Easy to build projects for everyone

FEB 78

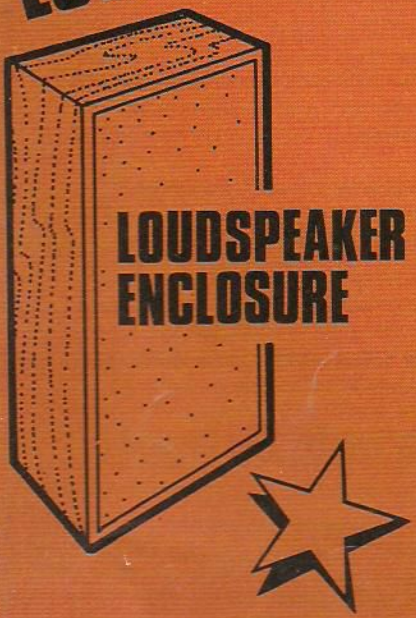
40p

Everyday ELECTRONICS

A.C. METER CONVERTER

CHASER LIGHT DISPLAY

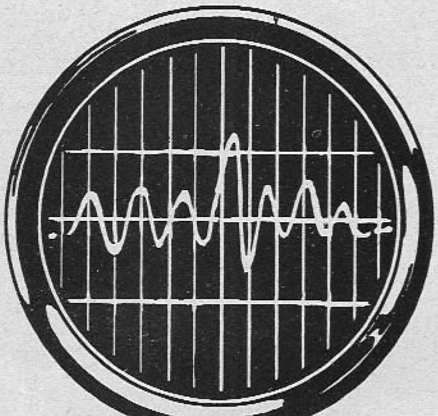
LOW COST



CAR SYSTEM ALARM

LOOK! Here's how you master electronics.

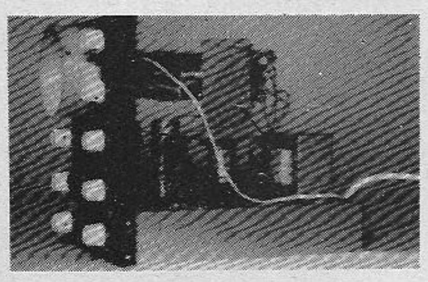
....the practical way.

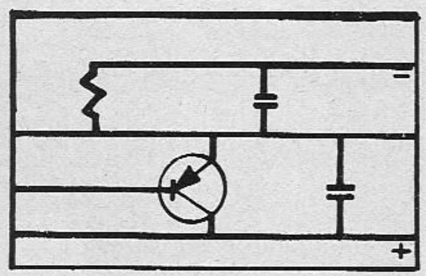


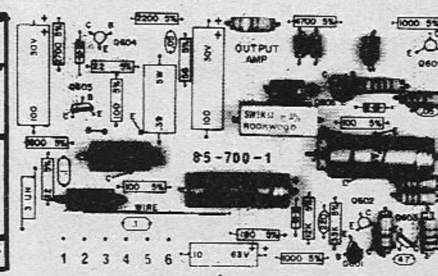
This new style course will enable anyone to have a real understanding of electronics by a modern, practical and visual method. No previous knowledge is required, no maths, and an absolute minimum of theory.

You learn the practical way in easy steps mastering all the essentials of your hobby or to further your career in electronics or as a self-employed electronics engineer.

All the training can be carried out in the comfort of your own home and at your own pace. A tutor is available to whom you can write, at any time, for advice or help during your work. A Certificate is given at the end of every course.







1 Build an oscilloscope.

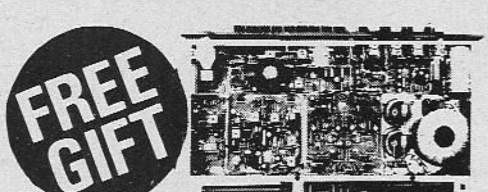
As the first stage of your training, you actually build your own Cathode ray oscilloscope! This is no toy, but a test instrument that you will need not only for the course's practical experiments, but also later if you decide to develop your knowledge and enter the profession. It remains your property and represents a very large saving over buying a similar piece of essential equipment.

2 Read, draw and understand circuit diagrams.

In a short time you will be able to read and draw circuit diagrams, understand the very fundamentals of television, radio, computors and countless other electronic devices and their servicing procedures.

3 Carry out over 40 experiments on basic circuits.

We show you how to conduct experiments on a wide variety of different circuits and turn the information gained into a working knowledge of testing, servicing and maintaining all types of electronic equipment, radio, t.v etc.



All students enrolling in our courses receive a free circuit board originating from a computer and containing many different components that can be used in experiments and provide an excellent example of current electronic practice.

Free!

To find out more about how to learn electronics in a new, exciting and absorbing way, just clip the coupon for a free colour brochure and full details of enrolment.

British National Radio & Electronic School

P.O. Box 156, Jersey, Channel Islands.

NAME ____________________

ADDRESS ____________________

EEB2 Block caps please

Now even better, even more powerful! The unique wrist calculator.

AVAILABLE ONLY AS A KIT.

Assembling the Science of Cambridge wrist calculator.

The wrist calculator comes as finished components, ready for assembly. All you need is two or three hours, and a fine-tip soldering iron.

If anything goes wrong, we'll replace damaged components free. We want you to enjoy building the kit, and to end up with a valuable, useful, powerful calculator.

Contents.

Acrylic/ABS case and display window parts. Two-part stitched strap and spring bar clips. PCB. Special direct-drive chip (no interface chip required). Display. Keyboard components. Batteries.

Each of the 34 components is contained in a plastic box; and neatly shrink-wrapped, accompanied by full instructions for assembling and using the calculator. All components are fully guaranteed.

KIT ONLY £9·95 Plus VAT, P&P

A wrist calculator – the ultimate in common-sense portable calculating power. Goes where you go, ready for action at a flick of your wrist.

By virtue of its size, a wrist calculator is different to a pocket calculator. And now this wrist-machine has another difference. It has even more power than some much larger pocket calculators!

And what's more, because it's a kit, supplied to you direct from the manufacturer, it costs just £9.95 (plus 8% VAT, P&P). And for that you get a calculator with extra power, and all the satisfaction of building it yourself!

Put real calculating power up your sleeve.

The Science of Cambridge wrist calculator gives you the full range of arithmetic functions (+, −, ÷, ×, =). It uses ordinary algebraic logic, which means you enter calculations as you would write them. It has a % key, the convenience functions, $\sqrt{x}$, $1/x$, x^2 and a full 5-function memory.

And incredibly, it has a clear-last-entry key, pi, brackets, and ⁻/₊. It even has an automatic linear metric conversion function!

Very few ordinary calculators have the same functions for the same sort of money.

Now 10 keys can do the work of 32.

All those functions, from just 10 keys? In such a small calculator? The secret lies in the special four-level keyboard. Each level has a different set of functions. Simple two-way switching system allows you to select any keyboard level quickly and easily. Each set of functions is carefully grouped, to let you whisk through calculations with the minimum of switching.

And the answers come up bright and clear, too. The display uses 8 full-size red LED digits. It has wide-angle magnification, and is easily visible under any light conditions.

More battery power, too!

With the Science of Cambridge wrist-calculator, you'll get up to 30 hours use between battery changes (that's a lot of calculating!).

The wrist calculator kit is available only direct from Science of Cambridge. If, for any reason, you're not completely satisfied with your wrist calculator, return it to us within 10 days for a full cash refund. Send the coupon today!

Science of Cambridge Ltd.
(Previously Sinclair Instrument Ltd)
6 Kings Parade, Cambridge, Cambs. CB2 1SN.

To: Science of Cambridge Ltd., 6 Kings Parade, Cambridge, Cambs. CB2 1SN.
*Please send me..........................(qty) Science of Cambridge wrist calculators kits, at £9.95 plus 80p Vat and 25p P&P (total £11) each.
Overseas orders may be subject to postal surcharge .
*I enclose cheque/PO/money order for £..........................

NAME____________________

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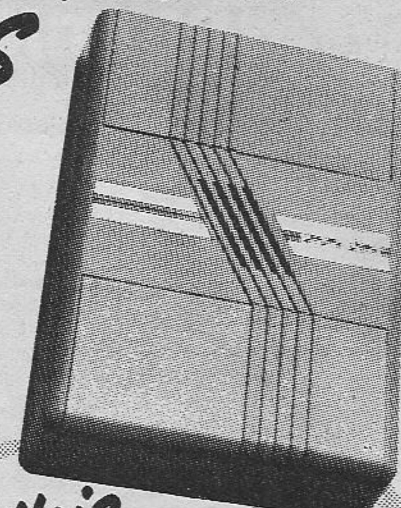
EE
*Complete as appropriate (please print)

TUNE IN TO THE WORLD OF MICROPROCESSORS



Give your friends a warm welcome

Here's the Chroma-Chime—a perfect example of British scientific achievement brought right to your own front door. Now—you can be among the first enthusiasts in the world to build your own electronic musical door chime—a door chime with no moving parts. There are 24 of the world's favourite and best known tunes pre-programmed onto the microcomputer chip so that all you have to do is to set the Chroma Chime's built-in selector switches to a code to index the "tune of the day" from the repertoire:

Greensleeves	Beethoven's "Fate Knocking"	Soldier's Chorus
God Save the Queen	The Marseillaise	Twinkle, Twinkle Little Star
Rule Britannia*	Mozart	Great Gate of Kiev
Land of Hope and Glory	Wedding March	Maryland
Oh Come All Ye Faithful	Cook House Door	Deutschland uber Alles
Oranges and Lemons	The Stars & Stripes*	Bach
Westminster Chimes*	Beethoven's Ode to Joy	Colonel Bogie
Sailor's Hornpipe	William Tell Overture	The Lorallie

*These tunes play longer if the push button is kept pressed.

Since everything is done by precise mathematics, it cannot play the notes out of tune.

The unit has comprehensive built-in controls so that you can not only select the 'tune of the day' but the volume, tempo and envelope decay rate to change the sound according to taste.

Not only visitors to the front door will be amazed, if you like you can connect an additional push button for a back door which plays a different tune!

This kit has been carefully prepared so that practically anyone capable of neat soldering will have complete success in building it. The kit manual contains step by step constructional details together with a fault finding guide, circuit description, installation details and operational instructions all well illustrated with numerous figures and diagrams.

- Handsome purpose built ABS cabinet
- Easy to build and install
- Uses Texas Instruments TMS1000 microcomputer
- Absolutely all parts supplied including I.C. socket
- Ready drilled and legended PCB included
- Comprehensive kit manual with full circuit details
- No previous microcomputer experience necessary
- All programming permanently retained is on chip ROM
- Can be built in about 3 hours!
- Runs off 2 PP3 type batteries.
- Fully Guaranteed

The CHROMA-CHIME is exclusively designed by

CHROMATRONICS

River Way, Harlow, Essex.

Build this 24 Tune Electronic Door Chime for only £18*

*Complete chroma-chime Kit includes P&P + VAT

- * *A great introduction to the fascinating world of microcomputers.*
- * *Save pounds on normal retail price by building yourself.*

To CHROMATRONICS, River Way, Harlow, Essex, U.K.

Please send ☐ Chroma-Chime Kits at £18·00 each including VAT and post and packing

PLEASE USE BLOCK CAPITALS

Name ____________________

Address ____________________

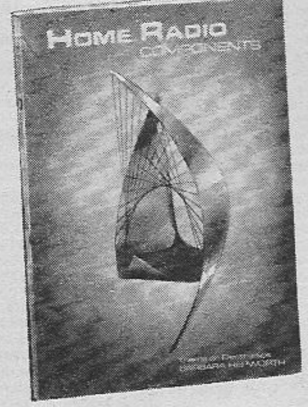
I enclose cheque/PO value £ ____________
or debit my ACCESS/BARCLAYCARD account No.

Signature ____________________

N.B. The CHROMA-CHIME is also available, fully assembled, price £24·95 inc VAT and post and packing.

EE2/78

Start the New Year well by buying this famous Component Catalogue!



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Sparkrite mk2

Capacitive discharge electronic ignition kit

VOTED BEST OF 8 SYSTEMS TESTED BY 'POPULAR MOTORING' MAGAZINE OCT '74

- **Smoother running**
- **Instant all-weather starting**
- **Continual peak performance**
- **Longer coil/battery/plug life**
- **Improved acceleration/top speeds**
- **Optimum fuel consumption**

Sparkrite Mk. 2 is a high performance, high quality capacitive discharge, electronic ignition system in kit form. Tried, tested, proven, reliable and complete. It can be assembled in two or three hours and fitted in 15/30 mins.

Because of the superb design of the Sparkrite circuit it completely eliminates problems of the contact breaker. There is no misfire due to contact breaker bounce which is eliminated electronically by a pulse suppression circuit which prevents the unit firing if the points bounce open at high R.P.M. Contact breaker burn is eliminated by reducing the current to about 1/50th of the norm. It will perform equally well with new, old, or even badly pitted points and is not dependent upon the dwell time of the contact breakers for recharging the system. Sparkrite incorporates a short circuit protected inverter which eliminates the problems of SCR lock on and, therefore, eliminates the possibility of blowing the transistors or the SCR. (Most capacitive discharge ignitions are not completely foolproof in this respect). All kits fit vehicles with coil/distributor ignition up to 8 cylinders.

THE KIT COMPRISES EVERYTHING NEEDED

Ready drilled pressed steel case coated in matt black epoxy resin, ready drilled base and heat-sink, top quality 5 year guaranteed transformer and components, cables, coil connectors, printed circuit board, nuts, bolts, silicon grease, full instructions to make the kit negative or positive earth, and 10 page installation instructions.

OPTIONAL EXTRAS

Electronic/conventional ignition switch.
Gives instant changeover from "Sparkrite" ignition to conventional ignition for performance comparisons, static timing etc., and will also switch the ignition off completely as a security device, includes: switch connectors, mounting bracket and instructions. Cables excluded.
Also available RPM limiting control for dashboard mounting (fitted in case on ready built unit).

CALLERS WELCOME. For Crypton tuning and fitting service – 'phone (0922) 33008.

PRICES INCLUDE VAT, POST AND PACKING.

IMPROVE PERFORMANCE & ECONOMY NOW

Note—Vehicles with current impulse tachometers (Smiths code on dial RV1) will require a tachometer pulse slave unit. £3·35 inc. V.A.T. p & p.

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POST TODAY!

Quick installation — **No engine modification required**

Electronics Design Associates, Dept., EE 12
82 Bath Street, Walsall, WS1 3DE. Phone: (0922) 33652

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Address ....

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	QUANTITY REQD.
Mk. 2 DIY Ass. Kit @ £11.80	
Mk. 2 Ready Built Negative Earth @ £14.97	
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Ignition Changeover switches @ £4.30	
R.P.M. Limit systems in above units @ £2.42	

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No. THY3A/200	3 Amp.	200 volt	TO64	32p
No. THY3A/400	3 Amp.	400 volt	TO64	40p
No. THY5A/50	5 Amp.	50 volt	TO66	25p
No. THY5A/400	5 Amp.	400 volt	TO66	40p
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D32 **15p**

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No. S18	4 x Standard Slide Switches	40p*
No. S19	4 x Miniature Push to Make single hole mounting	40p*
No. S20	3 x Miniature Push to Break single hole mounting	40p*
No. S21	Push button Switch Pak 4 x Assorted types multi bank and singles Latching and non-Latching	£1.00*

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16201	18 Electrolytics	4.7μF – 10μF
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16162	24 Ceramic Caps	470pF – 3300
16163	21 Ceramic Caps	4700pF – 0.047μF

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16213	60¼W.	100 ohm – 820 ohm
16214	60¼W.	1K – 8.2K
16215	60¼W.	10K – 82K
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16217	40½W.	100 ohm – 820 ohm
16218	40½W.	1W – 8.2K
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No. MVR7824	μA7824	TO220	85p
Negative			
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A pocket size instrument capable of detecting T.T.L. D.T.L. Flip Flop and other pulse circuits. It is easy to use and operates from the 5V. D.C. supply of the circuit under test. The logic levels are indicated by 2 red LED's one for High and the other for Low. There is also a green LED for the Pulse Mode of the unit.
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AC126	14p	BC178	12p	BF195	•9p	TIP32B	35p	2N1711	15p
AC127	16p	BC179	12p	BF196	•12p	TIP32C	36p	2N1893	28p
AC128	16p	BC182	•9p	BF197	•12p	TIP41A	34p	2N2218	15p
AC128K	24p	BC182L	•9p	BF200	25p	TIP41B	35p	2N2218A	18p
AC176	16p	BC183	•9p	BFX29	22p	TIP41C	36p	2N2219	15p
AC176K	24p	BC183L	•9p	BFX84	18p	TIP42A	36p	2N2219A	18p
AC187	16p	BC184	•9p	BFY50	12p	TIP42B	37p	2N2221	15p
AC187K	26p	BC184L	•9p	BFY51	12p	TIP42C	38p	2N2221A	16p
AC188	16p	BC212	•10p	BFY52	12p	TIP2955	65p	2N2222	15p
AC188K	26p	BC212L	•10p			TIP3055	42p	2N2222A	16p
AD161/		BC213	•10p	MPSA05	•22p	ZTX107	•6p	2N2369	10p
162 MP	80p	BC213L	•10p	MPSA06	•22p	ZTX108	•6p	2N2904	14p
AF139	30p	BC214	•10p	MPSA55	•22p	ZTX109	•7p	2N2904A	15p
AF239	30p	BC214L	•10p	MPSA56	•22p	ZTX300	•7p	2N2905	14p
BC107	6p	BC251	•10p	OC44	12p	ZTX301	•7p	2N2905A	15p
BC108	6p	BCY70	12p	OC45	12p	ZTX302	•9p	2N2906	12p
BC109	6p	BCY71	12p	OC71	9p	ZTX500	•8p	2N2906A	14p
BC118	•10p	BCY72	12p	OC72	12p	ZTX501	•10p	2N2907	12p
BC147	•8p	BD115	40p	OC75	10p	ZTX502	•12p	2N2907A	13p
BC148	•8p	BD131	•35p	OC81	14p	2N696	10p	2N2926G	•8p
BC149	•8p	BD132	•37p			2N697	10p	2N2926Y	•7p
BC154	•16p	BF115	17p	TIP29A	35p	2N706	7p	2N3053	12p
BC157	•9p	BF167	19p	TIP29B	36p	2N706A	8p	2N3055	35p
BC158	•9p	BF173	20p	TIP29C	38p	2N708	8p	2N3702	•7p
BC159	•9p	BF180	25p	TIP30A	36p	2N1302	12p	2N3703	•7p
BC169C	•10p	BF181	25p	TIP30B	37p	2N1303	15p	2N3704	•6p
BC170	6p	BF182	25p	TIP30C	38p	2N1304	15p	2N3903	•11p
BC171	•6p	BF183	25p	TIP31A	32p	2N1307	18p	2N3904	•11p
BC172	•6p	BF184	25p	TIP31B	33p	2N1308	22p	2N3905	•11p
BC173	7p	BF185	25p	TIP31C	34p	2N1309	22p	2N3906	•11p

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Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
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BA100	6p			BYZ18	28p	OA91	7p	IN5400	10p
BA115	5p	BY100	15p	BYZ19	28p	OA95	7p	IN5401	11p
BA144	5p	BY127	•10p					IN5402	12p
BA148	10p	BYZ10	32p	OA47	5p	IN34	5p	IN5404	13p
BA173	10p	BYZ11	32p	OA70	5p	IN60	6p	IN5406	16p
BAX13/		BYZ12	32p	OA79	7p	IN914	4p	IN5407	17p
OA200	5p	BYZ13	30p	OA81	7p	IN4148	4p	IN5408	19p

LINEAR I.C.'s

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TBA810	12 pin QIL	•£1.00	UA703	TO99 (Plastic)	20p	72558	(Dual 748) TO99	45p
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LM380	14 pin DIL	•80p	72741	14 pin DIL	20p	76115	14 pin QIL	•£1.25
LM381	14 pin DIL	•£1.35	UA741C	TO99	20p	NE555	8 pin DIL	32p
72709	14 pin DIL	28p	72747	14 pin DIL	55p	NE556	14 pin DIL	60p
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Contains 6 pieces of copper laminate board, box of etchant powder, measure, tweezers, marker pen, high quality pump drill, Stanley knife and blades and 6 in. metal rule.
Full easy to follow instructions.
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5m of 18 sw Multi-core Solder.
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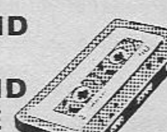

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EDITORIAL OFFICES
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Projects... Theory... and Popular Features...

With the festive season just behind us we now have to face, weatherwise, the most gloomy and and most treacherous part of the annual round. The unkind weather which is synonymous with the months of January and February is of particular concern for motorists. This time of year that generally forgotten part of the car—the battery—suddenly zooms large in the minds.

Even if we have not personally experienced trouble these cold and damp mornings, doubtless warning sounds have been heard in the neighbourhood as less fortunate fellows struggle to induce life into their dormant vehicles. At times such as these we realise just how everything depends upon that source of electrical energy.

One way to ensure that the battery is maintained in good condition ready to cope with the severe demands of winter is to avoid unnecessary consumption, at all times. Leaving side lights and accessories switched on unintentionally is a common human failing.

An easy remedy is to install an electronic "reminder" that will give instant warning if electrical circuits are left on when the ignition is turned off. So this month's article describing a *Car System Alarm* has topical interest for all who drive.

Talking of the wintry scene, there is in this issue of EVERYDAY ELECTRONICS a cheerful palliative that the younger generation will appreciate. Our *Chaser Light Display* will give the colour, sparkle and zip that nowadays is considered an essential accompaniment to any performance of pop music. For use at "home" or "away", this unit is bound to be a winner.

And now, looking ahead—which is what most of us do this time of the year . . . There is not just the spring to think of, to boost our morale. There is next month's EVERYDAY ELECTRONICS with a special gift for each reader. Read more about it on page 287.

It goes without saying that the wise reader will make certain of his or her copy by ordering well in advance. Of course, *you* are wise, but we must give this general reminder to alert those who may take a more casual view of things. We shall be sorry, but will not accept any blame if anyone misses out next month!

Fred Bennett.

Our March issue will be published on Friday, February 17. See page 287 for details.

Readers' Enquiries

We cannot undertake to answer readers' letters requesting modifications, designs or information on commercial equipment or subjects not published by us. All letters requiring a personal reply should be accompanied by a stamped self-addressed envelope.

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Everyday ELECTRONICS

VOL. 7 NO. 6 FEBRUARY 1978

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CAR SYSTEM ALARM

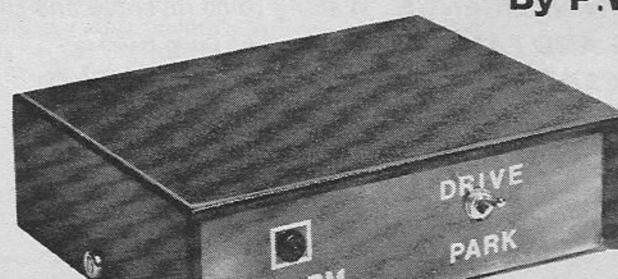
By P.W. Bond

INTRODUCTION

THIS article describes the construction of a simple alarm for use in the car which alerts the driver if any circuits are left switched on when the car has been parked. Hence it acts as a reminder for the driver to prevent his battery from discharging unnecessarily.

The unit described gives an audible and visual alarm when the ignition is switched off and the side or headlights or any chosen accessory is switched on.

The audible alarm can be silenced when the driver wishes to park the car with the lights on. This could be when the car is parked on a busy but poorly lit street at night.



The completed unit.

The circuit will accept the voltage variations produced by the regulators in the car. The actual installation in the vehicle is relatively simple and does not disturb the wiring too much. A word of advice though. If readers have not worked on car electrical systems before, get the help of someone who has. To thoughtlessly tamper with the car electrical system could render the vehicle disabled, but what is more important it could make the car dangerous to drive.

This circuit is intended for negative earthed vehicles, which covers the majority of those on the road. A positive earth version can be made and a brief outline of how this is done is given later.

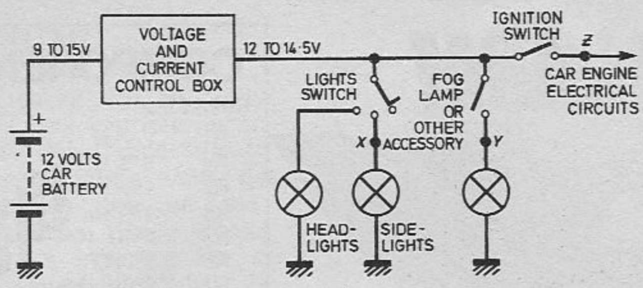


Fig. 1. A typical car electrical system.

CIRCUIT ACTION

The average car electrical system is often seen as mysterious bundles of coloured wires and connector clips, but the basic circuits are very simple.

A much simplified circuit taken from a typical car electrical system is shown in Fig. 1. The car battery has a nominal 12 volts between its terminals, but this varies when it is being charged and discharged.

To adjust the voltage and current to the various loads a control box is connected to the positive terminal of the battery. Hence when any of the circuits are energised, current flows from the battery, through the control box and switch to the load.

To economise on wiring, the chassis of the vehicle is connected to the negative battery terminal, hence the term "negative earth". The common return to the battery is thus made through the car metalwork.

SWITCHES

When the side or headlight switch is closed, point *X* goes to the battery potential of 12 volts and the lights illuminate. This switch is rather unusual since it has a special wiper which connects both the side and headlights to the battery simultaneously when in the headlight position.

The wiper bridges side and headlight connections so that they come on together. Consequently, when any lights are on the point *X* will be at 12 volts. Similarly, when the accessory is switched on, shown here as a fog lamp operated by a switch on the dashboard, the point *Y* will rise to 12 volts. And when the ignition is turned on the point *Z* will rise to 12 volts.

In the system chosen for the project, the load "on" condition represents the logic "high", and when the load is switched "off" this is the logic "low", since the monitor points *X*, *Y*, or *Z* fall to earth potential. The logic levels at the monitor points can be analysed by the alarm unit and under adverse conditions, with lights or accessory on and the ignition switched off, the audible and visual alarm is produced.

START HERE FOR CONSTRUCTION

CIRCUIT BOARD

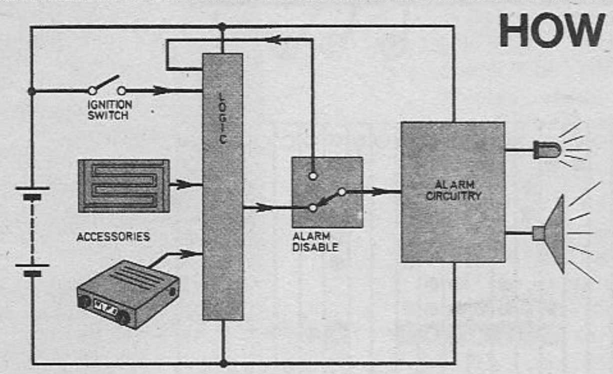
Owing to the relative simplicity of the circuit the unit was built on a small piece of stripboard. The use of an i.c. in the design calls for some strips to be broken. The size and layout of the components and the breaks in the strips are shown in the diagram in Fig. 3. Note too that the board is mounted using two 4BA nuts and bolts through two holes in the board with rubber grommets used as spacers. A 3mm drill can be used for the holes and this may also be used for the breaking of the copper strips. Alternatively, the strips can be broken using a spot face cutter, a tool made for this job.

SOLDERING

Mount the components as shown in the diagram, but remember to solder in the transistors last. The integrated circuit is mounted in a 14 pin d.i.l. holder, this is advised because the static charges from soldering irons can damage CMOS i.c.s unless special care is taken. The i.c. should not be put in the circuit until the unit is ready for testing, and not removed from its special foam protector, sooner than necessary.

The case used was a small metal one with a black vinyl covered steel top. These are commercially available at reasonable cost, so the actual shaping, and bending of a piece of aluminium is hardly worth its bother unless one has special desire to make one.

HOW IT WORKS



Normally the voltage from the ignition switch when switched on, is at a "high" logic level. This condition when applied to the logic circuitry inhibits the alarm. Basically the logic circuitry is a NOR gate. This means there is no output when *either* the ignition *or any* of the accessories are on.

When the driver leaves his vehicle with the ignition switched off, there will be no high logic level from the ignition to prevent the alram from coming on. The circuit thus gives an alarm when any accessories are left on and with the ignition switched off.

The alarm consists of two gates connected to form an oscillator.

A switch is included to disable the alarm when the vehicle is left but the accessories, say the sidelights are still required on. Although only two accessories are shown there can of course be many more.

CAR SYSTEM ALARM

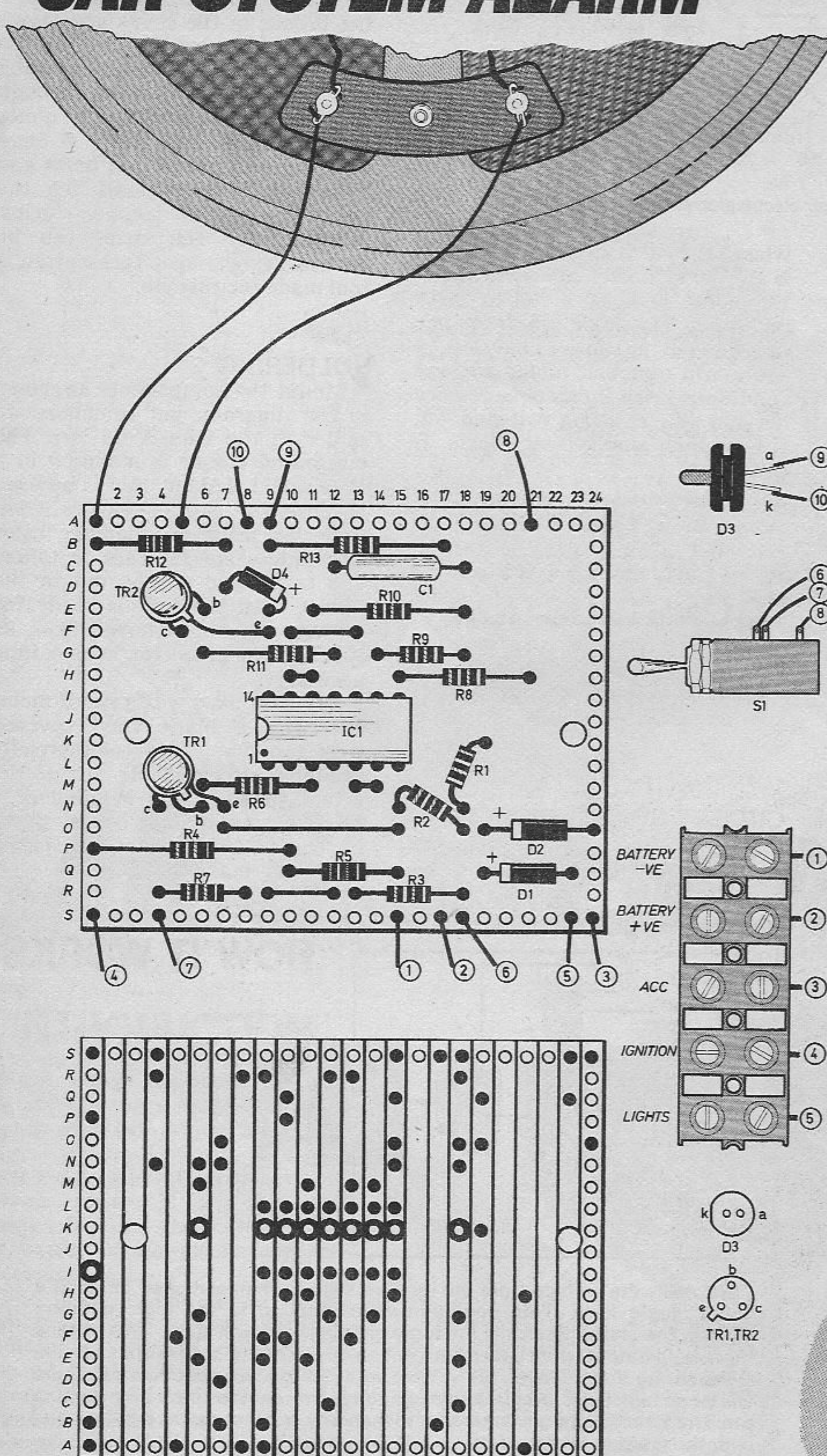


Fig. 3. Interwiring details, circuit board component layout and underside of the stripboard showing breaks in the copper tracks.

COMPONENTS

Resistors

R1	2·2kΩ
R2	6·8kΩ
R3	15kΩ
R4	470kΩ
R5	1MΩ
R6	5·6kΩ
R7	820Ω
R8	15kΩ
R9	1MΩ
R10	470kΩ
R11	5·6kΩ
R12	47Ω see text
R13	100Ω

All ¼ watt carbon ± 10%

See **Shop Talk** page 262

Capacitor

C1	1000pF ceramic

Semiconductors

D1	1N914 or similar silicon
D2	1N914 or similar silicon
D3	TIL209 red light emitting diode
D4	BZY88C12V 12V 400mW Zener
IC1	CD4001AE CMOS Quad 2-input NAND
TR1	BC108 silicon *npn*
TR2	BCY72 silicon *pnp*

Miscellaneous

S1	miniature single-pole double-throw
LS1	miniature loudspeaker with coil impedance 8 to 25 ohms approximately 70mm diameter

Stripboard: 0·1 inch matrix 24 strips by 19 holes; metal case type WB1 internal dimensions approximately 150 × 110 × 40mm; 5-way 2A terminal block; 14 pin d.i.l. socket for IC1; piggy-back push on connectors; 4BA fixings; connecting wire; small rubber grommet (2 off).

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS £3·50 excluding case

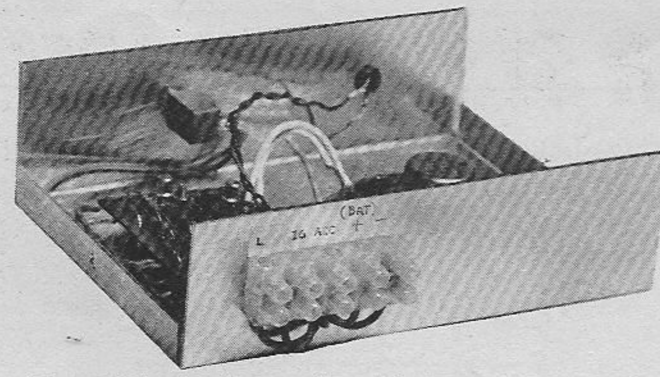
CASE MOUNTED COMPONENTS

The loudspeaker will be fairly small, only a few centimetres in diameter, and these generally do not have any mounting holes. So it is necessary to glue the loudspeaker in position, which means that a grille or covering for it would be impractical. What is recommended instead is to draw a circle where the loudspeaker is to be, the diameter being about 5mm smaller than the loudspeaker. Now the circle is drilled with holes of about 3mm in diameter, this is in effect a grille, and allows the sound to escape through the base of the unit.

WIRING

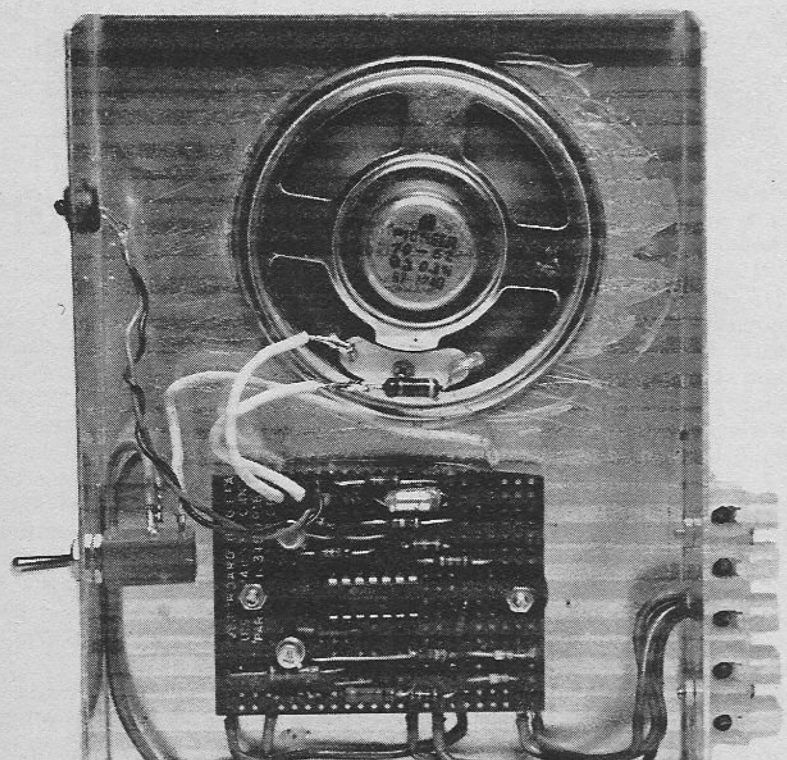
The l.e.d. and the switch are then mounted on the front panel, using holes of the appropriate size. Note not to cut the wires of the l.e.d. since the length of the leads identifies the electrodes of the device.

Connecting wires should be left fairly long because there are several connections to be made at the terminal strip located at the rear of the unit; it was found that 15cm long leads were adequate for this.


Rear view of the unit showing the mounting of the terminal block for connecting to the car wiring.

The board itself should be mounted using 6BA nuts and bolts, but before this is done check the strips for solder bridging the copper strips. This is likely to happen when using a large solder bit on 0·1 inch matrix stripboard as used here.

Once the board is fitted in place, it's a very destructive business taking it out again, so be sure and check the wiring thoroughly before assembly.


Interior view of the unit showing positioning of components.

VOLUME

Resistor R12 is mounted separately. This is done to facilitate changing the value of this if the volume level needs altering. The maximum value should be in the order of a few hundred ohms. If the value of the resistor needs to be increased from that shown, then replace R12 by a 470 ohm preset potentiometer. By adjustment of the preset, a suitable volume level can be found with the alarm conditions present.

Remove the preset and measure its resistance. Choose the nearest preferred value fixed resistor to be the new R12. Alternatively, try various values between 47 and 220 ohms until required level is reached.

TESTING

Before the actual installation of the alarm in the car it is best to check the unit, because it's not always easy to poke and prod about under the dashboard with a screwdriver in your right hand and a copy of EVERYDAY ELECTRONICS in your left hand.

A battery such as a small radio can be used to represent the car battery conditions. Connect the positive terminal to the battery connection on the strip at the rear of the unit, and the negative terminal to the earth connector. Now connect short lengths of lead from the terminal strips connectors and leave bare wire ends.

Put S1 to the DRIVE condition, and connect the accessory and light leads to the positive terminal of the battery, and the ignition lead is left free.

The alarm should now be energised indicated by the l.e.d. and the tone bleeps. When S1 is

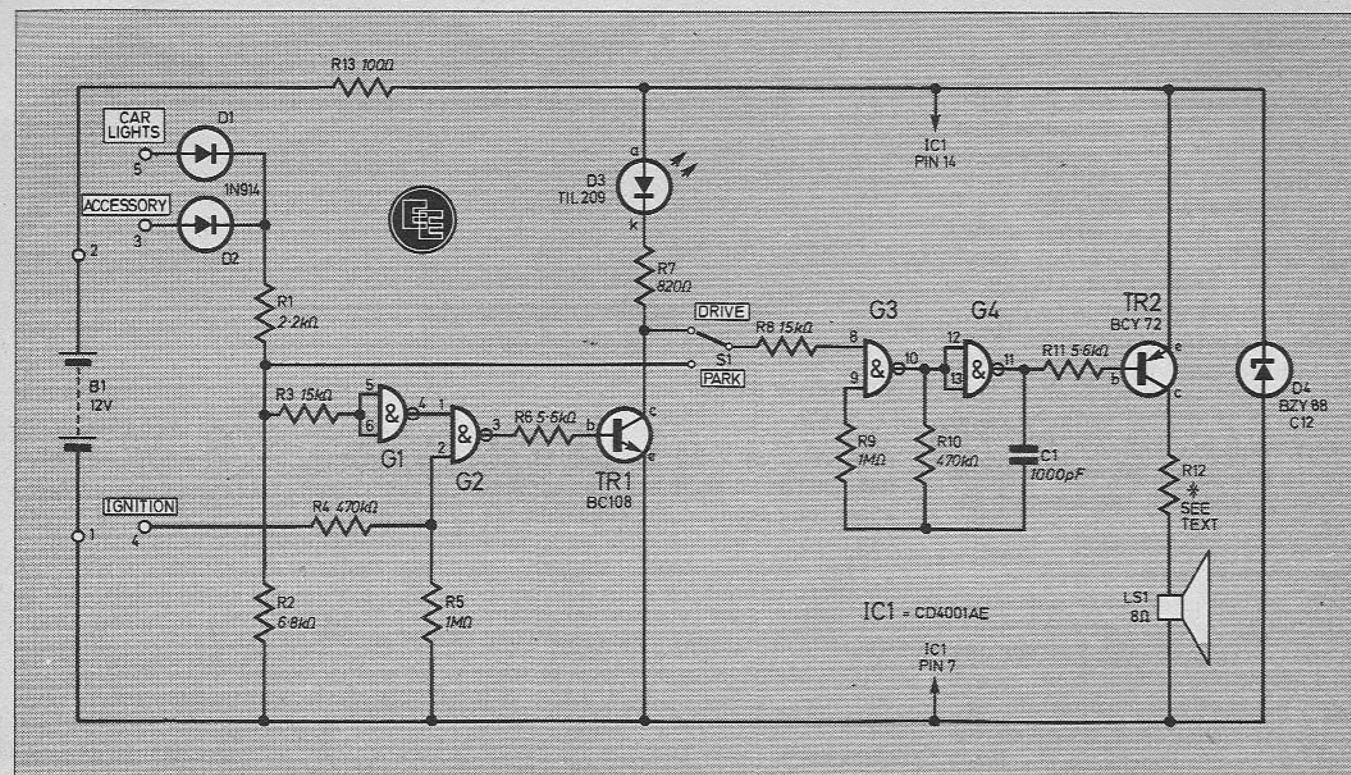


Fig. 2. Complete circuit diagram of the Car System Alarm.

CIRCUIT DESCRIPTION

The practical alarm circuit is shown in Fig. 2. Voltage is derived from the car battery with R13 and D4 stabilising the voltage to the CMOS integrated circuit. The lights and accessory switches are monitored by the OR-gate comprising D1 and D2.

Although only two circuits are shown to be monitored, by the addition of extra diodes several more can be monitored. In the prototype, lights and manually switched fog lamps were monitored, but a facility for monitoring the heated rear window heater was added later.

Diodes D1 and D2 are arranged with a potential divider to feed NOR gate G1. The actual arrangement is a positive OR-gate which makes the input of G1 go high when the lights *or* the accessory or both are at the logic high state. Gate G1 is wired to be an inverter which in turn feeds G2 which acts as a NOR gate.

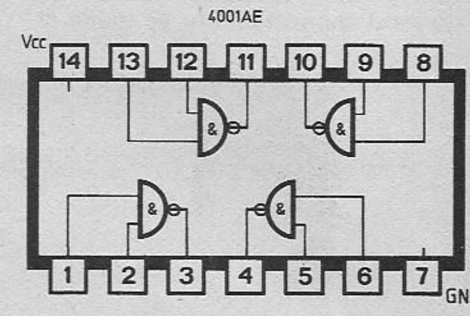
Let's assume that the driver has parked the car, switched the ignition off and accidentally forgotten to restore the light switch to the off position. The logic gates G1 and G2 deduce that this has occurred and hence the output of G2 goes high. This causes TR1 to conduct and D3 lights up. With the switch in the DRIVE position, the near earth potential at TR1 collector causes a logic low to be fed to the enabling gate of the multivibrator. So oscillation results, the frequency of which is determined by R9 and C1.

In this instance the astable multivibrator oscillates at about 450Hz. The squarewave output is fed to TR2 and the loudspeaker so that the transistor is made to conduct on the negative cycles of the squarewave. The tone is thus reproduced in the loudspeaker.

PARKING

Now let's suppose that the driver wishes to leave the car for a short time but finds it necessary to leave the sidelights on. To stop the tone from sounding and causing a nuisance, S1 is thrown into the PARK condition. This causes the enabling input of G3 to be high since it is directly connected to the output of the OR-gate (D1 and D2). So, until the driver either restores the light switch or puts the switch S1 back to the DRIVE position, the tone is muted; D3 remains lit to indicate that the alarm conditions are still present.

When the driver returns and drives away, the alarm must be restored, but if they forgot to do this then when the lights and accessories are finally switched off, the tone will sound once more.



Pin configurations for the CD4001AE.

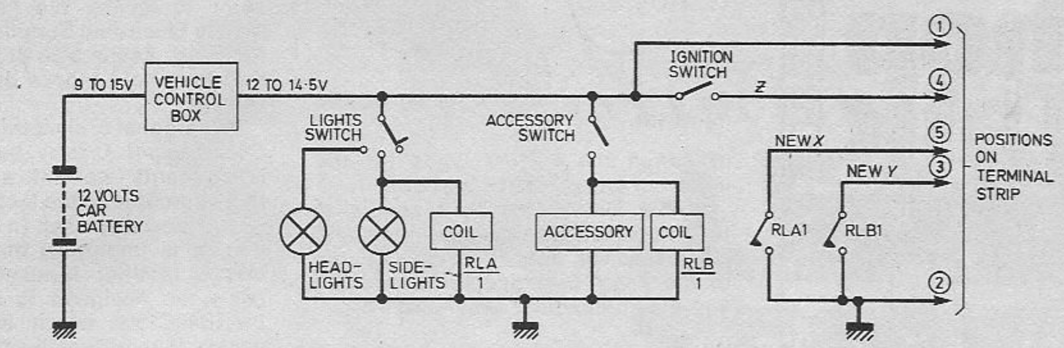


Fig. 4. Circuit diagram for use on Positive Earth vehicles.

operated the l.e.d. is still lit, but the alarm tone should stop. Now when the ignition lead is applied to the positive terminal of the battery, the l.e.d. should dim, and the alarm bleep should sound again. When S1 is restored to the DRIVE position the tone bleep will stop and the l.e.d. remains unlit.

INSTALLATION

If the test proves that the unit works then proceed with the installation as follows.

Find suitable points in the car electrical wiring to derive the battery and earth connections, in the prototype the light switch pole had a 12 volts fed to it so that was used, and a bolt was undone under the glove compartment to provide the earth.

Any similar connection to the bodywork can be used, but after the bolt is undone for the wire to be connected to it, restore the tension in it.

Connect long lengths of coloured wire to the various parts of the system which is being monitored and run the leads neatly to the area where the unit is to be sited.

Using double connecting tags (piggy-back connectors) on the switches solder the coloured wires to matching connectors and invent some kind of colour code for identification. Re-assemble the switches into the mounting after ensuring that the electrical connections are sound.

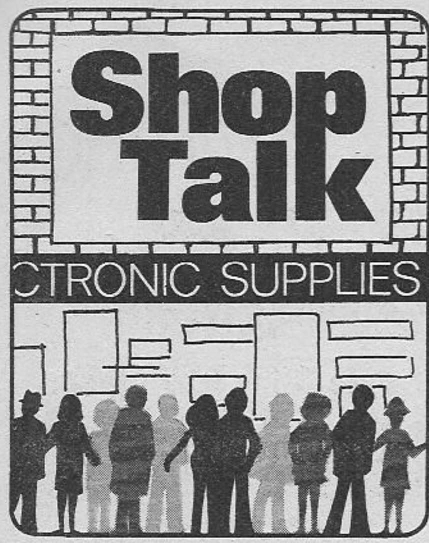
Mount the unit as near to the driver as possible so as not to make the driver over-reach. The colour coded wires are then terminated in the unit itself after the test leads have been removed.

Finally re-test the unit when all wiring is complete, check for faults to the car lights and ignition circuits by starting the vehicle and operating the circuits which have been connected to the unit.

POSITIVE EARTH

For readers wishing to use the unit for positive earthed vehicles, the circuits to be monitored should be wired in parallel with small reed relays and the contacts of these should be fed to the alarm unit, according to the wiring diagram shown in Fig. 4.

The alarm unit should prove to be a great aid to forgetful drivers, but it is quite probable that the unit will never be used once the habit of checking switches is stuck in one's mind. ⌑



By Brian Terrell

New products and component buying for constructional projects.

IT HAS been brought to our attention by followers of the *Teach-In 78* series that kits of parts for this series purchased from Bi-Pak contain some transistors with non-standard pin configurations. The particular device in question is the 2N3702.

The standard package for this device is classified as TO-92 which is a plastic case with in-line lead-outs, see Fig. 1a. This is one of the Texas Silect range (SILicon EConomy Transistor).

The types supplied by Bi-Pak have a TO-18 case, which at first sight looks identical to the TO-92, but closer inspection will show that the lead-outs are sited in a triangular configuration (called a "pin circle") as shown in Fig. 1b. You will notice that all the leads have different relative positions. The device can still be used to carry out the *Teach-In* experiments but the lead-outs will need to be preformed to fit the layouts in the article.

We are in receipt of a photostat copy of a letter sent to a reader by Bi-Pak explaining the anomaly in which they say that they were unaware of this at the time; now that this has been brought to their attention readers are assured that all future kits despatched will contain the correct transistors. Also they have told us that they will exchange the correct types for the incorrect ones already sent out.

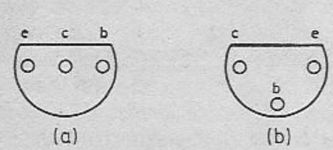


Fig. 1. Pin arrangements (a) for 2N3702 (b) Bi-Pak 2N3702

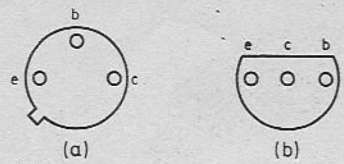


Fig. 2. Pin arrangements for (a) BC184L (b) BC184

Bi-Pak kindly sent us a couple of the incorrect pinning types for test purposes. We tried them in a couple of the *Teach-In* experiments/modules and they functioned satisfactorily.

New type number

According to Texas literature, a particular device may be encapsulated in a different package, case and/or lead-outs or other, but to avoid confusion a new type number is given to the device. For example, the 2N3702 having a TO-92 encapsulation, is also packaged in TO-18, but is given a type number 2N5447. The electrical parameters of the two are identical.

Also, it is not uncommon to find transistors of the same basic type number with different pin configuration, but this is usually accompanied by a different casing. For example, the BC184 transistor will sometimes be found in advertisers lists followed by the letter "L". See Fig. 2a and b for the lead-out details.

A suffix letter does not always convey pinning information. The BC108 is available as BC108A, BC108B and BC108C. All have identical pinning and case, but differ basically in gain performance. Generally speaking, A, B and C suffixes refer to minor differences in electrical parameters whereas K and L are reserved for pin configuration and case alterations.

This month's constructional projects

No component buying problems are envisaged for two of this months projects, *Stereo/Mono Lead Tester* and the *Car System Alarm.* All components should be available from a number of suppliers.

Almost in this category is the *A.C. Meter Converter* for only the one per cent resistors could prove troublesome to locate. We have contacted Maplin Electronic Supplies, P.O. Box 3, Rayleigh, Essex SS6 8LR who tell us that they hold stocks of the required values.

Our biggest project this month is the *Chaser Light Display* but only a few components warrant a mention on this page. Due to the fact that a printed circuit board is used in the construction, it is important that the correct bridge rectifier is used. The p.c.b. has been designed to accommodate the B40C1500 which is a 1·5 amp device. If an alternative type number is to be used, ensure that the lead-outs are as the specified type otherwise disastrous results will arise.

The specified type is available from A. Marshall (London) Ltd., Dept. EE, 40-42 Cricklewood Broadway, London, NW2 3ET and costs 92p including V.A.T. postage and packing.

The triacs specified are rated at 6 amps 400 volts, but almost any device with the above rating or higher can be used. If other types are used, alternative heatsinks may need to be obtained. The TIC225D triacs and TV-4 heatsinks are available (four of each) from A. Marshall Ltd., at the above address at a total cost of £4·72 including postage, packing and V.A.T.

The "phase" switch S4 calls for a 4-pole 2-way rotary type and this may be difficult to locate. The more common 4-pole 3-way rotary wafer is recommended. The "third way" should be ignored.

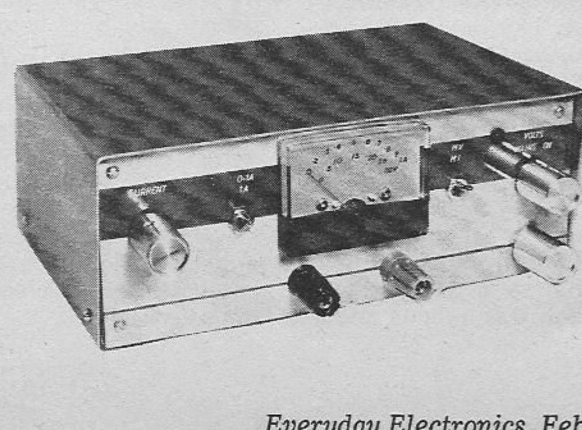
Kit news

The latest news we have received from Arrow Electronics is that they are now marketing an excellent range of Leader "do-it-yourself" test gear kits.

One of the good points about these kits is that they come complete with a comprehensive instruction manual enabling the inexperienced constructor to produce a first class piece of equipment.

We hope to publish a more detailed report on the Leader kits in the near future, but further information and prices can be obtained from Arrow Electronics Ltd., Leader House, Coptfold Road, Brentwood, Essex, CM14 4BN.

Photograph of a completed Leader LPU-103 Power Supply Unit featuring variable current limiting.



Stereo/Mono LEAD TESTER

By M. Simpson

INTRODUCTION

THE unit to be described here was designed with the guitarist and pop group in mind. With the number of foot pedals available as separate units, it is not uncommon for the guitarist to use several foot units in series to obtain certain effects.

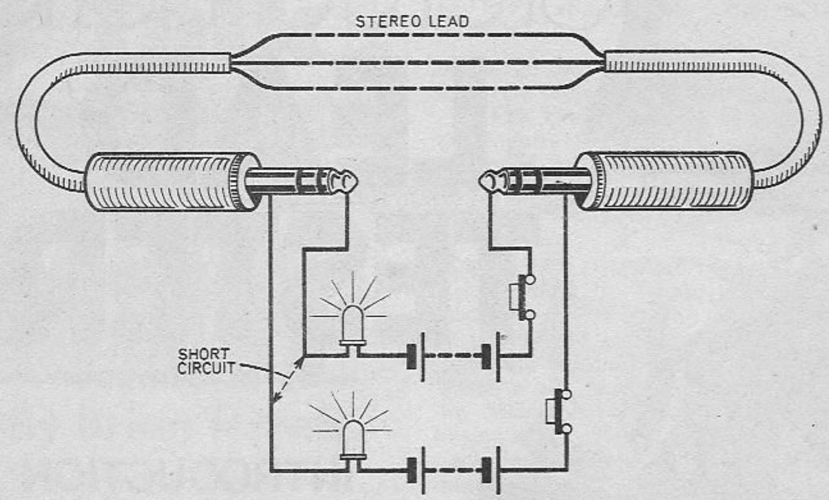
This generally means a large number of leads inter-connecting the units to the guitar and amplifier. Thus a fault on one or several of the leads could cause problems tracking down the fault, as well as wasting a lot of time. This is undesirable especially when playing to an audience. If every lead could be rapidly tested before use, then this situation is less likely to arise.

This design was thus evolved to enable anyone to find a faulty lead and, indeed tell precisely what the fault is. Common faults that arise, which this unit will find, are as follows:

1. Open circuit on one or all wires.
2. Short circuit to any other wire.
3. Incorrectly wired jack plug.
4. Intermittent faults — usually found as crackles on the public address system.

The unit consists of four push to make switches. One is the battery/l.e.d. test switch (S4). The other switches, S1 to S3, are for each individual lead of the stereo lead. In the case of mono leads, S1 and S2 perform the same function due to the standard mono jack plug shorting out two terminals on the stereo sockets used.

HOW IT WORKS...



The Stereo/Mono Lead Tester is basically a three-position continuity checker. When a lead is plugged in and one of the switches is pressed the l.e.d. corresponding to that switch should light. If it does not then it would indicate that the lead is open circuit.

If the two l.e.d.s shown (there is actually three) both light together, then this would indicate a short circuit between those two leads. In practice the batteries are replaced by one and the l.e.d.s share one side of the battery supply. The unit may also be used to check intermittent faults.

START HERE FOR CONSTRUCTION

PRINTED CIRCUIT BOARD

A printed circuit board was made using a small off-cut from another project. The p.c.b. was made on a piece of fibreglass printed circuit board and etched in the usual way using ferric chloride.

A tip here is to cut the board to size, clean it up, place it underneath the diagram of the p.c.b., line it with the copper side up, and tap a compass point through the page to leave a small point on the surface of the copper in just the right place. Then draw on the areas with an etch resist pen, allow to dry and etch the boards as usual.

The holes are then drilled for the components (0·8mm for resistors and diodes, 1·2 mm for presets and 1mm for Veropins). The components are then mounted on the p.c.b. as shown in Fig. 2 and carefully soldered in position. Take careful note of diode polarity, usually the cathode end has a black or white line near it.

WIRING

Finally the wiring to the switches and the l.e.d.s is completed following the remainder of the wiring also shown in Fig. 2.

The box used had dimensions of 115mm × 75mm × 40mm but any size will do so long as the components will fit inside. The size quoted is about the smallest in which all the components will fit comfortably. The box was made of a white thermo-plastic which proved easy to drill. Layout of the components is not critical but all the switches and l.e.d.s must be easy to operate and see.

It is important to get the wiring absolutely correct in the unit as a fault might cause problems later. It is, therefore, recommended that a colour code be devised and rigidly adhered to for each l.e.d./switch arrangement when wiring up.

TESTING

The unit when built should be thoroughly tested using two stereo jack plugs and six lengths of coloured wire. The wires are attached to the plugs and labelled. Thus, when the two plugs are inserted into the unit with all six ends not connected, the l.e.d.s should not light except when the BATTERY TEST switch S4 is pressed.

Now connect up the six loose wires by twisting the loose ends together so that the plugs are correctly wired. Then test the unit by pressing the test buttons individually. The l.e.d. above each button should only light and none other.

Components

See Shop Talk page 262

Resistors
R1, 2, 3 680Ω (3 off)
All resistors are carbon $\frac{1}{4}$W $\pm$ 5%

Potentiometers
VR1, 2, 3 1kΩ miniature horizontal presets (3 off)

Semiconductors
D1 TIL209 green light emitting diode
D2 TIL209 yellow light emitting diode
D3 TIL209 red light emitting diode
D4, 5, 6 IN914 silicon diode

Miscellaneous
SK1, 2 standard stereo jack sockets (2 off)
S1-4 push to make, release to break push switches (4 off)
B1 PP3 9V battery
Small plastic box 115mm × 75mm × 40mm; four stick on rubber feet; printed circuit board; battery clip; connecting wire; solder.

Stereo/Mono
LEAD TESTER

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS
£3·50
excluding case

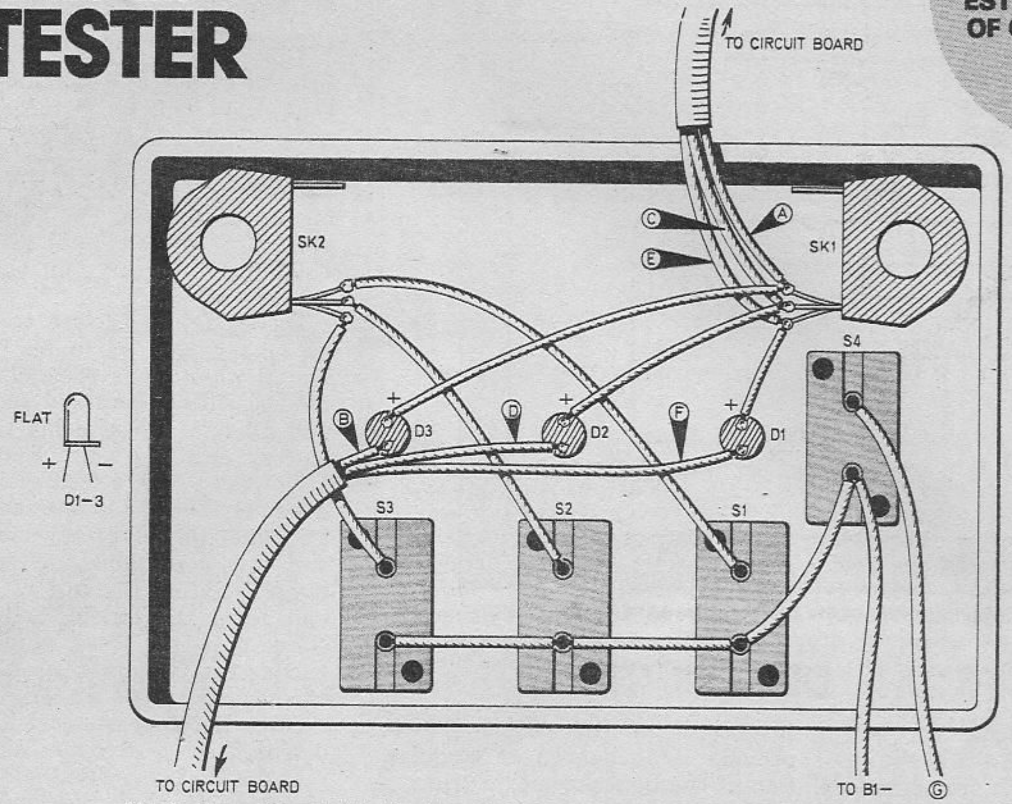
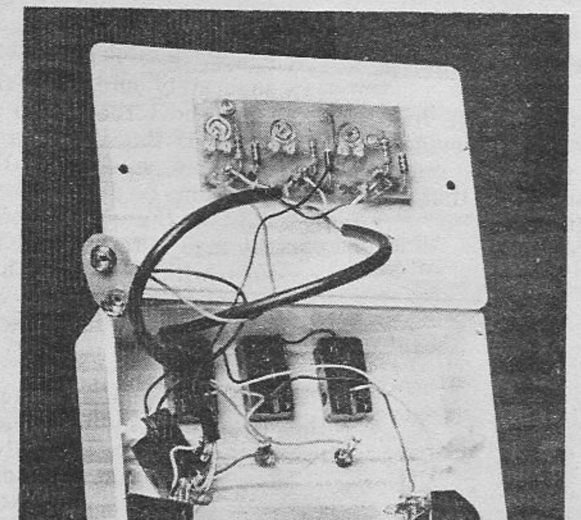


Fig. 2a. Interwiring details for the switches, light emitting diodes (l.e.d.s) and stereo jack sockets.



Interior view showing the circuit board mounted on the lid. The positioning of the switches, sockets and light emitting diodes can be seen.

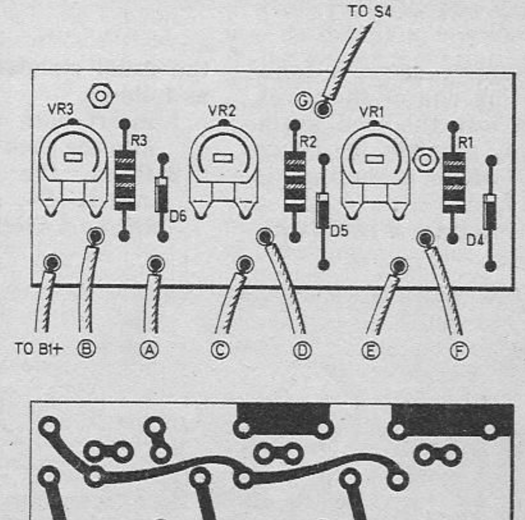


Fig. 2b. Printed circuit board component layout and the underside of the board showing copper tracks after etching (full size).

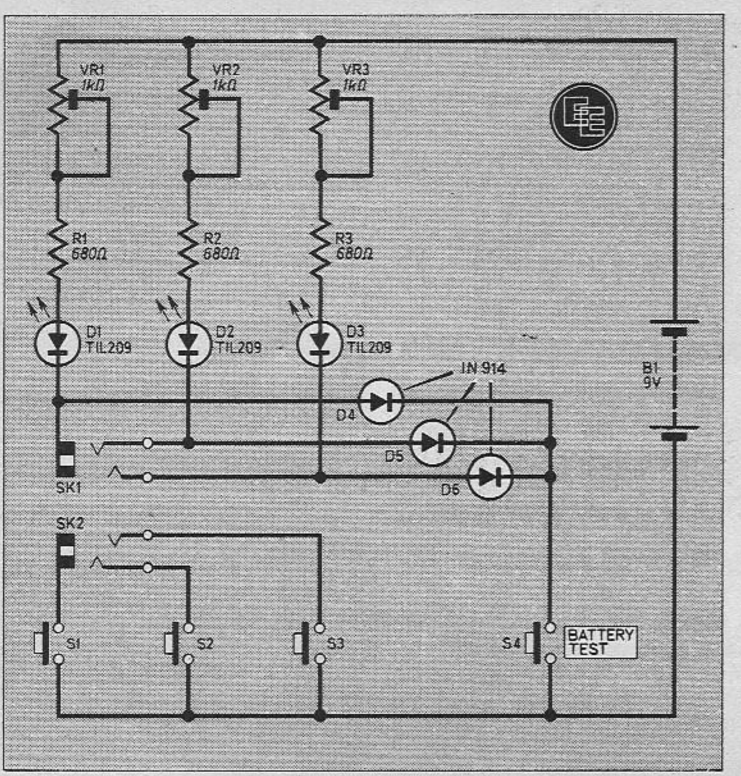


Fig. 1. Circuit diagram of the Stereo/Mono Lead Tester

CIRCUIT DESCRIPTION

The complete circuit for the Stereo/Mono Lead Tester is shown in Fig. 1. The circuit is very simple and uses three l.e.d.s to indicate the state of a lead under test. The three preset potentiometers VR1 to VR3 are used to control the brightness of the l.e.d.s, and to provide some degree of equalisation of the light output.

This was found necessary as different colours of l.e.d. appear to give different light outputs—red being most efficient. Resistors R1 to R3 are to prevent the full battery voltage appearing across the l.e.d.s and to limit the maximum current from the battery. In the prototype values of 200 ohms were tried, however, it is recommended that these resistors be preferably 680 ohms.

This means that maximum brightness and the maximum current drain will be reduced. However, a good l.e.d. should still be visible in bright daylight but the battery will now last a lot longer on full brightness. The adjustment of the presets will still give good equalisation of the light output of the l.e.d.s.

Diodes D4 to D6 are connected in such a way as to be forward biased when S4 is pressed, i.e the diodes will conduct and the l.e.d.s will all light up showing that the battery and l.e.d.s are working.

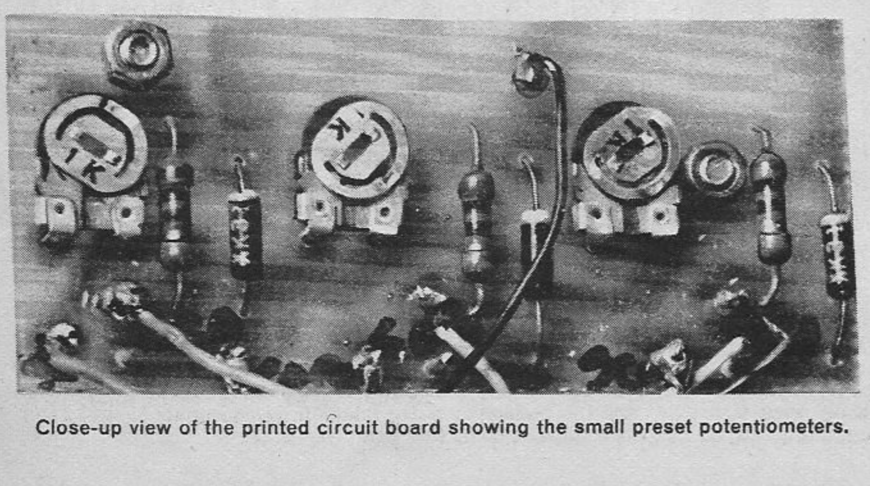
However, with a lead under test, when S1, S2 or S3 is pressed diodes D4, D5 or D6 will be reverse biased and, thus non-conducting and effectively isolating the rest of the circuit from the circuit under test. Note that the lead under test carries the current from SK1 to a corresponding contact on SK2 and thus to the depressed button. This is true if the lead is not faulty.

If the lead is faulty, then current may flow through the lead to the depressed button but the correct l.e.d will not light—or possibly two will light, depending on the fault.

Now deliberately cause a fault by, say, shorting one of the wires to earth and test the lead again and note the number of l.e.d.s which light when a button is pressed.

The test method for a lead (with the usual standard jack plugs) is as follows:

1. Insert both ends of the lead into the jack sockets provided.
2. Press the BATTERY CHECK switch (S4) and note that all the l.e.d.s light up.
3. Press switches S1 to S3 separately and note that the l.e.d. above the switch pressed lights. If this is the case, then the lead is alright. If more than one l.e.d. lights, or none light, or the wrong l.e.d. lights, the lead is faulty and, depending which l.e.d.s light, a reasonable idea of what is wrong can be deduced.

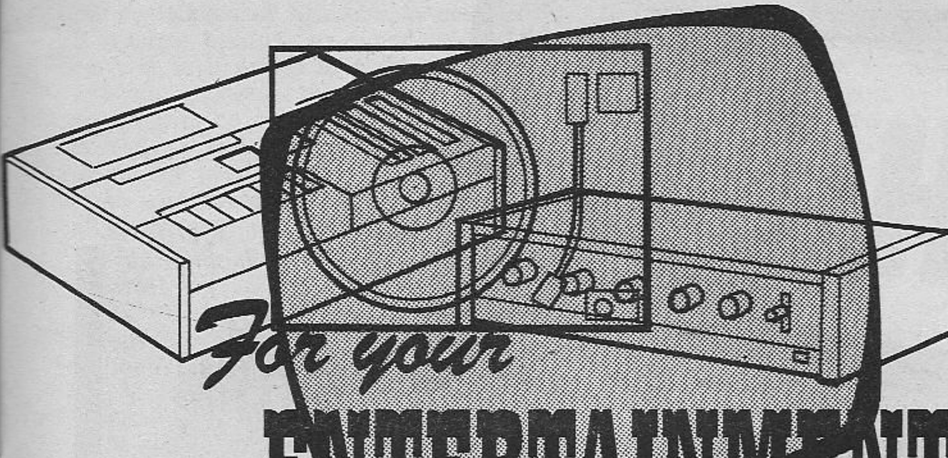


Close-up view of the printed circuit board showing the small preset potentiometers.

A table of common faults and their repair could be made and used for reference at a later date.

Thus, the unit is simple to operate, quick to indicate faults and gives a good idea of what is wrong so that the lead can be fixed at a later date.

Intermittent faults can be found by leaving the button(s) depressed and shaking or moving the lead until an l.e.d. flashes. ⌑



For your ENTERTAINMENT

By ADRIAN HOPE

A Shocking Affair

DON'T just breathe a sigh of relief that you weren't affected when, as reported in the national press last Autumn, three hundred families in a London council housing estate found they were without an electrical earth. For those who did not read the newspaper report of this literally shocking event, it went along these lines.

One of the three hundred families installed a new washing machine, and immediately got an electric shock from it. An engineer was called in under guarantee, and all concerned have him to thank for checking and finding that all the earth leads from *all* the flats ended up at one big dead end in the basement, leaving not one single flat with a hard electrical earth. This, of course, had left all the residents at risk of getting a lethal shock from any piece of equipment with a supposedly earthed chassis that went live.

Allegedly, thieves had stripped all the copper wire and then replaced the ducting so neatly that no one noticed.

Now I have no way of knowing whether the earthing wires were ever installed in the first place, but it brings other incidents to mind that prompt a reminder that everyone should at some time check that their equipment really is earthed, and not just an illusion.

Years ago in the country I knew of a schoolteacher who was getting shocks off the metal earth ducting of his house wiring. It emerged that the metal earth ducting was all electrically isolated from earth, and thus a potential death trap.

Only a few months ago I attended a press show in a large London cinema for which special equipment had been brought into the projection box. Every now and again I noticed switch clicks on the sound track, and afterwards asked why this was. The visiting engineer told how he had found that there wasn't a proper "hard" earth for the projection box!

Bear in mind the kind of current needed to run a cinema projection box (hundreds of amps for the projector arcs), and you have an idea of how astonishing that situation was.

And was it an isolated case? I doubt it. Recently I attended another press show at a small modern London cinema, and there again switch clicks were frequently to be heard over the sound track.

So check for your own interest and safety that all your earth leads really do lead to earth, not just to thin air. To check, connect a resistance meter or a simple torch bulb and battery continuity tester between the EARTH pin of a wall socket and the kitchen cold water supply. This should show a short circuit—if it doesn't, find out why.

If in doubt call in your local electricity board.

Magnetic Driver

The shape of things to come? Recently, at one of the Philips Electrical factories on the Continent, I was astonished to see a driverless truck pulling a pallet of packing cases round the factory floor and into the storeroom.

Every now and again the battery powered truck would appear through a door at one end of the factory, weave almost in drunken manner around corners, disappear behind one production line, emerge from behind another, and trundle off out again through another door. Anyone who wanted to load anything onto the truck or take something off simply pushed the stop button as it passed and then sent it off on its way again.

There was no sign of any track guiding the truck, and I wondered aloud what on earth would happen if such an obviously powerful object hit anyone who had failed to notice the police-like flashing light which it carried.

It turned out that the truck was guided along a predetermined route by a magnetic track buried under the factory floor, a sensor on the underside following the magnetic field and steering the truck wheels.

When someone finally did step in front of the beast, it stopped dead, sensing their presence by a flexible sensor. As it stopped, the truck flashed lights and emitted all manner of violent howls until the obstruction moved away.

Explosive Tune

Just how and when did the modern style of solid or "cricket bat" guitar begin? Charlie Christian was using one with Benny Goodman's band in the late Thirties and the very early Forties (he died in 1942); and he is generally believed to have first experimented with an electric guitar in Oklahoma City in 1937.

But was Charlie Christian using an ordinary acoustic guitar with an acoustic pickup to sense vibrations on the guitar belly and convert them into electric signals for amplification? Or was he using a magnetic pickup where vibrating metal strings directly induce a current into induction coils?

It is, of course, this type of induction pickup that makes possible the modern solid guitar, which produces electrical signals but virtually no acoustic sound.

It's an interesting question, which surprisingly involves military history. The story goes that in the early 1940's in the Battle of the Atlantic something very dangerous to shipping appeared in the water; the acoustic mine. In what seemed quite miraculous manner, these mines exploded only when a ship with a particular sound came close.

It was all thanks to a brilliant nasty, idea by a German at Kiel. What he did was stretch a metallic string over a magnet and tune the string to the pitch of the sound which the engines of the hunted ship would make. So as the ship got closer to the mine the tuned string inside would start to vibrate sympathetically, and this vibration used to induce an electrical current in a coil. This induced current was then used to trigger the mine fuse and detonate it.

The story goes on that after the War someone else had the decidedly bright idea of using exactly the same technique to generate musical sounds. If this aspect of the story is true, then we have the German Navy to thank for the modern breed of electric guitars.

If the story is wrong, then the German Navy may have had jazz guitarist, Charlie Christian, to thank for the magnetic mine.

TEACH-IN 78 Part 5

BY GEORGE HYLTON

INDUCTANCE—RESONANCE—AMPLIFIERS

BEFORE continuing this month with our main subject of amplifiers, we shall take the opportunity to discuss one particular subject which has not been mentioned so far in the series. Tied in with this, is the story of coils and transformers, all of which completes the basic "elements" of electronics. First then the subject of **inductance**.

INDUCTANCE

Earlier in the series we told you how Oersted had discovered that a current in a wire creates a magnetic field which can interfere with a compass needle. In fact a current *anywhere* creates a magnetic field, but we are concerned with wires at the moment.

It was soon realised that the field can be intensified by coiling up the wire. In this way the current, as it goes round and round the coil, adds more and more field. Coils of insulated wire wound such as this are often used as electromagnets.

Now, it occurred to some people that if a current produces a magnetic field, then the process should work in reverse. A magnetic field should produce a current in a nearby conductor. But it did not seem to happen. Laying magnets beside wires or coils did not create currents.

The mystery was finally solved by Michael Faraday after years of careful research. He reasoned that the current-inducing effect of a magnetic field might be quite small. So he constructed an arrangement designed to make the effect as intense as possible. Faraday took a ring of iron and wrapped two insulated coils round it (Fig. 5.1).

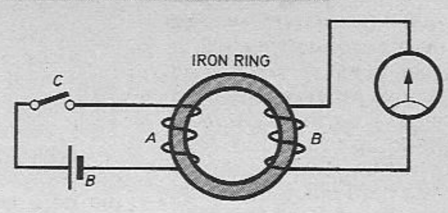


Fig. 5.1. Probably the best known of Faraday's experiments. Here the two coils A and B are *coupled* by the iron ring.

Coil *A* is an electromagnet energised by the battery. Its field is concentrated in the iron, which carries it through the receiving coil *B*. Any current induced in *B* is registered by the meter.

Faraday found that no current was registered. Then he noticed that the meter pointer gave a slight kick at the instant *S* was closed to energise coil *A*, and a much larger kick when *S* was opened. In between, with coil *A* energised constantly, nothing happened. This observation was one of the most important ever made. It led to the dynamo, the electric motor, the transformer and indirectly to radio.

As Faraday then realised, current flows in *B* only when there is *some change* in the magnetic field of *A*. In this case, the change is when the field builds up from nothing or when it decays from its steady value to nothing.

A steady field has no effect.

This is rather surprising; after all, the battery is supplying energy all the time. Where does it go? Well, in the steady state, after the field has built up, all the energy is used up in driving current through the resistance of the wire in coil *A*. All this energy is wasted, because if *A* had no resistance the same current in it would still produce the same field. But with no resistance to overcome a battery would have no work to do. If the beginning of the coil were connected to the end current would flow round and round for ever.

An electromagnet is in real life totally inefficient, all the energy used to create the field is wasted.

The point about coils is that a current in a coil creates a magnetic field. If coil *B* in Faraday's arrangement is disconnected, a rising or falling field in *A* still has an effect. The changing field induces an e.m.f. in coil *B*. Naturally, a current only flows if the coil in which the voltage is induced is part of a complete circuit. But the voltage appears anyway, complete circuit or not. So the true effect of a changing magnetic field is to induce voltages rather than currents.

A changing current flowing in a coil has an effect on the coil itself. It is obvious that it must have, when you remember that the coil is in the middle of its own magnetic field. The effect is that the coil impedes the flow of current. It does so by generating a voltage which tries to push current in the reverse direction to the current flowing through it. This voltage is usually called a **back e.m.f.** and occurs in all sorts of inductive devices such as electric motors.

The size of the back e.m.f. depends partly on the coil itself, the greater the number of turns the greater the back e.m.f. and therefore the higher the impedance. But it also depends on the rate at which the current is changing.

The faster the current changes, the greater the back e.m.f. and therefore impedance. In a.c. circuits the rate of change of current is greater as the frequency is made higher. So the impedance of a coil must increase as the frequency is raised.

The ability of a coil to generate a back e.m.f. is used as a measure of the *electrical* size of the coil.

A coil which produces a back e.m.f. of 1 volt when the current through it changes at the rate of 1 ampere per second has an inductance of 1 henry.

COIL CORES

The inductance of any coil is increased by winding the coil on a "core" of iron or ferrite material. Transformers for mains and audio frequencies use cores of silicon-iron or various magnetic alloys. The cores are built up from stacks of sheetmetal stamped out as thin insulated laminations. Laminations are usually in the shape of the letters E, I, or a U with sharp corners. Some transformers often use C cores.

Iron laminations cannot be used at high frequencies. Instead, dust-iron cores are used. These are made by pressing together fine particles of iron, insulated from one another. Dust-iron is useful at frequencies from about 100kHz to 100MHz.

Ferrite is a more versatile material which is made in a number of grades and shapes. Between them they cover a frequency range of about 1kHz to 1,000MHz. Ferrite is a hard black brittle material which belongs to the same physical class of materials as pottery and china; i.e. the ceramics. It is made by moulding the powdered materials then baking them at high temperatures until the particles fuse.

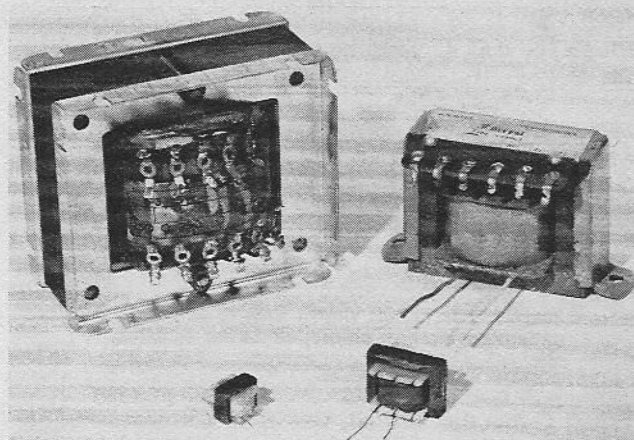
The most familiar ferrite component is the aerial rod used for l.w. and m.w. reception.

The amount by which the inductance of a coil is increased by its core depends on many factors. At low frequencies, with special magnetic alloys such as Mumetal and tape-wound ring cores, the inductance can be tens or even hundreds of thousands of times what it would be if the core were absent. On the other hand at high radio frequencies, where the core is adjustable the increase may be only in the order of two times. When talking about this type of increase the word *permeability* is often used.

Permeability is the factor by which the inductance would increase if the coil were embedded in a large mass of core material, so that all the magnetic field of the coil when carrying current would be in the core. Practical coils are not like this and there is always some "stray field" outside the core, and this reduces the increase of inductance.

The practical increase of inductance is called the effective permeability.

Much depends on the geometry of the core. A 10cm ferrite rod aerial made of material with true permeability of 500 may have an effective permeability of five when the coil is in the centre of the rod, falling



A few examples of transformers using laminated iron cores.

to three when it is near one end. It follows that the inductance can be adjusted by sliding the coil along the rod. Much greater increases in inductance are given by cores which form closed loops of magnetic material threaded through the centre of the coil. Mains transformers always use this type of construction.

It is usually desirable in transformers to minimise the stray field, so that the magnetic field of the primay is coupled strongly by the core to the secondary winding.

Increase in inductance means that fewer turns are needed on a coil. This calls for less wire so the resistance of the winding is reduced, giving higher efficiency in a transformer and a higher quality-factor in a tuning coil. Unfortunately, all core materials are "lossy", that is, the core absorbs energy from the coil, so the improvement is less than might be expected. The core losses increase with frequency, and this effect is worst with high permeability materials.

This is why laminated metal cores are not usable at high frequencies, and why the grades of ferrite usable at v.h.f. and u.h.f. provide only modest increases in inductance. In fact, at u.h.f. it is quite common practice to use brass cores for any adjustment necessary. The brass *reduces* the effective permeability and so lowers the inductance.

TUNED CIRCUITS

Inductors and capacitors are energy-storage devices. Capacitors store energy as an electric charge, and we have already investigated the process of charging and discharging.

Inductors store energy in quite a different way. When a current flows in an inductor a magnetic field is created in and around it. The energy is in the field. To recover the stored energy you must stop the current. The field then collapses, and as it does so it induces a voltage in the inductor. The size of this voltage depends on how fast the current is switched off—the faster the greater.

An inductor and a capacitor can be connected together as in Fig. 5.2. If the switch *S* is put in position 1, and left closed long enough for the circuit to settle down after the initial inrush of current all that happens is that *C* stays fully charged to the supply voltage. If *S* is now placed in position 2, *C* discharges through the coil, *L*. This, however, gives *L* a magnetic field.

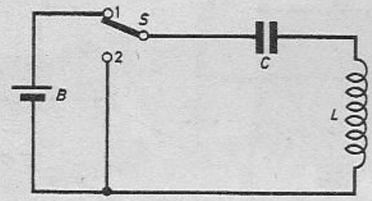


Fig. 5.2. The circuit shown here is helpful in understanding how an inductor behaves when connected to a source of energy.

When *C* has discharged, this field collapses, inducing a voltage in *L* which drives a current which again charges *C*. And so on, for ever and ever. Or, rather, it would go on for ever and ever, if there were no resistance in the circuit. In practice there is of course, in the resistance of the wire which forms the coil, so every time current flows some of the energy is used up, and the charge/discharge process is made weaker. If the resistance is small, and the oscillation dies away slowly, we say that the circuit has a high Q. This is the symbol for "quality factor".

The process just described has a familiar counterpart in mechanical terms. This is the pendulum. If you push the weight of a pendulum to one side, and hold it there, you might say that this represents the *LC* circuit with the switch in position 1 with *C* charged.

If you now let the weight go, corresponding to changing *S* to position 2, the energy stored in the displaced weight allows the pendulum to swing. It accelerates until it reaches the bottom of the arc through which it moves. From then on it has to climb, so it slows down and eventually reaches some height where it can go no further. It then falls back again, and so on. Each swing is a little shorter than the last, because energy is used up in overcoming air resistance, friction in the pivot, and so on.

The time it takes for the pendulum to swing from one end of its travel to the other *and back again* is called its **period.** In an *LC* circuit, the period is the time it takes from the moment when *C* begins to discharge until it becomes charged again *with the same polarity.* This is illustrated by the graph in Fig. 5.3. and shows how the voltage on the capacitor charges with time. The period need not be measured from peak to peak.

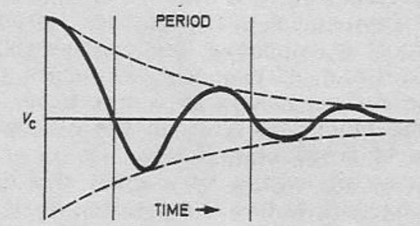


Fig. 5.3. Graph showing what the output waveform of the previous figure would look like.

For most purposes it is easier to measure from zero to zero and this is indicated in the figure. The period is the same in both cases, of course. In fact, if you measure from *any* point in one cycle of charge-discharge-recharge to the same point on the next cycle you get the same period.

In an *LC* circuit the period depends on the sizes of *L* and *C*, that is the number of henries and the number of farads. To be precise, the period depends on the product of *L* and *C*, that is *L* times *C*.

Another way of describing the behaviour of a pendulum or *LC* circuit is to count the number of cycles of oscillation in a given time. In electronics, where the oscillations are usually rapid, the standard time is one second. The oscillation is then said to go through a particular number of cycles per second. This number is called the frequency. Cycles per second is, however, an old-fashioned term, so the word Hertz, symbol Hz, has been adopted. It does of course mean the same.

The frequency of an *LC* circuit, usually called a tuned circuit, is also dependent on the sizes of *L* and *C*. But in this case, since the frequency goes *up* as the period goes *down,* the mathematics come out differently. In fact, the frequency is proportional to one divided by the square root of *L* times *C*. Also, to make the units come out right, the number 2π has also to be included. This gives the awkward-looking formula:

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

The frequency of oscillation is often called the natural frequency or the resonant frequency. An excellent way of understanding tuned circuits is to make a rigid pendulum by drilling a hole through a large heavy stick, or metal bar, or something similar and hanging it on a small nail through the hole, or a piece of string, so that it can swing freely to and fro. Even if the pendulum is very heavy, a tiny push given repeatedly at the right time is enough to build up the oscillation. You can prove this by pushing it with something weak, such as a piece of thin wire, which would bend if too much pressure were applied.

This build-up of oscillations, which shows that energy is being stored in the pendulum, takes place only if you push at the right times. If you try to make the pendulum swing at the wrong frequency you will find that it resists your efforts.

In circuit terms, the equivalent to this behaviour is that a small voltage or current applied to an *LC* tuned circuit will build up oscillations at the natural frequency but not at some other frequency remote from the natural one. If a *mixture* of equal currents at different frequencies is applied then stored energy builds up most at whichever frequencies are closest to the natural one. After a few tens or hundreds of cycles these natural frequency currents and voltages have become much greater than the others. This is the process of frequency selection.

A tuned circuit with a very great capability for energy storage is said to be very selective, or to have high selectivity. Obviously, selectivity is a necessary property of a radio receiver, whose aerial picks up many transmissions on different frequencies, only one of which is required by the listener.

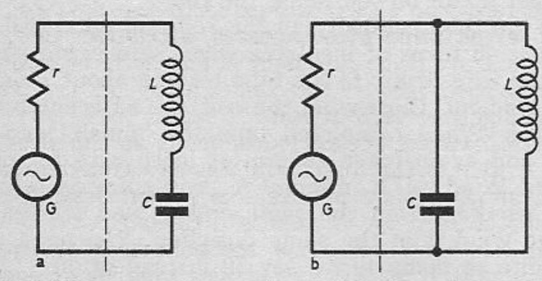


Fig. 5.4. Two ways of connecting an inductor and a capacitor. The first is in series, the second in parallel.

Now let us see how a tuned circuit behaves when an a.c. signal is applied to it. Fig. 5.4. Here the a.c. signal comes from a generator, *G*. There are two ways of connecting up. In Fig. 5.4a all the current flows through the generator, *L* and *C*. If the generator operates at the resonant frequency, the current builds up in such a way that a small "push" from the generator creates a large flow of current. The generator finds it easy to make a large current flow, which is the same as saying that to the generator the *LC* circuit offers little resistance to current flow. In fact, if *L* and *C* were electrically perfect they would offer no resistance at all at their resonant frequency, and the current would depend only on the generator's voltage and the resistance *r*.

At frequencies different from the natural one, the generator finds itself out of step with the stored voltage and current. The *LC* circuit's resistance has increased.

The circuit in Fig. 5.4b shows a different situation. Current can now surge back and forth between *C* and *L* without going through the generator. A small current from the generator at the right frequency, causes a large current to build up and circulate in *L* and *C*, but all this stored current need not flow through the generator itself. It turns out that in this case, at the resonant frequency, the *LC* circuit has a *high* impedance. At other frequencies remote from the natural frequency the impedance becomes *low*.

The first circuit is sometimes called an **acceptor** circuit, because it accepts current readily at the natural resonant frequency. However, electronic engineers usually refer to it as a **series-tuned circuit** from the way in which *L* and *C* are connected. The second circuit is sometimes called a **rejector** circuit or an anti-resonant circuit but electronic engineers call it a **parallel-tuned circuit.**

RESONANCE

So far we have not explained the term resonant which is the one most frequently used in talking about tuned circuits in electronics. Resonant is really an acoustical term. You read about people speaking in resonant tones, for example. In scientific acoustics, **resonance** refers to the property of organ pipes, piano strings, etc., to be frequency selective. If you blow into the open mouth of an empty bottle in the right way you produce a musical note. This is resonance.

What happens is that the hissing sound of your breath contains a mixture of frequencies, which makes the air in the bottle vibrate as sound waves. Sound travels to the bottom of the bottle, is reflected as an echo, and arrives back at the mouth. If it arrives back at just the right moment it reinforces the sound which is now coming from your breath, and a stronger wave then travels back to the bottom of the bottle, and so on. It is like the gentle, repeated push of the pendulum all over again, but in a different form.

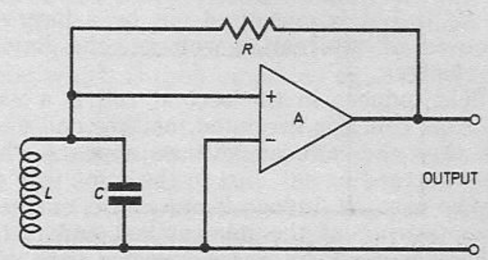


Fig. 5.5. A simple oscillator circuit. The circuit is tuned by the combination *LC* circuit.

In electronics, we often need to generate a particular frequency continuously. This can be arranged by connecting an *LC* tuned circuit to an amplifier with positive feedback, Fig. 5.5. This arrangement is the electronic equivalent of blowing into the empty bottle. All amplifiers generate electrical noise, that is, random mixtures of frequencies. As you can see, the *LC* circuit, fed via *R*, picks out the wanted frequency and feeds it back into the amplifier.

It emerges, reinforces any noise at the correct frequency, and is fed back again via *R* into the *LC* circuit and so on. The *LC* circuit quickly acquires a large circulating energy at its resonant frequency, which provides an input signal for the amplifier. So long as you do not take too much energy from the output, but always leave enough to sustain the oscillation, the system will generate an output for you for ever, or at least until the battery runs down or some component fails.

There are many different forms of *LC* oscillator. The commonest ones use a single transistor but a more complicated form of tuned circuit. The point is that a single transistor does not provide an amplified output voltage which is in step with the input. The output of a single stage voltage amplifier is exactly

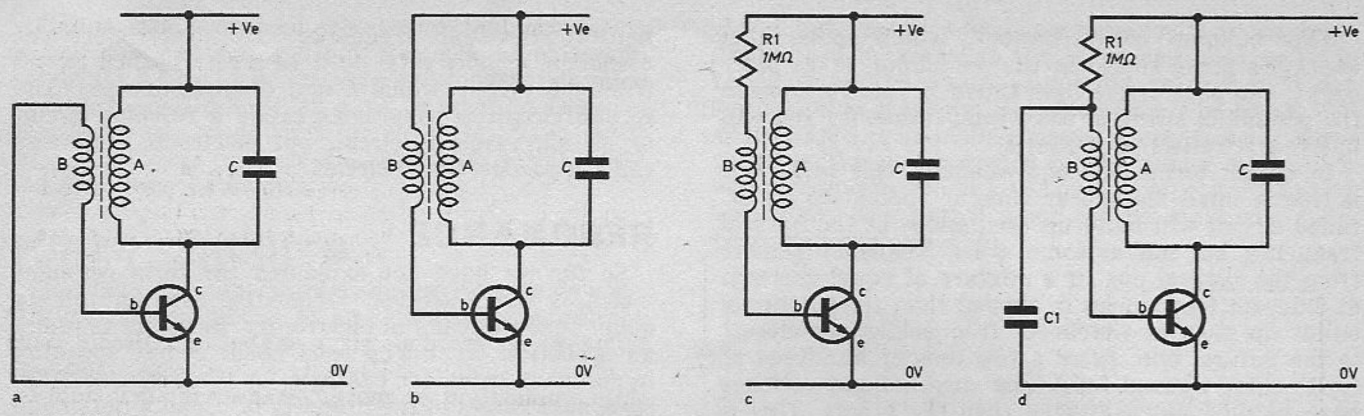


Fig. 5.7. Four ways of connecting our coil into a transistor circuit. The first (a) will not work as there is nothing to turn the transistor on. In (b) the transistor is turned on too much, whereas although (c) is satisfactory, the a.c. current is impeded. By adding a capacitor as in (d) this problem is solved.

out of step with the input. It is an inverting amplifier, if the input goes positive, the output goes negative. This is of no use for making an oscillator, since any signal fed back from output to input would *oppose* the existing input signal, instead of reinforcing it. To make the output signal assist the input it is necessary to turn it "upside down" so that positive becomes negative and negative positive.

One method of inverting the signal is to use a device called a transformer. The basic idea of a transformer was the iron ring in Faraday's experiment, Fig. 5.1. If coil *A* is energised not by a battery but by a source of alternating voltage, the field continually changes.

This field induces in the second coil *B* a varying voltage. Now coil *B* is insulated, neither end need be earthed, thus the induced voltage appears whether the coil is earthed or not. Just in the same way either end may be earthed. Indeed if one end is earthed the voltage appearing at the non-earthed end can then be in phase or could be phase inverted with respect to the voltage on coil *A*.

This arrangement can thus be used as a phase inverter, to turn signals "upside down".

OSCILLATORS

Up till now a great deal of theory has been discussed regarding tuned circuits, coils and phase. Now it is time to put that theory into practice by looking at a practical oscillator.

First, however, we shall make a particular kind of coil. The constructional details of which is shown in Fig. 5.6. You will notice that one coil is wound on top of the other, this form of winding means that the field of one is concentrated very nicely into the second coil. We say that the coils are tightly coupled.

The coil is wound on a piece of ferrite rod about 10cm × 9mm.

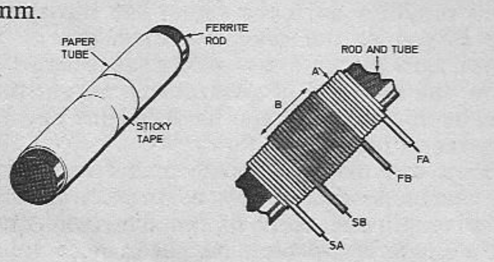


Fig. 5.6. Constructional details for our coil. Insure that the ends of the wires are clearly in identified as shown.

Before winding your coils cut a long strip of thin card or thick paper, not quite as wide as the rod is long. Wrap it round the rod so that it forms a rigid tube and tape it so that it cannot unwind. You should find that it can be slid along the rod.

Put the tube centrally on the rod and wind coil A, of about 40 turns of insulated wire. Before you start, tape the wire firmly to the tube leaving about 150mm for a lead-out. Close-wind the coil, i.e. adjacent turns touching. When completed tape the "finish" end in place and again leave 150mm of loose wire for connecting. Wind coil B on top of A, proceeding as before. Start winding from the same end as you started A at, and wind it in the same direction. You need not use quite so many turns, say 30 instead of 40.

We shall use A as the inductance *L* of an *LC* parallel-tuned circuit. *C* can be a polyester or polystyrene capacitor of 10nF in value. When this *LC* circuit is connected correctly to a transistor, using the transformer phase inverting properties of the two coils the transistor should oscillate. The *tuned* coil A will be connected in the collector circuit since this is the output. Coil B will be connected to the base.

The simplest connection, Fig. 5.7a, will not work because there is nothing in it to turn the transistor on. The next simplest, Fig. 5.7b, in which the earthy end of B is connected to battery positive turns on the transistor too hard. The usual method of turning a transistor on is to feed a small current into the base. This is what you did earlier when estimating the current amplification.

The circuit in Fig. 5.7c does this but is still not satisfactory because the high resistance R1 greatly reduces the amount of a.c. current which can flow when a voltage is induced in coil B. The a.c. path is through base to emitter then through the battery to R1 and so back to the coil. The battery offers no impedance to a.c.

To enable a.c. to flow freely we connect C1 as in Fig. 5.7d. If C1 has a large enough capacitance it will offer little impedance to a.c. signals. These can then flow from coil B through the base/emitter part of the transistor and back to B via C1 without having to go through R1 at all.

For making measurements of the a.c. voltage across the coil, it is convenient to have one end earthed. Also it is more convenient when wiring up the circuit to connect the positive end of R1 to the collector rather than the battery. This makes very little difference to the operation of the circuit and in fact is a very common way of **biasing** a transistor, that is turning it on to the required degree.

The circuit we finally use is shown in Fig. 5.8. It incorporates these two conveniences, and you will see that it does all the other things we want as well.

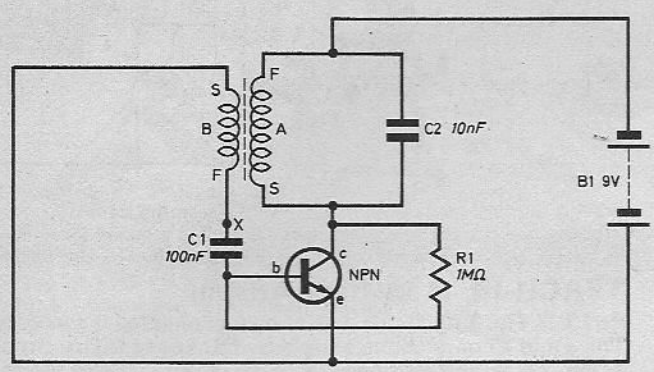


Fig. 5.8. The final circuit we use. This is constructed using the NPN module and the homewound coil. Note the connections to the coil. To check that it is working the VOLTAGE INDICATOR may be used.

The letter S and F refer to the start and finish of the windings. It is important to connect as shown, otherwise the circuit will not oscillate. When it does oscillate, it is at a high frequency, about 200kHz. This is far too high to hear, so we have to detect the oscillation some other way. First you can do it by connecting your VOLTAGE INDICATOR to point X where the coil joins C1. There is no d.c. voltage here because C1 blocks the d.c. from the battery. There can however be plenty of a.c. We measured about 5V.

The other test is to place a radio close to the ferrite rod and tune across the long and medium wavebands. At various points you hear a whistle, caused by your oscillator interfering with an incoming broadcast. To prove it is your oscillator and not the TV in the next room or something else, touch the collector of your NPN module. This produces a small change in frequency, which you can hear. You will also find that sliding the ferrite rod in and out of the coils produces a large change of frequency. Evidently the position of a coil core can have a large effect on the inductance.

AMPLIFIERS

An amplifier is a device which makes small quantities greater. In electronics the quantities which are amplified are voltage, current and power. Amplifiers can be made which will increase any of these, frequently all three at once.

An amplifier uses the energy of its battery or power supply to make enlarged copies of the quantities in question, which are known in general as the input signals. To begin with, we shall consider a *voltage* amplifier.

A common kind is the **operational amplifier** (abbreviated to op-amp), so called because it is designed to carry out certain mathematical operations in one kind of computer, the analogue computer. The input signal is a small voltage, the output signal a larger one, perhaps thousands of times larger.

The standard symbol for an operational amplifier is a triangle with two input points and one output point. Fig. 5.9.

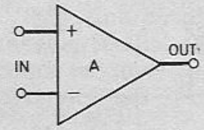


Fig. 5.9. The standard symbol for an operational amplifier. This has two inputs; the inverting (negative symbol), and the non-inverting (positive symbol).

The plus and minus signs at the input do not have their usual meaning. Here they show which direction the amplified output moves when an input is applied. The plus sign means that the output voltage changes in the same direction as the input, positive for a positive input, negative for a negative input. The minus sign means that the amplified output voltage changes in the opposite direction to the input. That is a positive input voltage produces a negative output voltage, and vice versa.

This process of changing the polarity of the signal is known as *phase-inversion* or just inversion. The terminal with the minus sign is known as the inverting input terminal, and the plus sign marks the non-inverting input terminal.

Now, what happens if the non-inverting terminal is connected to the output terminal? Any small fluctuation in the output voltage caused, say, by the battery voltage changing slightly, gets amplified, producing a larger fluctuation which reinforces the original one and which is then amplified again, and so on for ever.

If 2V is applied to both the inputs, for example, the 2V at the non-inverting input is cancelled by the 2V at the inverting input, so the amplifier behaves as if it had no input at all. This kind of amplifier is called a **differential amplifier** because it responds to the difference between the two inputs. Suppose the

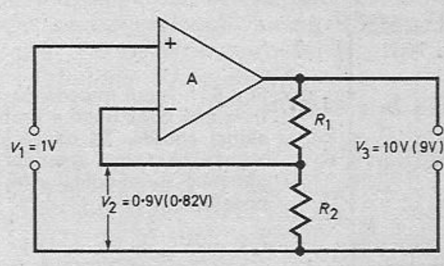


Fig. 5.10. By adding two resistors as a potential divider, the op-amp can have any gain as desired.

amplifier has a voltage gain of 100 but we need only to amplify a 1V input by 10, to produce 10V output. The amplifier can be arranged to have an effective gain of 10 by adding a feedback circuit, Fig. 5.10.

Here resistors R1 and R2 are so proportioned that 0·9V is fed back to the inverting terminal. The effective input is now $1V - 0{\cdot}9V = 0{\cdot}1V$. When this 0·1V is amplified 100 times the required 10V output is produced. The voltage divider formed by R1 and R2 has to divide the output voltage by about 11 in order to provide the required effective gain.

Now, so far nothing has been accomplished that could not have been done just as effectively by attenuating the input voltage to 0·1V before applying it to the amplifier. The beauty of the negative feedback arrangement becomes clear when we consider what happens if the gain of the amplifier changes.

Suppose it falls to 50. This would normally reduce the output by half, to 5V. But as you can see from the figures in brackets the output is reduced only to 9V. The negative feedback has kept the effective gain close to the target value. It turns out that the more gain is sacrificed the more protected the effective gain is against variations.

This is most useful, because it is not at all easy to make an amplifier with a precise gain, because of variations in transistors, components, supply voltages and so on. There are other benefits, too, such as a reduction of distortion. Practical operational amplifiers often have voltage gains of around 10,000, but on data sheets the gain, called the open-loop gain, meaning the gain with no feedback, is often expressed in decibels.

A voltage gain of 10,000 is equivalent to 80 decibels.

INPUT IMPEDANCE

So far, in talking about amplifiers, we have said nothing about what an amplifier input looks like to a signal voltage. In fact, we have assumed that the impedance between an amplifier's input terminal and earth is infinitely large.

In practice, however, the input impedance may be low enough to have to be taken into careful consideration. If it is too low it may seriously affect the input signal. The reason is that most of the signals met with in practice come from signal sources; microphones, aerials, gramophone pick-ups, tape playback heads etc, which themselves have appreciable internal impedances. Such a signal source can be represented on a circuit diagram as a voltage generator V_s in series with an impedance R_s. Fig. 5.11.

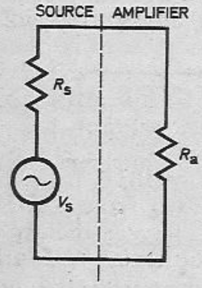


Fig. 5.11. Input impedance of amplifiers can pose quite a problem to a signal source. To obtain maximum output from the amplifier the impedance R_a should be as large as possible.

When this is connected to an amplifier whose own input impedance is R_a a current flows. This causes a voltage drop in both R_s and R_a. Only the voltage across R_a is applied to the amplifier. The other part is lost in R_s, that is, it stays inside the signal source.

To minimise this loss of signal it is necessary for R_s to be small in comparison with R_a. You can see that these two resistors form a voltage divider, whose output appears across R_a. Thus if R_s is twice the size of R_a two thirds of the signal voltage is lost.

Next month we shall continue with amplifiers and go on to build a practical working module.

See *Shop Talk* concerning the leadouts of the 2N3702 transistor.

TEACH-IN 78 Matters Arising

Part 3. In Fig. 3.10, the l.e.d. is shown connected incorrectly. The *a* and *k* connections should be transposed. The circuit in Fig. 3.9. is correct however.

Part 4. The answer to question one of *Part Three* should be 5 ohms and not 2 ohms as stated.

QUESTIONS

1. A negative signal is applied to the inverting terminal of an op-amp. The output is:
   a. positive
   b. negative
   c. zero
2. A changing magnetic field in an inductor induces:
   a. current
   b. a voltage or e.m.f.
   c. nothing
3. An acceptor circuit is:
   a. L and C in parallel
   b. L and C in series
   c. R and C in parallel
4. Coils are said to be tightly coupled when:
   a. they are twisted firmly round their former
   b. they are close together
   c. all the field of one passes through the other
5. To a.c. signals the impedance of a battery is normally:
   a. very low
   b. very high
   c. voltage divided by current from the battery
6. A 2 ohm resistor and 4 ohm resistor are connected in parallel. The total resistance is:
   a. 6Ω
   b. 2Ω
   c. 1·33Ω
7. A transistor has a collector load of 1kΩ and a bias resistor between collector and base of 220kΩ. If its collector voltage is about half the supply voltage, its d.c. current amplification is about:
   a. 220
   b. 100
   c. 220,000
8. A transformer has a 100 turn primary and a 400 turn secondary. If 3 ohms is connected to the primary the secondary "sees":
   a. 12Ω
   b. 0·75Ω
   c. 48Ω

ANSWERS *(To Part four)*

1. 1 mA per volt (a)
2. 5 volts (a)
3. 9 milliamps (c)
4. 1000 seconds (c)
5. 17 milliseconds (a)

READERS LETTERS

Off the track

With reference to the December 1977 issue of EVERYDAY ELECTRONICS, I would like to point out a mistake regarding the 'Hovertrain.

In "For your Entertainment" Mr. Hope states: "For a while a length of track and a prototype vehicle sat forlorn in a field at Cranfield; but I understand that bulldozers have now moved in . . .".

This is a mistake: The vehicle sat in a hanger. It was NOT at Cranfield. It was in Earith in Cambridgeshire.

The firm my father works for, bought the buildings and land. Part of the terms of purchase was that they knocked down the track. It is now, the hardcore of the yard. This was 2½ years ago.

As for the train? It was transported to a train museum, but it fell off the lorry less than half a mile from its "home".

Before it went, however, I managed to see the train at very close quarters. The linear motors were very impressive.

On the train itself, at the back, there were two wheels with car tyres on which were used to stabilise the train. Mounted on the top of the train was an arrester hook for use in emergencies in case it didn't stop. On one occasion when this hook was tried, with the train going at about 15 m.p.h. the train's hook caught the wire and it stopped with just feet to spare.

The track itself was about 1¼ miles long, and ran parallel to the "Old Bedford Drain" in Earith.

The villagers were very annoyed when the project was scrapped.

V. J. Wood,
Earith,
Cambs.

Mr. Hope replies . . .

The machine and short length of track I saw were definitely in a field at Cranfield—I found them while killing time before a trip on the Goodyear airship that landed there a few years ago. I took photographs and still have the negatives buried somewhere in my files.

I met Prof. Laithwaite on a TV programme recently and it was he who told me of the scrapping etc. So perhaps there were two prototypes?

Incidentally at Cranfield (in a hanger) I also found the old TSR2 prototype.

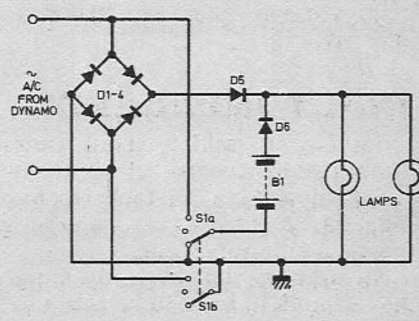
Dynamo back-up

I read and enjoy your magazine every month and I have recently constructed the "Dynamo Back-up" published in your September '77 issue.

One problem I encountered was that my dynamo system used an earth return, and the dynamo and lamp housing was designed accordingly. For this reason, it was necessary to isolate either the lamps or the dynamo from the frame, when adding the back-up.

Also the modification shown below uses a D.P.D.T. three position slide switch instead of a 2-way toggle switch, to allow the back-up to be completely bypassed if desired.

A. Hearne,
Co. Waterford,
Eire.



The above circuit suggested by Mr. Hearne has not been tested by us.

BOOK REVIEWS

THE FABULOUS PHONOGRAPH 1877-1977
Author Roland Gelatt
Price £6·50
Size 215 × 145mm 349 pages
Publisher Cassell

THE new world was the birthplace of the gramophone, so the American title is appropriate. A vast industry was producing cylinder and disc talking machines long before Europe got involved. Yet after a promising start, a demise set in when the novelty wore off what was chiefly seen as a rather frivolous toy. Here European countries came to the rescue. The artistic contributions made by the Old World revitalised the whole business of recorded music and elevated the gramophone to the status of a serious musical instrument where it is firmly established today.

All this we learn through this absorbing story, where commercial rivalry, not only in invention and technical development, but in wooing international artists and orchestras, is a dominant theme. Many instruments were involved in the battle over the years. Many companies entered the arena; many subsequently disappeared or changed beyond recognition through amalgamations during these exciting 100 years.

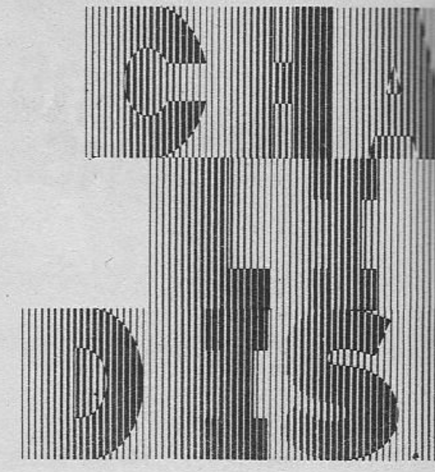
The Fabulous Phonograph is a second revised edition of a work hailed as a classic upon its first appearance in 1955. This latest edition has been brought out to coincide with the centenary of the phonograph, invented by Edison in 1877.

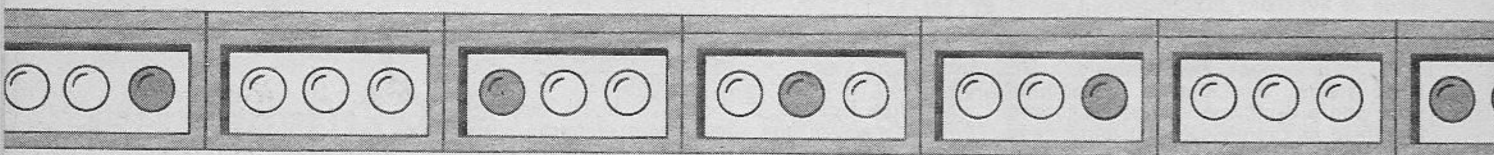
The first 300 pages cover the story from first beginnings (1877) up to 1955, with an approximately even balance between technical, commercial and artistic development. The technical evolution of the phonograph is described through American eyes, and British activities ignored. Thus the word "Radiogram" does not appear in the book, and those ingenious mechanical devices for changing records get no mention.

The last 35 pages cover the 22 years from 1955 to the present, and in view of the tremendous changes brought about in this period (largely through electronic achievements) the space allocated is sadly disproportionate to the rest of the book.

Thus the introduction of the microgroove long playing record, stereo (and now quadrophony), and the phenomenal success of pop music since that first recording by Presley in 1956, receive rather summary treatment, considering their great impact on technical and, even more especially, upon social affairs.

F.E.B.





Most disco's and "pop" bands today are equipped with lighting effects such as sound-to-light, strobe, colour wheel, ultra-violet light, etc. This article describes a further effect that is now in use on the disco/band scene. It is a four-phase sequential display or Chaser Light Display.

The unit to be described has speed, direction, freeze and effect controls and is capable of handling one kilowatt per channel (but with limitations—see later).

START HERE FOR CONSTRUCTION

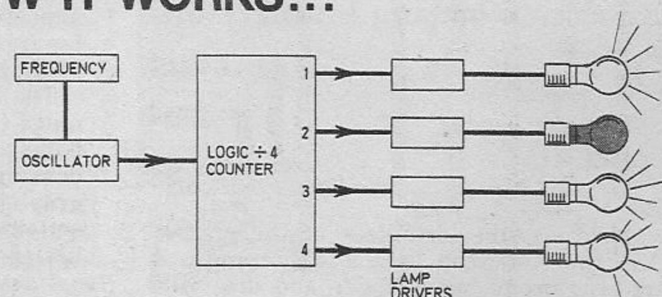
PRINTED CIRCUIT BOARD

Most of the components are mounted on a piece of printed circuit board, the full-size pattern of which is shown in Fig. 1. A Dalo etch resist pen can be used for most of this but rub-down transfer pads are recommended for the component connection points.

When the etchant resist is completely dry the board should be placed in a saturated solution of ferric chloride. Care needs to be exercised when handling this chemical as it is very corrosive. Avoid contact with the skin. A photographic plastic or enamel tray is a suitable container for holding the etchant.

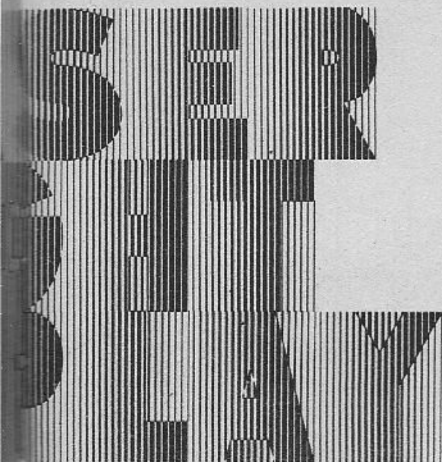
The board should be laid face down and the contents of the tray constantly agitated for speedy results. Inspect the board from time to time using a pair of tweezers to hold the board, and when all the unwanted copper has been removed, thoroughly wash the board

HOW IT WORKS...



The variable frequency oscillator produces a train of square wave pulses suitable for inputting to a TTL logic section which acts as a divide by 4 counter with four independent outputs. The state of each output (high or low, logic 1 or 0) is dependant on the number of pulses received from the oscillator.

At any one time there are three high outputs (four distinct arrangements) or this can be reversed by switching to produce a single high and three low states. A high output on a particular channel turns on the lamp drivers and causes the bulbs of that channel to light. The net result from a train of input pulses is a constantly changing flashing light system, which when correctly arranged will produce a "running" light effect.



By J. McBride

under running water. Remove the etch resist using a scouring pad and then drill the board to suit the component lead-out wires. Drill 4BA clearance holes to provide fixing to the case and then assemble the components as shown in Fig. 4. Note the use of Veropins for connection to case mounted components.

TRIAC HEATSINKS

The next stage of construction concerns the triacs. These need to be mounted on heat sinks, each one isolated from the other and all isolated completely from the case. To accomplish this the four heatsinks are mounted on a sheet of Paxolin that is bolted to the back panel with spacers interposed between board and back panel; Fig. 3 gives details and lead-out identification of the TIC225D triacs specified.

CASE AND WIRING

The case used in the prototype was an integral aluminium base/front/rear panel type with removable fabric covered steel lid. This case is available from many sources and has a type number RB5 with dimensions 280 x 190 x 90mm although any similar size will do.

Begin by drilling the case to accept the case mounted components, including the p.c.b. and triac/heatsink assembly and then fix all these in place and wire up according to Fig. 4.

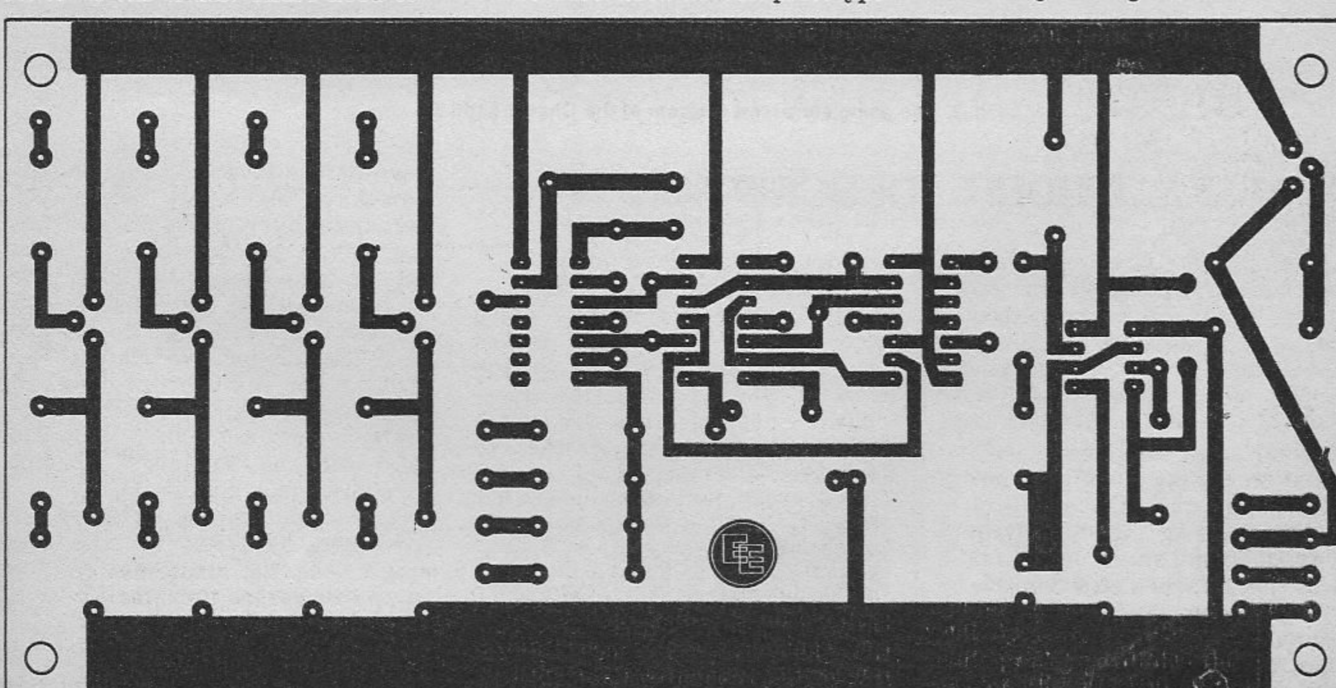


Fig. 1. The copper pattern to be etched on the Chaser Light Display component board, shown full size from copper side.

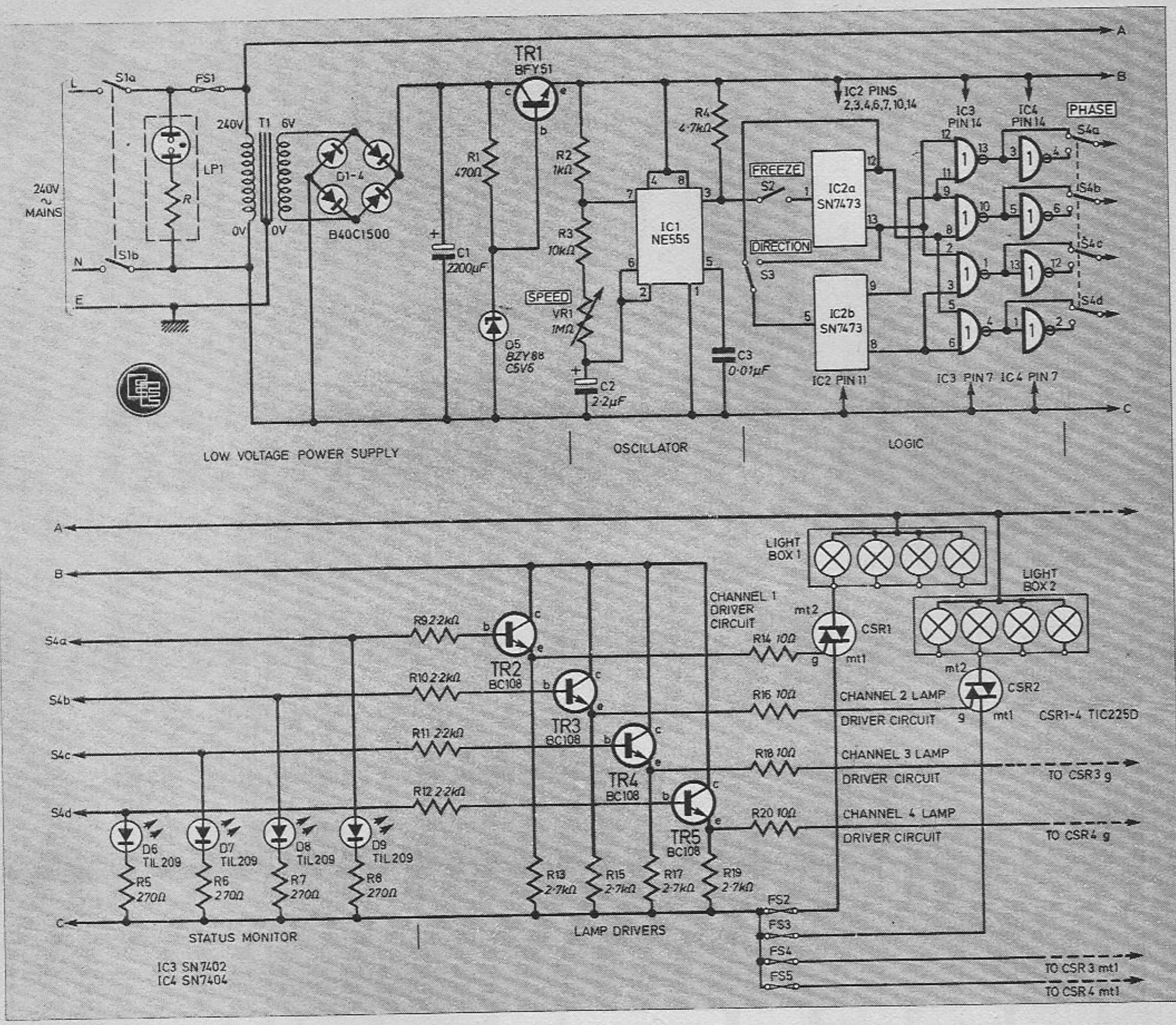


Fig. 2. The complete circuit diagram of the Chaser Light Display.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Chaser Light Display is shown in Fig. 2. and can be seen to consist of five distinct sections: a mains derived low voltage power supply unit (Zener stabilised); a square wave oscillator (clock oscillator); a logic coding section; an l.e.d. status monitor; power switches.

Mains voltage enters the unit and is stepped down by T1. Full-wave rectification is achieved by means of the diode bridge D1 to D4 and the resulting pulsed waveform smoothed by reservoir capacitor C1. The resulting d.c. voltage is placed across the Zener diode and its series resistor.

The Zener voltage, 5·6 volts, is coupled to the base of TR1 which turns on the latter and makes available at the emitter a voltage level of 5 volts (since the base/emitter junction drops 0·6 volts). This level is required for the TTL logic i.c.s.

The oscillator consists of IC1 which is a 555 timer i.c. wired as an astable multivibrator. Output is at pin 3 which is normally at zero volts when the voltage on C2 is less than two-thirds the positive supply voltage level.

The capacitor is charged up via R2, R3 and VR1 and when the voltage on the positive plate reaches two-thirds the supply rail, the internal circuitry of the i.c. switches and causes pin 3 to be at 5 volts. At the same time a discharge path is placed across C2 consisting of R3 and VR1 causing the voltage level on the positive plate to reduce. When this reaches one-third the supply line, the internal circuitry resets and pin 3 drops to zero volts and the capacitor begins to charge up again to repeat.

The output on and off times are governed by VR1, i.e. the frequency of the oscillator can be varied by means of VR1.

LOGIC CIRCUITRY

The output of IC1 is fed to the logic circuitry composed of IC2 and

IC3, two flip-flops (connected in series) feeding four NOR gates respectively interconnected to form a divide-by-four non-overlapping sequential outputs. To help understand the action of this section, consider Table 1, the truth table for the two flip-flops connected in series.

It can be seen that two 1's (high output) and two 0's (low output) are obtained at every phase. The four outputs are cross-coupled to feed four NOR gates. A NOR truth table is shown in Table 2. We can see that the output is always zero except when the two inputs are low simultaneously. The composite truth table is shown in Table 3 and shows that only one gate is producing a high output at any one time and each gate producing such an output level every fifth pulse.

Switch S2 can be operated to hold the logic section output at the last clock pulse state. In this position the lights are no longer "running". Operation of S3 changes the direction of apparent motion.

The four NOR gates are each directly coupled to the inputs of four inverters. A high or low input to these gates (as their name suggests) causes a low or high output respectively. A switch at each output allows this gate to be bypassed if desired.

If all switches are in the positions shown, one channel will be on at each phase; if all the switches are operated one channel will be extinguished at each phase. The latter gives the impression of lamps moving along in groups of three.

The outputs from the logic gates are monitored by the four l.e.d.s D6 to D9 which mimic whatever the main lamps are doing.

TRIAC DRIVERS

Transistors TR2 to TR5 act as TTL-triac interfaces and are turned on when a high state exists thereby causing a voltage step at the emitter to feed the triac gates through gate current limit resistors R13, 15, 17, 19. The triac is turned on when it receives a positive voltage at its gate which then causes the main lamps to be lit. The lamps are extinguished when the triac turns off and this results when the gate voltage/current is reduced below a threshold level when TR2 (3, 4 or 5) is turned off by its base receiving a logic zero (low state).

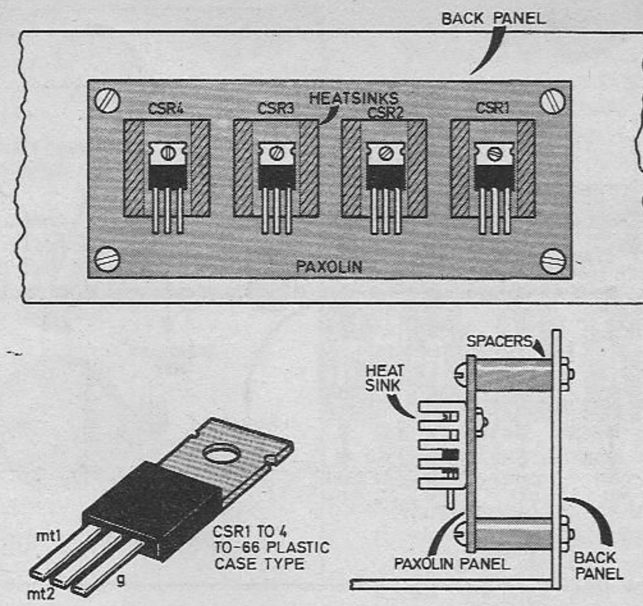


Fig. 3. Details of the triac mounting arrangement and heatsink fittings. Also shows pin configuration for the specified triacs.

Connection to the "light boxes" (or box) is made via a terminal block fitted to the rear panel of the case. Since high currents will be flowing through this terminal to the bank of light boxes, a heavy duty block is required. Use one rated at 15 amps or more to cover all eventualities.

Each terminal block will need to hold four cables (if four separate light boxes are used) or a number equal to the number of light boxes. Wiring details between the master unit and each box is shown in Fig. 5. Use 5 amp wiring to interconnect the lamps and each box to the master.

Table 1: Truth table for two flip-flops wired in series

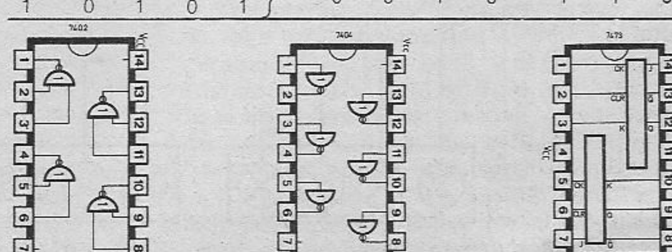
Clock	Q_A	$\bar{Q}_A$	Q_B	$\bar{Q}_B$
0	1	0	1	0
1	1	0	1	0
0	0	1	1	0
1	0	1	1	0
0	1	0	0	1
1	1	0	0	1
0	0	1	0	1
1	0	1	0	1

Table 2: Truth table for a NOR gate

Input 1	Input 2	Output
1	1	0
0	1	0
1	0	0
0	0	1

Table 3: Composite truth table for two flip-flops in series feeding four NOR gates followed by four inverters

Clock	Q_A	$\bar{Q}_A$	Q_B	$\bar{Q}_B$	Gate Outputs G3a	G3b	G3c	G3d	Gate Outputs G4a	G4b	G4c	G4d
0	1	0	1	0	0	1	0	0	1	0	1	1
1	1	0	1	0								
0	0	1	1	0	1	0	0	0	0	1	1	1
1	0	1	1	0								
0	1	0	0	1	0	0	0	1	1	1	1	0
1	1	0	0	1								
0	0	1	0	1	0	0	1	0	1	1	0	1
1	0	1	0	1								



Pin and internal details of the three logic i.c.s employed in the Chaser Light Display.

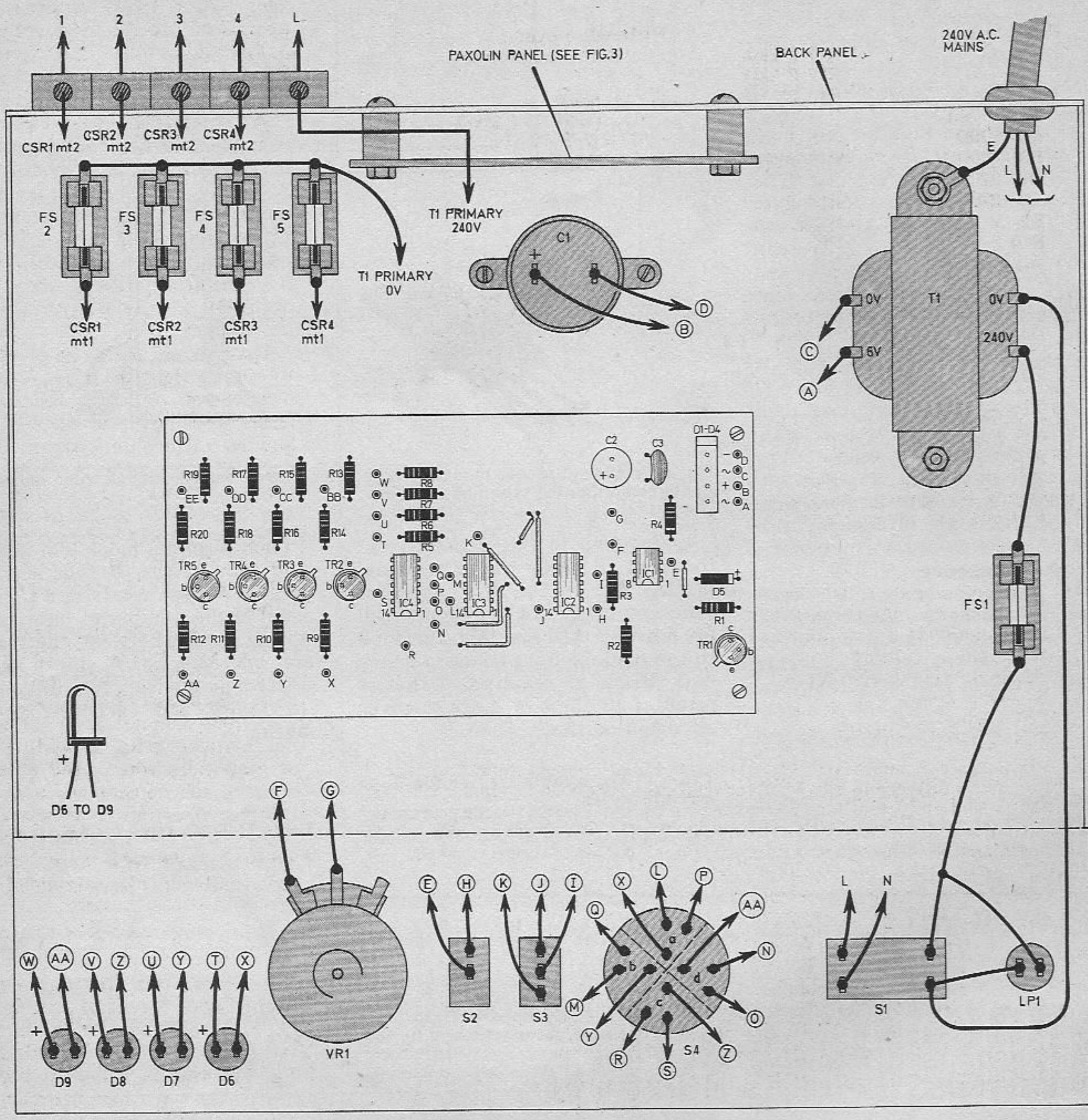
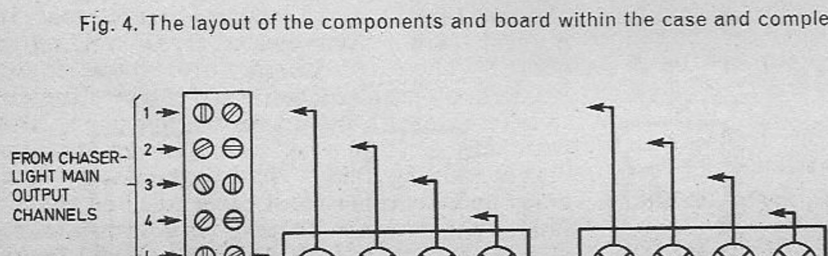


Fig. 4. The layout of the components and board within the case and complete wiring up details of the main unit.



CHASER LIGHT DISPLAY

Fig. 5 Light box wiring details to the main unit.

COMPONENTS

Resistors
R1 470Ω
R2 1kΩ
R3 10kΩ
R4 4·7kΩ
R5 270Ω
R6 270Ω
R7 270Ω
R8 270Ω
R9 2·2kΩ
R10 2·2kΩ
R11 2·2kΩ
R12 2·2kΩ
R13 2·7kΩ
R14 10Ω
R15 2·7kΩ
R16 10Ω
R17 2·7kΩ
R18 10Ω
R19 2·7kΩ
R20 10Ω
All ¼ watt carbon ± 10%

Potentiometer
VR1 1MΩ carbon lin.

Capacitors
C1 2200μF 10V elect.
C2 2·2μF 6V elect.
C3 0·01μF plastic or ceramic

See **Shop Talk** page 262

Semiconductors
D1 to D4 B40C1500 1·5 amp bridge rectifier
D5 BZY88C5V6 5·6V 400mW Zener diode
D6, 7, 8, 9, TIL209 red light emitting diode (4 off)
IC1 NE555 timer i.c.
IC2 SN7473 Dual J-K flip-flop
IC3 SN7402 Quad 2-input NOR gates
IC4 SN7404 Hex inverter
TR1 BFY51 silicon *npn*
TR2, 3, 4, 5 BC108 silicon *npn* (4 off),
CSR1, 2, 3, 4 TIC225D

Miscellaneous
T1 mains primary/6 volt 500mA secondary
LP1 panel mounting mains neon
S1 double-pole on/off rated at 10A 250V a.c.
S2 single-pole on/off
S3 single-pole double throw
S4 4-pole 2-way
FS1 1 amp 20mm
FS2, 3, 4, 5 5 amp 20mm (4 off)

Printed circuit board size 178 × 78mm; 20mm chassis mounting fuse-holders (5 off); fixing clip for C1; metal case type RB5 or similar (280 × 190 × 90mm); solder tag; 5-way 15 amp terminal block; heatsinks type Redpoint TV-4 or similar for triacs (4 off); Paxolin panel for mounting heatsinks; 4BA fixings and spacers; mains cable; rubber grommet.

USE OF CHASER

When used properly the chaser will give fascinating light-shows. The lights are best arranged in groups of four. Each fourth colour being the same. Five groups of four along the bottom of a stage gave the best effect to date.

Alternatively, four floodlights can be used to change the colour or the ambient lighting in a hall. A totally different display can be made from 4, 8, 12 or as many multiples of four as you wish of low powered bulbs arranged in concentric circles. These would need accurate positioning to give the best effect.

Care should be taken at all times to ensure that the triacs are never overloaded or over heated. The triacs specified will take 6 amps, but here a problem arises. A standard 13 amp outlet will not allow three channels (the maximum at any one time) to be used to full capacity. Check before the venue that even this can be supplied as some halls have very poor mains supply.

No suppression has been fitted to this unit for the simple reason that no interference was detectable when switching over 1 kilowatt per channel (only one channel loaded) using a wide variety of amplifiers when used at even a quarter of normal volume level. Interference on a common, unsuppressed 100 watt amplifier was about 250mW with all volume and tone controls fully advanced. ⌑

BOOK REVIEWS

MODEL ENGINEERING
Author Martin Evans
Price £7·95
Size 245 × 190mm 210 pages
Publisher Pitman

This is a handsome book incorporating a lavish selection of photographs of models with locomotives predominating but including trams, tractors, cars, boats and even clocks. These excellent examples of the model maker's craft very nearly succeed in overshadowing the text which does nevertheless occupy 121 out of a total of 210 pages.

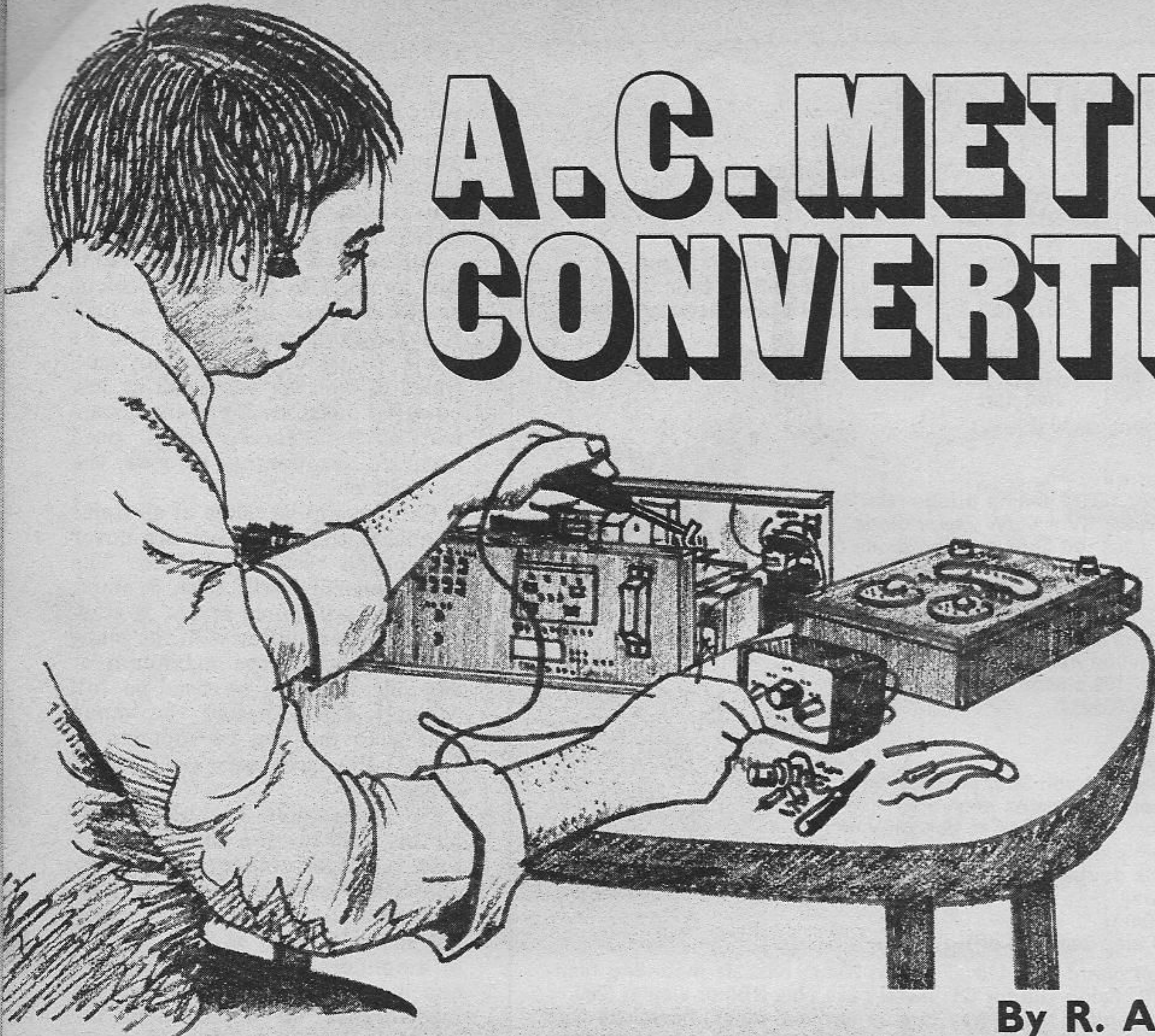
On practical matters there are chapters devoted to the home workshop and essential hand tools; and the more specialised machines used in model engineering: the lathe, the drilling machine, and the grinding machine. The text is aimed at the newcomer and is well illustrated with line diagrams and with photographs of typical equipment.

Other practical matters discussed include castings and materials; and the joining of metals (six different methods—from bolts and studs, to welding are explained). There is a glossary of engineering terms.

The photographs alone could well entice a reader to take up model-making as another hobby. If so, the remainder of this book will give him the essential insight into the field of light engineering. We suspect many an electronics constructor will find the prospect fascinating and not an unnatural transition for one already coversant with electronic model making. In any event, for the electronics constructor in general this book could prove a useful extension and back-up to other works of reference he may possess dealing with workshop matters.

F.E.B.

A.C. METER CONVERTER



By R. A. Penfold

INTRODUCTION

WHEN working in the field of audio equipment, one of the most useful pieces of test equipment to have in the workshop is an a.c. millivoltmeter. This is needed in order to check most of the parameters of an amplifier and is also very useful for general servicing and testing purposes.

Many electronics enthusiasts, especially beginners, may be put off building an audio millivoltmeter by the cost and complexity of a good quality instrument. The unit which forms the subject of this article is designed to provide a low cost alternative to a millivoltmeter, and it can be used in conjunction with any multimeter having an a.c. range of about 5 or 6 volts f.s.d. or less.

The basic unit is really just an amplifier which has two switched voltage gains of 10 (20dB) and 100 (40dB). Thus, if it is added ahead of a multimeter switched to its 5V a.c. range, this set-up will have an input sensitivity of 500mV with the amplifier in the x10 mode, and 50mV with it in the x100 mode. It can therefore be used to convert a multimeter into a millivoltmeter.

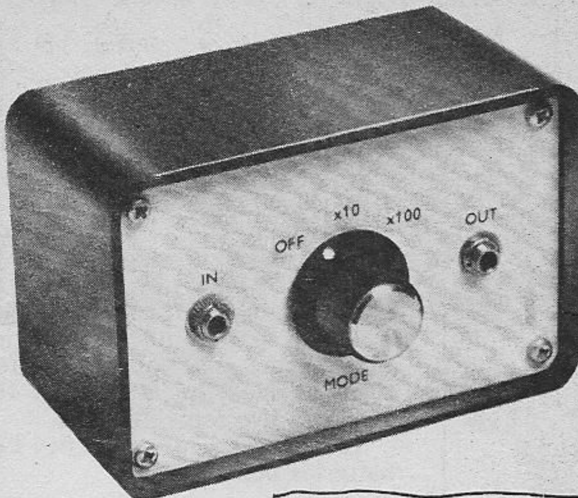
The number of ranges obtained and the accuracy of those ranges is largely dependent upon the specification of the multimeter used. The author's instrument has low a.c. voltage ranges of 1·5, 3, and 5V f.s.d., which provides six ranges when the converter is added (15, 30, 50, 150, 300, and 500mV f.s.d.). Accuracy has proved to be more than adequate for all normal requirements.

There are other possible uses for the unit. For instance, it can be added ahead of the Y-input of an insensitive oscilloscope in order to enable low level audio measurements to be made.

START HERE FOR CONSTRUCTION

The prototype is constructed in an A.B.S. case with a steel front panel, and the unit is constructed in such a way that it is tailored to fit this particular case. It is therefore advisable to use the specified case, even though the unit could be adapted to fit other cases of a similar or larger size.

The front panel is drilled with a central 10mm diameter hole to take S1, with SK1 to the left of



A.C. METER CONVERTER

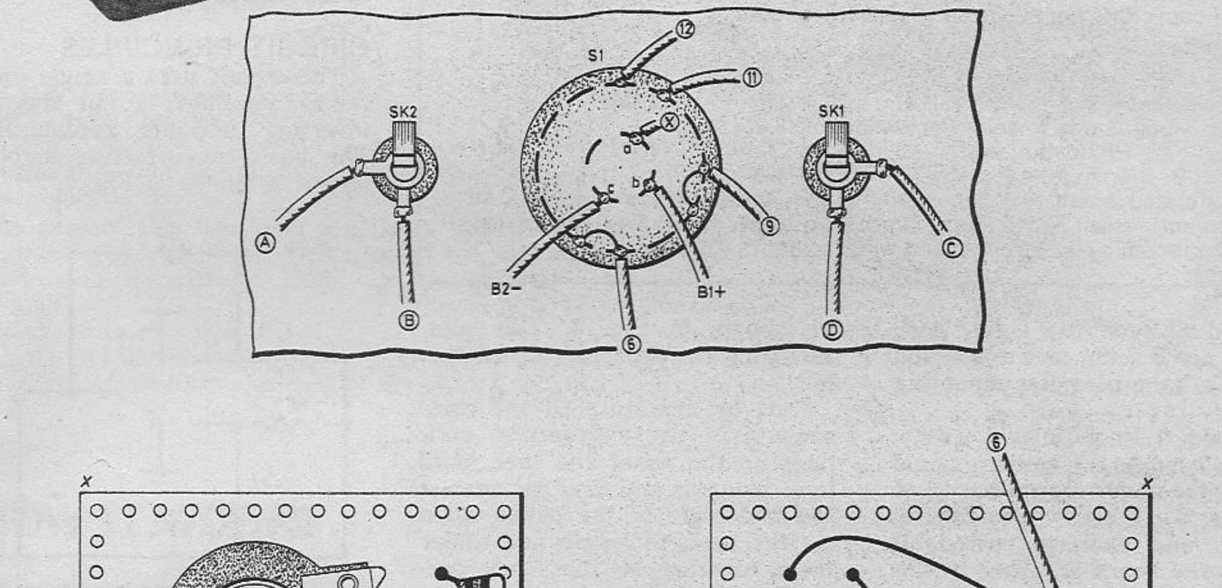


Fig. 3. Component layout and wiring for the plain perforated board. The wiring for the front panel components S1, SK1 and SK2 are also shown.

COMPONENTS

Resistors
R1 18Ω
R2 1·8kΩ 1%
R3 20kΩ 1%
R4 1MΩ
R5 180kΩ 1%
All resistors are carbon ¼W ± 5% except where stated

Potentiometers
VR1 2·2MΩ standard horizontal preset

Capacitors
C1 47nF
C2 100nF
C3 100nF
C4 3·3pF ceramic
C5 470nF
All capacitors are polyester except where stated

Integrated Circuit
IC1 748C 8 pin d.i.l.

Miscellaneous
S1 4-pole 3-way rotary wafer switch
B1, 2 9V PP3 batteries
SK1, 2 3·5mm jack sockets
Perforated board 0·1 inch matrix 23×14 holes; plastic case type M2 (Doram); small round knob; two battery clips; two 3·5mm jack plugs; wo crocodile clips; connecting wire; solder.

See **Shop Talk** page 262

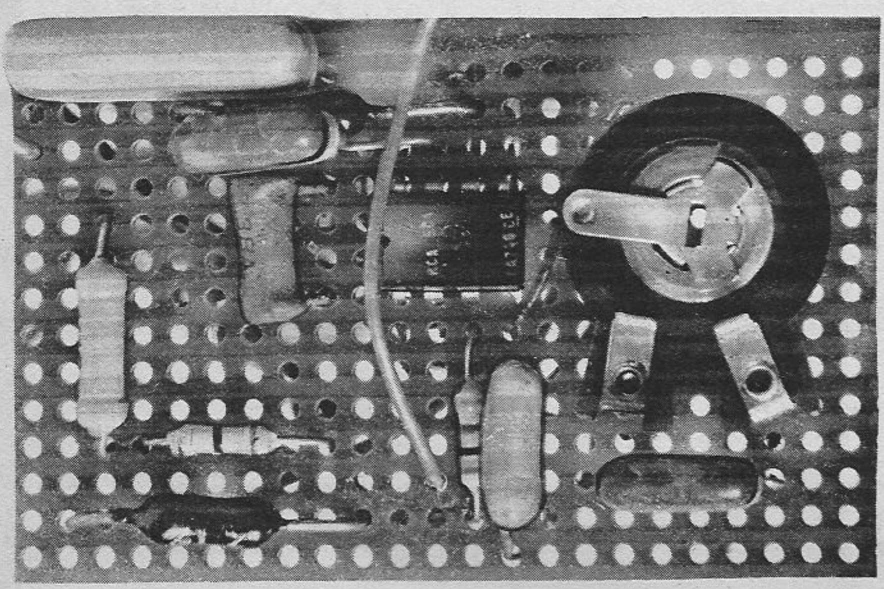
this and SK2 on the right. Both sockets are 3·5mm jack types and require a 6mm diameter mounting hole.

A plain 0·1inch matrix s.r.b.p. panel is used as the constructional basis of the circuitry, and has 23 × 14 holes. Use a hacksaw to cut this to size, and exercise reasonable care as the board is rather brittle.

Details of the component layout and underside wiring of the panel are shown in Fig. 3. This also shows all the other wiring of the unit.

Start by mounting all the components in the appropriate positions on the panel and then bend their leadouts and tags flat against the underside of the panel. Then cut the leads to length and solder them together so that they conform to the wiring diagram. Then connect the single link wire.

Finished circuit board showing positioning of components.



Position the completed component panel between S1 and SK2 so that it has its component side facing SK2 with C5 immediately below SK2. Then wire the panel up to the rest of the unit using ordinary insulated connecting wire. The two connections to SK2 are taken to the component side of the panel and all others are made to the underside.

This is important, since the finished component panel is slotted into the appropriate set of guide rails in the case, and this effectively divides the interior of the case into two separate parts.

There is a space for the two PP3 batteries behind SK1.

CIRCUIT PRINCIPLES

The circuit uses a single operational amplifier i.c. in the non-inverting amplifier configuration. The basic non-inverting amplifier circuit is shown in Fig. 1.

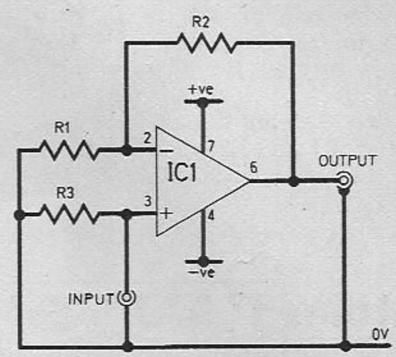
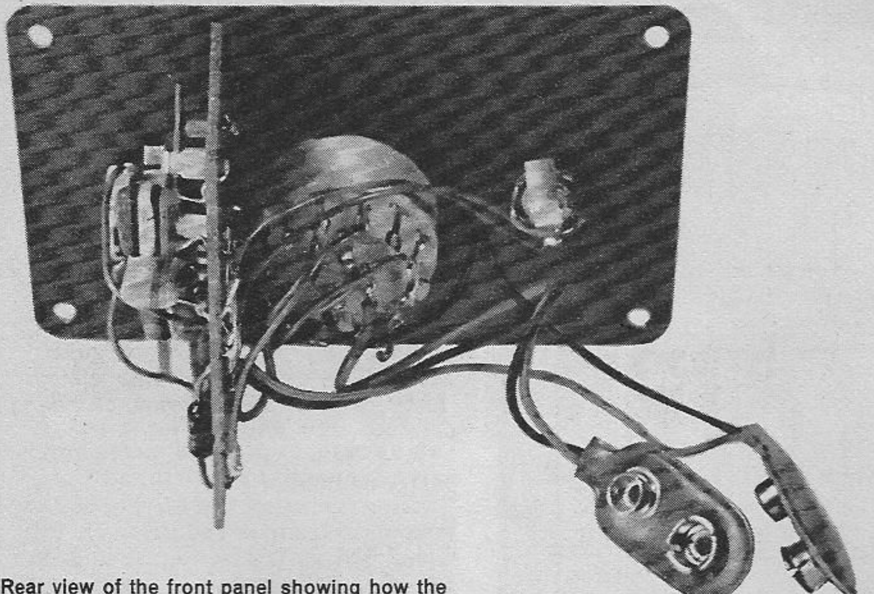


Fig. 1. The basic non-inverting amplifier circuit.

An operational amplifier has an extremely high voltage gain, this being something in the order of 100,000 times for the 748C device used in this circuit. There are actually two inputs to an operational amplifier; the inverting (−) input, and the non-inverting (+) one. The output voltage of the device is equal to the difference between the two inputs multiplied by the voltage gain of the device.

An op-amp is a little unusual in that it operates from a dual balanced power supply with the earth line being at what, in effect, is a centre tap on the supply lines. When the (+) input is positive of the (−) one, the output goes positive of the earth line. The output swings negative when the (+) input is negative of the (−) one.

Practical amplifier circuits which incorporate an op-amp rarely use the full voltage gain of the device



Rear view of the front panel showing how the circuit board is positioned between SK2 and S1.

(the "open loop voltage gain"), but use negative feedback to reduce the gain of the circuit as a whole to the required level. This gain is termed the "closed loop voltage gain".

In the skeleton circuit of Fig. 1, resistors R1 and R2 form the feedback network while R3 *ties* the non-inverting input to the earth potential. Under quiescent conditions the circuit will balance itself with the inputs and the output at earth potential.

This is assured by the feedback action of the circuit. For example, due to the potential divider action across R1 and R2, the voltage at the negative input would be taken above that at the positive input if the output were to go positive for some reason. This would unbalance the inputs, causing the output to swing negative, back to earth potential.

Completed unit.

DETERMINATION OF GAIN

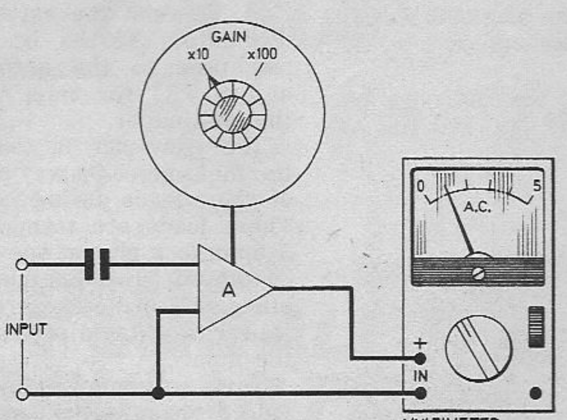
This negative feedback action also determines the closed loop voltage gain of the circuit. Assume that R2 has nine times the value of R1, and that a positive input of 1V is applied to the positive input. The inputs will be unbalanced and the output will swing positive, but only by as much as is necessary to balance the inputs once again.

In this case it must swing 10V positive so that there is 9V across R2 and 1V across R1. There will then be 1V at the (−) input, and the circuit will be balanced.

It should now be apparent from this that the gain of the circuit is set by the ratio of R1 to R2, and is ten times in this instance. The voltage gain of the circuit is equal to R1+R2 divided by R1.

By giving R1 and R2 switched ratios of 1 to 9 and 1 to 99, an amplifier with gains of 10 and 100 can be produced.

HOW IT WORKS...



The A.C. Meter Converter is basically an a.c. amplifier with a switched gain of either 10 or 100. The gain being selected by varying the ratio of two resistors. Thus the set-up can be used to measure low level voltages which would be imperceptible using a standard multimeter alone.

For example, an input of 100mV would produce a very low reading with a multimeter switched to say, the 5V range. The converter could thus increase this value ten times to give a reading of 1V on the meter. This would produce 1/5 f.s.d. on the meter and would thus be easier to see. Naturally the reading is divided by ten to obtain the correct 100mV reading.

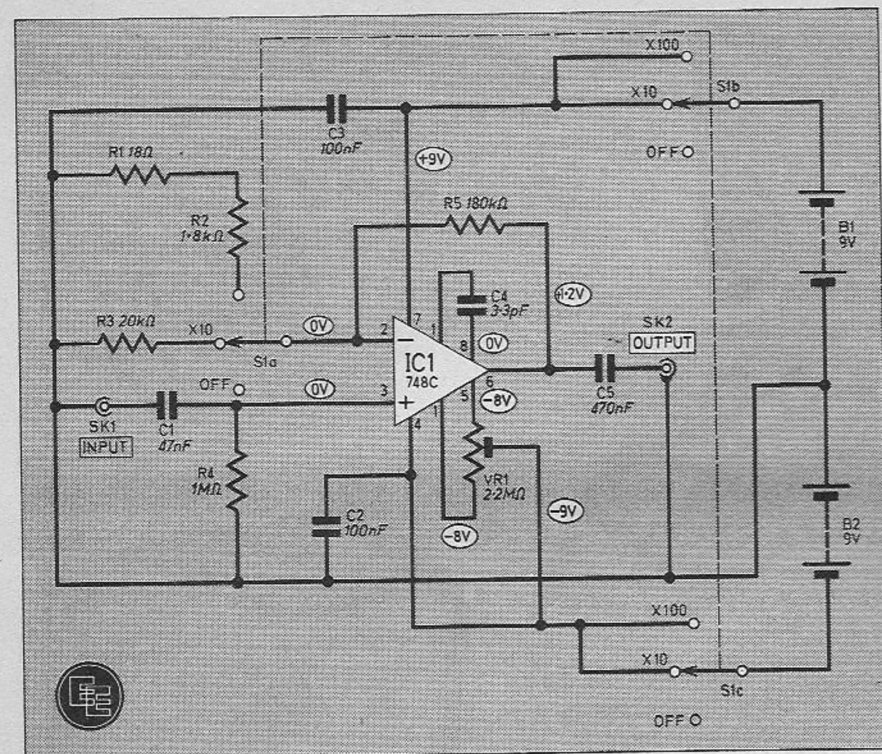


Fig. 2. The complete circuit diagram of the A.C. Meter Converter.

needed to ensure stable operation of the device. C2 and C3 are supply decoupling components, and they also aid stability. C1 and C5 are the input and output d.c. blocking capacitors respectively.

Potentiometer VR1 is an offset null control, and is used to adjust the output of the amplifier to earth potential under quiescent conditions. In a theoretically perfect circuit this would not be required.

However, the 748C does not achieve perfection, and although theoretically no bias current should flow into either input of an op-amp, in practice a small current is needed by each input.

This can upset the biasing of the circuit causing a reduction in the available output voltage swing, or in an extreme case it could even prevent the circuit working altogether in the x100 mode. The offset null control enables compensation to be made for the inadequacies of the i.c., and ensures that good results are obtained.

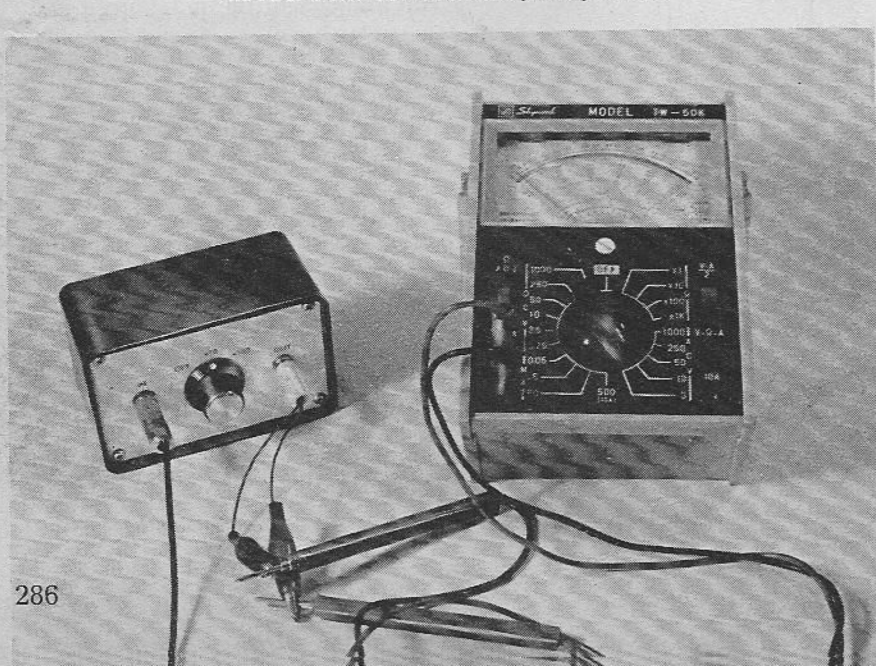
CIRCUIT DESCRIPTION

The circuit diagram of the A.C. Meter Converter appears in Fig. 2. When S1 is in the x10 position resistors R3 and R5 are the feedback network, and R1, R2, and R5 form this network with S1 set to the x100 position. With S1 in the first position the supply is disconnected, and the unit is switched off.

Applying negative feedback to the circuit produces an extremely high input impedance at the positive input, and the input impedance of the amplifier as a whole is approximately equal to the value given to R4. It is preferable for the unit to have a fairly high input impedance so that it only lightly loads the test circuit. Resistor R4 has therefore been given a value of 1 megohm.

Capacitor C4 is the compensation capacitor for the i.c., and this is

The A.C. Meter Converter set-up ready for use.



ADJUSTMENT AND USE

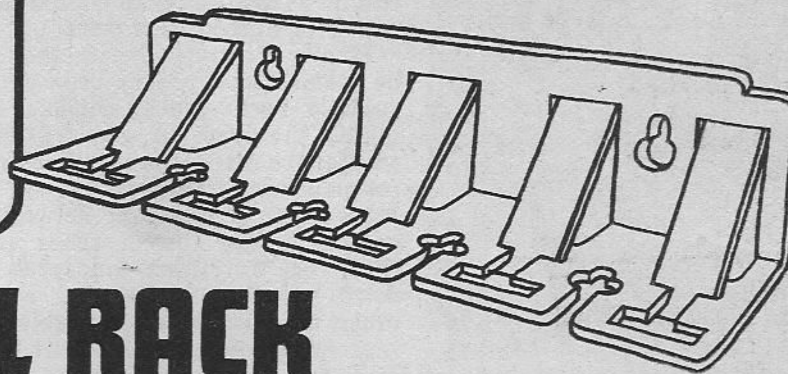
Variable resistor VR1 must be adjusted before the unit is ready for use. Start with the slider of VR1 at about the centre of its track and then switch the unit on with S1 in the x10 mode. Connect a multimeter set to read 10V d.c. f.s.d. between the earth line and the output of the i.c. (negative test prod to the output). Then adjust VR1 for zero reading on the multimeter.

The converter is connected to the multimeter by way of a couple of short leads during normal use. These leads are terminated in a 3·5mm jack plug at one end, and a couple of crocodile clips at the other. An ordinary screened test lead with suitable prods is used at the input.

This arrangement should provide a virtually flat frequency response over the audio frequency spectrum, and the unit has sufficient output voltage swing to properly drive a 5V f.s.d. meter over this frequency range. In the x100 mode though, the response and drive capability of the unit fall off quite rapidly above about 20kHz.

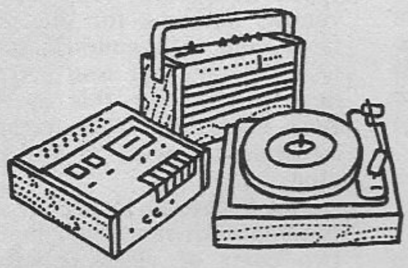
This presents no problems with the majority of tests. ⌑

next month



FREE TOOL RACK

Holds four small tools. A boon for every workshop.



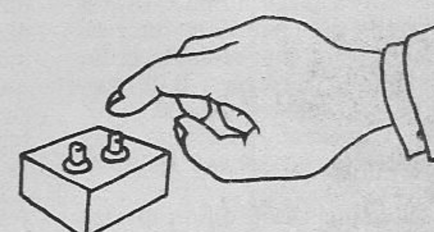
THE AUDIOTEST

This useful piece of equipment comprises a loudspeaker and loudspeaker amplifier stage for testing radio receivers, record players, tape recorders, and pre-amplifiers having an output power not exceeding 10 watts.

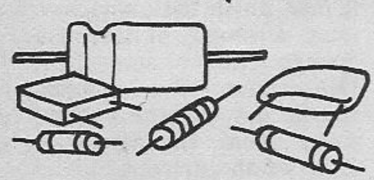
A simple M. and L.W. radio tuner is incorporated as a speech and music source, and to provide entertainment in the workshop.

CATCH-A-LIGHT

A reaction game with a difference, based on six lamps numbered 1 to 6. The two players have to respond immediately a pair of lights stop blinking and switch on that one of their own pair which is nearest the stationary light. The first to do so is the winner, and there can be no argument since the winning light automatically blocks the opponent's lights.



C/R SUBSTITUTION BOX



A simple project which will be found extremely valuable when designing and experimenting with circuits. Produces a variety of C and R values immediately "on tap".

PLUS ALL THE REGULAR FEATURES

There is a tremendous demand every month for Everyday Electronics. Readers are strongly urged to place a firm order with their newsagent. Reliance upon casual purchase is unwise, because stocks may quickly be exhausted. So please remember, and take action now!

Everyday ELECTRONICS

MARCH ISSUE ON SALE FRIDAY, FEBRUARY 17

LOW COST LOUDSPEAKER ENCLOSURE

By J. Smith

THERE are a large number of old 3 ohm loudspeaker drivers available from out-of-date radio and television receivers. It is possible to use these drivers with modern transistor amplifiers. The trick necessary is to use three in series.

By selecting three different size drivers and fitting them into a suitable cabinet a wide response range loudspeaker system is obtained having an impedance of 9 ohms. Very good results using simple stereo amplifiers, approximately 3 watts output, from designs published in this and other magazines are possible.

DRIVE UNIT SELECTION

Three different driver units should be selected to complement each other. All three should be fitted with back spider suspension (behind the cone) if possible. Front spider units tend to distort on loud signals.

First a bass unit is necessary; an 8in or elliptical driver will perform well here. Select a driver with a deep cone, because these perform better on bass signals. The ultimate performance obtained from the loudspeaker system depends a great deal on this bass driver unit, so look around for a good one.

The mid tones are well reproduced using either a shallow cone 8in, or a 6in unit; almost anything will do as long as it can handle the power (1 watt in each driver).

Finally the treble driver should be a small loudspeaker drive unit (with a back spider) capable of taking the load. In general, the smaller the driver the better it will reproduce high notes.

No filters or crossover networks are used. The system relies entirely on the three loudspeaker drive units complementing each other, the bass driver incapable of reproducing high notes, whilst the small treble driver will not be able to reproduce the bass. Of course, the middle drive unit reproduces a little of each.

This arrangement will make the hi-fi expert shudder, but the system works far better than most of the cheaper (under £50) stereo systems on the market.

CONSTRUCTING THE CABINET

The cabinet is very simple to build and may be any desired dimensions big enough to accommodate the loudspeaker drive units. Biggest is best for this design, so if you wish to impress friends with an elaborate enclosure by all means do so.

The principle constructional features of a cabinet to house 8in 6in and 3in units is shown in Fig. 1. The wood used is veneered chipboard for the enclosure and blockboard for the baffle.

First calculate the size of your baffle and remember that this gives the *inside* dimensions of the enclosure. Allow an extra 6mm clearance on the inside measurements to accommodate the loudspeaker cloth and construction errors.

The blockboard and chipboard can be purchased, ready cut, from your local do-it-yourself supplier, who will also cut the loudspeaker driver holes. Be absolutely sure that these holes are smaller than the driver to allow for fitting, but not so small that the cone touches the wood on its outward excursion.

CORNER BLOCKS

The "waste" from these holes is used to make the corner pieces in the enclosure. The optional hole in the baffle board is not cut until after the unit is tested and is only of interest to those who wish to make a pseudo reflex cabinet.

The corner pieces of the enclosure are first screwed to the chipboard and the whole unit temporarily assembled to see that it fits together, persons fitting a back must allow for this when they position the rear corner brackets. Once satisfied that the unit will fit nicely together take it apart and reassemble the enclosure using Evo-Stick resin woodworking adhesive to join the chipboard and corner pieces.

FINISHING OFF

Finally finish the exposed chipboard ends with "iron on" wood veneer, obtained for this purpose from your do-it-yourself supplier. (An ordinary flat iron set to low heat is used for this operation.) Keep everything clean during construction and wipe off any surplus glue.

Finish the enclosure by lightly rubbing with sandpaper and apply two coats of clear polyurethane varnish, allowing 24 hours between coats. With reasonable care the finished enclosure should look very attractive.

FINISHING BAFFLE

Anyone wishing to make a pseudo reflex cabinet should follow the instructions given later, but those wishing to have an open back, or a back with holes cut into it may finish the baffle board. First glue a sheet of 3mm or 6mm sponge rubber across the front. Use ordinary Evo-Stick, and when this is dry cut the sponge rubber away from the round holes in front of the drivers.

Next stretch a piece of loudspeaker cloth right over the unit and tack to the rear of the baffle board. Stretch this cloth very tightly over the sponge rubber securing with drawing pins before tacking, otherwise it will sag and not look very professional.

Bolt the driver units to the baffle and wire in series. Screw the baffle into the enclosure using four screws fitted from the back through the corner pieces. The clearance hole for the screws should be drilled at an angle which allows the screwdriver to be handled easily from the rear of the enclosure.

Materials

Baffleboard

Blockboard—508 × 280 × 19mm
Driver Units—A-6in B-3in C-8in

Enclosure

Side Panels
514 × 324 × 19mm Veneered Chipboard (2off)
Top and Bottom
324 × 324 × 19mm Veneered Chipboard (2off)
Back—514 × 286 × 19mm Chipboard or 5-plywood

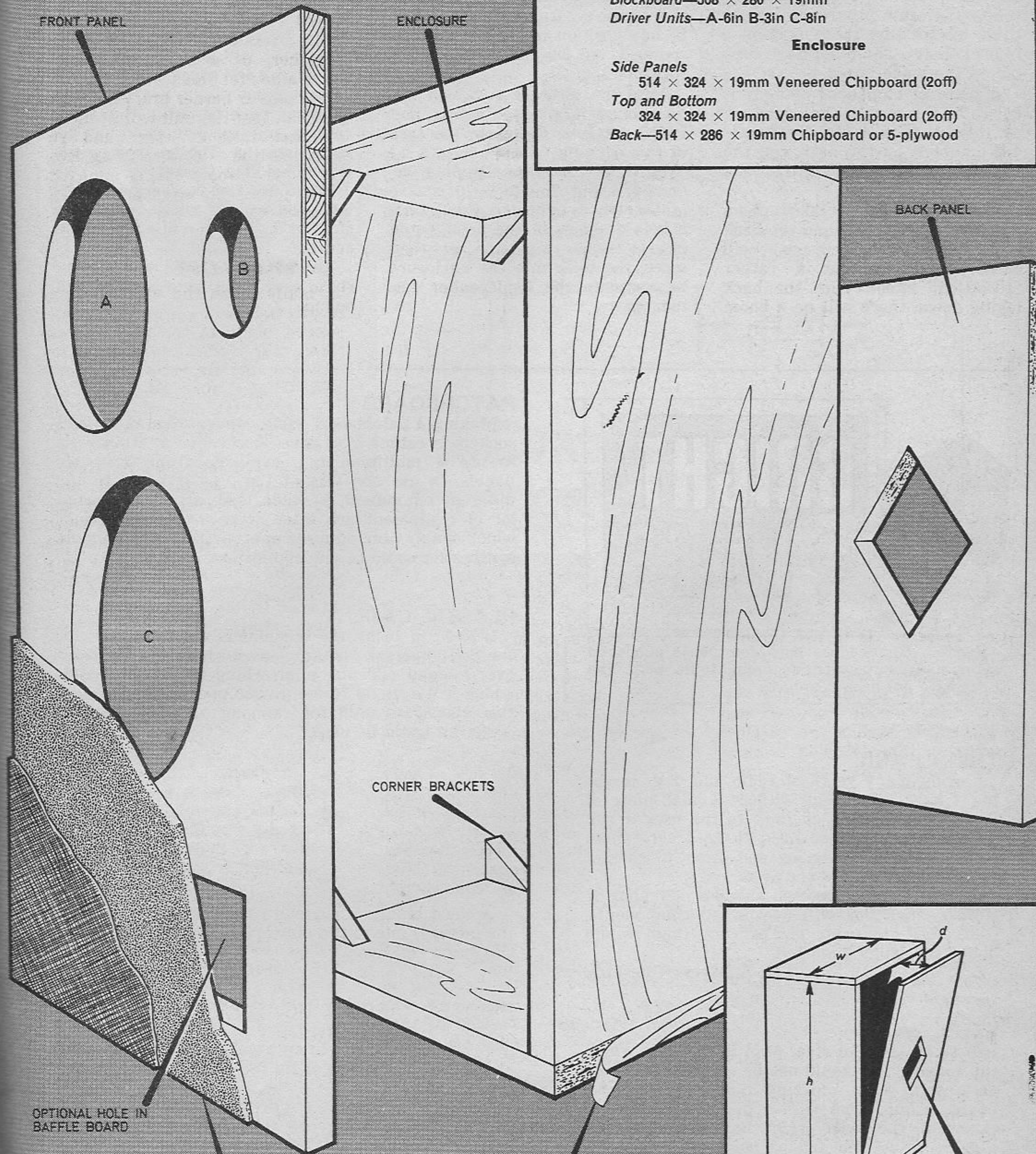


Fig. 1. Constructional details for a low cost loudspeaker enclosure. The method of working out the size of hole required to "tune" the enclosure for best response is shown inset.

BACK

Readers fitting a back or those making a pseudo reflex unit will follow the same procedure for the back, except that those making a reflex cabinet should not have completed the baffle board.

A piece of chipboard or 5-ply is cut to fit the rear of the enclosure as tightly as possible. Terminals are mounted on the back and the loudspeaker is connected to an amplifier.

Play music rich in bass frequencies and notice that when the back is pushed into the enclosure it will cause distortion and a rather "throttled" effect. With the back laying down, there will be a boom on certain passages as the cabinet resonates.

Hold the back as shown in Fig. 1 and find the "best" position. This will not be critical but there should be one position where the boom is reduced, but the speakers are not throttled.

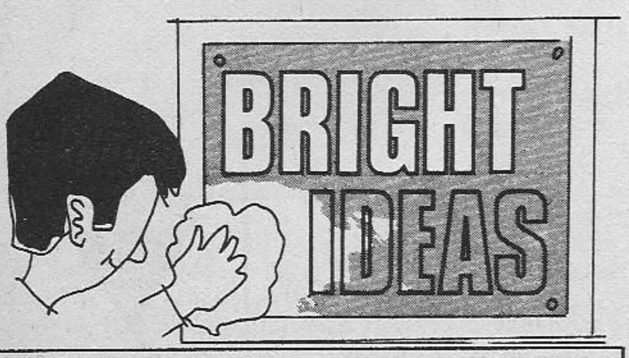
Note the distance *d*, which will be around 12mm to 50mm, possibly even less. Calculate the area of this opening $(d \times h) + (d \times w)$ to give the size of opening required, about 760 to 1270 square millimetres is expected. Finally cut a hole or holes in the back, equal in area to that calculated, and then screw the back into the enclosure to complete the loudspeaker system.

REFLEX HOLE

Readers making a pseudo reflex cabinet obviously leave the back alone and cut *their* hole in the baffle board. The driver units should be removed first, otherwise wood dust will get into the voice-coil air-gap and cause distortion.

Having cut the "reflex" hole the baffle is covered with the foam rubber and speaker cloth as described earlier. The finished unit is assembled and tested.

Providing the reader has selected good drivers whose cones are clear of dust or iron filings and "on centre", they will be pleasantly surprised at how good and efficient these very cheap loudspeakers will sound. ⌘



Readers' Bright Ideas; any idea that is published will be awarded payment according to its merit. The ideas have not been proved by us.

THIRD HAND

During many years of radio and T.V. servicing, I have never been without a small piece of Plasticine. There is no limit to the uses it can be put to. It may be used to hold very small components for soldering and other items that require that "third hand".

A small amount pressed out in a matchbox or similar small box will hold small components, transistors, diodes etc. and prevents them rolling about and being damaged.

T. A. Myers, Cheshire.

STEEL WOOL

A small piece of steel wool is one item which the constructor should not be without. It can be very useful when soldering components to Veroboard, a quick rub with a piece of steel wool cleans all the oxide which has formed on the copper strips and makes soldering easier. A second use of steel wool is for removing the enamel coating on copper wire, a quick rub will remove all but the most stubborn of enamels.

R. S. Patel, Leicester.

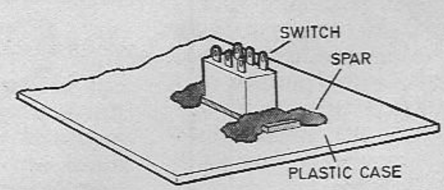
PATCHBOARD

Making a patchboard using conventional plugs and sockets is rather expensive. A cheaper alternative is to use a multipin plug, available from computer panels. In use one side of the plug is wired to the different equipment. Flexible leads from the second lot of equipment are fitted with spade connections which simply plug onto the appropriate pins. A simple synthesiser could be one application.

P. Baily, Glasgow.

PLASTIC CASE

Instead of using the recommended metal case for the *Soil Moisture Monitor* I used a plastic case. However I found difficulty in attaching the on/off switch, which had a metal frame, to the plastic case. I found that the spars used for carrying parts of a model Airfix kit could be used.



A short length is cut and used as a batten to affix the metal frame to the plastic lid. The diagram shows this more clearly.

N. J. Phillips, London N20.

PRINTED CIRCUIT BOARD

I have found an alternative to the normal types of printed circuit board. In my version hardboard is used as the base and strips of tin foil as the current carrying conductors.

The foil is cut to the required shape and stuck onto the hardboard, holes are then drilled as required, and nuts and bolts fitted. The leads of the components are then simply wound round the bolts and screwed in place. To prevent short circuits from occurring insulating tape may be stuck on the underside.

V. Bennett, Surrey

SQUARE ONE ...FOR BEGINNERS

WE ARE HERE TO HELP YOU - NO MATTER HOW NON-TECHNICAL YOU MAY BE, JUST READ ON!

CONSTRUCTIONAL ARTICLES

All constructional articles in EVERYDAY ELECTRONICS are presented according to a standard pattern. The intention is to make it easy for the constructor to get to grips with the essentials.

Newcomers should note this standard arrangement, which includes the following major sections:

Introduction; How It Works; Start Here For Construction; Components; and Circuit Description.

INTRODUCTION

The very first section is the *Introduction* and is of course required reading. The general information given here will enable you to decide whether the project is one that appeals and has some immediate use.

HOW IT WORKS

In its own "box" (not always on the first page, please note), *How It Works* gives the reader a brief overall description of the circuit operation, and the kind of situation in which the project is employed. The accompanying illustration is usually a combination of *block diagram* and pictorial representation of some typical parts or associated equipment or apparatus with which the electronic unit is used.

BLOCK DIAGRAM. This is a very simple kind of diagram, where every important section of a *circuit diagram* is represented by a block—usually a rectangle, but some other shapes are used for certain forms of circuitry.

For example, an *amplifier stage* is conventionally indicated by a triangle, like an arrow-head pointing to the right. This "block" is "read" from left to right, as is conventional in all circuit diagrams, thus the input is applied to the left-hand side of the triangle and the output appears at the right hand tip (see Fig. 1).

The individual blocks are always labelled so that it is quite clear what portions or stages of the main circuit they represent.

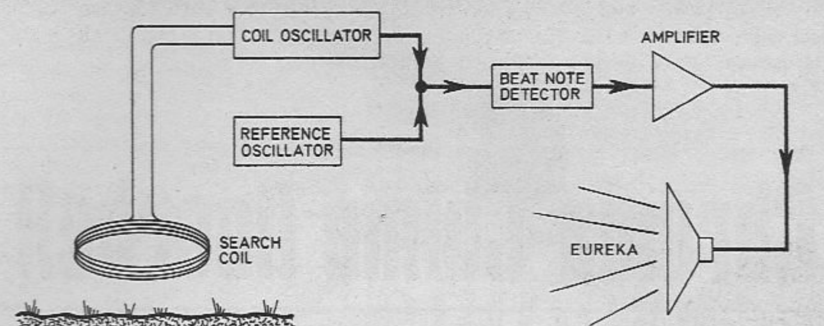


Fig. 1. A typical block diagram. This is taken from the How It Works section of the Treasure Locator (October 1977 Issue—back issues not available)

For brevity and simplicity, single lines are used to show the interconnections between the blocks. Arrows are often included to show direction of signals. These single lines must be interpreted as meaning actually *two* conductors in practice, to make the normal kind of circuit connections. But sometimes the connections are depicted in full detail, as when individual components are drawn.

EARTH SIGNS indicate a common connection. In other words, one can mentally link all such signs together. This applies equally to circuit diagrams. (We shall be discussing circuit diagrams in a future *Square One*).

Apart from their use in *How It Works* block diagrams are commonly used to supplement circuit diagrams. They provide an overall key to the circuit and are especially important and helpful when the circuit is large and complex.

The block diagram helps the reader to "break down" the complete circuit into recognisable sections, thus enabling one to quickly understand and find one's way around the main diagram, no matter how involved it may appear at first glance.

START HERE FOR CONSTRUCTION

Having read the *Introduction* and *How It Works*, one can move on to the Constructional Details.

This part of the text (well signposted with an arrow head) describes, step by step, the building of the project. The accompanying illustrations showing the construction and assembly in detail must be carefully studied as well. They provide a complete blueprint for the constructor to follow. Every component and every connection is shown. So all you really have to do is follow the illustrations!

COMPONENTS

Before any building can commence, the necessary components and other items must be obtained. This brings us to the final essential department in our constructional articles—*Components*. This provides a complete list of all you will require. Note carefully any reference to *Shop Talk*, since this regular feature enlarges on particular shopping matters, suggesting sources of supply, or possible alternative types in light of current experience concerning availability and so on.

CIRCUIT DESCRIPTION

So now you are all set to go ahead. However, if you really are interested in electronics you are bound to read the *Circuit Description*—sooner or later. Although this is by no means essential before starting on your very first project. Good luck!

EE SPECIAL REPORT

Chroma-Chime Doorbell

How about an electronic door chime that greets your caller with *Oranges and Lemons, Rule Britannia,* or *Colonel Bogey*—or any one from twenty-four jingles available at the turn of a switch? This is not all, however; a second bell-push can be fitted and a different tune allocated to it so you know instantly whether your caller is at the front or the back door.

All of this comes in the form of one small compact self-contained unit, housed in a white plastic case with removable panels giving access to the batteries and to the controls. The latter consist of the two tune-selector controls, providing a choice from the total repertoire of 24 tunes, a tempo (or speed) control, a tone control, and a volume control.

This then is the Chroma-Chime, which first appeared on the market last summer.

The Chroma-Chime is powered by two PP3 batteries and under average conditions a life of at least one year is obtainable before replacement is necessary.

As well as the ready-made unit, the Chroma-Chime is now also available as a kit for the home constructor. Before we discuss this kit, a few words about the Chroma-Chime in general.

A MINICOMPUTER

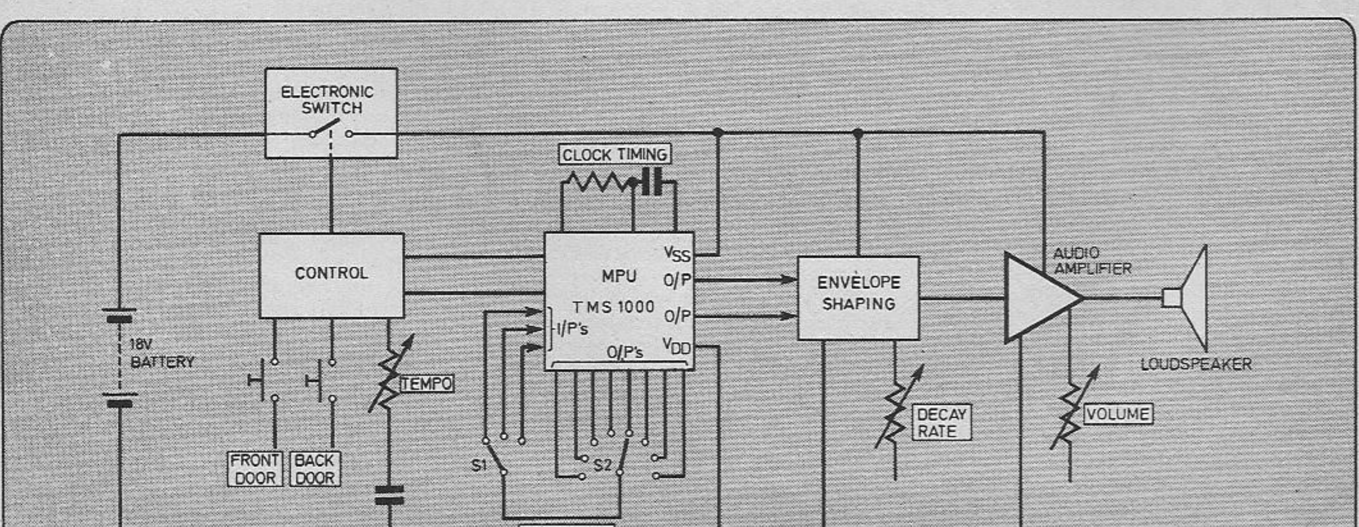
How is this all achieved in such a small (and deceivingly simple) unit? The answer is—a microprocessor, which forms the heart of the Chroma-Chime circuit.

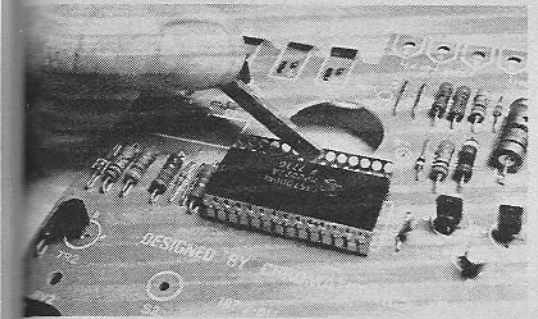
Microprocessors are the very latest technological development and they are now beginning to play a very significant role in electronics. Most of their applications so far have been in industrial equipment but they have a great future in the consumer area. The Chroma-Chime is amongst the very first of microprocessor-based products designed especially for the domestic market. It is a point of especial interest that this instrument has been designed by a British Engineer.

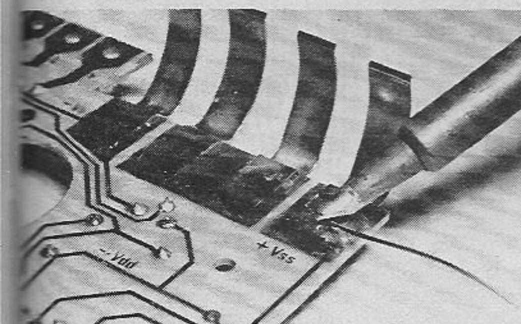
The Chroma-Chime designer conceived the general idea and then compiled the necessary programme, using his extensive experience with conventional full-size digital computers. The resultant programme was then implanted into the mini-computer chip during manufacture by Texas Instruments. The uniquely programmed chip is given its own identification mark.

This is a typical example of how a custom-designed dedicated microprocessor is originated. Dedicated means that the microprocessor is assigned one particular task (which may be extremely complex) and will perform that task once it is fitted into the appropriate circuit with (usually) a

Fig. 1. Block diagram of the Chroma-Chime electronic doorbell.







The above photos are reproduced from the Chroma-Chime assembly Manual.
Top: Breaking off the i.c. socket retaining strips after wiring has been completed.
Bottom: Soldering the battery contacts onto the p.c.b.
Our heading picture shows the complete kit of parts for the Chroma-Chime.

number of additional standard components including, probably, discrete semiconductors or other integrated circuits.

To most users, including constructors, the microprocessor can be considered as just another building block. We don't have to know anything about its internal organisation. But if we are project or equipment *designers* then an intimate knowledge of the microprocessor is necessary in order to design the surrounding or peripheral circuitry (just mentioned above) to complete the entire project.

As a matter of general interest, the microprocessor used in the Chroma-Chime is Texas Instruments type TMS1000 (CS107-01/MP0027A). This device (MPU in Fig. 1) is actually a minicomputer, because it includes in the single chip in addition to the processing unit (MPU), a 256 bit Random Access Memory (RAM) and a Read Only Memory (ROM) with 1,024 Bytes. In the latter is permanently stored a complete set of instructions needed to digitally encode each of the 24 different tunes. There is a total of 318 notes in the program.

The block diagram (Fig. 1) shows the general arrangement of the Chroma-Chime. The control, envelope shaping, audio amplifier and electronic switch sections are built up from conventional discrete components.

HOME CONSTRUCTION KIT

The Chroma-Chime is available as a kit, and apart from an appreciable saving in money compared with purchasing a factory built unit, the assembly of this kit is a rewarding exercise for the amateur for it provides him with his first experience in handling a microprocessor and also, of course, a lasting object he can take pride in. The sound of the Chroma-Chime is bound to provide comment from every new visitor. What better way to demonstrate one's ability as an electronics enthusiast!

Here we are dealing with one of the very latest developments in micro-electronics. Yet the constructor need have no fears about tackling this project, provided he has already handled a lightweight soldering iron and has a general awareness of components and how one assembles them on to a printed circuit board.

If necessary, a short soldering practice session making wire connections to a few pins or small nails tapped into a small block of wood would be a wise precaution and provide confidence to go ahead.

There are two good reasons for recommending this kit to the average constructor.

First, the "mechanical" design is well planned. All parts (other than the loudspeaker) are mounted on one printed circuit board. This is clearly marked with the location for every part.

Second, the assembly manual provided with the kit is an excellent guide. It explains everything in clear language and close-up photographs show in detail various stages in the assembly. No one need ever feel lost if constant reference to the manual is made during the actual assembly work. A technical description and complete circuit diagram are also included.

The few tools required are listed in the manual. A further point might be made in connection with the soldering iron. This must be a miniature instrument, with a rating of 10—30 watts. The bit size is crucial. The manual advises a bit of less than $\frac{1}{8}$in (3mm) at the tip. We suggest one of $1\frac{1}{2}$mm, as we used when assembling our sample kit, though a 2mm bit should be quite suitable. (A somewhat larger bit could be an advantage when soldering the battery contacts since here comparatively large areas are involved. A 3mm bit is ideal for this purpose).

Multi-core solder (22 s.w.g.) is provided, in more than sufficient quantity for the entire operation.

ASSEMBLY WORK

The first step should be a careful reading of the entire manual. Then one will have acquired a good overall appreciation of the task ahead.

Organise your workplace. Unpack the components, carefully checking each item against the list in the manual. Familiarise yourself with each component.

Be especially careful when examining the semiconductors. The transistor leads are identified in a chart in the manual, but earlier versions of the manual contained an error concerning the pin configuration for the transistors type BC172 and BC327. This was rectified by an amendment slip enclosed with our sample.

Alternative types of transistor may be supplied with some kits, but all should be clear from details in the manual.

The miniature diodes need careful scrutiny to establish their polarity, the identification marks being very small.

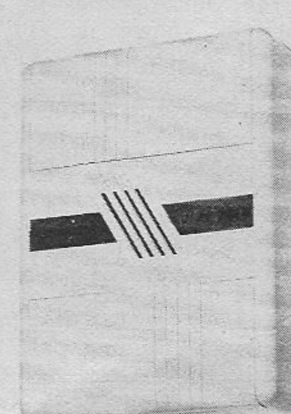
We would suggest that during the assembly and soldering operations the p.c.b. is placed on a soft pad, such as a folded cloth, to retain the p.c.b. in position and also to prevent damage to components.

Follow the instructions precisely, checking and double checking the identity and position of each component as it is mounted on the board.

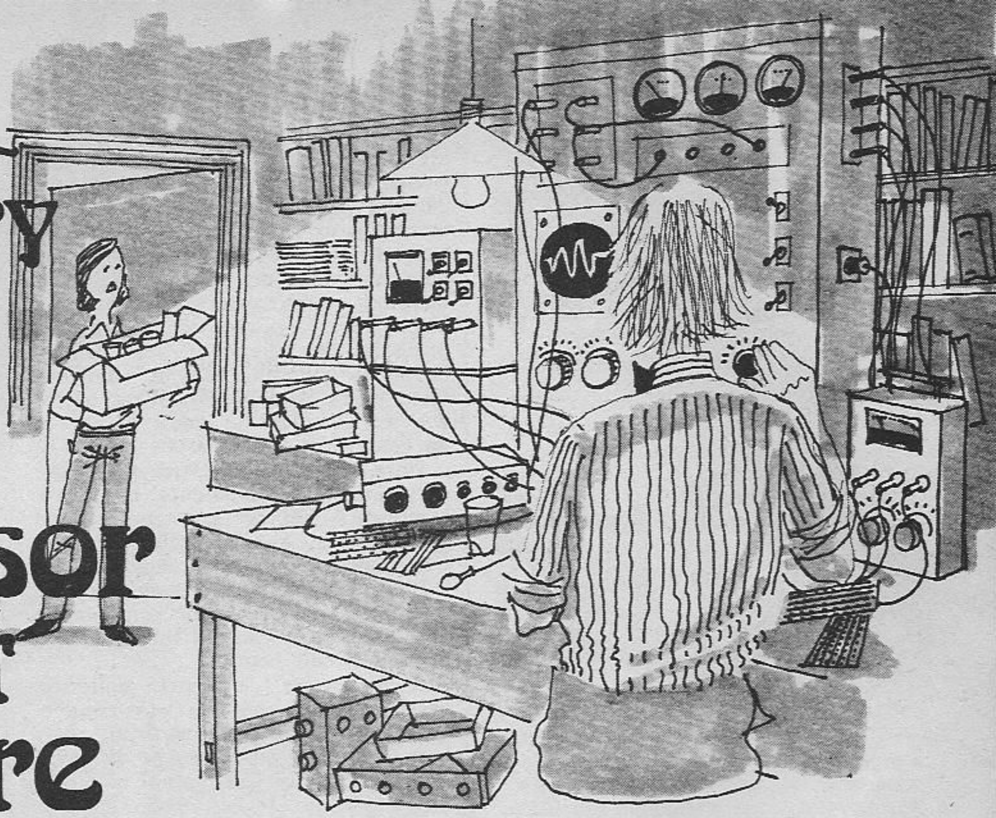
Soldering is a task calling for the utmost care and concentration. The manual gives the sound advice that the soldering iron should not remain in contact with a semiconductor for longer than 5 seconds. This is a sound rule to follow in general, for all soldering operations.

Once the p.c.b. is completed, the remaining work is straightforward, all items fitting into their allotted places in the plastic case. After installing two PP3 batteries the unit is ready for testing according to the procedure given in the manual. If you haven't made any mistakes the Chroma-Chime will burst forth with tune A3, which is Beethoven's 5th Symphony theme. But if, perchance, nothing happens at first the manual gives a detailed checking routine to follow.

A separate leaflet provides full Installation and Operating Instructions.



The Extra-ordinary Experi-ments of Professor Ernest Eversure



by Anthony John Bassett

LAST month the Prof. and two of his friends, Lilian Whiteley and Dr. Angus R. Paterson, together with Bob discussed an experiment that they were going to carry out with the radiaesthetic preamplifier that Lilian had brought along to the Prof's laboratory.

We join them this month with Bob helping to set up the experiment.

SETTING UP THE EXPERIMENT

Bob secretly chose one of the five different substances which the Prof.'s experimental robot had supplied and placed behind an opaque screen arranged to divide one of the work-benches in the laboratory as shown in Fig. 1. Under cover of the opaque screen he tipped a small sample of the chosen substances on to the small copper plate attached to the input of the preamplifier, as the Prof. had instructed.

"Ready" he announced, and Lilian began to swing her small Perspex pendulum above the copper plate attached to the output of the preamplifier by way of a screened lead extending past the opaque screen. After a few moments she announced, to Bob's amazement:

"You forgot to switch on the preamplifier, Bob."

"How did you know that?" he asked,

"It has a completely silent on/off switch!"

"Because the action of the preamplifier considerably modifies the responses I get when swinging the pendulum above the output plate; ah, that's better!" she informed him as he switched the preamplifier on, "now I will be able to let you know which one of the five substances you have chosen."

Bob watched fascinated as Lilian swung the small Perspex pendulum alternatively over the output plate, and over each of the five reference samples which the robot had supplied. These were separate samples of the same five substances, each consisting of a small heap of the substance on a sheet of paper numbered to correspond with the container from which the samples had been taken.

Lilian carefully adjusted the effective length of the pendulum by rolling the thread up on the plastic rod, or by releasing it, until at a certain length adjustment, she observed that the pendulum would

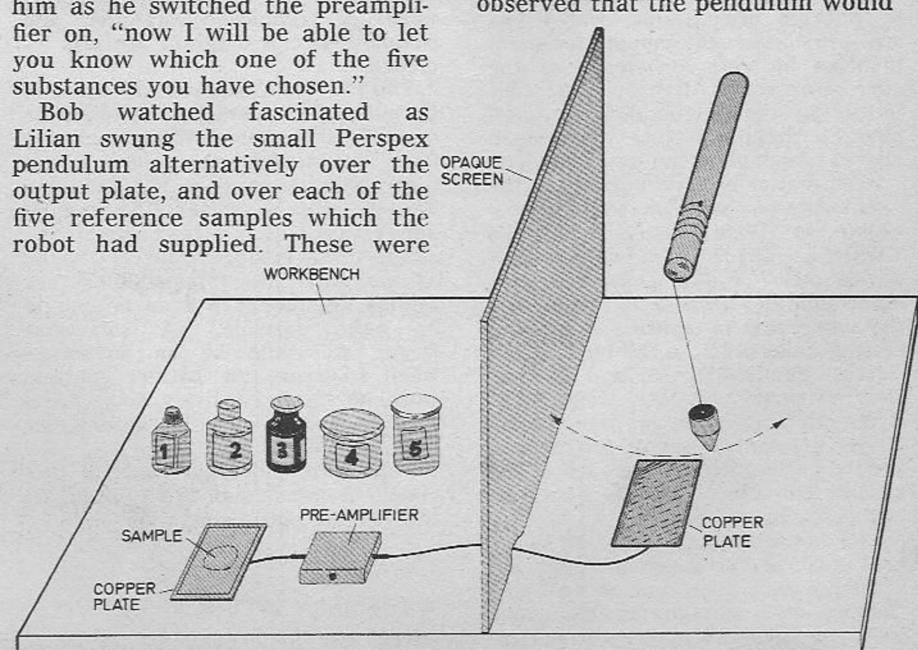


Fig. 2. The various parts of the Radiaesthetic Amplifier

gyrate, swinging in horizontal circles, over the output plate and also when swinging above a particular one of the samples. Over the other four samples, however, it did not gyrate but simply swung back and forth.

"It's Number 3!" she announced.

Now Angus, who had been quietly watching this procedure together with the Prof., secretly changed the samples on the input plate of the preamplifier.

EXPLANATION

"Will you explain to us just how you arrive at this conclusion?" he asked.

"Certainly, Angus", Lilian agreed obligingly.

"I have the pendulum adjusted to a certain length so that when I swing it over samples 1, 2, 4, 5, I just start it swinging back and forth then let it take its course. It just continues to swing back and forth. But when I swing it over sample Number 3 a dowsing reaction becomes evident, through my own nerves and muscles, causing the pendulum to change from back and forth oscillation to a horizontal gyration.

I don't try to make it gyrate, just start it swinging back and forth, then let it take its course to either continue back and forth, or else change to gyration. By changing the length of the pendulum I can adjust it so that it will gyrate in this manner over any one of the sample, each at a different length.

"Now I can make tests by swinging the pendulum over the output plate of the pre-amplifier. The influence of the sample on the input plate is boosted by the preamplifier and passes along the centre wire of the screened cable, becoming evident by pendulum indicated neurophysiological reactions over the output plate.

"This is how I discovered that Bob had placed a sample of substance Number 3 on the input plate. I have adjusted the pendulum to gyrate over my reference sample of substance Number 3, then when I swung it over the output plate it also gyrated."

ANOMALOUS RESULT

Lilian once again swung the pendulum over the output plate, but it failed to gyrate—and just continued back and forth.

"Angus!" she looked at him suspiciously, "you have removed the sample!"

She continued to make tests, swinging the pendulum alternatively over the output plate and the various samples, until at a certain length it would gyrate over either the output plate, or over one of her reference samples, but not over the others.

"It's Number 1!" she announced. "You changed the sample on the input plate from Number 3 to Number 1!"

"That's right", said Bob, "the sample I first put on the input plate was from container Number 3—and I can see that now a sample from container Number 1 has been substituted. But Prof.," he remarked, "this is amazing! I do not understand it; we have not learned anything like this at school. What I want to know is . . . . . what does the preamplifier do, for a start? If the influence will travel along a wire why not just have a length of wire with a copper plate at each end and no preamplifier in between?"

"No sooner said than done!"

To be continued

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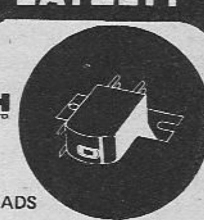

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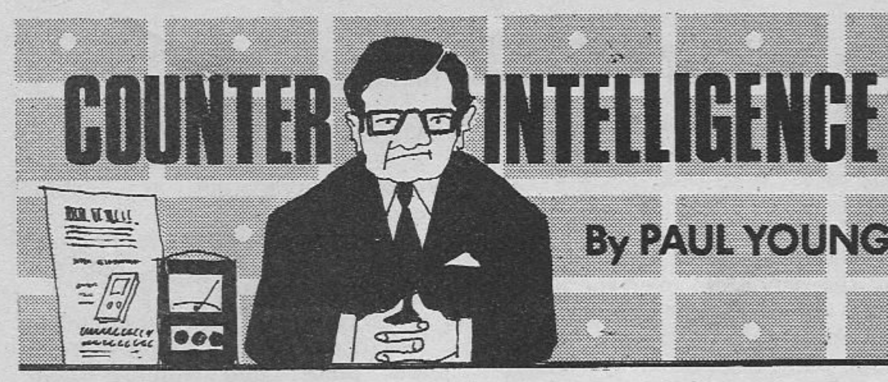

Age cannot wither her, nor custom stale, her infinite variety. Naturally all our readers know that this was written by a lad called Will Shakespeare about an Eygptian dolly called Cleopatra, but seeing it quoted the other day made me think what an apt description it was of the electronics hobby, especially the "infinite variety" bit! Just consider the range of projects that Everyday Electronics has offered you.

In addition to all this, there is the wonderful prospect of branching out and experimenting on your own. In other words to be an inventor.

The first requisite of an inventor is to be inquisitive. I well remember at school we had a dear old chemistry master who told us, if you put A on B hydrogen would be produced, or X on Y would produce carbon dioxide. Being incorrigible even at that early age, I wanted to know what happens if I put A on Y or B on X!

As the dear old gentleman would often leave us for long periods alone in the laboratory I was able to indulge my whims and carry out such unique experiments as dropping large lumps of sodium down the school drains. The school was rebuilt many years ago and I suffered only from slightly singed eyebrows.

However, the readers of this magazine are more sensible and better informed and I am convinced we have many a lurking Edison or Marconi among their ranks.

Waiting To Be Invented

Do not be put off by the dismal Jimmys who tell you there is nothing left to invent. Professor George Russell Harrison, in his book *Atoms in Action* explodes this theory. He quotes two examples of urgent need.

One, a source of portable power, something the size of a match box, two ounces in weight, that would give out the power of a twelve-volt car battery. Invent that, and you would put the oil sheikhs in the dole queue overnight.

Two, the perfect insulator. An idea was seriously considered several years ago to pipe electricity across from Norway, where they have an abundance due to unlimited water power. It was abandoned because there was no suitable insulating material.

Without delving too deeply into the intricacies of the problem, the losses in the cable would amount to about 1,000 volts per mile. The distance across from Norway to England at the nearest points is 600 miles. To have anything left say, at Newcastle, it would need to leave Bergen with a pressure of 600,000 volts and no insulating material has yet been made that can stand up to that voltage.

I expect I should qualify this, because I have no doubt an insulating material has been made with this capability but, as you will appreciate it must also be a viable proposition to produce it commercially.

The Kitchen Table

I often wonder what conditions most of you work under. Some no doubt have a spare room, beautifully converted, some a corner in the garage and some work on the kitchen table. It is pure guesswork, but I would say the latter were by far the largest group. This method poses problems, at the most inconvenient moment, Mum wants to lay for dinner.

For two or three years I have been toying with the idea of a table top bench come work shop that you would lay on the table and immediately have everything to hand, Soldering Iron, Tools, Mains, Aerial and Earth, but as soon as you received the signal to scram, you picked it up by the handle, stuck it in the corner of the garage until the washing-up was completed. I was therefore most interested to see the review of an electronic workshop, in Everyday Electronics last month. I congratulate the firm concerned on their enterprise in meeting a definite need.

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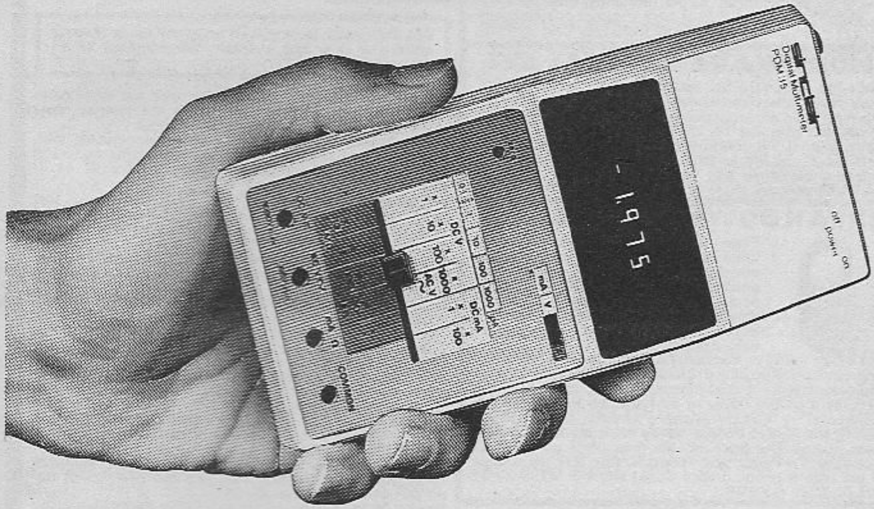

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Note: 10 MΩ input impedance.

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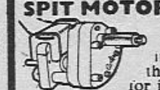

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Negative Resistance

NEGATIVE resistance is a rather puzzling term. It is often used in connection with oscillators of various special kinds. A negative resistance oscillator is, in general terms any kind of "black box" which oscillates when the right kind of impedance is connected to it a tuned circuit for example.

In other words a negative resistance is something which supplies energy, unlike an ordinary positive resistance which of course absorbs energy or at any rate turns electrical energy into heat. Positive resistance, or just plain common or garden resistance if you like, is in many ways like friction. Mechanical friction resists movement it tends to prevent one surface from sliding over another. Resistance also inhibits movement, only in this case it is the movement of electrons through a circuit.

Friction

Friction, like the Roman god Janus, has two faces. The one we are mostly concerned with in life is the bad face, the friction which resists smooth movement of machinery and consumes energy to no purpose. But friction has a good face too, and this good aspect is so widespread that we just do not give it a thought. Yet friction is a sort of glue that holds the world together. Without it no nail would stay for long in a piece of wood; screws would fail to grip; zips would unzip; knots would untie and stitches loosen. Things would just fall apart.

In the electrical world resistance likewise prevents disasters. If resistance were to disappear no battery could stay charged because current would run out of it through the air or any insulator. All voltage differences would instantly disappear, short-circuited by the things which at present hold them apart, resistances and insulators. Electronics would be impossible.

Like friction, we just take for granted this helpful aspect of resistance. It is the unhelpful aspect that bothers us, the nasty habit resistance has of getting in the way of the currents we want to have flowing. If only you could buy negative resistors how useful they would be! If a relay coil had a positive resistance of 100 ohms and your circuit could not drive enough current through it for lack of voltage all you would need to do would be to connect minus 100 ohms in series. This would cancel the coil resistance and allow current to flow unimpeded.

Or should the minus 100 ohms be connected in parallel?

Negative or Positive

That's an interesting question because there are two kinds of negative resistance, a series kind and a parallel kind. Before showing you how to experiment with them however let me ask one question. What happens if instead of connecting minus 100 ohms in series with your 100 ohm coil to cancel its resistance you connect only minus 80 ohms? Simply arithmetic says that there is still 20 ohms left uncancelled. What you have done is to reduce the coil's effective resistance but not to cancel it. But what if you over-cancel, so to speak, by connecting say minus 150 ohms? Then you should still have minus 50 ohms left. What effect does this have on the circuit?

This uncancelled negative resistance supplies energy to the circuit. You can see why it must do so by thinking about positive resistance and then reversing things. If you apply 10 volts to a positive resistance, a certain current flows. Halve the voltage to 5 volts and the current drops to half and so on. With negative resistance the opposite must happen. Reducing the voltage must increase the current. If you go on halving the voltage so it gets closer and closer to zero the current must get bigger and bigger. Evidently the current is coming, not from the battery but from the negative resistance itself. This after all is just what you could expect: positive resistance absorbs energy but negative resistance must emit energy. In other words a negative resistor, if you could find one, would be a source of energy!

Oscillators

Well, there are plenty of sources of energy about; generators; batteries and so on. So a battery must be a negative resistance, OK? Well yes, except that if you connect a battery to say a tuned circuit it doesn't oscillate, not after the first few moments anyway. But if you connect a negative resistance to a tuned circuit it does oscillate.

Unfortunately you cannot go into a shop and buy a negative resistor. To do so would be the same sort of thing as buying an amplifier which works without a power supply. Amplifiers amplify all right. But only because they are supplied with more watts of mains or battery power than ever comes out as audio power. What they really do is convert power in one form, say d.c. power, into another form, say a.c. In the process some energy is wasted; the amplifier's transistors get warm.

It is just the same with negative resistance. You can make circuits and devices which have negative resistance all right. But in order to make them work you have to put in more energy than you get out. If you try to take out more than you put in the thing just stops being a negative resistance.

Practical Circuit

That is why real life negative resistances are always sort of embedded in positive resistances. One practical negative resistance circuit is illustrated in Fig. 1.

This "artificial negative resistance" circuit may be constructed in any convenient way, the layout is not at all critical.

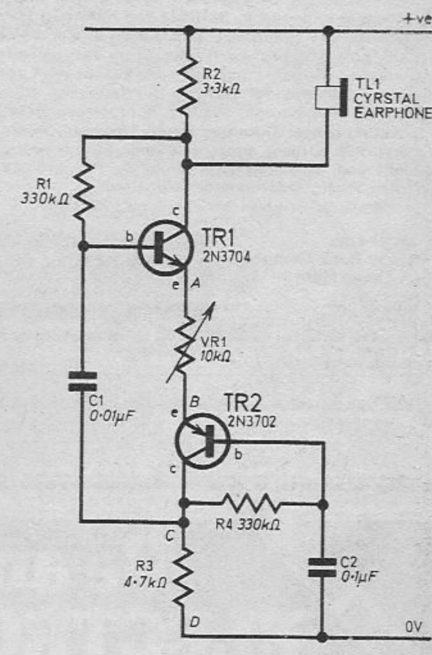

Fig. 1. A simple circuit to illustrate the effect of negative resistance.

When finished with this "negative resistance" you can use the parts for something else! Incidentally, this circuit is not fussy about transistor types, supply voltage, or component values.

Adjusting VR1 produces an audio tone in the earphone. When it is at maximum there is no oscillation. As it is reduced, oscillation begins and continues (with change of frequency) even when zero. If VR1 and R3 are now exchanged it is found that in its new position (C and D) VR1 stops the oscillation when set to zero but allows it when set to maximum – the opposite state of affairs from the original one. The explanation is that in the original (A and B) position VR1 is in series with a negative resistance so when too large the net resistance is still positive. In the C and D position it is in parallel with a negative resistance and so must be larger than the negative resistance if it is not to swamp it.

There is no tuned circuit in Fig. 1 and this "negative resistance oscillator" operates as a relaxation oscillator or astable R/C oscillator. If VR1 is in the A and B position (where it acts as a regeneration control) and a parallel-tuned circuit is connected across C and D the circuit can be set to oscillate at the natural frequency of the tuned circuit.

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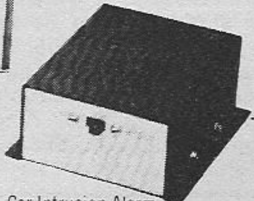

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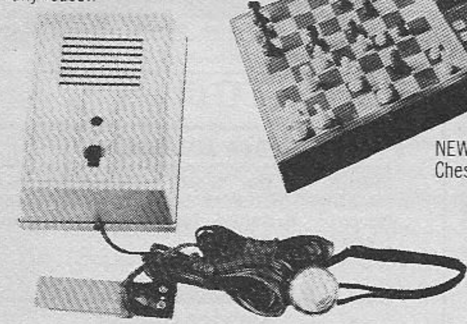

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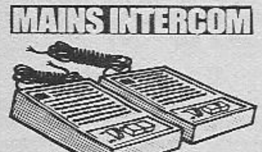

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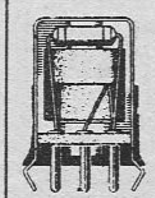

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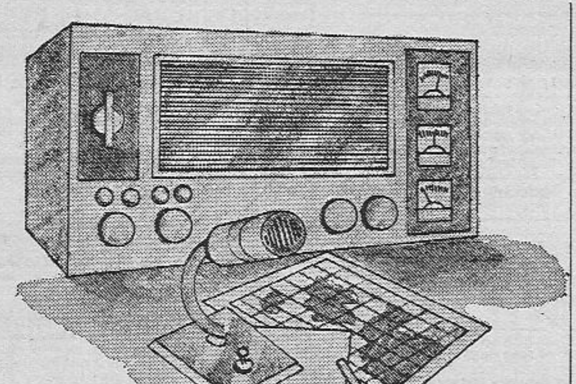

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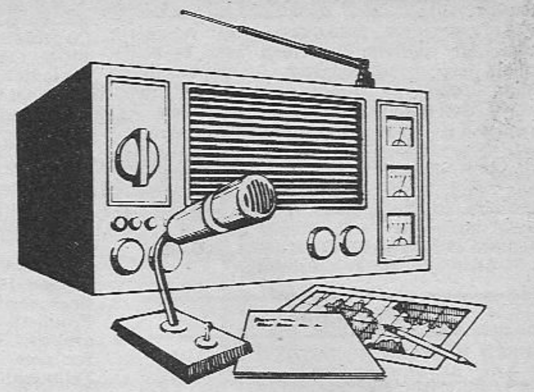

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2N3638A	·16	2N6109	·50	BC153	·27	BCY70	·25	BFS98	·30	TIP42C	1·00
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2N3641	·20	2N6122	·41	BC157	·14	BCY72	·24	BFX30	·35	TIP3055	·55
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CA3080A	1·88	MC1304	1·40	TBA510	2·21
CA3086	·60	MC1305	1·40	TBA510Q	2·30
CA3088	1·70	MC1310	1·91	TBA520	2·21
CA3089	2·52	MC1327	1·54	TBA520Q	2·30
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CA3130	·98	MC1350	·90	TBA530Q	2·07
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LM301N	·40	MC1352	1·10	TBA540Q	2·30
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LM308C	1·82	NE556	1·10	TBA560Q	3·22
LM308N	·85	NE565	1·30	TBA570	1·29
LM309K	1·85	NE566	1·65	TBA570Q	1·38
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LM318N	2·26	SAS560	2·50	TBA651	2·20
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AAZ17	0·18	BAX16	0·10	OA95	0·10	IN4150	0·19
BA100	0·18	BB103	0·30	OA200	0·10	IN5400	0·14
BA102	0·18	BB104	0·40	OA202	0·14	IN5401	·165
BA144	0·12		0·30	IN914	0·07	IN5402	·175
BA145	0·18	BY126	0·29	IN916	0·07	IN5404	·185
BA154	0·10	BY127	0·38	IN4001	0·06	IN5406	·225
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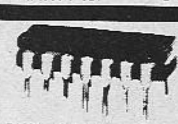

7400	0·16	7412	0·21	7438	0·55	7460	0·21	7485	1·85	74118	0·90	74160	1·41				
7401	0·16	7413	0·51	7440	0·21	7470	0·46	7486	0·41	74119	1·80	74161	1·41				
7402	0·16	7414	1·80	7441	1·03	7472	0·38	7490	0·61	74121	0·49	74162	1·41				
7403	0·16	7416	0·61	7442	0·76	7473	0·43	7491	0·98	74122	0·45	74163	1·41				
7404	0·26	7417	0·61	7445	1·35	7474	0·43	7492	0·61	74123	0·58	74164	1·23				
7405	0·26	7420	0·21	7446	1·23	7475	0·58	7493	0·61	74141	1·03	74165	1·23	74182	1·08		
7406	0·74	7423	0·39	7447	1·17	7476	0·51	7494	0·74	74145	1·06	74167	3·70	74184	2·46	74192	1·62
7407	0·74	7425	0·39	7448	1·17	7480	0·45	7495	0·78	74151	1·11	74174	1·52	74185	2·46	74193	1·62
7408	0·29	7427	0·39	7450	0·29	7481	1·10	7496	1·03	74153	1·11	74175	1·35	74188	2·00	74196	1·17
7409	0·29	7430	0·21	7451	0·21	7482	0·67	7497	4·60	74154	1·85	74176	1·23	74189	3·99	74197	1·17
7410	0·21	7432	0·39	7453	0·21	7483	1·33	74100	1·15	74155	1·11	74180	1·77	74190	1·91	74198	2·93
7411	0·29	7437	0·55	7454	0·21	7484	0·85	74107	0·43	74157	0·98	74181	3·70	74191	1·91	74199	2·93

74C MOS

74C00	0·26	74C85	1·90
74C02	0·26	74C86	0·68
74C04	0·26	74C90	0·91
74C08	0·26	74C107	1·30
74C10	0·28	74C151	2·62
74C20	0·26	74C157	2·35
74C30	0·26	74C160	1·18
74C32	0·26	74C161	1·18
74C42	0·92	74C162	1·18
74C48	2·30	74C163	1·18
74C73	0·58	74C164	1·04
74C74	0·69	74C173	0·95
74C76	0·58	74C174	0·95

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		22 pin	0·30
8 pin	0·15	24 pin	0·35
14 pin	0·16	28 pin	0·45
16 pin	0·18	40 pin	0·55

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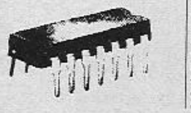

CD4000	0·24	CD4018	1·15	CD4041	0·96	CD4059	5·45	CD4081	0·25	74LS02	0·24	74LS138	1·27
CD4001	0·24	CD4019	0·70	CD4042	0·96	CD4060	1·27	CD4082	0·25	74LS04	0·27	74LS151	1·13
CD4002	0·24	CD4020	1·27	CD4043	1·15	CD4063	1·25	CD4085	0·81	74LS08	0·24	74LS157	1·17
CD4006	1·34	CD4021	1·15	CD4044	1·05	CD4066	0·80	CD4086	0·81	74LS10	0·24	74LS160	1·40
CD4007	0·24	CD4022	1·10	CD4045	1·59	CD4067	4·25	CD4089	1·77	74LS13	0·65	74LS161	1·50
CD4008	1·10	CD4023	0·24	CD4046	1·52	CD4068	0·25	CD4093	0·91	74LS32	0·25	74LS162	1·50
CD4009	0·64	CD4024	0·84	CD4047	1·15	CD4069	0·25	CD4094	2·13	74LS42	1·01	74LS162	1·50
CD4010	0·64	CD4025	0·24	CD4049	0·64	CD4070	0·65	CD4095	1·19	74LS74	0·48	74LS163	1·50
CD4011	0·24	CD4027	0·64	CD4050	0·64	CD4071	0·25	CD4096	1·19	74LS75	0·60	74LS164	1·52
CD4012	0·24	CD4028	1·02	CD4051	1·06	CD4072	0·25	CD4510	2·00	74LS76	0·40	74LS173	2.35
CD4013	0·60	CD4029	1·30	CD4052	1·06	CD4073	0·25	CD4511	2·30	74LS85	1·45	74LS174	1·20
CD4014	1·15	CD4030	0·64	CD4053	1·06	CD4075	0·26	CD4516	2·00	74LS86	0·48	74LS175	1·20
CD4015	1·15	CD4031	2·53	CD4054	1·32	CD4076	1·17	CD4518	2·00	74LS90	1·00	74LS	
CD4016	0·64	CD4035	1·34	CD4055	1·50	CD4077	0·66	CD4520	2·00	74LS92	0·90		
CD4017	1·15	CD4037	1·10	CD4056	1·50	CD4078	0·25	74LS00	0·24	74LS107	·44		

TRIACS plastic pack 400V

6 Amp	0·70	16 Amp	1·10
8 Amp	0·75	20 Amp	1·70
12 Amp	0·85	25 Amp	2·00

THYRISTORS Plastic C106 118

4A 100V	0·35	8A 100V	0·43	12A 100V	·57
4A 200V	0·40	8A 200V	0·49	12A 200V	·65
4A 400V	0·49	8A 400V	0·62	12A 400V	·81

VOLTAGE REGULATORS

500mA TO202 Positive 5, 12, 15, 24v **1·10**
500mA TO202 Negative 5, 12, 15, 24v **1·05**
1 Amp TO220 Positive 5, 12, 15, 24v **1·55**
1 Amp TO220 Negative 5, 12, 15, 24v **2·00**

VEROBOARD

·1 MATRIX COPPER BACKED BOARD

2·5″ x 5″	50p	3·75″ x 5″	55p
2·5″ x 3·75″	42p	3·75″ x 3·75″	50p
2·5″ x 17″	1·54	3·75″ x 17″	1·98

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SPDT **66p**
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As above but micro
SPST **50p** SPDT **55p** DPDT **60p**
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Polyester C280 250v
·01 —·1 5p, —15·22 **6p**
·33, ·47, **10p** 1μf **17p**
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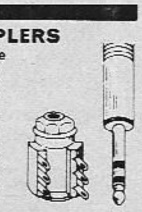
PLUGS- SOCKETS- COUPLERS

	PL.	SK.	Line
DIN 2 pin loudspeaker	10p	7p	10p
3, 4, 5, 6, 7 pin	15p	12p	15p
COAX Standard T.V.	10p	10p	30p
PHONO. Red, Bl., Wh., Gr. Yel	10p	7p	10p
JACK ¼″ mono plastic	16p	20p	20p
¼″ mono screened	25p	—	30p
¼″ stereo plastic	25p	25p	25p
¼″ stereo screened	35p	—	45p
3·5m standard	10p	12p	10p
2·55m standard	10p	10p	—
MAINS USA 2 pin flat	15p	15p	15p



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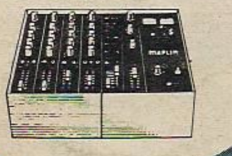

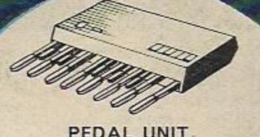

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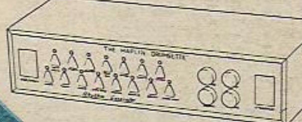

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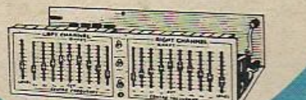

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