Easy to build projects for everyone

everyday electronics

OCT. 76
35p

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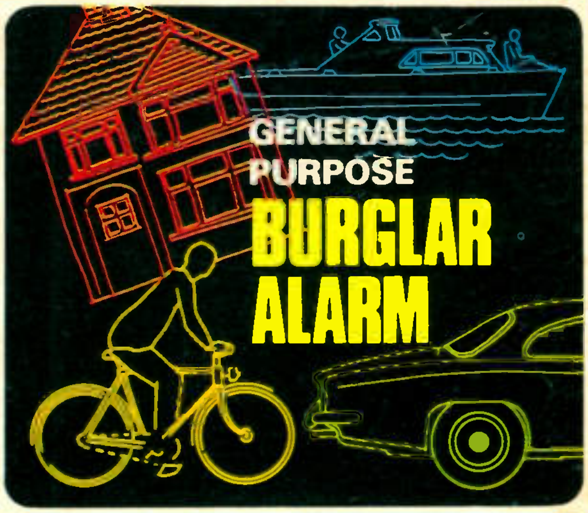
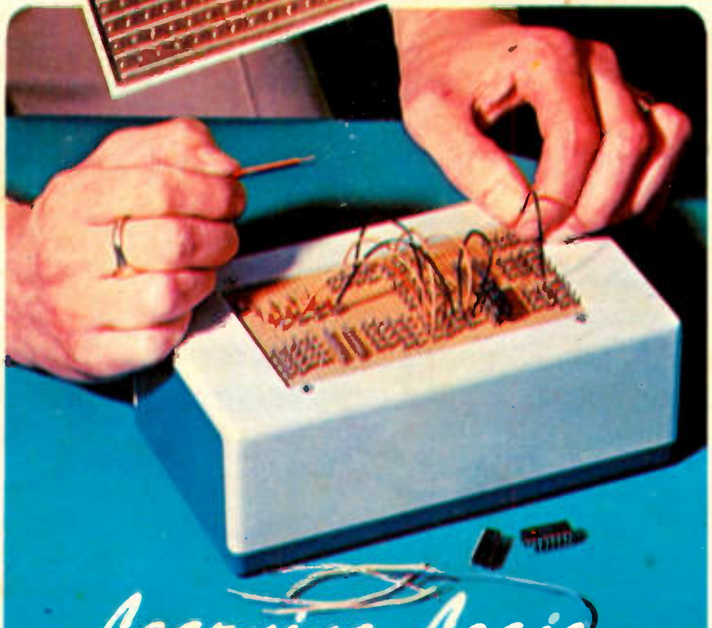
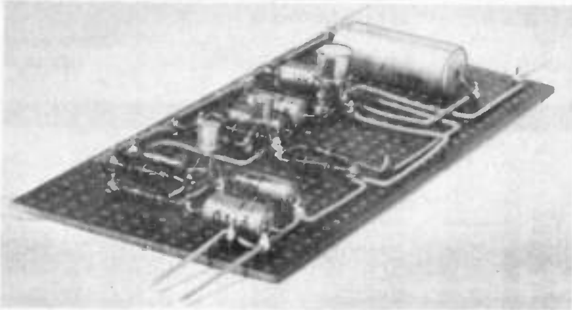


GENERAL PURPOSE
BURGLAR ALARM

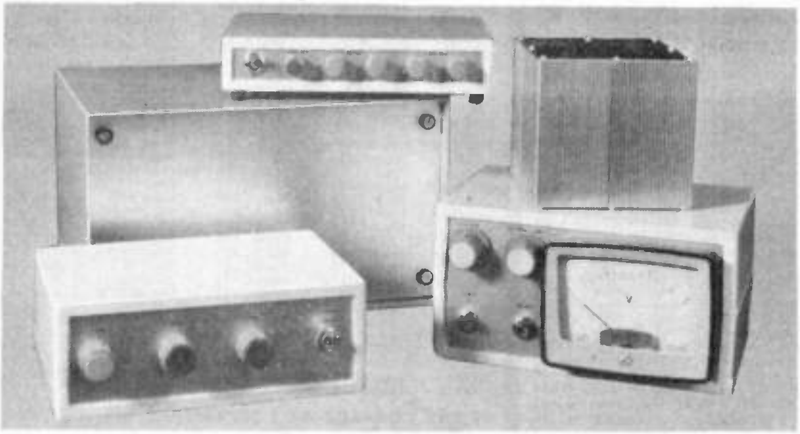


Learning Logic
NEW SERIES
DOING IT DIGITALLY

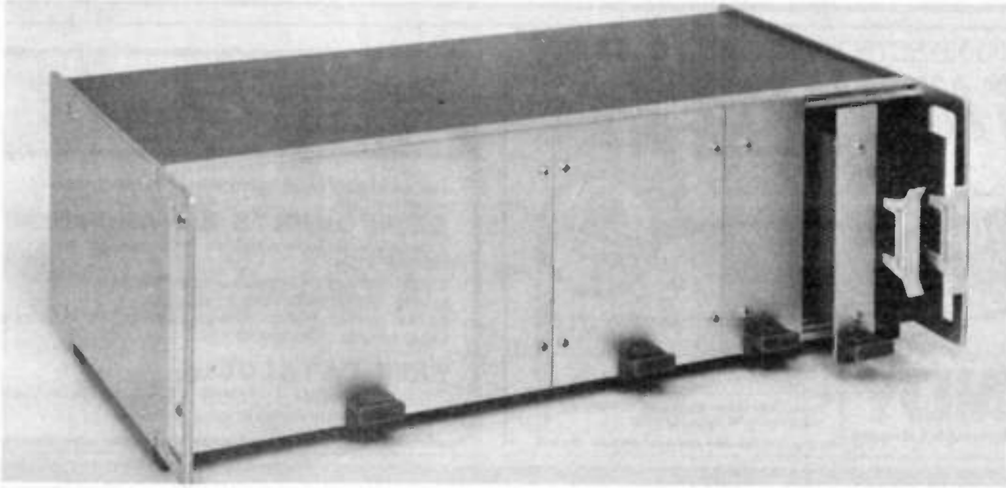
ALSO INSIDE...
ONE-TRANSISTOR RADIO
CAR REV. COUNTER



Veroboard® Universal Wiring Boards



Plastic and Metal Verobox®



19" Card Frame/Case

SINCLAIR IC20
IC20 10W + 10W stereo IC amplifier kit with free booklet and printed circuit £4·95.
PZ20 Power supply kit for the above £3·95.
VP20 Volume, tone-control and preemp kit £7·95.

Send sae for free leaflet.

JC12 AMPLIFIER

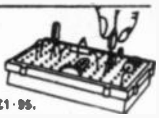
6W IC audio amp with free data and printed circuit £2·25*

DELUXE KIT FOR JC12
Contains extra parts for the pcb and volume and tone controls. Mono version £2·33. Stereo £4·95.

JC12 POWER KIT
Supplies 25V 1Amp £3·95.

JC12 PREAMP KITS
Type 1 for magnetic pickups, mics and tuners. Mono £1·50. Stereo £3·00. Type 2 for ceramic or crystal pickups. Mono 88p. Stereo £1·76.

Send sae for free leaflet.

S-DECS AND T-DECS*

S-DeC £2·24 T-DeC £4·05
u-DeCA £4·45 u-DeCB £7·65
IC carriers:—
16 dil: plain £1·07
with socket £2·21
10TO5: plain 99p, with socket £1·95.

FERRANTI ZN414
IC radio chip £1·44. Extra parts and pcb for radio £3·65. Case 99p. Send sae for free data.

SINCLAIR PROJECT 80 AUDIO MODULES
FM tuner £13·25. Q16 £6·50. PZ5 £4·95. PZ6 £8·76. PZ8 N/A. Trans for PZ8 £5·00. Z40 £5·75. Stereo 80 £11·95. Project 805Q £16·95. Quad decoder £14·95.

BI-PAK AUDIO MODULES
S450 Tuner £19·95. AL60 £4·33. PA100 £13·45. MK60 audio kit £27·20. Teek 60 £8·95. Stereo 30 £15·95. TC30 £4·00. AL250 £16·15. Send sae for free data.

SAXON ENTERTAINMENTS AUDIO MODULES
SA1208 £16·00. SA1204 £13·30. SA608 £11·95. SA604 £10·30. PM1201/8 £11·45. PM1202/8 £14·95. PM1202/4 £14·95. PM1201/4 £11·45. PM601/8 £8·95. PM301/8 £8·70. Send sae for free leaflet.

JC40 AMPLIFIER
New integrated circuit 20W amplifier kit complete with chip, printed circuit and data £3·95.

Send sae for free leaflet.

PRINTED CIRCUIT KIT £3·90*
Make your own printed circuits. Contains etching dish, 100 sq ins of pc board, 1lb ferric chloride, etch resist pen, small drill bit, laminate cutter.

SINCLAIR BLACK WATCH

Fully assembled with free bracelet £20·95*.

SINCLAIR CALCULATORS*
Cambridge % £7·35. Cambridge Scientific £11·45. Oxford 300 £13·30. Programmable Scientific with free mains unit £24·95. Mains adaptors are available for all models (state model) £3·20.

CBM CALCULATORS*
796MD 8 digit/%/memory N/A. 897D 8 digit/%/4 function memory £7·50. SR7919D 8 digit or 5+2/ memory/trig/log/pi/powers £11·00. SR1800 £20·55. SR4148R (R) £30·40. SR4190R (R) £42·95. (R) free charger. Mains adaptors for other models £3·20.

NOVUS CALCULATORS*
750 6 digit £5·30. 835 8 digit/%/sq. root/const/4 function memory £7·60. 4525 10 digit programmable scientific (R) £45·00. 4510 £13·20. 4515 (R) £37·95. 4520 (R) £23·65. (R) free charger. Mains adaptors for other models £4·20.

MISTRAL I 24HR DIGITAL CLOCK KITS*
Includes pcb, power supply, case, ½" display, chip and all parts. Kit £10·95. Built £12·90. Also Mistral 2, deluxe assembled version with alarm and tilt sleep-over facility £13·95.

NATIONAL MA1001H DIGITAL CLOCK MODULE*
Complete module including ½" display and clock chip fully assembled on a 1½" x 3" pcb. Just add a power supply, switches etc to produce a 24hr clock with alarm and auto-dim. N/A.

SEND SAE FOR OUR DIGITAL CLOCK LEAFLET

BATTERY ELIMINATOR BARGAINS
STABILIZED POWER UNITS*
Millenia series. Switched 1 to 30V in 0·1V steps.
1A output: Kit £11·45. Kit + case £14·40. Built £18·40.
2A output: Kit £13·95. Kit + case £16·90. Built £20·95.

6-WAY SPECIAL £5·20

Switched output of 3, 4½, 6, 7½, 9, 12V at 500mA

6-WAY DOUBLE RADIO MODEL £6·20
Switched output 3+3/4½+4½/6+6/7½+7½/9+9/12+12V at 250mA. Also 15/18/24V single.

3-WAY MODEL
Switched output of 6/7½/9V at 250mA with 4-way multi-jack plug and free matching socket £2·95*.

RADIO MODELS
50mA with press-stud battery connectors. 9V £3·25. 6V £3·40. 9+9V £4·95. 6+6V £4·95. 4½+4½V £4·95. Also 9V 300mA £3·95.

CASSETTE MAINS UNITS
7½V output with 5 pin DIN plug. 50mA £3·45. 300mA £3·95.

CAR CONVERTORS
Input 12V DC. Output 6/7½/9V DC 1A regulated £4·75*.

BATTERY ELIMINATOR KITS
Send sae for free leaflet on range.
100mA radio types with press-stud battery terminals. 4½V £1·95. 6V £1·95. 9V £1·95. 4½V + 4½V £2·60. 6V + 6V £2·65. 9V+9V £2·60.

100mA cassette type with 5 pin DIN plug. 7½V £1·95.

Transistor stabilized 8-way type for low hum. 3/4½/6/7½/9/12/15/18V. 100mA £3·15, 1A £6·50.

Heavy duty 13-way types 4½/6/7/8½/11/13/14/17/21/25/28/34/42V. 1 Amp Model £4·40. 2 Amp Model £6·95. Car Convertor kit Input 12V DC. Output 6/7½/9V DC 1A regulated £1·95.

MAINS TRANSFORMERS
6-0-6V 100mA 95p. 9-0-9V 100mA 95p. 18V 1A £1·65. 0/12/15/20/24/30V 1A £3·60. 12-0-12V 100mA £1·05. 0/12/15/20/24/30V 2A £4·95. 20V 2½A £2·25.
6-0-6V 1½A £2·16. 9-0-9V 1A £2·45. 12-0-12V 1A £2·65. 15-0-15V 1A £2·05. 30-0-30V 1A £3·60. 6·3V 1½A £1·95. 0-24V twice 100mA £1·65.

SWANLEY ELECTRONICS
Dept. EE, PO BOX 68, SWANLEY, KENT.

Post 30p on orders under £2, otherwise free. Prices include VAT. (Overseas customers deduct 7% on items marked *, otherwise 11%). Official orders welcome.

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OPEN 6 DAYS A WEEK, 9 to 5. Callers Welcome.

VAT INCLUSIVE PRICES—NO EXTRAS TO PAY, JUST ADD 20p POST.

VEROBOARD
100 sq ins asstd size offcuts (no tiny bits). All 0·1 or mixed £1·20. 17 x 3¾" x 0·1 sheets £1·00.

CAPACITORS
Miniature ceramic plate, 50V 5%. 22pF to 1000pF 2p; 1500F to ·047uF 4p. Polystyrene, 160V 2½%. 10pF to 1000pF 4p; 1200pF-10,000pF 5p; Polyester 250V Mullard C280 ·01 to 0·1uF 4p; ·15, ·22 5p; ·33 6p; ·47 8p; ·68 10p; 1uF 12p; 2·2uF 19p; 3·3uF 63V 24p. Electrolytic, 0·47, 1, 2·2, 4·7, 10, 22, 47uF 25V all 8p; 100uF 25V 7p; 100uF 63V 9p; 220uF 16V 7p; 220uF 25V 9p; 220uF 50V 11p; 470uF 16V 9p; 470uF 25V 11p; 470uF 63V 16p; 1000uF 16V 15p; 1000uF 25V 16p; 1000uF 50V 32p; 2200uF 16V 20p; 2200uF 25V 27p; 2200uF 40V 48p; 4700uF 16V 43p. All are wire ended horizontal mounting types.

TRANSISTORS AND IC's

AC127	15p	BD131	38p	2N2369	22p
AC128	15p	BD132	40p	2N2646	42p
AC176	10p	BD138	40p	2N2926G	12p
AC187	19p	BD139	44p		
AC188	18p	BD140	46p	2N3053	18p
AD161	40p	BF161	28p	2N3054	40p
AD162	40p	BF194	14p	2N3055	38p
BC107	10p	BFX29	22p	2N3440	54p
BC108	10p	BFX84	20p	2N3442	120p
BC109	10p	BFY50	15p		
BC109C	15p	BFY51	15p	2N3702	19p
BC182	12p	BFY52	15p	2N3703	10p
BC183	12p	TIP41A	60p	2N3704	10p
BC184	12p	TIP42A	75p	2N3705	10p
BC212	14p	TIP2955	80p	2N3708	10p
BC213	14p	TIP3055	42p	2N3819	22p
BC214	14p	2N706	13p	2N4415	10p
BCY70	15p	2N1613	20p	2N5294	38p
BCY71	15p	2N1613	20p	2N5294	38p
BCY72	15p	2N2219	26p	40673	50p

741 8 pin DIL 25p; 555 Timer 40p. 8 pin sockets 12p.

44 Page Illustrated Catalogue only 10p + large SAE. FREE with orders over £2.

DIODES & LED's
1N4001, 2 5p; 1N4003, 4 5p; 1N4005 7p; 1N4006 8p; 1N4007 9p; 1N4148 4p. OA81 5p, OA91 5p, BY127 12p, 100V3A 12p, 400V 3A 15p. Bridges: 50V 1A 22p; 800V 1A 40p; 250V 2½A 40p; 250V 5A 70p. TIL209 Red LED 15p; 0·2" Red 22p, green or yellow 24p.

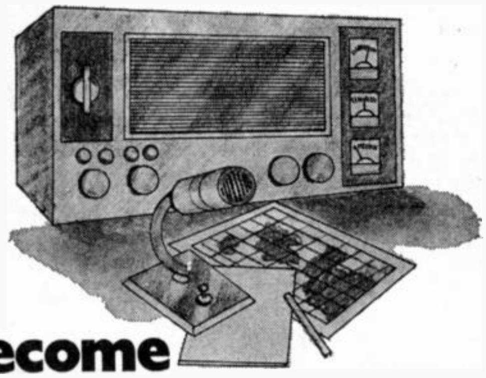
RESISTORS
Miniature ¼W Carbon Film Hi-stabs. All values from 1 ohm to 10 Megohm 5% (Over 1M 10%) 1½p each. 1W Metal film 5%. All values from 27 ohms to 10M. 2½p each.

WIRE
Enamelled copper wire on 2oz reels. SWG/Price: 16/32p; 18/34p; 20/30p; 22/38p; 24/40p; 26/42p; 28/44p; 30/40p; 32/48p; 34/50p; 36/52p; 38/54p; 40/56p. Connecting wire, 40 x 2 metre lengths solid core asstd colours £1. 5 x 5yd coils flex 25p.

TRANSFORMERS
6-0-6V 100mA 90p; 9-0-9V 100mA 95p; 12-0-12V 100mA £1; 12-0-12V 50mA 90p; 12-0-12V 1A £2·65; 6-0-6V 1½A £2·10; 6·3V 1½A £1·75; 24V 1½A £2·10; Bell transformer in white case, gives 4, 8, or 12V at 1A £1·90.

DEVELOPMENT PACKS
Save ££££'s by buying a full range of components at one go! All full spec marked devices, no rejects or old stock.
50V Ceramic Plate Capacitors 5%. 10 of each value from 22pF to 1000pF. Total 210. £2·70. Save £1·50!

Carbon Film min. resistors, ¼W 5%. 10 each value from 10 ohms to 1M, total 610. £6. Save £3·15!
Electrolytics. 10 each value 1, 2·2, 4·7, 10, 22, 47 & 100uF. All 25V. Total 70 for £3·20. Save £1·10!



Become a radio amateur.
Learn how to become a radio-amateur in contact with the whole world. We give skilled preparation for the G.P.O. licence.

WAA

Free!

Brochure, without obligation to: EEK106

BRITISH NATIONAL RADIO & ELECTRONICS SCHOOL,
P.O.Box 156, Jersey, Channel Islands.

NAME ____________________

ADDRESS ____________________ (Block caps please)

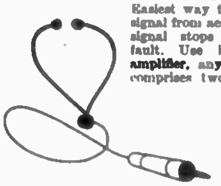
DRILL CONTROLLER

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. £3·45 including post and VAT. Made up model £1·00 extra.

NUMICATOR TUBES

For digital instruments, counters, timers, clocks, etc. Hi-vac XN11 Price £1·25 each. Post and VAT paid.

RADIO STETHOSCOPE



Easiest way to fault find, traces signal from aerial to speaker, when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything. Complete kit comprises two special transistors and all parts including probe tube and crystal earpiece, £3·95, twin stetho-set instead of earpiece VAT and postage incl.

MAINS TRANSISTOR PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: main transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only £2·50 including post and VAT.

MOTORISED DISCO SWITCHES

With six 10 amp changeover switches, adjustable over 360° switches are rated at 10 amp each so a total of 2000w's can be controlled and this would provide a magnificent display. Mains operated. PRICE £4·25. DITTO BUT 12 SWITCH £5·75 DITTO 9 SWITCH £4·95. POST AND VAT PAID.

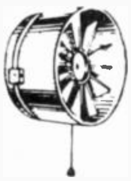
MAINS MOTOR

Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heaters, etc. New and perfect. Snip at 95p + VAT & Postage 35p.
1" stackmotor £1·56 + VAT & postage 35p. 1½" stackmotor. £2 + VAT and Postage 40p.

WINDSCREEN WIPER CONTROL

Vary speed of your wiper to suit conditions. All parts and instructions to make. £3·75 post and VAT paid.

EXTRACTOR FAN



Cleans the air at the rate of 10,000 cubic feet per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc. It's so quiet it can hardly be heard. Compact. 5½" casing comprises motor, fan blades, sheet steel casing, pull switch, mains connector and fixing brackets. £5·25 INCLUDING POST & VAT
Monthly list available free; send long stamped envelope.

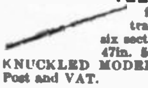
28 RPM GEARED MAINS MOTOR

This is a substantial motor (1" stack induction type) quite powerful definitely large enough to drive a rotating display or a tumbler for polishing stone etc. Approximate overall size 4" × 3½" × 2½" these are ex-unused equipment, carrying our normal ex-equipment guarantee. PRICE £2·95 POST and VAT PAID.

GLAMORIZE YOUR ROCKS

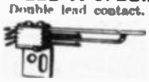
The way to make rock samples, stamps etc, really show themselves off is to light them by means of our miniature UV tube. This is only 6w's so the electricity costs are negligible. Complete kit comprises UV tube and it's 2 mounting holders, control choke and starter.
Total price £3·75 POST and VAT PAID.

TELESCOPIC AERIALS



for portable car radio or transmitter. Chrome plated—six sections, extending from 7¼ to 47in. 50p + 15p. Post & VAT. KNUCKLED MODEL FOR F.M. 80p + 17p Post and VAT.

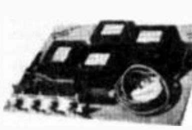
NEED A SPECIAL SWITCH



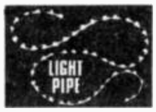
Double lead contact. Very slight pressure closes both contacts 15p each. Plastic pushrod suitable for operating. 10p each, 10 for 85p.

MULLARD UNILEX

A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost any one in easy-to-assemble modular form and complete with a pair of Goodmans speakers this should sell at about £30—but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only £14·00 including VAT and postage.



LIGHT PIPE



A mains operated travelling light array, 24ft long it uses 180 miniature bulbs which flash in sequence to make bands of light move along the tube. The tube can be draped around a particular item or set and cannot fail to attract attention—complete kit consists of—24ft of translucent tubing—140 min lamps—3yds multicore cable—motorised switch—taps for quick connections and full wiring instructions. £15 for complete kit. Post and VAT paid.

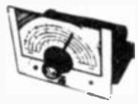
TWIN OUTPUT POWER PACKS

These have two separate R.C. smoothed outputs so can operate two battery radios or a stereo amp without cross modulation (they will of course operate one radio/tape cassette/calculator, in fact any battery appliance and will save their cost in a few months). Specs: Full wave rectification, double insulated mains transformer—total enclosed in a hard P.V.C. case—three core mains lead terminal output—when ordering please state output voltage 4½v, 6v, 7½v, 9v, 12v, or 24v. Price £3·95 .Post and VAT included.

BURGLAR ALARM
ONE TRANSISTOR RADIO
CAR REV. COUNTER

To receive parts for the projects featured this month, send the estimated price + 40p post. Any cash adjustment can be made later.

SHORTWAVE CRYSTAL SET

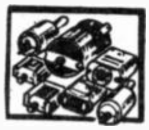


Although this uses no battery it gives really smashing results. You will receive an amazing assortment of stations over the 19, 25, 31, 29 metre bands–Kit contains chassis front panel and all the parts £1·50—crystal earphone 55p including VAT and Postage.

HONEYWELL PUSH BUTTON PANEL MOUNTING MICRO SWITCH

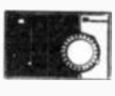
1-2-3-Bank, each bank consisting of the changeover micro switch rated at 10 amps 250 volts. Through panel fixing by 2 lock nuts complete with black 1" diameter knob. Prices:—1 bank 40p—2 bank 55p—3 bank 70p.

ONLY £1·50 FOR SEVEN ELECTRIC MOTORS



7 powerful batt. motors as used in racing cars and power models. Output and types vary for use in hundreds of projects—Tools, toys, models, etc. All brand new reversible and for 1½-12v batts. Wiring diagrams inc. VAT and Post PAID.

SMITHS CENTRAL HEATING CONTROLLER



Push button gives 10 variations as follows: (1) continuous hot water and continuous central heating (2) continuous hot water but central heating off at night (3) continuous hot water but central heating on only for 2 periods during the day (4) hot water and central heating both on but day time only (5) hot water all day but central heating only for two periods during the day (6) hot water and central heating on for 2 periods during the day time only—then for summer time use with central heating off (7) hot water continuous (8) hot water day time only (9) hot water twice daily (10) everything off. A handsome looking unit with 24 hour movement and the switches and other parts necessary to select the desired programme of heating. Supplied complete with wiring diagram. Originally sold we believe at over £15. We offer these while stocks last at £7·50 each INCLUDING VAT and Postage.

THIS MONTHS SNIP

ROOM THERMOSTAT

Famous Satchwell, elegant design, intended for wall mounting. Will switch up to 20 amps at mains voltage, covers the range 0-30°C. Special snip this month £2·50, post and VAT paid.

MICRO SWITCH BARGAINS

Rated at 5 amps 250 volts, ideal to make a switch panel for a calculator and for dozens of other applications. Parcel of 10 for £1·00 VAT AND POST PAID.

ONLY £1·50 FOR SEVEN ELECTRIC MOTORS

7 powerful batt. motors as used in racing cars and power models. Output and types vary for use in hundreds of projects—Tools, toys, models, etc. All brand new reversible and for 1½-12v batts. Wiring diag. inc. VAT, Post PAID.

SWITCH TRIGGER MATS

So thin, is undetectable under carpet but will switch on with slightest pressure. For burglar alarms, shop doors, etc.
24in × 18in £2·33. Post and VAT 60p.
13in × 10in £1·85. Post and VAT 50p.

MAINS TRANSFORMERS

All standard 230-250 volt primaries

		£ p
1v	1 amp (special)	2·32
2·4v	5 amp	1·95
6·3v	2 amp	1·57
6·3v	3 amp	2·19
9v	1 amp	1·19
9v	3·5 amp	2·13
12v	1½ amp	1·85
12v	1 amp	1·25
6·5v 0-8·5v	1 amp	1·85
18v	1 amp	1·85
24v	2 amp	2·82
24v	3 amp	4·75
12-0-12v	50mA	1·56
6-0-6v	50mA	1·56
8-0-8v	½ amp	1·85
25v	1½ amp	2·44
50v 2 amp & 6·3v	1 amp	5·63
60v 5 amp & 5v	1 amp	9·35
27v	8 amp	5·63
30v	37 amp	27·50
80v tapped 75v & 70v	4 amp	6·87
230v-60mA & 6·3v	1·5 amp	2·19
275-0-275v at 90mA & 604v	3 amp	2·82
EHT Transformer 5000v 23mA	(intermittent)	6·87
Charger Transformers		
6v and 12v	2 amp	1·87
6v and 12v	3 amp	2·82
6v and 12v	5 amp	4·25

Add 30 pper £1 to cover postage and VAT.

MULTI SPEED MOTORS

Six speeds are available 500, 850, and 1,100 r.p.m. and 8,000, 12,000 and 15,500 r.p.m. Shaft is ¼ in. diameter and approximately 1 in long. 230/240v. Its speed may be further controlled with the use of our Thyristor controller. Very powerful and useful motor size approx. 3 in. dia. × 5 in. long. Price £2·00 including Post and VAT. Speedcontrol switch 50p + 4

SPIT MOTOR WITH CARTER GEAR BOX

Probably one of the best spit motors made. Originally intended to be used in very high priced cookers however this can be put to plenty of other uses, for instance your garden barbecue or to drive a 'tumbler' for stone polishing; in fact, there are no ends to its uses. Normal mains operation. £2·25 including post and VAT.

SOUND TO LIGHT UNIT

Another new kit this month is single Channel Sound to Light Unit, complete kit including plastic container, main components include 5 amp thyristor, plus transformer, variable pot with on/off switch and theoretical circuit diagram.
PRICE £8·00 Post and VAT paid.

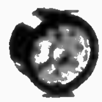
SMITHS 24-HOUR TIMER HEART

Really the 'Autoset' without its plastic case. This is a 24 Hour twice on, twice off, clock switch which will repeat until reprogrammed. Switches rated at 15 amps. Limited supplies.
PRICE £4·45 INCLUDING POST and VAT.

PRESSURE SWITCH

Containing a 15 amp change over switch operated by a diaphragm which in turn is operated by air pressure through a small metal tube. The operating pressure is adjustable but is set to operate in approx. 10in of water. These are quite low pressure devices and can in fact be operated simply by blowing into the inlet tube. Original use was for washing machine to turn off water when tub has reached correct level but no doubt has many other applications. £1·25 each inc. post & VAT.

DC HIGH CURRENT PANEL METERS



3½" wound wide angle 240 movement meters, flush mounting fitted with external shunts, made by Crompton Parkinson, brand new, still in maker's cartons. These are a real bargain at £6·00 each inc. VAT & POST. Reasonable quantities available in the following ranges 0-15 amps, 0-20 amps, 0-30 amps, 0-40 amps.

MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete, with heat sinks and connection tags, data supplied.

Model 1153 500mW power output £1·56 inc. post and VAT.
Model 1172 1W, power output £1·85 inc. post and VAT.
Model EP9000 4 watt power output £2·90 inc. post and VAT.
EP 0901 twin channel or stereo pre amp £2·90 inc. post & VAT.

TERMS: Where order is under £5 please add 40p surcharge to offset packing expenses

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everyday electronics

PROJECTS..
THEORY.....

ESCAPE PLAN

This month heralds the beginning of the busy season for home constructors. The dedicated will need no reminding or urging. But to any of the uncommitted who may chance upon these words we could offer some encouragement and advice.

Every autumn finds numbers of people hunting about for ideas to help occupy and usefully employ their leisure time in the months ahead. Something "different" is usually the goal. Something to provide an escape channel from those other channels on v.h.f. or u.h.f., maybe.

Well, there's plenty to choose from, as *Floodlight* and other evening class or further education prospectuses make abundantly clear. But if you want to be independent and do your own thing at home, why not go for something really different and give electronics a try?

IT'S LOGIC

We open this new season with the first part of a series entitled *Doing It Digitally*. This series starts from scratch and progresses in easy steps. It describes simple experiments which demonstrate everything in an unmistakeable fashion. It offers an ideal way to learn the basics of digital and logic techniques which are playing an ever-increasing part in modern electronics.

The newcomer to electronics should be completely at home with this series. Yet *Doing It Digitally* is more than a beginner's series. Many experienced constructors use digital circuits quite frequently, while perhaps not being entirely conversant with the fundamentals involved. Here is a good opportunity for them to brush up on their knowledge.

Oh, yes, even amongst the professionals there will be some who, perhaps because of long confinement in analogue areas, will find this series a useful revision.

STARTERS

Our menu this month appropriately includes a couple of Starters to wet the appetite. What is more, a piece of circuit board to accommodate both circuits comes free with our compliments.

So here's to an enjoyable and rewarding season with do-it-yourself electronics. It can't really fail to be so, with EVERYDAY ELECTRONICS every month providing stimulating designs plus valuable down-to-earth technical information and guidance in all constructional matters. O.K?

Fred Bennett.

Our November issue will be published on Friday, October 15

See page 529 for details.

Editorial Department: Everyday Electronics, Fleetway House, Farringdon Street, London EC4 4AD. Phone 01-634 4452.
Advertisement Department: Everyday Electronics Advertisements, Fleetway House, Farringdon Street, London EC4 4AD. Phone 01-634 4504.

..EASY TO CONSTRUCT
..SIMPLY EXPLAINED

VOL. 5 NO. 10 OCTOBER 1976

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

BACK NUMBERS, LETTERS AND BINDERS

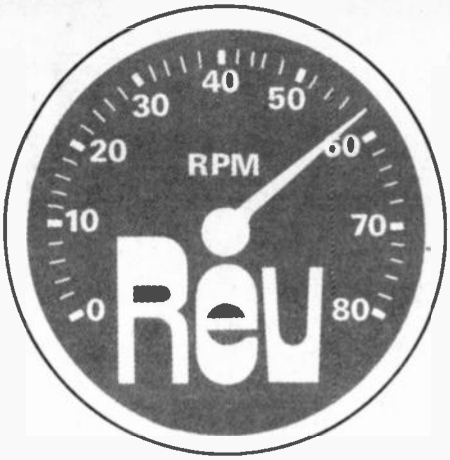
We are unable to supply back copies of Everyday Electronics or reprints of articles and cannot undertake to answer readers' letters requesting modifications, designs or information on commercial equipment or subjects not published by us. An s.a.e. should be enclosed for a personal reply. Letters concerning published articles should be addressed to: The Editor, those concerning advertisements to: The Advertisement Manager, at the address shown opposite.

Binders for volumes 1 to 5 (state which) are available for £2·10, including postage, from Post Sales Department, Lavington House, 25 Lavington St., London SE1 OPF

PUTTING YOUR GIFT TO GOOD USE
SEE PAGES 509, 510

An inexpensive unit requiring only supply connections to the car wiring.

Car Rev Counter



By C. J. ALLEN

THIS article describes a very simple and neat Car Rev. Counter. It will work with either polarity system (positive or negative earth), and connection couldn't be simpler, there being no need to break into the ignition system to detect voltage or current wave-forms, as in most commercially available models. Another advantage is that no converter is needed for using it with electronic ignition systems.

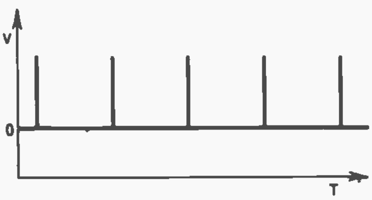


Fig. 1a. Ignition pulses

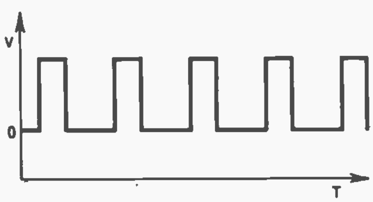


Fig. 1b. Waveform produced by monostable

THEORY

In a conventional 4-cylinder, 4-stroke car, each revolution of the engine causes two sparks to be produced by the ignition coil. At an engine speed of 3,000 r.p.m., say, there will therefore be 100 sparks, or pulses, per second; as shown in Fig. 1(a).

If now each pulse fires a monostable multivibrator with an astable period of *T*, the wave-form of Fig. 1(b) is produced.

The two graphs have been repeated for an engine speed of 6,000 r.p.m. in Figs. 1(c) and 1(d) and if Figs. 1(b) and (d) are studied it can be seen that if the areas contained under the pulses are added and then divided by time (or integrated) a voltage will be produced which is proportional to the engine speed.

In this design, the wave-form is mechanically integrated using the meter movement's inertia and return hair-springs. This produces a very linear speed/deflection relationship.

The period *T* is set such that, at the maximum displayed engine speed *T* is fractionally less than the period between adjacent sparks, at that speed; i.e. 3·75mS in this case. Different speed ranges and engines with more or less cylinders can easily be accommodated by simply varying this period.

CIRCUIT

The circuit, as can be seen in Fig. 2, is extremely simple. The common "555" timer is used in its standard monostable configuration, the period being set at 1·4

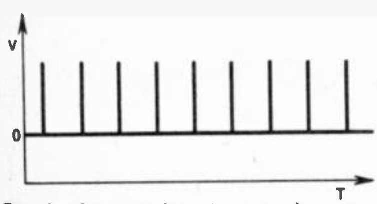


Fig. 1c. Increased engine speed corresponding to 1a.

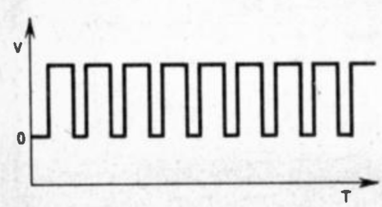
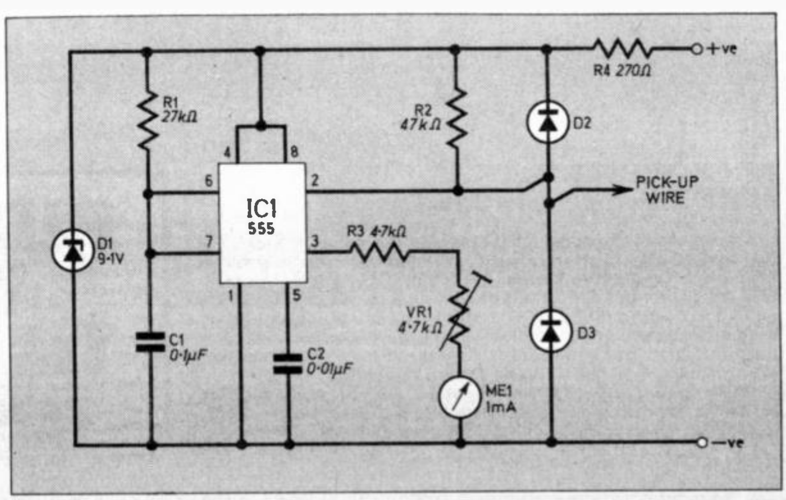
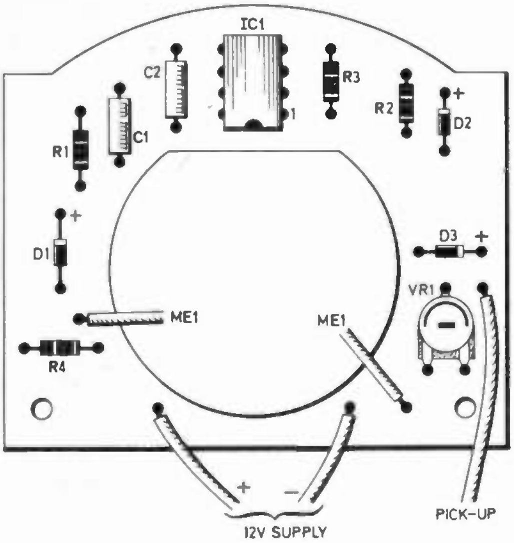


Fig. 1d. Increased engine speed corresponding to 1b.

Fig. 2. Circuit diagram of the Car Rev. Counter.





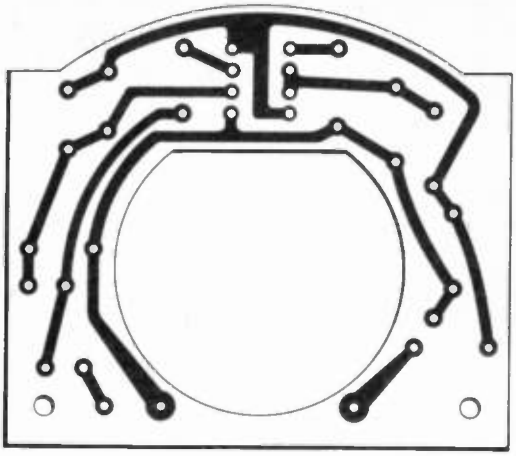
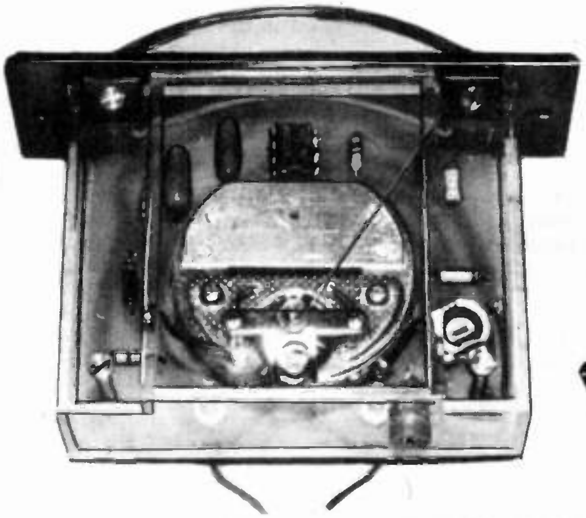
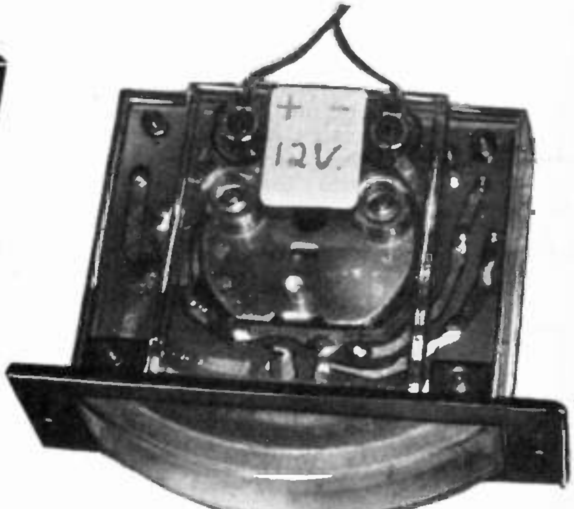


Fig. 3. Construction of the Car Rev. Counter. Circuit board shown full size.





Photographs of the completed unit.

Components

See **Shop Talk** Page 512

Resistors
- R1 27kΩ
- R2 47kΩ
- R3 4·7kΩ

(R1–R3: ¼ Watt metal oxide.)

Potentiometer.
- VR1 4·7kΩ pre-set.

Capacitors
- C1 0·1μF (0·068μF for 6-cylinder engines.)
- C2 0·01μF
- Both Polyester 100V

Diodes
- D1 9·1 volt 400mW Zener diode.
- D2, D3 IN914 or similar general purpose diodes (2 off)

Integrated Circuit
- IC1 555 Timer.

Miscellaneous
- ME1 1mA d.c. moving coil edgewise meter, model PE70.
- Copper clad circuit board 67 x 57 mm. Nuts, washers, bolts, wire, wander-socket etc.

×C1×R1; approximately 3·7mS.

As the trigger input (pin 2) on this i.c. has a high input impedance, the only load seen by the pick-up wire is 47 kilohms (R2) and this is sufficiently high to use inductive pick-up for triggering it. In fact all that is necessary is to place the pick-up wire near the ignition coil. Diodes D2 and D3 are included to limit the voltage to pin 2 to within the circuit's limit.

The output (pin 3) is fed via R3 and the calibration pre-set VR1 to the 1mA meter-movement.

A simple stabiliser R4 and D1 is used to allow for variations in the car's voltage supply. No decoupling was found necessary but C2 was included to prevent possible spurious triggering of the i.c. by noise on the power rail.

CONSTRUCTION

All the components are mounted on a printed circuit board (p.c.b.) which, in turn, is mounted inside the meter's case surrounding the actual movement. The p.c.b. pattern is shown, full size, in Fig. 3.

Before the board is etched it is recommended to check that it fits inside the case, altering it where necessary. The circuit may need slight filing to clear two of the bolts that hold the case together.

Be careful dismantling the meter as it is extremely delicate; care should be taken not to put any undue pressure on the pointer as it bends easily. The scale simply clips in place. All this will, however, become apparent when it is actually done.

The only alteration necessary to the case is the drilling of a hole to take a miniature wander-socket, as shown in the photograph.

ASSEMBLY

When the components have been soldered on the board as in Fig. 3 this may screwed into the case using the holes which originally contained the meter connection tags, these terminals now act as the power input tags. The re-calibrated scale should next be clipped into place, followed by the meter-movement, having first soldered thin pieces of insulated wire to the connections on the latter. These wires, plus one from the pick-up input socket, should then be soldered to the p.c.b. Finally the case's other half can be screwed in place.

THE SCALE

The original scale is calibrated 0-1mA in forty steps. This is immediately suited for re-calibration to 0-8000 r.p.m. in steps of 200 r.p.m.

With a bit of patience and a steady hand re-calibration is fairly easy; unwanted black lettering and lining can be removed by scraping with a razor blade and new lines and letters inserted using Letraset or a thin India Ink pen.

CALIBRATION

Calibration must be done before installation in the vehicle and with the case's top half removed to gain access to VR1.

The best method is to use a square-wave oscillator set at 100Hz (150 for a 6-cylinder engine) and amplitude between 10 and 20 volts. Connect one wire to the unit's negative power terminal and the other, via a 100pF capacitor, to the pick-up socket. A dry battery is sufficient to power the circuit which takes less than 10mA. Adjust VR1 to give a reading of 6,000 r.p.m..

The unit may alternatively be calibrated in another vehicle which already has a rev. counter fitted, adjusting VR1 to give the same readings.

MOUNTING

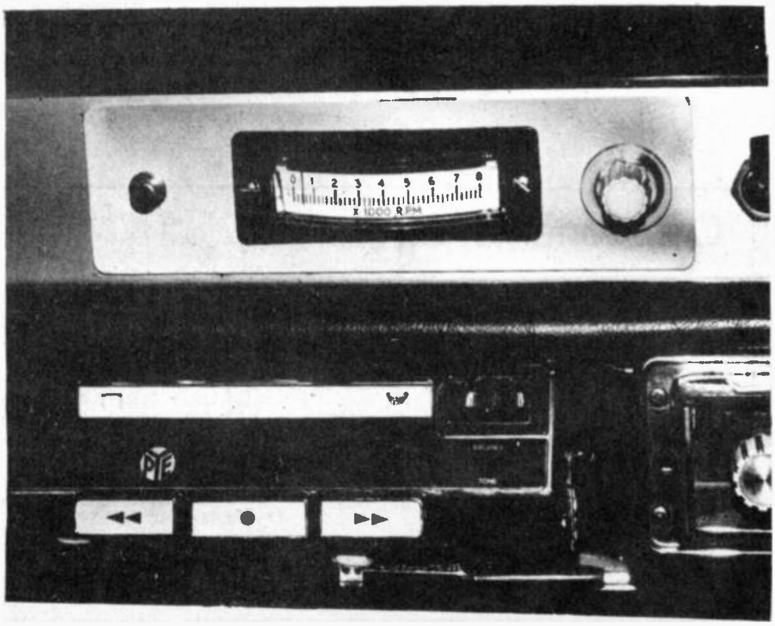
The unit may be mounted anywhere in the car by either cutting a rectangular hole (7cm×3cm) somewhere in the fascia and using the meter's existing mounting-screw holes, or suitable brackets may be bent up.

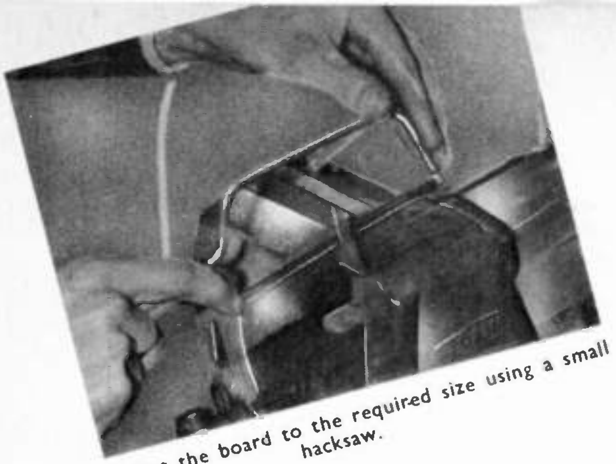
As the meter itself is fairly delicate, if the car's engine is rough or if it is to be used for rally-cross etc., the meter should be mounted in foam-rubber or some other similar media.

The earth lead may be connected to any convenient earth point and the live wire to any point in the car's electrical system that is switched by the ignition key. An insulated wire should be taken, from the meter's input socket, into the engine compartment where it should be taped, for a few inches, to the outside of the h.t. lead from the coil to the distributor.

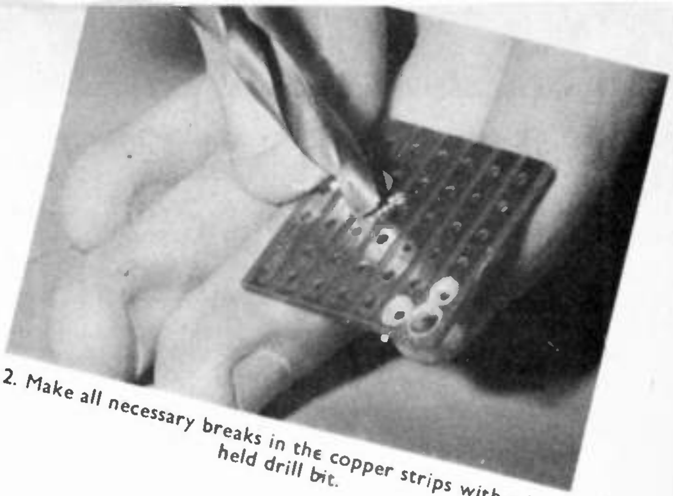
The unit should now function perfectly. ⌑

Photograph of the completed unit fitted to the dash board. New scale marking of the meter is shown.





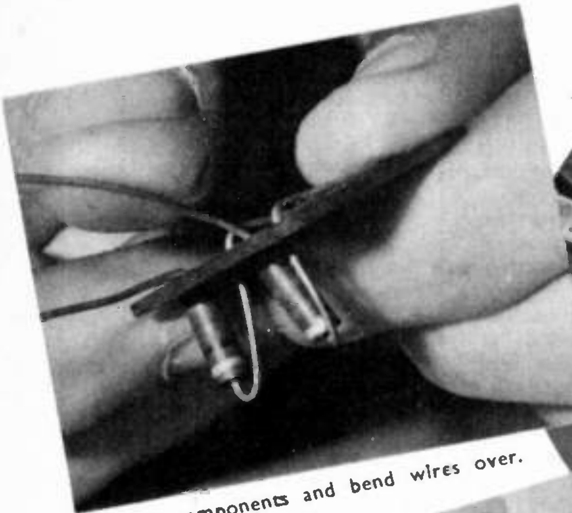
1. Cut the board to the required size using a small hacksaw.



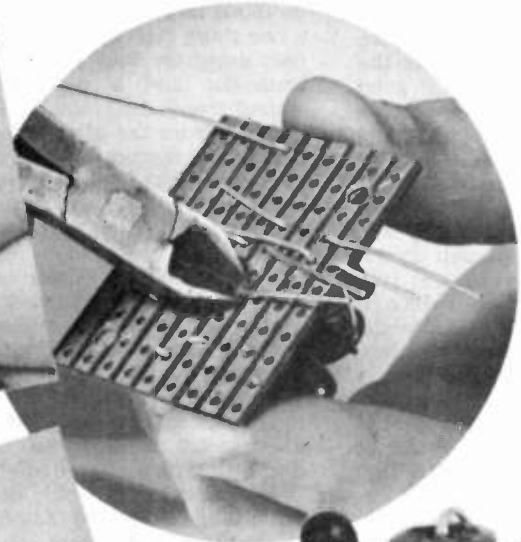
2. Make all necessary breaks in the copper strips with a hand held drill bit.

USING WIRING BOARDS

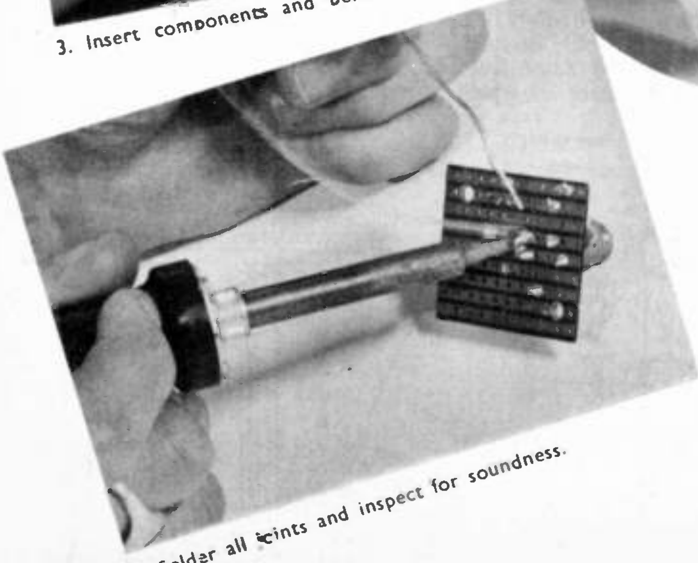
The series of photographs on this page will enable you to put your free piece of wiring board to good use.



3. Insert components and bend wires over.



4. After checking the layout cut off excess wire.



5. Solder all joints and inspect for soundness.

6. The finished board ready to take any flying leads —check construction before testing.

Try these for

1 MICROPHONE PRE-AMP

SOONER or later, most experimenters will find the need to amplify the output from a microphone—a facility not always available in amplifiers.

Since cost often has to be considered, it is natural to ask whether an existing receiver or amplifier can be used for this purpose, by adding something to it. Depending on the individual's pocket, the microphone used could either be a crystal, dynamic, or even ribbon type, but since the dynamic type is capable of good performance at a very reasonable cost, it is a very popular and logical choice.

However, regardless of the type finally selected, the output will be very much lower than, say, that of the conventional crystal pickup, and will require considerable amplification before it is large enough to be fed into the pickup terminals of a standard audio amplifier.

Furthermore, if we happen to select a crystal type, it is essential that the input circuit to which it may be connected provide a high impedance, ideally about 5 megohms but certainly not less than one megohm. If it is otherwise, the bass response of the microphone will be seriously attenuated. Our simple pre-amplifier is designed to satisfy both these requirements.

CIRCUIT

The circuit may appear a little unconventional at first, and it may be helpful to discuss briefly some of its more important features. It is a two stage directly coupled amplifier, using an *npn* (BC109) first transistor and a *pnp* (BC214) second transistor.

Apart from the direct coupling, the main feature is the input circuit of TR1, designed to provide the high input impedance necessary for the crystal microphone.

The 220 kilohm resistor and the 0·22μF capacitor, connected as shown between the emitter and base, is known as a "bootstrap" arrangement, which has the effect of increasing the input impedance to a much higher value than that of the 220 kilohm resistor, by decreasing its shunting effect.

This circuit functions, broadly, something along the same lines as the emitter follower, in which a voltage is applied to the input load, so that very little current can flow through it from the signal source. Thus the source "sees" what appears to be a high-resistance.

Components

Resistors
- R1 390kΩ
- R2 470kΩ
- R3 220kΩ
- R4 56kΩ
- R5 2·2kΩ
- R6 10kΩ
- All ¼W ± 10% carbon

Capacitors
- C1 33pF
- C2 0·1μF
- C3 0·22μF
- C4 33μF elect. 12V
- C5 0·1μF

Transistors
- TR1 BC109 silicon *npn*
- TR2 BC214 silicon *pnp*

Miscellaneous
- Veroboard 11 holes by 10 strips (half of free piece with this issue); connecting wire.

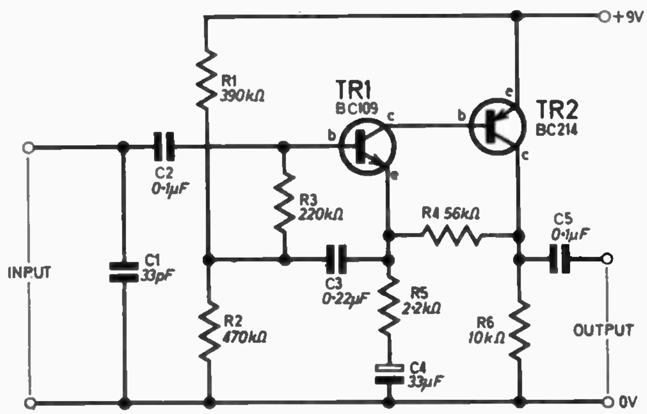


Fig. 1. Circuit diagram of the microphone preamplifier.

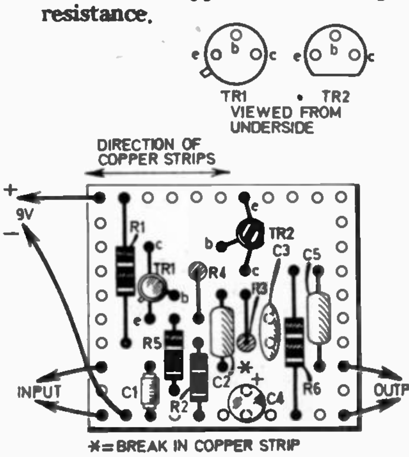


Fig. 2. Layout of components.

Starters...

(WE SUPPLY THE BOARD)

2 MULTIVIBRATOR

ESTIMATED COST OF COMPONENTS excluding V.A.T.

£0.65

The 56 kilohm (R4) and 2·2 kilohm (R5) resistors provide both negative feedback and thermal stabilisation for the transistors. The 33μF capacitor (C4) supplies the a.c. path to chassis. The 10 kilohm resistor (R6) to chassis is the collector resistor for TR2, and the output developed across it is extracted via the 0·1μF capacitor.

OPERATION

This little unit performs very satisfactorily from a 9V supply.

Although there are quite a few components to be accommodated on the piece of circuit board, the project is simple to construct and presents no problems. The component layout is illustrated in Fig. 2. It should be noted that it is necessary to cut the input/output copper strip at the point indicated in order to maintain the correct circuit and to mount all the components on the piece of board.

When it has been built and the equipment set up for test, don't be surprised if the whole thing screams its head off as soon as the volume control is advanced. This will be due to acoustic feedback caused by the microphone picking up signals from the speaker and feeding them back into the system. This is quite normal, and it is best to place the microphone as far away from the speaker as possible. ⌑

The multivibrator has a number of uses in radio and electronics, as we shall see.

A multivibrator produces an essentially square wave output, and it can be shown that a square wave comprises a fundamental sine wave plus odd order harmonics which would extend to infinity with a perfectly square wave.

USE

In practice it is impossible to achieve a perfect square wave output so the number of harmonics produced is finite. Nonetheless, output wave shapes very nearly square are possible, and the harmonics from an audio frequency fundamental will extend well into the r.f. region.

Thus, the harmonic output of a multivibrator may be used for testing or fault-finding, in either radio or audio equipment. In this role it is used as a simple signal generator and, with its output connected to the input of the equipment being examined, it will produce an audible tone in the loudspeaker, or headphones, if all is in order.

Components

Resistors
R1 1kΩ
R2 100kΩ
R3 100kΩ
R4 1kΩ
All ¼W ± 10% carbon

Capacitors
C1 4700pF
C2 4700pF
C3 0·1μF

Transistors
TR1 BC108 silicon *npn*
TR2 BC108 silicon *npn*

Miscellaneous
Verobard 11 holes by 10 strips (half of the free piece with this issue); connecting wire.

Ideally, we need a considerably more refined square wave generator than this simple device in order to make measurements on the equipment. However, observations with this simple instrument can be most instructive.

Continued over

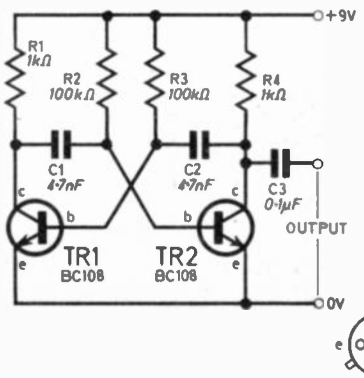


Fig. 1. Circuit of multivibrator.

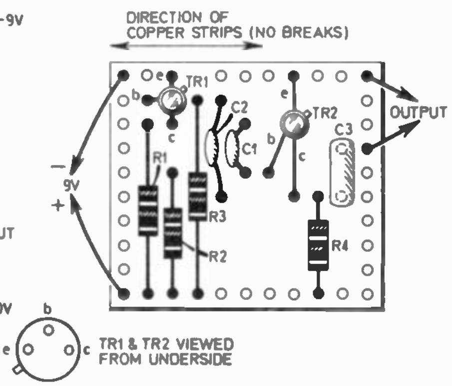
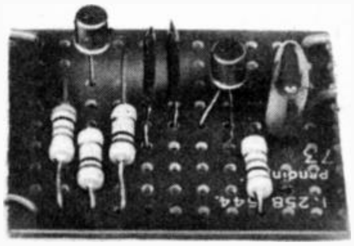


Fig. 2. Component layout.

Try these for Starters

ESTIMATED COST OF COMPONENTS excluding V.A.T.

£0.50



CIRCUIT

The actual operation of this circuit is that one transistor (say TR1) is cut off while the other one (TR2) conducts fully, this condition alternating between them at a rate determined by the value of R2/C1 and R3/C2.

To trace faults in radio receivers and audio amplifiers, the best method is to start at the loudspeaker end of the equipment and inject a signal into the final stage. If a signal is heard in the loudspeaker, work toward the input, stage by stage, until no signal is heard. This shows at which point the equipment is faulty and a more localised and thorough examination around the stage should reveal the fault.

Using the values shown in the circuit diagram, the multivibrator should oscillate at approximately 7kHz. By feeding its output into the aerial of a communications receiver it was found that the frequency range covered was from the broadcast band to 20MHz after which the signal dropped off rapidly. ⌑

By Mike Kenward

New products and component buying for constructional projects.

Sometimes everything seems to be against us; this month we were going to give you a bumper page because a host of information on catalogues and new products has come in from various firms, together with other interesting items we would have liked to tell you about. However, because of various problems we are unable to give this information this month and must confine ourselves to a short article and the major points.

Catalogues

Doram Electronics Limited, have published a new "Edition 3" catalogue priced at 60p and a new construction kit brochure price 25p.

Should customers order both publications together Doram are offering a special price reduction of 15p so customers only pay a total of 70p and, in addition each customer will receive two 25p vouchers which may be used at any time as a refund when placing orders for components, accessories and construction kits.

A special feature of the main catalogue is that during its life span customers will receive free, up-date amendment leaflets giving information on new lines and price changes. Doram are at P.O. Box TR8, Leeds, LS12 2UF.

The new Heathkit catalogue will be available by the time you read this. The catalogue is free and contains seven new kits—it is available from Heath (Gloucester) Ltd., Gloucester, GL2 6EE.

As we have said before, it helps us to help you if you always mention EE when buying anything connected with our projects or mentioned in our pages.

Car Rev. Counter

The meter for the *Car Rev. Counter* is the most expensive item and the correct one must be purchased if the circuit board shown is to be employed inside the meter case. The particular type is available from the larger suppliers.

Burglar Alarm

Only one component used in the *General Purpose Burglar Alarm* is not widely available—the C106 thyristor. This particular device or its equivalent the W106 thyristor should be used as its gate current and voltage are much lower than other types. Don't be misled by suppliers, most of them will tell you almost any thyristor could be used but in this case we suggest you get the correct ones which are available from Electrovalue, 28 St. Judes Rd., Englefield Green, Egham, Surrey, or from Marshalls, 42 Cricklewood Broadway, London, NW2 3ET.

One Transistor Radio

Once again none of the components for the *One Transistor Radio* should cause any buying problems but it is interesting to note that Home Radio are offering 500mm (20 inches) of damaged 10mm diameter ferrite rod with a promise that it will include at least 3 pieces 100mm long and 6 formers (aerial type) for 65p including V.A.T. and postage, or 45p to callers. This would obviously provide a great saving for anyone who builds or intends to build a few radios.

Home Radio advertise regularly.

Try These for Starters

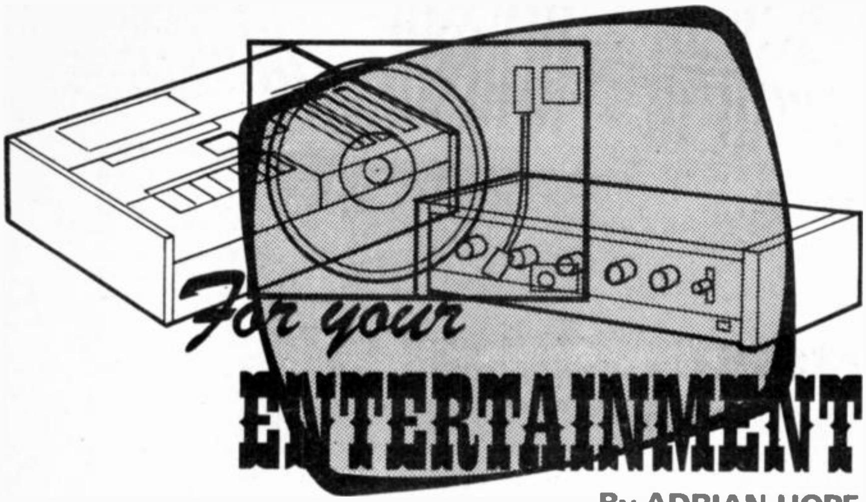
The two projects which can be built on the free piece of wiring board supplied with this issue should not create any component buying problems.

If you do not have a component shop in your area, we suggest you send your order to one of our advertisers and if you are new to this hobby, it would be a good idea to buy one or two component catalogues while you are at it.

D.I.D.

Doing It Digitally, our new series will no doubt interest many existing and new readers and not only provides an introduction to digital i.c.s. but also a chance for many people to brush up on their logic. We hope a number of suppliers will soon be offering kits for the first four parts (the list given in this issue). In addition to the list some readers may like to buy a type 90-40-087 Verocase and a d.p.d.t. toggle switch, although these are not essential.

However, there should be no problems with any parts and most of our component advertisers should be able to supply—tell them what they are for when ordering as they should have knowledge of the series.



For your ENTERTAINMENT

By ADRIAN HOPE

Telephones For Trains

It is now well known that the Japanese built a super-fast (200km/hour) "bullet" train to link Osaka with Tokyo for the 1970 World's Fair. In fact there are numerous bullet trains, shuttling frequently on the dead straight track that cuts a swathe across Japan. This is where the difference between the Japanese high speed train and the Advanced Passenger Train planned for the UK later this decade shows itself.

Whereas the bullet trains need straight tracks the APT will be able to negotiate bends and thus use existing tracks. To handle the bends reliably, and without risk of driver error, the APT will automatically interrogate transponders alongside the tracks. These will continually send information to the driver's cabin in the APT to provide a permanent readout on a digital display of the maximum safe speed for the APT over the length of track currently being negotiated.

The Japanese trains all have an on-board telephone system which can both receive and send calls. Anyone riding on the train can thus phone home or you can direct-dial the train to contact a passenger. The charge depends on where the train is at the time of the call in relation to the outside number called, but the maximum cost is £1 for the first three minutes (for a local call of course).

Train telephones are now also common in the USA and Europe, but although the first radiocommunication with a train took place in the thirties in England (a bunch of hams linked up with the Flying Scot), British Rail argue that there is insufficient demand for a telephone on an inter-city train. The problem is that a telephone on board a train is an expensive item. Simple on-air radio communication is useless because the radio link is broken every time the train passes through a cutting or tunnel. This is why most of the old tube lines in London still rely on the primitive and generally unsatisfactory system of requiring the driver or guard to stop the train, climb out and clip the wires of a portable handset onto a pair of bare phone lines that run alongside the track through the tunnels.

Remote Control

On London's Victoria line however the trains are remote controlled, and the driver given telephone contact with the outside world, via a carrier wave transmission system with communication to and from the conductor live rails. This is relatively simple because the rails carry only d.c. to power the trains (at around 600 volts) and this will not normally affect the a.c. control signals and audio frequency telephone link.

The Japanese bullet trains are remote controlled (just as on the Victoria line the driver is really redundant) and make telephone contact with the stationary world in exactly the same way. The snag is that the rails drastically attenuate the signal they carry, and it is necessary to provide frequent repeater stations, to keep the signal strength at a reasonable level.

It is for this reason that, if and when an on-board public telephone system is developed in the UK, it is likely to use the more modern technique of a "leaky" coaxial cable stretched along the track side to radiate the signals to the train. This system is currently in use by London Transport on an experimental basis, but of course only to provide a communication link with the driver and guard. So far as I know no country in the world yet provides a public telephone on their underground trains!

Equipment Repairs

Here's a couple of hard-learnt tips that can save a lot of grief. When you buy any kind of audio or electronic equipment, do try and keep the original box and packing. If the equipment develops a fault, returning it to the retailer or manufacturer will be far less miserable if you have exactly the right packaging ready to hand. But your troubles may not end there.

To safeguard themselves against dishonest customers and clumsy delivery men, most firms have a checklist which they fill out whenever a new piece of equipment is received. A tick is put on a form against the appropriate box—good condition, fair, poor, and so on—to record its state on arrival. But this puts the poor old customer at the mercy of just about everyone else involved.

Recently, I saw an electrostatic headphone control box that had developed an internal fault and been sent back in 100 per cent good-as-new condition to the manufacturer. It was returned after repair, covered in scratches apparently put there by an ape with a monster screwdriver, but accompanied by a checklist rating its condition on arrival as "poor". There are two ways to safeguard yourself against this kind of nonsense. Photograph, e.g., with a Polaroid camera, any piece of good-as-new equipment before you return it for repair and, wherever possible, deliver by hand and insist on the condition being noted in your presence before you leave.

T.V. Games

Whereas it now costs around £300 to equip a domestic TV set with a decoder to receive Ceefax and Oracle teletext transmissions, the cost could well have dropped to around £25 by 1978. More likely to interest the average reader however, is the fact that domestic TV table tennis games suddenly are starting to get cheaper all the time.

The original invention was made in the USA around five years ago. It was probably intended as a military training aid, because the first design was for a photoelectric gun which caused a spot on a TV screen to disappear when correctly aimed at the spot. Then the idea of chase games was developed, and finally table tennis, football, hole-in-the-wall and a whole range of other fun ideas.

A single chip which carries all the essential circuitry for enabling a domestic TV set to play a wide range of games and read out the score is now available. You can understand why no one is shouting about this yet. Several domestic games using discrete circuitry are on the market and when they work they work well. But the two I have used both went wrong and they are still pretty expensive. But now the chip is available new games will appear that are far cheaper *and* far better than the older ones. It will then be as hard to sell an old style game as it is to sell an old style calculator. So beware.

TEACH-IN 76

By A.P. STEPHENSON

Part Thirteen

13.1 OSCILLATORS

Oscillators are black boxes which generate periodic voltage waveforms, i.e. voltages which vary in a regular manner. They may be divided into sinusoidal and non-sinusoidal such as rectangular, square, pulse, triangular, sawtooth etc., see Fig. 13.1a which shows some typical oscillatory outputs which are required in electronics).

Nearly all oscillators rely on a very simple principle. A voltage amplifier normally has an external input signal but an oscillator uses its own output as the input signal; Fig. 13.1b shows the basic idea behind this strange black box. A "feedback" loop which allows a certain fraction, β, of the output to re-enter the input, is causing the oscillations, (the circle with "β" inside represents some network which is tapping off this fraction and could be a simple voltage divider or a complex network containing capacitors, inductors etc).

There is one important proviso however—the phase of the feedback must be in such a direction as to re-inforce the input. For example; if the input to the amplifier rises in the positive direction the amplified output must arrive back at the input as a rise. This is called **positive feedback**, to distinguish it from the "negative" feedback which we used in amplifiers to increase stability.

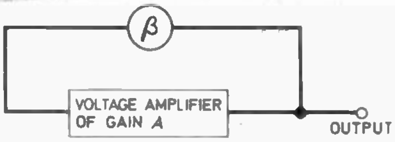
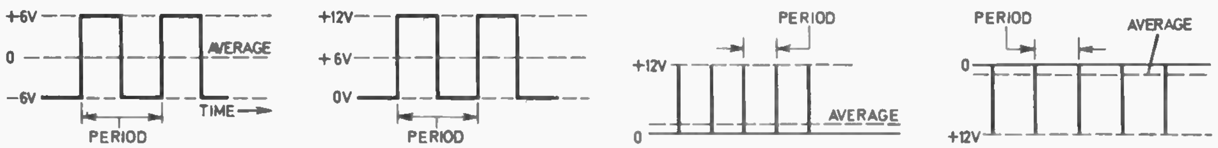


Fig. 13.1b. The oscillator in "black box" form.

An oscillator may be described as an amplifier which is persuaded to be unstable. There is a very simple but extremely useful equation which is used to design the feedback loop:

Fig. 13.1a. Non-sinusoidal waveforms.

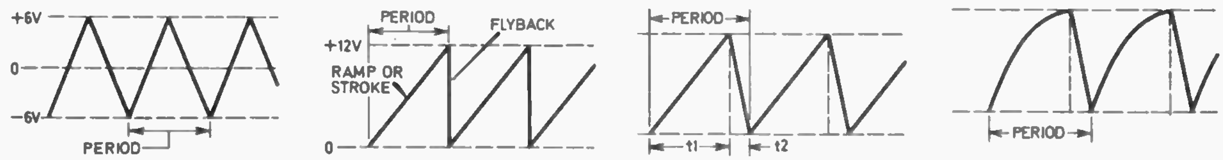


(i) Rectangular wave with average value of zero volts and amplitude of 12 volts.

(ii) Rectangular wave with average value of +6 volts and amplitude of 12 volts.

(iii) Narrow positive going pulses of 12 volts amplitude. The average value is slightly positive.

(iv) 12 volt negative going pulses with a slightly negative average. Period is longer than in (iii).



(v) Symmetrical triangular wave with zero average level and 12 volts amplitude.

(vi) Sawtooth wave with postive going ramp and instantaneous flyback.

(vii) Positive going ramp with finite flyback time.

(viii) Non-linear ramp.

$$A' = \frac{A}{1 - \beta A}$$

where A is the gain of the amplifier without the feedback loop; β is the fraction of output fed back; A is the gain of amplifier with feedback loop.

Note something very extraordinary about this equation if βA happens to equal 1. The value of A' would be $A/0$ which is infinity. An "amplifier" with a gain of infinity doesn't need an input—even an angry glance at it could plunge it into oscillation!

Example

An amplifier has an "open-look" gain A of 100. What fraction of the output must be fed back in phase in order to ensure oscillations?

For oscillations, $\beta A = 1$, so $\beta = 1/A = 1/100 = 0{\cdot}01$. This fraction is normally quoted as a percentage, in which case we would say "1 per cent positive feedback" is required. A value of β less than this would not cause oscillations; A value greater is more than necessary.

Notice from the equation that the higher the gain A of the amplifier the less feedback is required, which is why very high gain amplifiers are always on the verge of instability, i.e. they change from amplifiers to oscillators if the input gets a sniff of the output (due to a wire being too close and inducing inductive or capacitive e.m.f.s.).

13.2 SINE WAVE OSCILLATORS

It is not easy to generate a pure sinewave—in fact it is impossible because transistors are not perfect devices. However reasonably good replicas can be obtained by trying to keep the feedback percentage just enough (and no more) to keep the oscillations going. If the feedback is allowed to increase above this critical point the sinewave becomes grossly distorted by "squaring" at the tops and bottoms.

The frequency of the oscillations can be controlled by using feedback circuits in which the fraction β is only correct at one frequency. The *LC* resonant circuit discussed previously in a.c. theory can be used to provide such a frequency selective feedback network. A very simple oscillator is shown in Fig. 13.2a, which if adjusted correctly, can generate good sinewaves at some predictable frequency.

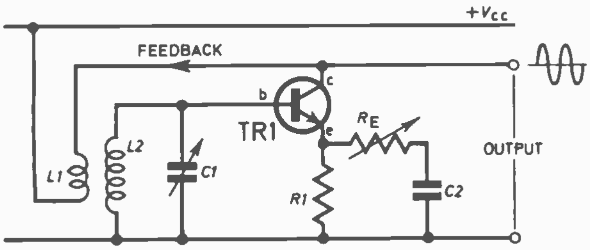


Fig. 13.2a. A simple inductive feedback oscillator.

The coil *L2* and variable capacitor *C1* provide "the tuned" resonant circuit, the frequency being given by: $f = 1/\sqrt{(2\pi\ L2C1)}$. The amplifier is a conventional grounded emitter stage with bias provided by *R1* and gain controllable by R_E. The feedback "loop" is by transformer action between *L1* and *L2* and we will assume that the feedback is sufficient to maintain oscillations.

But how do they start?

Well when the circuit is first switched on, the first pulse of collector current through *L1* induces a small e.m.f. into *L2* which trembles back and forth into the capacitor *C1* producing a tiny sinewave. Because this sinewave is fed to the base via *C2* the amplifier has a small starting signal.

Once started, the signal is amplified and fed back again causing a higher signal, and so on. The amplitude grows and would eventually be distorted by the limits imposed by the power supply. To prevent this, the gain must be adjusted (or calculated by mathematics) so that oscillations are just maintained, ticking over like a car at the traffic lights.

The capacitor *C2* has two basic functions, (a) to prevent the coil *L2* shorting the base to ground and (b) acting as a kind of automatic throttle control. The higher the signal on the base, the greater is the base current and therefore more electrons are on the right hand plate of *C2*.

Because a surplus of electrons is, by definition, a negative change, the base forward bias is automatically reduced as the signal grows—which is what we want to prevent the oscillator going wild and distorted. The average charge on *C2* depends on the time constant $C2 \times R_E$, but the details are admittedly difficult and (regrettably) must be filed in a thick folder marked "for later study".

There are several modified versions of this kind of oscillator, the two most well known are the **Hartley** and **Colpitts** oscillators shown in Fig. 13.2b in skeletal form only, i.e. just sufficient detail to show the feedback loops.

Only one coil is used and the feedback fraction depends on how far up the oscillatory circuit the emitter is tapped, the Hartley version taps the coil while the Colpitts version uses a capacitive voltage divider.

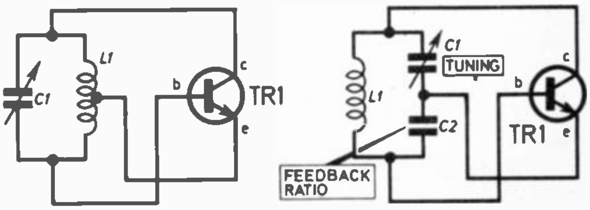


Fig. 13.2b. Simplified circuits of Hartley (left) and Colpitts Oscillators (less power and bias supplies).

13.3 CR SINEWAVE OSCILLATORS

THE THREE-SECTION DIPPY

The Dippy oscillator is shown in Fig. 13.3b.

From a.c. theory, we know that a single CR network can produce a phase shift of something less than 90 degrees. If a signal is passed through two such sections the total shift is something less than 180 degrees, and if through three sections, less than 270 degrees. In Fig. 13.3a, providing all resistors equal and all capacitors equal, the total phase is exactly 180 degrees at a frequency, $f = 1/2\pi\sqrt{(6CR)}$ and the output voltage is exactly 1/29th of the input.

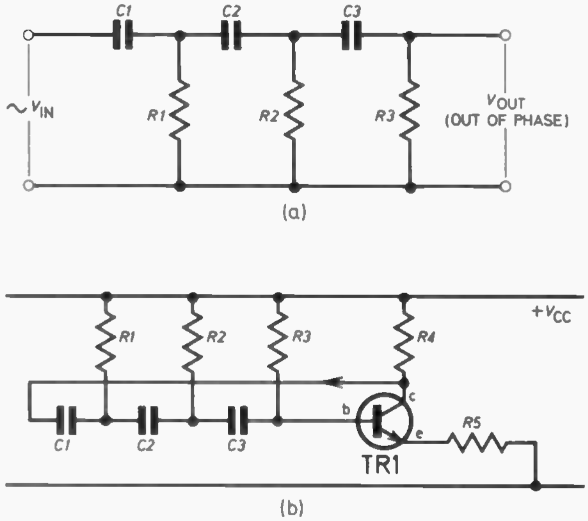


Fig. 13.3(a). 180 degree phase shift network (b) three-section Dippy oscillator.

To turn this network into an oscillator, the output is fed into a common emitter amplifier (which always shifts by 180 degrees) with a gain of 29, see Fig. 13·3b. Since the total shift is 360 degrees the feedback is positive with $\beta A = 1$, so the circuit will oscillate.

THE WEIN-BRIDGE OSCILLATOR

There is a network called a Wein-Bridge, see Fig. 13.3c with the following properties:

At a frequency given by $f = 1/2\pi CR$ the output voltage is exactly in phase with the input (zero phase shift) and is exactly one third of it in voltage.

To turn this network into an oscillator, the amplifier must have a gain of 3 and must have zero phase shift. This is achieved in the circuit of Fig. 13.3d by using two common emitter stages which brings the final collector output in phase.

The feedback loop is therefore positive and oscillatory.

The proof of the operations is rather difficult and demands a little more *j* notation fiddling than we had space for last time!

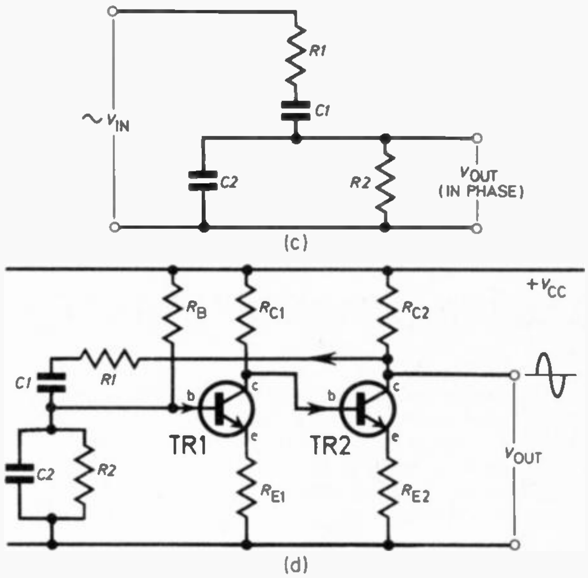


Fig. 13.3(c). A Wien bridge zero degree network and (d) the Wein bridge oscillator.

13.4 PULSE CIRCUITRY

To generate or use the strange waveforms shown in Fig. 13.1a it is necessary to operate transistors under rather extreme conditions. In fact we depart from the delicately adjusted base bias (which was found to be essential in signal amplifiers) and launch into a kind of "all or nothing" world.

A transistor is used as an electronic switch, either conducting heavily or not conducting at all. The input to the base is no longer a "signal" (in the sense that it requires amplification); instead it is merely a trigger to change the transistor over from on to off or vice versa. Fig. 13.4a shows a circuit with an actual switch in the base circuit and Fig. 13.4b and c shows the output voltage distribution with switch on and off. One might ask of course why couldn't the switch itself be used to change the output volts from zero to 6 volts—why have the transistor at all?

A glance at the figures however (plus a bit of Ohm's law) will reveal that a small current in the switch circuit "turns on" a much larger current through the output circuit.

With such circuits, we arrange the values such that when the transistor is "on" it is in saturation. This means that heavy current flows through R_C and the voltage drop across it leaves the poor transistor almost voltless! It just can't pass any more current even if we increase the base current by lowering R_B.

In saturation, although we may have a twinge of

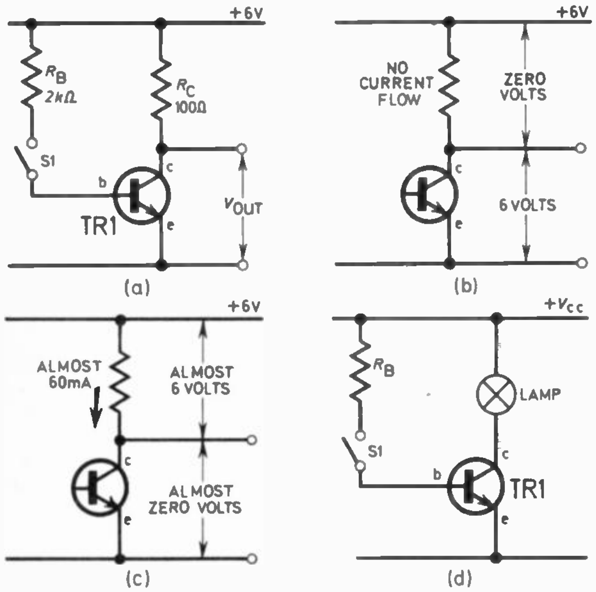


Fig. 13.4(a). A simple electronic switch (b) output is high due to no collector current (c) output low due to heavy collector current (d) a simple solid state lamp switch.

pity for the transistor, it is quite happy and relatively cold, because although it is passing a very heavy current, the voltage across it is very small.

Since heat is proportional to power (which is volts *times* amps) the high current is cancelled by a low voltage. In the case of a BC107 the saturation voltage at 60mA collector current is less than 0·1 volt which would mean a power in the transistor of 0·1V x 60mA = 6 milliwatts.

We must learn how to design such a switch circuit because a large slice of electronics is devoted to its application. We will take as our example the lamp circuit of Fig. 13.4d. Suppose it is a small pea-lamp (like the two on the Circuit Deck) rated 6V 60mA.

The battery must therefore be 6 volts and the transistor when in saturation must be capable of passing 0·06 amps (60mA). We shall use one of our BC107's with its "typical" h_{FE} value of 200.

Now we come to a rule of thumb applicable in a rough way to switch design: To ensure saturation assume the h_{FE} is only a tenth of its normal value.

Thus we take h_{FE} as 20, which means we require a base current of about 60mA/20 = 3mA.

Now the voltage across R_B is about (6 — 0·6) volts = 5·4 volts, but in crude switch circuits who cares about such accuracy? Lets say 6 volts and forget the 0·6 altogether—don't be horrified because even expert designers take such short cuts when they know it is safe to do so. This makes R_B = 6 volts/3mA = 2 kilohms. Notice the lamp is behaving as a 100 ohm resistor which makes Fig. 13.4d identical with Fig. 13.4a. (What a coincidence!)

One word of warning about the rule of thumb above. There is a limit imposed by the manufacturers on the maximum allowed base current so the "divide h_{FE} by 10" rule must always be subject to this limit.

13.5 PULSE TRIGGERING

The base can be switched on or off by a pulse from some other circuit as shown in Figs. 13.5a and b. If R_B is returned to ground, the transistor is off and the output is high in the "resting" condition. The input pulse jerks the base upwards, the transistor is then on and the output goes low. The terms "high" and "low" are often used to describe the output voltage state when it is unnecessary to state actual voltages.

If R_B is returned to + V_{CC}, the resting state is on and the output is low. The negative going trigger pulse temporarily reverses the state.

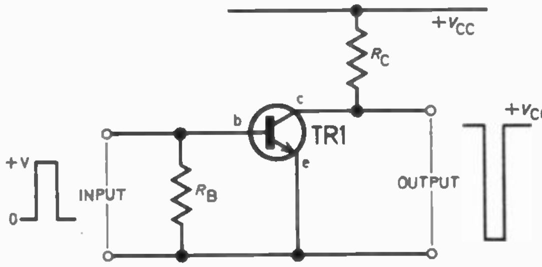


Fig. 13.5a. Input pulse momentarily switches on transistor.

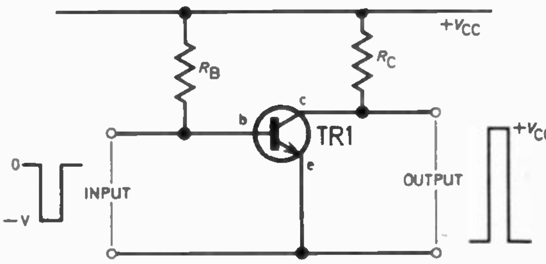


Fig. 13.5b. Input pulse momentarily switches transistor off.

TEACH-IN '76 EXPERIMENTS AND EXERCISES

EXPERIMENT 13A

To demonstrate saturation and relaxation.

PROCEDURE

Saturation

Assemble the components on the Circuit Deck as shown in 13A.1, leaving S1 in the off position and the 25 kilohm potentiometer set to minimum resistance.

The lamp should be glowing reasonably well because the transistor should be deep in saturation (there is only the 1 kilohm resistor left in the base circuit). Measure the voltage across emitter and collector to confirm $V_{CE\,(sat)}$ is about 100mV.

Rotate the potentiometer slowly and note that even with maximum resistance the lamp is almost as bright although probably (depending on your specimen) the transistor is coming out of saturation.

Relaxation

Rotate the potentiometer to maximum resistance and close S1. The lamp should extinguish and will remain off for a time approaching 20 seconds when it will mysteriously come on again. This will happen each time you open the switch and immediately close it again. The off time can be shortened by reducing the potentiometer resistance.

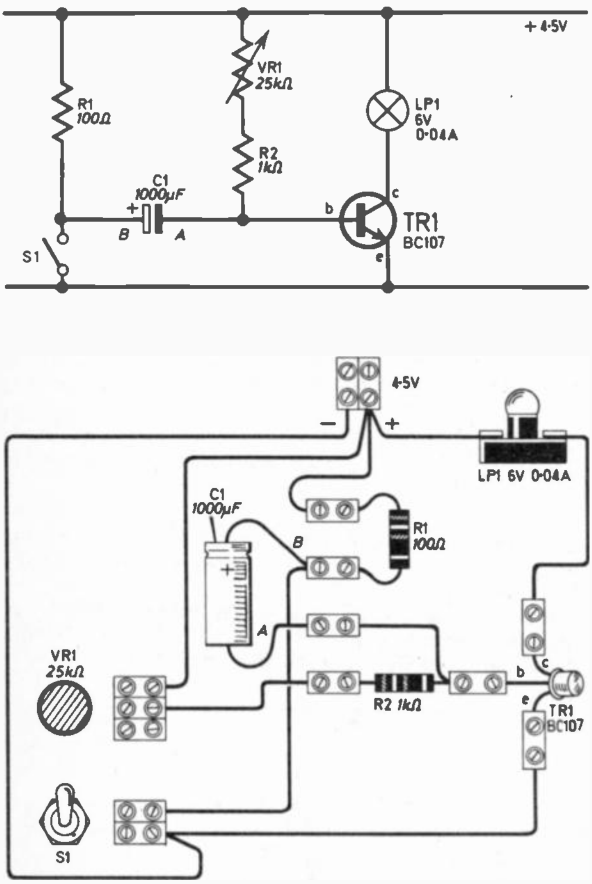


Fig. 13A1. Theoretical circuit and physical layout of components for experimental 13A.

Explanation

With S1 open, plate *B* is at +4·5V and plate *A* is about 0·6V. The voltage across the capacitor is therefore 3·9 volts. When S1 is initially closed, plate *B* drops downwards to zero volts, i.e. a drop of 4·5 volts. A capacitor cannot instantly loose its voltage so plate *A* also drops 4·5 volts downwards, i.e., from +6 volts to −3·9 volts!

This means the base of the transistor is cut-off, a state of affairs which lasts for as long as it takes plate *A* to struggle up from a negative value back to the normal testing position at 0·6 volts. This "struggle" depends on the time constant of C1 and the total resistance in the base circuit.

If we assume that the total voltage to which the base is aiming is the battery +4·5V, then the time is about 0·7*CR*. With a total resistance of 26 kilohms, the time would be 1000μF x 26kΩ x 0·7 = 18·2 seconds.

The 100 ohm resistor would have negligible effects on the calculation and is included only to protect the battery when S1 is closed. Remember, however, that 4·5 volts/100 ohms drains 45mA from your batteries all the time S1 is closed and it would be wise to increase the resistor to 470 ohms if you intend to repeat this experiment ad nauseam.

EXERCISES

13.1 An amplifier has a gain *A* of 2000. What percentage positive feedback will ensure oscillation?

13.2 A three-section Dippy oscillator using 10 kilohm resistors and 0·01 microfarad capacitors in the feedback network. What is the oscillation frequency?

13.3 A wien bridge network has 100 kilohm resistors and 0·01 microfarad capacitors. What would be its frequency if part of an oscillator?

13.4 The "Q" terminal of a bistable is low. What happens if a pulse to *reset* is applied?

13.5 An astable multivibrator has coupling capacitors of 0·1 microfarads and base resistors of 10 kilohms. What is the oscillation frequency?

Answers

13.1 0·05 per cent **13.2** 650 hertz approx. **13.3** 160 hertz approx. **13.4** Nothing, because it is already reset. **13.5** 833 hertz approx.

PLEASE TAKE NOTE

There is a wire link missing from the physical diagram Fig. 2 of the *Couples* game published in the August '76 issue. The switches S1 and S2 (Jim and Joy) each have an uncommitted tag—these should be joined with a length of wire.

In the *Fermentation Indicator* September '76 one of the sensor leads is shown in the wrong position in Fig. 4, page 460. The lead coming from pin 13 of IC1 should be moved down one strip so that it comes from pin 12 as per circuit diagram.

On page 463 of the September issue, the switch specified for *Clunk Click Jogger* should be a push-to break, release-to-make type.

Your Career in Electronics

by Peter Verwig

CABLE AND WIRELESS LTD.

It is now over a year (August 1975 issue) since telecommunications was discussed in *Your Career in Electronics*. On that occasion the employer was the Post Office with a virtual monopoly of telecommunications within the United Kingdom.

This month we take a look at the international telecommunications business and, in particular, Cable and Wireless Ltd. who own and manage a number of intercontinental trunk routes as well as being shareholders and managers of a number of internal telecommunication companies in other countries, principally in the Caribbean, the Middle East and Far East. A career with Cable and Wireless will particularly appeal to young people keen on work overseas.

Cable and Wireless Ltd. is a nationalised corporation owned by the British nation through the Government. It is run on strictly commercial principles and is outstanding among nationalised industries in being consistently profitable in its overall operations although, of course, there are loss-making sectors in areas where traffic is minimal and yet a service has to be maintained in the public interest or, for example, where capital investment for future expansion has been made and the extra capacity provided has not yet been taken up by users.

HISTORY

Cable and Wireless has a distinguished history, pre-dating even the Post Office in telecommunications although not in postal services. It all started with a company formed on May 18, 1868, called the Anglo-Mediterranean Telegraph Company Ltd. It was at the beginning of the age of instant world communications.

Today it takes some effort to imagine the impact of the early electric telegraph. In 1866 when the first transatlantic telephone cable was laid, news and messages which had previously taken 12 days by sea could now be received by wire in minutes by Morse code.

Samuel F. B. Morse, by the way, was one of the early electrical hobbyists, his normal occupation being portrait painting and his "contraption" was considered absurd when first proposed, a fate shared by most innovators.

The early impetus for a telegraph link from Britain to India came from the Indian Mutiny in May 1857. Nobody at home knew about the event until it was over and when the news eventually broke the nation was shocked at the massacres carried out by both sides. A telegraph link to India, then the "jewel" in the crown of the British Empire, would clearly be of enormous value.

A student from the Cayman Islands, operating a submarine cable test set at Porthcurno.

The Anglo-Mediterranean Telegraph Company laid a cable between Malta and Alexandria and this was to be the central link. The following year the British India Submarine Telegraph Company was formed to lay a cable from Bombay to Suez and the Falmouth, Gibraltar and Malta Telegraph Company would complete the chain to England via Gibraltar and Portugal. Signals were taken overland between Suez and Alexandria.

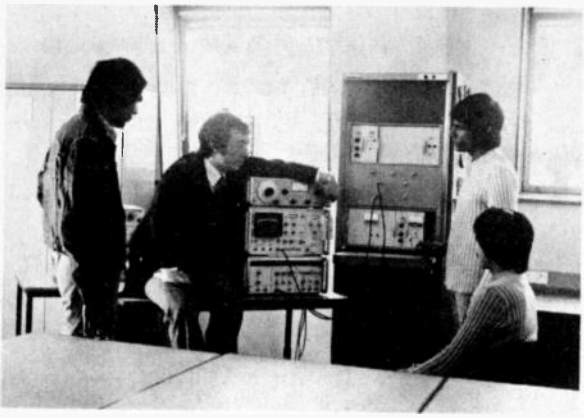
The final submarine cable link to Porthcurno, Cornwall, was completed in June 1870. The three companies were merged in 1872 to form the Eastern Telegraph Company as a single group which rapidly expanded the system in other directions.

All the early cable companies were formed by men of vision and private enterprise. They risked their personal fortunes and that of investors in pioneering the new science of submarine cable telegraphy. Each extension led to the formation of new companies because money had to be raised to finance each operation. By 1888 £40 million of capital had been sunk at the bottom of the sea but it was earning revenue.

MERGERS

Many of the early companies were interlocking and it was inevitable that they should merge into larger units. Thus, we find that when Cable and Wireless Ltd. was formed in 1934 it acquired some 28 companies and services which had been built up over the years.

In 1945, one of the first acts of the newly elected Labour government was to eliminate private shareholders interests in the overseas telecommunication service of Great Britain, India and the



Instructor Alan Petts explains line telephoning to three young students from Hong Kong.

Satellite earth station instructor Dave Boulton in an informal session with students from Fiji.

Dominions by the acquisition of the shares by the respective governments. The British government acted on the recommendation of the Commonwealth Telecommunications Conference which had suggested such a course and the "appointed day" for the change to public ownership was fixed for January 1, 1947.

In 1950 we find Cable and Wireless having lost all its internal British operation to the Post Office and a great number of its overseas branches had been taken over by the local governments concerned. But it still retained its telegraph cable network of 155,000 nautical miles and a fleet of cable ships.

Cable and Wireless, though now smaller in size, still had a great future and many technical challenges ahead. It was the beginning of a great electronics era which was to see the emergence of high capacity submarine cables and the threat of competition from communication by earth satellite.

Cable and Wireless had been through it all before in the 1920s when Marconi had opened up Empire Communications by wireless using shortwave and beam aerials. The new-fangled wireless telegraphy was not as reliable as cable and suffered from the disadvantage that the signals could be received by anybody with suitable apparatus and was thus not private, but it was much cheaper to install and run and there was considerable price cutting on services, to the detriment of the cable operators.

The situation was resolved by the acquisition of the communications business of the wireless companies including that of Marconi's Wireless Telegraph Company although Marconi's retained its manufacturing assets. The two services, cable and wireless, were henceforth regarded as complementary rather than competitive and the spirit of togetherness was eventually reflected in the new title of Cable and Wireless in 1934.

During the immediate post-war years the first priority was further development of the cable system using co-axial cable and submerged amplifiers (repeaters) to maintain signal strength every few miles. The first of the new Commonwealth links was CANTAT from Oban, Scotland, to Hampden, Newfoundland, costing £9 million and providing 80 speech circuits over 2,000 miles.

The second, COMPAC, was to connect Vancouver, Canada to Australia and New Zealand at a cost of £28 million and the third, SEACOM, would link in Asian Commonwealth countries over a 7,000 mile route at a cost of £23 million.

SATELLITES

In the late 1960s Cable and Wireless moved into space communications and today it now has a chain of satellite ground terminals as part of its world-wide communication system, complementary to the submarine cable network. Early fears that satellite communications would kill off the cable business did not materialise.

The enormous growth in international communications traffic during the past ten years has ensured the future of both main systems plus others, such as radio troposcatter and microwave line-of-sight links where appropriate.

In fact the latest project of Cable and Wireless is the completion of the longest microwave system in the world linking, over a distance of 800 miles, the chain of twelve islands in the Caribbean from Tortola in the north to Trinidad in the south.

In over 100 years of history, in peace and in war, Cable and Wireless was always a pioneer and built up in the first 40 years an unchallenged monopoly in world communications. Today the company and its business associates are still the world's largest international telecommunication operators employing more than 10,000 people in over 50 countries.

EXPANDING TECHNOLOGY

Submarine cables is still an important part of the business and there are six cable-laying and repair ships in the Cable and Wireless fleet. But the greatest expansion in technology in recent years has been in other telecommunications disciplines. If we look at Hong Kong, one of the company's principal operating centres, we find every form of technology employed.

Two earth satellite stations for all types of international traffic, including colour TV, to destinations either east or west, computerised Telex, a computerised switching centre for the telegraph service handling two million messages a month, troposcatter, h.f. and v.h.f. radio links, leased circuits for banks and airlines which include data transmission and message storage, and engineering services for the airport. Cable and Wireless even runs the computerised tote for the race track and the sound system for the City Hall.

It is said that Hong Kong as a great trading centre has a communications requirement equal to that of the whole of the Australian continent. And it is still expanding. A new cable, with a capacity of 1,840 voice circuits is currently being laid between Hong Kong and the Philippines by c.s *Mercury*, largest of the C and W fleet, and then on to Okinawa by a Japanese cable layer. Total cost £22 million and Cable and Wireless will own 40 per cent of the system due for completion next year.

The company's two latest space communications installations are in the Seychelles and Fiji, both inaugurated this year and now in full operation. In the Gulf, Cable and Wireless has earth satellite stations at Bahrain and Dubai with a third station at Qatar. New Telex systems are being installed by the company in the Kingdom of Swaziland, and in Iraq.

Modernisation and expansion of services in so many countries provides a strong demand for enthusiastic engineers for design, commissioning, operating and maintaining Cable and Wireless installations throughout the world. These positions are all of great responsibility and challenge and engineering entry into the company is therefore relatively strict and selective. But if you've got what it takes to work in Cable and Wireless the company has all the facilities to help you along the career path.

Loading submarine co-axial high-capacity cable into one of the three cable tanks in C.S. "Mercury".

TRAINING

There are four company training colleges located at Porthcurno, Cornwall, Hong Kong, Bahrain and Barbados. The largest and that of most interest to our UK readers is at Porthcurno in eight buildings on 50 acres of Cornish cliffs. Porthcurno was the original land terminal for submarine cables into the UK and at one time was the entry point for 14 cables of the British Commonwealth network totalling 155,000 miles of ocean cable.

It was natural that the training college should be sited where the action was and Porthcurno has been a training centre for more than 100 years. Some of the early test equipment is still working and a popular exhibit with students. Porthcurno ceased to be a cable terminal in 1970, but some of the old cable ends trail away on the sea bed for 40 or 50 nautical miles and are used to demonstrate cable testing techniques.

About 200 students a year attend Porthcurno Engineering College, most being Cable and Wireless staff from the UK and overseas. About 100 are under instruction at any one time, with provision for 80 single students in residential accommodation. The college is completely self-contained with ample leisure and sports facilities for off-duty hours. As there are 30 lecturers, student groups are small, seldom exceeding 16, sometimes at little as one person.

Many of the lecturers have recent experience in the field, coming into the college for a few years, generally not more than six, and then returning to their normal occupations. Thus, as well as the hard core of permanent lecturers and administrative staff there is plenty of up-to-date practical experience available to students, essential with ever-changing technology.

ENTRY REQUIREMENTS

If you are without technical qualifications there is a long basic course of 21 months. The educational standard required for entry is five GCE's minimum including 'A' level Mathematics and Physics or City and Guilds Practical Mathematics and Engineering Science.

There is, however, some flexibility in the mix with, for example, the possibility of being accepted with one 'A' level in Maths or Physics, or five good 'O' level passes provided they include Maths, Physics and English. The basic course is normally for students in the 17-23 years old bracket, age on entry being in the range 17-21. You must be unmarried.

The basic course will turn you into a technician engineer with a leaning towards either line or radio technology and you will then be posted overseas to gain practical field experience in your chosen discipline. While overseas you are expected to continue studying and, if successful, you may qualify for advanced training. If so you are likely to be brought home for a term of 14 weeks at an external technical college and then back to Porthcurno for Advanced Vocational Studies, or you may by-pass the external college if you have passed the appropriate exams overseas by private study.

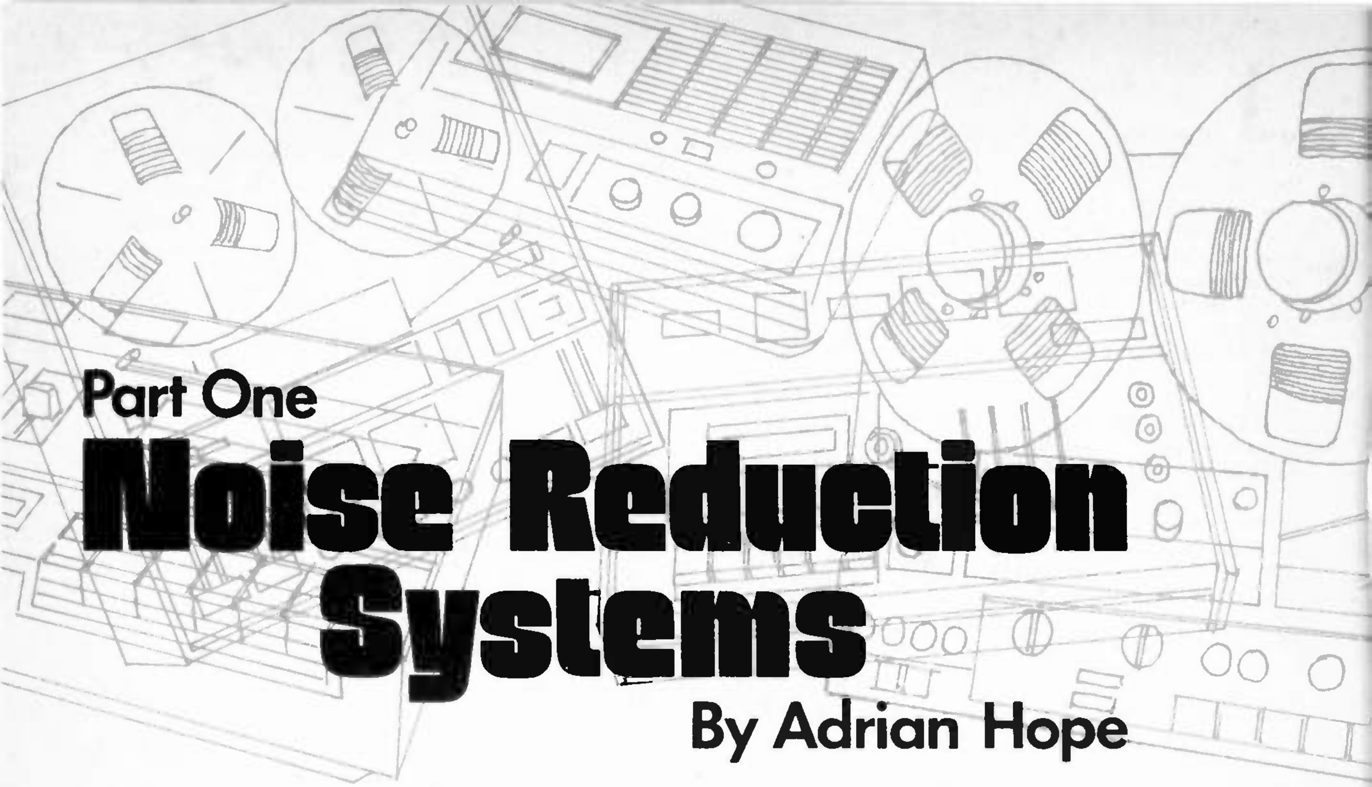
Finally, there are Advanced Module courses on systems and equipment at Porthcurno of typically up to six months duration. Those showing outstanding academic and practical ability may be selected for a sandwich course leading to B.Sc.

GRADUATES

Graduates in electrical and electronic engineering by-pass all the basic training but depending on their experience and company requirements will almost certainly spend some of their initial service on Advanced Module courses after an introductory course in the company's role in the telecommunications industry.

Further training is provided as and when necessary during your career. Note the insistence on adequate training. You may, on entry, be an amateur enthusiast but you will be a professional engineer in the end and have the opportunity to climb the management ladder if you show organisational and administrative ability.

Many of the top managers in the 1,000-strong London head office have been recruited from the mobile engineering staff as, indeed, have many of the overseas managers. ⌘



Part One

Noise Reduction Systems

By Adrian Hope

ONLY ten years ago, the phrase "noise reduction" would have meant muffling a noisy machine. Now, to anyone even remotely interested in audio, it means something quite different—to cut down on process noise such as tape hiss. Unfortunately, in the area of noise reduction, as quadraphonics, it is only too easy to talk about the subject without understanding it. What follows in this and subsequent months is intended as an aid to understanding the whole area of hifi noise reduction.

Rightly or wrongly, I believe that one of the major causes of confusion in the area of noise reduction is our tendency to talk and think of the various systems by name rather than by working principle. Spread between the professional and amateur or domestic market, the household names in noise reduction are Burwen, dbx Dolby, DNL and JVC ANRS. All are different and all are incompatible with each other.

Often there are several systems under the same brand name, which also are mutually incompatible. No one explanation can cover all systems, and some are as dissimilar as chalk and cheese; on the other hand others can be regarded as much of a muchness. As a deliberate policy, the general description that follows as Part I refers to no specific noise reduction system by name. Only when the topic has been understood in general terms do the specifics make sense. These will be dealt with in the subsequent parts.

All recording and transmission processes, be they disc, tape, film or radio, introduce their own noise. Attempts at reducing this "process noise" are almost as old as the media themselves and virtually every domestic sound reproduction system, be it hifi or lowfi, old or new, already incorporates some noise reduction circuitry. Some parts of this circuitry function automatically and other parts are under manual control.

TONE CONTROLS

Although the treble tone control on a radio or amplifier may be used to compensate for individual audio peculiarities of a programme source or an environment in which it is played, the main purpose of the treble tone control is to enable the listener to cut down on high frequency noise.

Turning the control back rolls off some of the high frequencies reaching the loudspeaker, and in so doing reduces the single, most irritating noise that encrouches on domestic listening—hiss. Hiss of course is the high frequency noise generated by film grain or the oxide particles that coat magnetic recording tape, by the material of a disc or by electron noise for instance in a radio receiver straining to pull on a weak station.

The simplest form of noise reduction circuit is thus a filter that rolls off whatever area of the frequency range suffers most from unwanted noise. The unwanted noise may not always be high frequency hiss, it may also be low frequency hum or mechanical rumble noise from a gramophone turntable; in the latter case the tone control simply rolls off the low frequencies.

Refined noise controls take the form of switchable filters which are tuned to act in just that area where the noise is most noticeable, rather than simply roll off all the top or all the bottom in the manner of a conventional treble or bass cut control. But every passive network of this type suffers from the obvious disadvantage that in cutting out the unwanted noise it inevitably cuts out any wanted signal of the same frequency.

To use an analogy, to which we shall later return several times, if the violins of an orchestra produce musical notes of the same pitch as tape hiss, rolling off the hiss noise will roll off some of the violin sound as well. Likewise, if a string bass produces notes of around the same frequency as mains hum, rolling off the hum will roll off some of the string bass as well.

Long ago it dawned on engineers that one way round this problem was to work out in advance which frequencies would be reduced at the reproduction stage, by the use of tone controls and filters, and put a disproportionately high amount of wanted signal on the recording or transmission medium at these frequencies. Thus when the roll-off occurs, the unwanted noise is reduced and the wanted signal will be reduced, but only back down to its original level (i.e. before it was artificially boosted prior to recording or transmission).

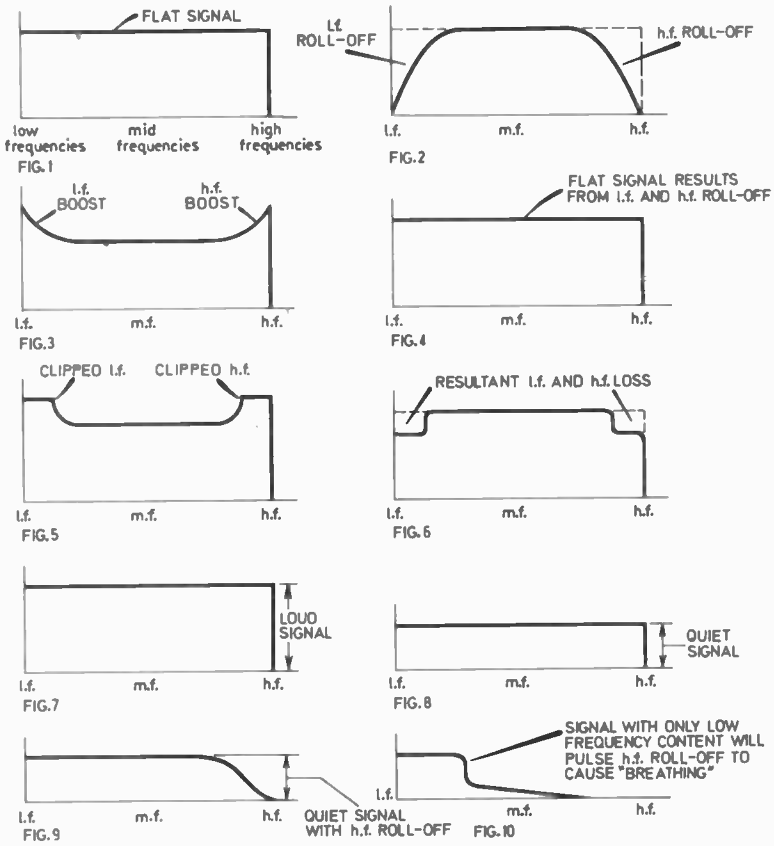
EQUALISATION

This technique is called equalisation, and it accounts for the automatically operating noise reduction circuitry which is present in modern audio equipment. Discs, radio broacasts and film soundtracks are all equalised with pre-emphasis (boost) of some frequencies before recording or transmission, and equalised again with de-emphasis (reduction) of those frequencies on playback or reception.

A rather more complicated, but nevertheless comparable, situation exists for tape. Because pre-emphasis and de-emphasis for recording and broadcasting follows standard boost and cut curves, there is no need for the user of the equipment even to know that such circuitry is included.

Simple, passive noise reduction (with tone controls) is clearly unsatisfactory, and the success of equalisation techniques is limited by the restrictions imposed by the characteristics of the recording and transmission medium. In practice there is a very definite limit to the extent by which noise prone frequencies (both high and low) can be boosted before the recording or transmission medium (tape, disc, film or radio wave) is over-modulated. The signal either clips or distorts and the final result on playback sounds far worse than it would with a little extra noise.

To illustrate the problem already mentioned, Fig. 1.1 shows, in highly schematic form how an original sound signal may have a



Figs. 1.1 to 1.10 illustrating boost and cut techniques at various frequencies.

notionally equal amount of low and high frequencies. When it is reproduced, the low and high frequency ends can be passively rolled off (Fig. 1.2) to reduce hum and hiss but, with it, useful programme material. So, as shown in Fig. 1.3, the original signal can be boosted at its low and high frequency ends, so that rolling off theoretically returns it to normal (Fig. 1.4). But, as shown in Fig. 1.5, it may be impossible to record or transmit the low and high frequencies if they are boosted too high, so they are clipped off and on playback (Fig. 1.6) sound distorted.

DYNAMIC FILTER

Turning now to noise reduction systems that are used *in addition* to the standard practices described above, it is logical to refer first to the dynamic filter approach. In many respects a dynamic filter or "noise gate" may be regarded as a manual tone control which is continually operated by an automatic and unseen hand. At first sight, this seems a clumsy approach, and it is certainly far from perfect; but with sophistication it can give surprisingly effective results, thanks to a peculiarity of the human ear.

Take a blank cassette, and play it on a cassette machine without any noise reduction facility switched in. Note the volume level and listen to the hiss through the loudspeakers, caused mainly by the random aggregation of the oxide particles in the tape coating moving past the playback head. Now record a musical passage with loud and soft passages on the tape, and replay it at the original volume setting. Whereas the hiss level sounded loud when the tape was blank and still sounds loud in the soft musical passages, it will sound virtually unnoticeable when loud music is recorded on the tape.

The hiss is of course still there, but it is drowned out, or masked, by the music. Thus a dynamic noise filter passes high level

The Pioneer CT 4141 cassette tape deck with Dolby circuitry.

signals through its circuitry without any effect on them whatsoever. But when the signal drops in level, the circuitry detects this and brings into operation a treble filter which progressively rolls off the high frequencies. In this way the hiss is reduced just when it would start to become noticeable (because it is no longer being drowned by the music) and as the music rises in level again the filter is taken out of operation.

It is easy to see how difficulties can arise with the unsophisticated adoption of this basic approach. If the circuitry senses the overall level of the signal present, regardless of its frequency content, the presence of a thumping bass will bring the high frequency filter into and out of operation. Thus the sound of tape hiss will be "modulated," or come-and-go, in time with the bass notes, to produce highly noticeable breathing sounds. Also, no system can have instantaneous attack and decay so the operation of the filter will always lag slightly behind the signal that is controlling it.

Furthermore, the circuitry cannot be expected to distinguish between musical sounds in the high frequency range (such as violins) and unwanted high frequency noise (such as tape hiss). The latter problem becomes acute when the violins play quietly, perhaps producing only a little more high frequency sound than the tape itself.

To clarify this, Fig. 1.7 schematically shows an audio signal which is equally loud over its whole frequency range and this passes unaffected through a dynamic noise filter; Fig. 1.8 shows a signal which is equally quiet over its whole range and which, as shown in Fig. 1.9, will have its high frequencies rolled off when it passes through a simple dynamic filter.

So far, so good, but see now Fig. 1.10 which shows a signal that is loud in its bass end with virtually no high frequency content. If such a signal pulsates (as with bass notes), it will cause the modulation of tape noise in a simple dynamic filter, by pulsing the filter circuit into and out of operation and making the sound of tape hiss come, and go or breathe in time with the pulses.

Various sophistications of the basic idea are adopted in modern circuitry. Usually these involve sensing the high and low frequency content of the signal separately and filtering only when appropriate to avoid modulation and breathing.

COMPRESSION

Many years ago, it was realised that one method of reducing noise (other than by gating or equalisation with pre- and de-emphasis) was to ensure that no low level signals need ever be handled by the recording or transmission medium.

Consider the notional example of a piece of classical music with a wide dynamic range, in other words, continuous variation between very quiet musical sounds and very loud musical sounds. If this music is recorded or transmitted in its virgin state, the quietest sounds may well end up merging with the hiss or hum process noise of the medium and thus be lost on reproduction. If, on the other hand, the dynamic range of the music is compressed, so that the quieter sounds seem louder and the louder sounds seem quieter, then there will be no sounds so quiet that they get lost in amongst the process noise.

By hi-fi standards the result is unacceptable because the final sound is unreal; but it is a compromise adopted in the recording industry (for pop singles) and in broadcasting (e.g. on Radio One), where it is considered more important to have an overall meaty signal level which always rises above the background noise than it is to have realistic dynamic range.

Compression is best understood with reference to Fig. 1.11 and 1.12. In Fig. 1.11 the constant straight-slope transfer characteristic of a theoretically perfect recording or transmission chain is shown. Whatever level signal is fed in at one end (at levels *A*, *B*, *C*), an exactly equivalent level signal will be fed out again at the other end (*a*, *b*, *c*). However, with the non-constant compression characteristic of Fig. 1.12, the same signals (*A*, *B*, *C*) fed in will produce an output of signals *a*, *b*, *c*, with a squashed dynamic range, so that there is an unnaturally reduced difference in their relative levels.

EXPANSION

Just as it is old to compress the dynamic range of signals in this manner, so it is equally old to expand signals, to produce an unnaturally large dynamic range. Expansion works in exactly the mirror-image fashion of compression. As shown in Fig. 1.13, when the signals of level *A*, *B*, *C* are fed in they emerge with an exaggerated difference in level, *a*, *b*, *c*. Immediately a possible solution to extra noise reduction becomes obvious.

If a signal is compressed in a compressor when it is recorded or transmitted it will have a better chance of emerging unscathed by noise when it is reproduced; but of course it will be distorted in

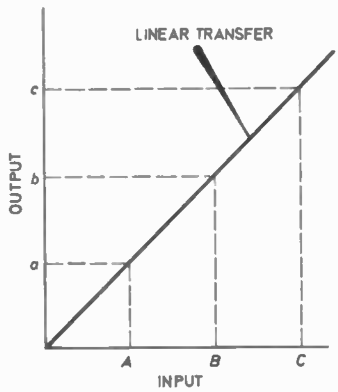


Fig. 1.11 Linear transfer.

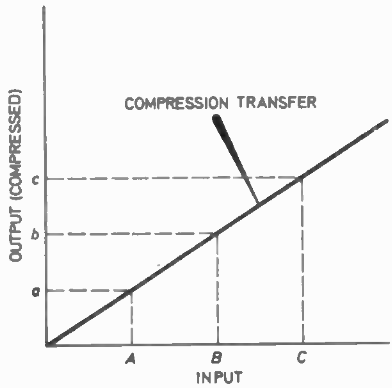


Fig. 1.12 Compression transfer.

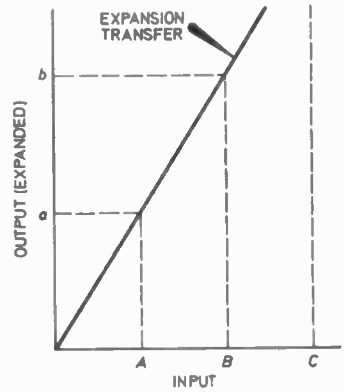


Fig. 1.13 Expansion transfer.

dynamic range. If, however, the compressed signal is fed through a mirror-image expander at the reproduction stage, it will remain unscathed by noise but have its original dynamic range reinstated.

This is exactly how the so-called compandor (compressor-expander) system of noise reduction works. The compandor concept dates back to well before the War, and it has long been a useful answer to the problem of noise in telephone line and other circuits, where high fidelity is not of prime importance. There are, however, inherent difficulties in compandor systems which have always stood in the way of their adoption in high fidelity systems.

One problem is that of overshoot. Both the compressor and the expander must incorporate circuitry which senses the level of the signal being processed and alters the characteristics of the circuit to boost or reduce it according to the governing compress or expand characteristic. But no circuitry can operate instantaneously, and some signals may pass (or at least start to pass) through the circuitry at too high level. The recording or transmission medium (the tape, film or disc recorder or the radio transmitter) may be unable to handle the excessive signal or transient, and will over-modulate, perhaps simply clipping it off.

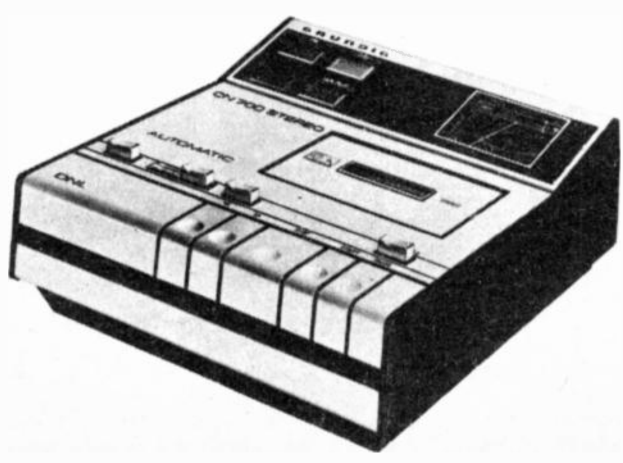
As anyone who has over-recorded on tape will know, once distortion such as clipping has been introduced it can never be removed. Another problem with the basic compandor parallels that encountered with active noise filters. The compandor must in mirror image fashion follow or "track" the action of the compressor to restore the compressed signal to its original form. If the signal varies rapidly in overall level, there may be mis-tracking. Moreover, if a loud signal at one pitch range comes and goes it may cause modulation of another, such as tape noise, with resultant breathing sounds. Furthermore, any error that is induced into the signal by the compressor, for instance any unintentional exaggeration of one frequency with respect to another, will be further exaggerated in the expander.

Over recent years, different researchers have adopted different approaches to curing or circumnavigating the problems inherent in compandor systems. One line of approach has been to doctor or "weight" the frequency response of the compandor, for instance by adding high frequency pre-emphasis (artificial boasting of all high notes) during compression, with mirror-image de-emphasis or de-boosting on expansion. This is intended to minimise tape modulation noise and reduce distortion problems.

Also the sensing circuitry of the compressor and expander has been refined to a considerable extent, to make its action fast enough to be inaudible but not so fast as to introduce audible transient distortion. Furthermore, complex filtering arrangements are adopted in an effort to prevent the change in level of one frequency in the signal modulating the system in its handling of another, quite different, frequency.

Next month a simple compandor and details of various systems.

The Grundig CN700 stereo recorder which incorporates a dynamic noise limiter.



ONE-TRANSISTOR RADIO

By R.A.PENFOLD

Can receive many stations.

EVEN though this simple receiver uses just one transistor, it is capable of receiving several stations on the m.w. band at a reasonable volume from a crystal earphone. The prototype can receive BBC Radios 1, 3, and 4, plus the World Service of the BBC and a couple of pop pirate stations. It should also receive BBC m.w. local radio stations in areas where these are in operation.

Since the receiver uses so few parts, construction is very simple and straight forward and the design is also very inexpensive to build. The current consumption of the set is extremely low, being about 400 microamps, and this gives many months of operation at low cost from a PP3 battery.

HOW IT WORKS

A complete circuit diagram of the receiver is shown in Fig. 1. Operation of the circuit is as follows: L1 is the ferrite aerial coil, and it is this which picks up the radio signals and produces small electrical signals from them. Capacitor C1 is the tuning capacitor, and this enables L1 to cover the entire m.w. band, permitting the desired transmission to be received while all others are rejected. This type of circuit is known as a parallel tuned circuit. Capacitor C2 also forms part of this tuned circuit, and it is adjusted to give correct frequency coverage of the m.w. band.

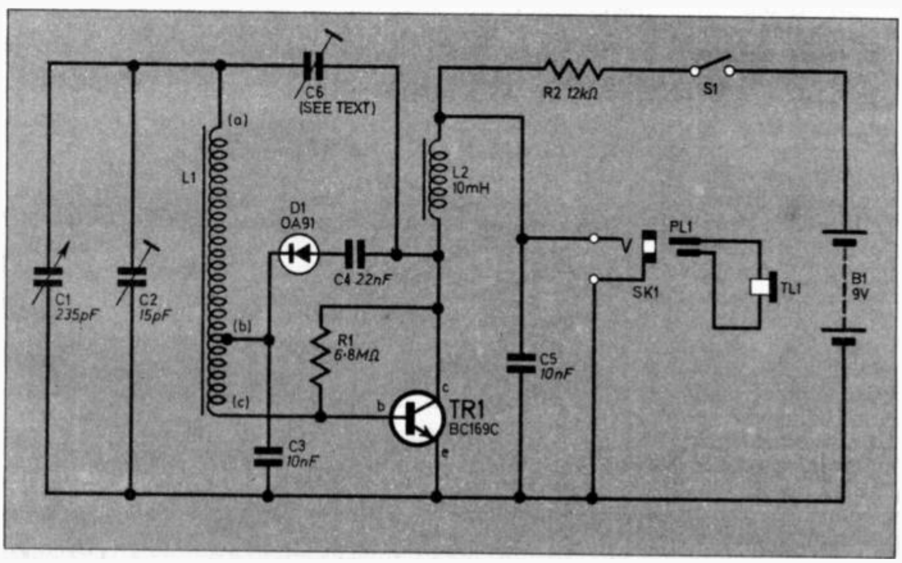
The electrical signals developed across L1 are at a fairly high impedance, and cannot be successfully fed direct into the base of TR1, with its rather low input impedance. The signal is therefore fed from a low impedance tap on L1. This tap is coupled to earth at r.f. by C3, which provides d.c. blocking, and the lower end of L1 couples to the base of TR1.

Transistor TR1 operates as a high gain common emitter r.f. amplifier having L2 as its collector load, and R1 as its base bias resistor. The positive supply is fed to the circuit via R2 and C5 which operate as an r.f. decoupling network.

The amplified radio signals appear at the collector of TR1, and are fed via C4 to D1, which is an ordinary diode detector. The r.f. half cycles appearing at the output of D1 are smoothed to a small d.c. bias by C3, and this leaves only the audio signal. This is fed via the lower part of L1 to the base of TR1.

Now TR1 operates as a high gain common emitter audio amplifier. Coil L2 has a very low impedance at audio frequencies (a

Fig. 1. The circuit diagram of the One Transistor Radio.



few ohms), and so at r.f. R2 is in effect connected straight to TR1 collector. Equally, C5 has a very high impedance at a.f., and so it can be ignored. R2 thus becomes the collector load for TR1 at a.f., and the amplified audio signal is developed across it. From here it is fed to SK1, and then to the earphone. Switch S1 is the ordinary on/off switch.

REGENERATION

From this description it will be seen that TR1 is used to amplify the signal twice, first at r.f., and then after detection it amplifies it at a.f. This process is known as reflexing.

It is also possible to make TR1 amplify some of the signal twice while it is at r.f. This is known as regeneration and is the purpose of C6, which is a very low value capacitor. This sends some of the amplified r.f. signal at the collector of TR1 back to the aerial, from where it is coupled back to the base of TR1 for amplification for a second time. This produces a very worthwhile increase in gain, and also increases the selectivity of the receiver (its ability to select just one station where there are two or more close together).

The level of regeneration must be carefully controlled though, as if too much is applied to the circuit the circuit will break into oscillation, and proper reception will not be possible.

FERRITE AERIAL

The ferrite aerial is home made, and is wound using approx. 34 s.w.g. enamelled or d.c.c. copper wire on a 50mm x 10mm ferrite rod (see Fig. 2).

If a rod of about the correct length cannot be obtained (see *Shop Talk*), then one can be broken from a longer rod. Use one corner of a triangular file to cut a groove around the circumference of the rod at the place where it is to be broken. It can then be easily broken over the edge of a workbench at this point.

The winding starts 10mm from one end of the rod, and the wire is taped to the rod with a narrow band of insulation tape. Leave a leadout about 75mm long. Then carefully wind 70 turns of wire around the rod, making sure that the turns run neatly side by side down the rod. Space the turns as closely as possible.

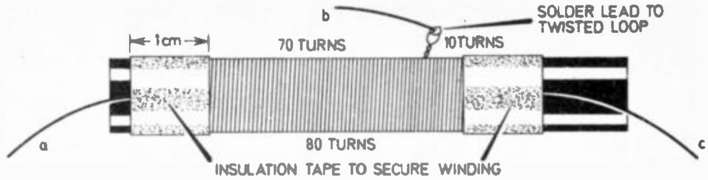
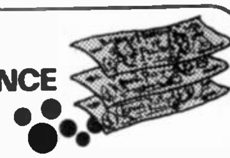


Fig. 2. Winding details for the ferrite coil.

After 70 turns have been wound, throw up a small loop in the wire, as shown in the diagram, and then add a further ten turns in the same manner as before. Another band of insulation tape is used to hold the end of the winding in place, and a 75mm leadout is left.

The insulation is stripped from the loop of wire, and an insulated lead is soldered to the loop. A further band of insulation tape (omitted from the diagram for clarity) is then wound around the tapping to prevent the coil from unwinding at this point.

FOR GUIDANCE ONLY



ESTIMATED COST OF COMPONENTS excluding V.A.T.

£2.50 excluding case

CASE DRILLING

A ready made plastic case is used to house the receiver. This has a front panel, on which the unit is built, and a moulded outer casing onto which the front panel is screwed. Any case similar to that specified can of course be used, provided it is made from a non-metallic material.

It is strongly recommended that the general layout employed on the prototype, and which can be seen in the accompanying photographs, is adhered to. Deviating from this may cause a loss of performance, or even instability.

Capacitor C1 requires two short (approximately 6mm long) 6BA countersunk mounting screws. These should not be allowed to penetrate so far into the frame of C1 that they foul either its moving or fixed vanes. If the

Components

Resistors

R1	6·8MΩ
R2	12kΩ

¼W ± 10% carbon

Capacitors

C1	235pf variable (165pf+70pf in parallel or similar)
C2	trimmers fitted to C1—see text
C3	10nf disc ceramic
C4	22nf type C280
C5	10nf disc ceramic

Semiconductors

TR1	BC169C silicon *npn*
D1	OA91 germanium diode

Miscellaneous

TL1	crystal earpiece with lead and plug
SK1	socket to suit TL1
B1	PP3 battery and connector
L1	Ferrite rod 35mm long 10mm diameter and wire for coil—see text
L2	10mH ferrite cored choke
S1	d.p.d.t. slide switch (only one pole needed—see text).

Plastic or wood case approximately 100 x 70 x 50mm; control knob; 0·15 inch matrix Veroboard 7 strips 13 holes; connecting wire; 6BA fixings etc.

See Shop Talk

See page 512

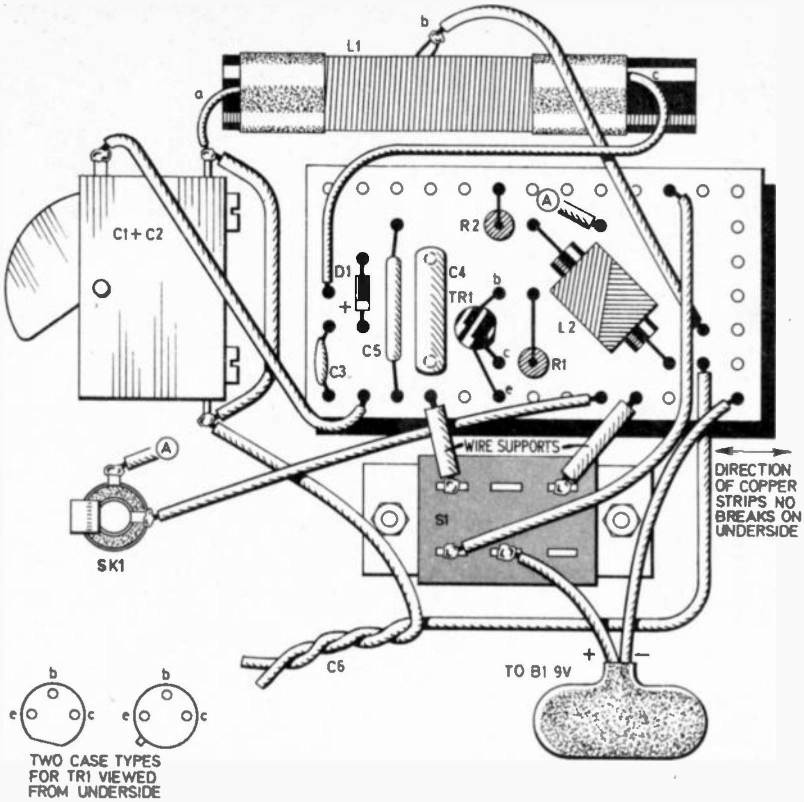


Fig. 3. Layout of the components on the wiring board and inter-connection details.

screws are a little too long, fit washers over them between the front of C1 and the front of the case, to lessen their penetration.

WIRING

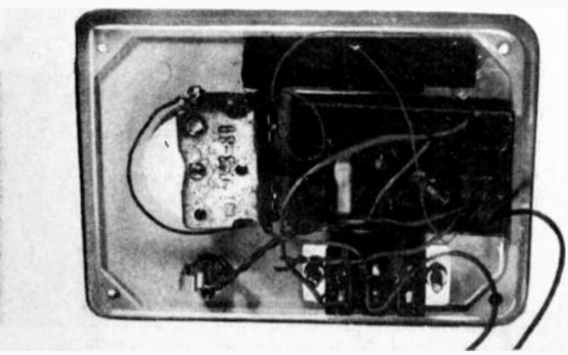
All the small components are mounted on a 0·15in matrix stripboard panel having 13 holes by 7 copper strips.

When a board of the required size has been cut out using a hacksaw, the components are mounted on the board and connected in the positions shown in Fig. 3. This diagram also shows all the other wiring of the receiver. All the connecting leads are made of thin insulated wire, except the two short wire supports for the component panel. These are made from a fairly heavy guage wire (about 14 s.w.g.), and for ease of construction should be the last connections to be made. They are used to secure the panel to a couple of spare tags on S1.

Capacitor C6 is home made by twisting together a couple of pieces of single strand (for rigidity) insulated wire, as shown in the diagram.

The capacitor specified for C1 has built in trimmers (C2) which must be fully screwed down to give the correct frequency coverage. If a different type of component is used and it is not fitted with trimmers, then a 15pf polystyrene capacitor should be connected across C1 in place of these. Note that C1 has two sections and that these are connected in parallel to obtain the required capacitance swing.

The ferrite aerial is glued in position using Bostik No. 1 or a similar adhesive. There is a space for the battery inside the case behind S1 and SK1.



Photograph of the prototype showing layout of components and board on lid of case.

ADJUSTMENT

Before connecting the battery and earphone, and switching on, carefully check the wiring for mistakes, and correct any that are found.

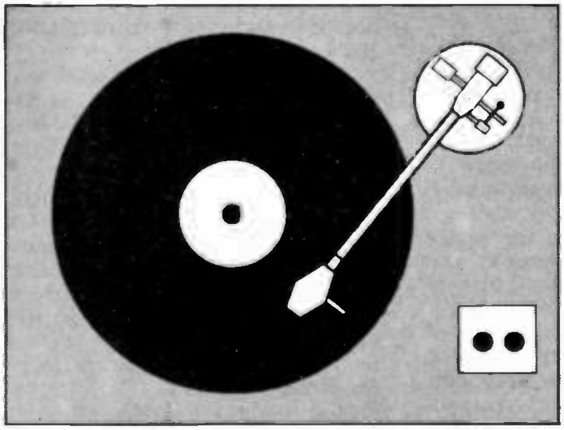
When all is well, switch the set on and rotate the control knob of C1 to search for a station. If whistles are heard as the tuning knob is turned, try slightly untwisting the two wires forming C6. If no whistles are evident, then the effect of twisting the two wires more tightly together can be tried.

For best results the two wires are twisted together as much as is possible without a whistle being produced as the set is tuned across a station, on any part of the waveband. ☐

Next Month...

CLEAR SKY INDICATOR

For the amateur astronomer—an "electronic eye" to watch a selected area of the sky and provide a remote indication when no clouds obscure the view.



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Get rid of those unwanted noises from old, worn or poor quality records; reduce mechanical noise from the deck or use this stereo filter with a cassette deck to reduce tape hiss.

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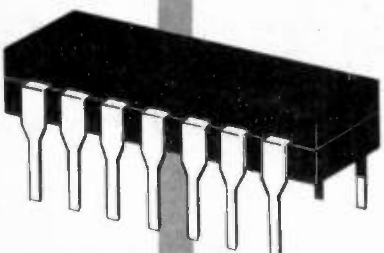
Doing it Digitally...

New Series

By O.N. Bishop



Part 1 of a new series providing an introduction to, or revision of, digital techniques.

THIS SERIES describes some of the things that can be done with digital integrated circuits; it does not go into the theory of how they work, but tells what they can do and how they can be made to do it.

Digital circuits are the building blocks of computer systems and many types of automatic control. They can also be used in the home for all kinds of things, some useful and some just amusing.

Because of the very large demands of the computer industry, digital integrated circuits (or i.c.s as they will be called from now on) are cheap and getting cheaper.

No special knowledge of i.c.s, computers, electricity or mathematics is needed to be able to build the projects described in this series. What knowledge is needed can be learnt from experience as the series progresses.

The circuits used in the series require only the cheapest and most readily available components and most of the components bought will be used over and over again for building up different projects. When the experimenting is over these same components can be built into permanently useful devices.

The series has been written to do two things: to give clear instructions on making a large number of useful or interesting devices using i.c.s; and to provide a basic understanding of what can be done with i.c.s so that the reader can design and build devices of his own.

DIODE GATES

Before we look at integrated circuits it would be as well to familiarise ourselves with simple logic gates using basic components such as resistors, diodes and transistors.

A diode is a two-terminal device which lets current flow easily in one direction but not in the other. There is a special type of diode called a "light emitting diode" which gives out light when current is flowing forward through it.

Both diodes and light emitting diodes used in this series can only carry quite a low current and for this reason a resistor must be placed in series with them to limit the current they carry.

For the first experiment five components are necessary: a 6V battery; two small silicon diodes; a 560 ohm resistor and a light emitting diode.

The circuit diagram of Fig. 1.1a shows how the five components are connected and Fig.1.1b indicates the physical arrangement. Note the markings on the diodes and the lead identification of the l.e.d. These must be as shown or the circuit will not perform properly.

Now for the experiment.

When neither of the diodes is connected to the positive terminal of the battery does the l.e.d. light?

Touch the free end of one of the diodes to the positive. Does the l.e.d. light?

Touch the other diode to the positive terminal. Does the lamp light?

Finally touch both free ends to the terminal. What happens to the l.e.d. now?

The results obtained should look like this:

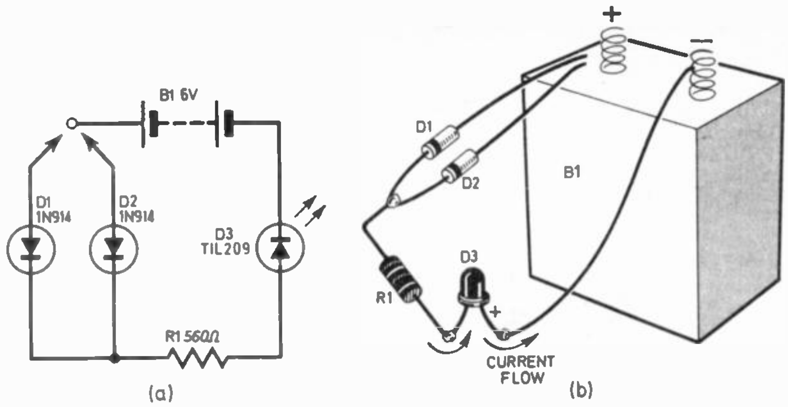


Fig. 1.1 A simple gate using two diodes. (a) shows the circuit diagram and (b) the physical layout

With no diode connected
Lamp not alight
With one diode connected
Lamp alight
With other diode connected
Lamp alight
With both diodes connected
Lamp alight

To put it more simply:

If one OR the other OR both diodes are connected, the lamp lights. Connected any other way, the lamp does not light.

PROBLEM SOLVING

This circuit could be used to solve a very simple logical problem: Suppose a person likes to go to the cinema whenever there is a thriller showing and he also likes to go on Fridays whether the film is a thriller or not—just for the sake of a weekend treat. His preferences could be expressed as "he goes to the cinema if the film is a thriller OR if the day is Friday OR if the film is a thriller and the day is Friday, otherwise he does not go".

Connect one diode when there is a thriller and the other when it is Friday, the lamp will light when he should go to the cinema.

A very simple problem and one that really did not need a circuit to solve it—but then this is a very simple circuit.

THE "OR" GATE

The circuit is one of the simplest logical circuits—it solves problems involving the term "or". If two events are possible (such as the film being a thriller and the day being Friday, or one or the other diode touching the battery terminal) then the lamp will **light when either one event occurs OR the other OR both.** It will stay out when neither event occurs (the film is a western and the day Wednesday).

The circuit of Fig. 1.1 really consists of two parts: one part is made up of diodes and performs the OR logic—this part is called the OR gate; the l.e.d. and the 560 ohm resistor were merely there to indicate the state of the gate—whether it was open or closed. Other ways of indicating the state of the gate could have been used, such as a voltmeter as shown in Fig.1.2.

In Fig. 1.2 parts of the circuit which are at or near the voltage of the positive terminal of the battery are shaded. These parts are said to have a "high" potential. Relatively speaking, the rest of the circuit is at a "low" potential.

If a voltmeter reading up to six volts is available these results can be verified.

The four diagrams can be summarised by making out a table to show which parts of the circuit are high and which parts low. Write H for high and L for low. The results are shown in Table 1.1.

This kind of table is called a "truth table". It shows the output of the OR gate for all possible inputs—all possible ways the diodes could be connected.

This OR gate is the simplest one to construct and it has been des-

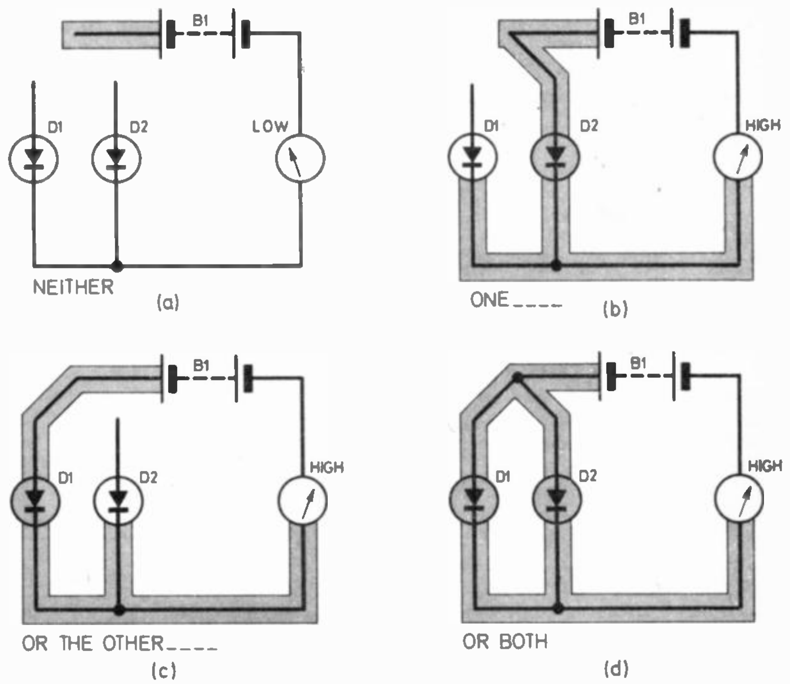


Fig. 1.2 The four states that the circuit of Fig. 1.1 can take. The shaded wires indicate parts of the circuit which are "high"

Table 1.1. Truth Table of Fig. 1.2

Inputs Diode 1	Diode 2	Output
L	L	L
L	H	H
H	L	H
H	H	H

Components

Resistors

150Ω ¼W (4 off)
150Ω ¼W (1 off)
560Ω ¼W (1 off)
10kΩ ¼W (2 off)
2·2kΩ ¼W (2 off)
all ± 10%

Capacitors

0·1μF polyester (2 off)
1μF elect. 16V (2 off)
470μF elect. 16V (2 off)

Semiconductors

IN914 or similar silicon diodes (4 off)
TIL209 or similar l.e.d. (4 off)
2N2926 silicon *npn* transistors (2 off)
SN7402 quad 2 input NOR gate (1 off)
SN7400 quad 2 input NAND gate (1 off)
SN7473 dual J-K bistable (1 off)
SN7493 4-bit binary counter (1 off)

See **Shop Talk** Page 512

Miscellaneous

1·5V, HP7 batteries (4 off) with holder to make 6V battery with connector
0·1 inch matrix Veroboard 36 strips by 50 holes (1 off)
Soldercon pins (200 off)
High impedance (crystal) earpiece (1 off)
80Ω approx 60mm moving coil speaker (1 off)
1kΩ carbon potentiometer (log) (1 off)
Connecting wire—single strand—300mm lengths various colours (4 off)

cribed in detail to show how electronic components can be connected to solve logical problems.

Usually, many more gates are needed to solve the sort of problems encountered in normal life and many more gates are needed to solve the sorts of problems which interest scientists, or to perform mathematical calculations. In later parts other types of gate will be described as well as the uses to which they can be put.

FOUR INPUT GATE

Before leaving the OR gate, try to work out what would happen if, say, four diodes were connected to make a gate. The circuit is shown in Fig. 1.3 and if four diodes are available the circuit could be constructed to check the results.

If one or more of the diodes is connected to the postive terminal (i.e. is made "high") the l.e.d. will light (output high). In other words, if A OR B OR C OR D OR any combination of these is high the output is high.

The truth table is shown in Table 1.2.

It will be seen that there are 15 ways of getting H and only one way of getting L as the output.

The logical problem requiring this circuit might be "a person goes to cinema if there is a thriller OR if it is Friday OR if there is no good programme on TV OR if a friend invites him. Will he go tonight or not?"

With all those H outputs it seems that he must be very fond of the cinema! But suppose his friend does not like westerns—what does he do then? This requires some logic which is a bit more complicated and to solve it some different gates are needed.

TRANSISTOR SWITCHES

In constructing a radio or amplifier it helps a lot to know how a transistor works. In this series it is simply being used as a switch so it is not important to know how it works only what it will do and how it is used.

The majority of transistors have three leads coming from them, some typical ones being shown in Fig. 1.4. The three leads are connected to parts inside the transistor called the base (b), the collector (c), and the emitter (e).

To see how the transistor operates connect it in the circuit of Fig. 1.5. Leave the final connection to the positive until the circuit has been checked against the wiring diagram.

Connect the l.e.d. to the positive terminal of the battery. This completes the path from positive, through the l.e.d. and the resistor, through the transistor and so to the negative terminal of the battery.

Is current flowing through this path? If it were the l.e.d. would be alight. Since the l.e.d. is not on it is clear that the transistor

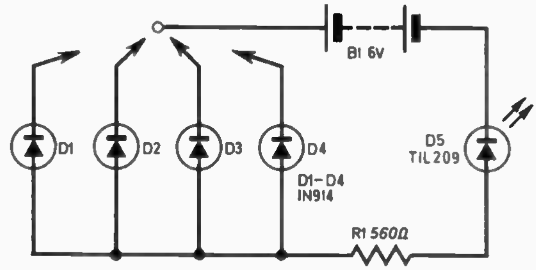


Fig. 1.3 A four input diode gate

Table 1.2. Truth Table of Fig. 1.3

Inputs A	B	C	D	Output
L	L	L	L	L
H	L	L	L	H
L	H	L	L	H
L	L	H	L	H
L	L	L	H	H
H	H	L	L	H
H	L	H	L	H
H	L	L	H	H
L	H	H	L	H
L	H	L	H	H
L	L	H	H	H
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H	H	L	H	H
H	L	H	H	H
L	H	H	H	H
H	H	H	H	H

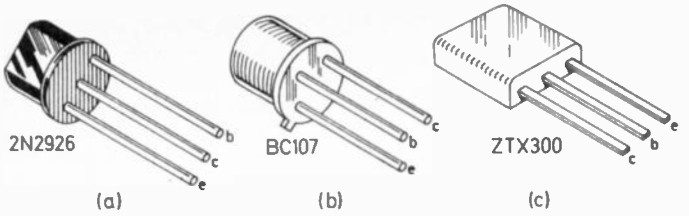


Fig. 1.4 Four types of commonly encountered transistors showing lead identification

must be preventing the flow of current.

Keeping the l.e.d. on the battery positive, touch the free end of the 10 kilohm resistor on the battery negative. Does the l.e.d. light?

Finally touch the 10 kilohm resistor on the battery positive. Is the l.e.d. on?

The transistor is acting as a switch — when the resistor is touched to negative (or disconnected) the switch is off, when to positive it is on.

WHY THE TRANSISTOR?

It might be wondered why the transistor is needed as a switch—why not an ordinary type?

There are several reasons: an ordinary switch has to have something to push the lever across—usually a finger—a transistor switch is operated by electric current; a transistor switch operates much faster than a mechanical switch—this being very important in computers where there are millions of switching operations to be carried out; a transistor switch is very reliable—it can switch on and off millions of times without breaking down — an ordinary switch would be worn out with such treatment.

There is still one point which could cause some bother: if a resistor is necessary to the battery to switch the transistor on, why not do away with the transistor and simply have the l.e.d. and its resistor wired in series? The l.e.d. would then light when the 560 ohm resistor was touched against the battery terminal!

The answer lies in the amount of current required to light the lamp. In the circuit of Fig. 1.5, current passing through the l.e.d. when it is alight is about 13 milliamps (0·013 amps). When the 10 kilohm resistor is connected to positive, the current passing through it is only 0·5 milliamps (0·0005 amps), see Fig. 1.6.

By using the transistor a very small current can be used to switch on a current large enough to light the lamp. This is a very useful way of saving power. It means that small batteries or light duty mains power supplies can be used and that very little heat is generated in the circuits.

Also it means that the transistor can be switched by devices such as photocells which produce only small currents, and that the transistor can be used to drive devices requiring large currents such as relays, motors and indicator lamps. Later in the series many circuits using transistors as switches will be found.

Before leaving Fig. 1.5, try writing a Truth Table for it. The solution is shown in Table 1.3.

Next month integrated circuits proper will be described together with a special re-useable board (as shown on the cover of this issue) which can be used for a multitude of experiments.

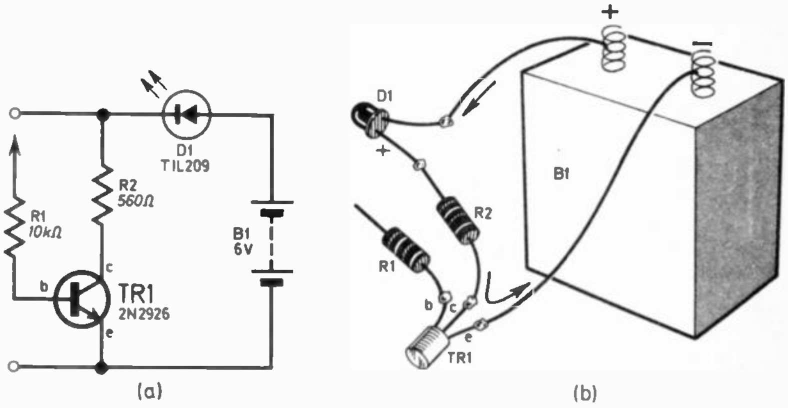


Fig. 1.5 The transistor used as a switch. The circuit is shown in (a) and the physical layout in (b).

Table 1.3. Truth Table of Fig. 1.5

Inputs (Connection of 10 kilohm resistor)	Output (State of l.e.d.)
L	L
H	H

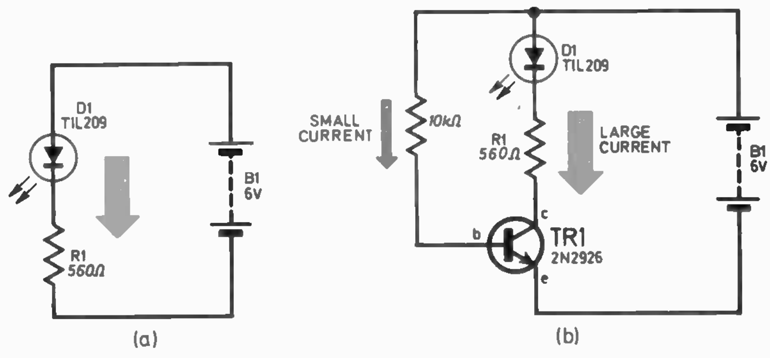
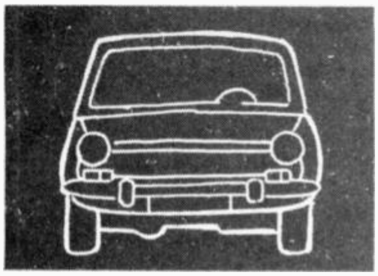
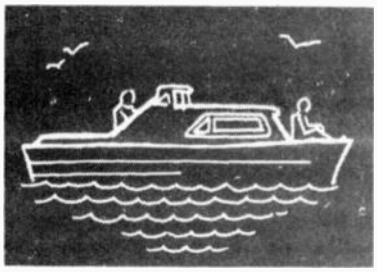


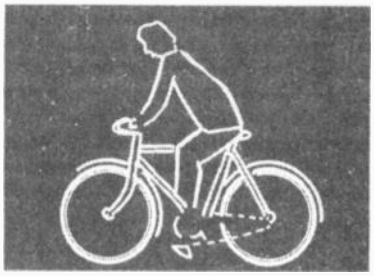
Fig. 1.6 (a) shows that a large current (relatively speaking) is needed to switch the l.e.d. on whereas at (b) a tiny current and a transistor achieve the same end.

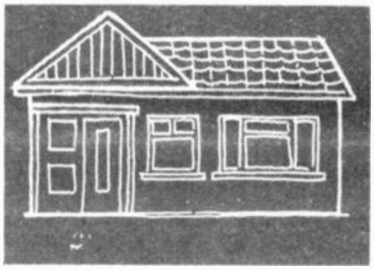




General Purpose BURGLAR ALARM

By D.H. WILLIAMS





Can be used for normally "open" and normally "closed" systems.

THIS article shows the development of a thyristor burglar alarm control module from a basic circuit to a full function module with testing facilities. The finished circuit can be built on a piece of stripboard 12 strips by 28 holes.

THYRISTOR OPERATION

The thyristor uses a small current in the gate/cathode circuit to control a large current in the anode/cathode circuit (Fig. 1).

Until triggered by a small current (I_{gt}) in the gate circuit, no current can flow from anode to cathode. When a current is applied to the gate the device starts to conduct between the anode and cathode and internal feedback causes it to remain in a conducting state even if the gate current is removed.

Conduction continues until the current through the thyristor drops below the "holding current" at which point the internal feedback is insufficient to maintain conduction and the device returns to its "off" state.

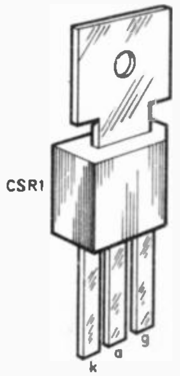
The theoretical symbol and the lead configuration of the thyristor used in the article are shown in Fig. 1.

GATE CIRCUITS

For alarm circuits there are two different conditions which must operate the thyristor, either opening a normally closed switch or closing a normally open switch.

Referring to Fig. 2a, if points *A* and *B* are connected to a normally closed switch the current through R1 is shorted to the negative rail and no current can flow into the gate. When the switch is opened current flows into the gate and triggers the thyristor.

In Fig. 2b points *C* and *D* are connected to a normally open switch, closing the switch applies the supply voltage to the gate through R2. Resistor R3 is used to decrease the sensitivity in this configuration, as without this the thyristor can trigger with as much as 2 megohms between *C* and *D*.



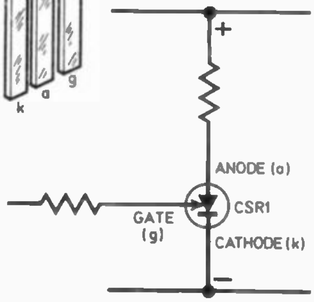


Fig. 1. Thyristor circuit symbol and lead-out details of the C106B1.

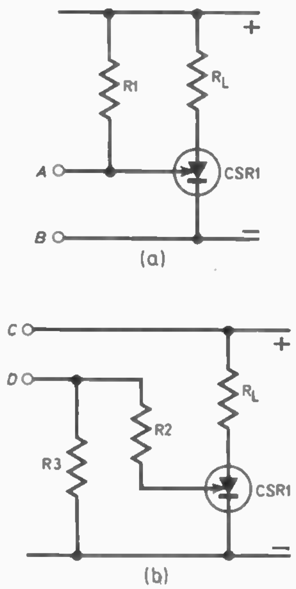


Fig. 2. (a). Breaking link between AB or (b) making CD—operates thyristor.

BASIC ALARM

The two gate circuits are used together in the basic alarm shown in Fig. 3. Diode D1 has been incorporated so that the normally closed loop does not short the gate to the negative rail which would prevent the normally open circuit triggering the thyristor.

Capacitors C1 and C2 suppress any transients or "spikes" picked up on the wiring, which may activate the alarm. Resistor R4 en-

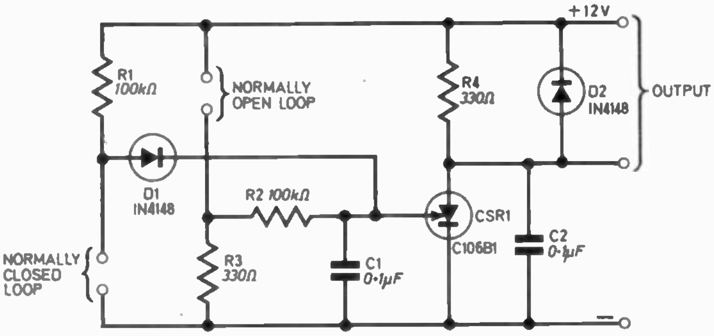


Fig. 3. The gating circuit for both normally open and normally closed systems.

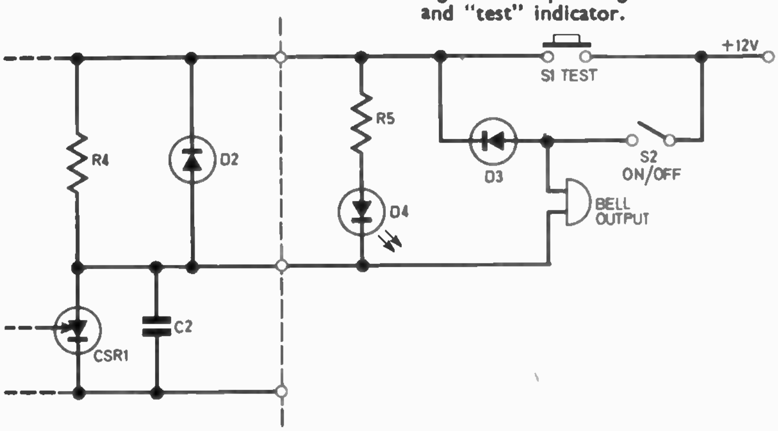


Fig. 4. Incorporating a test switch and "test" indicator.

sures that the current through the thyristor does not drop below the holding current.

One of the disadvantages of this circuit is that the bell rings if the alarm is switched on when a fault is present. The remedy is simple, a test switch is wired up so that when it is operated it applies power to the circuit but not to the bell, which can only ring when the on/off switch is operated. The additions needed for this are shown in Fig. 4.

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS excluding V.A.T.

£4.00 excluding remote switching loops and bell

When S1 is closed the circuit operates as before except that if a fault is present D4, an l.e.d., lights and the bell remains silent. Closing S2 enables the thyristor to ring the bell.

If one of the battery leads should become disconnected or the battery go flat, then pushing the test button would not cause the l.e.d. to light, which would seem to indicate that the alarm can be switched on, the alarm however, will not operate.

A more definite indication of the condition of the alarm would be given if operating the test switch caused either a "fault" or a "clear" indication, as failure of one or other of the indicators to light would point to a fault in the control system itself.

Another useful facility would be a "bell test" switch which operates the alarm independently of the on/off switch and allows the user to test the module as well as the bell.

THE FINAL CIRCUIT

The circuit which includes the above testing facilities is shown

Components

Resistors

R1	100kΩ
R2	100kΩ
R3	330Ω
R4	560Ω
R5	330Ω
R6	330Ω

All ¼ W ± 10% carbon

Capacitors

C1	0·1μF C280 type
C2	0·1μF C280 type

Semiconductors

CSR1	C106B1 thyristor
D1-D7	IN4001 diodes (7 off)
D8	TIL 209 red l.e.d.
D9	TIL 209 green l.e.d.

Miscellaneous

S1	s.p.s.t. key operated switch
S2	s.p. push to make button
S3	s.p. push to make button

Veroboard 17 strips by 28 holes by 0·15 inch matrix, 8 way plastic terminal block, connecting wire

NOTE:
Materials and components for the protective switching loops are not included in this list, nor is the alarm (bell etc.) or a power source. These must be selected to suit the protected property.

See Shop Talk

See page 512

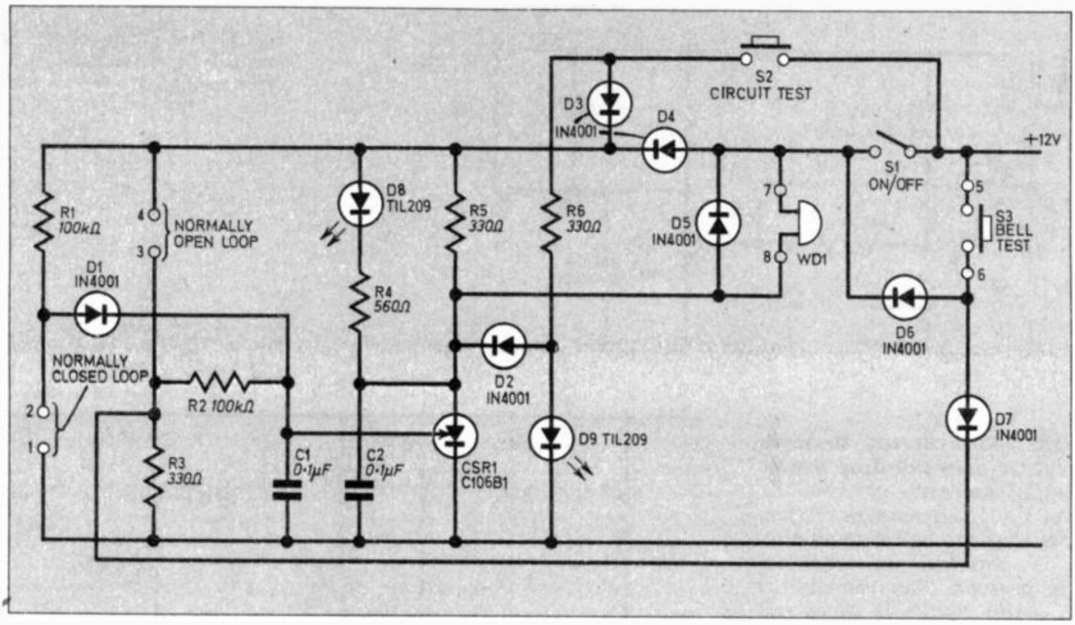


Fig. 5. The circuit diagram of the Burglar Alarm system.

in Fig. 5. The bell test simply switches the alarm on and simultaneously applies a trigger voltage to the gate circuit to ensure the thyristor switches on and therefore rings the bell.

The bell test may also be used remotely as a "personal attack" alarm by using latching switches.

The "clear" indicator is wired in such a way that if the thyristor switches on (fault condition) it shorts R6 to the negative rail and the l.e.d. (D9) does not light. If the thyristor stays switched off (clear condition) the l.e.d. draws current through R6 and lights.

Diodes D2 and D3 prevent the l.e.d. drawing current when the alarm is switched on by blocking the voltage at the junction of R5 and the anode of the thyristor, and also the voltage at the cathode of D4.

CONSTRUCTION AND USE

The layout of the final circuit is shown in Fig. 6. No details are given regarding a suitable cabinet as the size of this is determined mainly by the size of the chosen battery.

As the standby current drain of the module is only 120 micro-amps the important consideration is the ability of the battery to supply enough power to operate the bell for a reasonable time.

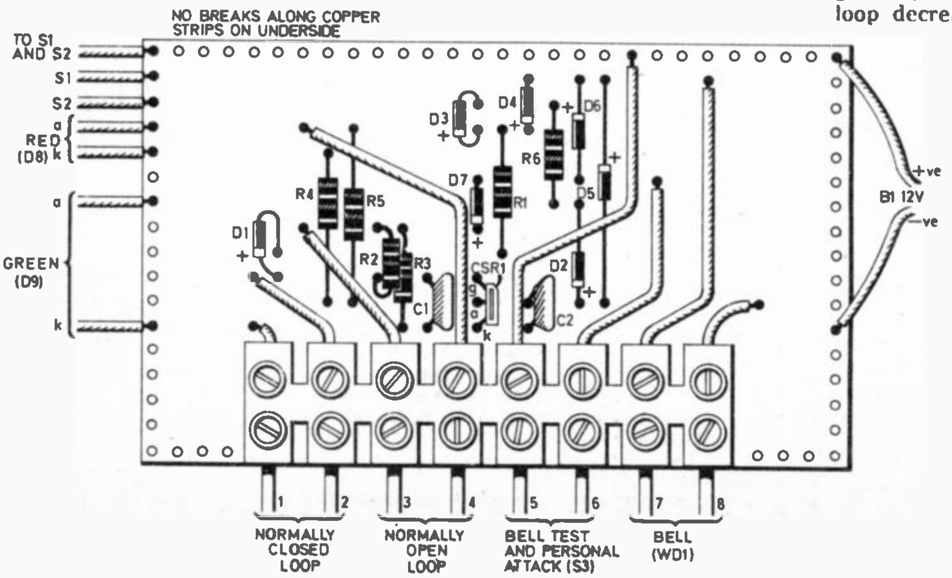
Although designed for use on 12 volts, this is not critical, the prototype worked down to 4 volts. The circuit can be powered by three $4\frac{1}{2}$ volt bell batteries connected in series without modification.

In use the alarm will activate if the normally closed loop resistance increases to 10 kilohms or greater, or the normally open loop decreases to 10 kilohms or less. These figures vary from thyristor to thyristor depending on the sensitivity of the device used.

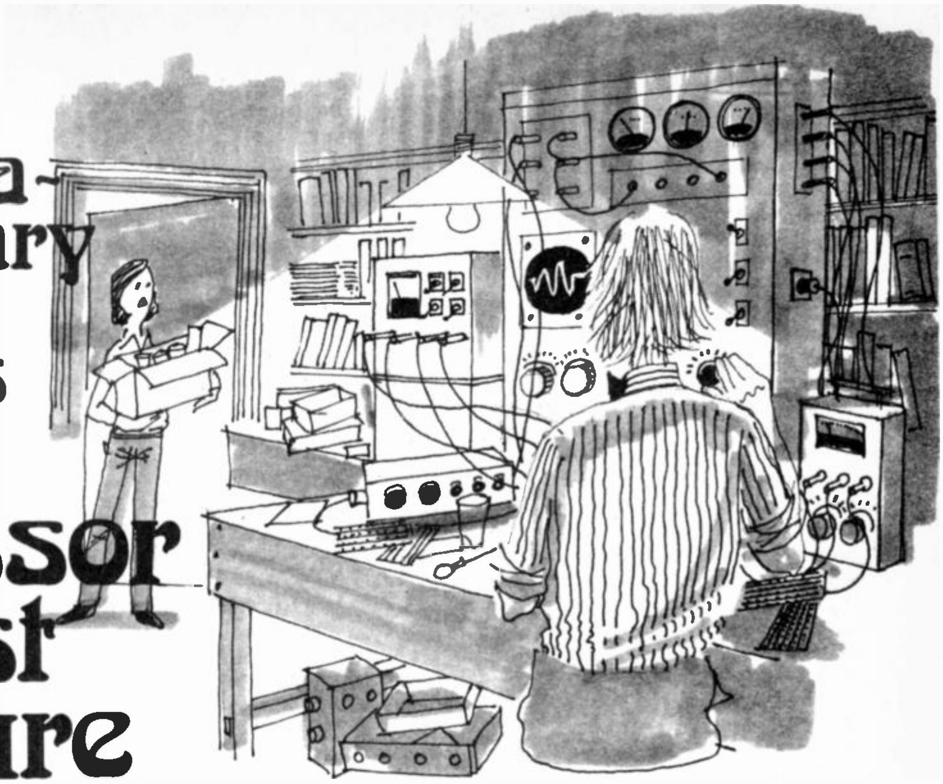
One prototype was able to withstand a short circuit across the bell terminals with a current of 6 amps through the thyristor for one minute without any ill effects. It also withstood a gate current of 45mA for one minute which is about 90 times the maximum.

Wiring of the protected property is left to the constructor.

Fig. 6. Layout of components on the board and wiring up details.



The Extra-ordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

HERE is a drawing of the older design, which relies on a change in air-pressure for its effect." The Prof. quickly drew a diagram on his sketch pad, see Fig. 1.

"The distance between the lever and contact *A* is adjusted so that natural variations in air pressure, or small changes in the speed of the fan, will not set off the alarm, but if an entrance sufficiently large to admit a human being is made, the alarm goes off!

"A second contact, *B* can be added, and this may be connected to a separate bell if the system is required to give a warning of high air pressure for some other purpose.

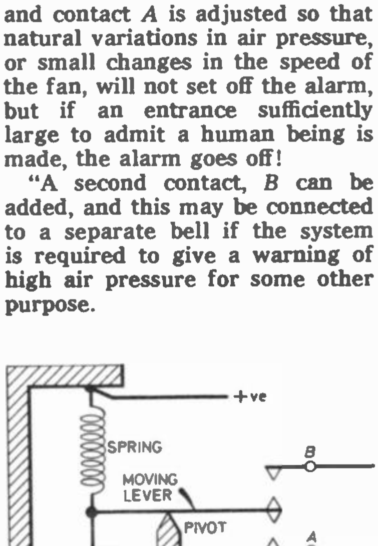


Fig. 1. As pressure reduces, moving lever applies power to bell via spring.

LATCHING RELAY

"A latching relay can be added to either of the contacts to keep the alarm ringing even if the lever returns to its normal position in between them."

"Prof., I've forgotten how a latching relay works I wonder whether you would explain it to me," Suzy requested.

"Certainly Suzy" said the Prof.

The Prof. drew another sketch on his pad see Fig. 2. "This is a circuit similar to the alarm on the previous sketch (Fig. 1) but with contacts *A* and *B* joined together so that the alarm will go off for either high or low pressure. When the moving lever touches either contact *A* or contact *B*, current flows through the relay coil, the relay contacts move over and this allows current to flow through the alarm circuit.

"When the moving lever moves away from the contacts *A* and *B*, the current ceases to flow through the relay coil and the alarm ceases to sound. But there is another set of contacts on the relay, and if switch S1 is closed, the circuit operates differently, as the relay 'latching action' can then occur.

"When S1 is closed, this puts the extra pair of contacts in parallel with contacts *A* and *B*. As soon as the moving lever touches *A* or *B*, the extra set of relay contacts closes and keeps the relay coil energised so that the alarm now continues to sound even if the moving lever no longer touches contacts *A* or *B*.

"Now, to stop the alarm, switch S1 may be opened, and the alarm will then stop only if *A* and *B* are also open circuit. You can easily see how switch S1 controls the latching action of the relay; by operating S1 you can choose whether or not latching action can occur."

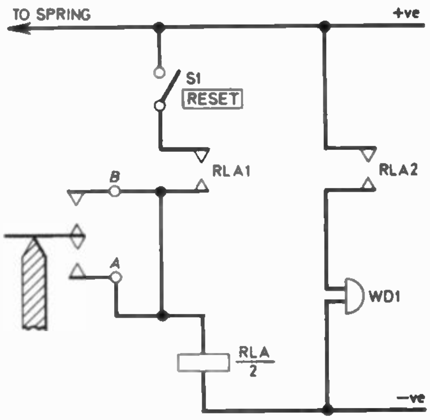


Fig. 2. Barometric alarm with latching relay and reset switch.

"Thanks, Prof.," said Suzy gratefully, "I remember now how a latching relay works. It seems to be a very useful device, and I suppose that most burglar alarms make use of a latching relay circuit or an electronic equivalent of it."

"Yes," the Prof. confirmed, "I suppose that latching relays are amongst the earliest types of electrically operated devices which have some form of a 'memory'.

"Now although there exist a great many electronic circuits, such as bistable circuits, and devices such as the CSR, which can be used for memory purposes, and which will in many cases act as replacements for relays, another very useful technique is to use electronic devices in conjunction with relays."

"Oh"! remarked Bob, "was one of your earlier visitors doing something like that? I noticed a gentleman with fluorescent bright green fingers; he was carrying a green relay, a number of green transistors, and resistors covered in green stripes on a green background. I did not dare go too near in case I caught the gardening bug!"

"Yes" remarked the Prof. "It can indeed be very infectious; I find gardening quite fascinating and, as with most fields of human endeavour, electronics can be very useful to the serious gardener in quite a number of ways.

"I have been discussing with my visitor, Percy Flower, an avid gardening and electronics enthusiast, a number of circuits which could be useful, and one of these, a barometric alarm circuit, is very similar to the barometric burglar alarm which we have just been discussing.

"Like the burglar alarm, it has an aneriod capsule and spring, and contacts *A* and *B* for low and high pressure respectively. However, as changes in the weather occur more frequently than the burglary of well-protected premises, Mr. Flower found that the contacts *A* and *B* on his barometric alarm circuit were becoming eroded by the relay coil current, and sometimes they would stick to the moving lever.

"Now although he tried putting a paper capacitor, and also a diode, in parallel with each of the contacts, what my visitor really wanted was a circuit which would greatly reduce the current through the contacts *A* and *B* without reducing the current through the relay coil to an extent where it would be insufficient to operate the relay.

"A very simple way to reduce the contact-current by the use of only one transistor, one capacitor and one resistor, can be used, and this reduces the current by a factor equal to the d.c. current gain of the transistor."

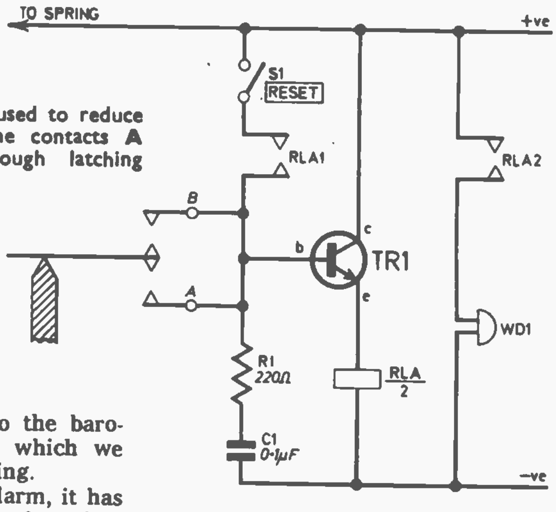
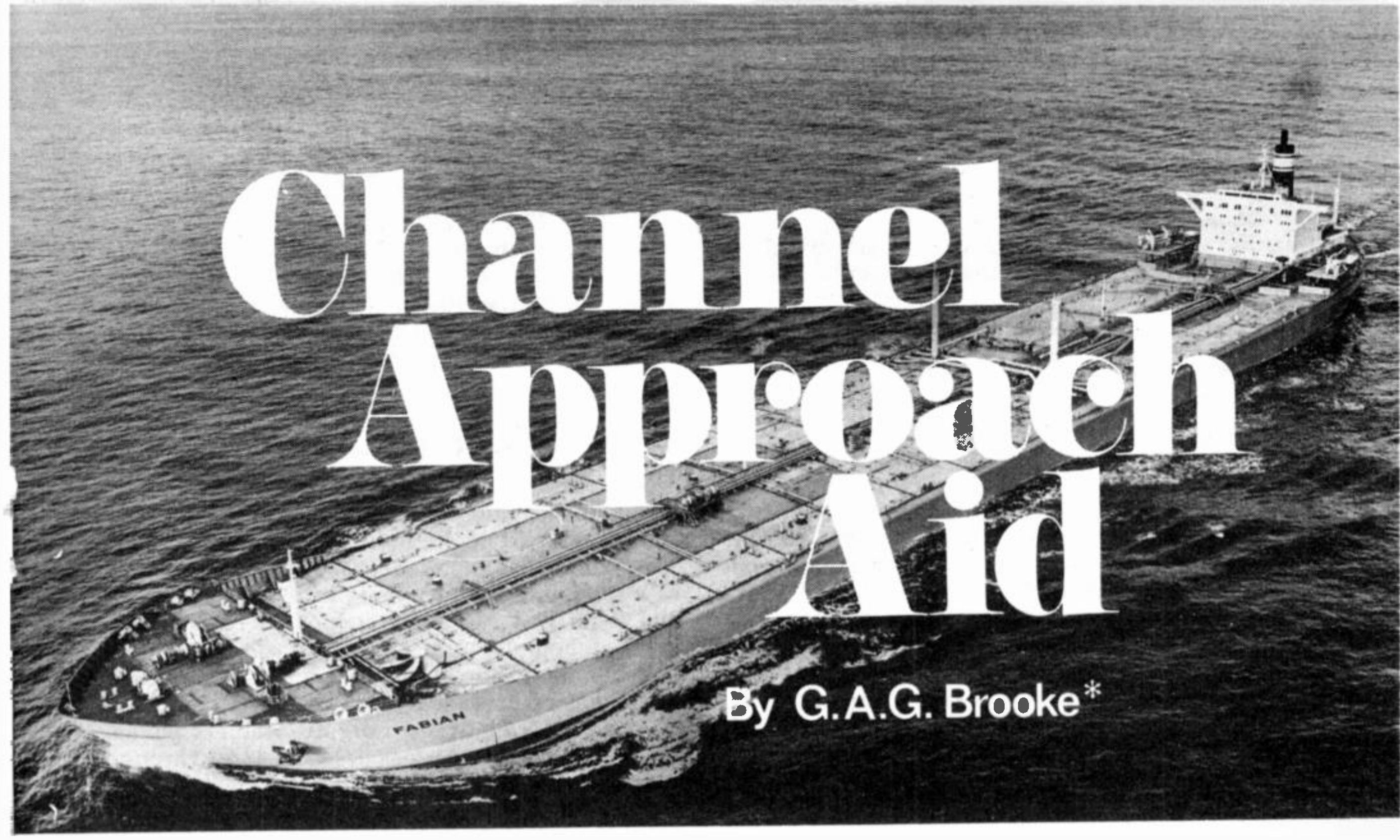


Fig. 3. The transistor is used to reduce the current through the contacts **A** and **B** and also through latching contacts.

The Prof. drew another circuit on his sketch pad to illustrate this as can be seen in Fig. 3.

"If the transistor has a current gain of about 50, when the contacts close, they will supply a small bias current to the base of the transistor which will start to amplify, so that a much larger current will flow from the collector to the emitter and into the relay coil. So if the gain of the transistor is about 50, the current flowing through the contacts will be about 50 times less than if the relay coil were directly connected to the coil as in the previous two circuits.

"Of course a small current also flows through the resistor and charges the capacitor when the contacts close, but in terms of contact erosion this is also very small."



Channel Approach Aid

By G.A.G. Brooke*

The advent of VLCCs (Very Large Crude Carriers) and supertankers, by which is meant vessels over 150,000 tons, has produced new and very difficult problems for their Masters and pilots. Years of experience of ordinary vessels give pilots uncanny extra sensory abilities, in much the same way that London bus drivers thread their way through traffic seemingly without a care in the world. A pilot, by definition, is a specialist in topography, both visible and underwater, of the port and, where appropriate, the esturial approach in which he operates.

In the ordinary course of his business he has come to depend largely on transits, observing familiar landmarks in relation to the jackstaff in the bows. By long experience he knows that when a certain, buoy, light or landmark is in line that he should then apply so much helm, and he is proficient at estimating rate of swing against a familiar skyline. He is also sensitive to physical accelerations and decelerations of the vessel. But the new very large ships have upset all this.

The enormous size of these vessels, most of which have the bridge mounted aft, means that the jackstaff may be up to a quarter of a mile away from the pilot, the immense weight means considerable difficulty in stopping and very slow rates of acceleration, and the steering becomes very sluggish at slow speeds. But the greatest difficulty of all comes in the estimation of speed. A Decca Radar engineer during the sea trials of the present equipment boarded a VLCC at sea and was under the impression that the ship was still stationary when it was making 7 knots.

A pilot would make a far better estimation, but this simple example of a layman's experience highlights the extraordinary unreality of the environment of a VLCC even in good visibility. In bad visibility it may not be possible to see the tugs or the bows of one's own ship. Tidal velocity is a big factor. For ordinary ships one may estimate the effect by observing the movement of surface water. For deep draught VLCCs an undercurrent in the opposite direction to surface movement may have greater influence.

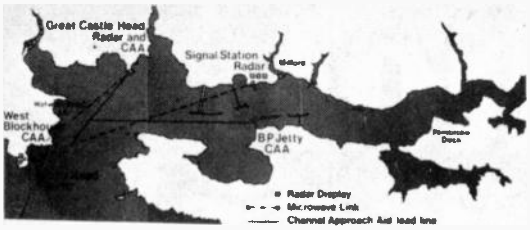
The pilot and helmsman may be regarded in engineering terms as parts of a multi-loop feedback system correcting errors in position and course. To achieve the desired result the inputs must measure linear and angular velocity and acceleration. In conventional pilotage these inputs are available to the pilot through his natural senses and his responses are conditioned by his repeated experience, becoming more refined as his judgement and skills improve. Put the same man aboard a VLCC and though his skills are the same his judgement is impaired because the quality of his inputs becomes effectively degraded.

ON-BOARD AID

There are of course instruments available such as gyro compass for direction, the log for speed and the Decca Navigator system for positioning but none are sufficiently accurate or instantaneous to be of service to a pilot in the

*Decca Radar Ltd.

Decca Radar Coverage at the Port of Milford Haven



particular instance of a supertanker making the final approaches to a port. The position is particularly acute at Milford Haven where there is a sharp turn to be made before the final approach to the oil terminals. It is vital to turn accurately, i.e. not too soon or too late or the confines of the channel may be exceeded; and not going too fast or the vessel will overshoot.

It takes a mile or more to stop a supertanker at about 7 kn., but too slow a speed loses steerage way. Something had to be done and the Milford Haven Conservancy board, after consultation with the pilots, called for an on-board aid from Decca, which the company has developed from an original concept by the Royal Radar Establishment, Malvern.

The design philosophy was based on the following features:

(a) The aid should be operative for the whole of the approach, turn and slow-down phases.

(b) It should inform the pilot of *speed*, *distance* from predetermined points and *deviation* from leading lines throughout all phases.

(c) The information should be precise and presented in easily readable form.

(d) There should be safeguards against any ambiguities of measurement from whatever reason.

(e) That self-check facilities be incorporated and that any malfunction is immediately apparent.

(f) The on-board equipment should be fully portable and operate independently of ship's power system and ship's normal navigation equipment.

(g) The internal power supply must be of sufficient "life" to last throughout the approach phase.

The eventual system, known as the Channel Approach Aid, consists of an onboard unit (the Aid) working in conjunction with any number of permanent shore beacons (there are three at Milford Haven, but we will only consider one of these here. The Aid, (self-powered by batteries) about the size of a brief case and weighing 22lbs, is taken onboard with the pilot when he embarks in the outer approaches to the harbour. He places it in the bridge window so that it is facing approximately in the direction of the desired beacon, selects this beacon and switches on.

The pilot is then provided with a running record on bright digital displays of range (nautical miles or feet), speed (knots or feet per min.), and offset (feet) either side of the leading line (the beacon having of course been placed in line with the centre of the channel). Range can either be to the beacon or any other predetermined point in between; in the case of the first beacon at Milford Haven it is to the turning point.

HOW THE SYSTEM WORKS

The principle of operation is not too complicated. The main complexities arise from the coding systems of the pulses and the very extensive built-in validity checks. The consequences of a stranding are terrifying in all aspects, financial (ship and cargo are valued in tens of millions of pounds), pollution (a constant anxiety), and danger to crew, not to mention dislocation of the entire port. So system integrity is a must.

As in all radar-type ranging systems advantage is taken of the constant velocity through space of radio waves. By measuring the time interval between the transmission of a pulse and its return from a target it is possible to determine range. For ordinary surveillance purposes, radars transmit a very powerful pulse and receive back the scattered reflections from one or more targets which themselves are completely passive, taking no active part in the operation.

In the case of the Channel Approach Aid interest is centred on a single target, the shore beacon. The latter is an active device with a receiver and a transmitter which, when a signal from the Aid is detected, actually transmits a reply. This system has two prime advantages:

(a) The response signal is very many times stronger than that from a passive reflector thus enabling a very low-power transmitter to be used in the Aid and a comparatively insensitive receiving system.

(b) A coding system may be used to ensure that no response is possible from the shore beacon unless a genuine interrogation from an Aid is received.

COMMUNICATION

We now have a basic radar-type ranging system with a communications link superimposed. The on-board unit and the on-shore unit can, in effect, "talk" to each other. We might imagine the "conversation" in human terms: Aid (selected to Beacon 1), "Hallo Beacon 1, are you receiving me?"

Beacon 1 receives the signal but is so programmed that it remains mute to any signal other than that coded for Beacon 1. So before it replies it examines the signal carefully to make sure that it is a genuine signal from an

Aid and addressed to itself. Having satisfied itself that the signal is valid it replies, "Receiving you loud and clear."

The Aid, happy to get a reply, nevertheless remains suspicious and decides to try again, just to be on the safe side, and the dialogue is then repeated. The reason why such repetition is needed is that microwave transmissions will bounce off objects in the vicinity. If, for example, another ship is up-channel it could be that the shore beacon is not receiving the line-of-sight signal from the Channel Approach Aid but a reflection of it from the other ship. Reflections can also be received from objects on the shoreline. In either case a single interrogation may produce a response because the code is correct, but the range measurement will be wrong unless the transmission path is direct line-of-sight and not via a third object.

In practice one may expect multiple reflections which are constantly changing with the movement of own-ship and the relative movement of other ships. In the ordinary way such interfering signals are greatly reduced by using highly directional aerials which give a sharp pencil beam. But in the case of the Aid the beam width is wide because of limitations in aerial structure in a small volume of space, and because a very highly defined beam would present considerable difficulties in alignment to acquire the shore beacon in the first instance, and then constant re-positioning of the equipment to keep it in line with the beacon as own-ship's heading is changed. One may also expect very strong interference pulses from radars on other ships which may superimpose themselves on the pulses of the Channel Approach Aid system.

IDENTIFICATION

The problem of identification is solved by the coding in the signal format. No response can be triggered unless the signal carries the correct beacon code. The decision as to whether true range is being measured, as distinct from a spurious range caused by reflection of the signal from other objects, is made by the internal circuits of the Aid.

The concept of repeated interrogation has already been touched upon. The Aid makes a total of 100 interrogations (99 interrogations when switched to nautical miles/knots) in rapid succession in a burst of signals. As each interrogation is made the reply is compared with those from previous interrogations, any inconsistency detected causing the reply to be rejected. In order to achieve 100 correct replies the Aid makes up to 256 interrogation attempts. If still unsuccessful it has a further 256 attempts, during which it ignores the offset part of the reply in order to increase the likelihood of obtaining a valid speed and distance answer.

Only after 100 interrogations have been successfully and consecutively concluded is the signal regarded as valid and an average is determined. After a lapse of 13·2 seconds a second burst of interrogations takes place and if this, too, is successfully concluded a second average is taken and the speed is computed from the elapsed time (i.e. distance run) between the two bursts. Range and speed are shown on the front panel displays which are updated approximately every 14 seconds.

A further protection in the Aid is provided by a threshold detection circuit in the receiver which only accepts signals above a certain amplitude, thus rejecting any signals which are fading badly. An Automatic Gain Control system prevents overloading when very close to the shore beacons. Another possibility, that either the on-board unit or shore beacon might receive spurious reflection from their own transmissions, is obviated by allotting them different transmitter frequencies.

SIGNAL FORMAT

A simple signal format is used consisting of two pulses transmitted in succession from the Aid. The spacing may be set to any one of four pre-set intervals of time in the range 13·6 to 53·9 microseconds by the beacon selector switch on the front panel. The shore beacon receiver has a circuit which will only accept pulses with a particular spacing and only when a pair of matching pulses is received will it respond with an identical pair. These are then followed by a third pulse the timing of which (in relation to the second pulse) is dependent on the direction from which the second received pulse was

The Decca Channel Approach Aid. Weighing 22lbs, and transported in a waterproof covering this is taken aboard with the pilot. At Milford Haven it functions in co-operation with one of three shore beacons, as selected, to provide speed, distance to any predetermined point and distance offset either side of the leadline. The Aid is entirely independent of any other system and incorporates its own batteries.

received. The time delay of the third pulse in relation to the second is proportional to the difference in bearing between the Aid and the leading line on which the shore beacon is aligned.

BEARING MEASUREMENT

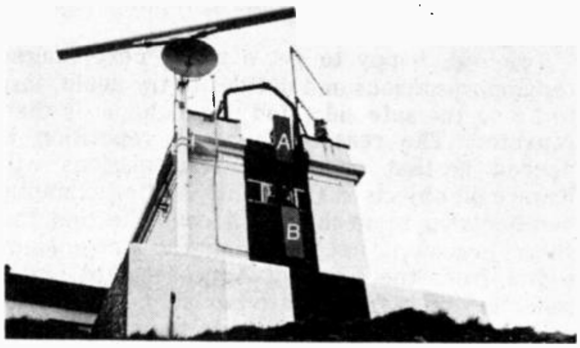
The shore beacon has a much more elaborate aerial system than the onboard unit. Basic operation is on the interferometer principle. In this case there is a horizontal array of five aerial elements. No. 1 element is only for receiving radar data and transmitting back to the onboard unit. No. 2 is a reference for 3, 4 and 5. The baseline of the array is at right angles to the leadline of the channel.

If the Aid is plumb on the leadline all the aerial elements will receive its signal at the same instant, but as soon as the Aid moves off to one side the path of its signal will be progressively shorter to the elements on that side and longer to the others; because the waveform has further to travel the phase on arrival will of course be different in each case. After measurement of this difference by a phase comparator unit a signal is derived which is proportional to the azimuth angle—or bearing—from which the signal came. Offset (in these cases of very small angles) equals range times the angle in radians.

Aerial elements nos. 3, 4 and 5 are necessary because, especially at the wider angles of incidence, the phases repeat themselves to cause ambiguity. Also, the further from the reference the more accurate the measurement. Accordingly a logic unit accepts readings simultaneously from 3, 4 and 5, matters being arranged so that the information is complementary from the phase point of view and that the channel fed by no. 3 indicates left or right and whether within the arc 7 degrees to 25 degrees from the leadline, no. 4 whether within 2¼ degrees to 7 degrees and no. 5 a very much smaller bracket. Actual bearing accuracy near the leadline is ⅛ degrees, lessening as the signal source (i.e., the Aid) moves outwards.

Two such (horizontal) aerial arrays are actually used, one immediately above the other in order to overcome Lloyd's mirror effect and the possibility of a spurious echo being received. (Lloyd's mirror effect is when there is both a direct signal and an indirect one, probably reflected off the water. Should they arrive at the aerial out of phase they will cancel out and no signal will be received). It is also possible that at this instant a reflected signal may be received from say another ship close to the leadline and accepted as legitimate.

If two arrays are employed vertically the chances of them receiving a signal at the same phase are much reduced; so the angle as measured by both arrays are compared; if found



One shore beacon of a Channel Approach Aid. Marked A and B are the two aerial arrays, mounted vertically. To the left is the scanner of the separate harbour radar system.

to be equal, then and only then is the third pulse containing the angle informations transmitted. The two arrays are virtually standard Decca 4ft. slotted waveguide aerials from the Group 9 series of radars stood on end. What can be termed a bonus of this arrangement is that the horizontal polarisation normally provided by these aerials now becomes vertical polarisation which much reduces the hazard of interference from the harbour radar and ship's radars operating in the vicinity.

The phase measurement is done on the second of the twin pulses from the Aids. Pulse two from the Aid is used to determine offset from the leading line. As with the first two pulses, the third pulse is constantly monitored in the Aid for consistency over a number of transmissons and the offset reading inhibited if inconsistencies are detected.

BEACON ACQUISITION

There is no "tuning in" required to the beacon except to select the number of the shore beacon it is required to "home" on. As has already been mentioned, there is considerable latitude in pointing the Aid in the direction of the beacon and it is a fact that most tankers arrive fairly accurately on compass bearing and it generally suffices to position the Aid squarely in the wheelhouse window with the aerials directed fully forward along the centre line of the ship.

A complete confidence check is, however, incorporated and this is brought into action when the align position of the scale switch is selected. The Aid will then continuously interrogate the beacon and the replies can be observed by watching the appropriate beacon lamp. When the lamp lights the beacon has been acquired and the Aid is then rotated until the beacon lamp shows maximum brilliance.

FAULT INDICATIONS

If the shore beacon is inhibited from transmit-

ting offset (i.e. bearing) information because the phase measurement differs between the two aerial systems the offset digital readout will be extinguished.

The beam width of that part of the shore beacon aerial system used for phase measurement is ±8 degrees and therefore the Offset distance in feet that can be measured is proportional to the distance of own ship from the beacon, decreasing as own ship closes in on the beacon. If own ship is outside the limits of ±8 degrees the Offset reading will indicate the offset appropriate to the ±8 degrees angle but the left or right indicator lamp will flash.

If there are insufficient valid replies from the shore beacon both the range and speed digital displays will flash on and off. If the scale switch is selected to turn and own ship passes beyond the turn point, the range display will have passed beyond the zero reading and as no negative reading is possible the displays are extinguished until either distance to beacon is selected or another beacon is selected.

The battery low lamp, will flash to indicate a low battery state but the equipment will still be usable.

CONSTRUCTION

The Channel Approach Aid is housed in a GRP case which has metallised screening on the internal faces except for the aerial aperture. Two separate aerials are used, one for receive and one for transmit. In both cases they are printed circuit dipoles. There are two main electronic assemblies in the case. One group comprises the aerials, the transmitter and receiver, and the power supply for the local oscillator. The other group comprises the logic circuits, the displays and their drive circuits, the main power supplies and all the controls.

The equipment is completely solid state; the great bulk of the circuitry is achieved by some 160 TTL integrated circuits of proven reliability.

Economies in battery drain are important and these are obtained in two ways: The 13 LED 7-segment displays would normally use 13 decoder drivers. By using multiplexed tri-state logic only one decoder driver is used for seven of the displays and a second decoder driver for the remaining six displays.

All but essential circuits (i.e. timing, number storage and visual displays) are switched off for over 80 per cent of the operating time as they are not required except when actively transmitting and receiving. The contrast can be seen when align is selected and the circuits are continuously powered. If left selected to align the ting and receiving.

The shore beacon installation consists of completely duplicated equipment normally operating from the ordinary power lines supplemented by a local emergency supply. ▣

Physics is FUN!

By DERRICK DAINES

Heat and Voltage

WITH the sun blistering down outside, now seems as good a time as any to talk about heat and to conduct a few experiments on it. As every schoolboy knows, there are three forms of heat transference—conduction, convection and radiation—and many interesting studies to be made on each. At first sight, there may not seem to be much in the nature of heat that would interest the electronics enthusiast, but once you've burnt a hole in your jacket with a soldering-iron or put your hand on a hot coil, you will appreciate there is a lot in the subject for us!

Perhaps the simplest lesson to be learned apropos heat and electronics is that a current in a wire will dissipate some of its energy as heat. Experimentation has shown that this applies to ANY current in ANY wire, solely excepting the new science of super-cooled conductors, which is beyond the scope of many of us to experiment with. For ordinary purposes then, some energy is lost whenever we put a current through a wire. This energy loss generally manifests itself in the first instance as a voltage drop and then as discernible heat.

As an illustration of this, owners of model railways are invited to take voltage readings at various points along their layout; it will be found that the voltage is lowest at the point furthest away from the supply (Fig. 1). On a small layout this voltage drop may be only 0·5 volt or less and will require a sensitive meter to measure, but it is there nevertheless. Large layouts may have a considerable voltage drop that must be offset by extra supply lines to the point concerned if the performance of model locos is not to drop off.

Thermocouple

Heat has been described as the great sink down which all wasted energy is poured; energy that is not readily or efficiently recoverable. The energy that has been lost in transferring the electrical energy along the wire has been lost down the sink—it has been turned into small quantities of heat.

The reverse process is also possible—that of turning heat directly into electrical energy, but with a great loss of efficiency, as will become obvious.

Twist together the ends of a copper wire and an iron wire as shown in Fig. 2. If the free ends of the wires are connected to a meter and the twisted joint held over a flame, the small deflection of the meter needle will show that a very weak current has been formed. This current is called a thermo-current and we have a basic thermocouple.

Homemade Thermopile

Several thermocouples together are called a thermopile. Proceed as follows. Cut 6 pieces of copper wire each about 5 cm long and one of about 20 cm. Cut the same number and lengths of iron wire. Proceed to twist them together alternately by their ends—copper, iron, copper, iron, etc.—leaving the long pieces until last, as in Fig. 3. The result is thermopile that will show a current-deflection on most meters, when the junctions are heated, since the weak currents from each copper/iron junction are added together.

Of course, as a source of electrical energy the thermopile is grossly inefficient, but it has wide use as a temperature-sensitive device in rugged conditions—inside a kiln or furnace, for example, where the current is amplified and used to give an accurate reading of the temperature inside the kiln.

Coincidentally, it has been found that although current flows, there is no movement of copper atoms into the iron or vice-versa even after long periods. This throws light on the nature of electricity; the nuclei of the metal atoms must remain in their respective materials, while their satellites, the electrons, are free to move.

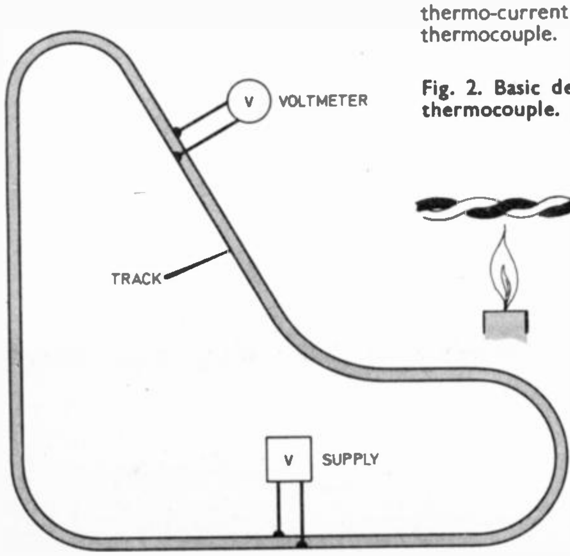
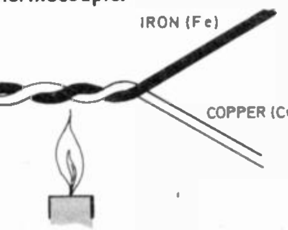


Fig. 1. Voltage measurements taken around the track will show voltage drop is maximum furthest from the supply.

Fig. 2. Basic detail of a simple Cu-Fe thermocouple.



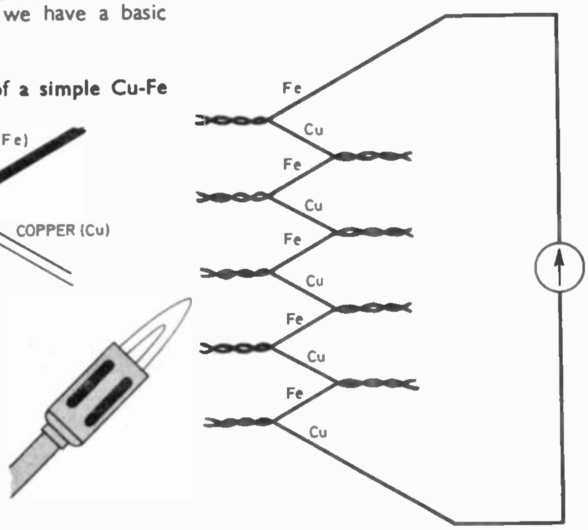


Fig. 3. When the Cu-Fe junctions are heated, the meter will be deflected by the accumulative effect of each thermocouple.

GEORGE HYLTON brings it down to earth

Inductors and Capacitors

"EVER since *I have been doing electronics*", writes John Hague of York, "*I have been faced with inductors, coils and capacitors and have wondered how to find the values of these components for certain jobs. Please could you give me some advice?*" There are really several questions involved in this request, which is no doubt why the editor, in sending on John's letter, dropped his usual reserve and remarked sympathetically that it was a "tough one".

To make life a little easier, I'll tackle only one aspect of the problem—how to decide how much inductance and capacitance is needed in a particular case.

The common application of an inductance is to form a tuned circuit, in conjunction with a capacitance. Such a circuit is often called an *LC* tuned circuit from the letters *L* & *C* which are the usual symbols for inductance and capacitance. In an *LC* tuned circuit, increasing either *L* or *C decreases* the frequency.

Example

Let's look at a practical example of the kind of problem which crops up. A design for a simple radio receiver contains the tuned circuit shown in Fig. 1. This specifies a variable tuning capacitance of 300pF. (That is, the capacitance with the moving plates fully meshed with the static ones is 300pF.) You have a very nice tuning capacitor, which you would like to use, but its capacitance is 500pF, not 300pF as specified. Can the inductance be changed to make this possible?

The answer is yes, it can. Changing the 300pF capacitance to 500pF reduces the tuned frequency. To raise the frequency again to its original value calls for a corresponding *decrease* in the inductance. There are two inductances *L*1 and *L*2 in Fig. 1. Only L1 need be considered, as far as tuning goes. *L*2 is just a coupling winding, to lead out the signals to the rest of the circuit. So, how much must L1 be reduced?

The answer is really quite straightforward. The frequency depends on both *L* and *C*, as you know. In fact, frequency depends on *L times C*. If you change *C*, you must change *L* in such a way that the product (*L* times *C*) is still the same.

In the example, we have 300pF and 200μH. So long as we keep working in the same units (pF and μH) we can, in working out, forget the units and just use the numbers. Here $LC = 300 \times 200 = 60{,}000$. We need a new *L* such that with our new *C* of 500 we still have $LC = 60{,}000$.

In mathematical terms, $500L = 60{,}000$. You'll find that the new *L* has to be 120 to make this work out. So L1 must be reduced from 200μH to 120μH (L2 can be left as it is.) If you want the rule spelled out, it is:

$$\text{New } L = \frac{\text{Old } L \times \text{Old } C}{\text{New } C}$$

which, in the form of an instruction, says: "Multiply the original inductance by the original capacitance, and divide the answer by the new capacitance".

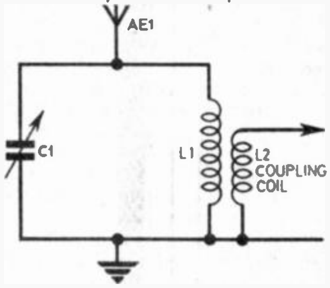


Fig. 1. A simple parallel tuned LC circuit.

The Reverse

It may happen in other cases that you can make *C* what you like but are stuck with some fixed value of *L*, different from the inductance specified by the design. In this case, the rule is:

$$\text{New } C = \frac{\text{Old } L \times \text{Old } C}{\text{New } L}$$

If you think about it, you'll see that you can, in theory, use any value of *L* you like and always get the frequency you need by using the appropriate *C*. (Or any value of *C* then use the appropriate *L*). In practice, however, the range of values which can be used is quite restricted.

Limits

In high-frequency tuned circuits, a lower limit to *C* is imposed by "stray capacitance" between wires, inside transistors, and so on. This can easily be as much as 20pF. At still higher frequencies stray inductance becomes a problem. Even a straight piece of connecting wire has some inductance, so in a practical circuit there's always an irreducible minimum of inductance of a few thousandths of a micro-henry.

In low frequency tuned circuits, another factor comes in. It becomes difficult to obtain sharp tuning if *L* is small and *C* large—unless a very big coil is used for *L*. Also, large values of *C* are expensive, because generally speaking electrolytic capacitors cannot be used and the alternative paper or plastic-film capacitors cost much more.

Formulae

Many people find the formula for a tuned frequency;

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

difficult to use. It is possible to obtain alignment charts (also called nomograms and abacs) which do the job for you. All you do is join the known quantities with a straight line and then you can read the unknown one from a scale; e.g. if you know the frequency and the inductance you can read off the required capacitance.

If you are slightly more mathematical you can use modified formulae which avoid the awkward square root. To do so you must first work out a new quantity which I'll call *F*. To find *F* you work out the square of the frequency f and multiply by 40:

$$F = 40f^2$$

The formulae for finding *L* and *C* are now:

$$C = \frac{1{,}000{,}000}{F \times L} \text{ (picofarads)}$$

$$L = \frac{1{,}000{,}000}{F \times C} \text{ (microhenries)}$$

The frequency must be in megahertz, *L* in μH, and *C* in pF.

Example:

What inductance tunes 500pF to 500kHz?

First, 500kHz = 0·5MHz, and $40f^2$ becomes $40 \times 0{\cdot}5 \times 0{\cdot}5 = 10$. The inductance needed is $(1{,}000{,}000)/(10 \times 500) = 200\,\mu$H.

". . . Now, you're saying to yourself, would a supply decoupling capacitor be the answer to the voltage drops in the power supply wiring . . ."

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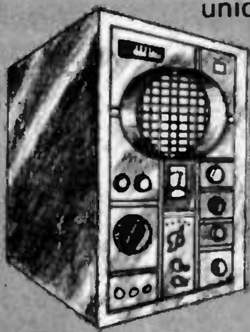

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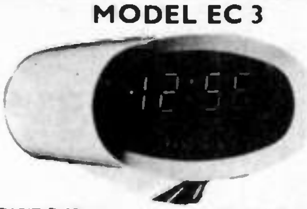

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