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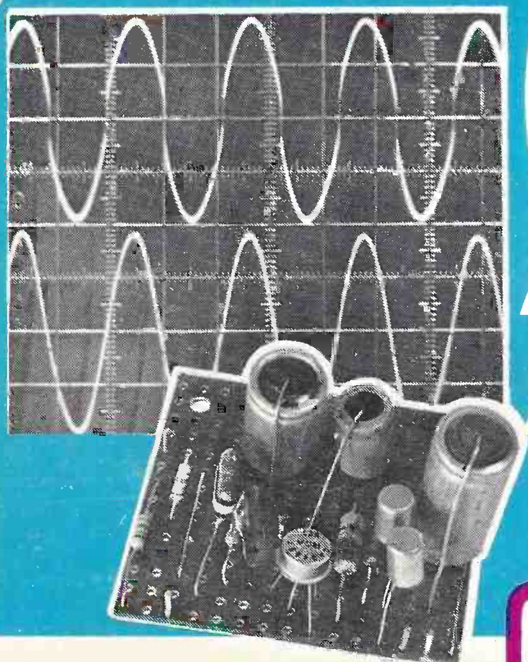

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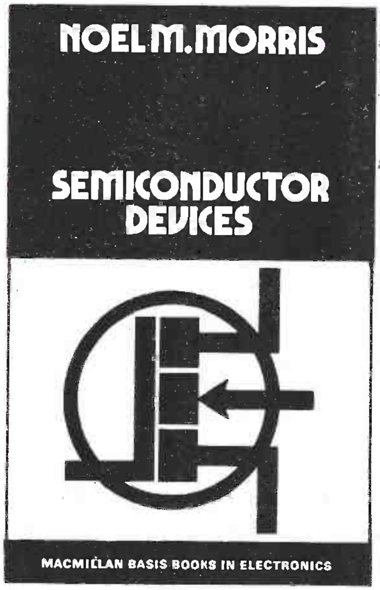

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Following a summary of the physical basis of semiconductor elements — in non-mathematical terms — a study of bipolar and field-effect transistors leads to considerations of monolithic integrated circuits. More advanced charge-coupled devices, semiconductor memories and optoelectronic devices are studied in some detail.

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Two full size loudspeakers $13\frac{3}{4}$ x 10 x $3\frac{3}{4}$in. Player unit clips to loudspeakers making it extremely compact. Overall size only $13\frac{3}{4}$ x 10 x $8\frac{3}{4}$in. 3 watts per channel, plays all records 33 rpm 45 rpm. Separate volume & tone controls 240v AC mains

Attractive Teak finish Weight 13lbs
Bargain Price **£22.50** 85p carriage

GARRARD MINICHANGER

Plays all size records, 3 speed Size 12 x $8\frac{1}{2}$in. Complete with stereo/mono cartridge

£9.95 Post 75o

CASSETTE RECORDER MOTOR ONLY. 6 Volt. Will replace many types Ideal for models £1.25

BLANK ALUMINIUM CHASSIS. 18 s.w.g. $2\frac{1}{2}$in. sides 6 x 4in. 70p; 8 x 6in. 90p; 10 x 7in. £1.15; 14 x 9in. £1.50; 16 x 6in. £1.45; 12 x 3in. 87p; 16 x 10in. £1.70. Ali boxes, many sizes in stock.

ALUMINIUM PANELS 18s.w.g. 6 x 4in. 15p; 8 x 6in. 25p; 10 x 7in. 30p; 12 x 5in. 30p; 12 x 8in. 40p; 16 x 6in. 45p; 14 x 9 in. 50p; 12 x 12in. 55p; 16 x 10in. 75p.
ALUMINIUM ANGLE BRACKET 6in long x $\frac{3}{4}$ x $\frac{3}{4}$ 15p.

$1\frac{1}{2}$inch DIAMETER WAVECHANGE SWITCHES 45p. EA. 2 p. 2-way, or 2 p 6-way, or 3 p. 4-way. 1 p 12 way, or 4 p 2-way, or 4 p 3-way
TOGGLE SWITCHES. sp. 20p. dp. 25p dp. dt. 30p. D.P.D.T. CENTRE OFF 65p. S.P.D.T. CENTRE OFF 45p. Many types TOGGLE SWITCHES in stock

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER BRITISH MADE

Ideal for Mike, Tape P.U., Guitar, etc. Can be used with Battery 9-12v. or H.T. line 200-300V. D.C. operation. Size $1\frac{3}{4}$" x $1\frac{1}{4}$" x $\frac{3}{4}$". Response 25 c.p.s. to 25 Kc/s, 26 db gain. For use with valve or transistor equipment. Full instructions supplied. Details S.A.E. **£1.45** Post 30p

NEW ELECTROLYTICS CONDENSERS

2/350V	20p	250/25V	18p	16+16+16/275v	45p
4/350V	20p	500/25V	20p	50+50/300V	50p
8/350V	22p	100+100/275v	65p	32+32/450V	75p
16/350V	30p	150+200/275v	70p	100+50+50/350V	85p
32/500V	50p	8+8/450V	50p	32+32+32/350	75p
25/25V	10p	8+16/450V	50p	30,000/25V	95p
50/50V	10p	16+16/450V	50p	4700/63V	95p
100/25V	10p	32+32/350V	50p	420/500V	£1.50

LOW VOLTAGE ELECTROLYTICS CONDENSERS
22, 25, 50, 68, 150, 470, 500, 680, 1500, 2200, 3300, mfd all 6 volt 10p ea.
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220, 330, 1000, 4700, mfd all 4v. 10p ea.
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V 10p.
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1000mF 12V 20p , 25V 35p , 50V 47p ; 100V 70p.
2000mF 6V 25p ; 25V 42p ; 50V 57p ; 4700/63V 95p.
2500mF 50V 62p ; 3000mF 25V 47p ; 50V 65p.
5000mF 6V 25p; 12V 42p; 35V 85p; 50V 95p.
500V-0·001 to 0·1 10p; 0·25 12p; 0·47 25p
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PAPER 350V-0·1 7p, 0·5 18p; 1mF or 2mF 150V 15p.
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MICRO SWITCH sub min 25p.
TWIN GANG. "0-0" 208pF + 176pF £2. TWIN 365pF 50p.
Slow motion drive 365pF + 365pF with 25pF + 25pF 65p.
500pF standard twin gang 75p. 120 PF twin gang 50p.

ELAC 9 x 5in. HI-FI SPEAKER, TYPE 59RM. THIS FAMOUS AND WIDELY USED UNIT NOW AVAILABLE AT BARGAIN PRICE 10 WATT, 8 OHM. CERAMIC MAGNET. **£3.45**

NEON PANEL INDICATORS, 250V Red or Amber, 30p
RESISTORS, $\frac{1}{4}$w., $\frac{1}{2}$w., 1w 20%, 2p; 2w. 8p. 10 to 10M.
HIGH STABILITY, $\frac{1}{2}$ w. 2% 10 ohms to 10 meg., 12p.
Ditto 5%, Preferred values, 10 ohms to 10 meg., 5p.
WIRE-WOUND RESISTORS, 5 watt, 10 watt, 15 watt, 10 ohms to 100K, 12p each; 2w 0.5 ohm to 8.2 ohms 15p.
TAPE OSCILLATOR COIL. Valve type 35p
FERRITE ROD 6" x $\frac{1}{2}$" 30p; 6" x $\frac{3}{8}$" 20p; 3" x $\frac{3}{8}$" 10p.
TAG STRIP 28 way 14p.

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ALL POST 50p each

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350-0-350 80mA. 6·3v 3·5a, 6·3v 1a or 5v 2a. £5.80
300-0-300 120mA. 6·3v 4a C.T.; 6·3v 2a £7.00
220v 45mA. 6·3v 2a. £1.75
HEATER TRANS 6.3v 3 amps £1.45 $\frac{1}{2}$amp. 95p
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs
2 amp 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24, 30v £4.60
1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60, £4.60
2a. 6, 8, 12, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £7.00
3a 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £8.70
5a. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £11.25
5, 8, 10, 16v $\frac{1}{2}$a £2. 6-0-6v 500mA £1. 9v 1a £1
12v 300mA £1. 12v 500mA £1. 12v 750mA £1.
40v 2a tapped 10v or 30v £2.95. 20v 3a £2.
40v 2a £2.75 30v 5A and 34v 2A ct. £3.50
20-0-20v 1a £2 30v $1\frac{1}{2}$a £1.75 20v $\frac{1}{2}$a £1.75, 1a £2
1 amp Transformer, mounted on panel with input and output fuses supplies 0, 20v, 40v, 60v or 20-0-20v £3.50
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CHARGER TRANSFORMERS. Input 200/250v for 6 or 12v $1\frac{1}{2}$a £2.75 4a £4.60.
FULL WAVE BRIDGE CHARGER RECTIFIERS:
6 or 12v outputs $1\frac{1}{2}$a 40p; 2a 55p, 4a 85p.

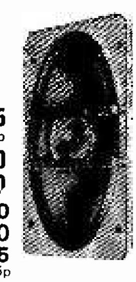
R.C.S. STABILISED POWER PACK KIT

All parts including printed circuit and instructions to build this unit Voltages available: 6v, 7·5v, 9v, 12v. Up to 100mA output.
Please state voltage required. **£2.95** Post 45p

STEREO FM/AM TUNER AMPLIFIER CHASSIS BY KUBA

This all transistor chassis has push button selection for long, medium short and V.H.F. wave bands. Features A.F.C. on V.H.F. band with automatic stereo beacon light Volume tone and Balance controls with push button mains on/off switch. Amplifier accepts ceramic cartridge and has record playback socket fitted. Four watts per channel output Chassis size 17 x 4 x 5in **£33.50** POST £1.50

E.M.I. $13\frac{1}{2}$ x 8 in. SPEAKER SALE!



With tweeter And crossover. 10 watt State 3 or 8 ohm **£5.95** Post 45p
15 watt version 8 or 15 ohm **£8.50**
20 watt version 8 or 15 ohm **£9.50**
as illustrated
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Bookshelf Cabinet **£7.50**

Teak Veneer. For above units .... Post £1.50

R.C.S. 10 WATT AMPLIFIER KIT

This kit is suitable for record players, tape play back, guitars, electronic instruments or small P.A. systems. Two versions are available. A mono kit or a stereo kit. The mono kit uses 13 semiconductors. The stereo kit uses 22 semiconductors with printed front panel and volume, bass and treble controls. Spec 10 watts output into 8 ohm, 7 watts into 15 ohms. Response 20 cps to 30K/cs. Input from 20mV high imp. Size $9\frac{1}{2}$in x 3in x 2in.

Mono kit **£11.25** Stereo kit **£17.50** post 45p

LOUDSPEAKERS P.M. 3 ohms, 7 x 4in. £1.25; $6\frac{1}{2}$in. £1.50; 8 x 5in. £1.60, 8in £1.75, 10 x 6in. £1.90; 10in. £2.50
SPECIAL OFFER LOUDSPEAKERS! All Brand New. 3 ohm, $2\frac{1}{4}$in. $2\frac{5}{8}$in, $3\frac{1}{2}$in, 5in, 8 ohm, $2\frac{1}{4}$in, $2\frac{3}{4}$in; 5 x 3in. 5in 15 ohm, $3\frac{1}{2}$in, 5in, 6 x 4in, 5 x 3in, 7 x 4in, 25 ohm, $2\frac{1}{4}$in, 3in, 5 x 3in, 7 x 4 in; 35 ohm, 3in, 5in. 80 ohm, $2\frac{1}{4}$in, $2\frac{3}{4}$in 120 ohm, 3in **£1.25** EACH

TWEETER VOLUME CONTROL 15 ohm 10 watt with 1in. long threaded bush for wood panel mounting. Will suit all tweeters 75p

RICHARD ALLAN TWIN CONE LOUDSPEAKERS. 8in. diameter 4W £2.50, 10in. diameter 5W £2.95, Post 25p. 12in. diameter, 6W £3.50, 3 or 8 or 15 ohm models.
SPEAKER COVERING MATERIALS. Samples Large S.A.E.
Horn Tweeters 2-16Kc/s 10W 8 ohm or 16 ohm £3.60.
De Luxe Horn Tweeters 2-18 Kc/s, 15W, 8 ohm £6.80
TWO-WAY 3,000 cps CROSS OVERS 3, 8 or 15 ohm £1.90
3 WAY CROSSOVER 850 cps and 3000 cps (25 watt) £2.20
100 WATT HORN TWEETER £10.95

GOODMANS CONE TWEETER £3.25

18,000 cps. 25 watts. 8 ohm.
$5\frac{1}{2}$in. Woofer 10 watt. Price £4.95.

ELECTRO MAGNETIC PENDULUM MECHANISM

1.5v d.c. operation over 250 hrs continuous on SP2 battery. fully adjustable swing and speed. Ideal displays teaching electro magnetism or for metronome; strobe etc. 95p. Post 20p

WEYRAD TYPE COILS

P50/1AC	60p	RA2W	£1.20	Twin Gang	£2
P50/2CC	40p	OPT1	85p	Printed Circuit	85p
P50/3CC	40p	LFDT4	85p		

COAXIAL PLUG 10p. PANEL SOCKETS 10p. LINE 18p. OUTLET BOXES, SURFACE MOUNTING 40p
BALANCED TWIN RIBBON FEEDER 300 ohms. 5p yd
JACK SOCKET Std. open-circuit 20p, closed circuit 25p; Chrome Lead Socket 45p. Phono Plugs 10p. Phono Socket 8p. JACK PLUGS Std Chrome 30p, 3·5mm Chrome 15p. DIN SOCKETS Chassis 3-pin 10p, 5-pin 10p, DIN SOCKETS Lead 3-pin 18p; 5-pin 25p; DIN PLUGS 3-pin 18p; 5-pin 25p VALVE HOLDERS 5p, CERAMIC 10p, CANS 5p.

R.C.S. 100 WATT VALVE AMPLIFIER CHASSIS

Professional model. Four inputs, Treble, Bass, Master Volume Controls. Ideal disco, P.A. or groups. 5 speaker outputs very robust job
S.A.E. for details **£85** plus £2.50 carr.

NEW MIXER/AMP 150 WATT

PROFESSIONAL TRANSISTOR AMPLIFIER **£68**
4 inputs 3 outputs separate volume treble and bass controls. Ideal disco or group, P.A. amplifier Carr. £1.50
(Send for leaflets on Disco Gear, Cabinets, etc.

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Components Lists 10p. Cash price includes VAT Rail Selhurst. Tel. 01-684 1665

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JUST A FEW BARGAINS ARE LISTED - SEND STAMPED ADDRESSED ENVELOPE FOR A QUOTE ON OTHER REQUIREMENTS. PAY A VISIT. OVER 90% OF STOCK BELOW QUANTITY WHOLESALE PRICE. ALL PRICES INCLUDE THE ADDITIONAL DISCOUNT IN LIEU OF GUARANTEE

Goods sent at customer s risk, unless suficient payment for registration (1st class letter post) or compensation fee (parcel post) included.

VALVE BASES

Printed circuit B9A–B7G **3p**
Chassis B7–B7G **9p**
Shrouded chassis B7G–B9A–B8A ... **10p**
B12A tube ... **9p**

Car type panel lock and key **40p**
16 volt 4 amp charger, bridge rectifier **79p**
GC10/4B **£3.00**

Speaker 6" x 4" 5 ohm ideal for car radio **70p**

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**

5 x 50pF or 2 x 220pF trimmers **20p**

BOXES — Grey polystyrene 61 x 112 x 31mm, top secured by 4 self tapping screws **$32\frac{1}{2}$p**
Clear perspex sliding lid, 46 x 39 x 24mm **10p**

ABS, ribbed inside 5mm centres for P.C.B., brass corner inserts, screw down lid, 50 x 100 x 25mm orange **48p**; 80 x 150 x 50mm black **70p**; 109 x 185 x 60mm black **£1.10**

ALUMINIUM

3" x 2" x 1" **39p**
$2\frac{3}{4}$" x $5\frac{1}{4}$" x $1\frac{1}{2}$" **45p**
4" x 4" x $1\frac{1}{2}$" **45p**
4" x $2\frac{3}{4}$" x $1\frac{1}{2}$" **45p**
4" x $2\frac{1}{2}$" x 2" **44p**
4" x $5\frac{1}{4}$" x $1\frac{1}{7}$" **54p**
12" x 5" x 3 **£1.20**
10" x 7" x 3" **£1.22**
12" x 8" x 3" **£1.50**

SWITCHES

Pole	Way	Type	
4	2	Sub. Min. Slide	**18p**
6	2	Slide	**20p**
1	3	13 amp rotary	**6p**
2	1	2 Amp 250V A.C. rotary	**20p**

12 bank, multi-pole/way push-button (4 interlocking) **30p**
S.P.S.T. 10 amp 240v. white rocker switch with neon. 1" square flush panel fitting **20p**
S.P.S.T. dot 13 amp, oblong, push-fit, rocker **15p**

RESISTORS

$\frac{1}{8}$-$\frac{1}{4}$-$\frac{1}{2}$ watt **1p**
1 watt **2p**
Up to 15 watt wire wound **6p**
1 or 2% five times price.
Cinch 8 way std 0.15 pitch edge connector **20p**

Semiconductor Data Book 171 pages. Covers Japanese types 25A12 through to 2SD335. Type/connection/parameter details **£1.50** No VAT

AUDIO LEADS

5 pin din plug 180° both ends $1\frac{1}{2}$ Mtr., **80p**
3 pin din to open end, $1\frac{1}{2}$ yd twin screened **35p**
Phono to Phono plug, 6ft. **35p**

POTS

Log or Lin, single or dual, switched carbon or wire-wound, rotary or slider. All types **16p**
1.5m Edgetype **3p**

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** + **85p** post and packing
7lb for **£1.95** + **£1.20** post and packing

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

1k horizontal preset with knob **3p**

3" Tape Spools **3p**
1" Terry Clips **4p**
12 Volt Solenoid **30p**

THERMISTORS

VA1008, VA1034, VA1039, VA1040, VA1055, VA1066, VA1082, VA1100 **10p**
VA1077, VA1005, **15p**

TV KNOB

Dark grey plastic for recessed shaft (quarter inch) with free shaft extension **5p**

ENM Ltd. cased 7-digit counter $2\frac{1}{4}$ x $1\frac{3}{4}$ x $1\frac{1}{4}$" approx. 12V d.c. (48 a.c.) or mains **75p**

RELAYS

12 volt S.P.C.O octal mercury wetted high speed **40p**
P.O. 3000 type, 1,000 OHM coil, 4 pole c/o **40p**
Mains or 12v d.p.c.o heavy duty octal **50p**

ZM1162A INDICATOR TUBE

0-9 Inline End View. Rectangular Envelope 170V 2·5M/A **£1**

REGULATED TAPE MOTOR
9v d.c. nominal approx $1\frac{1}{2}$" diameter **60p**

12v 8 amp Transformer **£2.50 (p&p 85p)**

Ferric Chloride, Anhydrous mil. spec. 1lb bag **40p**

3.5mm metal stereo plug **20p**

JAP 4 gang min. sealed tuning condensers **20p**

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	10p	12p	16p	20p
25	4p	5p	6p	8p	10p	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	22p	40p	75p	—	£1.50	—	—
2000	23p	37p	45p	—	—	—	—	—

As total values are too numerous to list, use this price guide to work out your actual requirements

8/20, 10/20, 12/20 **Tubular tantalum 20p each**
16-32/275V. 100-100/150V. 100-100/275V **30p**; 50-50/385V. 12,000/12V, 32-32-50/300V, 20-20-20/350V **60p**; 700 mfd/200V **£1.00**; 100-100-100-150-150/320V **£2.00**.

RS 100–0–100 micro amp null indicator Approx. 2" x $\frac{3}{4}$" x $\frac{3}{4}$" **£1.50**

INDICATORS

Bulgin D676 red, takes M.E.S. bulb **30p**
12 volt or Mains neon, red pushfit **18p**
R.S. Scale Print, pressure transfer sheet **.10p**

CAPACITOR GUIDE – maximum 500V

Up to .01 ceramic **3p.** Up to .01 poly **4p.** .013 up to .1 poly etc. **5p.** .12 up to .68 poly etc. **6p.** Silver mica up to 360pF **8p.** then to 2,200pF **11p.** then to .01 mfd **18p.** **8p.** .1/600: **12p.** .01/1000, 8/20. .1/900, .22/900, 4/16. .25/250 AC (600vDC) **40p.** 5/150, 9/275AC, 10/150, 40/150.

Many others and high voltage in stock.

FORDYCE DELAY UNIT

240 volt A.C./D.C. Will hold relay, etc., for approx. 15 secs after power off. Ideal for alarm circuits, etc. **£1**

CONNECTOR STRIP

Belling Lee L1469, 4 way polythene. **6p each**

$1\frac{1}{4}$ glass fuses 250 m/a or 3 amp (box of 12) **6p**
Bulgin, 5mm Jack plug and switched socket (pair) **30p**

Reed Switch 28mm. body length **5p**

MAINS DROPPERS

66+66+158 ohm, 66+66+137 ohm
17+14+6 ohm, 266+14+193 ohm **5p**
50+40+1k5 ohm
285+575+148+35 ohm
25+35+97+59+30 ohm **5p**

$5\frac{1}{4}$" x $2\frac{3}{4}$" Speaker, ex-equipment 3 ohm **30p**
2 Amp Suppression Choke **8p**
PAXOLINE
3 x $2\frac{1}{2}$ x $\frac{1}{16}$" **4p**
$4\frac{5}{8}$ x $\frac{1}{2}$ x $\frac{1}{8}$", **1p**
PCV or metal clip on MES bulb Holder **4p**
VALVE RETAINER CLIP, adjustable **2p**

OUTPUT TRANSFORMERS

Sub-miniature Transistor Type **25p**
Valve type, **40p**

Transformers 6 volt $\frac{1}{2}$A **25p**
Whiteley Stentorian 3 ohm constant impedance volume control way below trade at **80p**
RS Yellow Wander Plug Box of 12 **25p**
18 SWG multicore solder **$2\frac{1}{2}$p foot**

THE RADIO SHACK

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Open 10 a.m. till 7 p.m. Tuesday to Saturday. VAT receipts on request
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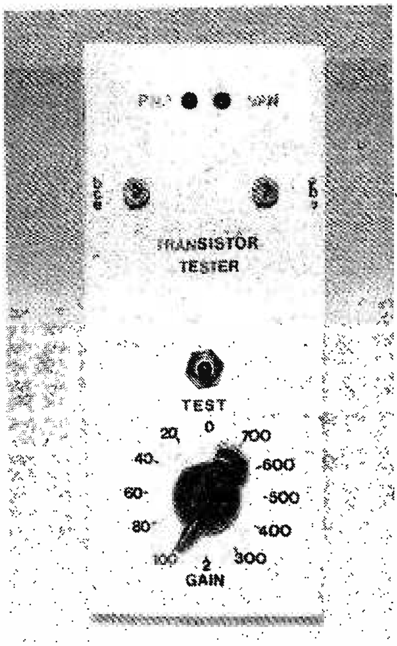


METERLESS TRANSISTOR TESTER

By Bruce Woodland

This test instrument allows the rapid determination of polarity and large signal gain of bipolar transistors. An l.e.d. readout replaces the usual moving-coil meter, conferring economic advantages and resistance to mechanical shock. The battery current demand is low and virtually the absolute minimum of manipulations is necessary to evaluate a transistor.

Many constructors augment their transistor supplies by the purchase of mixed untested transistors and reclaimed devices from computer boards. Again, during the design of circuitry it is often desirable to have at least a rough idea of the gain of a transistor even when this is a new marked device. For all these requirements some form of transistor tester is necessary.

SPECIFICATION

A quick look at the data sheet of any transistor will demonstrate the large number of tests which must be carried out to fully evaluate it. Fortunately, most home constructor applications require answers to three questions only:

1. Is the device functional?
2. What is its polarity?
3. What is its gain?

When a large number of devices are to be checked a testing instrument which is quick to use and involves the minimum of manipulations is obviously the most desirable. The tester to be described falls into this category and readily provides answers to the three basic questions just noted. No meter is incorporated, and so the cost and size can be kept to quite a small level.

PRINCIPLE

The block diagram of Fig. 1 illustrates the principle of operation of the transistor tester. A square wave oscillator provides an alternating voltage such that one output is at 2.7 volts positive when the other is at 2.7 volts negative, and vice versa, both voltages being

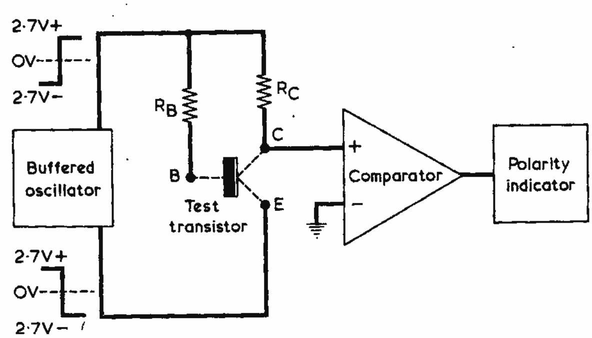


Fig. 1. Block diagram illustrating the operation of the meterless transistor tester

with respect to earth. One output is applied to the emitter of the transistor under test, whilst the other is applied to the transistor base via RB and to the transistor collector via RC.

If the transister is a p.n.p. type (and assuming the requisite values in RB and RC) it will be turned on when the collector is negative and the emitter positive. The collector will then be positive of earth. When the polarities at the collector and emitter are reversed the transistor simply becomes non-conducting. Thus the presence of a p.n.p. transistor is indicated by a positive voltage at the collector during the half-cycles from the square wave oscillator when the voltage applied to RB and RC is negative. During the other half-cycles the collector will also be positive because a positive voltage is then applied to RC.

The reverse holds true with an n.p.n. transistor, the collector of which goes negative.

The collector is connected to the non-inverting input of an operational amplifier which has two light-emitting diodes wired in opposing polarity in its feedback loop. If the non-inverting input goes positive the op-amp output follows, lighting the l.e.d. which indicates "p.n.p.". Similarly, when the non-inverting input goes negative the other l.e.d. lights up, to indicate "n.p.n.".

If the transistor under test has an open-circuit collector, both l.e.d.'s will be illuminated, because the op-amp output then follows the square wave oscillator. The same will happen if the value RB is too high to allow the transistor to turn on.

BIAS RESISTOR VALUE

We may next investigate the value of RB which is required to cause the collector of the test transistor to be just at mid-rail voltage, i.e. at earth potential, during half-cycles when the transistor is conductive. The full rail voltage is twice 2.7 volts, or 5.4 volts, and we shall assume that the test transistor is a silicon type with a base-emitter forward voltage drop of 0.7 volt. Under these circumstances the current in RC is 2.7 volts divided by RC, whilst the current in RB is 5.4 volts minus 0.7 volts, or 4.7 volts, divided by RB The gain is IRC divided by IRB, and this is equal to the first expression in Fig. 2. The second equation then gives an expression for RB. In the practical circuit RC is 4.3kΩ., leading to the third and fourth equations in Fig. 2.

It will be seen from the last equation that RB in kilohms is equal to gain mutliplied by 7.5. Thus, the collector of a transistor with a gain of 20 will be at earth potential when RB has a value of 150kΩ. The corresponding value of RB for a gain of 40 is 300kΩ., for a gain of 60 is 450kΩ., and so on.

The last equation in Fig. 2 is a little inaccurate for germanium transistors, with their base-emitter forward voltage drop of about 0.15 volt, but the error is not in practice of any serious significance. Most transistors encountered these days are, of course, silicon types.

We can now see how the arrangement of Fig. 1 can be employed for first determining the polarity of a transistor and then its gain. Should RB initially be given a relatively low value the test transistor, if serviceable, is bound to be turned on, whereupon one of the two l.e.d.'s will light up to indicate polarity. The value of RB is then increased until the collector of the test transistor passes earth potential, causing both l.e.d.'s to be illuminated. The value of RB at which this occurs then gives an indication of the gain of the transistor.

$$\text{GAIN} = \frac{2.7}{\text{RC}} \times \frac{\text{RB}}{4.7}$$

$$\text{RB} = \text{GAIN} \times \frac{\text{RC}}{2.7} \times 4.7$$

$$\text{RB}\,(\text{k}\Omega) = \text{GAIN} \times \frac{4.3}{2.7} \times 4.7$$

$$\text{RB}\,(\text{k}\Omega) = \text{GAIN} \times 7.5$$

Fig. 2. Equations developing the relationship between RB and test transistor gain when the transistor collector is at earth potential

WORKING CIRCUIT

The full working circuit appears in Fig. 3. This has two integrated circuits, of which IC1 is a CMOS MC-14049 hex inverter/buffer and IC2 is a 741 op-amp. Two of the inverters of IC1, in association with C1, R1 and R2, form a simple square wave oscillator with a roughly equal mark-space ratio running at approximately 2.5kHz. The remaining four inverters are parallel coupled in pairs to increase their current sink and source capabilities, and are arranged to provide complementary polarity outputs from the oscillator. One output connects to the emitter of the test transistor and the other to R6, which replaces RC of Fig. 1. RB of Fig. 1 is replaced by R7 and whatever resistance, in R8 to R17, is switched in by S2.

A CMOS device is employed for IC1 as it is necessary to have a symmetrical voltage swing about earth. A t.t.l. device would be unsuitable.

The feedback loop around IC2 includes LED1, LED2 and R4. R3 sets the sensitivity such that 0.1 volt difference between the test transistor collector and earth corresponds to a flow of 10mA in the appropriate l.e.d. The l.e.d. current is limited by R4. When the non-inverting input goes positive the i.c. output follows and LED1 lights up. LED2 is illuminated when the non-inverting input goes negative.

A dual rail supply which is nominally 2.7 volts positive and negative of earth is given by the circuit comprising R5, ZD1, ZD2, C2 and C3. The press-button S1 ensures that power is only demanded from the 9 volt battery during an actual test, thus prolonging battery life. The current requirement is about 16mA, whereupon a PP3 battery is quite suitable.

It may be felt that, bearing in mind the internal output stage of a 741, a dual 2.7 volt supply may be insufficient to allow the l.e.d.'s to be illuminated. No

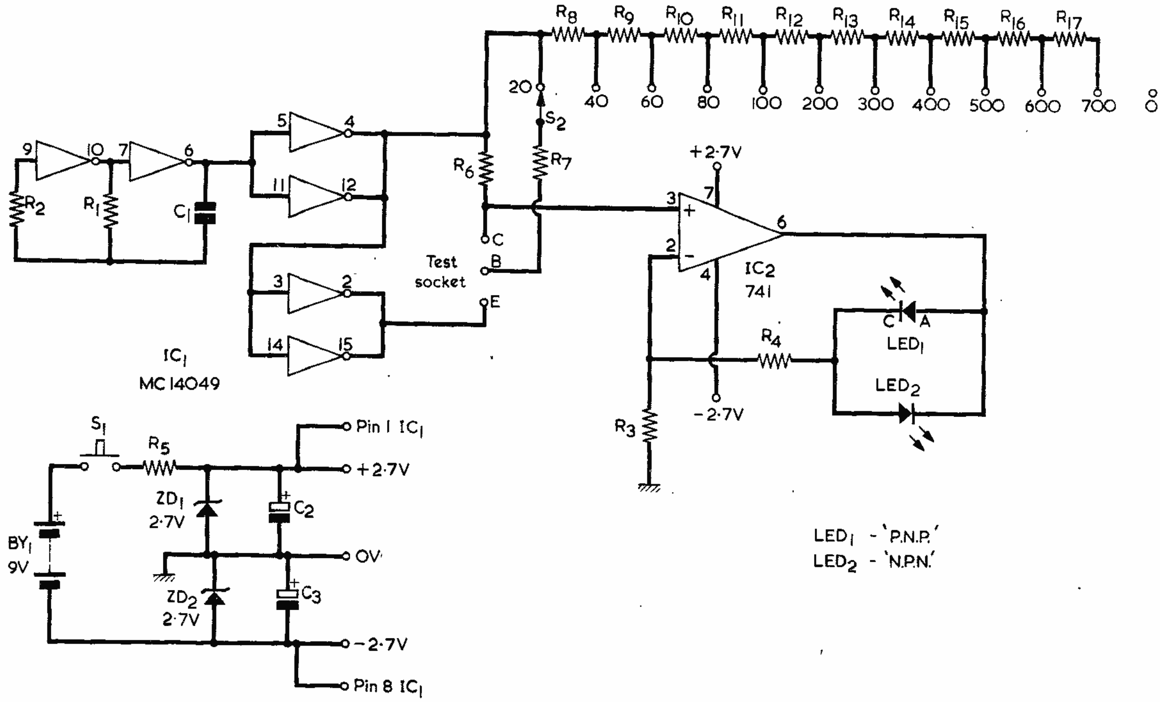


Fig. 3. Full circuit diagram for the transistor tester. The numbers at the contacts of S2 indicate the corresponding gain figures

COMPONENTS

Resistors
(All $\frac{1}{4}$ watt 5%)
- R1 39kΩ
- R2 68kΩ
- R3 10Ω
- R4 68Ω
- R5 220Ω
- R6 4.3kΩ
- R7 150kΩ
- R8 150kΩ
- R9 150kΩ
- R10 150kΩ
- R11 150kΩ
- R12 750kΩ
- R13 750kΩ
- R14 750kΩ
- R15 750kΩ
- R16 750kΩ
- R17 750kΩ

Capacitors
- C1 0.01µF type C280 (Mullard)
- C2 20µF electrolytic, 10 V. Wkg.
- C3 20µF electrolytic, 10 V. Wkg.

Semiconductors
- IC1 MC14049 or CD4049
- IC2 741, 8 pin d.i.l.
- ZD1 BZY88C2V7
- ZD2 BZY88C2V7
- LED1 red l.e.d. (see text)
- LED2 red l.e.d. (see text)

Switches
- S1 press-button, push to close, miniature
- S2 1-pole 12-way rotary, miniature

Battery
- BY1 9 volt battery type PP3 (Ever Ready)

Miscellaneous
- Pointer control knob
- 8 pin i.c. holder
- 16 pin i.c. holder
- Battery connector
- Printed circuit board
- Materials for case (see text)

trouble was experienced in this respect with the prototype, which worked satisfactorily with battery voltages down to 6 volts. Taking into account the relatively high slope resistances of 2.7 volt zener diodes at low currents, this would indicate a comfortable voltage margin. The author employed l.e.d.'s of about 0.2in. diameter obtained from Radio Shack of Battersea.

CONSTRUCTION

The construction of the tester can be carried out in any reasonable manner preferred by the reader, and the following details of the author's instrument may be helpful as a guide.

The prototype is housed in a home-made case having internal dimensions of 5¼in. long by 2in. wide by 1½in. deep. The sides and ends consist of ¼in. wood and the front panel of s.r.b.p. sheet. The sides, ends and front are covered overall with Formica. The back consists of a piece of aluminium with flanges at the end which provide a push fit.

The printed circuit board is mounted on three ½in. spacers tapped 6BA, these being secured to the s.r.b.p. panel by countersunk 6BA screws whose heads are covered by the outside Formica. The body of S1 is between the front panel and the component side of the printed board, appearing betweeen R5 and ZD2. A miniature press-button was employed here. Larger push-buttons would necessitate increased spacing between the front panel and the board, and a corresponding increase in case depth. The author fitted two transistor sockets on the front of the case, one wired for transistors with a BCE lead-out configuration and the other for transistors with a CBE configuration. The l.e.d.'s are mounted directly on the printed board, being positioned such that their forward ends just fit into two holes drilled for them in the front of the case.

The ten transistors, R8 to R17, are mounted directly to the tags of S2. There is just sufficient space behind the printed board to take a PP3 battery, this being insulated from the copper pattern of the board by a piece of foam plastic sheet. The front panel is marked up with gain figures for S2, these corresponding to the gain figures shown in the circuit diagram of Fig. 3. The legend "PNP" appears alongside LED1 and "NPN" alongside LED2. The indentifying letters "B", "C" and "E" appear, as applicable, beside the transistor holders.

The printed board is reproduced full-size in Fig. 4.

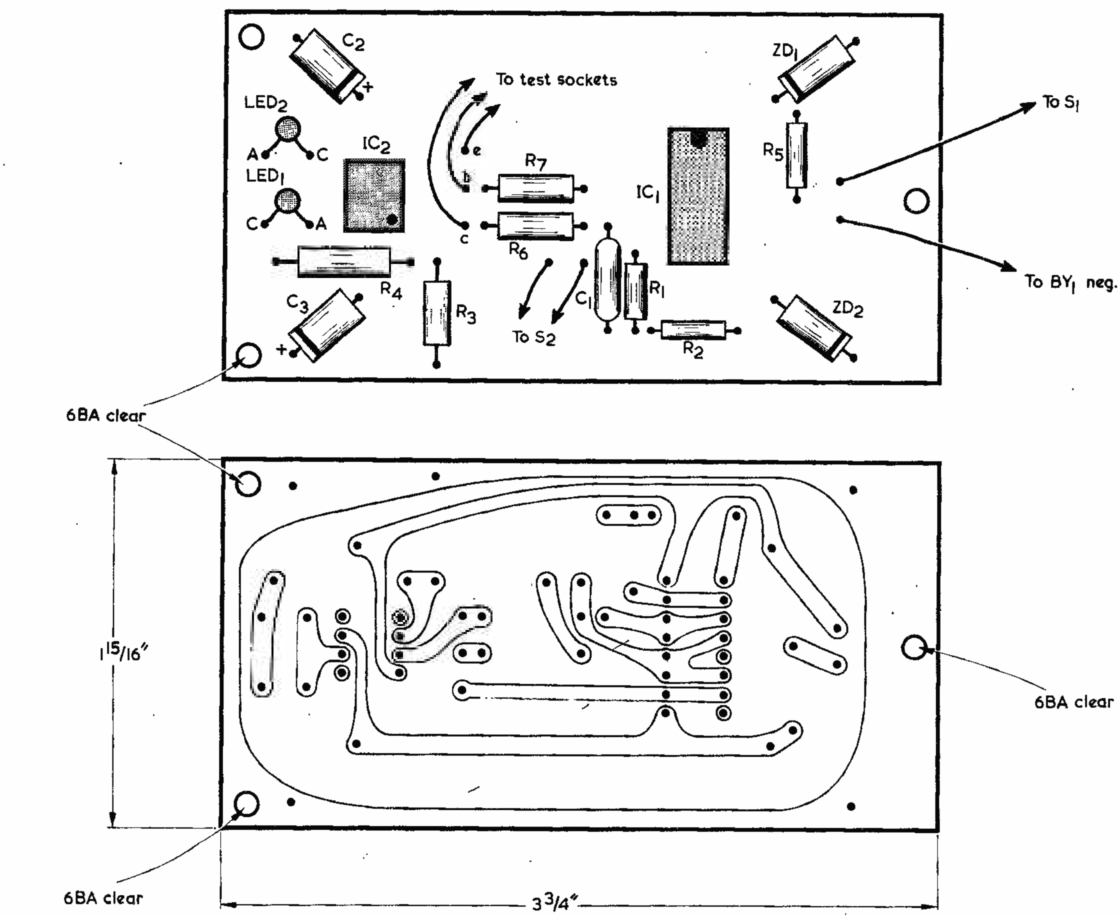
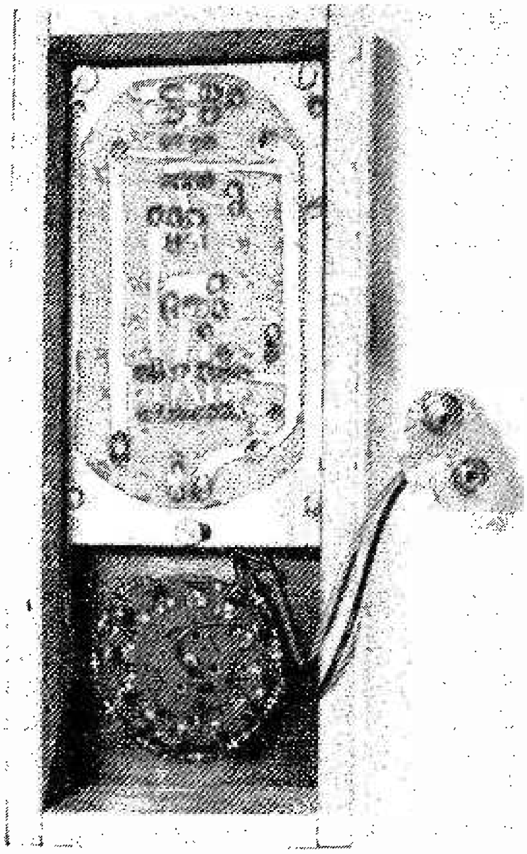


Fig. 4. Component and copper sides of the printed board. This is reproduced full size for tracing



Layout inside the tester. There is space for a PP3 battery over the printed board

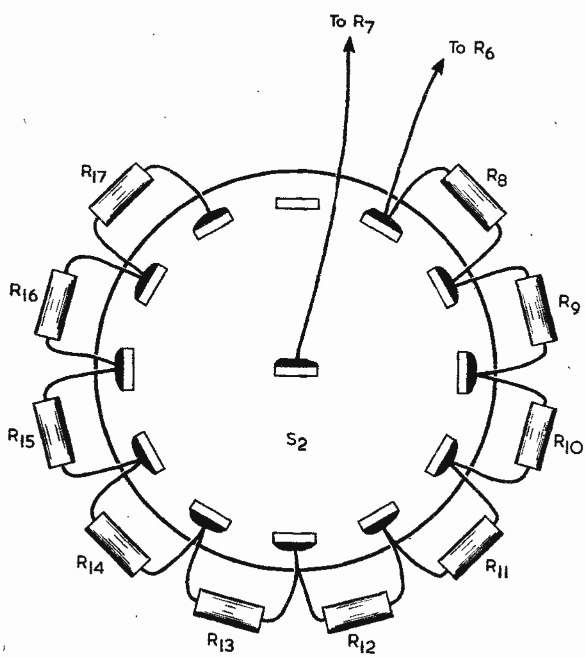


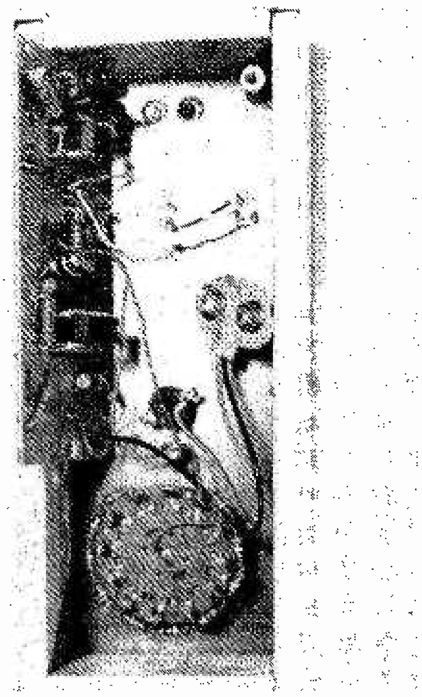
Fig. 5. Resistors R8 to R17 are wired directly to the tags of S2. The two wires connect to R6 and R7 on the printed board

It is strongly recommended that integrated circuit holders be used for IC1 and IC2, whereupon these two i.c.'s may be plugged in after all soldering is completed and the wiring has been checked. Fig. 5 shows the resistors which are soldered to the tags of S2.

USING THE TESTER

To use the tester first connect the transistor to be checked to the instrument. Set S2 to "20" and press S1. If the transistor is a satisfactory component and has been connected correctly, either the "PNP" or the "NPN" l.e.d. will light.

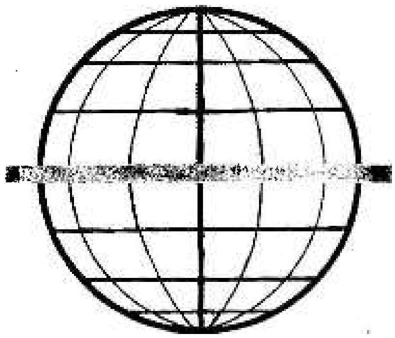
Keeping S1 pressed, rotate S2 to higher gain figures until both l.e.d.'s light up. The highest gain setting with only one l.e.d. alight is the value taken, the exact value lying between the two figures. If the transistor is not faulty, both l.e.d.'s should be alight when S2 is in the "O" position.



In this view the printed board has been moved to one side. On the front panel can be seen the two holes for the l.e.d.'s, the connections to the transistor holders and switch S1

Normally, the transition from one l.e.d. being alight to two being alight should be of an abrupt nature as S2 is moved from one position to the next. However, it may be found with quite a few transistors that the second l.e.d. commences to glow faintly at the setting of S2 which is just below that at which both l.e.d.'s are fully illuminated. This will occur if the gain of the transistor is such that the collector voltage is just short of reaching earth potential. The gain figure is then that at which the second l.e.d. glows faintly, and will be more accurate than is given when the change from one l.e.d. to two l.e.d.'s is of an abrupt nature. ■

500th EDITION OF WORLD RADIO CLUB



Report by Ron Ham

Since it began on July 1st, 1967, more than 32,000 members have joined World Radio Club, a popular weekly programme broadcast by the BBC World Service for the benefit of shortwave listeners, and those who want to know more about the technical side of radio communication.

During the past decade, the lifetime of the programme, there has been a fantastic advance in electronics which has reflected in the design of radio receivers and transmitters, broadcasting and recording techniques, and in the world of amateur radio. Throughout this period, World Radio Club producers have done their best to keep its listeners informed of the progress with hundreds of outside interviews at places where the developments were being made. The Club's reporters have been to both national and international exhibitions and talked to representatives on their stands about their particular radio products. Listeners have heard reports from factories, schools, research labs, and the armed forces, in fact they have talked about anything from the worlds smallest television set to the giant radio telescope at Jodrell Bank. Frequently outside specialists have been called in to take part in a particular programme along with their regular team. Often an article of special interest has appeared in one of the technical journals and soon afterwards, the author, or a representative of that journal, has been invited to WRC to discuss the subject further.

With this sort of background it was no surprise when the BBC invited, for the first time, an audience of radio enthusiasts to Bush House (HQ BBC World Service) to witness, and celebrate the recording of the 500th edition of World Radio Club, and furthermore, to take part in the programme by putting questions to a panel of experts. As usual, Frank Hennig, G3GSW, was in the chair and the panellists were Bill Wood, Head of the BBC's Engineering Information Department, Desmond Colling of the International Shortwave League, and Henry Hatch, G2CBB well known to listeners because, for many years he has answered members' technical problems in a straightforward and uncomplicated manner.

Questions from the audience about AM or FM, Fading, Amateur call signs, frequency allocations, and the sunsport cycle were adequately answered by the team in the true club spirit which has been the programme's hallmark since it began.

Among the enthusiastic studio audience were many people who had taken part in previous programmes as well as representatives from the technical press, radio clubs, and shortwave organisations. The RSGB President, Lord Wallace of Coslany and General Manager, George Jessop, G6JP, were in the audience and Lord Wallace delighted everyone when he told Frank Hennig that now he is President, everybody calls him George which emphasises the friendly atmosphere which exists throughout the world of amateur radio.

Richard Lambley, G8LAM, who has been producing the programme on a temporary basis read a letter of good wishes from the European DX Council and Reg Kennedy, regular producer, told of the time when his tape recorder belched out smoke while he and former chairman, Peter Baresby, were flying with the RAF in a piston aircraft over the north-Atlantic interviewing the crew for WRC. It was the human items like these that helped to make the evening of February 11th a most enjoyable one for all of us who were there.

The writer would like to add his good wishes for the future of World Radio Club, and to thank the BBC for a wonderful evening.

NEWS . . . AND .

MASSIVE EXPORT CONTRACT

It is pleasant to report a massive export contract won by companies in the GEC-Marconi Electronics group. The contract, worth £150 million, has been awarded to GEC-Transportation Projects Limited for the provision of electrification, telecommunications, signalling and locomotive equipment operating at 25kV a.c. for Brazil's Federal Railway Network.

As well as system design responsibility, the contract includes the supply of equipment and services for a new "steel railway" which will run from the iron ore centre of Belo Horizonte to the major steel complex at Volta Redonda a distance of some 400 kilometres.

When completed in early 1982 the new rail link will carry quadruple-headed trains of up to 12,000 tons at speeds reaching 60 kilometres per hour. It is expected to transport 50 million tons of iron ore each year from Belo Horizonte and Jaceaba to Volta Redonda, and it will also provide a limited passenger service between the areas.

In addition, the contract provides for the electrification of the existing line which runs for some 450 kilometres from the port of Sepetiba near Rio de Janeiro via Volta Redonda to Manoel Faio near Sau Paulo.

This latest contract, the largest ever placed by the Brazilian Railway Authority, involves several GEC companies in the supply of equipment. Electrical equipment for the locomotives will be manufactured by GEC Traction Limited; signalling systems by GEC-General Signal Limited, substation equipment by GEC Switchgear Limited and GEC Power Transformers Limited, and cables, microwave radio and multiplex communications equipment by GEC Telecommunications Limited and Telephone Cables Limited. Further, the overhead contact system will be provided by Balfour Beatty Power Construction Limited, and a training programme for the Brazilian operating staff will be arranged by Transmark, the British Rail consultancy organisation.

GEC-Transportation Projects was set up in 1972 to seek comprehensive contracts in the expanding field of railway electrification and metro systems, incorporating equipment manufactured by the GEC product companies. It has certainly achieved an outstanding success in its Brazilian venture.

AID TO INSTALLING FM RADIO AERIALS

A single co-axial downlead can be used to connect both a television aerial and an FM radio aerial, using a new twin TV/FM outlet unit introduced by MK Electric.

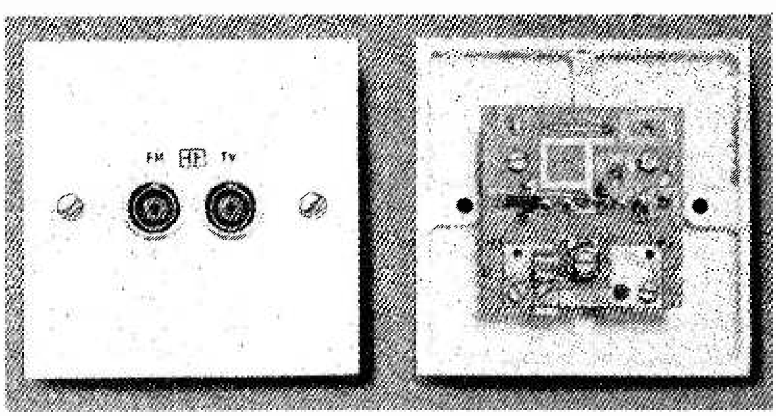
This means that a householder can make use of his existing television downlead when he decides to install an FM aerial in the loft or developers can add to the "sellability" of new homes by providing for connection of FM radio as well as television aerials.

Two of the new MK 3522 isolated TV/FM socket-outlets units will be required, installed on a "back-to-back" arrangement with one in the normal television aerial outlet position and the other suitably located in the loft. The co-axial downlead is connected to the rear of this second unit, and the TV and FM aerials are connected into the front-plate using normal co-axial plugs.

The twin TV/FM outlet unit will fit into the same box as the normal co-axial TV outlet and the two sockets are clearly engraved "TV" and "FM".

Although suitable for use in this way, the new twin outlet unit has been introduced by MK primarily to meet stringent regulations that have been proposed for multi-outlet aerial installation in blocks of flats etc. It is anticipated that, if introduced, these regulations will call for a 2,000V isolation value for the outlet units.

Recommended retail price of the 3522 isolated TV/FM co-axial socket-outlet is £3.08 plus VAT.



RADIO AMATEURS ASSIST SCIENTIFIC EXPEDITIONS

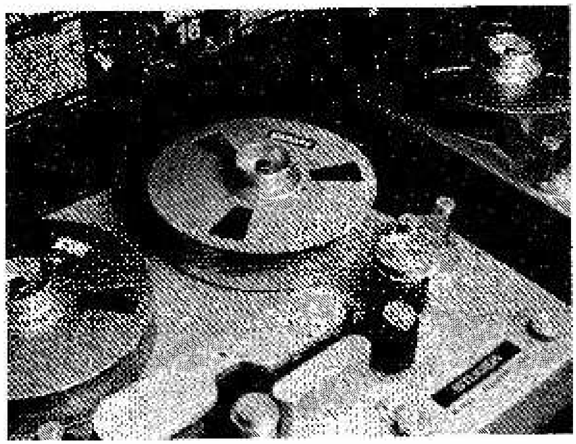
Following our comments in the January issue regarding the giving of news of activities and evelopments outside the scope of the individual shack or workshop, we are indebted to the latest edition of Region 1 News, the Journal of the International Amateur Radio Union Region 1 Division, for news of cooperation between Italian Radio Amateurs and recent scientific expeditions.

At the beginning of 1976, a team of fifteen Italians explored the King George Islands in Antarctica. This expedition was directed by Italian radio Amateur Remato Cepparo, I1SR. The programme of the expedition included biological studies, geological observations and exploration of some of the Island's mountains. One of the mountain peaks was named "CIMA RADIOAMATORI", to commemorate the very helpful work carried out by radio amateurs in sustaining communications between the expedition and Italy. Radio contact with the expedition was maintained by radio Amateurs from the town of Monza, near Milan, most of the contacts being on the 14MHz Amateur band.

During July and August of last year, another Italian expedition visited Greenland and they had a volunteer radio operator in I4CDH. The expedition call sign was I4CDH/OX. The base camp was near Umiamako Muna, close to latitude 72°N, and the radio station was operated from a tent.

. . . COMMENT

EMI LAUNCH NEW PROFESSIONAL AUDIO RECORDING TAPES



EMI Tape Limited, of Hayes, Middlesex, has introduced a new range of professional audio recording tape — the EMITAPE 830 series.

The EMITAPE 830 range is based on a high-output low-noise professional tape developed specifically for high quality reproduction in studio mastering and broadcast applications. Its most significant features are increased high/low frequency magnetic remanence values and an excellent signal-to-print ratio. In addition, the extremely low modulation noise and low head wear properties previously associated with the highly successful EMITAPE 815 broadcast quality tape have been incorporated in the new product.

The new tape initially will be available in three formats: 831 non-backed standard play; 832 matt-back standard play, particularly good for non-pressure pad high-speed spooling; and 833 long play for use with low tension battery recorders, with a range of widths to suit studio requirements.

The 830 series has a much higher magnetic remanence which gives an improved signal to noise ratio of 77dB. This has been achieved by EMI Tape's new oxide formulation and a new type of production process. Reduced intermodulation and third harmonic distortion gives the tape, for instance, less than ½% third harmonic distortion at the 1KHz I.E.C. (International Electro Technical Commission) reference level. To provide a greater built-in overload fail-safe, EMI Tape has improved the headroom to give a maximum output of +8.5dB for 3% harmonic distortion at 1KHz. This high 1KHz output is complemented by a similar output at 10KHz.

NORTHERN RADIO SOCIETIES' ASSOCIATION

The Annual Convention and Exhibition of the NRSA, which is sponsored by radio societies in the North of England, will take place at Belle Vue, Manchester on Sunday, 24th April, 1977.

The doors will open at 11.00 am and there will be a record number of trade exhibitors in attendance, as well as club display stands.

Other highlights will include a Grand Raffle, an Inter-Club Quiz and a Construction Contest (s.a.e. for rules to Mr. John D. Clifford — G4BVE of 10 Arley Avenue, Bury, BL9 5HD).

XEROZA RADIO MOVES TO LONDON

Xeroza Radio, formerly of Bishop's Tawton, Devon, have now removed to new premises at 306 St. Paul's Road, Highbury Corner, London N.1.

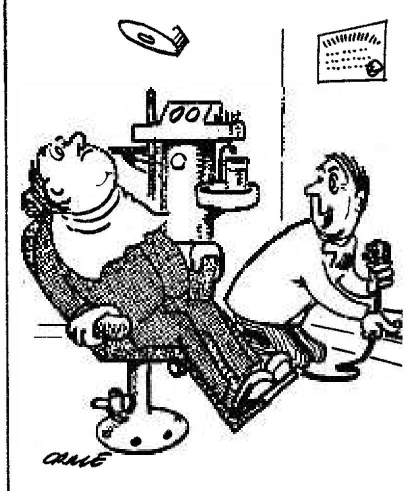
They have extensive stocks of electronic components and carry a complete range for radio and electronics constructors.

The business is under the control of Mr. Tom Powell who has had many years experience in the component field.

● Mrs. Rita Shepherd, G3NOB, has retired from the position of Honorary Secretary of the Radio Amateur Invalid and Bedfast Club. The new Honorary Secretary is Mr. H. R. Boutle, G2CLP, who is, incidentally, Business Manager of the famous Shuttleworth Collection of aircraft. Mr. Boutle's address is 14, Queen's Drive, Bedford MK41 9BQ.

● Messrs Radio Shack, of 161 St. John's Hill, Battersea, London SW11, have informed us that they have on a number of occasions recently been confused with the famous American firm of the same name who are, of course, associated with the Tandy Corporation of Bilston Road, Wednesbury, W. Midlands. This can cause particular difficulty when components or equipment is involved.

We trust that readers will note the distinction to avoid inconvenience to both firms.



"Looks as though all you'll need this time is two small stoppings and a 13 amp fuse!"

SUGGESTED CIRCUIT

POLARITY/BASE RESOLVER

By G. A. French

It is often possible to obtain job-lots ofunmarkedbipolar transistors at very low cost, whereupon it then becomes necessary to sort these out into n.p.n. and p.n.p. types, and to determine their lead-out functions. Such a process can be very tedious if, say, a multimeter switched to an ohms range is employed to find the transistor polarity, and it can still be excessively time-consuming if a standard transistor gain meter is used. This article describes an extremely simple and inexpensive item of test equipment which not only determines the polarity of a bipolar transistor but also identifies its base lead-out. In consequence, much of the initial sorting of unmarked transistors can be carried out with negligible difficulty and expenditure of time. The test instrument also provides a rough and ready check for transistor serviceability, since it will indicate whether a transistor has an open-circuit or short-circuit junction.

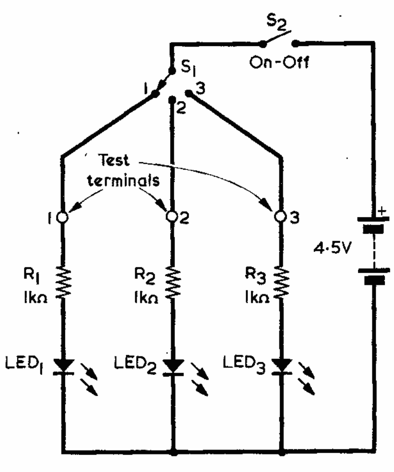


Fig. 1. The circuit of the polarity/base resolver. Despite its sophisticated performance this requires very few components

RESOLVER CIRCUIT

The circuit of the polarity/base resolver appears in Fig. 1, and it will be seen that it requires very few components. There are three test terminals, three light-emitting diodes, three resistors, a 3-way rotary switch, a single pole on-off switch and a 4.5 volt battery.

The transistor to be checked is connected to the three test terminals with S2 closed. S1 is then taken through its three positions. If all three l.e.d.'s light up for one position and only one l.e.d. lights up at the remaining two positions, then the transistor is an n.p.n. type and the switch position at which all three l.e.d.'s are illuminated corresponds to the base lead-out. Thus, should all the three l.e.d.'s be lit when the switch is at position 3, then the base lead-out connects to test terminal 3.

If it is found that all three l.e.d.'s light up at two positions of S1 and a single l.e.d. is lit at the third position, the test transistor is p.n.p. Further, the switch position at which the single l.e.d. is illuminated corresponds to the base lead-out of the transistor.

The currents flowing in the circiut are low and there is no necessity to turn off S2 when connecting a transistor to the terminals. S2 can be turned on at the start of a checking session and turned off at the end. Its function is merely to prevent battery current drain when the instrument is not in use.

The operation of the circuit is quite easy to follow and it is helpful to remember that a bipolar transistor can be looked upon as two junction diodes connected back-to-back, as in Fig. 2. It should also be borne in mind that "conventional current" is assumed to flow from positive to negative, and that it flows in a diode in the direction indicated by the arrow-head which constitutes part of the diode symbol. It also flows in the direction indicated by the emitter arrow-head in the transistor symbol.

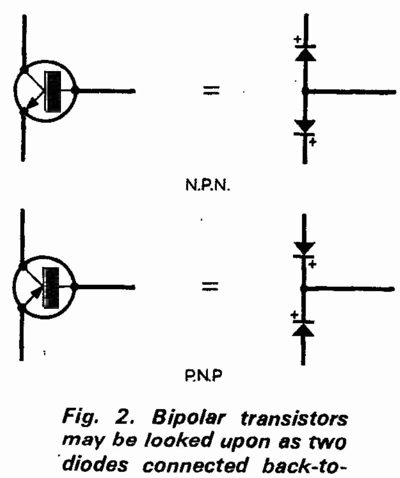


Fig. 2. Bipolar transistors may be looked upon as two diodes connected back-to-back. The corresponding diodes for n.p.n. and p.n.p. transistors are shown here

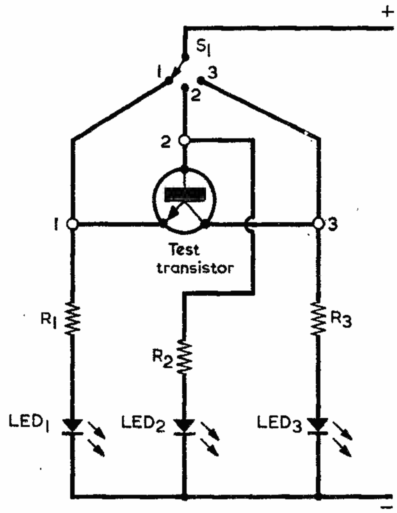


Fig. 3. Connecting an n.p.n. transistor to the resolver. All three l.e.d.'s are lit when the switch is in position 2

N.P.N. TRANSISTOR

Fig. 3 illustrates the situation where an n.p.n. transistor is connected to the test terminals. We shall assume that the base lead-out is connected to terminal 2.

When switch S1 is in position 1, current flows through R1 and LED1, causing this l.e.d. to light up. Current cannot flow into the remainder of the circuit because it is stopped by the emitter-base junction of the transistor, which acts as a reverse connected diode. As a result, only LED1 is illuminated. If S1 is taken to position 3, current flows in R3 and LED3, causing this l.e.d. to be illuminated. Again, current cannot flow into the rest of the circuit because the collector-base junction of the transistor functions as a reverse connected diode. In consequence. only LED3 is lit.

If S1 is taken to position 2, current flows in R2 and LED2, whereupon LED2 lights up. Both the base-emitter and base-collector junctions now act as forward connected conducting diodes, and current flows through these into R1 and LED1 and into R3 and LED3. As a result, all three l.e.d.'s are illuminated.

To sum up, taking S1 through its three positions causes a single l.e.d. to be illuminated at positions 1 and 3, and all three l.e.d.'s to be illuminated at position 2. These results indicate that the test transistor is an n.p.n. type and that its base is connected to terminal 2. Had the base been connected to terminal 1 the three l.e.d.'s would have lit up with S1 in position 1. Similarly, if the base had been connected to terminal 3, the three l.e.d.'s would be illuminated with S1 in position 3.

P.N.P. TRANSISTOR

We turn next to the situation which arises when a p.n.p. transistor is connected to the test terminals, as occurs in Fig. 4. Once more we connect the base lead-out to terminal 2 and we shall start by examining the situation when S1 is in position 2.

With the circuit in this state, current passes through R2 and LED2, causing this l.e.d. to light up. Current cannot flow to terminal 1 because the base-emitter junction of the transistor acts as a reverse connected diode. Similarly, current cannot flow to terminal 3 since the base-collector junction also acts as a reverse connected diode. Thus, only LED2 lights up.

When we come to consider the remaining positions of S1, circuit functioning becomes more complex and takes advantage of active transistor operation in addition to passive diode conduction.

Fig. 5(a) shows the situation with S1 in position 1. Current flows through R1 and LED1, and LED1 lights up. The emitter-base junction of the transistor acts as a forward conducting diode and current flows also into terminal 2 and thence into R2 and LED2. LED2 becomes illuminated. Since there is now a relatively high current in its emitter-base junction the transistor turns on and passes collector

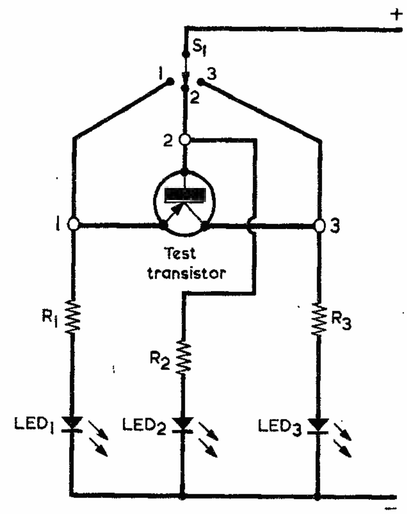


Fig. 4. Here, a p.n.p. transistor is connected to the circuit. With S1 in position 2, only one l.e.d. is illuminated

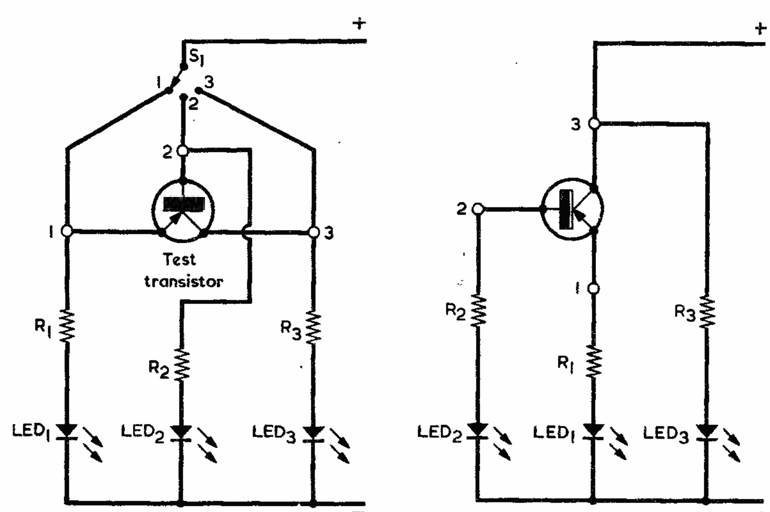


Fig. 5(a). When the switch is in position 1, all three l.e.d.'s light up

(b). With the circuit redrawn, the transistor may be recognised as being in the common emitter mode.

current, this flowing into R3 and LED3, which also lights up. The consequence is that all three l.e.d.'s are illuminated.

The circuit can be more readily followed if we omit the switch and redraw the circuit of Fig. 5(a) in the manner shown in Fig. 5(b). What we now have can be readily recognised as a common emitter amplifier with base bias from the negative rail being provided via LED2 and R2. The transistor is therefore turned on and causes collector current to be passed via LED3 and R3. Since the base and collector currents are approximately equal the circuit configuration requires only that the transistor has a current gain of unity, and such a requirement will obviously be met by any serviceable transistor.

In Fig. 6(a) we have the switch in position 3, whereupon current flows in R3 and LED3. The collector-base junction of the transistor acts as a forward connected diode and allows current to flow into R2 and LED2. Due to a minor anomaly associated with the bipolar transistor, current also flows from the emitter of the transistor into R1 and LED1. All three light-emitting diodes become illuminated.

To follow this situation more clearly, Fig. 6(b) shows the circuit of Fig. 6(a) rearranged and without the switch. Now, due to the symmetrical construction of a junction transistor it is possible for the device to function as a working transistor with the collector acting as an emitter and the emitter acting as a collector. The current gain offered by a transistor working in this mode is, normally, much lower than that given when the transistor is connected correctly but, in practice, the gain is found to be greater than the unity figure required by the present circuit. In Fig. 6(b) a base current flows in the base-collector junction (with the collector acting as an emitter) whereupon current flows in the circuit connected to the emitter (acting as a collector).

Reviewing the circuit operation illustrated in Fig. 4 to Fig. 6(b), a single l.e.d. lights up when S1 is in position 2 and all three l.e.d.'s light up when S1 is in positions 1 and 3. This identifies the transistor as a p.n.p. type with its base connected to terminal 2.

PRACTICAL POINTS

The author checked the prototype circuit with a wide range of transistors of both polarities, these consisting of modern silicon small signal and power types, and germanium small signal and power types. A few of the germanium transistors were very early types, such as the OC44, OC45 and OC71. All transistors checked out successfully in the manner just described.

Although not encountered by the author, there is a slight risk that some germanium power transistors may pass reverse leakage currents which

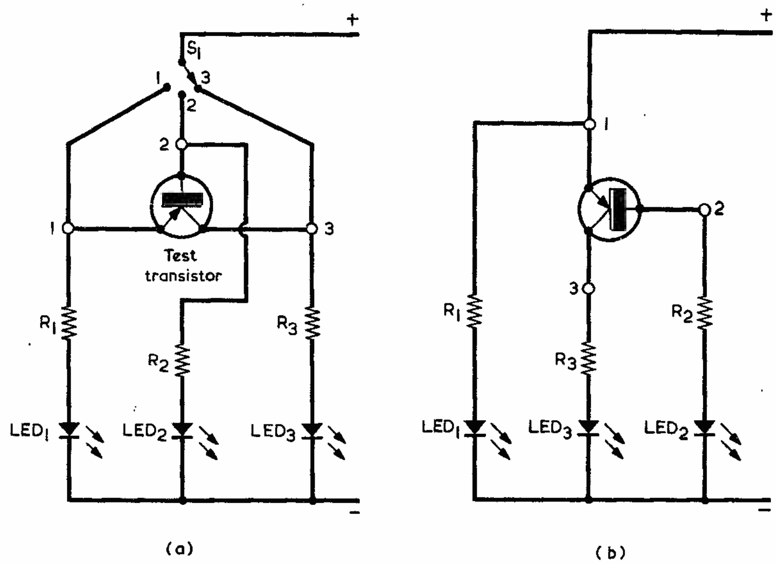


Fig. 6(a). All three l.e.d.'s are lit also when the switch is in position 3

(b). Rearranging the diagram shows transistor operation more clearly

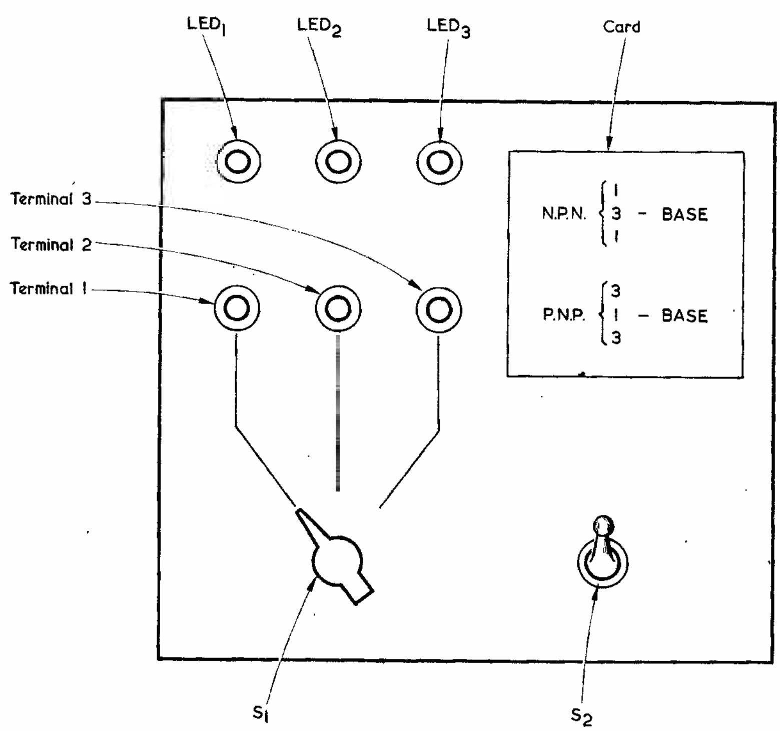


Fig. 7. A suitable front panel layout for the polarity/base resolver

could cause an l.e.d. to be partially illuminated when, properly, it should be extinguished. If this should occur, the partly lit l.e.d. should be considered as being extinguished and the transistor concerned looked upon as a specimen which passes a suspiciously high reverse leakage current. It is possible also that some p.n.p. transistors may not function adequately in the "wrong way round" mode of Figs. 6(a) and (b). Such an eventuality has to be mentioned for completeness but, in the writer's experience, it simply did not happen with any transistor checked by him.

Should it be found that a transistor does not cause illumination of the l.e.d.'s in one of the two manners just described, it is possible that it has a short-circuit or open-circuit junction or that it is, say, a field-effect transistor. A transistor with four lead-outs may be a bipolar type having one lead-out connecting to a shield and to the metal can. This lead-out can be identified with an ohmmeter before connecting the remaining three lead-outs to the test terminals.

The current flowing in each l.e.d. is of the order of 2mA and, assuming a forward voltage drop of 2 volts in each l.e.d., the highest voltage appearing at the test terminals will be 2.5 volts only. These low currents and voltages should not damage any transistors, including field-effect types, connected to the test terminals. In Fig. 5(a) the emitter current of the transistor is the sum of the base and collector currents, i.e. about 4mA. Similarly, the collector current in Fig. 6(a) is about 4mA. Such a current is still more than adequately low to ensure that no damage is caused to the transistor.

The three l.e.d.'s can be any small red types having reasonable sensitivity. Red l.e.d.'s Type 4, as supplied by Doram Electronics, were employed in the prototype circuit, and these give a surprisingly high light output at a forward current of 2mA. However, most other l.e.d.'s should offer a similar performance. With the Doram l.e.d.'s the anode lead-out is shorter than the cathode lead-out. The cathode lead-outs are those which connect to the negative rail.

The unit can be assembled in a small plastic case with S1, S2, the three l.e.d.'s and the test terminals on the front panel. A suggested panel layout is shown in Fig. 7. S1 is provided with a pointer knob, and lines are drawn on the panel linking it with the corresponding test terminals. This gives quick operation and there is no need to show the numbers 1, 2 and 3 on the panel itself. Also affixed to the panel is a card stating that n.p.n. transistors are identified by the fact that all three l.e.d.'s are lit at one switch position, whilst all three l.e.d.'s are lit at two positions for p.n.p. transistors. The card gives a reminder that the base lead-out is identified by three l.e.d.'s for n.p.n. transistors, and by one l.e.d. for p.n.p. transistors. ■

THE "M5" POCKET RECEIVER

Although this medium wave receiver is small enough to fit into a pocket it incorporates a full size 5 by 3 inch elliptical speaker and is specifically designed for economy of operation. The first two transistors are employed in a reflex circuit which provides a high level of amplification both at radio and at audio frequencies.

Almost all small portable receivers, whether commercially built or designed for home construction, have a weakness, in the author's opinion, in that too small a proportion of the space available is allowed for the speaker and the battery. Miniature speakers do not make a pleasant sound. The quality given by the 5 by 3 in. elliptical speaker used in the present design is far better than that obtainable, say, from the speaker measuring 2½in. in diameter. And very small batteries like the PP3 normally employed in such receivers cause expensive running costs unless the current passed is only about 2 or 3mA — hardly practicable if speaker operation is required at anything above a whisper.

The present receiver uses a battery consisting of two HP2 or SP2 cells, giving a nominal 3 volts from which 25mA is drawn. A perfectly satisfactory output volume is obtained for a pocket receiver. For similar results to be obtained from a 9 volt battery a current of about 10mA would need to flow (we are considering total receiver current, not that drawn by the output stage only.). At the time of writing, two HP2 cells cost rather more than one PP3. Two SP2's cost less, but these will not give quite the same life as HP2's. According to figures supplied by Ever Ready, HP2 cells will give 205 hours at 25mA for an end point of 25% of the initial voltage, this assuming use at 4 hours per day. Under the same conditions only 18 hours use will be obtained from a PP3 at 10mA. Allowing for the extra cost of two HP2's, the economy of the arrangement used in this receiver is still about 8 times as good as that which would be given by a similar output from a PP3 battery. Which, when all is said and done, is worth having. Who would not jump at a mini which averaged 320 m.p.g.!

SPEAKER

The case of the receiver measures approximately 5½ by 4½ by 1½in., and the set can be carried in a jacket pocket or lady's handbag. It is built around the Doram Electronics 3-4 Ω speaker code number 248-785, which has nominal dimensions of 5 by 3in. In practice the speaker is a little less than 5½in. long and is 2¾in. wide. The mounting centres are 125.5 by 39.6mm., or approximately 5in. by 1½in., whilst the magnet diameter is ⅞in. We have been assured by Doram Electronics that, so far as can be reasonably maintained, speakers supplied against the code number just given will continue to have the same dimensions as that used in the prototype.

If a speaker having different dimensions is employed there may well have to be changes in the dimensions of the sections of the red receiver. This comment applies also to speakers having a magnet of different diameter. However, the circuit will work well with any 3 Ω speaker, and constructors who are not interested in miniature design can obtain excellent results using, say, an 8 by 5 in. speaker.

With reference to the name given to this receiver, the design is based on the author's "Miniflex" principle, which has formed the basis of four receivers appearing in earlier issues of this journal. A number of improvements have been made in the design and, of course, the layout and component details are quite new. The choice of title, "M5", is thus understandable.

Constructors are advised to study the diagrams carefully, and to read all the constructional details, before commencing work on the receiver. This will ensure that the parts are assembled together in correct manner.

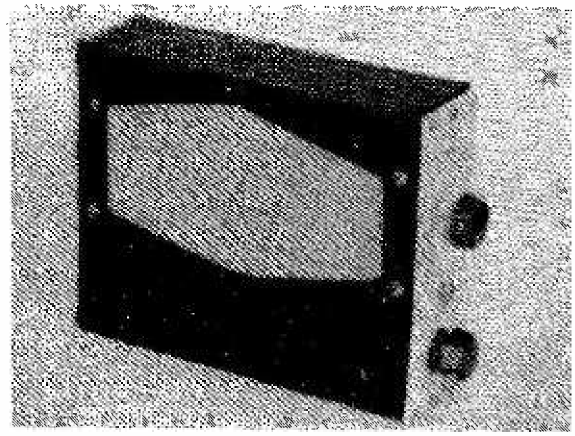
CIRCUIT DETAILS

The circuit is shown in Fig. 1. The signal is picked up on the ferrite aerial winding, L1, which is tuned by VC1, and is applied to the base of TR1. Capacitor C1 provides a capacitive tap across the tuned circuit and allows reaction in the Colpitts mode to be provided without the necessity for a separate feedback winding. Selectivity is controlled to some extent by the value of C1. A value of 1,000pF gives slightly greater signal strength but with a small reduction in selectivity, whilst 470pF gives very good selectivity but with possibly unsatisfactory reaction at the higher frequen-

Part 1

By

Sir Douglas Hall, K.C.M.G.



cies. The value of 680pF quoted in the Components List gives a good compromise.

TR1 is an emitter follower, and the r.f. signal at its emitter is applied to the base of TR2. At radio frequencies TR2 functions as a high gain common emitter amplifier, producing an output signal across the r.f. choke L2. This is applied to diode D1, which rectifies the signal and applies the detected a.f. back to the base of TR1 via L1. Note that D1 is a silicon diode and that a germanium diode must not be used here. C2 shunts the diode and allows some feedback of the r.f. signal for regenerative purposes.

Once again TR1 functions as an emitter follower and the signal across R1 is applied to the base of TR2 which, at audio frequencies, similarly functions as an emitter follower. Indeed, the two transistors form a Darlington pair at a.f., whereupon the output at TR2 emitter is at very low impedance — of the order of 50 Ω. An interstage transformer, T1, is then employed

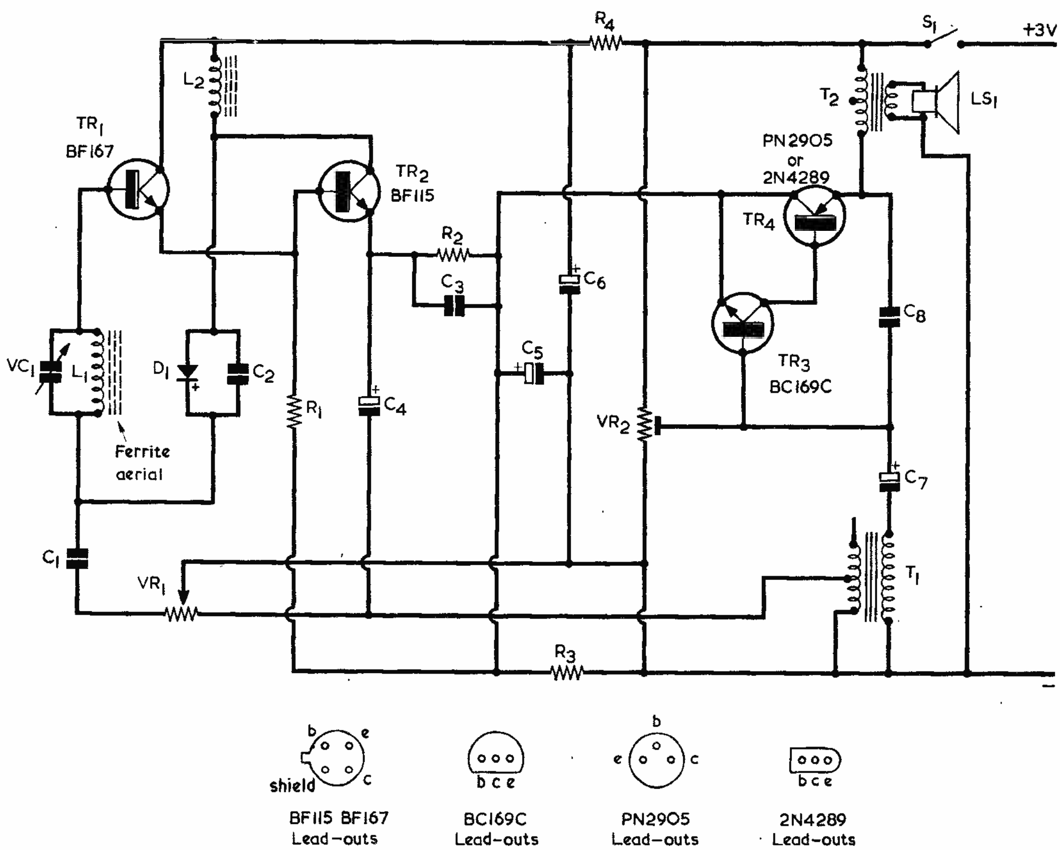


Fig. 1. The circuit of the "M5" medium wave portable receiver

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)
R1 6.8k Ω
R2 390Ω
R3 2.2 Ω
R4 82 Ω
VR1 220 Ω potentiometer, linear (see text)
VR2 100k Ω pre-set potentiometer, 0.1 watt skeleton, horizontal

Capacitors
C1 680pF silvered mica
C2 47pF silvered mica
C3 0.1μF plastic foil
C4 100μF electrolytic, 3 V. Wkg., axial (Siemens)
C5 1,000μF electrolytic, 3 V. Wkg., axial (Siemens)
C6 100μF electrolytic, 3 V. Wkg., axial (Siemens)
C7 2.2μF electrolytic, 25 V. Wkg., axial (Siemens)
C8 47pF silvered mica
VC1 300pF variable, "Dilemin" (Jackson)

Inductors
L1 ferrite aerial (see text)
L2 2.5mH r.f. choke, type CH1 (Repanco)
T1 Interstage transformer type LT44 (Eagle)
T2 Output transformer type TT56 (Repanco)

Semiconductors
TR1 BF167
TR2 BF115
TR3 BC169C
TR4 PN2905 or 2N4289
D1 1S44

Switch
S1 d.p.d.t. slide switch (see text)

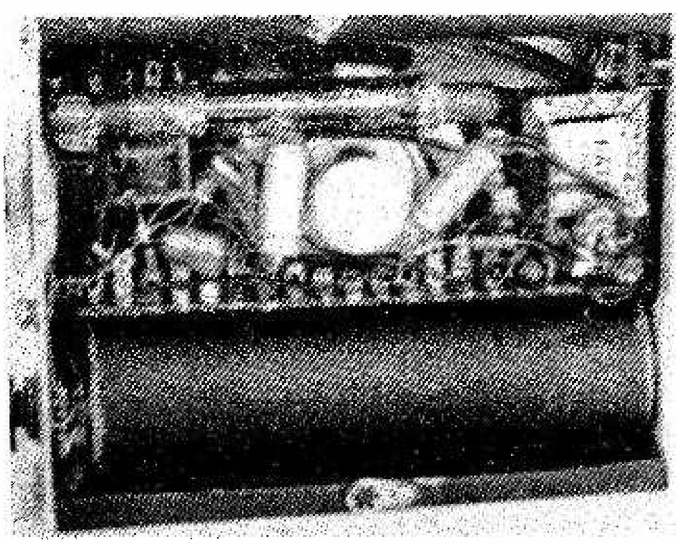
Speaker
LS1 3-4 Ω 5 by 3in., code no 248-785 (Doram)

Miscellaneous
2-off HP2 cells (Ever Ready)
28-way tagstrip (see text)
Ferrite rod, 4 by ⅜in.
Spring clip, type no. LK-2721 (Lektrokit)
2-off control knobs
6BA studding
Spring (see text)
Materials for case (see text)
Nuts, bolts, wire, etc.

to give a step-up in voltage (as against the more usual step-down arrangement encountered in transistor circuits). There is in consequence a "free" voltage amplification of 10 times before further a.f. amplification is given by TR3.

TR3 gives a very large degree of amplification and its collector connects directly to the base of TR4, which operates as a Class A emitter follower output transistor. TR4 emitter couples to the primary of output transformer T2, whose secondary couples in turn to the speaker. Pre-set potentiometer VR2 sets the bias current for the base of TR3 and is adjusted such that TR4 passes an emitter current of 23mA. A typical transistor in the TR4 position can be expected to have a current amplification of 150, whereupon a base current of about 150μA will produce the desired emitter current. This base current is also, of course, the collector current of TR3. Since TR3 collector current is only about 150μA, and since it has a current gain of about 500, its input impedance is high and there is no significant damping of the winding of T1 which feeds it. The overall amplification is therefore good as also, within the limitations of the output power available, is the quality of reproduction.

R3 provides negative feedback at d.c. for TR3 and TR4, a.f. feedback being cancelled here by the large



The internal construction of the receiver. The cylindrical assembly at the bottom holds the two HP2 cells, which constitute the battery value capacitor, C5. The main purpose of C8 is to prevent amplification by TR3 and TR4 of any r.f. signal which may filter through to these two transistors. C8 also provides a little top cut.

Volume and reaction are controlled by VR1. As the slider of this potentiometer approaches the end of the track connecting to C1 regeneration increases. On the other hand, as the slider approaches the end of the track connecting to the input winding of T1 the resistance across that winding reduces until, at zero setting, no audio signal at all is applied to TR3. The overall effect is that of an efficient reaction control combined with an equally efficient audio frequency volume control.

The type of component chosen for T2 is important. The d.c. resistance of its primary must be very low, as is essential when a 3 volt supply is available and only a small voltage drop can be afforded. Initially, the author employed an R.S. Components output transformer type T/T7. This has now been discontinued, but the author mentions the fact in case readers may have one of these transformers in their spares box. A suitable alternative is the Repanco type TT56 output transformer. The Repanco transformer is modified by the removal of its clamp.

Due to the small size of the receiver and other factors, a number of the components have to be specified by make and type. All the electrolytic capacitors are Siemens axial types, these being listed by Electrovalue Ltd., 28 St. Jude's Road, Englefield Green, Egham, Surrey, TW20 0HB. Potentiometer VR1 is a type P20 component, also available from Electrovalue. One of the two alternatives for TR4, the PN2905, is again stocked by Electrovalue.

Slide switch S1 should be a miniature d.p.d.t. slide switch having fixing centres at approximately $1\frac{1}{8}$in. (29mm.). A miniature 28-way R.S. Components tagstrip is required, and this can be obtained from Doram Electronics as a 28-way tagstrip type B. The ferrite rod is 4in. by $\frac{3}{8}$in. and may be obtained in this size, or can be a longer rod cut down. In the latter instance a V-cut is made with a triangular file all round the rod at the point where it is to be broken and it is then tapped sharply against the bench. The ferrite rod is held by a $\frac{3}{8}$in. spring clip, this being a Lektrokit part no. LK2721 which is available (in packets of 10) from Home Radio. Home Radio can also provide 12in. lengths of 6BA brass studding (threaded rod), which is required for the receiver assembly.

A small spiral spring is required for fitting between the two cells. This can be obtained from a cycle or hardware store, and further details of it are given later.

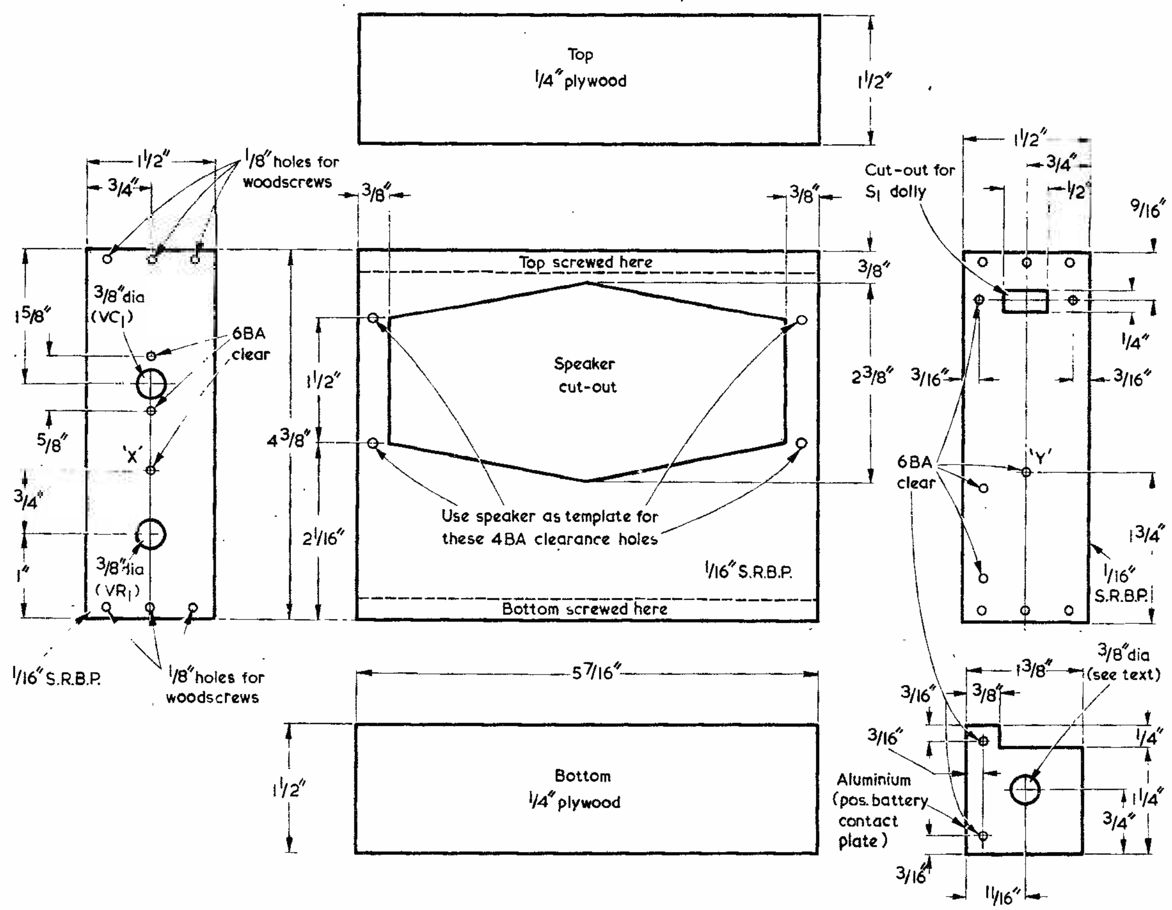


Fig. 2. Details of the sections which make up the receiver case

CONSTRUCTION

Construction starts with the cutting out of the items shown in Fig. 2. It will be seen that the materials used here are small pieces of $\frac{1}{4}$in. plywood, $\frac{1}{16}$in. s.r.b.p., and aluminium sheet of any gauge between 16 and 20 s.w.g. First cut out and drill the s.r.b.p. speaker panel and cut out the top and bottom plywood panels. Screw the top and bottom to the speaker panel using five countersunk screws for each plywood piece and then cover this assembly with Fablon of a suitable choice.

Take up VR1. The metal back of the case of this potentiometer makes contact with the negative side of the battery formed by the two HP2 cells, and it will be found that an extension of the plastic spindle protrudes slightly at the back (to couple with the switch in a combined potentiometer and switch). File down this extension, so that the HP2 cell will be able to make reliable contact with the potentiometer back.

Next cut out the two s.r.b.p. sides. The two 6BA clear holes on either side of the spindle hole for VC1 take 6BA bolts which secure the capacitor in place. It will be found that VC1 frame is very close to, or touches, the speaker frame when the sides are assembled, and it may be necessary to shift the 6BA clear holes very slightly to the left, as shown in Fig. 2. This was not needed with the prototype, but the point can be checked at the present state of construction. The orientation of VC1 can be seen in the wiring diagram of Fig. 3.

The fixing holes and dolly slot dimensions for slide switch S1 on the right hand s.r.b.p. panel (again as seen in Fig. 2) correspond to those required by the switch used by the author. They may require slight modification with other switches. When mounted, the body of the switch is on the inside of the s.r.b.p. panel.

The aluminium plate in Fig. 2 provides the battery positive connecting point. The $\frac{3}{8}$in. hole in its centre is not drilled all the way through, and drilling ceases when the tip of the drill just appears. The resulting depression ensure good seating for the battery positive stud. The contact plate is used as a template to mark out the corresponding two 6BA clear holes in the s.r.b.p. panel. Position of the aluminium plate on the s.r.b.p. panel so that there is a $\frac{1}{4}$in. free at the bottom (to give clearance for the plywood bottom panel) and $\frac{1}{16}$in. clearance on either side, then mark out and drill the holes in the s.r.b.p. panel. Fit the contact plate, and cover both the s.r.b.p. panels with Fablon. A contrasting colour of Fablon for the sides, as against the front, top and bottom, gives an effective finish. The prototype had plain black for the front, top and bottom, and plain yellow for the sides and back (to be described later). Mount VC1, VR1 and S1, and also wire in C1, all as shown in Fig. 3. Then put the two s.r.b.p. panels on one side for the time being.

Make up a sleeve of paper or Fablon about 3in. long, and put it on the ferrite rod. Close-wind 70 turns of 26 s.w.g. enamelled wire in a single layer on this sleeve, the winding starting about $1\frac{1}{4}$in. from one end of the rod. Anchor the coil ends with tape and put the rod on one side for use later.

Mount the speaker over a piece of thin gauze, using three 1in. roundhead 4BA bolts and one $\frac{1}{4}$in. roundhead 4BA bolt. Following the view shown in Fig. 3, fit the three 1in. bolts at the bottom and upper left hand speaker holes, and the $\frac{1}{4}$in. bolt at the upper right hand speaker hole. As will be deduced from the diagram, two tagstrips and the ferrite aerial clip will be mounted on the 1in. bolts.

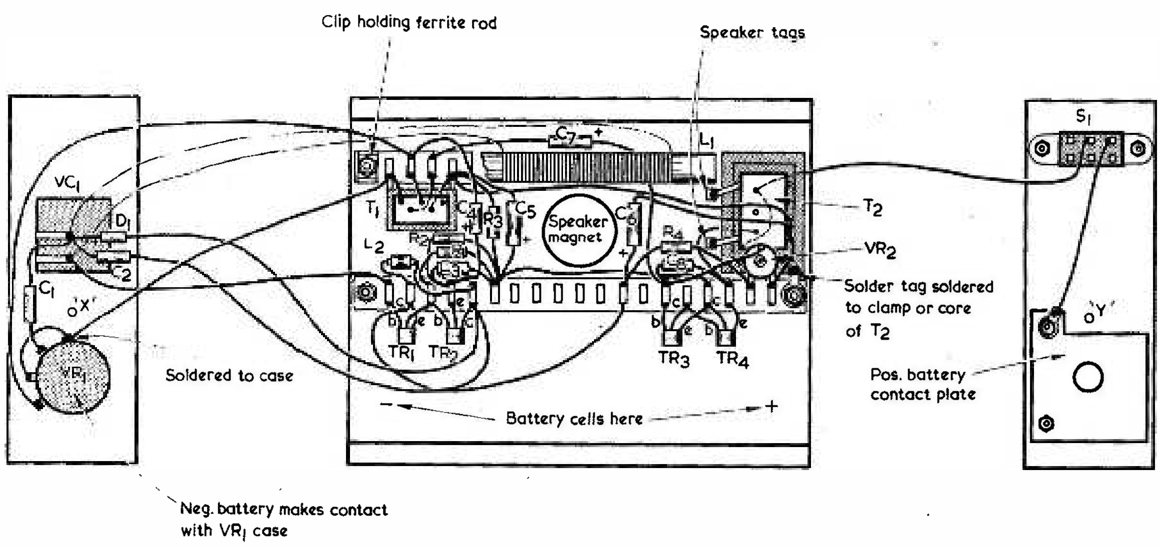


Fig. 3. Wiring and layout of the components in the receiver. Note that part of the circuit is completed via the clamp feet of T1

NEXT MONTH

In next month's issue, the concluding article will complete the constructional details for this receiver and will describe the simple setting up procedure required to bring it into full working order.

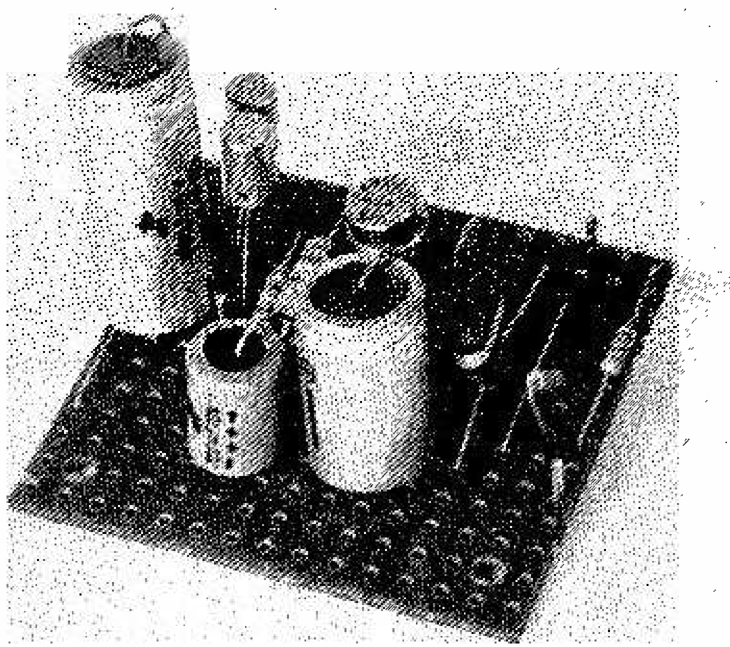
(To be concluded)

SPECIAL PROJECT . . .

CMOS AUDIO AMPLIFIER

By R. A. Penfold

Incorporating a linear CMOS integrated circuit, this unusual a.f. amplifier offers a low quiescent power supply drain and requires no protection against thermal runaway in the output transistors.



As anyone who has designed a Class B transistor a.f. amplifier will know, one of the main problems is the elimination of significant levels of crossover distortion. This type of distortion is particularly troublesome since it increases with decreasing output power, and it is at low levels that the distortion is most noticeable.

OUTPUT STAGE

A basic Class B emitter follower output stage is shown in Fig. 1. TRA is the driver transistor and the circuit is set up such that under quiescent no-signal conditions its collector potential is approximately mid-way between the positive and negative supply rails. If a signal is applied the collector then goes

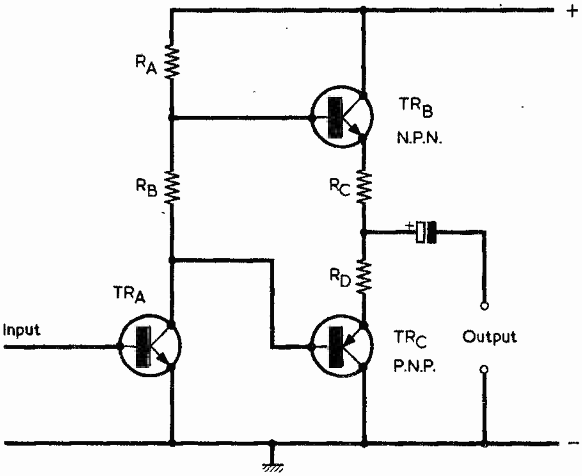


Fig. 1. Basic circuit for a complementary emitter follower Class B output stage

positive and negative in response to the signal waveform. When it goes positive, transistor TRB becomes conductive and acts as an emitter follower, causing a corresponding voltage to be passed to the output load. TRC becomes conductive as an emitter follower when the collector of TRA goes negative. TRB and TRC do not offer any voltage gain but provide a high level of current amplification, whereupon the output load can have a relatively low impedance. The load is normally, of course, a loudspeaker.

Let us assume for a moment that RB is not in circuit and that the bases of TRB and TRC are connected together. If the output transistors are silicon types, TRB will not then become conductive until its base is taken some 0.65 volt positive of its base and, in the same way, TRC will not become conductive until its base is taken about 0.65 volt negative of its emitter. The result will be a very high degree of crossover distortion in the output signal, as is illustrated in Fig. 2 where the central part of the signal waveform is not amplified at all. The waveform in Fig. 2 has a peak amplitude of some 3 or 4 volts, and it is obvious that the crossover distortion will become proportionately more severe for signals of lower amplitude.

Germanium transistors do not become conductive until the base is taken about 0.2 volt forward of the emitter. If TRB and TRC of Fig. 1 were germanium transistors, they would not amplify until the signal at TRA collector passed 0.2 volt positive and negative of the quiescent level. Again, a high degree of crossover distortion would result.

It is to prevent crossover distortion that resistor RB is interposed between the bases of TRB and TRC. The collector current of TRA flows through RB, and the latter can be given a value such that it drops about 1.3 volts (twice 0.65 volt) for silicon output transistors or about 0.4 volt (twice 0.2 volt) for germanium output transistors. Thus, both output transistors are just conductive under quiescent conditions, and respond to small as well as large signal excursions at the collector of TRA. In consequence the crossover distortion is reduced.

It is not, unfortunately completely eliminated. This is because the current gain of the output transistors is lower when they are just conductive than it is when they pass an appreciable collector and emitter

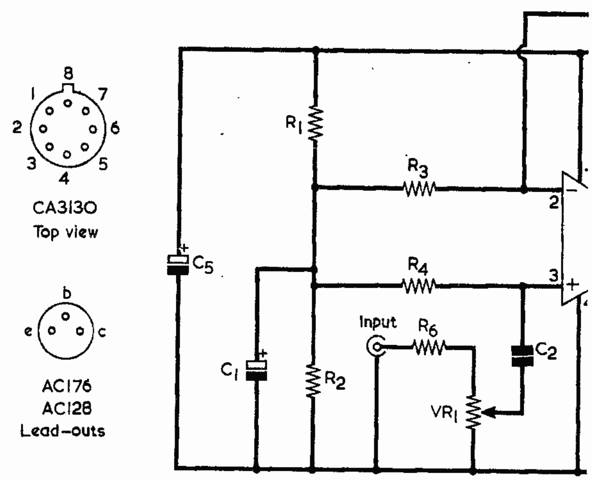


Fig. 3. The circuit of the CMOS audio amplifier. The
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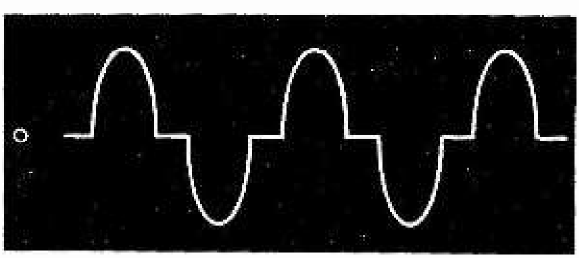

Fig 2. If RB of Fig. 1 were omitted and the output transistor bases connected together, a sine wave input would be reproduced at the output in the manner shown here

current. One way of further reducing the crossover distortion which still remains is to give RB a higher value again, causing the output transistors to pass an appreciable current under quiescent conditions. Such an approach, however, raises further problems.

THERMAL RUNAWAY

If the two output transistors pass a significant current under quiescent conditions there is a waste of supply power, and this is an undesirable feature if the amplifier is battery driven. What is, perhaps, a more important point is that there is an increased risk of thermal runaway.

Should the temperature of the output transistors increase due to normal power dissipation or to a high

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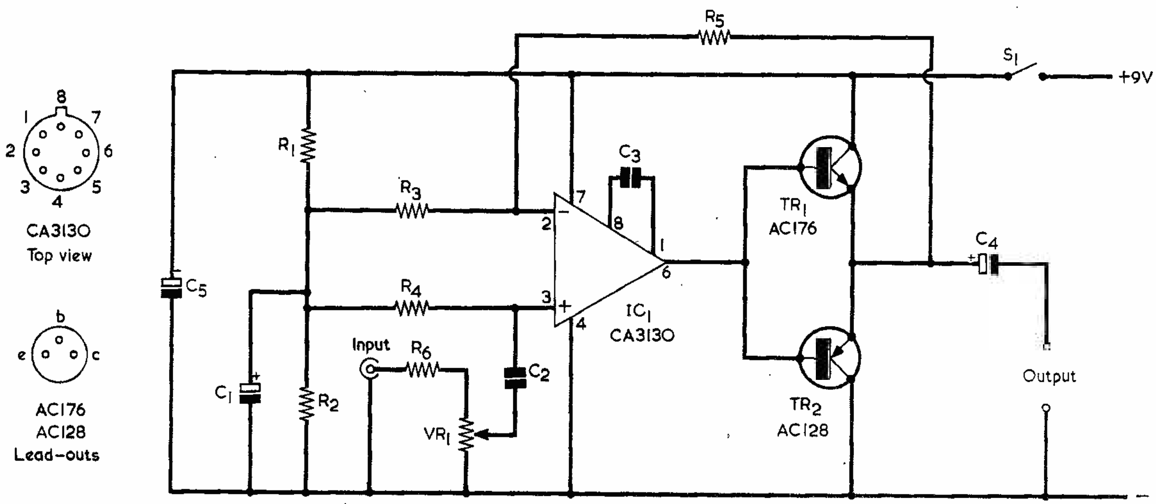

Fig. 3. The circuit of the CMOS audio amplifier. The output transistors are cut off under quiescent conditions

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Should the temperature of the output transistors ıcrease due to normal power dissipation or to a high ambient temperature, their base-emitter turn-on voltages become decreased, whereupon they are capable of passing under quiescent conditions an increased current. This in turn raises their temperature again, with a consequent further reduction in base-emitter turn-on voltage. The process is self-sustaining and can lead eventually to the transistor temperatures becoming so high that they burn out. The effect is known as thermal runaway.

Partial prevention of thermal runaway can be achieved by replacing RB with a temperature sensitive voltage dropping device such as a thermistor, a diode or a diode-connected transistor. The voltage across the device falls as its temperature increases, whereupon the base-emitter voltages applied to the output transistors decrease. An approach of this nature assists in preventing thermal runaway due to high ambient temperature, although it cannot guard against temperature rise due to power dissipation in the output transistors themselves unless the voltage dropping device is thermally coupled to them.

Another method of reducing the risk of thermal runaway consists of inserting low value resistors, RC and RD, in series with the emitters, as illustrated in Fig. 1. If the output transistor current increases, so does the voltage dropped across the resistors, with a corresponding reduction in the transistor base-emitter voltages. Naturally, some of the output power is wasted in the resistors.

In the amplifier circuit which is described in this article, advantage is taken of a CMOS linear op-amp to provide an output stage having none of the drawbacks which have just been detailed. Both the output transistor bases are connected together, whereupon the risk of thermal runaway is removed and resistors RC and RD are not required. Also, the very high gain of the CMOS op-amp enables a negative feedback loop to be set up which brings crossover distortion down to a negligibly low level.

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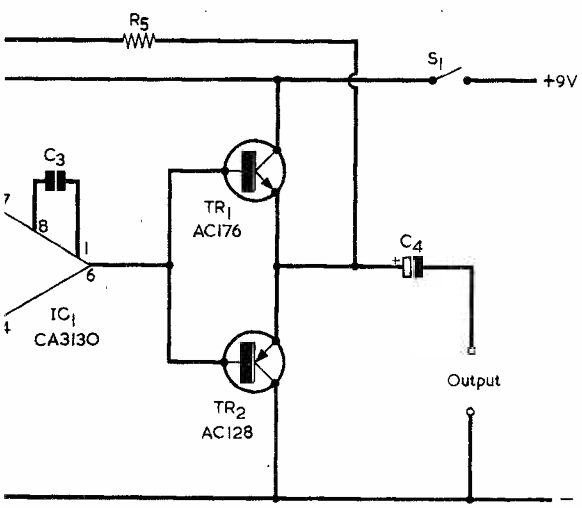

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THE CIRCUIT

The complete circuit of the amplifier is given in Fig. 3, and it will be seen that this is quite simple and requires few components. The input and driver stages are provided by the CMOS op-amp, which is a CA3130. The output transistors are germanium types rather than silicon, since their lower base-emitter forward voltages permit a slightly higher output voltage swing. They are connected in a complementary emitter follower output circuit. The amplifier will provide an output power of about 300mW into a 15Ω speaker. Higher impedance speakers can also be used but will cause a reduction in the maximum output power. With a 40Ω speaker, for example, the maximum output power is limited to about 125mW. Speakers with impedances lower than 15Ω should not be used.

An input of slightly more than 100mV r.m.s. is required for maximum output, and the input impedance is about 120k Ω. Both these figures apply when the volume control, VR1, is set to maximum. They can be altered to some extent to suit individual requirements by changing component values, and this aspect is discussed later.

The amplifier has a quiescent current demand of approximately 3.5mA from the 9 volt battery, this consisting of the current drawn by IC1 plus a small current in R1 and R2. In the absence of an input signal only leakage current flows in the output transistors. At full output the current consumption is at an average level of around 50mA.

COMPONENTS

Resistors
(All fixed values $\frac{1}{4}$ watt 5%)
R1 5.6k Ω
R2 5.6k Ω
R3 12k Ω
R4 220k Ω
R5 220k Ω
R6 10k Ω (See text)
VR1 220k· potentiometer, log

Capacitors
C1 330μF electrolytic, 10 V. Wkg.
C2 0.1μF type C280 (Mullard)
C3 150μF ceramic
C4 680μF electrolytic, 10 V. Wkg.
C5 100μF electrolytic, 10 V. Wkg.

Semiconductors
IC1 CA3130
TR1 AC176
TR2 AC128

Switch
S1 s.p.s.t. switch

Miscellaneous
Speaker (see text)
9 volt battery
Battery connector
Veroboard, 0.15in. Matrix
Veropins, 0.15in. type
Input socket (see text)
Screened wire.

All in all, the circuit of Fig. 3 is very versatile and will have many possible uses.

Considering the circuit in detail it will be seen that IC1 is used as a non-inverting amplifier. Both its inputs are coupled via resistors to the junction of R1 and R2, which provides a voltage which is central between the supply rails. C1 is a bypass capacitor.

Since the input impedance of the non-inverting input at lead-out 3 of the i.c. is extremely high, R4 can have any value. The input impedance of the amplifier can, if desired, be altered by changing the values of R4 and the volume control. C2 provides d.c. blocking at the non-inverting input. The 10k Ω resistor, R6, has no significant effect on a.f. performance and is merely a surge current limiting resistor to protect the i.c. if the input is derived from a battery powered preamplifier.

C3 is the compensating capacitor for the i.c. and prevents if from breaking into oscillation. No connection is made to lead-out 5 of the i.c. The output is taken from lead-out 6 and is applied directly to the bases of TR1 and TR2. C4 is the output d.c. blocking capacitor, whilst C5 is the supply bypass capacitor for the whole amplifier. S1 is the on-off switch.

NEGATIVE FEEDBACK

Negative feedback from the emitters of TR1 and TR2 to the inverting input of the i.c. is provided by R5 and R3. The voltage gain of the amplifier is equal to (R3 + R5) divided by R3, and this works out as a little under 20 times, or 26dB, with the resistor values specified. The open loop voltage gain of the CA3130 (i.e. the gain without feedback) is extremely high, being typically 320,000 times. Thus, a very large amount of negative feedback is provided in the circuit.

The manner in which the feedback takes up the output base voltage range at which neither transistor conducts is quite simple. Assume that both the non-inverting input and the output of the i.c. are at zero potential. Theoretically, the output transistors are non-conductive and there is no negative feedback. The non-inverting input now starts to go positive. The slightest positive excursion at the op-amp input will cause its output to swing to the positive level required to cause TR1 to become conductive, whereupon the negative feedback loop will then come into operation. Similarly, the slightest negative excursion of the input will take the op-amp output sufficiently negative to turn on TR2 and cause the feedback loop to be completed once more.

As an input signal passes through zero level there will be an instant when the op-amp has its full open loop gain and its output swings from one transistor base to the other, thereby re-introducing negative feedback and normalising the gain. The input signal range over which the op-amp output changes from one transistor to the other is extremely small, whereupon crossover distortion is virtually eliminated.

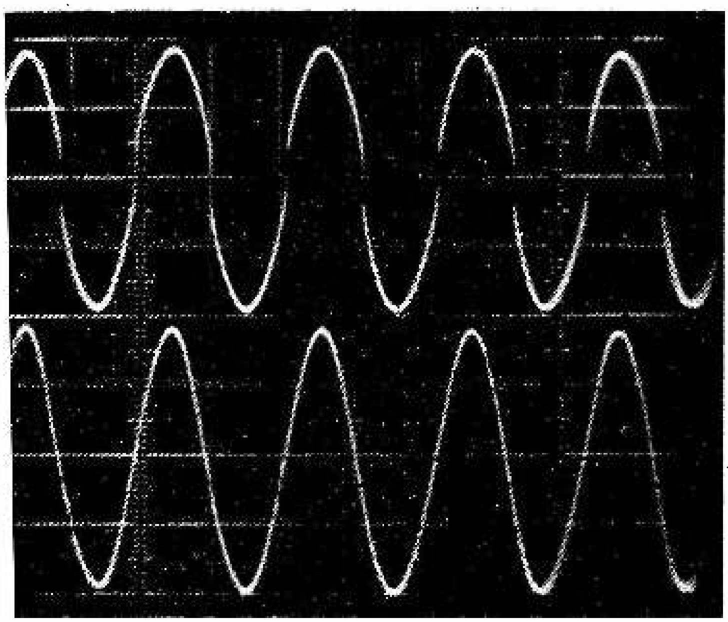
The assumption was made just now that the op-amp non-inverting input and output were at zero level. In practice, the op-amp output would not remain steady at zero level but, due to the very high open loop gain, would swing from one transistor base to the other, actuated by the inevitable low noise level at the input.

In the accompanying oscillogram the lower trace shows a 500Hz sine wave applied at a power level of a few milliwatts to a 15 Ω speaker. The corresponding waveform at the output of the op-amp is illustrated by the upper trace. The greatly increased gain in the op-amp near the waveform centre can be clearly observed.

CONSTRUCTION

The amplifier is assembled on a piece of Veroboard of 0.15in. matrix having 15 holes by 14 copper strips. The component and copper sides of this board are shown in Fig. 4. Before mounting any components, the two 6BA clear holes are drilled and the three breaks made in the copper strips.

The components and wire links may then be soldered to the board. To avoid damage to the integrated circuit, the soldering iron employed must

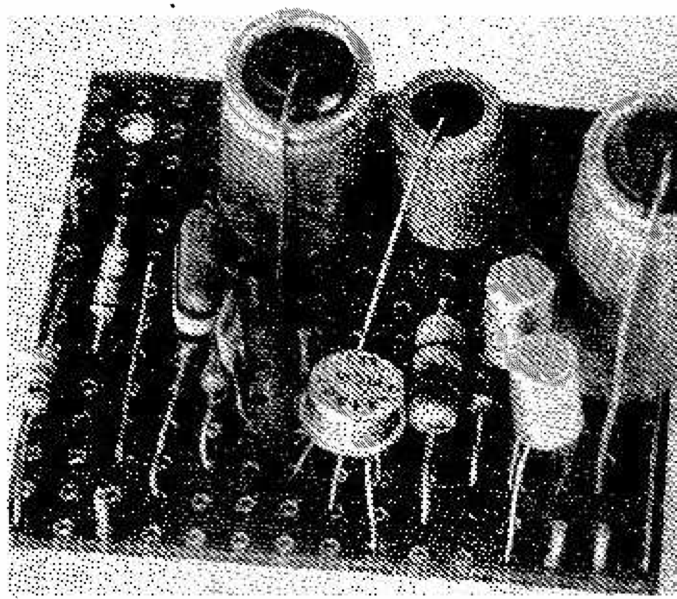


The lower waveform is that of a 500Hz sine wave applied at a low level to the speaker whilst the upper trace shows the corresponding waveform at the output of the operational amplifier have a realiably earthed bit. Being germanium transistors, TR1 and TR2 are more liable to damage by heat than silicon types, and their lead-outs should be soldered reasonably quickly. Veropins are fitted for the external connections to the speaker, the battery, S1 and VR1. R6 is not fitted on the board and is wired between VR1 and the input socket. The latter can be a jack socket, phono socket or any other type of socket preferred. S1 may be ganged with VR1 if desired.

The circuit has a fairly high gain and input impedance, and the input and output are in phase. Screened leads must therefore be used in the input circuit. Otherwise, there could be feedback between the output and input wiring with consequent instability.

A suitable battery is the Ever Ready PP9.

The output quality is well above average for a simple battery operated amplifier, and this is due to the large amount of negative feedback which is employed. The noise level is also very low, as is to be expected when an op-amp provides the voltage amplification. The unweighted noise level of the prototype (input short-circuited) is approximately -80dB.



Another view of the amplifier

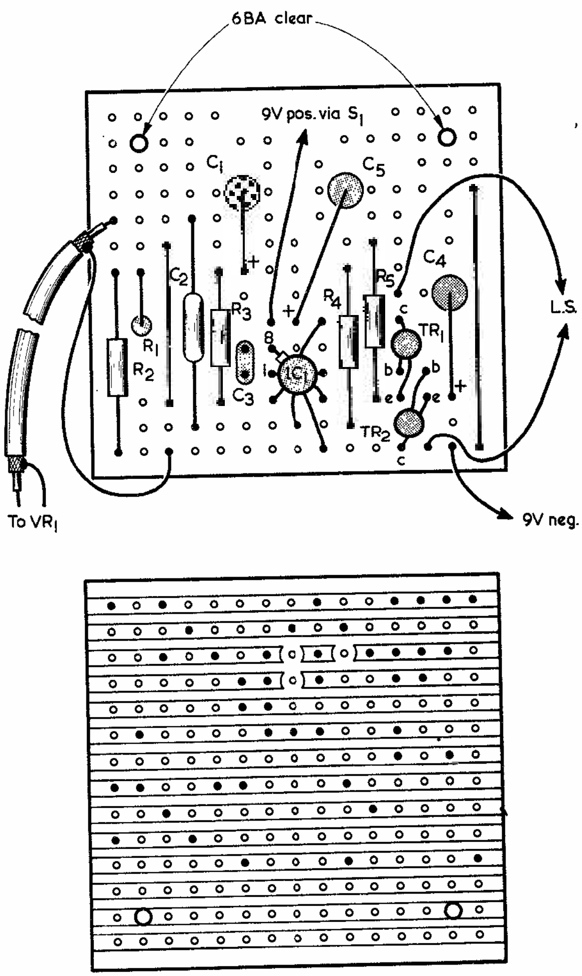


Fig. 4. Component and copper sides of the Veroboard panel on which the amplifier is assembled

MODIFICATIONS

If required, the gain and input impedance of the circuit are easily modified. The voltage gain is varied by altering the value of R5, working to the expression for gain which was given earlier. However, R5 should not be given a value greater than 680k Ω as the output quality may then deteriorate. With R5 at 680k Ω the input required for maximum output is only about 35mV r.m.s. Slightly in excess of 2 volts r.m.s. is required at the amplifier output for maximum power.

The input impedance is determined by VR1 and R4. It is desirable for these to have approximately the same value whereupon the input impedance (with VR1 set to maximum) is approximately R6 plus one-half of R4. If the input impedance is reduced significantly the value of C2 should be increased proportionately, as there will otherwise be a loss of bass response. If an electrolytic capacitor is employed here, the negative lead-out connects to VR1 slider. Instability may be a problem if the input impedance is increased, and this can be cured by adding a 100pF capacitor between lead-out 3 of the i.c. and the negative rail. This reduces the input impedance of the circuit at high frequencies and so reduces unwanted feedback to an insignificant level. There is plenty of space for the extra capacitor on the Veroboard panel.

R6 is included to meet the manufacturer's specification that input currents at the inputs of the CA3130 should not exceed 1mA. If the amplifier were preceded by a pre-amplifier with an output coupling capacitor, the situation is feasible in which a current surge could flow at switch-on or switch-off of the pre-amplifier. R6 has a value suitable for a pre-amplifier powered by a 9 volt battery. It should be increased for pre-amplifiers with a higher supply voltage. A value of 15k Ω would be suitable if the pre-amplifier had a 12 volt supply, and so on. As already stated, R6 plays no part otherwise in the functioning of the amplifier. ■

"HEADS OR TAILS?"

by J. R. Davies

Apart from describing a very simple electronic "heads or tails" device, this article also illustrates a method of obtaining a 50-50 square wave from a 555 timer.

Electronic 2-state gambling devices which offer a random output when a push-button is pressed have become popular over recent years. Currently, design has reached the stage where the output of a multibibrator is passed, via a press-to-break push-button, to the clock input of a J-K flip-flop. Two light-emitting diodes are driven by the Q and not-Q outputs of the flip-flop, these outputs changing state with each pulse from the multivibrator. There is then a true 50:50 possibility of either l.e.d. being illuminated when the push-button is pressed.

The circuit to be described here incurs a slight regression in design approach because it does not take advantage of the true 50:50 option provided by a J-K flip-flop. On the other hand it is extremely simple to assemble, requires very few components and can be set up for 50:50 operation as closely as can be determined by a multimeter set to an appropriate voltage range What will be of greater interest to the serious experimenter is the fact that the circuit demonstrates a means of obtaining a 50:50 square wave from a 555 timer when it is connected as a standard astable multivibrator.

CIRCUIT OPERATION

The circuit of the 555 "Heads or Tails" appears in Fig. 1. For the time being components VR1 and R1 should be ignored.

After switch-on at S2, C1 commences to charge via R2 and R3 until the voltage at its upper plate reaches two-thirds of supply potential. The comparator at pin 6 of the i.c. is then triggered, causing the internal flip-flop to change state and pin 7 to go low in voltage. The capacitor then discharges via R3 on its own until the voltage on its upper plate falls to one-third of supply potential. The comparator coupled to pin 2 is then actuated, pin 7 becomes open and the capacitor charges once more via R2 and R3. The oscillations thus continue with the upper plate of C1 alternately rising to two-thirds of supply potential and falling to one-third of supply potential.

The output at pin 3 goes high when the capacitor charges and goes low when the capacitor discharges. When the output is high a current flows through R5 and LED2, whereupon this l.e.d. lights up. With the output low, current flows through R4 and LED1, causing the latter l.e.d. to become illuminated. In consequence the two l.e.d.'s light successively. The output at pin 3 is virtually completely isolated from the internal comparator trigger circuits.

If push-button S1 is pressed, the circuit to pins 2 and 6 of the i.c. is broken. Should this occur at an instant when the capacitor is charging it continues to charge until it reaches supply potential, and the output at pin 3 remains in the high state with LED2 continually lit. Had the circuit been broken when the capacitor was discharging, it would continue to discharge and the output at pin 3 would be maintained in the low state, with LED1 continually illuminated. Thus, pressing S1 causes either LED1 or LED2 to remain lit, and this provides the "heads or tails" function of the circuit. Releasing S1 causes the multivibrator to resume oscillation with LED1 and LED2 alternately flashing.

The circuit runs at a frequency of the order of 7Hz. This is sufficiently slow to enable the alternate illumination of LED1 and LED2 to be perceived but,

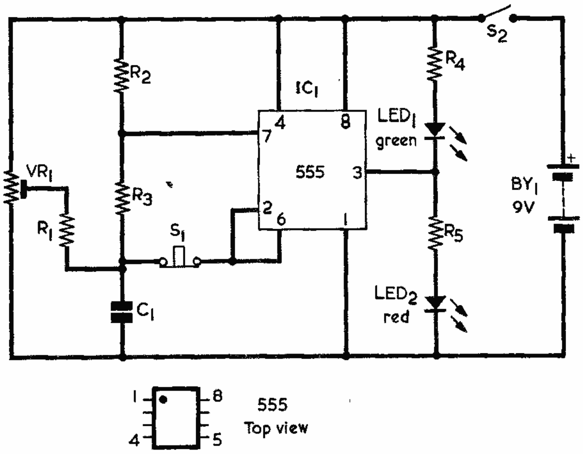


Fig. 1. The circuit of the 555 "Heads or Tails?" A feature of the design is that VR1 can be adjusted for a 50:50 square wave output from the 555

COMPONENTS

Resistors
(All fixed values ¼ watt 5%)

R1 470kΩ
R2 4.7kΩ
R3 100kΩ
R4 1kΩ
R5 1kΩ
VR1 100kΩ, pre-set potentiometer, skeleton

Capacitor
C1 $1\mu F$ plastic foil

Semiconductors
ICI 555
LED1 green l.e.d.
LED2 red l.e.d.

Switches
S1 push-button, press-to-break
S2 s.p.s.t., toggle

Battery
BY1 9 volt battery

with human reaction time at about a third of a second, is just too fast to allow the push-button to be pressed at the appropriate instant by observation of the l.e.d.'s. Assuming that the output at pin 3 is a 50:50 square wave, the selection of either l.e.d. then becomes a random process.

SQUARE WAVE OPERATION

If VR1 and R1, which we have ignored up to now, were not in circuit, the output of the 555 could not, however, be a 50:50 square wave. This is because the capacitor charges via the two resistors R2 and R3 and discharges via the single resistor R3. In consequence the charge section of the multivibrator cycle is longer than the discharge section. It would be possible to have the output approach a 50:50 sine wave by making R2 very much smaller than R3. In the present circuit R2 has a value which is about one-twentieth of R3 and so the charge period is some 5% longer than the discharge period.

It is also assumed when discussing the 555 i.c., that internal flip-flop triggering occurs at precisely two-thirds and precisely one-third of supply voltage whereas, in practice, there must be some tolerance in the resistances in the internal potential divider to which the comparators connect. In the writer's experience, however, there is a remarkably high degree of consistency between the performance of 555 i.c.'s of different manufacture so far as flip-flop actuation is concerned.

Thus, without VR1 and R1, the circuit can be looked upon as providing what closely approaches a 50:50 square wave. When VR1 and R1 are introduced it becomes possible to obtain a virtually true 50:50 output, because all that is required is to adjust VR1 such that the charge period of C1 is slightly reduced and the discharge period is slightly increased. If the output of the 555 were connected to an accurate oscilloscope, VR1 would merely be adjusted to provide the requisite square wave, this normally being given with the slider of VR1 slightly positive of the mid-supply voltage. For the circuit to operate R1 requires a value which is about 5 times that of R3 or greater.

VR1 may also be set up with the aid of a multimeter having (preferably) a resistance on its voltage ranges of 10,000 ohms per volt or more, and to see how this can be done it is necessary to examine the output circuit of the 555 i.c.

The output circuit is shown, in slightly simplified form, in Fig. 2, where the output transistors are TRB,

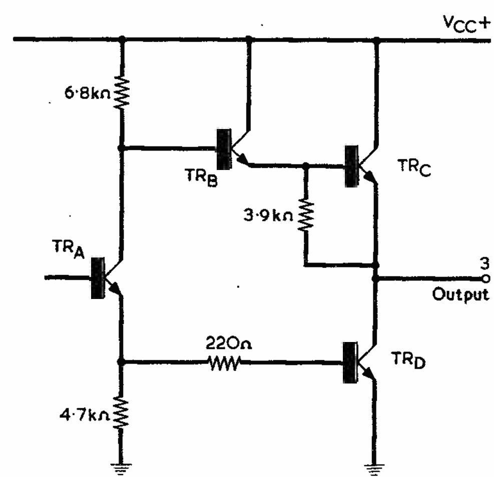


Fig. 2. The internal output stage circuit of the 555 timer i.c.

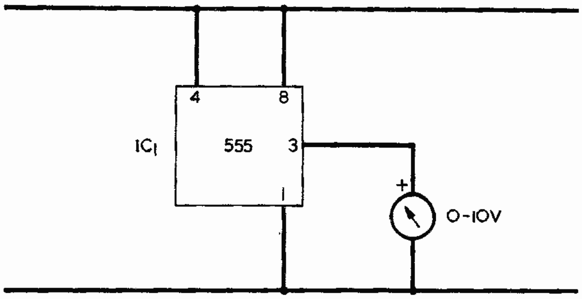


Fig. 3. Connecting a voltmeter to allow VR1 to be set up

TRC and TRD, these being driven by TRA. The earth symbols represent the negative supply rail. TRA is turned off when the output is required to be in the high state, whereupon the Darlington pair given by TRB and TRC receive an input base current via the 6.8kΩ resistor. For low output currents to the negative rail pin 3 then becomes negative of the positive supply rail by the voltage drops in two base-emitter junctions, these adding to a typical value of around 1.2 volts. For the low output condition TRA is turned on, driving a base current through TRD and drawing the base of TRB down to a low level. TRD turns hard on and, for low currents to the positive rail (and working from Signetics data) drops to considerably less than 0.1 volt.

A check for 50:50 square wave operation can therefore be carried out by connecting a voltmeter between pin 3 and the negative rail, measuring the voltage given when the output is high, then adjusting VR1 of Fig. 1 for an output voltage of exactly half that value with the multivibrator running. Assuming a virtually instantaneous change from the low to the high state and vice-versa, the length in time of alternate half-cycles of the output waveform will then be equal.

SETTING-UP

The setting-up process is illustrated in Fig. 3. The circuit of Fig. 1 is assembled with the exception that no connection is made between pin 3 and the junction of LED1 and R5. A multimeter switched to read 0-10 volts, or a suitable similar range, is connected between pin 3 and the negative rail. VR1 is adjusted to a central setting and S2 is closed. S1 is then pressed one or more times until a high reading is given in the voltmeter. This reading is noted. S1 is then released and VR1 is adjusted for an indication in the voltmeter which is exactly half the previous reading. Because of the relatively slow speed of the multivibrator the meter needle may vibrate slightly on either side of the central reading but this does not prevent an accurate reading being obtained. The circuit is then set up and can be brought into use by removing the multimeter and connecting the l.e.d.'s to the output.

The circuit functions satisfactorily with quite a high internal resistance in the battery and there is no need for a high value electrolytic bypass capacitor across the supply rails. C1 is a plastic foil capacitor, which nowadays infers a polyester dielectric. The two l.e.d.'s are mounted on the front panel of the completed unit in company with S1 and S2, and require panel mounting bushes. The author employed green and red l.e.d.'s Type 4, which are available from Doram Electronics and which have the anode lead (coupling to the positive supply) shorter than the cathode lead. However, any other similar l.e.d.'s may be employed instead.

The current drawn is of the order of 10mA with S1 closed or open, and a 9 volt PP6 battery would be suitable ■

MOBILE AMATEUR RADIO LOG REQUIREMENTS

One of the most pleasing of the changes which have been introduced into the new amateur radio transmitting licence regulations, now being issued to radio amateurs in this country by the Home Office, is that relating to the keeping of log books recording the activities of mobile amateur radio stations. The detail required in the past has been surplanted by much more reasonable — and practical requirements.

It is also now not necessary to take out a separate licence for mobile work. The new licence covers mobile operation from 'any vehicle or vessel, but not on the sea or within any estuary, dock or habour". It also covers mobile operation "as a pedestrian"! It should be noted that it does not permit operation from an aircraft nor may the station be used from a public transport vehicle. When used as a mobile station in the permitted manner, as indicated above, the suffix "/M" shall be added to the call sign.

The keeping of a Log Book, recording the times and other details of transmissions, has always been an accepted requirement of operating an Amateur Radio Station and is welcomed by all reasonably minded radio amateur operators. The requirements for mobile operation in this connection have, however, been somewhat onerous in the past. Now, however, the new requirements make things much easier and more practical. A separate log book may be maintained for mobile or pedestrian use, distinct from the main station log. "Entries made in respect of calls made when operating from a vehicle or vessel, or as a pedestrian, should be made as soon as practicable after the end of the journey and must consist of date, geographical area of operation, frequency band(s) used and time of commencement and end of journey".

It is interesting to note the inclusion of "Pedestrian mobile operation" along with vehicular mobile operation in the new licence regulations. This has no doubt been done because of the greatly increased popularity of "hand held" miniaturised radio telephony equipment which is now so readily available. It is now commonplace at radio gatherings and meetings, to see portable, miniaturised, amateur radio telephony equipment, slung over the sholders of those present in the manner and quite as conveniently as the more usually carried camera!

A.C.G.

ANTIQUE AND WARTIME RADIO

By Ron Ham

The author is presenting his collection of antique and wartime radio equipment this year from April 1st to October 31st at the Cornwall Aircraft Park at Helston, Cornwall.

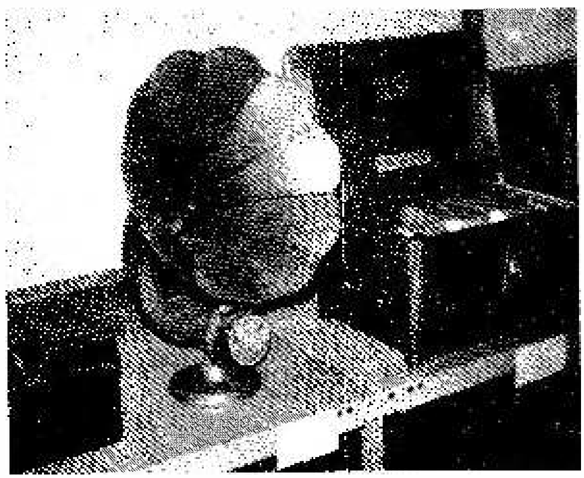
Here are some of the items which will be exhibited.

HORN LOUDSPEAKER

The first photograph shows a early receiving installation which comprises an Amplion horn loudspeaker together with a Gecophone "kit" receiver on its right. Just visible on the left is one of the first a.c. mains radios, this being of Philips manufacture. The loudspeaker, with its fancy wooden horn, sold for £5 5s. in 1924.

The second photograph takes us up to the start of World War 2, the set on the left being the aircraft transmitter-receiver type TR9, which was in use with the RAF from around 1938 to the early 1940's. This set, working on short wave frequencies, provided voice communication between aircraft, and between aircraft and ground. The receiver was a t.r.f. design with pre-set regeneration between its r.f. stages and employed the old 4 pin 2 volt filament valves. These were powered by a 2 volt accumulator mounted externally. Inside the housing are two further batteries: a 120 volt high tension battery and a grid bias battery.

To the right is a version of the transmitter-receiver type TR1133 which superseded the TR9. This operated on v.h.f betweeen 100 and 125MHz and the set illustrated has crystal controlled receiver oscillator tuning. The valves are 6.3 volt indirectly heated types and the equipment had 4 pre-tuned channels, selected by a push-button unit in the aircraft cockpit.



In the centre is an Amplion horn loudspeaker of 1924 vintage, this being flanked on its right by a Gecophone "kit" receiver and on its left by an early Philips mains set

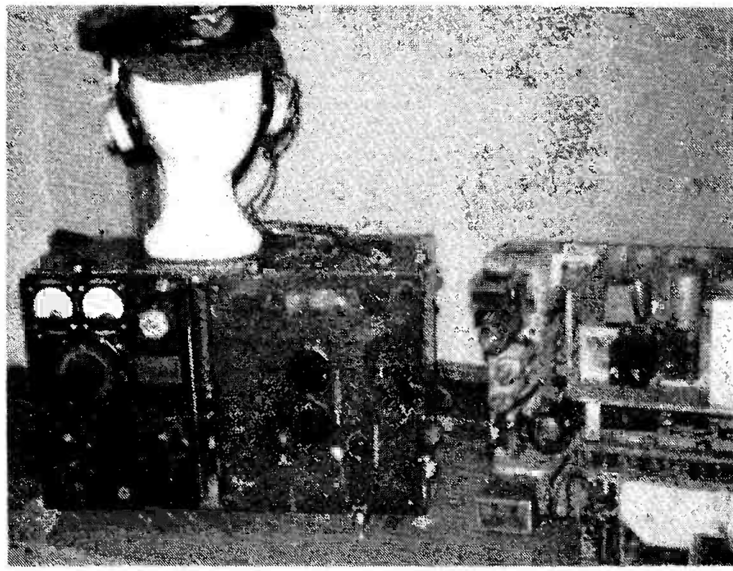
TWO "CIVVIES"

The third photograph shows two wartime receivers for which the author has great affection and which have attracted much attention on previous occasions.

The receiver on the left, made in 1943, is the medium-wave-only "WCR" or Wartime Civilian Receiver, and it is still in good voice after all these years. In the author's exhibition held at Worthing Museum last year it pounded out programmes from either BBC Radio 1 or BBC Radio Brighton for 12 hours every weekday throughout the 6 weeks of the exhibition.

What did you get in 1943 for your £12 3s 4d. (including Purchase Tax)? A bare but well made wooden cabinet with the absolute minimum of radio components on the chassis inside. The yellow metal dial (no glass) is inscribed with the words "Home" and "Forces", while underneath are just two knobs for volume and tuning, the on-off toggle switch being mounted on the chassis at the rear of the cabinet. The mixer and i.f. valves are red metallised types, there is a large glass rectifier and an equally large output pentode. Because the set was made in wartime the only indentification on the valves is a BVA number. To save both space and power requirements the signal rectifier is a Westector.

The set in the picture spent the latter part of its life in a garden shed, and when the author received it some three years ago he cleaned the chassis and valveholders, oiled the moving parts and used a vacuum cleaner to clean the muck from the



The equipment with the two meters at its top left is the TR9 aircraft transmitter-receiver, with which the RAF entered the last war in 1939. To its right is a TR1133 with the cover removed, this being the v.h.f. aircraft transmitter-receiver which replaced the TR9 set

loudspeaker. A cautious switch-on and the set burst into life, and has been going ever since with all the original parts.

NATIONAL HRO

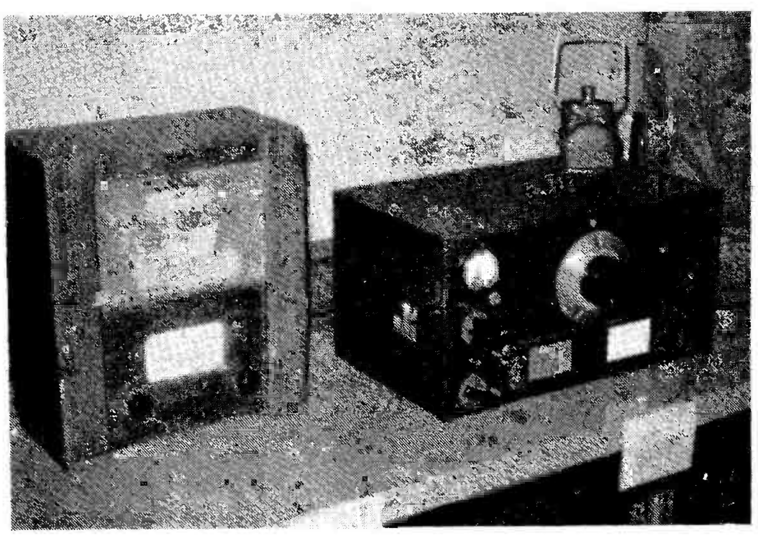
How many readers looking at the second receiver in the illustration will at once say that it is the "good old HRO"? And how right they will be; many of these sets were used during the war on active service and quite a number are still being employed by amateurs today.

The actual set in the photograph was the property of the late Nell Corry (G2YL) and is not one of the later versions with 6.3 volt valves. Instead, this is one of the originals with the old 2.5 volt Amercian UX-based valves.

A full description of the circuit and other details of this early communications receiver appeared in *The Wireless World* for August 18th 1938 (then published weekly at 4d). Its cost, with 4 coil units but less loudspeaker and power supply unit, was £49.15s.

Any HRO enthusiast will confirm that from the mechanical point of view the HRO is beautifully turned out. The tuning drive and dial are the highlights of the mechanical design; in fact, the effective tuning scale length is about 12 ft.

When Nell gave the author this set, shortly before she died, she warned that it had not been used for 25 years. The author located an old mains transformer made by Rich & Bunday in the mid-thirties which delivered 2.8. volts at 10 amps. Who could not resist coupling together these two old timers? An h.t. supply was soon knocked up and a speaker complete with transformer (the HRO output is at high impedance) connected to the receiver. Imagine the author's pleasure when the 9 valves all lit up, the "S" meter jerked into life and the set was once again receiving short wave signals. Knowing these old sets, the author had expected it to work, and he is delighted to have this particular model in his collection.



Two "civvy" receivers which played an important part in World War II. In the wooden cabinet is a Wartime Civilian Receiver which functioned on medium waves only. Many readers will recognise the other receiver, a very early version of the famous National HRO.

■

"NOTES FOR NEWCOMERS"

SURGE CURRENTS

by R. J. Caborn

It pays to keep an eye open for the possibility of large surge currents when designing new circuits

In the early 1940's the author was engaged in the repair of American communications receivers. One popular model had what appeared at the time to be a somewhat unusual b.f.o. switching circuit. When the receiver b.f.o. was switched on for the reception of Morse signals the automatic gain control bias line was connected by a section of the b.f.o. switching circuit to chassis. If this was not done the b.f.o. signal applied to the detector would cause a small a.g.c. voltage to be produced, thereby reducing receiver sensitivity.

LIMITER RESISTOR

The apparently unusual feature of this b.f.o. switching circuit appears in Fig. 1, where the switch section shown is that which takes the a.g.c. line to chassis. When the b.f.o. was off the a.g.c. voltage appeared across the 0.05μF capacitor, and this could rise to some 8 volts or so. Turning on the b.f.o. caused the capacitor to be short-circuited via the 100Ω resistor, whereupon the a.g.c. voltage, relative to chassis, was reduced to zero. It should be added that the receiver was, of course, a valve model in which the resistors in the a.g.c. circuit were of the order of 470kΩ or more. Compared with these the 100Ω resistor of Fig. 1 was virtually a dead short.

Why, then, had the designer put it in?

The answer is that it was a current surge limiting resistor. If the switch had short-circuited the capacitor directly there would have been a tiny spark at the switch contacts each time they closed, even from a 0.05μF capacitor charged to only 8 volts. The resultant damage to the contacts would probably have been quite negligible after hundreds of switch operations, but what would have happened when these went into the thousands, as could easily happen over the years? Wisely, the designer took no chances and made certain that the surge current at the instant of switch closure was always safely limited by the 100Ω resistor. The instantaneous surge current with the resistor in circuit could be of the order of 80mA. Without it, the instantaneous current as the capacitor discharged could well have been several amps.

Most of us have charged an electrolytic capacitor and then either accidentally or purposely discharged it. If the capacitor has a value of 100μF or so and is charged to several hundred volts, the spark at discharge can sound like a pistol shot. Connecting a switch direct across a charged capacitor of this nature and then closing it would lead to the very early demise of the switch.

So, whenever a circuit requires that a capacitor be rapidly discharged by a switch, it is always wise to insert a current limiting resistor in series, as was done in Fig. 1. In general, this requirement applies to capacitors above some 0.02μF, and it definitely applies to all electrolytic capacitors. For low voltage circuits a current limiting resistor of about 10Ω to 30Ω is usually quite adequate and in most instances a $\frac{1}{4}$ watt component will be satisfactory.

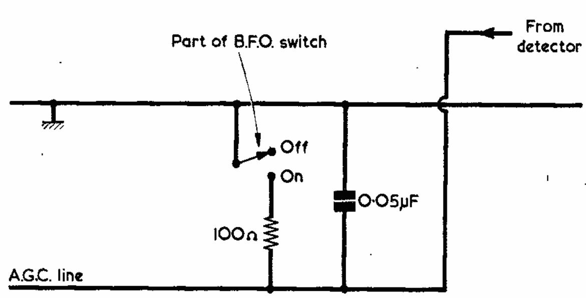


Fig. 1. Part of a b.f.o. switching circuit in a communications receiver. Its main interest lies in the use of a current limiting resistor in the capacitor discharge circuit

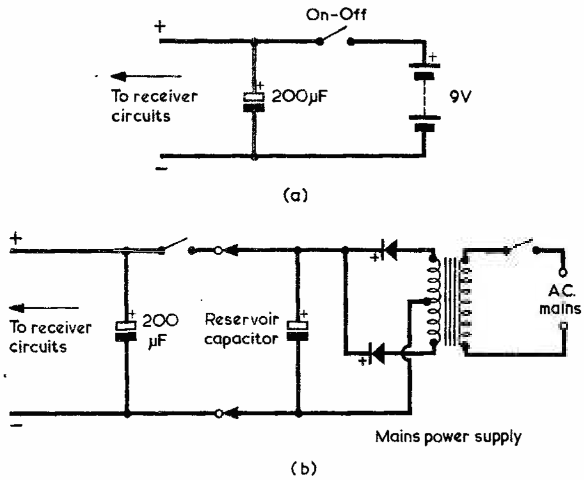


Fig. 2(a). In this common transistor radio circuit the switch-on current surge is mainly limited by the internal resistance of the battery (b). The switch-on surge can be significantly greater if the battery is replaced by a mains power supply.

SWITCH-ON SURGES

There is also a surge current when a voltage is suddenly applied to a discharged capacitor. A very common example is shown in Fig. 2(a) in which a 9 volt battery connects to a transistor radio having a capacitor of, say, 200μF across its supply rails. At the instant of switch closure a surge current flows into the discharged capacitor which can be looked upon, at that instant, as being a short-circuit. Fortunately, the magnitude of the current is largely limited by the internal resistance of the battery. With a PP9 battery this is of the order of 10Ω, whereupon the instantaneous surge current at switch-on is a little less than an amp.

The situation changes markedly if the set-owner decides to economise by replacing the battery with a mains power supply, as in Fig. 2(b). If, with this arrangement, the a.c. mains supply is switched on first, a rectified voltage at low impedance is developed across the reservoir capacitor. Turning on the receiver switch can then cause a surge current considerably higher than an amp to flow. Thus, to ensure long life of the receiver on-off switch it is always preferable to close the receiver switch before turning on the mains supply.

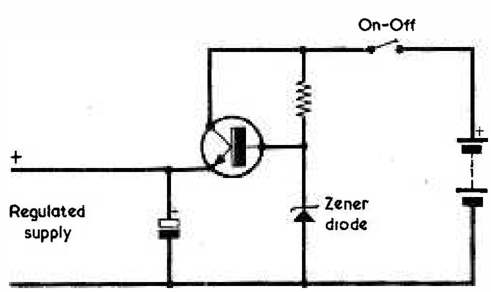


Fig. 3. A popular voltage regulator circuit. At switch-on a surge current flows into the discharged electrolytic capacitor connected to the transistor emitter

Another circuit in which an initial high current surge can flow at switch-on is given by the emitter follower voltage regulator of Fig. 3. At the instant of closing the on-off switch the transistor is turned fully on, and the surge current flowing into the discharged electrolytic capacitor is largely limited by the battery internal resistance only. For applications like this it is a good policy to choose a transistor which is capable of passing a peak collector current of an amp, even if the running current drawn from the emitter in normal use is only in the region of, say, 20mA. A good candidate here is the BFY50 which, although it is in a small TO-5 can, has a peak collector current rating of 1,000mA. If a transistor having a maximum collector current rating of the order of 100mA were employed, it is quite possible that it may mysteriously expire one day when the on-off switch is closed.

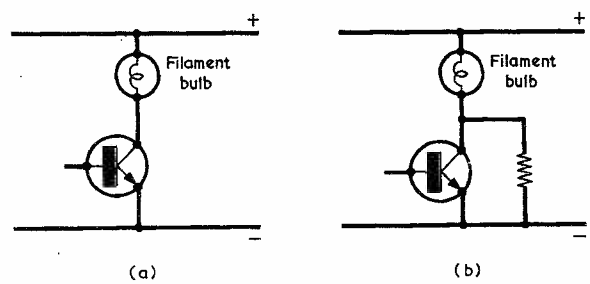


Fig. 4(a). A simple circuit in which a transistor is used to turn on a filament bulb (b). Adding a resistor, as described in the text, can reduce the initial switch-on current surge in the bulb

FILAMENT LAMPS

Apart from capacitors, another cause of heavy current surges is given by filament lamps. It does not always seem to be remembered that the cold resistance of a filament lamp can be lower than one-tenth of its hot resistance, whereupon switch-on surge currents can be surprisingly high. It is, indeed, a salutary exercise to check the cold resistance of several lamps with the aid of an ohmmeter. A 240 volt 100 watt domestic light bulb consumes some 0.4 amp when it is switched on and has a hot resistance of about 570Ω. The cold resistance of such a bulb is, typically, only 40Ω!

Turning to smaller lamps, a 2.5 volt 0.3 amp flash-lamp bulb will have a hot resistance, at 2.5 volts, of about 8Ω. Its cold resistance will normally be lower than 1Ω.

The fact that filament lamps have such relatively low cold resistance values should always be borne in mind when these are switched on by transistors, as occurs in Fig. 4(a). A useful dodge here is to add a resistor across the transistor, as in Fig. 4(b). When the transistor is turned off, the resistor allows a current to flow which causes the bulb filament to be just below the visible glow level. The bulb resistance is then well above its cold value, and less initial surge current flows in the transistor when it turns on and causes the bulb to light up at full brightness. ■

CATALOGUE
MAPLIN ELECTRONIC SUPPLIES

The new 1977-78 Maplin Electronic Supplies Catalogue has now been published and is readily available to readers who mail the coupon on the back page of this issue.

Considerably bigger than the previous Maplin Catalogue the present edition has no less than 216 large pages measuring 11¼ by 8in. with over 1,000 photographs and drawings. Over 30 pages give full details of constructional projects, and a considerable amount of useful information is provided with individual components including in particular linear integrated circuits.

The exceptionally wide range of items listed includes test gear, electronic organ components, TV game i.c.'s, disco effects, technical books, coils, transformers, cases, tools and a full and comprehensive selection of resistors, capacitors and discrete and integrated semiconductor devices. All products are identified by order codes or descriptions and type numbers, and a full index allows items to be located in the Catalogue with the minimum of delay.

Full information on ordering, postage and VAT is given in an early page in the Catalogue, with corresponding notes in French, German and Italian for overseas clients. The new Maplin Catalogue has been carefully prepared and is very well presented, and should be of considerable value to anyone interested in electronics.

TRADE NOTES

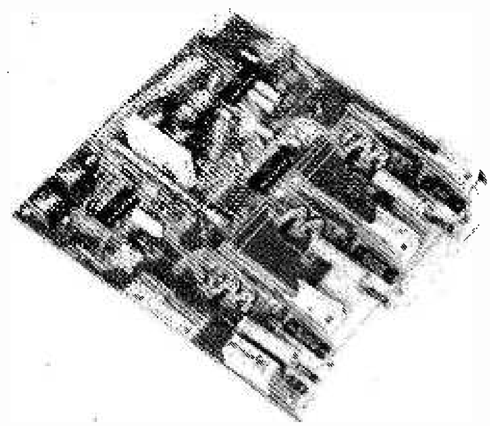
LEADLESS CHECKER

The first of the two accompanying photographs illustrates an intriguing item of test equipment which has just been introduced in the United States. Referred to as a Leadless Continuity Checker it is marketed by Transonics Electronic Distributors, 9305 N.E. 11th Street, Vancouver, Washington 98664.

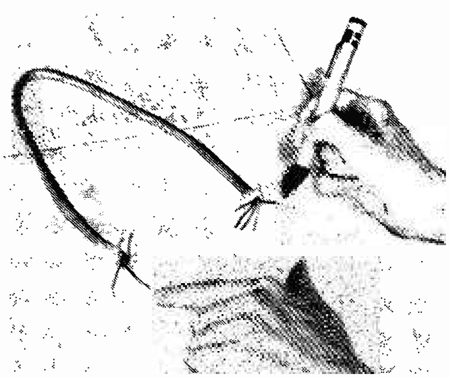
The interesting feature of the Leadless Continuity Checker is that it requires no return lead. The return circuit is made via the body of the person using the device. In the photograph, for instance, the person tracing through the multi-core cable simply puts the finger of one hand on the lead to be traced. The checker is then held in the other hand and its tip is applied to the leads at the opposite end of the cable in turn. When the correct lead has been located an l.e.d. built into the checker lights up.

The checker is also capable of testing capacitors and diodes. One lead-out of the component is held in one hand and the checker in the other; with diodes, both serviceability and polarity may be determined. Other functions associated with a continuity tester can also be carried out.

Since no return wire is required the checker may be conveniently clipped into a pocket like a pen. The voltage at the tip of the checker in the stand-by mode is 0.5 volt and maximum testing current is 11μA.



PAL DECODER



In the second photograph can be seen an assembled PAL decoder card, for colour television receivers, incorporating three new integrated circuits introduced by SGS-ATES. It is stated that these incorporate the highest degree of integration possible within 16 lead d.i.l. packages for the decoder application, and that the external component requirement is reduced by 10 to 20% compared with existing assemblies, thereby giving increased reliability and savings in space and cost.

The i.c.'s concerned are type numbers TDA2140, TDA2150 and TDA2160, and further advantages conferred are low spread of brightness, contrast and saturation controls with a consequent avoidance of pre-setting, a wide range of output black level adjustment, compensation for chroma delay line attenuation by an a.c.c. loop, high noise immunity, and the provision of a composite blanking and burst key pulse generator together with an independent video signal output for a sync generator.

Further information on the three i.c.'s and the associated circuitry is available from SGS- ATES (United Kingdom) Ltd., Walton Street, Aylesbury, Bucks.

SHORT WAVE NEWS

FOR DX LISTENERS

By Frank A. Baldwin

Times = GMT   *Frequencies* = kHz

We commence this month with some news of two clandestine transmissions and some schedules of programmes designed for local consumption in the Domestic Services of the countries concerned which may be heard here in the U.K.

● CLANDESTINE

The "Voice of Arab Syria" reportedly operates on **9510** from 0800 to 0900 in Arabic. The programmes are, of course, anti-government and critical of the present Syrian Regime.

The "Voice of the Communist Party of Turkey" now radiates anti-Turkish government programmes on **6200** daily from 0810 to 0840 (Sundays to 0900).

● DOMESTIC SERVICES

"Radio Pakistan", Karachi, has a Domestic Service which is best heard here in the U.K. from around 1500 through to 1810 on **3890** and **4735**. Programmes from Rawalpindi may be logged from around 1500 to 1800 on **4060** and from Islamabad from 1630 to 1810 on **3330** and on **4785**. All this information accords with their published schedule but past experience has taught that the actual frequencies used quite often differ from those announced or published.

There is also a Regional Network in which programmes in various local languages and English are taken from the above network and radiated from Quetta on **3240, 3270, 3990** and **5980** and from Peshewar on **3155** and on **6080.**

● IRAN

"Radio Iran" with its First Programme may be logged throughout the entire 24-hour period on various channels but that period from 1630 to 2030 is probably convenient for most listeners. The frequencies are **8215, 11930** and **15085,** the language of course being Persian (Farsi).

CURRENT SCHEDULES

The frequencies and times quoted here are correct at the time of writing but either can be subject to change at short notice.

● HUNGARY

"Radio Budapest" broadcasts to Europe in English from 1200 to 1240 (Monday to Friday inclusive only) on **6150, 7155, 9585, 11910, 15160** and on **17785;** from 1515 to 1530 (Tuesdays and Fridays only) a Dx programme on **6110, 7200, 7215, 9585, 11910** and on **15160;** from 2130 to 2200 on **5965 7150, 7200, 9655, 11910** and on **15415.**

● BANGLADESH

"Radio Bangladesh", Dacca, presents an External Service in English to Europe from 1230 to 1300 on **11900** and **15270;** from 1815 to 1915 on **11890** and **15410.**

● GREECE

"Voice of Greece", Athens, produces a daily newscast in English from 1920 to 1930 on **6140, 7215** and on **9675.**

● NETHERLANDS

"Radio Nederland Wereldomroep", Hilversum, operates in English to Europe as follows — from 0930 to 1050 on **5955, 6045, 7240** and **9660;** from 1400 to 1520 on **5955. 6045, 11740** (Madagascar transmitter), **15120, 15185** and **17810;** from 1830 to 1950 on **6020, 11730** and on **15375;** from 2000 to 2120 to West Europe from the Madagascar relay on **11730.**

● ROMANIA

"Radio Bucharest" schedule lists the following programmes for Europe. From 1300 to 1330 on **9690, 11940** and **15250;** from 1930 to 2030 on **6150** and **7195;** from 2100 to 2130 on **5990** and **7225.**

● BULGARIA

"Radio Sofia" has an External Service in English to the U.K. and Eire from 1930 to 2000 on **6070** and **9700** also from 2130 to 2200 on **9700.**

● ALBANIA

"Radio Tirana" is in English to Europe from 0630 to 0700 on **7065** and **9500;** from 1630 to 1700 on **7065, 9480** and on **11985;** from 1830 to 1900 on **7065** and **9480;** from 2030 to 2100 and from 2200 to 2230 also on the latter two channels.

● CZECHOSLOVAKIA

"Radio Prague" features programmes in English to the U.K. and Eire from 1900 to 1930 on **5930, 7245** and on **7345;** from 2000 to 2030 on **5930** and **7345** and from 2130 to 2200 on **6055.**

The Radio Prague Inter-Programme for Europe in English may be heard on **6055** and **9505** from 0745 to 0800; 0845 to 0900; 0945 to 1000; 1045 to 1100 and from 1145 to 1200 the programme consisting of a feature, news bulletin or news summary.

● TAIWAN

The "Voice of Free China", Taipeh, directs a programme in English to Africa, the Middle East and Europe from 2130 to 2230 on **9510, 9600, 11860, 15225** and on **17720.**

● PAKISTAN

"Radio Pakistan", Karachi, has an External Service in which programmes in English are radiated to Europe as follows — from 1100 to 1115 (a newscast read at slow speed) on **15110** and **17665;** from 1815 to 1820 (newscast) on **6115** and **7085** and from 2115 to 2145 (newscast and feature) on **6210** and **7085.**

The World Service directed to the U.K. is as follows — from 0830 to 1100 in Urdu on **15110** and **17665;** from 1915 to 2045 in Urdu, from 2045 to 2115 in Sylheti on **6210** and on **7085.**

● POLAND
"Radio Warsaw" produces programmes in English for Europe from 0630 to 0700 on **6135, 7270** and **9675;** from 1200 to 1230 on **6095** and **7285;** from 1600 to 1630 on **6135** and **9540;** from 1830 to 1900 on **6095** and **7285;** from 2030 to 2100 on **6095** and **7285** and from 2230 to 2300 on **3955, 5995, 6135, 7125** and on **7270.**

AROUND THE DIAL

● CHINA
Radio Peking on **6645** at 1404, OM and YL in Kazakh in the Domestic Service with a programme for minority groups, scheduled from 1400 to 1455.

Radio Peking on **6790** at 1357, YL in Standard Chinese to Taiwan scheduled from 0830 to 1903 and from 2000 to 0129 on this channel.

Urumchi on **4970** at 1441, YL in Kazakh in the Domestic Service.

PLA Fukien on **4380** at 1551. YL in Chinese to Taiwan and other offshore islands, scheduled on this frequency from 0230 to 1900.

Radio Peking on **6540** at 1933, OM in Italian in a programme directed to Somalia, scheduled from 1930 to 2000 at this point on the dial.

Radio Peking on **7620** at 1935, OM with a newscast in English directed to North and West Africa, scheduled from 1930 to 2030 (the programme — not a one hour news reading!).

Radio Peking on **7385** at 1400 when signing-on with "East is Red", followed by the Tamil programme directed to South Asia, scheduled from 1400 to 1430.

Wulumqi on **4110** at 1610, OM's in chorus, mandolin-type instrumental music in the Uigher Service.

Wuhan on **3940** at 1525, classical Chinese music, YL announcer.

Radio Peking on **6860** at 2025, signing-off with "Internationale" after the programme in Esperanto, scheduled Fridays and Saturdays from 2000 to 2030.

Wulumqi on **4220** at 1615, OM in Mongolian in the Home Service.

Wulumqi on **4500** at 1620, YL with aria in Chinese opera.

Radio Peking on **2460** at 1542, Chinese orchestral music, YL announcer.

● TURKEY
Ankara on **11880** at 1350, local music and songs in a programme for Turks abroad, scheduled from 0400 to 1330 and from 1630 to 2100 on this channel.

INDONESIA
RRI Palembang on **4855** at 1450, YL with songs in local-style, OM announcer, orchestral music.

● PAKISTAN
Radio Pakistan, Karachi on, **7280** at 1328, interval signal, identification and programme in vernacular.

Islamabad on **3330** at 0140, YL with song in the Home Service then local-style music programme.

Karachi on **7085** at 2145, signing-off with choral National Anthem after announcements in English.

Karachi on **3390** at 1555, OM with songs in Urdu, local-style music. Quetta on **3240** at 1511, YL with song in Urdu, orchestral music, OM announcer.

● BURMA
Rangoon on **4725** at 1410, YL in Burmese, local pop records. Suddenly off without National Anthem at 1415.

● KHMER REPUBLIC
Phnom-Penh on a measured **4908** at 1429, YL in Khmer (Cambodian), songs and music in the distinctive local style.

● CAMEROON
Garoua on **5010** at 1832, OM with the world news in English. Also at 2200 when signing-off with National Anthem and interval singing after epilogue in Arabic.

● NIGERIA
Lagos on **4900** at 2000, interval signal (talking drum), 6 pips, identification and the news in English. They have been logged on this channel since early December.

● BRAZIL-1
Radio Ribra Preto on **3205** at 0535, OM in Portuguese, local songs and music despite the schedule (should close at 0400). Still there as late as 0610 fade-out.

Radio Clube do Para on **4855** at 2218, OM with a sports commentary in Portuguese.

Radio Timbira on **4976** at 2126, OM in Portuguese, ads, jingles and identification.

Radio Poti on **4964** at 2135, OM's with a discussion in Portuguese.

Emisora Rual on **4948** at 2213, YL with song in Portuguese, OM with a talk at 2215.

Radio Dif, Sao Paulo on **6095** at 0120, OM with an excited commentary in Portuguese.

● VENEZUELA
Radio Occidente, Tovar, on **3225** at 2353, Latin American music in typical local style, OM announcer. The schedule of this one is from 1030 to 0300 and the power is 1kW.

Radio Valera, Valera on **4840** at 0216, OM in Spanish with a long talk about Venezuelan commercial and political affairs.

Radio Sucre, Cumana, on a measured **4959** at 0225, OM with a political talk in Spanish followed by identification and local-style dance music. The schedule is from 1000 to 0400 and the power is 1kW.

Radio Libertador, Caracas, on **3245** at 0131, OM with identification in Spanish followed by a political talk about the Presidency. The schedule of this one is from 1000 to 0400 and the power is 1kW. Reportedly there is a newscast in English from 2200 to 2230 which the writer has never yet succeeded in logging — but hope springs eternal!

Radio Monogas, Maturin, on **3325** at 0136, oddly enough in parallel with Radio Libertador on **3245** together with other Venezuelan stations on the 60 metre band.

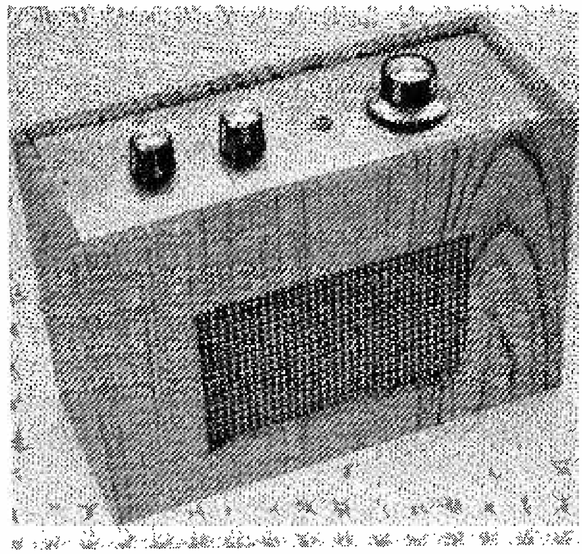
● BRAZIL — 2
Radio Nacional, Brasilia, on **11780** at 2059, which I must confess is a more reasonable hour to listen to South America, with the bell-chime interval signal, identification by OM and the English programme commencing with a newscast mainly composed of items about the Brazilian domestic scene.

● ECUADOR
Radio Quito, Quito, on **4920** at 0325, OM with a local newscast in Spanish with many mentions of Quito.

NOW HEAR THIS

● PAPUA NEW GUINEA
NBC Boroko on **4890** at 2000, National Anthem, OM in Pidgin with a newscast till 2010 then signal lost under interference.

MEDIUM AND LONG WAVE SUPERHET



by A. P. Roberts **Part 2**

In this concluding article the assembly of the component panel is described, after which details are given of final wiring and alignment.

COMPONENT PANEL

All the components and the ferrite aerial are mounted and wired up on a plain s.r.b.p. ("Paxolin") panel having the dimensions shown in Fig. 4. This diagram is reproduced full size and may be traced, if desired.

First, the panel is cut out to the desired size by means of a hacksaw, after which the two 6BA clear holes and the holes for component wires are drilled out. A small diameter drill is used for the component wire holes. Since it is possible that the constructor will not obtain a trimmer having precisely the same dimensions as that used by the author, the two holes for TC3 should be marked out with the aid of the actual component to be used. This should be a trimmer having a tag at each end of its body rather than two tags at one end. For greatest accuracy, the constructor is also advised to mark out the holes for the tags and mounting lugs of the oscillator coil and the two i.f. transformers with the aid of the components themselves. The same comment applies to TR2 and TR3. These two transistors have lock-fit pins instead of wire lead-outs, and the pins pass through the holes in the panel which are drilled for them.

The components are mounted on the panel and their lead-outs bent flat against its underside. The oscillator coil and i.f. transformers are held in position by bending their mounting lugs outward against the underside of the board. A similar procedure is adopted with the pins of IC1 and the tags of TC3. The ferrite aerial is secured to the panel by two lengths of single strand p.v.c. insulated wire. These are looped over the ferrite rod, taken through the appropriate holes in the panel, and then each set of wire ends is twisted tightly together so as to firmly secure the rod to the panel. Note that only the insulated wires should be twisted together. If the bare wire itself is twisted togethr it will constitute a shorted turn which will prevent the ferrite aerial from functioning properly.

When all the components have been mounted, the lead-out wires are cut to length where necessary and soldered together, as shown in Fig. 4. Tinned copper wire of around 22 s.w.g. is employed where lead extensions are required or to bridge wiring gaps. Note that part of the negative supply rail circuit is completed via the mounting lugs of the oscillator coil.

FURTHER WIRING

The component panel is secured to the front panel by means of a bracket having the dimensions shown

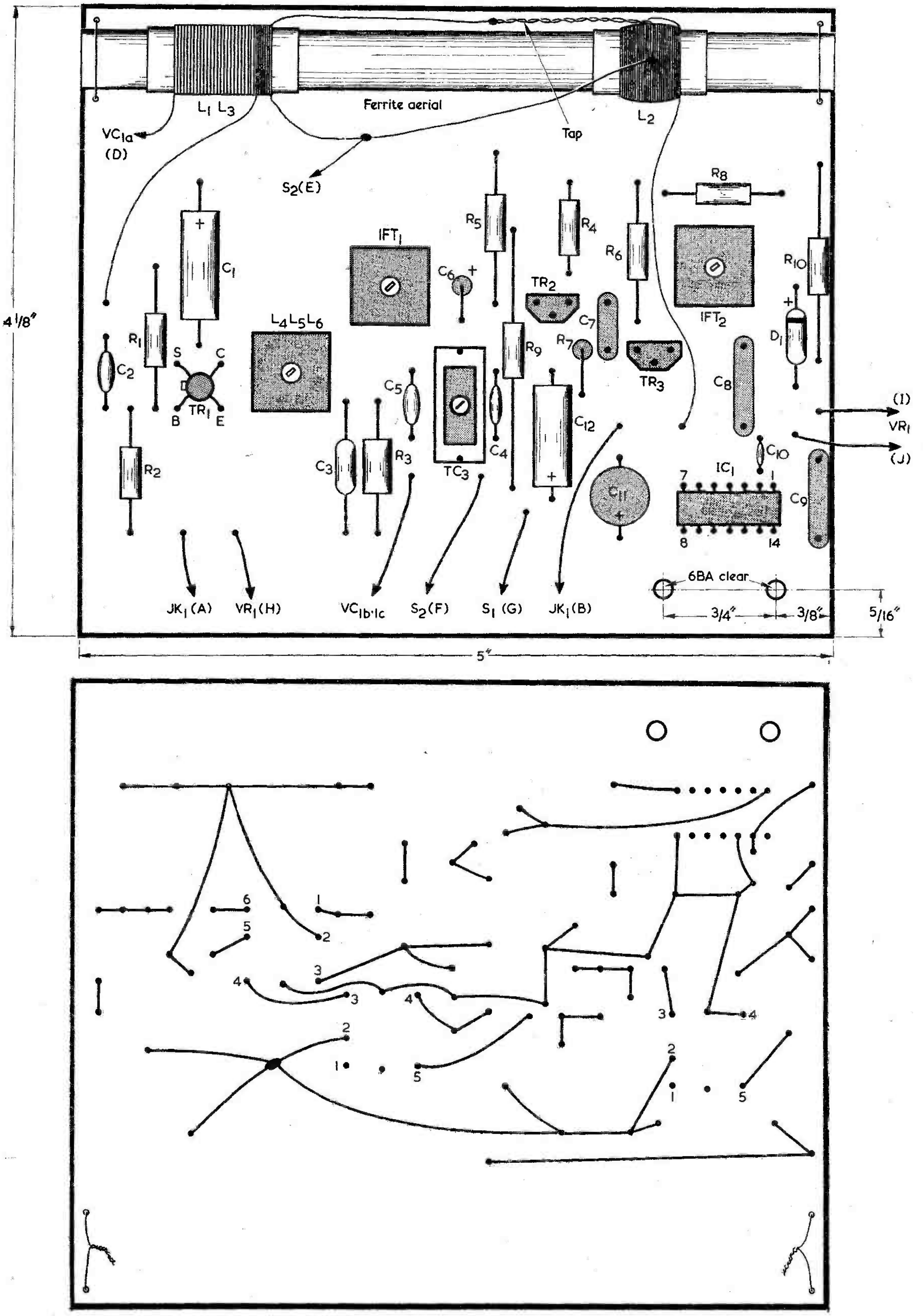
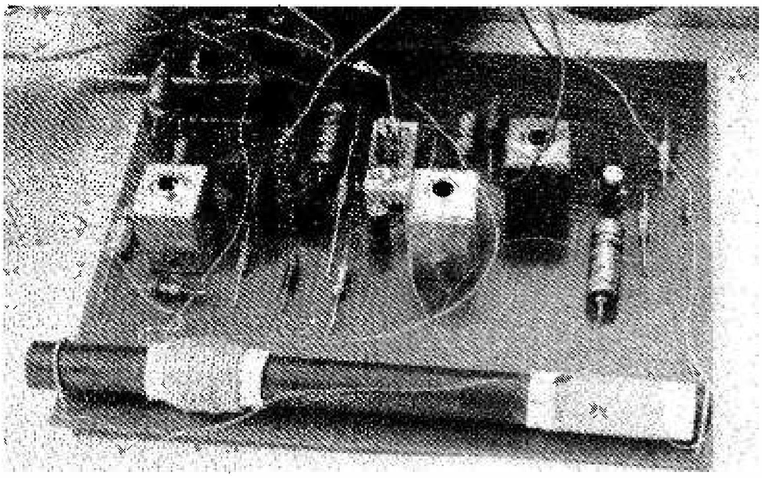


Fig. 4. The component and wiring sides of the component panel. This is assembled on a piece of plain s.r.b.p. board, and is reproduced full size



A close look at the component panel

in Fig. 5. This is secured to the front panel under the mounting bushes of VR1 and S2. The bracket is made of 18 s.w.g. aluminium. Should it be necessary for the 3in. dimension of the front panel to be increased, the 1¼in. dimensions of the bracket should also be increased by the requisite amount.

All the remaining wiring of the receiver is shown in Fig. 6. P.V.C. insulated wire is employed to couple the front panel and component panel sections together, and this should be kept reasonably neat and short. However, the leads to the speaker should be flexible and about 10 to 12in. long. Switch S2 is any single pole 2 way rotary switch. That employed in the prototype and visible in the photographs was a 4 pole switch with no connections made to three of the poles.

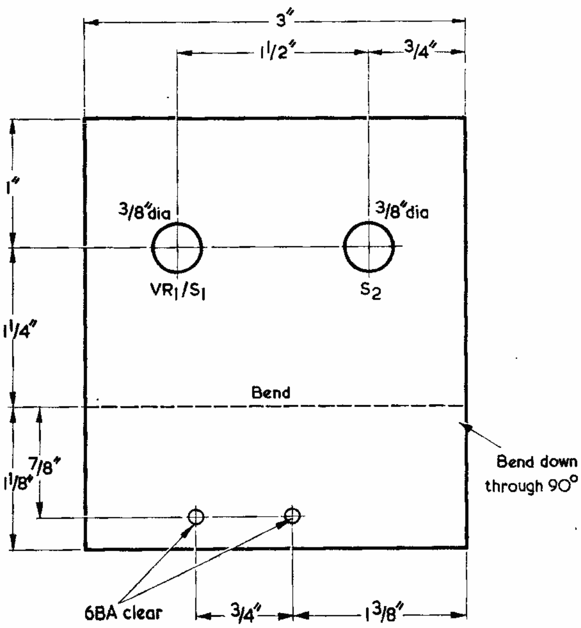


Fig. 5. The bracket which secures the component panel at the rear of the case

It should be possible to trace out the ferrite aerial connections from Figs. 4 and 6. If any doubt exists this can be dispelled by referring back to the circuit diagram of Fig. 1. The tap in L2 is electrically nearer the earthly end of the coil, which connects to the negative supply rail. If an ohmmeter is available, the resistance between the tap and the earthy end of the coil will be found much lower than the resistance betweeen the tap and the non-earthy end.

The quiescent current consumption of the set is about 7mA, but it rises to many times this value when the receiver is used at high volume levels. In the interest of good battery economy it is necessary to use a fairly high capacity 9 volt battery such as a PP6, PP7 or six HP7 cells in a suitable holder. There is plenty of space for the battery under S2, and a simple bracket can be made up to hold it in place.

ALIGNMENT

The i.f. and mixer-oscillator circuits have to be aligned before the front panel and component panel assembly can be fitted in the case. Alignment commences with the i.f. stages.

Upon initially switching on it should be possible to tune in one or two stations with S2 in the medium wave position. The medium wave aerial coil can be moved along the ferrite rod to peak one of the transmissions. If a multimeter having a sensitivity of 10,000 Ω. per volt or more on its voltage ranges is available, this can be connected across VR1 with the positive test lead connecting to the negative supply rail. It should be switched to read voltages of the order of several volts. The receiver is then carefully tuned to a station and the i.f. transformer cores adjusted for a maximum voltage reading.

In the absence of a meter the receiver may be tuned to a fairly weak station and the i.f. transformer cores adjusted for maximum volume. A strong signal cannot be used in this case because of receiver a.g.c. action.

The i.f. transformers are pre-aligned at the factory and very little adjustment of the cores should be required. Obviously, the cores must not be tampered with prior to the process of alignment. The cores

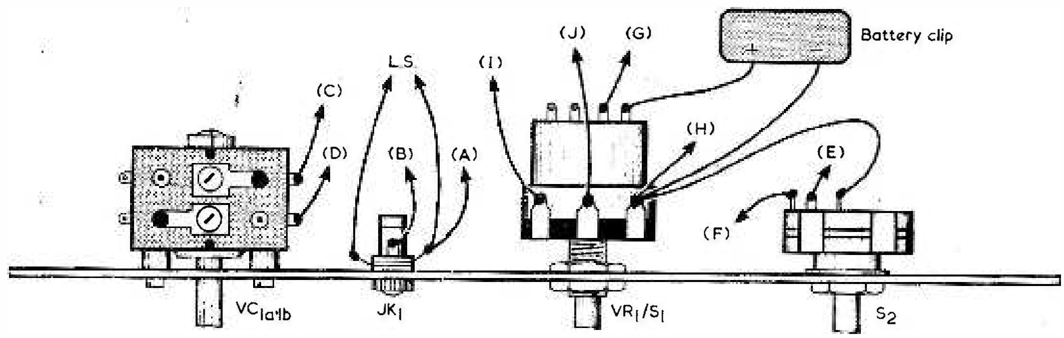
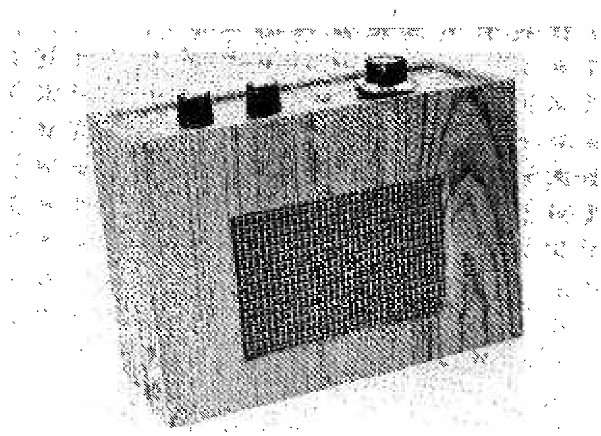


Fig. 6. The wiring to the components on the front panel. Not shown here is the bracket of Fig. 5. This is mounted behind the front panel on the bushes of VR1/S1 and S2



A further view of the completed receiver. The larger control knob is that for the tuning capacitor

should be adjusted with a proper trimming tool, such as the Denco type TT5. An ordinary screwdriver could damage them.

Trimmer TC2 is adjusted to give the set the correct frequency coverage. If no suitable r.f. signal generator is to hand it is probably best to wait until after dark when Radio Luxembourg on 208 metres can be received. TC2 is adjusted so that this station is received with the tuning capacitor close to its minimum capacitance setting.

If the multimeter is available and is connected across VR1, tune to a consistently strong signal at the high frequency end of the band (the same end as Radio Luxembourg) and adjust TC1 for maximum voltage. Tune to a similarly strong signal at the low frequency end of the band (tuning capacitor vanes nearly fully enmeshed) and move the medium wave coil along the ferrite rod for maximum signal strength. Retune to the high frequency end and re-adjust TC1, then return to the low frequency end and re-adjust the position of the medium wave coil on the ferrite rod. Repeat the procedure until no further improvement can be obtained.

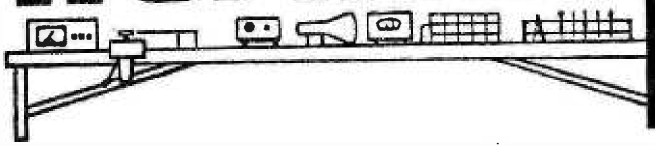
If no meter is available, these adjustments may be made for maximum volume, choosing weak transmissions instead of strong ones.

Carefully tape the medium wave coil to the ferrite rod so that it cannot be accidentally moved from its correct setting.

Put S2 to the long wave position, and set the tuning capacitor to about the centre of its range. Adjust TC3 to accurately tune in Radio 2 on 1,500 metres. Finally, slide the long wave coil along the rod for best reception and then tape it in place. Alignment is now complete and the front panel and component panel assembly can be fitted in the receiver case.

The procedure just described involves no adjustment of the oscillator coil core, which should be correctly set at the factory. If desired, the low frequency end of the medium wave range may be altered by adjusting the oscillator coil core, but this will then necessitate repeating the entire mixer-oscillator alignment process. In general, it is best to leave the oscillator coil core undisturbed, this being particularly the case when an r.f. signal generator is not available. ■

In your workshop



This month Smithy's assistant, Dick, sets out on the repair of a television receiver with a fault in the frame sync section. In the process he is given valuable, albeit somewhat disturbing, assistance by the Serviceman himself.

Whistling contentedly, Dick picked up the only set left on the "For Repair" rack, a 14 inch 625 line black and white television receiver, and carried it over to his side of the Workshop. He plugged it into one of the row of assorted mains sockets at the back of his bench, connected the u.h.f. aerial and switched on. At once the sound channel of one of the local transmitters became audible from the speaker of the set.

As he waited for the picture tube to warm up he glanced cheerfully out of the window. Outside, the warm glow of an April sun permeated the late afternoon sky. It was patent that God was in His heaven and, for the time being at any rate, all was well with Dick's particular world.

FRAME FAULT

The screen of the receiver lit up to reveal a bright and well contrasted picture which was out of vertical synchronisation. Humming to himself, Dick gazed for a moment at the frames as they rolled downwards, then he turned the set partly round, located the vertical hold control and adjusted it experimentally. He found a critical setting at which the picture remained steady momentarily then he took his hand away from the control.

The frames started to roll upwards.

"Well," came Smithy's voice at Dick's ear, "you've picked yourself a nice easy one this time."

Dick jumped.

"Dash it all, Smithy," he snorted. "I do wish you wouldn't keep creeping up on me like that. It's nothing short of shattering to suddenly have a disembodied voice blast into your lug-hole unannounced."

"I was talking," retorted Smithy, ruffled, "in my normal voice. It's a fine thing I must say if two people in the same working place can't speak to each other every now and again."

"Yes, but *you* don't just speak to people," stated Dick heatedly. "You sidle up to them first."

"I do not sidle," replied Smithy indignantly. "I've never sidled in my life."

"You're always sidling," accused Dick. "Stap me, you sidled just now. Anyway, I've forgotten what it was you said."

Smithy made a brave attempt to dissipate his irritation.

"What I said," he grated, "was that you've picked a nice easy fault."

"You mean this set?"

"I do."

"How is it easy then?"

"Well, just look at it. You've got an excellent picture with a steady line lock. All that's wrong with it is that there's a loss of frame sync at or after the sync separator. You couldn't have it much simpler."

"Simple you call it? Blimey, the fault could be anywhere. What about the frame timebase?"

"The frame timebase is almost certainly all right," pronounced Smithy. "Not only were you able to take the frame hold control to correct frame frequency, but you could also adjust it on either side of that frequency. When you had the frames rolling downwards the timebase was running above frame frequency and when they rolled up it was running below frame frequency. So the frame timebase is working just as it should do, and its hold control has a good wide range of adjustment. All that the timebase needs is a spot of sync."

"Perhaps you're right," admitted Dick grudgingly. "If there are no sync pulses getting to the frame timebase then it has no reference frequency to follow."

"That would be a true presentation of the facts if we were talking about a horizontal flywheel sync circuit," Smithy corrected him, "but the situation is different with a frame timebase. Don't forget that in a conventional frame timebase the frame hold control actually varies the length of the scan section of the timebase waveform, the short flyback section being the same length whatever the length of the scan section. You then adjust the frame hold control so that, without sync pulses, the timebase would run slightly below frame frequency. This corresponds to the scan section of the waveform being a little too long. The sync pulses trigger the timebase into flyback, so that the timebase then runs at sync pulse frequency."

"Fair enough," said Dick. "Well, I might as well get the service manual out for this set."

"There's no need," stated Smithy. "I've got it here."

SERVICE MANUAL

Smithy placed the manual in front of his astonished assistant, then opened it at the circuit diagram of the receiver.

"Hell's teeth," gasped Dick. "Have you got second sight or something?

First of all you almost completely diagnose what's wrong with this set, and then you produce its service manual out of thin air. I don't get it."

"All that's happened," explained Smithy patiently, "is that I finished my last job for the day just as you were picking up that TV. So I thought I'd do the TV with you, whereupon I first got its service manual out of the filing cabinet. Okay?"

"Yes, I suppose so," grunted Dick reluctantly. "But it seems to me that there's no end of sidling and pussyfooting going on this afternoon."

"Now just stop that," snarled Smithy. "I'm getting more than a bit fed up with your comments about my movements. Let's have a look at this circuit."

"All right then," said Dick, switching off the television receiver and turning his attention to the diagram. "Where's a good place to start?"

"At the vision detector," replied Smithy promptly, as he pointed to the appropriate section of the circuit. "Seeing that we've got a case of missing sync pulses it will be a good plan to trace through from the vision detector, keeping in mind the sync pulse polarity at the subsequent circuit points." (Fig. 1.)

"Well," said Dick, "for a start the 625 lines signal has negative modulation with sync pulse tips corresponding to maximum signal amplitude. The vision detector diode is connected so that it passes negative half-cycles, and so the sync pulses in the detected signal will be negative going."

"Very good," remarked Smithy, pleased. "Now, the signal at this stage splits into two directions. In one direction it goes off to the 6MHz intercarrier sound amplifier and in the other it goes to a video amplifier transistor. The intercarrier amplifier won't have any effect on frame sync pulses and so we carry on to the video amplifier transistor."

"The signal splits up in two directions there, too," remarked Dick, his finger tracing out the circuit lines in the diagram. "One direction is from the transistor emitter and the other is from the transistor collector."

"Right," confirmed Smithy. "The signal from the emitter goes to the video output transistor, which then couples to the cathode of the picture tube. Unless we have a really way-out fault we can next eliminate that part of the receiver as well. As a matter of passing interest, you'll see that there's a 6MHz acceptor tuned circuit coupled to the emitter. This is a 6MHz trap, and it prevents the 6MHz intercarrier signal getting to the video output stage."

"The signal we want is from the video amplifier collector," said Dick excitedly. "Look, it couples direct to the sync separator transistor."

"And so it does" agreed Smithy. "Now, the signal going to the video amplifier base had negative going sync pulses. The signal at the collector will be inverted and so it will have positive going sync pulses."

"How does that sync separator work, Smithy?"

"It just amplifies the most positive part of the signal," said Smithy. "If you forget that series 1kΩ resistor in its base circuit for the time being, the 0.22μF coupling capacitor charges up such that the base-emitter junction of the sync separator is fully conductive when the sync pulse tips are present. The signal amplitude is quite high at this point of the circuit, and so the

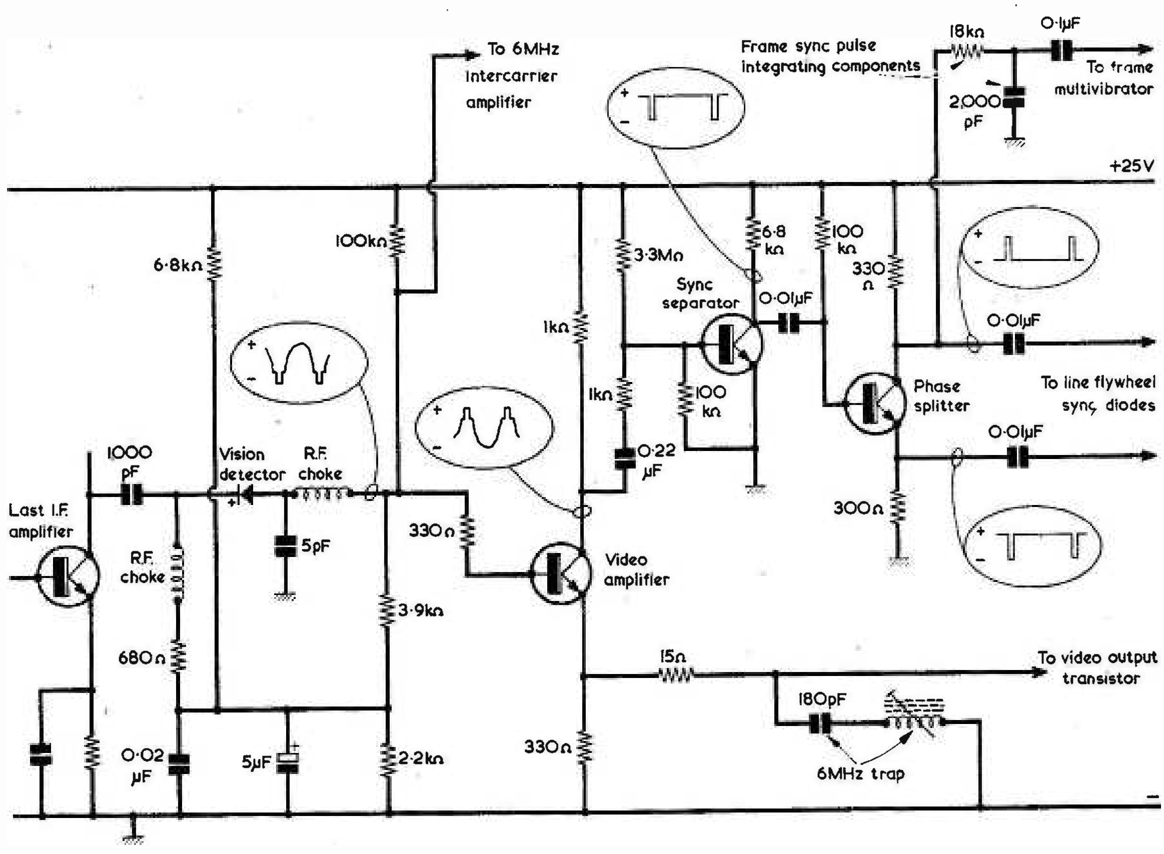


Fig. 1. The stages between the vision detector and the phase splitter transistor in the monochrome 625 line television receiver serviced by Dick and Smithy

sync separator transistor is simply cut off by the signal between pulses." (Fig. 2.)

"Then," said Dick slowly, "the sync separator only passes collector current when the sync pulses are present."

"That's right," agreed Smithy. "All you get at its collector are pulses which appear at the same time as the pulses applied to its base. These must, of course, be negative going."

FLYWHEEL SYNC

"You said to ignore that 1kΩ series resistor just now," said Dick. "What does it do?"

"Not a great deal," admitted Smithy. "In company with the 0.22μF capacitor it offers a time constant which enables the sync separator to handle the signal at its base more readily. Also, it limits peak charging current in the capacitor. Now, let's see where those negative going sync pulses at the sync separator collector go. In this particular receiver they are passed to a phase splitter stage whose major function is to operate the line flywheel sync section. However, our present interest is with frame pulses so we'll just give the line flywheel sync section a miss."

"Hey, wait a minute," interjected Dick. "We could at least take a quick look at it."

Smithy glanced at his watch and frowned.

"Well, it will have to be pretty quick, then," he remarked. "As we saw just now we have negative going sync pulses going into the base of the phase splitter. These will be large enough to turn off the phase splitter when they're present, with the result that we'll get large positive going sync pulses at the collector of the phase splitter and large negative going pulses at its emitter. These then go to the flywheel sync diodes coupled to the line timebase."

Smithy pointed to the diodes in the service manual diagram. (Fig. 3.)

"Those pulses," he resumed, "cause the two diodes to become conductive when the sync pulses are present and to be non-conducting when the pulses are absent. Applied to the centre of the diodes is a waveform derived from the line output stage which has a steeply falling ramp corresponding to the line flyback period and a much less steep rising slope corresponding to the line scan period. When the line timebase is running correctly the steep ramp is applied to the diodes at the same time as they are made conductive by the sync pulses. In consequence, and ignoring the line hold potentiometer for the moment, the voltage at the centre of the two 12k Ω resistors across the diodes becomes the same as that held by the steep ramp when the diodes conduct. This is the control voltage for the line timebase frequency. If the line timebase tries to run too slowly an earlier part of the steep ramp coincides with the sync pulses and the control voltage goes positive. Conversely, if the timebase tries to run too fast the control voltage goes negative. The control voltage is applied via what is effectively a smoothing circuit, which provides the flywheel effect, to the timebase oscillator, and it controls the oscillator frequency in such a manner as to counteract any changes in it." (Fig. 4.)

"What about that line hold potentiometer?"

"Ah," said Smithy, "I was coming to that. The line hold potentiometer

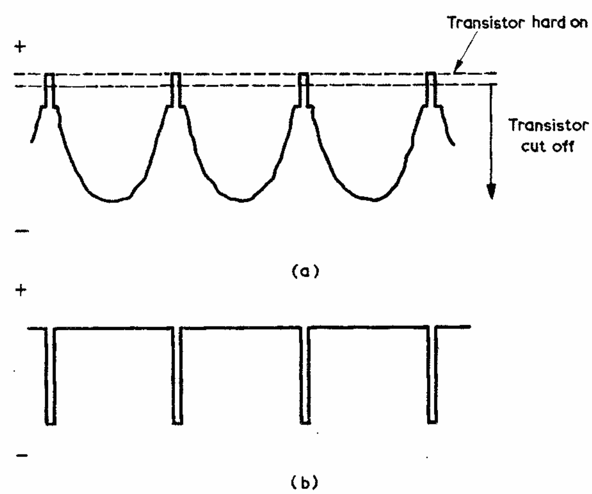


Fig. 2(a). The sync separator transistor is only conductive in the presence of sync pulse tips at its base

(b). The collector waveform of the sync separator consists, in consequence, of inverted sync pulse tips only

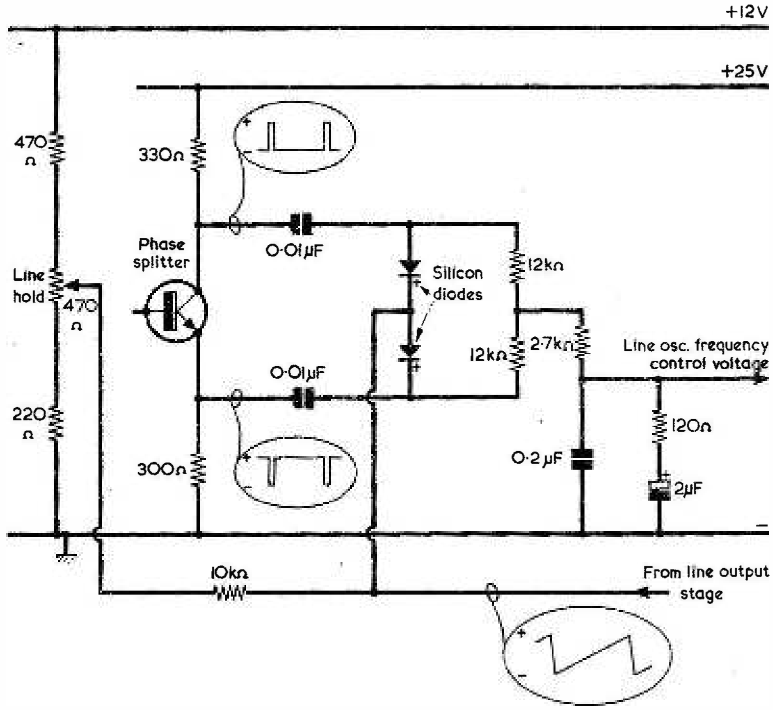


Fig. 3. The anti-phase pulses from the phase splitter are applied to the line flywheel sync diodes, causing these to be conductive when the pulses are present

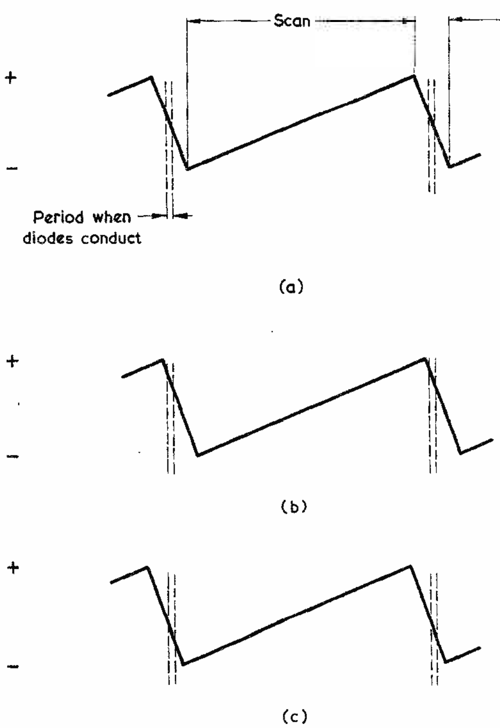


Fig. 4(a). Here, the pulses cause the diodes to be conductive at a central part of the steep ramp in the waveform from the line output stage

(b). If the line oscillator runs too slowly, an earlier part of the ramp is sampled by the diodes, giving a positive control voltage

(c). A later part of the ramp is sampled if the oscillator attempts to run too quickly

setting modifies the voltage present at the diodes when they conduct. It provides a reference voltage which allows the overall circuit to run at correct line frequency, with the frequency still being held steady by the sampling of the waveform from the line output stage."

Smithy stopped talking and looked expectantly at his assistant.

"Blimey," said Dick, "you really *were* quick with that explanation."

"I had to be," stated Smithy. "It's missing frame sync pulses we're looking for, not missing line sync pulses. Still, that little sojourn with the line flywheel sync circuit did have one beneficial result. Since the line sync is working, it's obvious that there are positive going sync pulses at the collector of the phase splitter. When the broad frame pulses are transmitted these should be integrated by the following 18kΩ resistor and 2,000pF capacitor, whereupon large positive going frame sync pulses are available for the frame timebase multivibrator."

"Let's take a look at that next," said Dick quickly.

FRAME MULTIVIBRATOR

"Oh, all right," conceded Smithy. "At least it will be more to the point to discuss this than it was to talk about the line flywheel sync circuit. Here's the multivibrator bit."

Smithy indicated another part of the diagram. (Fig. 5.)

"Now," he continued, "this multivibrator controls an output stage which drives the frame deflection coils and which provides its own waveform shaping. All that the multivibrator has to do is to run at the correct frequency and to give scan and flyback periods of the correct length. During the scan period the right hand transistor is cut off and during the flyback period it is turned on. Shall we have a go at it first without sync pulses?"

"Yes, please."

"Right," said Smithy. "We can start at a moment in the multivibrator cycle when the right hand transistor is off and is just about to turn on. It's turned off because its base has been taken positive by the 0.22μF capacitor, which is discharging into the resistors connected to the base. Don't forget that the transistors in this multivibrator are p.n.p. instead of n.p.n., as all the previous ones have been. When the right hand transistor starts to pass current its collector goes positive, reducing the current flowing via the 10kΩ resistor to the base of the left hand transistor. The collector current of the left hand transistor reduces, the collector voltage goes negative and turns the right hand transistor on harder via the 0.22μF capacitor. The usual cumulative amplification in a multivibrator then takes place and it ends with the right hand transistor fully on and the left hand transistor cut off. The circuit stays in this state for the short period required for the 0.22μF capacitor to charge via the emitter-base junction of the right hand transistor and the 330Ω resistor. This is the flyback period."

Smithy paused.

"That's all nice and easy to follow up to now," commented Dick. "What happens next?"

"As soon as the 0.22μF capacitor becomes fully charged the base current in the right hand transistor reduces and the base goes slightly positive. There is a reduction in collector current, causing the collector to go negative and allow a small base current to flow into the left hand transistor. This is all that is needed to start the reverse changeover in the multivibrator. As soon as the left hand transistor starts to draw current its collector goes positive, and the 0.22μF capacitor takes the base of the right hand transistor positive, completely cutting this transistor off. We have now started the long scan period, with the left hand transistor turned fully on, so that its emitter is negative of the base of the right hand transistor. The duration of this period is the time needed for the 0.22μF capacitor to discharge into the 120kΩ resistor and the 47kΩ pot."

"And that," chimed in Dick, "will be a much longer period than the one when it charged via the 330Ω resistor because the resistance values are a lot higher."

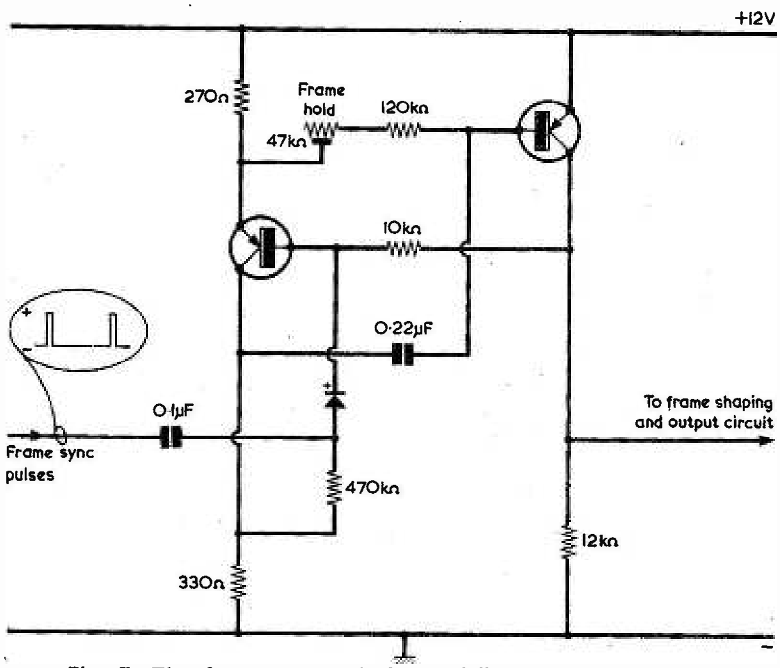


Fig. 5. The frame, or vertical, multivibrator in the television receiver. The 0.1µF capacitor is the same component that appears in Fig. 1, and the shape of the frame sync pulse is idealised. (This and the preceding circuits are slightly simplified versions of the circuit employed in the Thorn 1590-1591 series of television receivers.)

"You've got it," said Smithy. "Also, the length of the scan period is controlled by the 47kΩ pot, which in consequence becomes the frame hold control."

"Right," said Dick. "Let's now put in the frame sync pulses."

"They're easy," said Smithy. "As we already know they're positive going, and they're applied via a diode to the base of the left hand transistor. They then turn this transistor off and initiate the flyback period a little earlier than it would otherwise start. This assumes, of course, that the 47KΩ pot is adjusted so that the frame scan period without sync pulses is a little longer than the period when sync pulses are applied."

Smithy stopped and Dick gazed at the circuit diagram of the television receiver with enhanced understanding.

"I certainly," he remarked, "know my way around this circuit a lot better than I did before."

Smithy gave a mock bow.

"Our earnest aim," he intoned, "is to provide satisfaction for our clientele."

"Indeed. Now, as you said earlier on, the frame multivibrator must be working all right. And there must be positive going sync pulses at the collector of that phase splitter transistor."

"Correct."

"So that only leaves the components

in between."

"Which." pointed out Smithy, "consist of one 18kΩ resistor, one 2,000pF capacitor, one 0.1μF capacitor and a diode. With, perhaps, a possible suspect in the 470kΩ resistor connected to the diode. I told you it was an easy one."

FAULT LOCATION

"With a bit of luck I'll be able to find it with an ohmeter," pronounced Dick. "Anyway, here goes."

He disconnected the receiver from the mains and removed its back. After that he pulled his battered multimeter towards him, switched it to an ohms range and adjusted its set-zero control.

"I'll leave you to get on with it for a minute or two," said Smithy. "I've just got to finally screw up the back on the set I finished before I came over here."

Smithy walked back to his bench to complete his work, whilst Dick located the 18kΩ resistor connecting to the collector of the phase splitter transistor. He reasoned that as one side of this connected to two capacitors he would get an accurate reading of its value by simply applying his test prods to the resister lead-outs. This he next proceeded to do. (Fig. 6(a).)

The testmeter indicated 1.2kΩ.

"Smithy," he called out happily, "I've drawn blood first go! The 18kΩ resistor is reading low in value."

Jubilantly he picked up his soldering iron and applied it to the printed board, after which he carefully removed one of the resistor lead-outs from the board. Unknown to him, Smithy had now returned and was standing alongside him. As a routine check, Dick connected the testmeter prods to the 18kΩ resistor, which now had one of its lead-outs free of the circuit.

The meter showed 18kΩ.

A grin passed over Smithy's face and he moved quietly to the spares cupboard then returned, just as quietly, to his assistant's side.

Frowning, Dick soldered the resistor back in place on the board and measured its resistance once more. Again the testmeter indicated 1.2kΩ. Puzzled, Dick decided to check elsewhere. He next applied his testmeter between the receiver chassis and the junction of the 18kΩ resistor and the 2,000pF capacitor. The meter indicated zero ohms. (Fig. 6(b).)

"Ah," muttered Dick to himself, "that's more like it."

This time he unsoldered one lead of the capacitor from the board. He applied the testmeter prods to the capacitor and was rewarded again with a reading of zero ohms.

He unsoldered the remaining capacitor lead and removed it from the board. Silently, Smithy reached forward and presented him with a new 2,000pF capacitor.

"Oh thanks, Smithy," said Dick absently.

He bent the capacitor leads so that they would fit into the holes in the printed board, then suddenly stopped. A look of alarm spread over his face.

"Hey, what happened then?"

"I gave you a new 2,000pF capacitor."

Dick turned and pointed a trembling finger at the Serviceman.

"You've done it again," he accused. "Not only have you once more crept up on me without my knowing, but you've jumped one step ahead of me in fixing this set. There's something supernatural about you today, Smithy. It's either that, or you've got a time machine so that you can make little leaps back and forward in time."

"I just exercise," stated Smithy modestly, "a little informed foresight."

"Informed foresight?" repeated Dick incredulously. "The way you're acting you should be able to see into the middle of next week. I tell you, you're getting decidedly spooky. First of all, you've started gliding soundlessly around all over the place and when you get where you're going you just *hover!* And how on earth were you able to hand me a new capacitor just after I'd found out that the one in the set was short-circuited?"

"I guessed," explained Smithy, "that the 2,000pF capacitor in the set was shorted when the 18kΩ resistor read low when it was connected to the board and then showed its correct value when one of its leads was disconnected. Pretty well the only component which could cause these two readings was that 2,000pF capacitor."

"But," protested Dick, "how could that capacitor cause the low reading even if it was shorted?"

"Because it's connected to chassis, and the other end of the 18k Ω resistor couples via a 330 Ω resistor to the positive rail. In many transistor TV circuits there is quite a low resistance between a positive supply rail and chassis because of base bias networks and similar resistive circuits between the two. So these were effectively connected across the 18k Ω resistor by way of the short-circuited capacitor."

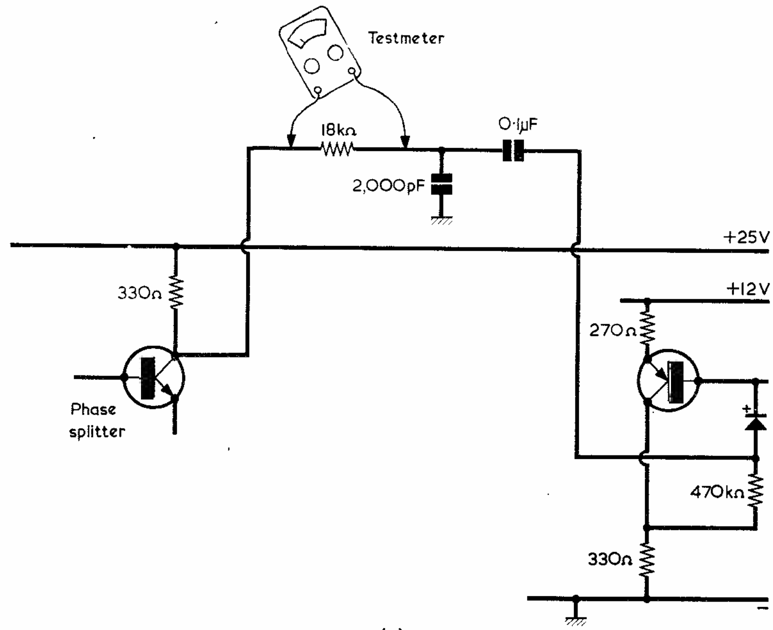
Dick continued to gaze suspiciously at the Serviceman.

"Well, fair enough," he remarked eventually. "But I hope you're not going to get up to any more tricks like that. This has been an extremely unsettling afternoon."

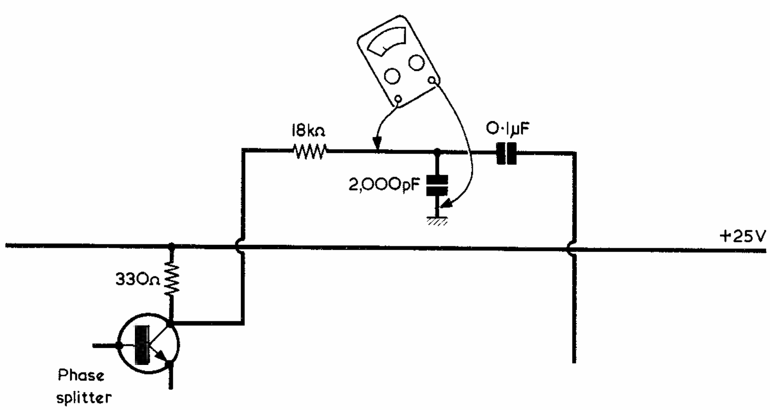
TEAMWORK

With which words Dick once more picked up his soldering iron and fitted the new capacitor to the board. After snipping off the excess lead-out wires on the copper side of the board, he turned the set round, plugged it into the mains again and switched it on.

After a period the cathode ray tube reproduced a picture which was firmly locked in both the horizontal and vertical directions. Dick checked the frame hold control, to find that this had a good and very satisfactory lock-in range. It was obvious that the frame



(a)



(b)

Fig. 6(a). Dick initially checked the resistance of the 18k Ω resistor in the frame sync pulse integrating circuit following the phase splitter. Part of the frame multivibrator is also shown here

(b). Dick's second check consisted of applying his testmeter to the 2,000pF capacitor

sync pulses were now finding their way, fully integrated and completely unobstructed, to the multivibrator in the frame timebase.

"There you are, Smithy," said Dick triumphantly, turning to his side. "Another set finished and . . ."

But Smithy had vanished.

Unnerved, Dick gazed around the empty Workshop. There was suddenly a rattle at the door handle, after which Smithy entered, rubbing his hands together briskly.

"Where the heck," asked Dick, "did you disappear to?"

"To my usual port of call," replied Smithy innocently. "I tend to pop out there now and again throughout the day. Ah, I see that that TV is working all right now. We did a good job there."

"We?"

"We," confirmed Smithy cheerfully. "There's nothing to beat teamwork between two people, where each one knows precisely what the other one is up to."

And it has to be recorded that Dick, on hearing this estimable observation on the part of the Serviceman, for once had no reply to offer at all. ■

Radio Topics

By Recorder

★ ★ ★ ★ ★ ★

I should imagine that I am in company with most electronically minded home constructors when I admit to the fact that I am something of a hoarder. I just can't bring myself to throw out things unless they have a nuisance value which definitely outweighs any advantage they may possess. Into this last category fall such obvious items as broken down capacitors and resistors which have shifted in value. The rest remain.

Although this means that quite a lot of space is cluttered up with components and hardware for which there is no apparent use, the availability of the odd part can at times be of considerable help in solving some of the more unusual problems that arise. Let me give a few examples.

POWER SUPPLY SWITCH

Amongst my equipment is a variable voltage power supply, the mains input of which is turned on and off by means of a double pole rotary toggle switch. When, some time ago, I turned the power supply on at the start of a working session the internal insulation between the two switch poles broke down, causing an impressive crack and the untimely demise of the cartridge fuse in the mains plug. What was obviously required was a new switch, but I just didn't have on hand a replacement of the same type. This fitted in a ⅜in. front panel hole, whilst all I had available were standard sized dolly operated toggle switches requiring a larger panel hole. I didn't particularly relish the idea of filing the existing panel hole wider to take one of these. One reason was that the rotary switch knob matched in with the remaining control knobs on the front panel, and a second reason was that I would in any case be able to get a new rotary switch of the correct type in a few days.

Then the inspiration bulb glowed. Hidden away amongst my junk was an old 1MΩ volume control with switch which had once been fitted to a valve radio. I mounted this volume control in place of the faulty rotary switch, connecting the wires from the previous component to the switch section at the back of the potentiometer. Obviously, no connections were made to the potentiometer tags themselves.

I was then in business again. After switching on with the improvised switch there was now a considerable amount of spindle travel available in the clockwise direction which served no useful function, but this didn't matter. I hadn't had to carry out any metal-bashing work on the front panel and I now had a perfectly satisfactory on-off switch. As things happen, it was about several months before I finally got round to obtaining a proper rotary switch and fitted it in place of the temporary one!

HEAT SINKS

At another time I was playing around with an a.f. amplifier circuit which had an AC127 and an AC128 in the output stage. These transistors are both housed in TO-1 cans, and they were running just a little warmer than I liked. Once again my stock of old parts came to the rescue and I unearthed a couple of valve top cap connector clips, which fit very nicely over TO-1 transistor cases. I soldered a 1in. square piece of tinplate to each clip and then passed the clips over the transistor bodies. A rough and ready form of heat sink, I'll agree, but it sufficed to keep those two transistors at a safely low operating temperature.

Turning to components which are rather more modern than the AC127 and AC128, I recently did some circuit experiments with i.c. op-amps having eight lead-outs disposed in a circle. I am not too keen on these, as I find the dual-in-line i.c.'s much more convenient to handle and wire up. So I wired the i.c.'s to the tags of B9A valveholders, the latter being mounted with the tags uppermost. Obviously, no connection was made to one of the valveholder tags. The resulting appearance was admittedly rather non-technical, but the valveholders adequately served their purpose in providing what were effectively 9-way circular tagstrips.

I also keep scraps of 0.1in. Veroboard if these are not too small. They are ideal as templates for marking out and even drilling the holes in a printed board for d.i.l. integrated circuits or their holders.

And so it goes on. It is quite amazing what uses one can find for odd parts, particularly those which have hung over from the old valve days. As for things like bolts, nuts and similar items, my collection goes back to the early 1950's. But then, who heard of a radio construction enthusiast who ever threw away a single nut or bolt?

A SOCIAL NOTE

Looking back over some of my jottings of 12 years or so ago, I detect a welcome change which has been brought about by the increasingly large numbers of colour television receivers installed throughout the country. In those earlier days of black and white TV's, one of the perils of being known as someone connected with electronics was being approached by acquaintances who wanted their television sets repaired on the cheap. It was surprising how many people, at that time, were prepared to drop the most outrageous hints in order to cajole you into fixing some clapped-out old monochrome receiver.

Not so nowadays, I'm happy to say. Anyone who has a colour TV regards it with the utmost veneration, and the last thing he wants is someone who doesn't wear a professional service engineer's hat tinkering around with its innards. And so you can relax in company and chat about electronics as much as you like, without being subject to the blandishments of those television owners whose sets "have only got a wire loose".

A pleasant change indeed.

TRANSISTOR TYPE NUMBERS

You would think that, if two transistors have the same type number, they should be identical regardless of the manufacturer. This is not always the case, however, and occasional differences tend to creep in.

An example I bumped into recently is concerned with the BFY50, BFY51 and BFY52 "family" of transistors. These are n.p.n. silicon planar transistors intended for general purpose industrial applications. They are listed by Mullard, in whose data they are described as being housed in a TO-5 can. They are also listed by Texas Instruments, who describe them as being in a TO-39 case!

The Mullard and Texas Instruments data on the transistors are virtually identical and each version of the transistor has the same lead-out layout, with the collector connected to the can. In practice, there isn't a great of difference between the TO-5 and TO-39 encapsulations, both of which have the usual locating lug. Whereas the width of the TO-5 can is 8.20 to 8.50mm., the width of the TO-39 can is 7.75 to 8.51mm., and other dimensional discrepancies are of the same minor order.

Still, it's a little disconcerting when one first encounters two different encapsulations for the same transistor.

Another transistor which appears in more than one guise is the n.p.n. 2N3404. This is listed by American General Electric and appears also in the old Brimar lists, and the lead-outs appear in the order: base, collector, emitter. It is listed also by Sescosem, however, who show the lead-out order as: collector, base, emitter.

It is very rarely that incongruities of this type crop up. I remember one popular f.e.t. whose manufacturer, some years ago, issued data sheets in which the drain and source lead-out identifications were transposed. In this instance the difference between the two sets of data didn't really matter as, in practice, the f.e.t. seemed to work quite happily connected either way round! ■

WORKSHOP AIDS

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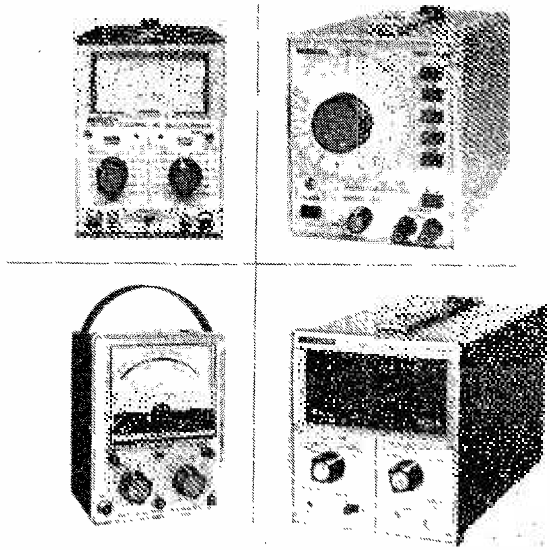

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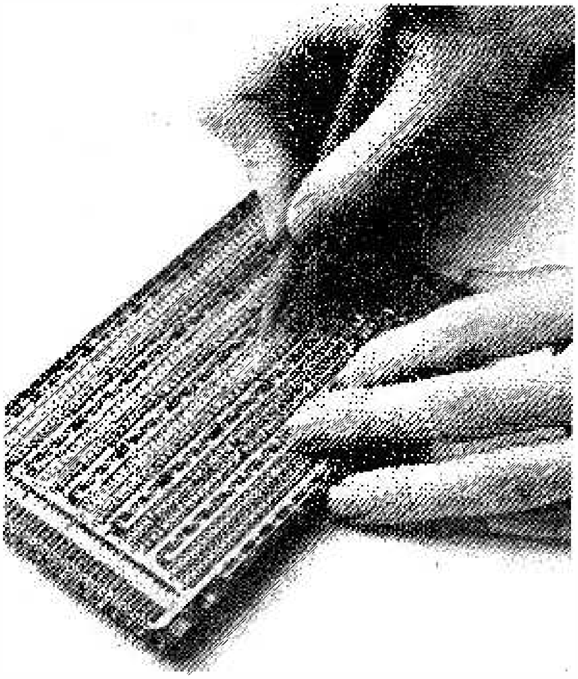

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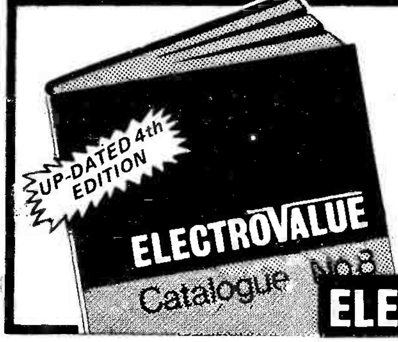

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FOR THE BEGINNER

SCREENING

Screening, or shielding, is employed to prevent unwanted signal radiation or pick-up, or unwanted coupling. In (a) a stray capacitive coupling exists between two equipment signal points, X and Y; this is almost completely removed in (b) by the metal screen (shown, as is customary, in broken line). Both points now have a stray capacitance to the equipment chassis, and virtually none with each other. Complete capacitive screening is achieved by enclosing one point in a metal casing, as in (c). These are examples of electrostatic screening.

The two radio frequency coils in (d) can have an inductive, or magnetic, coupling between them which is much greater than the stray capacitive coupling. One coil is placed in a metal screening can in (e): eddy currents induced in the inside surface of the can produce a magnetic field opposing that due to the coil and very nearly cancel it out. Complete isolation between the two coils is given in (f), where both are in cans.

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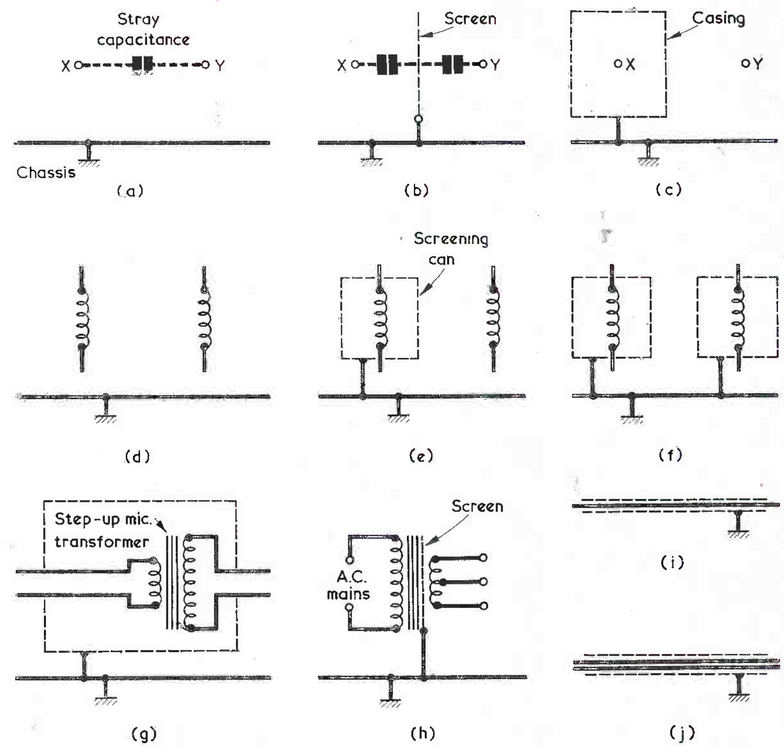
In (h) a non-magnetic metal shim, which does not form a complete turn, has been interposed between the primary and secondary of a mains transformer. This provides electrostatic screening between the windings. Screened cables are shown in (i) and (j).



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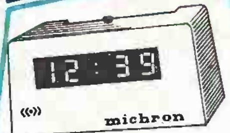

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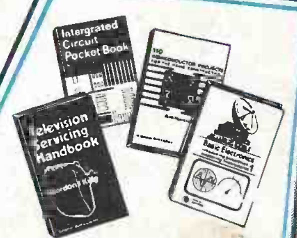

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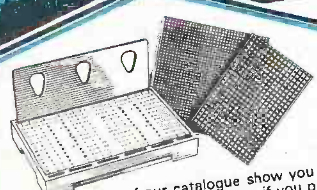

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