimbabwe programme "Voice of the Revolution", this being presented by the African National Council. The schedule of this programme, in English and vernaculars, is from 1915 to 1930 on Tuesdays, Thursdays and Saturdays and from 1945 to 2000 on Sundays, Mondays, Wednesdays and Fridays.

● AUSTRALIA–2

Radio Australia, Melbourne, at 0645 on **15270** with the interval signal – musical box rendition of "Waltzing Matilda", identification and commencement of the English programme directed to the U.K. This transmission is via the short path, that in parallel on **9570** is via the long path.

● INDIA

All India Radio, Delhi, at 2015 on **11620**, interviews with government ministers about internal affairs in the English programme.

● UGANDA

Kampala at 2055 on **4976**, African drums and music, station identification and the news in English at 2100.

● DOMINICAN REPUBLIC

Radio Norte, Santiago, at 0050 on **4807**, typical Latin American music with several identifications and time-checks in Spanish, full identification at 0100.

● VENEZUELA

Radio Popular at 0130 on **4810**, local music, songs in Spanish, many identifications.

Radio Maracaibo at 0150 on **4860**, record programme of local pops, identification in Spanish and time-check at 0200.

DUAL VOLTAGE POWER SUPPLY

By S. Essex

The addition of another diode to a bridge rectifier makes a second rectified output available.

OFTEN A NEED IS FELT FOR A MAINS POWER SUPPLY capable of providing two output voltages simultaneously, and these are usually given by two mains transformers or by two secondary windings on a single mains transformer. This article outlines a method by means of which, if the two rectified voltages required are such that one is double the other, a single centre-tapped transformer winding can supply both with only one additional diode rectifier. The method may also be employed to obtain a second rectified voltage from an existing bridge rectifier circuit when this is supplied by a centre-tapped mains transformer winding.

BASIC CIRCUIT

The basic circuit is shown in Fig. 1. In the circuit description which follows it will be assumed that no forward voltage is dropped across any conducting rectifier.

Let us commence by considering the bridge rectifier circuit on its own, and say that the peak voltage across the centre-tapped secondary winding is V volts. At the half-cycle peaks when the upper end of the winding is positive, as in Fig. 2(a), conventional current (from

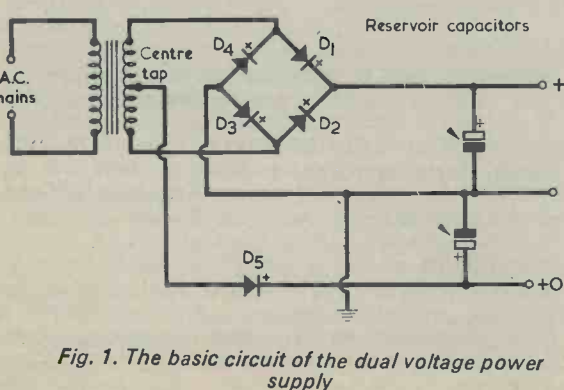
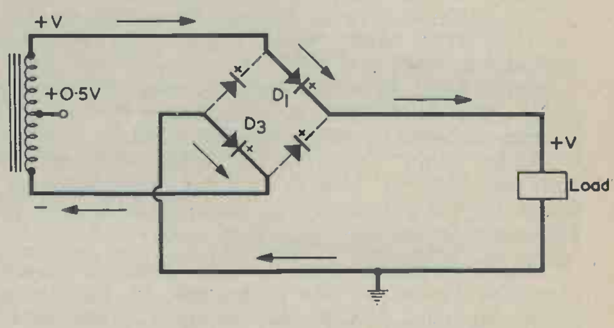


Fig. 1. The basic circuit of the dual voltage power supply



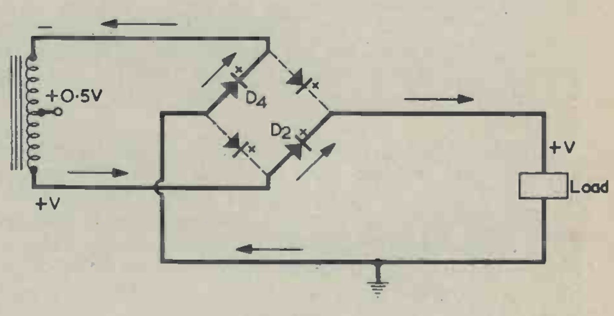


Fig. 2 (a). Current flow, as indicated by the arrows, in the bridge rectifier when the upper end of the transformer secondary is positive
(b). The current flow on the alternate half-cycles when the upper end of the winding is negative

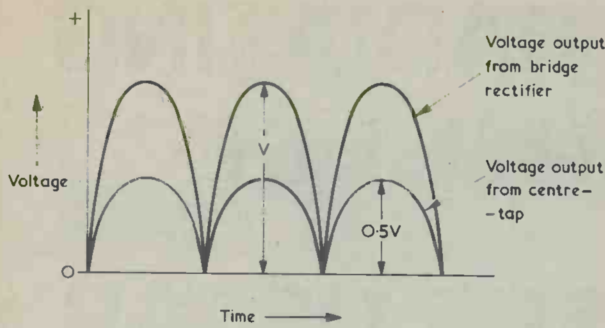


Fig. 3. Voltage waveforms at the output of the bridge rectifier (without a reservoir capacitor) and the secondary centre-tap

positive to negative) will flow through D1, the load and D3 back to the lower end of the winding. D2 and D4 are reverse biased and do not conduct. Since D3 is conductive the lower end of the winding is at the same potential as the zero voltage earth line. From this it follows that the centre-tap of the winding is positive of the earth line by 0.5V.

On the alternate half-cycle peaks when the upper end of the secondary is negative, as illustrated in Fig. 2(b), current flows from the lower end of the winding through D2, the load and D4 to the upper end of the winding. Since D4 is conductive, the upper end of the winding is at the same potential as the earth line. Once again, the winding centre-tap is positive of the earth line by 0.5V.

Fig. 3 shows the output voltage from the bridge rectifier, assuming that no reservoir capacitor is connected across it, together with the voltage at the centre-tap. Both voltages are with respect to the earth line. If a reservoir capacitor is connected across the output of the bridge rectifier, as it is in Fig. 1, it will charge up to the peak value of V volts. Similarly, if the centre-tap of the winding is coupled via a diode to a second reservoir capacitor, as is also shown in Fig. 1, a series of positive 0.5V peaks will be applied to it, and the second reservoir capacitor will charge up to 0.5V. The series diode is necessary since, if the second reservoir capacitor were connected directly to the centre-tap the bridge circuit could become unbalanced when a high load current is drawn from the bridge rectifier reservoir capacitor and a low load current from the 0.5V reservoir capacitor.

ALTERNATIVE OPERATION

If desired, the power supply may be operated with the 0.5V line connected to earth, whereupon two equal voltages of 0.5V which are positive and negative of earth are provided. The circuit is shown in Fig. 4. There is a serious restriction on the use of this arrangement, however, this being that the load current between earth and the negative 0.5V line must be greater than the load current between the positive 0.5V line and earth.

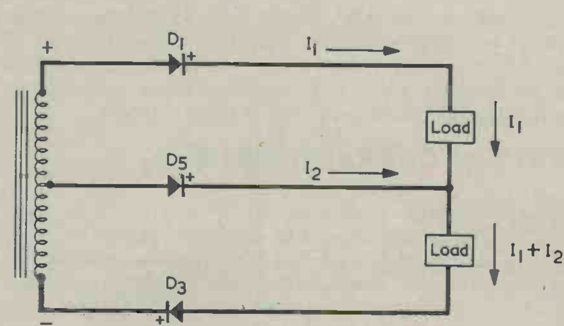


Fig. 5. It is necessary for the current to the negative line in Fig. 4 to be greater than that from the positive line if the required output voltages are to be maintained

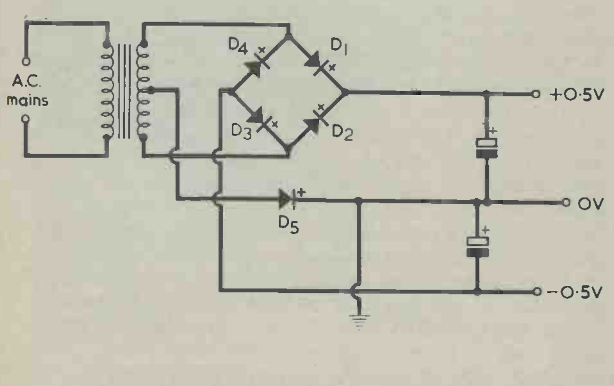
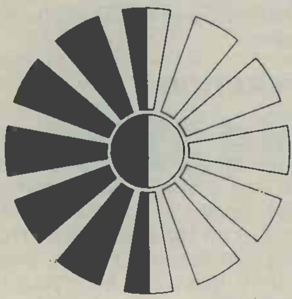


Fig. 4. Employing the circuit to produce equal voltages on either side of earth

The reason for the restriction is illustrated in Fig. 5. Here, the upper end of the transformer secondary is positive and diodes D1 and D3 in the bridge are conductive. The current in the upper load is the bridge rectifier current, whereas the current in the lower load is the bridge rectifier current plus the current passed by D5. Thus, for D5 to remain conductive the current in the lower load must be greater than that in the upper load. If it is not D5 becomes non-conductive and the earth line will take up a potential that is positive of the centre voltage between the positive and negative lines. A similar situation will arise on the alternate half-cycles when D2 and D4 are conductive.

For both the circuits of Fig. 1 and Fig. 4, the p.i.v. rating for the four bridge rectifier diodes should be greater than the peak voltage across the whole secondary winding, or greater than 1.414 times the r.m.s. secondary voltage. The p.i.v. rating for D5 should be greater than half the peak voltage across the secondary winding. ■

VERTICALLY RADIATING ANTENNA FOR OSCAR



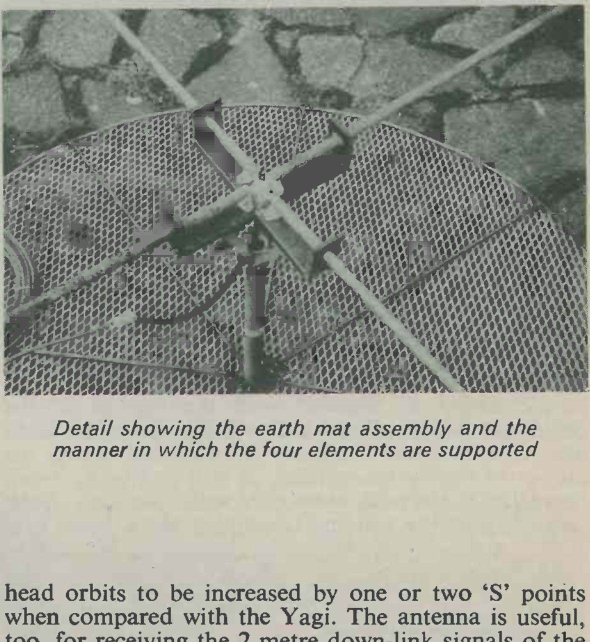
By Arthur C. Gee

THOSE READERS WHO READ THE WRITER'S ARTICLE, 'Tracking OSCAR', in the July 1974 issue of this journal will appreciate that, every so often, an orbit of OSCAR will pass more or less overhead. These orbits are particularly good for communication purposes as the distances involved are then at their shortest.

VERTICAL CHARACTERISTIC

The horizontal Yagi antenna, most frequently used for OSCAR communication, radiates primarily in a horizontal direction and not, of course, upwards, If, therefore, the best use is to be made of these overhead orbits a separate antenna having vertical radiating characteristics is well worth installing.

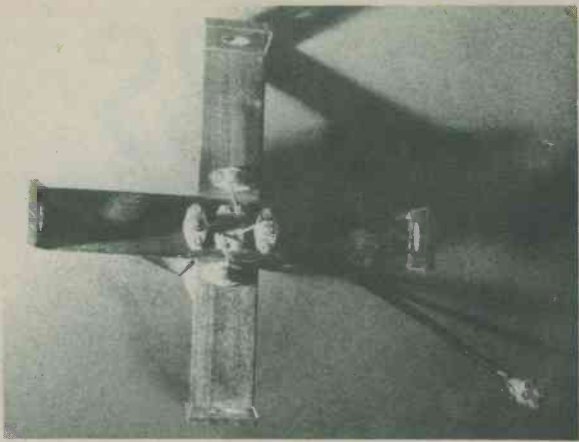
The writer has had such an antenna in use for a sufficient length of time to have been able to assess its performance. He has observed that without doubt it causes signal strength on many occasions during overhead orbits to be increased by one or two 'S' points when compared with the Yagi. The antenna is useful, too, for receiving the 2 metre down-link signals of the 70cm/2m repeater on OSCAR 7 when this is in a high amplitude orbit, and could be particularly appreciated by those who do not feel the expense and complication of installing a rotary beam is justified for this purpose.



Detail showing the earth mat assembly and the manner in which the four elements are supported

The completed vertical radiating antenna positioned on a flat garage roof

As can be seen from the accompanying diagram and photographs, the antenna comprises a crossed dipole array mounted above an artificial earth, the latter consisting of a metal 'mat' incorporating a circle of expanded metal. The expanded metal is strengthened by being fixed to a radial framework of metal rods terminating at a circular rod round the rim. This assembly can be home-constructed using stiff galvanised wire or, if preferred, it can be made up at a local metal prefabricating works or blacksmith's. The photographs give a good idea of how the earth mat is assembled, and its size and detailed construction are not critical. In the writer's case, the mat is 4 ft. in diameter. Arrangements must be made for the attachment of a short metal 'mast' at the centre to support the crossed dipole antenna.

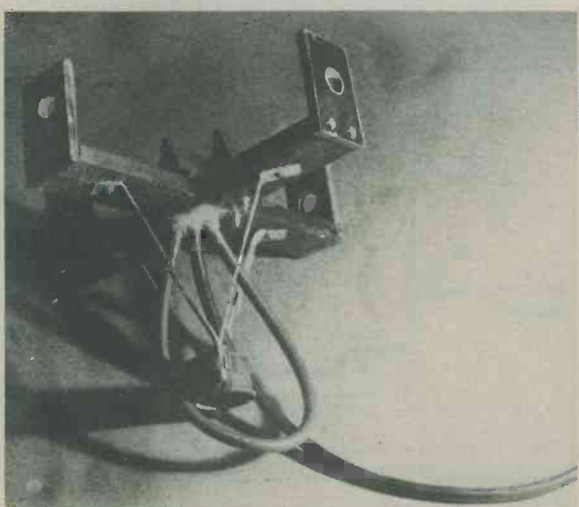


The inner ends of tne elements are secured to the four stand-off insulators shown here. The elements also pass through holes in the s.r.b.p. panels at the ends of the wooden cross arms

The antenna elements can be cut from old TV aerial tubing. The cross arms at the centre are of wood with four thick rectangular s.r.b.p. ('Paxolin') panels fitted at the ends. Each s.r.b.p. panel has a hole through which the associated element passes, and the inner ends of the elements are secured at four small stand-off insulators screwed to the wood. The wooden arms require a good coat or two of varnish to protect them against weather and damp.

ELEMENT LENGTH

The length of each element is $18\frac{1}{2}$ in. whereupon, taking in a gap of about 1 in. between the elements at the centre, the overall length of each dipole is 38 in. The dipoles have to be cross-connected by a phasing stub of 75Ω coaxial cable in the manner shown in the diagram.

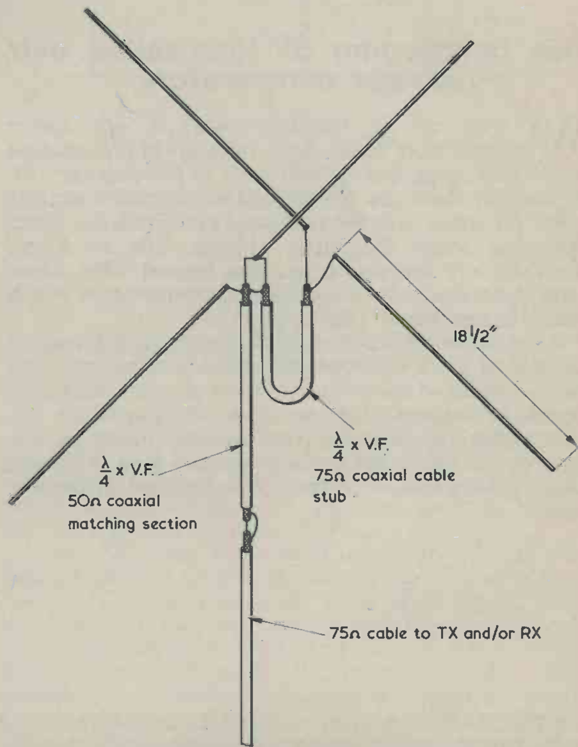


The method of mounting the cross arms to the mast. Also illustrated are the matching section and stub. All connections are made thoroughly weather-proof

The length of the stub should be a quarter wavelength multiplied by the velocity factor of the cable, which with 75Ω cable may be assumed to be 0.55. In the author's antenna the stub was made $10\frac{1}{2}$ in. long.

A matching section of 50Ω coaxial cable is also required to match the crossed dipoles to the 75Ω cable from the transmitter or receiver. The length of this section is again a quarter wavelength multiplied by velocity factor. Taking a velocity factor for 50Ω cable of 0.62, the matching section becomes $11\frac{3}{4}$ in. long.

The height at which the crossed dipole is mounted above the earth mat will determine the radiation pattern, and the experimentally minded can have an interesting time varying this if they like. In the writer's



The crossed dipoles forming the antenna require a 50Ω matching section and a 75Ω cross-coupling stub

case satisfactory vertical radiation was obtained with the crossed dipole 20 in. above the mat. It should be noted that no connection is made to the earth mat nor to the short mast supporting the dipole. When complete, the antenna can be placed on the shack or garage roof, as shown, or on any other suitable horizontal surface.

The writer employs the crossed dipole antenna in the following manner. The horizontal Yagi is used during the approach of the satellite then, when it reaches a point at a radius of about 200 miles from the writer's location, as indicated by the Tracking Indicator, a change is made to the vertical radiating antenna. The vertical antenna is used until the satellite has passed overhead – a period of 4 to 5 minutes – and then a return to the Yagi is made, this having in the meantime been rotated to its reciprocal bearing. ■

COMPARATORS

By D. Snaith

The functioning of long-tailed pair voltage comparators.

WE SEEM TO BE HEARING QUITE A BIT ABOUT comparators these days, notably in conjunction with timer integrated circuits such as the popular 555. In the 555 there are two comparators, one operating when an input voltage rises to $\frac{2}{3}$Vcc, and the other operating when the input voltage falls to $\frac{1}{3}$Vcc. Another very interesting i.c., the Intersil 8038 waveform generator, also contains two comparators which similarly operate at $\frac{2}{3}$Vcc and $\frac{1}{3}$Vcc.

It is always instructive to look directly at the internal circuits of i.c.'s and consider their functioning from the viewpoint of discrete component circuits. Integrated circuit techniques often result in designs which are quite some way removed from circuits employing discrete components, but the comparators used in devices such as the 555 can be readily understood in discrete terms.

COMPARATORS

Before proceeding further, it should be mentioned that there are a number of i.c.'s described as comparators which have been on the market for quite a few years now. These particular comparators are not the same as those in the 555 and 8038, and are roughly similar to operational amplifiers in that they have an inverting input and a non-inverting input. If the non-inverting input is taken positive of the inverting input the output swings positive, and if the non-inverting input is taken negative of the inverting input the output swings negative. Thus, the comparator compares the two input voltages and gives an output accordingly. The output swing with reference to earth with these comparator i.c.'s is limited to some 3 to 5 volts in the positive direction, and around zero volts in the negative direction. Comparators of this nature are, in consequence, intended normally for t.t.l. computer applications. Typical examples are the SN72710 and the SN72711.

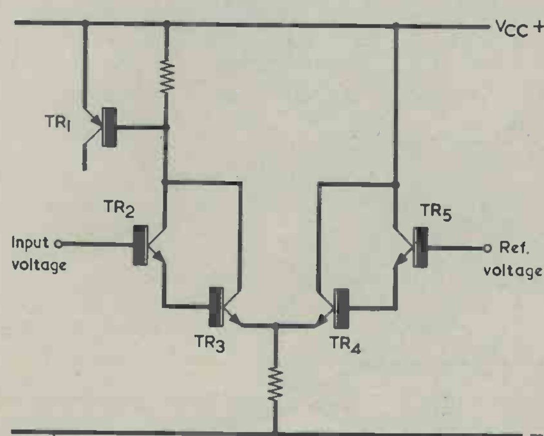


Fig. 1. An integrated circuit voltage comparator which causes TR1 to turn on when a positive-going input voltage is very close to the reference voltage

The comparators found in the 555 and similar devices are much simpler and merely employ four transistors in a long-tailed pair circuit. Fig. 1 shows a comparator which actuates an external circuit when an input voltage goes positive of a reference voltage. TR1 is a transistor which controls the external circuit. The long-tailed pair consists of two Darlington emitter followers, TR2 and TR3 forming one Darlington pair and TR4 and TR5 the other Darlington pair. The base of TR5 is coupled to a reference voltage which, in the 555, is $\frac{2}{3}$Vcc. The input voltage is applied to the base of TR2.

If the input is negative of the reference voltage TR2 and TR3 do not conduct. At the same time, TR4 and TR5 cause the voltage across the common emitter resistor to be equal to the reference voltage minus the voltage drop across two forward biased base-emitter junctions. If the input voltage is next caused to go positive, TR2 and TR3 will still pass no current until the input voltage is very close to the reference voltage. When the input voltage is equal to the reference voltage the two Darlington pairs pass equal currents, and when the input voltage has gone positive of the reference voltage only TR2 and TR3 conduct whilst TR4 and TR5 become cut off. They are cut off since the increasing positive input voltage has caused the voltage across the common emitter resistor to increase also.

When, as it goes positive, the input voltage very closely approaches the reference voltage, TR1 starts to pass current. It becomes fully conductive as the input voltage goes further positive. The speed with which TR1 turns fully on with increasing positive input voltage depends on the gain in TR2, TR3 and TR1 itself.

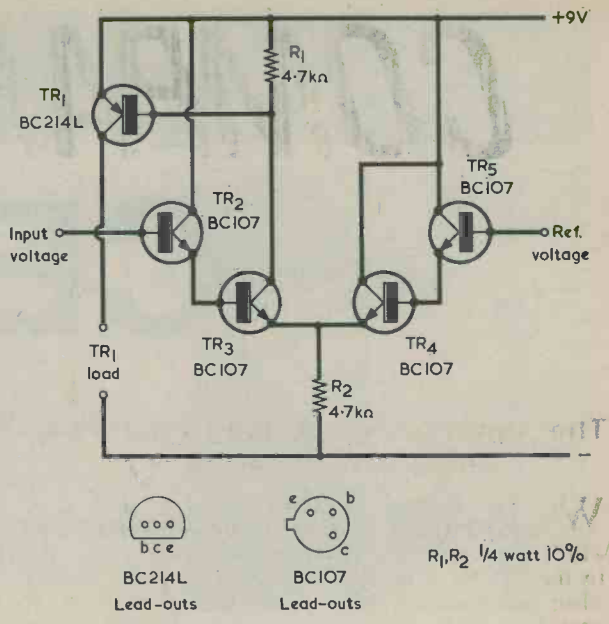


Fig. 3. A practical working comparator employing discrete components

NEGATIVE SENSING

A comparator which operates when an input voltage goes negative of a reference voltage is shown in Fig. 2.

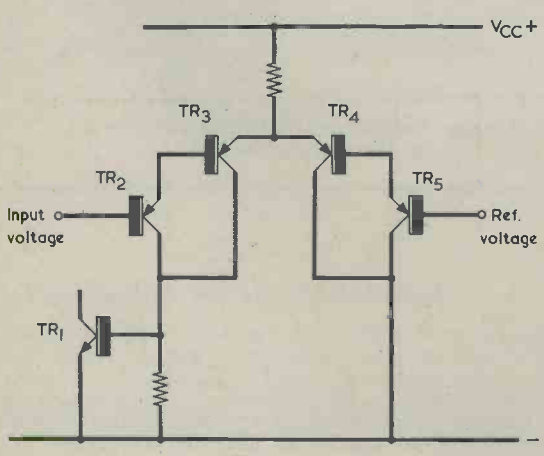


Fig. 2. By reversing all the polarities, a voltage comparator capable of responding to a negative-going input is produced

This is the same as Fig. 1 with all the polarities reversed, and it functions in the same manner. In the 555, the reference voltage is $\frac{1}{3}$Vcc.

In the 555 timer the control transistor, TR1, of the negative sensing comparator alters the state of a flip-flop. This comparator is the same as in Fig. 2, with the exception that the collector of TR2 is returned to the negative rail instead of to the collector of TR3. TR3 collector still couples to the base of TR1. This method of connection produces a somewhat more abrupt switching operation. Also, the common emitter resistor is replaced by a constant current source. The positive sensing comparator in the 555 is the same as Fig. 1 except that the control transistor is itself part of a flip-flop circuit, to which are also connected the collectors of TR4 and TR5. The two comparators in the 8038 i.c. are the same as in Figs. 1 and 2.

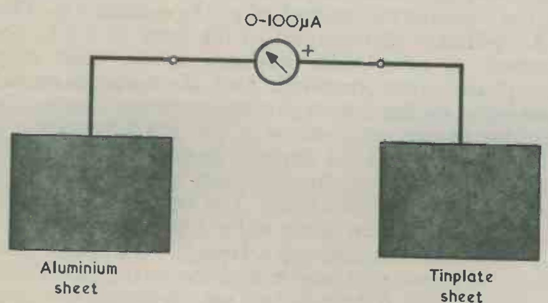
It is possible to make up a voltage comparator using discrete components, and a practical example is shown in Fig. 3. This is intended to operate when the input voltage goes positive of the reference voltage, and it functions in the same manner as Fig. 1. The collector of TR2 is returned to the positive rail instead of to the collector of TR3 in order to obtain a sharper turn-on in TR1. The circuit functions reliably for reference voltages between 2 and 8 volts positive of the negative rail. The input impedance at the base of TR2 is theoretically very high, but in practice it is desirable to keep the impedance of the input voltage source to less than around 500kΩ. The reference voltage may be obtained, if desired, from the slider of a pre-set 25kΩ potentiometer connected across the supply rails. For fast operation, the load current drawn from TR1 should be kept below some 5mA. ■

HUMAN CELL

By D. W. Savage

Or how to obtain energy (but not much of it) for absolutely nothing.

TAKE A SHEET OF ALUMINIUM AND ANOTHER SHEET OF tinplate. Connect the negative terminal of a 0–100μA meter to the aluminium sheet and the positive terminal of the meter to the tinplate sheet, as in the accompanying diagram. Then place one of your hands palm down on the aluminium sheet and the other palm down on the tinplate sheet. According to the areas of contact between your hands and the two sheets, the meter will give a current indication of 20μA or even more.



Two metal sheets are all that are required to set up a human electric cell

CELL ELECTRODES

What is happening here is that the two dissimilar metals form the electrodes of a cell. The electrolyte is provided by your body. The current produced varies with different people and, in general, is lowest with people having dry skin.

If available, a 0–50μA meter may be employed instead of the 0–100μA meter, and this will give a more dramatic effect because of the correspondingly greater deflection of its needle. The meter can consist of a testmeter switched to a 100μA or a 50μA range, if this is more convenient. A voltmeter connected to the two sheets can give readings of up to 0.5 volt.

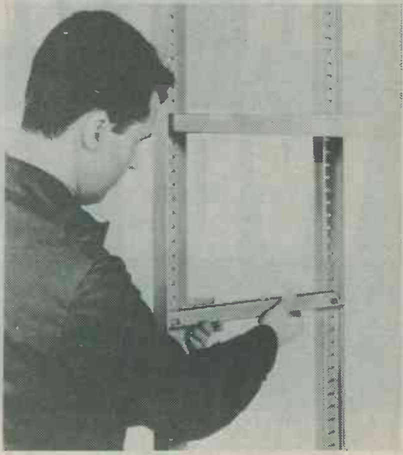
The sheets may be replaced by other objects of the same metal, such as cylindrical cans, provided that it is possible to obtain good contact between the hands and the metal. A current reading will not be given if the tinplate has been 'passivated' or has had a similar anti-corrosion surface treatment. Finishes of this nature can usually be recognised as they give the metal a yellow sheen.

Current readings are given with other dissimilar metals and an interesting field of experiment offers itself here.

We are suffering an energy shortage so, perhaps, individual people could in the future be provided with their own personal aluminium and tinplate electrodes. When enough people are present at one place, as at a football ground, they could then all be hooked up in series to produce a really sizeable human battery! ■

Trade News . . .

POLSTORE 83 SHELVING



The basic framework for a single bay is constructed from four special T-section uprights, a bottom and a top shelf. The uprights and shelves interlock and are secured at each corner by bolts which screw into backing plates having a V-shaped profile. Intermediate shelves sit on supports which are simply clipped into slots in the uprights.

Further bays are erected by using two uprights and top and bottom shelves for each bay.

The Rapid 83 system provides very rigid shelving with shelves that are easy and quick to move. The finish is in a tough stoved lacquer, charcoal grey for the uprights and light stone grey for the shelves, which makes shelving equally suitable for use in office, warehouse or factory.

A wide range of fittings and accessories enable the shelving to be easily fitted and economically adapted to a wide variety of uses.

A descriptive brochure is available from Polstore (Materials Handling) Limited, P.O. Box 23c, Esher, Surrey.

LITESOLD DE-SOLDERING TOOL

Suction to remove the solder melted by the electrically heated tip is provided by a stiff rubber bulb which is depressed by the thumb before applying the tip to the joint. Once the solder has melted the bulb is released and the solder is drawn into the tip/filter chamber assembly. The solder remains molten and is ejected by firmly squeezing the bulb.

Two tip bore sizes, 2 mm and 1.2 mm accommodate most component lead sizes. The tips are made of Permabit material for long life and the tool may be used as a normal soldering iron when components have to be replaced.

An effective tool for one-handed operation, the Litesold Adamin de-soldering tool is suitable for use on production rework stations, service departments and by field service engineers.

Full details are available from the manufacturers, Light Soldering Developments Limited, 97-99 Gloucester Road, Croydon, Surrey.

AUTOMATIC WIRE STRIPPER

The Scotchlok TH 213 tool is a pliers type stripper which operates without adjustment on wires from 0.75 to 6 mm^2 conductor area ($\frac{1}{32}$ to $\frac{1}{4}$ in^2). Quick and easy to use, the tool cuts into the insulation and strips it from the core in one simple action, without risk of damage to solid or stranded conductors. The TH 213 has a spring loaded return action so that it is always ready for immediate use, and has an auxiliary side wire cutter. The tool is reliable and comfortable for continuous use.

The 213 wire stripper is 183 mm ($7\frac{1}{4}$ in) long and weighs less than 180 g (approximately 6 oz).

For further information please contact Product Public Relations, 3M United Kingdom Limited, 380 Harrow Road, London W9 2HU.

In your workshop

This month Smithy the Serviceman gives his assistant, Dick, an insight into the world of simple gate logic. He also proves the accuracy of the two equations which express De Morgan's theorem.

"It's my Auntie Eff," said Dick chattily as he leaned against Smithy's bench.

Smithy applied his testmeter prods to the printed circuit board of the television receiver he was repairing.

"She wanted me to fix a light at her front gate."

Glancing down at the meter, the Serviceman gave a grunt of satisfaction.

"Well," said Dick, "it raised a number of problems."

Smithy switched off the television chassis, picked up his soldering iron and applied it to the printed board. Deftly, he pulled out one lead of a small polyester capacitor. He returned his soldering iron to its rest, then switched his testmeter to an ohms range.

"I said," repeated Dick in a determined tone, "that this front gate light of my Auntie Eff's caused me quite a few problems. For a start, there had to be a switch in the house and another at the gate."

But Smithy was entirely engrossed with the television chassis. He touched his testmeter prods together and adjusted the set-zero control.

"Also," continued Dick doggedly, "since her front gate is out in the open I thought it would be best to use a low voltage circuit rather than run the mains out to it."

AND GATES

Smithy applied his test prods to the capacitor leads, one of which was still affixed to the printed board whilst the other now projected, on its own, into mid-air.

"I put one on-off switch in the house," went on Dick, resolved to bring his story to a close, "and the other at the gate. Like this."

Smithy glanced at his meter, and gave a little smile as its needle obligingly indicated zero resistance. At the same time, Dick pulled Smithy's notepad towards him and commenced to sketch the circuit of the lighting system he had installed for his aunt.

"Excellent, excellent," stated Smithy, completely unaware of his assistant's presence. "I've spent nearly half an hour trying to trace that dratted capacitor. Let me see now, what's its value? Ah yes, 0.22μF at 350 volts working."

Smithy looked up, then gave a start as he suddenly found that his assistant was leaning over his bench less than six inches away.

"Ye gods," he gasped, "how long have *you* been here?"

"I've been here for *ages*," replied Dick in an exasperated tone. "I've been telling you all about this gate circuit I've made up for my Auntie Eff."

Smithy's eyes wandered down to the circuit Dick had drawn out. (Fig. 1.).

"A gate circuit?" he queried. "Why in the name of reason should an elderly spinster like your Auntie Eff want a gate circuit?"

"It's a perfectly reasonable thing for her to want."

"I know your aunts are all a bit off-centre," continued Smithy bemusedly, "but your Auntie Eff must be right outside the circle. What you've drawn there is an AND gate."

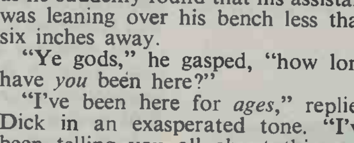


Fig. 1. The circuit of the front gate lamp installed by Dick. One switch is positioned in the house and the other at the gate

"An AND gate?"

"That's right," replied Smithy promptly. "If you say that each switch when closed, and the lamp when lit, represents 1, then the lamp is only at 1 when both switches are at 1. It's a circuit for an AND gate."

"Stap me," retorted Dick. "It's you that's outside the circle, Smithy. This isn't a circuit for an AND gate, it's a circuit for a flaming *front* gate!"

Smithy sighed.

"All right," he said resignedly, "tell me all about it."

"Well," replied Dick, "as you would have heard me saying earlier on if you hadn't had your head stuck into that darned set, this is a circuit for a light at my aunt's front gate. Because the light is out in the open I thought I'd make the circuit low voltage instead of running the mains out to the gate. There had to be a switch at the gate, but if the power was on continually the kids in the street would spend half their time switching the light on and off. So I put a second switch in series inside the house. The result is that if my aunt goes out in the evening she turns on the switch in the house, turning off the one at the front gate as she passes if it happens to be on. When she comes back she puts on the switch at the gate then turns off the lamp with the switch in the house after she's got inside."

"Where," asked Smithy, "did you get your low voltage from?"

"From an old heater transformer," replied Dick. "This had two 6.3 volt windings which I connected in series. I used a small 12 volt car sidelamp at the gate. And one of the low voltage supply leads is earthed to the mains earth."

"Fair enough," commented Smithy. "I'd have thought a slightly better idea would be to have the switch in the house connected in the primary circuit of the transformer. Like this."

Smithy scribbled out a second circuit. (Fig. 2.).

"Humph," conceded Dick, looking at Smithy's sketch. "Perhaps that would have been a better way of doing things. Anyway, why on earth did you start carrying on about AND gates as soon as you saw my circuit?"

"Because," stated Smithy, "what you had drawn is an elementary circuit which is often used to explain the working of an AND gate. The output is only present, or at 1, when both the first *and* the second switches are closed, or are similarly at 1."

TRUTH TABLE

"An AND gate, eh?" responded Dick, his interest rising. "Well, I suppose it's reasonable that someone who is as immersed in electronics as you are would have started thinking about AND gates as soon as you saw the circuit. If I remember correctly, the general idea is to introduce an AND gate with the switching circuit and then get on to the actual AND gate symbol. An AND gate is drawn like this, isn't it?"

Dick sketched a symbol on the note-pad.

"That's right," confirmed Smithy. "What you've drawn there is a 2-input AND gate. Let's stick some letters at the inputs and outputs to identify them. We can call the inputs A and B, and the output Y."

Smithy added the letters. (Fig. 3 (a).)

"Now," he went on, "this is the sort of gate we bump into when we're dealing with logic circuits, such as transistor-transistor logic or t.t.l. circuits. T.T.L. circuits use positive logic, which means that binary 1 is represented by a relatively high positive voltage and binary 0 by a relatively low positive voltage, both of these being with respect to ground, or earth. Now, with the AND gate we have here the output Y only goes up to 1 when input A *and* input B

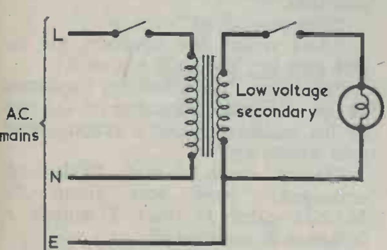
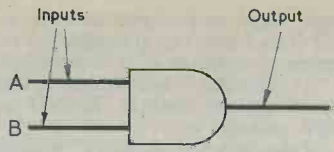


Fig. 2. An improved version of the circuit, as suggested by Smithy. The switch inside the house now controls the supply to the transformer primary



(a)

A	B	Y
0	0	0
1	0	0
0	1	0
1	1	1

(b)

0.0 = 0
1.0 = 0
0.1 = 0
1.1 = 1

(c)

Fig. 3 (a) A symbol for a 2-input gate (b) Truth table for the AND gate (c) Simple AND relationships taken from the truth table

are at 1. For all other states of the inputs the output is O. We can draw up a little truth table to cover this state of affairs.

Smithy quickly drew up the truth table. (Fig. 3(b).)

"That seems fair enough," commented Dick, examining the table critically. "When both A and B are 0, so also is Y. Y stays at 0 if either A or B on its own goes up to 1, and it changes to 1 when both A *and* B go up to 1."

"Good," said Smithy. "When we're dealing with logic circuits we use Boolean algebra, which is a bit different from ordinary algebra. To represent the expression 'A and B' we say A full-stop B, or just AB. The word 'and' is understood if the impression is given that the two quantities would be multiplied in ordinary algebra. Now, each entry in the Y column of our truth table represents the outcome of the corresponding entries in the A and B columns. So we can make up a little list showing simple relations between 1 and 0."

Smithy picked up his pen and wrote out the list. (Fig. 3(c).)

"Why," said Dick, "you've just transposed the entries from the truth table to the list."

"That's right," confirmed Smithy. "And what I've written down is that 0 and 0 equals 0, 1 and 0 equals

0 and 1 equals 0, and 1 and 1 equals 1. Well, that's enough about AND relationships for the time being, so let's look next at an OR gate."

Smithy drew out a further circuit on his pad. (Fig. 4(a).)

"Seeing that we started off the AND gate with switches," he continued, "we might as well do the same with the OR gate. The two switches I've now drawn represent the OR function; you get an output, 1, if either switch or both switches are closed, or are similarly in the state 1. Let's press on to the usual OR gate symbol."

Smithy drew the OR gate symbol on his pad. (Fig. 4(b).)

"That's familiar enough," commented Dick. "Now, let's see how it works. I suppose that when the inputs are both at 0 the output is at 0. But if either input goes up to 1, so also does the output. The output also goes up to 1 if both inputs go up to 1."

"Exactly," agreed Smithy. "You get an output 1 if either input A *or* input B *or* both go up to 1. Here, you can make up the OR gate truth table yourself."

Smithy handed his pen to Dick, who soon drew up the truth table. (Fig. 4(c).)

"Very good," commented Smithy. "What you've shown is that when both A and B are at 0 so also is Y. But Y goes up to 1 when either A or B, or both together, become 1. Now let's write out the simple relations we get from this little lot, remembering that in Boolean algebra we represent the term 'or' by a plus sign."

Smithy wrote out the relations. (Fig. 4(d).)

"This," remarked Dick, "is dead easy. What you've put down is that 0 or 0 equals 0, 1 or 0 equals 1, 0 or 1 equals 1, and that 1 or 1 equals 1."

"That's right," said Smithy briskly. "Let's get on next to NAND and NOR gates."

"Take it easy, Smithy," objected Dick. "I'm only just getting settled comfortably into what we've done up to now!"

INVERTER

"A NAND gate," continued Smithy, oblivious to his assistant's protests, "can be represented by an AND gate followed by an inverter."

"Hey, hang on a bit," protested Dick. "What's an inverter?"

"An inverter," stated Smithy, "is simply a device which inverts the input signal fed into it. If the inverter input is at 1 its output is at 0, and if its input is at 0 its output is at 1. There are several ways of representing an inverter on its own, and probably the most common of these is the triangle we use for an amplifier with a circle at its end. Like this."

Smithy sketched out the inverter symbol. (Fig. 5(a).)

"The circle," he went on, "is the item which actually indicates inversion. So, for a NAND gate we use the AND gate symbol with a circle added at its output end. Here's the NAND gate symbol, and here's its truth table."

Swiftly, Smithy drew the NAND gate symbol, following this with the truth table. (Figs. 5(b) and (c).)

"That seems simple enough," stated Dick, as he looked critically at the truth table. "The outputs from the NAND gate are simply the AND gate outputs inverted. What about the NOR gate?"

"You get the same sort of thing with the NOR gate," stated Smithy. "A NOR gate is an OR gate with an inverter following, and the symbol for a NOR gate is an OR gate with a circle at its output end. And its truth table shows the OR outputs all inverted."

Smithy scribbled out the last two items, then tore the now fully covered top sheet from his note-pad and laid it on his bench. (Figs. 6(a) and (b).)

"I should imagine," remarked Dick thoughtfully, "that you could write equations for these gates, showing what they do. With the AND gate, for instance, could you say its equation would be: Y equals A full-stop B?"

Smithy threw a pleased glance at his assistant.

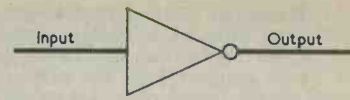
"Yes, you could."

"And would the equation for the OR gate be: Y equals A plus B?"

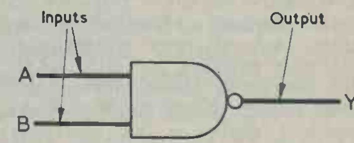
"Dear me," said Smithy, impressed at this unexpected acumen on the part of his assistant, "that's exactly what you would say."

"Good show," said Dick, encouraged. "Now how about the NAND gate? Is this: Y equals A full-stop B inverted?"

"Not exactly," replied Smithy. "What you says is that Y equals *not* the expression A full-stop B. In this instance the 'not' applies to the full A and B expression, and it's indicated in writing by putting a bar over the A and B terms. You can refer to single inverted letters as not-A and not-B



(a)

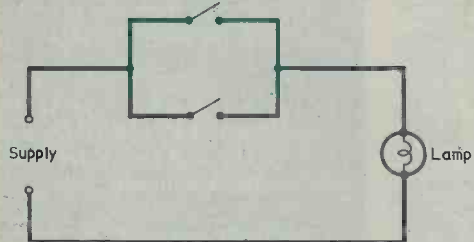


(b)

A	B	Y
0	0	1
1	0	1
0	1	1
1	1	0

(c)

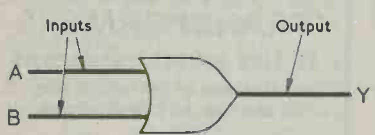
Fig. 5 (a) Common symbol for an inverter
(b) A 2-input NAND gate
(c) The truth table for the NAND gate



(a)

A	B	Y
0	0	0
1	0	1
0	1	1
1	1	1

(c)

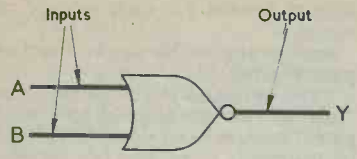


(b)

$0+0=0$
$1+0=1$
$0+1=1$
$1+1=1$

(d)

Fig. 4 (a) A switching circuit representing OR gate operation
(b) Symbol for an OR gate
(c) Truth table for the OR gate
(d) Simple OR relationships demonstrated by the truth table



(a)

A	B	Y
0	0	1
1	0	0
0	1	0
1	1	0

(b)

Fig. 6 (a) The NOR gate symbol (b) The NOR gate truth table

and you draw a bar over each individual letter. But when a complete expression is inverted you draw the bar over the lot. The ends of the bar then enclose the expression in the same way as two outside brackets do in ordinary algebra. It's easier to write these things than say them, so I'll write the equations for the four gates we've been talking about."

Smithy wrote out the four equations. (Fig. 7(a).)

AND	$Y = A.B$
OR	$Y = A+B$
NAND	$Y = \overline{A.B}$
NOR	$Y = \overline{A+B}$

(a)

AND	$Y = A.B.C$
OR	$Y = A+B+C$
NAND	$Y = \overline{A.B.C}$
NOR	$Y = \overline{A+B+C}$

b

$$\overline{A.B} = \bar{A}+\bar{B}$$
$$\overline{A+B} = \bar{A}.\bar{B}$$

(c)

Fig. 7 (a) Equations defining the functioning of 2-input gates (b) Equations for 3-input gates (c) The equations of De Morgan's Theorem

"You've only dealt with gates having two inputs up to now," said Dick thoughtfully. "Can you have gates with more than two inputs?"

"Oh yes," replied Smithy. "You can have quite a lot more inputs to a gate. If the gate is an AND gate, its output is at 1 only when *all* its inputs are at 1. With an OR gate, the output is at 1 when *any* one or more inputs is at 1. A NAND gate output goes from 1 to 0 only when *all* its inputs are at 1. And a NOR gate output goes from 1 to 0 when *any* one or more inputs is at 1. To get a bit of practice in, let's see you write out the equations for the four gates when these have three inputs instead of two. You can call the third input C."

"Fair enough," replied Dick, picking up Smithy's pen.

DE MORGAN

Frowning with concentration, Dick wrote out the operating equations for the four gates with three inputs. (Fig. 7(b).)

"You're really on the ball today," stated Smithy in a gratified tone, "and all those equations are correct. Well now, let's go a bit further with this Boolean algebra and take a look at two equations which are referred to as representing De Morgan's Theorum. The equations go like this."

Smithy wrote down the two equations. (Fig. 7(c).)

"Blimey," said Dick, looking uncertainly at Smithy's note-pad. "They're a bit involved, aren't they?"

"Not really," replied Smithy. "The De Morgan equations are quite simple, and they can be jolly useful if you're working on logic circuits. The left-hand side of the first equation has an inverting bar over the expression A and B, which means that this is the *not* version of the complete expression. The right-hand side has individual bars over each letter, and so it reads not-A or not-B. The second equation has the complete expression, A or B, inverted, and the right-hand side is not-A and not-B. Okay so far?"

"I think so."

"Right! Well, we can prove the first equation with the aid of a truth table. To start off with, we'll make up columns for A, for B, and for A and B. The fourth column will be for the expression A and B inverted, and this will represent the left-hand side of the equation. We'll then carry on to columns for not-A and not-B and a final column for not-A or not-B, which gives us the right-hand side of the equation. I'll start off by putting in the four possible combinations for A and B in the two first columns."

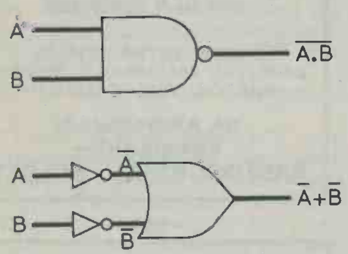
Smithy drew up the truth table and commenced to make his entries. (Fig. 8(a).)

"The third column," said Dick, looking suspiciously at the table, "is for A *and* B. How do we find the entries for this?"

"From the simple relations we found earlier," replied Smithy cheerfully.

A	B	A.B	$\overline{A.B}$	$\overline{A}$	$\overline{B}$	$\overline{A}+\overline{B}$
0	0	0	1	1	1	1
1	0	0	1	0	1	1
0	1	0	1	1	0	1
1	1	1	0	0	0	0

(a)



(b)

Fig. 8 (a) Truth table proving the first of the De Morgan's equations
(b) The gate circuits represented by the equation

"We've already seen that 0 and 0 equals 0, and that 0 and 1 also equals 0. So the first three entries in the third column are all 0's. The fourth entry is 1 because 1 and 1 gives 1. I'll leave you to fill in the fourth column, which is simply the third column inverted."

"This," boasted Dick, "is a piece of cake. I just have to put in a 1 where there's a 0 in the third column, and a 0 where there's a 1 in the third column."

Dick added the figures under the watchful eye of the Serviceman.

"That's exactly right," said Smithy. "Well, we've now got a column representing the left-hand side of the first De Morgan equation. You can fill in the not-A and not-B columns next."

"Okeydoke," said Dick obligingly. "This is a piece of cake again. All I have to do is put in 1's where there are 0's in the first two columns, and vice versa."

Dick soon had the fifth and sixth columns completed.

"All that remains," said Smithy, picking up the pen, "is to fill in the final column, for which we once more consult the simple relations we encountered earlier. This time they're the relations for the OR function. With these, 1 or 1 equals 1, 0 or 1 equals 1, 1 or 0 equals 1, and 0 or 0 equals 0. So, the final column consists of three 1's followed by a 0."

"I see," said Dick, as Smithy entered the figures. "Well that seems straightforward enough. Hey, I've just noticed something!"

"What's that?"

"This final column is the same as the fourth column!"

"Of course it is, you twit. That's the whole object of the exercise, and it shows that the first De Morgan equation is correct."

"How," asked Dick, "does this equation prove to be of practical use?"

"Well," replied Smithy, "let's apply the two inputs to gate circuits representing the two sides of the equation. The left-hand side would be given by applying the two inputs A and B to a NAND gate, whilst the second would be provided by applying the inputs to two inverters whose outputs couple to an OR gate. The two set-ups provide the same output, as is shown by the truth table, but one is obviously simpler than the other because it consists of one gate and an inverter whilst the other has one gate and two inverters. In practice there isn't much in it but, even so, making a comparison at this simple level does show that the first De Morgan equation offers a useful advantage. If somebody asked you to make up a gate circuit for not-A or not-B, you could take advantage of the equation and present him with a simple NAND gate which did the same thing."

As he was speaking, Smithy had sketched out the two gate circuits. (Fig. 8(b).)

SECOND EQUATION

"This," said Dick excitedly, "is really something! These gate circuits are certainly versatile."

"They are that," agreed Smithy. "Part of the art of basic logic gate design is to try and bring a gate circuit down to its simplest form. This can be done with the aid of simple relations of the type we have just seen, together with the De Morgan equations."

"Let's," said Dick eagerly, "have a go at proving the second equation. Can we do this with another truth table?"

"Oh yes," replied Smithy. "This will need columns for A and B just as before, after which we need a column for A or B, and one for the A or B expression inverted. We next have a further column for not-A, another for not-B and then a final column for not-A *and* not-B. Here, I'll start you off by filling in the A and B columns then I'll let you finish the rest."

Smithy drew out the truth table outline, entered the column headings and the four possible entries for A and B. He gave his pen to Dick and watched his assistant as he worked his way along the table. Eventually, Dick completed the final entry in the last column. (Fig. 9(a).)

"How's that?" he asked, looking expectantly at Smithy.

"That's a hundred per cent correct," responded Smithy. "Again, the fourth column and the final column are the same, which proves the second De Morgan equation. Let's draw the gate circuits needed for each side of the equation."

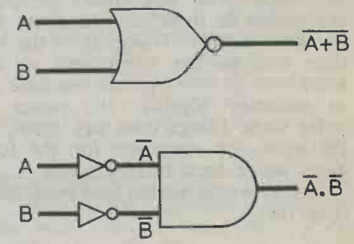
Smithy applied his pen to the notepad. (Fig. 9(b).)

"The left-hand side," he went on, "has the two inputs going to a NOR gate. The right hand side is represented by the inputs going into two inverters and then to an AND gate. So, once more, we have two quite different looking gate circuits, both of which give the same performance."

"This has been quite a revelation to me," stated Dick. "It's amazing what you can do with this gate circuit logic."

A	B	A+B	$\overline{A+B}$	$\overline{A}$	$\overline{B}$	$\overline{A}.\overline{B}$
0	0	0	1	1	1	1
1	0	1	0	0	1	0
0	1	1	0	1	0	0
1	1	1	0	0	0	0

(a)



(b)

Fig. 9 (a) Truth table dealing with the second De Morgan equation
(b) The equation involves the two gates shown here

"The real strength of the De Morgan equations," said Smithy, "is that they can be expanded into three or more terms. Here, I'll show you the equations for three, four and even six terms."

Smithy wrote down the equations. (Fig. 10).

"These equations can be a very powerful aid to the designer. If you've got to combine a lot of NOR or NAND functions, the equations can often enable the simpler of two gate options to be found."

"Can these further equations also be proved by truth tables, too?"

"Oh, definitely."

Smithy put out his hand towards his note-pad and, in so doing, glanced at his watch.

KEEPING BUSY

"Hey," he remarked wrathfully, "what the dickens have I been doing over the last half-hour?"

"You've been telling me," replied Dick cheerfully, "all about gates and De Morgan's Theorem."

"Well, I shouldn't have been," snorted Smithy, "I should have been fixing TV's instead. Darn it, Dick, you've gone and conned me yet again! When I'm supposed to be doing ordinary servicing work you've managed to trick me into talking about something quite different."

"All that happened," stated Dick innocently, "was that I told you about the light I'd put in at my Auntie Eff's front gate."

"Ah yes," said Smithy, frowning. "I remember that now. But, dash it all, *why* were you telling me about your Auntie Eff's front gate light?"

"Because I'd finished my last set for the day and I felt like a bit of a chat. The TV you've got on your bench is the only set that's now outstanding."

Smithy looked round at the "For Repair" racks. They were, indeed, empty.

"Well," he remarked, mollified. "It looks as though you have got some sort of excuse. What were you saying about truth tables?"

"I was wondering if you could draw up truth tables to prove the longer versions of the De Morgan equations."

"Yes, you can. As you've got nothing better to do, why don't you go back to your bench and make up truth tables for the equations when they have six terms? That will keep you occupied until I finish off this set."

Eagerly, the unsuspecting Dick returned to his bench to tackle the tables. Left to himself, Smithy gave a little chuckle at the thought that he should not be interrupted for quite some time now. As the Serviceman went to the spares cupboard for a new 0.22μF capacitor, he mentally calculated the number of lines that would be required in the truth tables for the equations with six terms. There would undoubtedly be at least twenty of them . . . ■

$$\overline{A.B.C} = \bar{A}+\bar{B}+\bar{C}$$
$$\overline{A.B.C.D} = \bar{A}+\bar{B}+\bar{C}+\bar{D}$$
$$\overline{A.B.C.D.E.F} = \bar{A}+\bar{B}+\bar{C}+\bar{D}+\bar{E}+\bar{F}$$
$$\overline{A+B+C} = \bar{A}.\bar{B}.\bar{C}$$
$$\overline{A+B+C+D} = \bar{A}.\bar{B}.\bar{C}.\bar{D}$$
$$\overline{A+B+C+D+E+F} = \bar{A}.\bar{B}.\bar{C}.\bar{D}.\bar{E}.\bar{F}$$

Fig. 10 The De Morgan equations can be expanded to any number of terms, as indicated by the examples shown here

CONSTRUCTOR'S CROSSWORD SOLUTION

Across

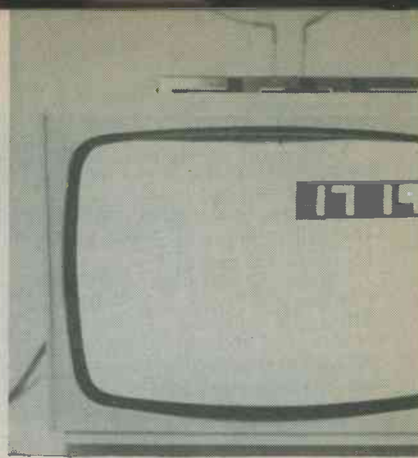
1, Meter. 4, Alpha. 7, Coulomb. 9, A.M. 10, Real. 12, Imp. 13, Erasers. 14, Ohm. 15, NOR. 18, It. 21, Henry. 22, As. 23, Watts. 24, Gauss. 25, In. 26, Hertz. 27, Ho. 29, Eel. 33, Ire. 34, Account. 35, E.H.T. 37, Onto. 38, So. 39, Station. 41, Stone. 42, Oiled.

Down

1, Marconi Wireless. 2, R.C. 3, Alessandro Volta. 4, Abase. 5, Ham. 6, Ampere's Solenoid. 8, Oars. 11, Arms. 12, Ion. 16, Ay. 17, Swan. 19, Tan. 20, Star. 22, Ash. 26, He. 28, Wien. 30, Let. 31, Raise. 32, Into. 36, Hot. 40, No.

Radio Topics

By Recorder



With the aid of new microcircuits developed by General Instrument Microelectronics, a TV receiver can be made to display the time or the channel number

One of the chore-horses which literally keep our modern world turning must surely be the car battery. Whenever I hear a car being started, and particularly when the engine is reluctant to fire, I always visualise the fantastic quantity of amps that the little car battery is furnishing for the starter motor. On checking with a reference on car mechanics, I see that the starter motor current can be reckoned in hundreds of amps.

AMPERE-HOURS

When chatting recently with a friend about batteries, he asked me if I had any idea of the ampere-hour capacity of a car battery. It is many years since I've had to think about the ampere-hour capacity of a battery and my mind went back to the 2 volt 20 ampere-hour accumulators that we used in the R.A.F. during the war. Working on the premise that a 12 volt car battery is about six times the size of those early accumulators I ventured a guess of about 120 ampere-hours. But I was wrong, and I found later that the average car battery is of the order of 50 ampere-hours, or even quite a lot less.

The ampere-hour capacity of a battery may be reckoned on either a 10 hour rate or a 20 hour rate. For the sake of simplicity, let's say it is the 10 hour rate. A fully charged 2 volt 20 ampere-hour accumulator will in consequence deliver 2 amps for 10 hours before it is discharged, giving the ampere-hour figure of 2 times 10, or 20. If we connect six 2 volt 20 ampere-hour accumulators in series to produce a 12 volt battery, the capacity of that battery will still be 20 ampere-hours. Should we draw 2 amps from the 12 volt battery, each of the six 2 volt accumulators will be delivering 2 amps and will still be discharged after 10 hours.

And this, as I realised afterwards, is where I went wrong in making the assumption that the ampere-hour rating of the car battery could be equated to that of a 2 volt accumulator in terms of physical size ratio. The ampere-hour capacity of a battery consisting of a series combination of identical cells will be equal to the ampere-hour capacity of any of its cells.

I.C. HOLDERS

In company with most other constructors I like to play around with integrated circuits. Whenever possible I obtain the d.i.l. version of the i.c. and I always use an i.c. holder instead of connecting direct to the i.c. pins. This is merely a personal preference, of course, but it is a lot easier to remove an i.c. from a holder if there is an error in the wiring than it is to unsolder it when it is connected directly to a printed circuit or to a Veroboard.

For experimental purposes I have several 16 pin i.c. holders each soldered to an oddment of 0.1 in. Veroboard having 10 holes by 16 strips. Each holder is soldered in at the centre of the Veroboard and the strips between the pins are cut. Thin flexible leads are soldered to the strips on either side of the i.c. holder, and the whole then presents a robust assembly which can be quickly wired up for an experimental circuit. Working in this way means that the connections to the i.c. are rather long but this hasn't caused me any trouble in practice. Even such devices as a 741 op-amp can be connected into a circuit with leads several inches long, although there is no guarantee that these might not cause instability in some instances. However, I have been lucky up to now and have not had any difficulties in this respect. After a new circuit has been checked with a Veroboard-cum-holder assembly, it can then be constructed permanently using more respectable methods of wiring.

Why have I only wired up 16 pin holders in this way? Because a 16 pin holder will take any d.i.l. integrated circuit having 16 pins or less, including the 8 pin 555 timer.

TV DISPLAY

The accompany photograph shows one of two possibilities offered by new m.o.s. microcircuits developed by General Instrument Microelectronics Ltd., 57–61 Mortimer St., London, W1N 7TD. In the illustration a TV receiver is displaying the time. Alternatively, it can show the channel number, this latter facility being provided in TV receivers having channel selection by a hand held remote control unit.

The microcircuit producing the display is the General Instrument 14 pin type AY-5-8300, and this can be coupled to the General Instrument AY-5-1203 digital clock microcircuit for the time display or to the varactor tuning circuits of the tuner for the channel display. The channel number appears for several seconds after a new channel has been selected or it can be displayed permanently if required by the manufacturer. With colour TV receivers the figures appear as coloured characters on a black background, the colours available being red, green, blue, yellow, magenta, cyan and white.

The AY-5-8300 can display channel numbers from 0 to 15. A 24 pin version, designated the AY-5-8310, offers two further options. For example, channel nine can be displayed as '9' or '09'. In the former case 16 channels can be displayed, and in the latter 100 channels.

In operation the display driver microcircuit is synchronised to the TV receiver by the field flyback pulse at the beginning of each new field. Then a vertical position counter is initiated which counts 49 line pulses before enabling the horizontal position counter. A 1.1MHz oscillator is also synchronised to the line flyback pulse at the beginning of each line in order to form a sharp character edge. The entire character including the black border is subsequently delineated in the next 35 lines.

COMBINING EQUIPMENT

Marconi Communication Systems Limited, which is a GEC-Marconi Electronics Company, has always presented a very creditable export performance. I see that they have now, in face of strong competition from American manufacturers, won an order to supply broadcast equipment for the tallest man-made building in the world, the CN Tower in Toronto.

The order, which was placed by Master FM Limited through the Canadian Marconi Company, calls for the supply of a combining unit which will take the outputs of all the f.m. radio stations operating in Toronto and broadcast them from the tower through a single aerial system.

The CN Tower, one third of a mile high, is to form the broadcasting and communications centre for the Metropolitan Toronto area, as well as providing a public viewing platform and restaurant at a height of some 1,200 feet. The combining unit that Marconi Communication Systems is supplying will initially combine the outputs of five f.m. broadcasts into a single aerial, although the system is capable of being expanded to combine a total of eleven programmes.

The system includes sophisticated control and monitoring equipment which provides accurate forward and reflected power measurement facilities on individual channels and on the combined output, taking executive action to switch transmitters off in the event of a high v.s.w.r. An interesting feature of the combiner design is the extremely low insertion loss, which means that the power dissipated in the unit is very low, avoiding the need for any form of forced air cooling.

The CN Tower will also house three Marconi high power u.h.f. television transmitters. These are all Marconi 55kW equipments, and two have already been delivered to the Canadian Broadcasting Company.

BATTERY CONNECTORS

An acquaintance recently wanted me to fix up a means of switching on and off a transistor radio in his bedroom without getting out of bed. The bedroom has a rather curious geometry with the bed in one corner up against the walls, and it is a little difficult to fit up a bedside table on which the radio could stand. What my friend required was a switch on the end of a length of flex which he could turn on and off whilst snuggled down under the sheets.

Since the lead between the switch and the radio would only be three to four yards long there was no point in thinking of relays or thyristors or anything like that. All that would be required was to interrupt the connection to one terminal of the radio battery and insert a 2-way flex with a single pole remote on-off switch at the other end. If the radio were then turned on at its own switch, it could be controlled by the remote switch. The resistance inserted by the 2-way flex would be negligibly low, and the length of wire should not cause any instability if the receiver had the usual high value electrolytic capacitor across its supply rails.

On looking at the radio I found it was fitted with a PP6 battery. At the end of two flexible leads from the radio circuitry was the usual 2-way battery connector with a male and a female contact clip. It seemed a pity to alter the existing wiring on the set, so I decided to think in terms of an adaptation which could be easily removed at a later date.

It is obvious that one 2-way battery connector can be plugged into another 2-way battery connector, and so I decided to obtain two more connectors of the type employed with a PP6 battery. The existing battery connector in the radio could then be plugged into a second connector, and the third connector plugged into the PP6 battery. One contact clip of the second connector would be wired directly to a corresponding contact clip on the third connector, whilst the remaining two contact clips would connect to the 2-way flex going to the remote on-off switch.

Now, the second battery connector had to provide the right polarity to the existing radio connector and the third battery connector had to provide the right polarity, by way of the remote switch, to the second connector. If the male contact clip of the third connector, which connects to the negative clip of the battery, were wired, either directly or via the remote switch, to the male contact clip of the second connector, the latter would then connect to the female contact clip of the radio connector. But the female clip of the radio connector is normally connected to the positive male clip of the battery. Similarly, if the female clip of the third connector, which connects to battery positive, were connected to the female clip of the second connector then this would connect to the male clip of the radio connector. But the male clip of the radio connector is intended to connect to the negative female battery clip.

Evidently, a little thought was needed. The solution of course was to connect the male clip of the third connector directly to the female clip of the second connector, to connect the female clip of the third connector to one lead of the 2-way flex and to connect the male clip of the second connector to the other lead of the 2-way flex. When the switch at the other end of the flex was closed it would then complete the circuit from the positive terminal of the battery to the radio, thereby turning it on.

And so it transpired. The existing radio connector was clipped to the second connector and the third connector to the battery. The radio worked perfectly well with this arrangement and could be turned on and off satisfactorily at the remote switch. Of course, it would have alternatively been possible to couple the radio connector to the *third* battery connector and connect the *second* battery connector to the battery. This time the remote switch would be in the negative side of the battery supply.

Perhaps chicken sexing would be easier. ■

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(Continued on page 125)

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(Continued on page 126)

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(Continued from page 125)

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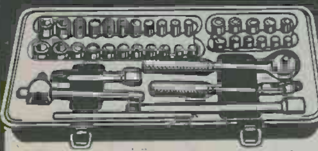

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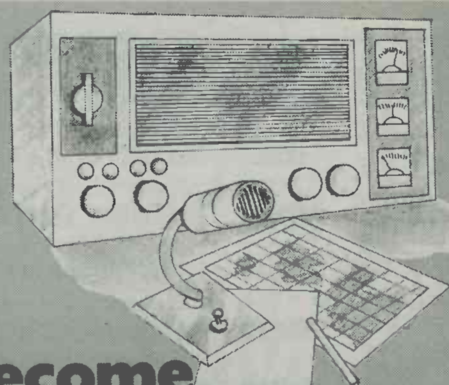

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ELECTRONICS DATA

FOR THE BEGINNER

PARALLEL RESONANCE

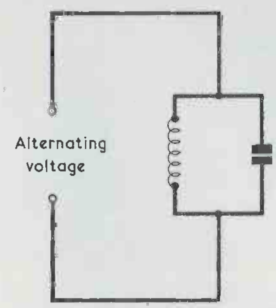
In last month's *Electronics Data* we applied an alternating voltage whose frequency can be varied to a series tuned circuit. In (a) we apply the voltage to a parallel tuned circuit. As with the series tuned circuit there must be an alternating voltage frequency where the inductive and capacitive reactances are equal.

The current from the alternating voltage source which flows in the inductor is out of phase with that which flows in the capacitor. Thus, when the two reactances are equal so also are the out of phase currents and they cancel out. This is the condition of resonance. If the inductor and capacitor were perfect components, no current would flow from the voltage source. In practice there are 'losses', mainly in the inductor, and a small current flows.

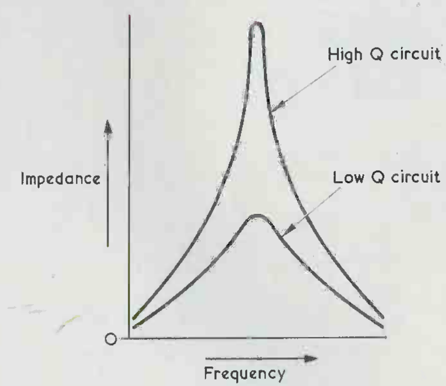
Response curves for the parallel tuned circuit are shown in (b), and impedance rises to a peak at resonance in the same way as did the current in the series tuned circuit. Whereas the impedance of the series tuned circuit is at its lowest at resonance, the impedance of the parallel tuned circuit is at its highest.

In the parallel tuned circuit the internal circulating current at resonance is greater than the current from the alternating voltage source, and the ratio between these currents represents the magnification factor, equal to Q, of the tuned circuit. A high Q tuned circuit gives a sharper response curve than does a low Q tuned circuit.

The equation in (c) gives resonant frequency in parallel tuned circuits having low 'losses' (i.e. Q values above around 10) and is the same as for the series resonant frequency. Again, the resonant frequency may be varied by making the capacitance variable, as in (d), or the inductance variable as in (e).



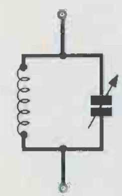
(a)



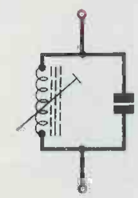
(b)

$$f = \frac{1}{2\pi\sqrt{LC}}$$

(c)



(d)



(e)