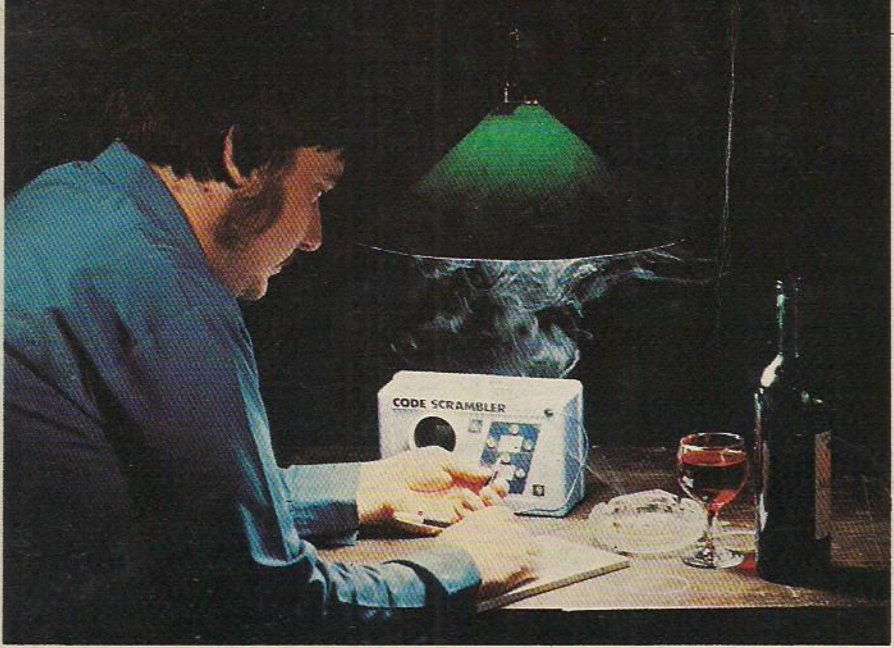
Easy to build projects for everyone

Everyday ELECTRONICS

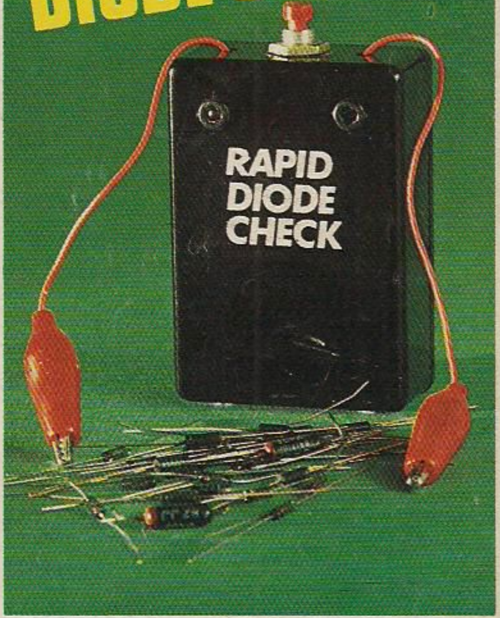
JAN. 78

40p

CODE SCRAMBLER

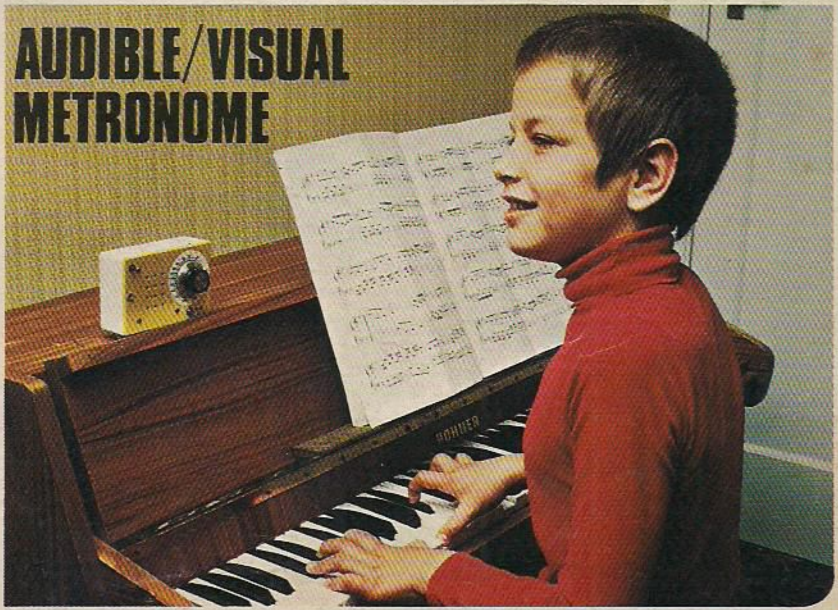


RAPID DIODE CHECK

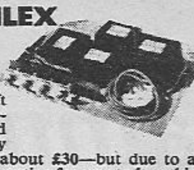


TOUCH SWITCH FOR BATTERY POWERED EQUIPMENT

AUDIBLE/VISUAL METRONOME



MULLARD UNILEX



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

WINDSCREEN WIPER CONTROL

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

ROOM THERMOSTAT

Famous Satchwell, elegant design, intended for wall mounting. Will switch up to 20 amps at mains voltage, covers the range 0-30°C. Special snip this month £3·00 post and VAT paid.

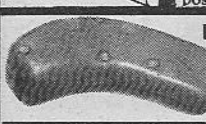
MICRO SWITCH BARGAINS

Rated at 5 amps 250 volts. Ideal to make a switch panel for a calculator and for dozens of other applications. Parcel of 10 for £1·00, VAT and post paid.

RADIO STETHOSCOPE

Easiest way to fault find, traces, signal from aerial to speaker, when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything. Complete kit comprises two special transistors and all parts including probe tube twin stetho-set £3·00 VAT and postage incl.

MICRO AMPLIFIER



Ex behind the ear deaf aids, complete with volume control £2·16.

DRILL CONTROLLER

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

SOUND TO LIGHT UNIT

Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450W). Unit in box all ready to work. £7·95 plus 95p VAT & Postage.

SWITCH TRIGGER MATS

Wiring dig supplied for complete house protection—'Keep Those Robbers Away'.
13" × 10" = £2·10
24" × 18" = £2·60

MULTISPEED MOTORS

Six speeds are available 500, 850 and 1,100 r.p.m. and 7,000, 9,000 and 11,000 r.p.m. Shaft is ¼" diameter and approximately 1" long. 230/240v. Its speed may be further controlled with the use of our Thyristor controller. Very powerful and useful motor size approx. 2" dia. × 5" long. Price £2·00 including Post & VAT.

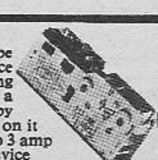
MAINS RELAY

With triple 10 amp changeover contacts—operating coil wound for 230 volts AC, chassis mounting, one screw fixing, ex unused equipment 60p each, 10 for £5 post and VAT paid.

SHORTWAVE CRYSTAL SET

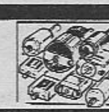
Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 19, 25, 29, 31 metre bands. Kit contains chassis front panel and all the parts £1·90 —crystal earphone 55p including VAT and postage.

HUMIDITY SWITCH



American made by Ranco, their type No. J11. The action of this device depends upon the dampness causing a membrain to stretch and trigger a sensitive microswitch adjustable by a screw, quite sensitive—breathing on it for instance will switch it on. Micro 3 amp at 250v. AC. Overall size of the device approx. 3⅜" long 1" wide and 1⅛" deep. 75p.

8 POWERFUL BATTERY MOTORS



For models, Meccano's, drills, remote control planes, boats, etc., etc. £2·00.

ROTARY PUMP

Self priming, portable, fits drill or electric motor, pumps up to 200 gallons per hour depending upon revs. Virtually uncorrodable, use to suck water, oil, petrol, fertiliser, chemicals, anything liquid. Hose connectors each end. £2·00 Post Paid.

MERCURY BATTERIES

Bank of 7 Mercury cells type 625 which are approx. ⅝" diameter by ⅛"-thick in plastic tube giving a total of 10·7 volts. Being in a plastic tube it is very easy to break up the battery into separate cells and use these for radio control and similar equipment. Carton of 25 batteries £1·60.

AMPLIFIER PANEL

6 photo sockets and d.p. changeover slide switch all mounted on insulating board. Glossy black finish size 2" × 8½" approx.—silly price 35p, or £1 for six.

THIS MONTH'S SNIP

is a miniature sealed relay 12v dc operated with two sets of change over contacts. The unique feature of this relay is its heavy lead out wires, these provide adequate support and therefore the relay needs no fixing; on the other hand there is a fixing bolt protruding through one side so if you wish you can fix the relay and use its very strong lead outs to secure circuit components—an expensive relay; but we are offering it for only 87p each. Don't miss this exceptional bargain!

MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied. Model 1153 500mW power output £1·50 including Post & VAT.

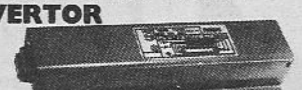
Model 1172 1W, power output £1·85 including Post & VAT.
Model EP9000 4 watt power output £2·90 including Post & VAT.
EP 9001 twin channel or stereo pre-amp. £2·90 including Post & VAT.

TANGENTIAL HEATER UNIT

3KW MODEL
£5·95
+ £1·50 P. & P.

A most efficient and quiet running blower-heater by Solatron—same type as is fitted to many famous name heaters—Comprises mains induction motor—long turbo fan—split 2 kw heating element and thermostatic safety trip—simply connect to the mains for immediate heat—mount in a simple wooden or metal case or mount direct onto base of say kitchen unit—price £4·95 post £1·50 control switch to give 2kw, 1kw, cold blow or off available 60p extra

FLUORESCENT TUBE INVERTOR



For camping—car repairing—emergency lighting from a 12v battery you can't beat fluorescent lighting, it will offer plenty of well distributed light and is economical. We offer invertor for 9" 6 watt miniature tube for only £3·25 with tube and tube holders as well. Ditto but 21" 3w £3·75.

SPIT MOTOR WITH CARTER GEAR BOX

Probably one of the best spit motors made. Originally intended to be used in very high priced cookers however this can be put to plenty of other uses, for instance your garden barbeque or to drive a tumbler for stone polishing; in fact there are no ends to its uses. Normal mains operation. £4·32 including POST & VAT.

TERMS:

Cash with order—prices includes VAT and carriage unless stated but orders under £6 must add 50p to offset packing etc.
BULK ENQUIRIES WELCOMED. Phone 01-688 1833

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MINI-MULTI TESTER

Amazing, deluxe pocket size precision moving coil instrument—jewelled bearings—1000 opv—mirrored scale.
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AC volts 10, 50, 150, 1000
DC amps 0-1 mA and 0-100 mA
Continuity and resistance 0-150K ohms.
Complete with insulated probes, leads, battery, circuit diagram and instructions.
Unbelievable value only £5·50p + 50p post and insurance.

FREE

Amps ranges kit enable you to read DC current from 0-10 amps. directly on the 0-10 scale. It's free if you purchase quickly but if you already own a mini tester and would like one send £1·50p.

IT'S FREE

Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived—often bargains which sell out before our advertisement can appear—it's an interesting list and it's free—just send S.A.E. Below are a few of the Bargains still available from previous lines.

12 Volt Heavy Duty Relay. Plug in type has three pairs of 10 amp change over contacts. Transpararent dust cover, price £1 + 8p. Suitable 11 pin base 27p + 2p.
4 Changeover Mains Relay. Upright mounting with perspex type dust cover, the really interesting feature is 4 sets of 10 amp changeover contacts. Price £1·62p + 12p.
12Volt Pump. Designed we believe as a bilge pump, this is 12 volt AC/DC motor coupled by a long enclosed shaft to a submersible pump. Suitable for water or most any fluids. Price £11·75p. Post 80p.
Just Arrived. Fruit Machines—working order—very impressive, choice of several but very heavy so you must collect. £50.
High Load 24 Hour Clock Switch. Made by the famous AEG Company for normal mains but with clockwork reserve has load capacity of 80 amps at 240v 50hz. Therefore suitable for dealing with large loads of say shop lighting, water heating, storage heaters etc. etc. Has triggers for on and off once per 24 hours but extra triggers will be available. Price £1·50p per pair. Size of clock approximately 8" × 5" × 5", totally encased but has lift up flap for ease of altering switching times. Price, new and unused £10·65p or used but guaranteed o.k. £6·50p.
Enclosed 24 Hour Clock. With contacts for breaking 10-12 amps at 240 volts. This one has two sets of on/off per 24 hours, price £7·60.
Smiths 24 hr. Timers—Heart only with over-ride similar to those used in the auto set etc. £4·75p + 38p.
Ditto but in grey plastic wall mounting case, with leads ready for attaching to plug and socket, price £6·98.
Light Dimmer. Our timer module with small mods makes an excellent light dimmer. Contains a 4 amp 400v SCR so it should be suitable for loads approaching 1kw Price of module with variable resistor and instructions £2·25p.
Push Pull Solenoids. For mains operated solenoid which will push as well as or instead of pull. Very heavy duty, we estimate this at 20lbs push or pull. 1¾" × 3½" × 4" made by Magnetic Devices Co. £7·50.
Always in Stock. Turntables with pick up lift, ideal for disco's at £11·95, post £2·25. We are also expecting some professional belt drive type at £25. Call or ring us for more information.
Reed Switches, standard 60 watt glass type. Normal open contacts glass lengths 2" diameter 3/16", 10 for £1 + 8p, 100 for £8 + 64p. 1000 for £65 + £5·20p.
Flat Reed Switches for stacking, greater quantity in confined space. Price 50p each + 4p.

F.M. Tuner and Decoder—two very well made (Japan) units—nice reproduction—£9·95 the pair.

Single Ended Types for jobs where it is not easy to bring a lead to each end. 75p each.
All these switches are normally open but can be biased to a normally closed position by fitting a magnet adjacent. The reed switch would then be opened by a magnet of opposite polarity being bought up to it
Ceramic Magnets suitable for operating reed switches, central fixing hole. 10 for £1·62p.
Music Centre Transformer 12-0-12 at 1 amp and 9 volt at ½ amp. Normal primary, upright mounting, impregnated and varnished for quiet operation. Price £2·95p. Post 54p.
'W' Shaped Fluorescent Tubes for porch light, box signs or where you want light evenly spaced over a confined area of approx. 10" × 10", 30 watts, made by Phillips price £1·62p. Post 54p.
Plinth for BSR Record Player still available at the record price of 95p + 12p. This is excellent value but unfortunately being a bulky and delicate item the postage has to be £1·50p + 12p so this is obviously only a bargain for callers.
(2) A similar model also available at the same price, this is somewhat larger and has a cut out for an amplifier.
Our Smokey Cover can be used with the above plinths, four small locating pins are fitted to the motor board. Size approx. 12¼" × 14½", price £2·50p + 32p. Post £2·00 + 16p.
Extension Speakers 8 ohm 4-5 watts handling power. We have 5 or 6 different models in stock, cheapest being the Partytime at £3·95p each, again only really a bargain for callers as postage is £1·50p per speaker.

B. BAMBER ELECTRONICS

Dept. P.W. 5 STATION ROAD, LITTLEPORT, CAMBS., CB6 1QE
Telephone: ELY (0353) 860185 (2 lines) Tuesday to Saturday

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PLUS A PRESENT FROM US OF A

10% DISCOUNT

ON ALL ORDERS RECEIVED FROM 1st to 31st DECEMBER

For items in our current ads and lists only

THIS OFFER IS FOR 1 MONTH ONLY

Slider Switches, 2 pole make and break (or can be used as 1 pole change-over by linking the two centre pins), 4 for **50p**.

A NEW RANGE OF QUALITY BOXES & INSTRUMENT CASES.
Aluminium Boxes with Lids.

AB10	5¼ × 4 × 1½	60p
AB13	6 × 4 × 2	80p
AB14	7 × 5 × 2½	£1·00
AB15	8 × 6 × 3	£1·30
AB16	10 × 7 × 3	£1·50
AB17	10 × 4½ × 3	£1·30
AB25	6 × 4 × 3	£1·00

Vinyl Coated Instrument Cases
Light Blue tops and White lower sections. Very smart fiinish.

WB1	5 × 2½ × 2½	60p
WB2	6 × 4½ × 1¾	£1·10
WB3	8 × 5 × 2	£1·60
WB4	9 × 5½ × 2½	£1·80
WB5	11 × 6½ × 3	£2·00
WB6	11 × 7½ × 3½	£2·25
WB7	12 × 6½ × 5½	£2·60
WB853	8 × 5½ × 3½	£2·00

MAINS TRANSFORMERS. Type 60/2. Mains input 200-210-220-230-240-250V a.c., output 0-20-40-60V at 2A, in Metal and Plastic case, approx. 7½ × 4½ × 4, fully fused (ideal for PSU) £3·00 each.

MAINS TRANSFORMERS. Type 15/300 240V input, 15V at 300mA output, **£1·50** each.

MAINS TRANSFORMERS. Type 45/100, 240, 220, 110, 20, 0V input, 45V at 100mA output, **£1·50** each.

MAGNETIC DEVICES PROGRAMMERS. Contain 9 fully adjustable cams and 9 change over micro-switches (rated approx. 1A at 240VAC) Needs slow-motion motor to drive (not supplied). Ideal for disco lights, sequence switching, etc. ex equipment **£1·50** each.

VIDICON SCAN COILS (Transistor type, but no data) complete with vidicon base **£6·50** each. Brand New.

FULL RANGE OF BERNARDS/BABANI ELECTRONICS BOOKS IN STOCK. S.A.E. FOR LIST.

NEW FOR THE VHF CONSTRUCTOR. A range of tuned circuits on formers with slugs and screening cans. Frequencies quoted are approximate, and range can be greatly extended by using varying capacitors in parallel.
Type S (½in. square, dumpy type).
Type SA 20 to 30MHz (when 33pf fitted in parallel).
Type SB 35 to 50MHz (with link winding).
Type SC 70 to 100MHz (with link winding).
Type SD 135 to 175MHz (with link winding)
Type M (Min. ⅜in. square types).
Type MA 19 to 28MHz (when 33pF fitted in parallel).
Type MB 22 to 32MHz (when 33pF fitted in parallel).
Type MC 25 to 35MHz (when 33pF fitted in parallel).
Type MD 38 to 50MHz (when 33pF fitted in parallel).
Type ME 45 to 60MHz (when 33pF fitted in parallel).
Type MF 100 to 200MHz (without slug) when 0 to 30pF variable fitted in parallel.
All the above coils available in packs of five only (same type) at **50p** per pack of 5.

SEMICONDUCTORS

BSX20 (VHF Osc/Mult). 3 for **50p**.
BC108 (metal can), 4 for **50p**.
PBC108 (plastic BC108), 5 for **50p**.
BFY51 Transistors, 4 for **60p**.
BCY72 Transistors, 4 for **50p**
PNP audio type TO5 Transistors, 12 for **25p**.
BF152 (UHF amp/mixer), 3 for **50p**.
2N3819 Fet., 3 for **60p**,
BC148 NPN SILICON, 4 for **50p**.
BC158 PNP SILICON, 4 for **50p**.
BAY31 Signal Diodes, 10 for **35p**.
BA121 Varicap Diodes, 4 for **50p**.

741CG op amps by RCA, 4 for **£1** -

RED LEDs (Min. type) 5 for **70p**.

PLEASE ADD 8% VAT UNLESS OTHERWISE STATED

PLASTIC PROJECT BOXES with screw on lids (in black ABS) with brass inserts.
Type NB1 approx 3in. × 2¼in. × 1½in. **40p** each.
Type NB2 approx. 3¾in. × 2¾in. × 1½in. **50p** each.
Type NB3 approx. 4¾in. × 3¾in. × 1½in. **60p** each.

MULLARD 85A2 85V STABILISER VALVES (Brand New) **70p** each or 2 for **£1·20**.

TO3 transistor insulator sets, 10 for **50p**

PERSPEX TUNER PANELS (for FM Band 2 tuners) marked 88–108MHz and Channels 0–70, clear numbers, rest blacked out, smart modern appearance, size approx. 8½in × 1½in., 2 for **35p**.

PLUGS AND SOCKETS
N-Type Plugs 50 ohm, **60p** each, 3 for **£1·50**.
PL259 Plugs (PTFE), brand new, packed with reducers, **65p each**
SO239 Sockets (PTFE), brand new (4-hole fixing type). **50p each**

SOLDER SUCKERS (Plunger type). Standard Model, **£5**. Skirted Model **£5·50**. Spare Nozzles **60p** each.

NEW MARKSMAN RANGE OF SOLDERING IRONS.

S125D 25W 240V **£3·80**.
S140D 40W 240V **£4·20**.
S125DK 25W 240V + bits etc., **KIT £4·90**.

BENCH STAND with spring and sponge for Marksman irons **£2·38**.
Spare bits MT9 (for 15W) **50p**, MT5 (for 25W) **45p**, MT10 (for 40W) **50p**.
ALL PRICES + 8% VAT.
TCP2 TEMPERATURE CONTROLLED IRON.
Temperature controlled iron and PSU. **£30** + VAT (£2·40).
SPARE TIPS
Type CC single flat, Type K double flat fine tip, Type P, very fine tip. **£1** each + VAT (8p).
MOST SPARES AVAILABLE.

MULTICORE SOLDER
Size 5 Savbit 18 s.w.g. in alloy dispenser, **32p** + VAT (3p).
Size C1SAV18 Savbit 18 s.w.g., **56p** + VAT (4p).
½ Kg. (1·1lb) 60 × 40, 20 s.w.g. on plastic reel **£3** + VAT (24p).

WELLER SOLDERING IRONS
EXPERT. Built-in-spotlight illuminates work. Pistol grip with fingertip trigger. High efficiency copper soldering tip.
EXPERT SOLDER GUN 8100D £9·90.
EXPERT SOLDER GUN KIT (spare bits, case, etc.) **£12·90.**
Spare bits **35p** pair.

A LARGE RANGE OF CAPACITORS AVAILABLE AT BARGAIN PRICES, S.A.E. FOR LIST.

MIXED COMPONENT PACKS, containing resistors, capacitors, pots, etc. All new. Hundreds of items. **£2** per pack, while stocks last.

ALU-SOL ALUMINIUM SOLDER (made by Multicore). Solders aluminium to itself or copper, brass, steel, nickel or tinplate, 16 s.w.g. with multicore flux, with instructions, Approx. 1 metre coil **40p** pack. Large reel **£2·75.**

VARICAP TUNERS Mullard type ELC1043/05. Brand New, **£4·40** + 12½% VAT.

BARGAIN PACK OF LOW VOLTAGE ELECTROLYTIC CAPACITORS. Up to 50V working. Seatronic Manufacture. Approx. 100. **£1·50** per pack + 12½% VAT.

OSMOR REED RELAY COILS (for reed relays up to ¼in dia., not supplied) 12V, 500 ohm coil, 2 for **50p.**

We now stock Spiralux Tools for the electronic enthusiast. Screwdrivers, Nut spanners, BA and Metric sizes, pop rivet guns, etc. S.A.E. for list.

Dubilier Electrolytics, 50µF, 450V, 2 for **50p**.
Dubilier Electrolytics, 100µF, 275V, 2 for **50p.**
Plessey Electrolytics, 470µF, 63V, 3 for **50p.**
TCC Electrolytics, 1000µF, 30V, 3 for **60p.**
Dubilier Electrolytics, 5000µF, 35V, **50p** each.
Dubilier Electrolytics, 5000µF, 50V, **60p** each.
ITT Electrolytics, 6800µF, 25V, high grade, screw terminals, with mounting clips, **50p** each.
PLEASE ADD 12½% VAT TO ALL CAPACITORS.

TV PLUGS AND SOCKETS
TV Plugs (metal type), 4 for **50p.**
TV Sockets (metal type), 4 for **50p.**
TV Line Connectors (back-to-back sockets), 4 for **50p.**
Please add 12½% VAT.

Terms of Business: CASH WITH ORDER. MINIMUM ORDER £2. *ALL PRICES INCLUDE POST & PACKING (UK ONLY). SAE with ALL ENQUIRIES Please.* PLEASE ADD VAT AS SHOWN. *ALL GOODS IN STOCK DESPATCHED BY RETURN. CALLERS WELCOME BY APPOINTMENT ONLY.*

CRESCENT RADIO LTD.

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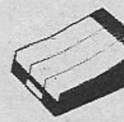
MAINS INTERFERENCE SUPPRESSOR
Designed to reduce unwanted mains interference caused by fridges, boilers, etc. The unit is fitted with a 3-pin 13A mains socket and 1·5m of 3 core cable and comes housed in a black plastic box with silver front panel.
Approx size: 116 × 77 × 54mm.
Max. current loading 3A.
OUR PRICE £9·35 + 8% V.A.T.

ABS PLASTIC BOXES
Ideal for the constructor. Fitted with 1mm front panels.
1005=105 × 73 × 45mm=**90p.**
1006=150 × 74 × 47mm=**£1·10**
1007=185 × 124 × 60mm=**£2·65**
1022=107 × 85 × 45mm=**82p.**
(sloping front) plus 8% V.A.T.

MAINS 'KEYNECTOR'



This connecting block connects any electrical equipment to the mains supply in seconds. Ideal for bench, garage, demonstrations, etc. Max. load 13A fused.
A bargain at £5·85 + 8% V.A.T.

BARGAIN TRANSFORMERS
240v PRIMARY—12-0-12v 500m/A SEC. Approx. size: 60 × 40 × 50mm. Fixing centres: 75mm.
PRICE: £1·80 + 8% V.A.T.
Also available MAINS TRANSFORMER with 18v 500mA SEC. Price and size same as above.

T1 MULTI-METER
Ideal tester for everybody interested in electronics. Weighing less than 100gm. and only 60 × 24 × 90mm.
RANGES: A.C. volts: 0-10v, 50v, 250v, 1,000v. D.C. volts: 0-10v, 50v, 250v, 1,000v. D.C. current: 0-1mA, 0-100mA. Resistance: 0-150Kohm.
OUR PRICE: £6·30 + 8% V.A.T.

FERRIC CHLORIDE
Anhydrous ferric chloride in double sealed 1lb poly. packs at **£1·25** + 8% V.A.T. per lb.

BARGAIN PROJECT BOX
A plastic box with moulded extrusion rails for PC or Chassis panels, with metal front plate fitted with four screws (all supplied). Internal size: 81 × 51 × 28mm.
OUR PRICE: 70p+8% V.A.T.

LOW NOISE LOW PRICE CASSETTES
+ 8% V.A.T.
Good quality tape in well made screw type cassettes. Presented in single plastic cases.
C60=45p., C90=55p., C120=65p.
10% DISCOUNT on ten or more cassettes of one type.

POWER SUPPLY UNIT TYPE 'PP1'.
Switched 3, 4½, 6, 7½, 9 and 12 volts at 500mA. With on/off switch and pilot light.
Size: 130mm × 55mm × 75mm approx.
OUR PRICE:
Only £6·00 + 8% V.A.T.

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Projects... Theory... and Popular Features...

Part of the fun of our hobby is building test instruments that will play their part in future experimental and constructional activities. Thus the electronics hobbyist has a deeper personal involvement in his subject than is generally the case with many other hobbies. Not only does he save money by building test instruments but he enjoys the additional pleasure and satisfaction that comes from constantly putting his own handiwork to practical use.

In a remarkably short time the constructor can acquire a good selection of inexpensive test gear entirely through his own efforts. Take the *Diode Checker* described this month: this small handy instrument will be a boon when checking these tiny components, and especially for determining the anode and cathode leads – a matter that can be quite perplexing to the inexperienced.

Continuing on this theme, next month we will give details of a converter unit designed to enable an a.c. millivoltmeter to be used for low level audio measurements. The month after we will present a C/R substitution box, a useful item for the experimenter and designer.

These are but a sample of forthcoming projects intended to equip the hobbyist, whatever his degree of involvement or experience, so that he can extract the maximum out of this hobby.

It is never too late (not too soon – for that matter) to start in electronics. Newcomers will always find something easy to bite onto every month in our *Square One* feature. This month *Square One* looks at the actual construction business – mounting components on circuit boards. The method illustrated is widely adopted in today's project building, and is simple and straight forward once one gets the hang of it. As with all things, practice makes perfect.

We are greatly delighted at the tremendous popular response to the new *Teach-In* Series. Our October and November issues were completely sold out. This unfortunately meant that a large number of would-be starters in electronics were disappointed. To help them, we are reprinting Parts 1 and 2 of *Teach-In '78*. For details see page 215.

This experience brings additional emphasis on the need for our readers to place a firm order with their newsagent. So if you were one of the unfortunates, do please take this step and so avoid any discontinuity in your own collection of EE's in the future.

Cordial greetings to all our readers from all of us on EE this Christmastide.

Fred Bennett.

Our February issue will be published on Friday, January 20. See page 225 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.

Telephone enquiries should be limited to those requiring only a brief reply. We cannot undertake to engage in discussions on the telephone, technical or otherwise.

Component Supplies

Readers should note that we do not supply electronic components for building the projects featured in EVERYDAY ELECTRONICS, but these requirements can be met by our advertisers.

Everyday ELECTRONICS

VOL. 7 NO. 5

JANUARY 1978

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

Back Number Service and Binders

Back issues of EVERYDAY ELECTRONICS (June 1977 onwards) are available worldwide at a cost of 60p per copy inclusive of postage and packing. Orders and remittance should be sent to: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF.

Binders for Volumes 1 to 6 (state which) are available from the above address for £2.85 inclusive of postage and packing.

TEACH-IN 78 REPRINTS

SEE PAGE 215.

AUDIBLE VISUAL METRONOME

By M. E. Theaker

INTRODUCTION

Two pre-requisites for playing music well, in addition to a musical instrument and sheet music, are the ability to play in tune and at the correct tempo. In order to achieve the first, tuning forks are necessary and to achieve the latter a metronome.

The most common form of mechanical metronome is the type devised by Maelzel nearly 200 years ago, which consists of a pendulum maintained by a clockwork mechanism. By adjusting a slide on the pendulum against a scale the beat may be varied typically between 40 and 210 beats per minute.

At the head of a sheet of music may be seen, for example, MM♩ =100, which indicates that the music should be played at the rate of 100 *crotchets* per minute, the MM standing for Maelzel's Metronome. Not all music carries such markings, particularly that written before the 19th Century. Instead the music may be marked *largo, andante* or other indication as to the speed of the music. Table. 1 gives an approximate relationship between these various markings and the number of beats per minute.

Table 1. Tempo related to beats per minute.

Terminology	Beats per minute
Largo	40 to 70
Larghetto	70 to 100
Adagio	100 to 125
Andante	125 to 150
Allegro	150 to 180
Presto	180 to 210

The idea of an electronic metronome is not new, but the vast majority of designs provide only an audible "tick" as indication of the beat. This is fine as long as the instrument is a relatively quiet one, such as a piano or guitar, but if the instrument is particularly loud, such as many brass wind instruments, then the audible tick will be drowned by the playing of the instrument.

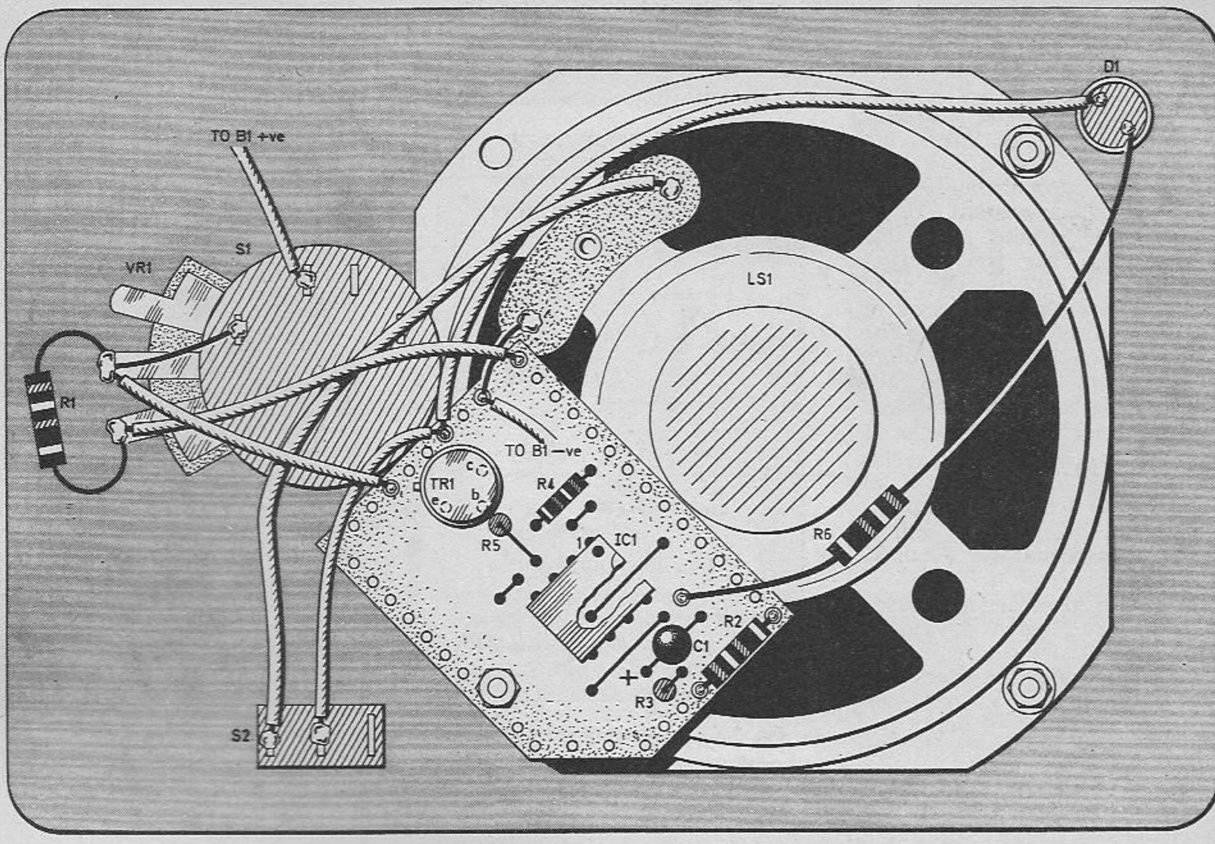
The Audible Visual Metronome described here provides a visual indication by means of a flashing light emitting diode as well as an audible "tick". The audible output may be muted when only a visual indication is required, for example during a recording session. The repetition rate of the metronome can be varied over the range 40 to 210 beats per minute by a single rotary control.

START HERE FOR CONSTRUCTION

The circuit is constructed on a piece of stripboard, 11 strips by 15 holes. A small piece is cut away from one corner to clear the side of the case when fitted.

WIRING DETAILS

The remaining wiring details are shown alongside the stripboard layout and is shown in Fig. 2. The



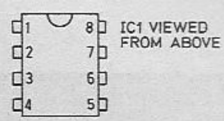
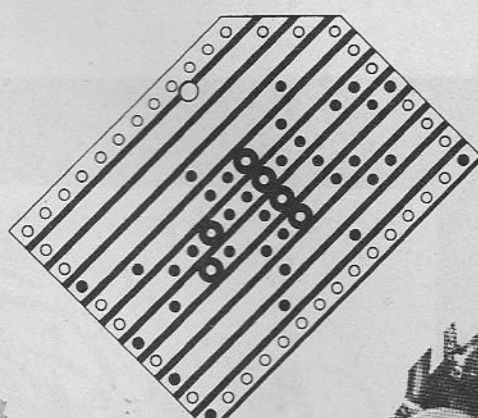
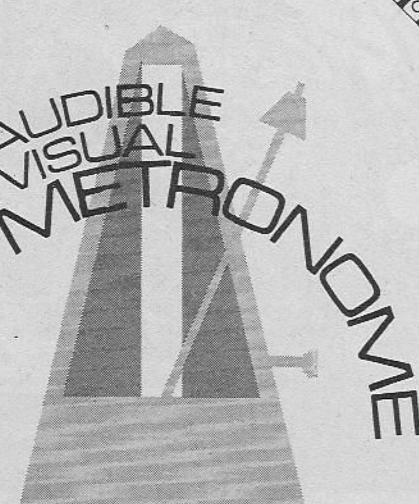
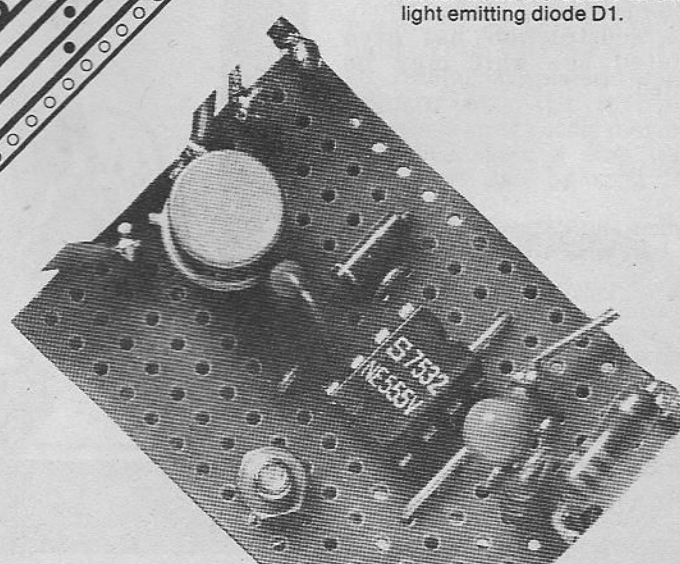


Fig. 2. Component layout and wiring for the Metronome. The breaks in the copper strips are shown on the left.





The completed wiring board. Note that R6 is soldered direct from the board to the light emitting diode D1.



CIRCUIT DESCRIPTION

The circuit for the Audible Visual Metronome is shown in Fig. 1.

The basis of the circuit is the NE555 integrated circuit timer and operates as follows. Capacitor C1 charges up via the battery through VR1, R1, R2 and R3 until the voltage reaches two thirds of the battery voltage, whereupon the i.c. discharges capacitor C1 through R3 until the capacitor voltage falls to one third of the battery voltage. At this point C1 starts to charge once again. This results in a series of short pulses at the output of the i.c. (pin 3) whose duration is determined by R2 and C1 and is fixed at approximately 7 milliseconds.

These short pulses are separated by a time determined by the values of VR1, R1, R2, R3 and C1. This time is adjustable between 278 milliseconds and 1·5 seconds, corresponding to 210 to 40 beats per minute. Resistor R2 controls the

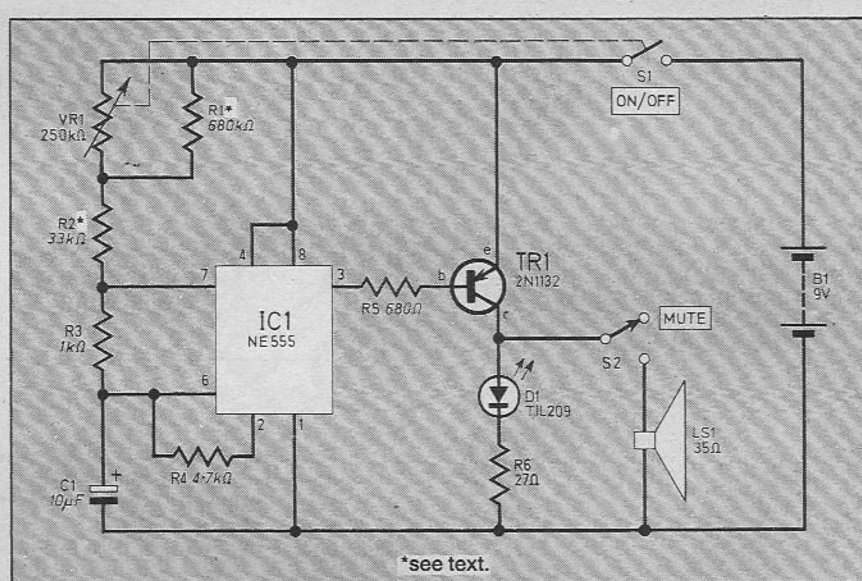
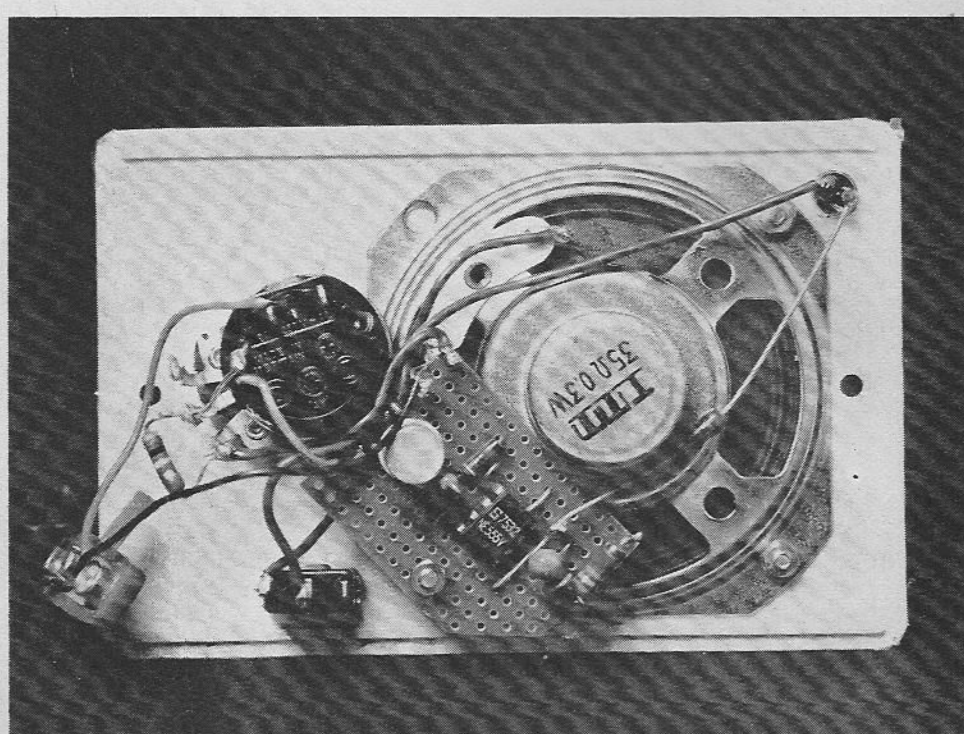


Fig. 1. Circuit diagram for the Audible Visual Metronome. For values of R1, R2 see text.

breaks in the copper strips should first be made, and Veropins inserted.

Next the wire link and resistors and capacitors are then soldered in place. Finally the i.c. is mounted, preferably in a socket, and the transistor is wired in place.

Once construction has been completed the unit may be calibrated.



The completed metronome with all the components mounted on the lid of the case.

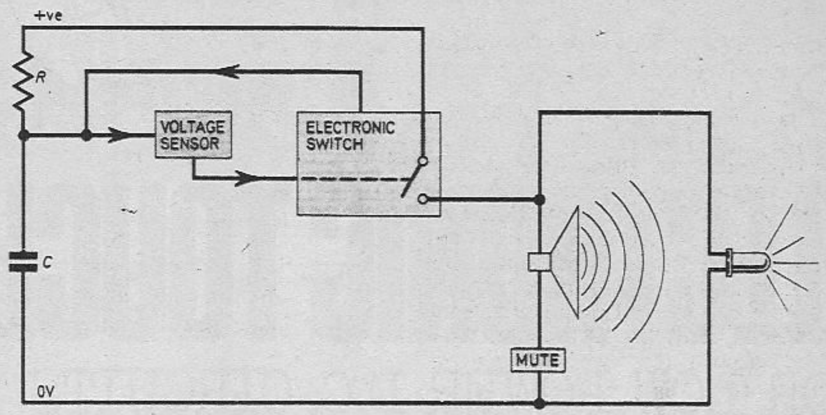
maximum number of beats per minute and is adjusted on test to compensate for variations in the value of C1. The purpose of R1 in parallel with VR1 is to reduce the resistance of VR1 from 250Ω to a nominal 185Ω to obtain the correct range.

Since the time for the charging and discharging of the capacitor is determined by proportions of the supply voltage, the number of beats per minute is unaffected by the battery voltage.

Resistor R4 is included to prevent the timer *latching* in the discharged state when first switched on.

The output of the timer circuit is fed via a current limiting resistor R5 to the base of a *pnp* transistor TR1, which drives a light emitting diode R6. This resistor limits the peak current to ·270mA. The transistor also feeds a 35 ohm loudspeaker via the switch S1 in order that the metronome may be operated in a visual-only mode.

HOW IT WORKS...



The circuit as shown is a simplified version of a multivibrator, the operation of which is as follows. The capacitor *C* charges up to the +ve supply potential via the resistor *R*. The purpose of the voltage sensor is to detect a certain voltage level on the capacitor, when this potential is reached, the sensor causes the electronic switch to apply the supply voltage (+ve) to the loudspeaker and the l.e.d. This results in a click and a brief flash from the l.e.d. At the same time the switch applies a certain feedback to the voltage sensor which causes the capacitor to discharge and repeat the entire process.
a rapid flashing from the l.e.d.

COMPONENTS

Resistors
- R1 680kΩ nominal 390kΩ, 470kΩ or 560kΩ } select on test
- R2 33kΩ nominal 27kΩ or 33kΩ } (see text)
- R3 1kΩ
- R4 4·7kΩ
- R5 680Ω
- R6 27Ω

All resistors are carbon ± 5% ¼W

Potentiometers
- VR1/S1 250kΩ log. with single pole switch

Capacitors
- C1 10μF 12V tantalum bead

Semiconductors
- TR1 2N1132 *npn* silicon
- IC1 NE555 timer i.c.
- D1 TIL209 red light emitting diode

Miscellaneous
- S2 sub-miniature s.p.s.t. toggle switch
- LS1 35 ohm loudspeaker 55mm diameter
- B1 9V PP3 battery

Stripboard: 0·1 inch matrix 11 strips × 15 holes; small plastic case, 115mm × 75mm × 35mm; large pointer knob; 6BA fittings; material for scale; connecting wire; battery connector; solder.

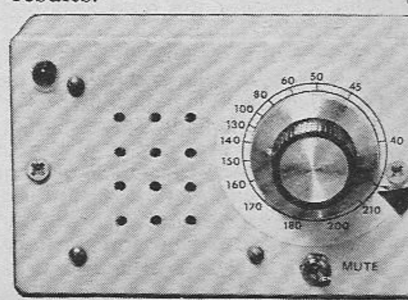
See **Shop Talk** Page 207

CALIBRATION

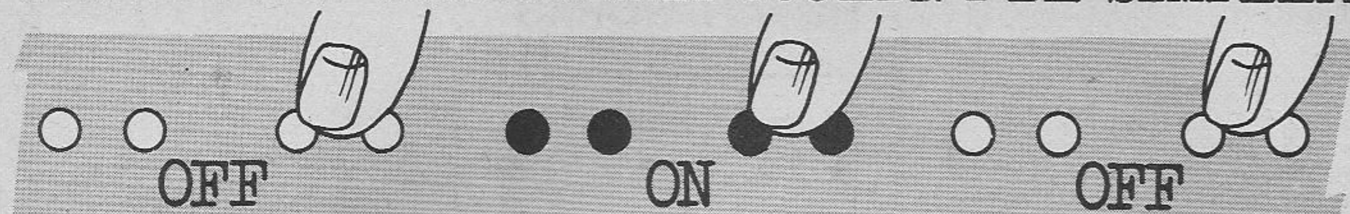
First set VR1 to minimum resistance (maximum speed) and select R2 by varying the resistance from the nominal 33kΩ until 210 beats per minute is achieved. To count the beats use a clock with a seconds hand or a stop watch.

Next set VR1 to maximum resistance and vary the value of R1 until 40 beats per minute is obtained. Having completed these initial adjustments, the intermediate markings on the scale may be filled in. Once again a stop watch of some sort can be used for this purpose.

Once calibration is completed the metronome may be finally assembled. The metronome should then give consistent and reliable results. □



FINGER TIP CONTROL...IT COULDN'T BE SIMPLER



ELECTRONIC TOUCH SWITCH

FOR LOW POWER D.C. CIRCUITS

By R. A. Penfold

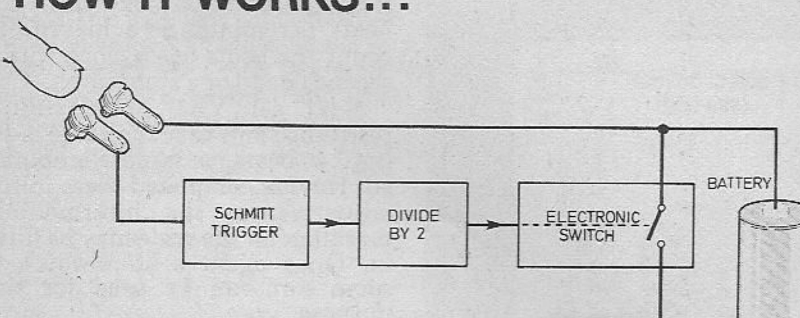
INTRODUCTION

A PURELY electronic switch which has no moving parts to wear out offers a very high degree of reliability and a virtually unlimited working life. Where a low powered d.c. circuit is to be controlled it is an easy matter to produce a suitable electronic switch of the touch operated variety. A simple and inexpensive circuit of this type forms the subject of this article.

This unit can be used to provide on/off switching for any 6 to 12 volt battery operated equipment which has a maximum current consumption of 100mA or less. Many pieces of equipment fall into this category, including many projects described in this magazine.

Only a single set of touch contacts are employed, and the state of the circuit changes state each time these contacts are touched. The circuit is based on a couple of CMOS logic i.c.s, and the unit provides an excellent introduction to CMOS devices.

HOW IT WORKS...



Normally the output of the Schmitt trigger is high (at positive supply level). Consider the load switched off. When the touch contacts are bridged by a finger for example, the output of the Schmitt trigger rapidly drops to a low state (zero volts). This rapid fall in level causes the output of the divide-by-two circuit to change from low to high. This causes the electronic switch to close and power is supplied to the load.

Removing the finger has no effect, for the output of the Schmitt trigger returns to a high level but this has no effect on the divide-by-two circuit as this only responds to *falling* changes. Touching the contacts again *will* change the output of the divide-by-two element, causing it to be low and turn off the electronic switch and hence power to the load.

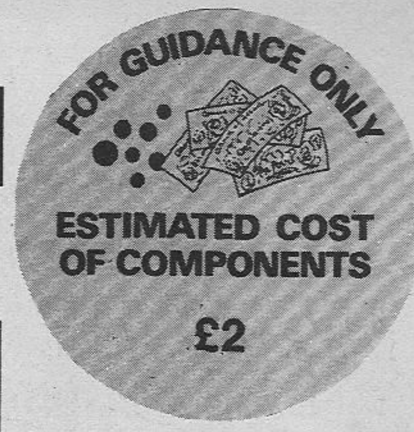
Thus power can be applied to or removed from the load as often as desired by successive operations of the touch contacts.

START HERE FOR CONSTRUCTION

All the components are mounted on a piece of 0.1 inch pitch stripboard. Start by cutting out a panel of the correct size (19 holes by 16 strips) using a hacksaw, and then drill out the two mounting holes using a drill bit. Next make the 15 breaks in the copper strips at the positions detailed in Fig. 1 of sufficient size to clear a 6BA or M3 bolt; 3.2mm was found suitable.

Next the components and the inevitable link wires should be soldered in position. Approximately 22 s.w.g. tinned copper wire is ideal for the link wires, but ordinary connecting wire can be used. It is advisable to start with the link wires followed by the resistors and transistor, leaving the i.c.s until last.

ELECTRONIC TOUCH SWITCH



COMPONENTS

Resistors
- R1 10MΩ
- R2 120kΩ
- R3 560kΩ
- R4 2·7kΩ
- All $\frac{1}{8}$ or $\frac{1}{4}$ watt carbon ± 10%

See Shop Talk Page 207

Semiconductors
- IC1 CD4011AE CMOS quad 2-input NAND gates
- IC2 CD4013AE CMOS dual flip-flop
- TR1 BC109 *npn* silicon

Miscellaneous
- B1 9 volts type PP3 or other voltage as required.

Stripboard: 0·1 inch matrix size 16 strips × 19 holes; 22 s.w.g. tinned copper wire; battery clip to suit B1; additional battery clip to suit equipment; M3 pan head bolt, nut and solder tag for touch contacts (2 off); connecting wire, solder.

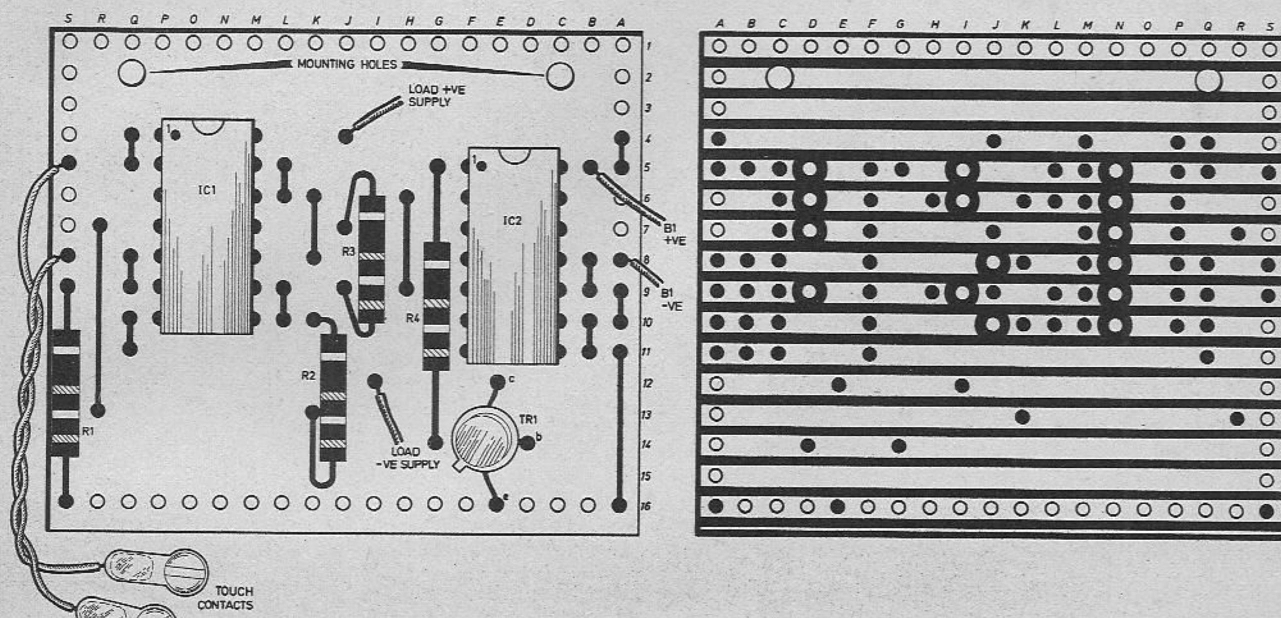


Fig. 1. Component layout and wiring of the touch switch circuit board. The breaks required on the copperside of the stripboard are shown on the right.

CIRCUIT DESCRIPTION

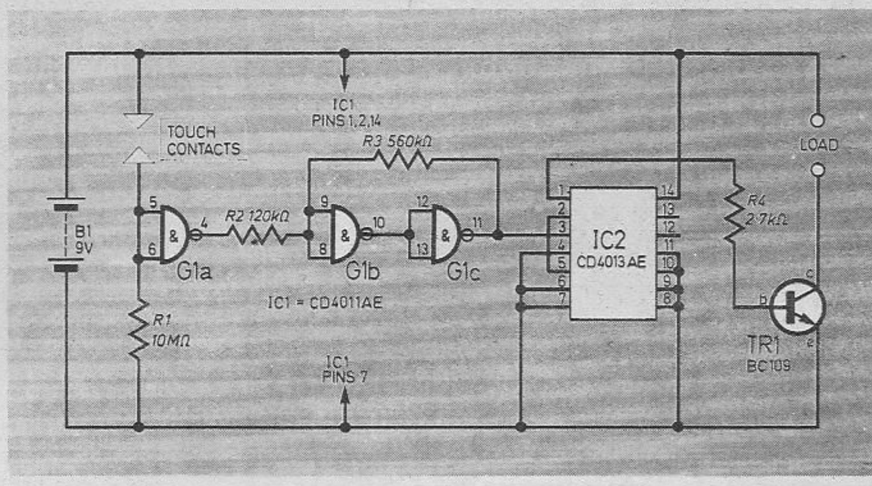


Fig. 2. The complete circuit diagram of the Electronic Touch Switch.

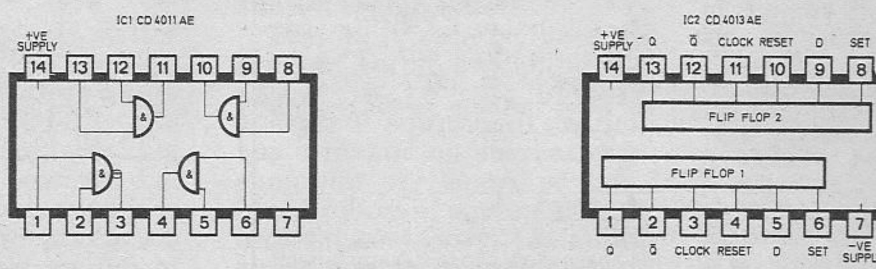


Fig. 3. The leadout details for the 4011 and 4013 integrated circuits.

CIRCUIT OPERATION

The complete circuit diagram of the unit is shown in Fig. 2 and the lead-out diagrams for the two i.c.s used are shown in Fig. 3. The Schmitt trigger circuit is based on three of the four NAND gates which are contained in CMOS logic i.c. type CD4011. These gates have their inputs connected in parallel so that they act as simple inverters: when its inputs are high the output of an inverter is low, and when its inputs are low the output of an inverter is high.

Gate G1a forming the first inverter has its input normally held low by R1, but when the touch contacts are operated a resistance will be present across them (the skin resistance of the operators finger). This will take the input high and the output will begin to go low.

Gates G1b and G1c are connected in series so that the input and output of this arrangement are in the same logic state, which is normally high. However, as the output of G1a swings low it will take the input of G1b low, as these two points are connected via R2. This causes the output of G1c to start to go low, and as it does so it will take the input of G1b further negative as these two points are connected by way of R3.

This regenerative action will rapidly result in both G1b input and G1c output assuming a low state.

When the operator's finger is removed from the touch contacts the trigger circuit will very quickly resume its original state with a regenerative action again being applied to G1b and G1c, but in the opposite direction this time.

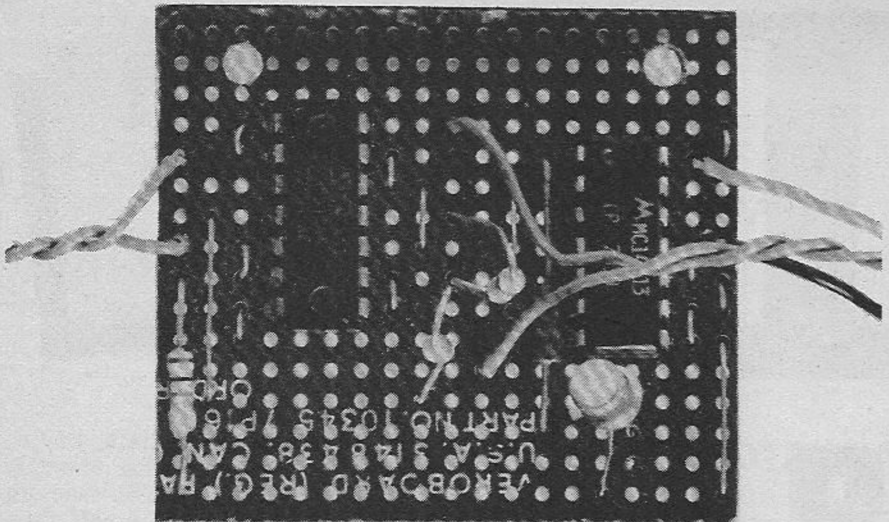
The output of G1c is fed to the input of one of the two flip-flops contained in IC2. The output of this i.c. is used to operate TR1 as a common emitter switch, and coupling between the two is provided by current limiting resistor R4.

INTEGRATED CIRCUIT

Now CMOS integrated circuits have two properties which make them ideal for use in this particular application. Firstly, and most importantly, they have an extremely low static power consumption, this only being about 0.01 microwatts for the two devices utilised here! They thus consume no significant power when the switch is in the off condition. A current of about 2.5mA is consumed when the circuit is in the on state, and this is the base current which is needed in order to keep TR1 turned on.

The second important feature is their ultra-high input impedance of around 1 million megohms. This means that the sensitivity of the circuit is only limited by the value given to R1; 10 megohms is the highest value which is readily available, and this gives a sensitivity which is more than adequate.

It is worth noting that unused inputs must be tied to one of the supply rails, as otherwise they might be operated by mains hum or other stray pick up. The i.c.s would then consume a significant current as they would be continuously operating, and would not be in a truly static condition.



The completed circuit board. Extreme care should be taken when soldering the i.c.s to the board and it may be wise to unplug the soldering iron when doing so.

Finally, wire up the component board to the battery connector, the touch contacts, and the main equipment.

There are several ways of arranging suitable touch contacts, and the author found that a couple of short M3 panhead screws mounted close together on an insulative front panel made neat and effective touch contacts. The connections to these screws are made by way of solder tags.

OTHER EQUIPMENT

As previously stated this piece of equipment is suitable for any battery operated device required less than 100 milliamps. If the device requires a voltage level other than 9 volts, then B1 should be changed to suit within the range 6 to 12 volts.

The two wires intended for connection to the other equipment could be terminated in a battery clip for connection to the battery clip perhaps already wired into the other equipment. One important point to remember when doing this is to swap over the wires on this extra set of battery connections to ensure correct polarity to the load. Any existing on/off switch in the equipment must be left in the on position or the switch removed and the resulting two wires connected together.

The prototype Touch Switch was successfully tried with the *Code Scrambler* project and could, if desired, be incorporated in the other two constructional projects.□

By Brian Terrell

New products and components buying for constructional projects.

OUR ESTIMATED cost box that appears with every constructional project has recently become a subject of comment from readers. Some critcise its worth or accuracy as they say that they have had to pay more than the quoted cost for their set of components, even as much as double in one case. On the other hand we have received praise for its inclusion and even reports that the components have been bought for less.

It must be emphasised that the estimated cost is only intended to be a guide. It does not include V.A.T. nor does it include postage and packing charges that usually accompany orders from mail order firms.

We arrive at the estimated cost by searching through well known catalogues and derive, where necessary, an "average price" per item. Prices of components from retailer to retailer vary considerably as was brought to light when compiling the list of suppliers and costs for the *Teach-In 78* kit published in *Shop Talk*, October issue.

For example, an inexpensive item such as a single-pole on/off toggle switch: prices excluding V.A.T. from three leading firms are 22p, 33p, 40p. We would use a figure of 33p. The highest price in the trio is 21 per cent up on the average. Generally speaking, if one item from a particular supplier is on the high side, then the rest of the components he supplies tend to be also. Add to this the V.A.T. and you have a new amount some 24 per cent up. It should be remembered though, that a supplier may major in one area, and although his prices may generally be higher, his major line, digital i.c.s or transistors for example, may be amongst the lowest prices available.

If you are, or plan to be a regular constructor of projects, it is advisable to obtain several catalogues and use these to select the "best buy". We are not suggesting that you place *n* different orders to *n* different suppliers because they are the cheapest for one particular component required, because you will then incur *n* separate post and packing charges which defeats the object. You could probably use two suppliers for each project (possibly one), depending on the particular requirements of the project, to keep your outgoings to a minimum.

If you are buying your components from a local retailer, you could find that his prices are even higher. The reason for this is that his turnover is less than the mail order firms so he doesn't stock such vast quantities of components. Consequently he cannot take full advantage of the quantity discounts enjoyed by the larger concerns, so when he adds on his percentage (profit) the retail price is that much more.

The one advantage with going to a local shop for your parts is instant delivery. Personal contact with your supplier can often provide suitable alternatives that he may have in stock if he does not carry the particular type number you ask for.

Constructional Projects This Month

No buying problems are envisaged for any of the constructional projects featured this month as all the components are available from a number of sources.

Both the *Rapid Diode Check* and the *Electronic Touch Switch* use CMOS integrated circuits. You will notice that the devices have different suffixes. The *A* and *B* refer to the maximum operating voltage, *A* – 15V, *B* – 18V. In these applications either can be used. The *E* tells us that the encapsulation is plastic with d.i.l. pins.

The only component requiring a mention in the *Code Scrambler* is the seven-segment display. Although the component list specifies a DL704, almost any common – cathode type display can be used, but then of course the wiring to the display will need to be altered to suit the pinning arrangement. The DL704 is available from Marshall's who advertise every month in E.E. and costs £2.00.

In the *Audible/Visual Metronome*, a 250 kilohm potentiometer with a single-pole switch is specified. The most common type of pot switch assembly is fitted with a double-pole switch in which case one half of the switch should be ignored as in the prototype.

Miniature toggle switches tend to be on the expensive side and there is no reason why a standard toggle could not be used instead if you wish to keep expenditure to a minimum. There is just enough room in the case to accommodate this size switch.

TEACH-IN 78 Part 4

BY GEORGE HYLTON

POTENTIAL DIFFERENCE — TIMING CIRCUITS

ONE of the first things we shall use our VOLTAGE INDICATOR for is to examine in more detail the current amplification of a transistor. In order to do so we need to know a bit more about voltage, current, and resistance.

OHM'S LAW

In the following circuits we will use d.c. voltages in the range 0 to 10V. The VOLTAGE INDICATOR cannot detect anything less than about 0·5V, so for practical purposes we will be dealing with 1 to 10V. The currents will be comparitively small, from a few tens of milliamps down to less than one micro-amp.

The major units, the ampere, the volt and the ohm are defined by a simple circuit Fig. 4.1. Here 1V drives 1A through 1 ohm. The usual symbols for voltage and current, E and I, are a little puzzling. Why not V and C? E is from "electromotive"; the voltage inside a source of energy such as a battery is called its electromotive force, I is from "instantaneous" and refers to the fact that currrent means "flowing".

It is the current flowing at one particular time. In the case of d.c. the same current may go on flowing for a very long time, of course. If you know any *two* of the three quantities I, E, and R in a circuit then the third one can be worked out. The value is fixed by the other two. The three ways of expressing this fact are:

Voltage=current ×resistance
Current=voltage÷resistance
Resistance=voltage÷current

These are called Ohm's Law relationships, and are the most useful bit of theory in electronics.

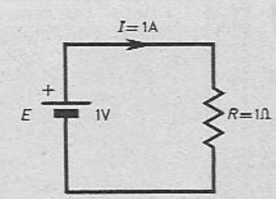


Fig. 4.1. Basic circuit to illustrate Ohm's Law.

CURRENT AMPLIFICATION

The circuit to measure current gain (amplification) is made by connecting two resistors to the NPN module Fig. 4.2. The experiment is to find how the output current I_C responds to changes in the input current I_B. Since we can only measure voltage with our VOLTAGE INDICATOR we have to deduce the current from the voltages across R_B and R_C.

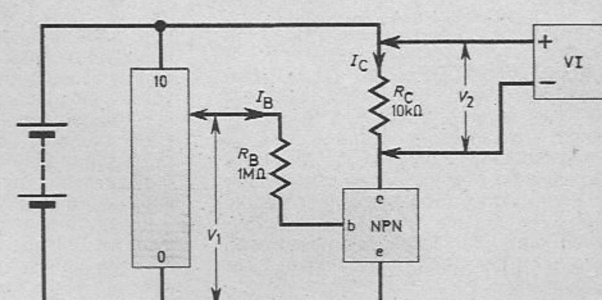


Fig. 4.2. Using the modules as shown, the current gain of the NPN module may be measured.

The voltage across R_B is determined by the input voltage V_1. So by Ohm's Law $I_B = V_1/R_B$. The voltage across R_C reveals I_C. $I_C = V_2/R_C$ again by Ohm's Law.

Make a table showing the voltages.

TABLE 4.1

V_1	0	1	2	3	4	5	6	7	8	9	10	V
V_2	0	0	2	4	6	7	8	9	9	9	9	V
$I_B = V_1/R_B$				3								µA
$I_C = V_2/R_C$				400					900			µA

Table 4.1. Draw a table similar to that shown, and record the voltages and currents obtained from the experiment in Fig. 4.2.

Now transform these into their corresponding currents, some values are already given. For I_B, each increase of 1V adds 1µA. For I_C, each change of 1V adds 100µA. Plot the currents as a graph Fig. 4.3. The straight portion gives the current gain; in our example a change in I_B of 6·5µA produced a change in I_C of 850µA, the current amplification is then given by I_C/I_B=850µA/6·5µA=130. The flat part of the curve happens when all the 9V supply is dropped in R_C leaving nothing to operate the transistor. If your curve is too steep, like curve X, increase R_B to 3·3MΩ, which gives 0·3µA per volt of V_1. If too shallow, like curve Y, reduce R_B to 330kΩ, giving 3µA per volt. The current amplification of a BC108 can be 100 to 800 in this type of circuit.

To measure the current amplification of the PNP module, turn the RESISTOR CHAIN upside down and connect as shown in Fig. 4.4. The gain is likely to be less than the NPN's, so use a value of 330kΩ for R_B (3µA/V). Note that for a *pnp* device to work it has to be "turned upside down". This has the effect of reversing the voltages.

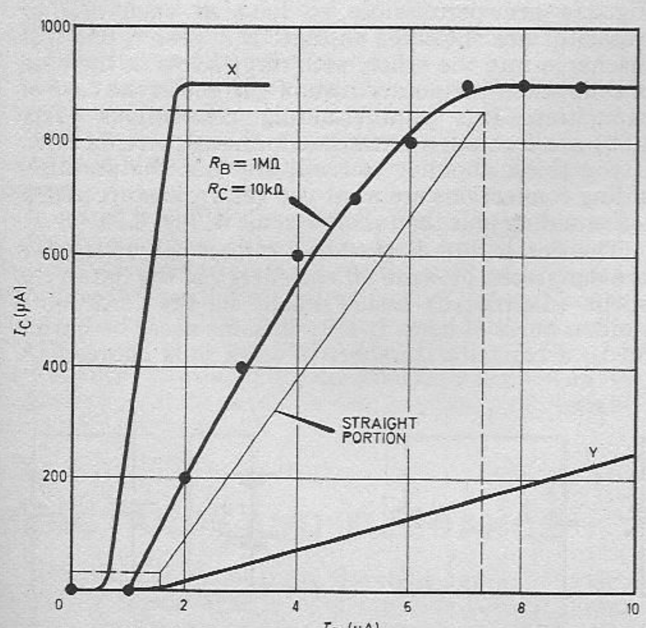


Fig. 4.3. Graph of collector current versus base current. The current gain is given by $I_C \div I_B$.

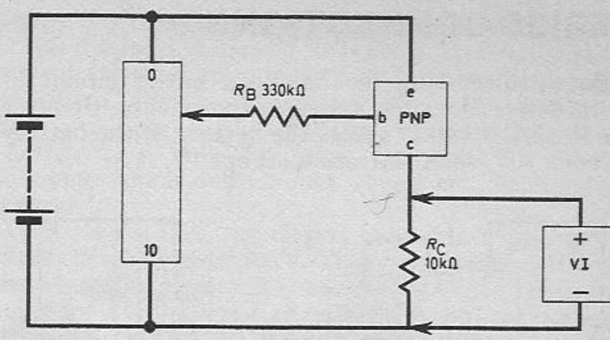


Fig. 4.4. The circuit here is to measure the current gain of the PNP module.

POTENTIAL DIFFERENCE

Now look at Fig.4.5. What voltage is V_{xy}? In circuits like this the two currents I_1 and I_2 are quite independent of one another. This is because each vertical pair of resistances (7kΩ+3kΩ) and (10kΩ+10kΩ) is connected directly to the battery. Taking either pair away leaves the other connected exactly as before.

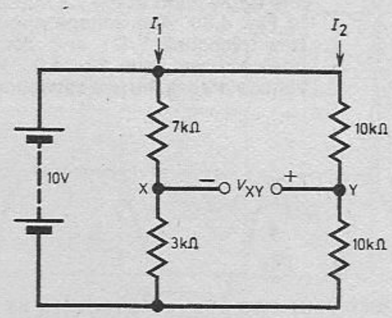


Fig. 4.5. A traditional circuit to illustrate *Potential Difference.*

If I_1 goes through the resistor chain, the upper seven 1kΩ resistors (which makes the 7kΩ) each drop 1V, making 7V total while the lower three drop 3V total. So, taking the negative supply line as zero, point X must be at +3V. In the other pair, since the resistances are equal each must drop half the supply voltage, which leaves point Y at +5V. The voltage between X and Y (i.e. V_{xy}) is the *difference* between the two voltages and is therefore 2 volts.

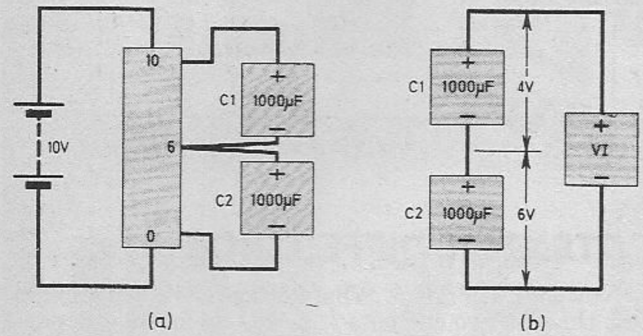
In electronics, this kind of voltage is usually called a **potential difference.** A potential is the voltage at a point such as X or Y when no current is taken from that point. As soon as current is taken, by connecting something, the voltage at X or Y changes because this extra current flows through one of the resistances (e.g. the 7kΩ) and this uses up more voltage. The difference in the voltages at each end of a resistance through which a current flows is often called a potential difference too (p.d. for short).

Quantities such as p.d. and e.m.f. are measured in volts and in this series we shall just call them all voltages, without specifying what kind they are.

An important variation on your experimental circuit is one where the potentials at the junctions of the resistance pairs are equal, V_{xy} is then zero. It follows that if X and Y are now connected together no current will flow through the connection because there is no voltage to drive it. The circuit is then called a *balanced bridge* circuit.

SERIES CONNECTIONS

Before discussing the balanced bridge circuit in more detail, do a few further experiments. Connect the RESISTOR CHAIN across the battery. If the battery delivers 10V, each 1kΩ resistor drops 1V.



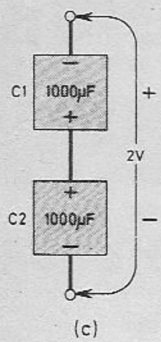


Fig. 4.6a. Connect the modules as shown to the RESISTOR CHAIN. Leave them charging for about 20 seconds. Now disconnect them and apply them to the VOLTAGE INDICATOR as in Fig. 4.6b. The voltage should be 10V. Now disconnect C1 and connect it up upside down as in Fig. 4.6c. What is the voltage across the two capacitors now?

Now connect your two 1000μF modules as shown in Fig. 4.6a. The voltages to which they charge are: C1, 4V; C2, 6V. If they are disconnected from the resistor chain but still connected together as shown in Fig. 4.6b; i.e., in series, the voltage across the pair is still 10V. *Voltages across capacitors in series add up.* You can check this by first connecting the VOLTAGE INDICATOR to 10 and 0 and setting it so that the l.e.d. just glows then removing it and connecting it to the charged pair of capacitors. The l.e.d. still just glows. Having confirmed this, reconnect C1 and C2 as before and after allowing 30 seconds for charging remove them. Now disconnect C1 and connect it in series with C2 but "upside down". Fig. 4.6c.

If the capacitor voltages are like battery voltages C1 is now pushing the opposite way to C2. But since C2 has 2V more than C1, it must win. Four volts of the available six volts in C2 is used up in overcoming the 4V on C1, leaving 2V, Fig. 4.6c. If the VOLTAGE INDICATOR is connected as shown you will be able to confirm that the 2V is there. So long as no current is drawn, however, each capacitor on its own still retains its original voltage. If you disconnect the capacitors and apply each one individually to the VOLTAGE INDICATOR you will find that the 4V and 6V are still there. These two different series connections (adding and subtracting) are usually known as *series aiding* and *series opposing*.

PARALLEL CONNECTIONS

You can use this series-aiding arrangement to extend the calibration of your VOLTAGE INDICATOR to voltages greater than the battery voltage. If a 1000μF is first charged to the battery voltage then connected to the resistor chain Fig. 4.7, the net voltage V can be set to points between V_{cc} and 2 V_{cc}. By charging two 1000μF and connecting them in series the calibration

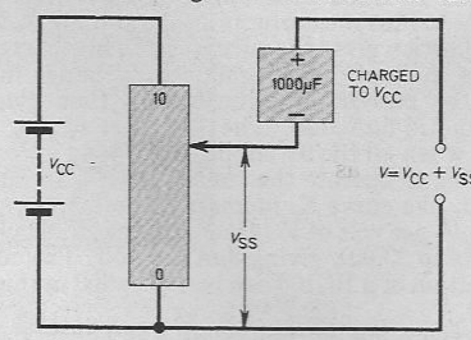


Fig. 4.7. By charging a capacitor to Vcc the net voltage V may be doubled. Twenty volts from 10V not a bad trick! Using this method the VOLTAGE INDICATOR may be calibrated in steps of 10V.

can be extended to 3 V_{cc}. In practice it is not worth trying to mark 1V steps, but if V_{cc} is 10V it is worth marking 15, 20, 25, 30V.

Some connections are forbidden. We do not mean that there is a law against them, only that it is inadvisable to make them. Parallel opposing connection Fig.4.8a are permissible so long as each cell or capacitor has the same voltage. If it hasn't, one will discharge into the other, with dire effects in the case of cells and a temporary rush of current in the case of capacitors. But parallel-aiding connections (Fig. 4.8b) are forbidden because enormous currents flow. If you think about it you will see that the parallel-aiding connections are what you get if you start with a series-aiding pair then short-circuit it. Fig. 4.8c.

The dotted line is the short circuit. Short circuits are dangerous because all the energy of the battery is spent (dissipated) inside itself, in the form of a sudden burst of heat. It may in some cases be harmful to a capacitor to short it when it is charged. A

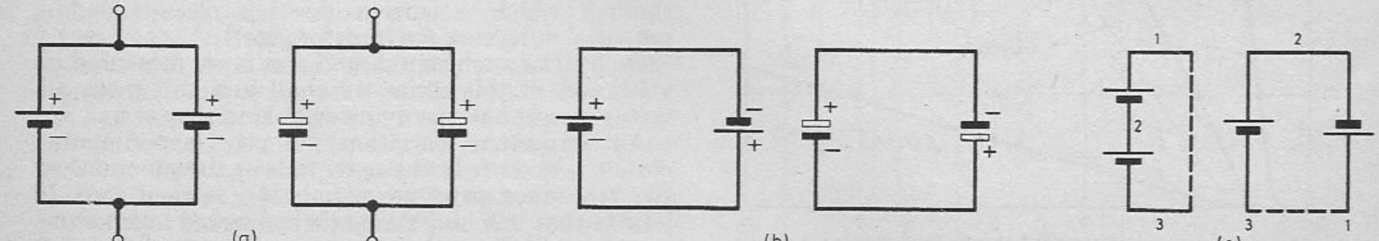


Fig. 4.8a. Parallel opposing connections as shown here are permissible only if the two voltages are the same. Fig. 4.8b & c. Parallel aiding connections as these are forbidden because you are effectively short circuiting the two components.

great deal of energy can be packed into some capacitors. If suddenly released in a short-circuit the dielectric may be damaged. For applications such as "electronic flash" for photography special capacitors are used which are designed for fast discharge.

Now let us have a look at what a capacitor seems like to an energy source such as a battery, when it is charged and discharged steadily Fig. 4.9. When the switch S is put in position 1, C charges through R1.

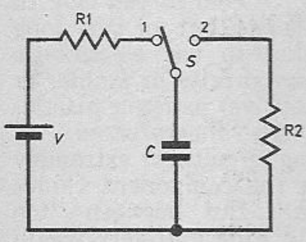


Fig. 4.9. Steadily charging and discharging a capacitor, some idea of the *rate of charge* is obtained.

While it is charging, the battery must supply energy. Given time it becomes fully charged. If S is now put in position 2, C discharges, the energy now being used up in driving current through R2. If C is large, the voltage in it changes slowly as shown by the graph in Fig. 10a. As soon as it is charged fully it is then discharged.

If now we substitute a much smaller C, but go on operating the switch at the same rate as before, the voltage on this small C varies as the lower curve Fig. 10b. That is, C charges much more quickly, and stays fully charged for relatively longer. Now, current flows from the battery only during the actual charging period, that is during the upward moving curved bits of the graph. Evidently the total amount of current removed from the battery by the smaller C is much less than the current removed by the larger C. Now, if a battery has to provide more current to one circuit than to another, that circuit must have a lower resistance.

In our circuit, R1 is the same for both capacitors. So the lower resistance "seen" by V when C is large must be entirely due to C itself. From this it is clear that, unlike large resistances which reduce current, large capacitances increase it.

The "resistance" of a capacitance is small when the capacitance is large.

This of course is in agreement with the idea of a capacitance as a container into which charge can be poured.

It is still possible to make the small C take as much current in a given time as the large one. To achieve this all you need to do is waggle the switch faster, discharging the small C more frequently. The greater the frequency of the charge/discharge cycles the faster the current is removed from the battery. So the "resistance" of a capacitor does not only depend on its capacitance, it depends on the *frequency* of charge-discharge cycles as well.

REACTANCE AND IMPEDANCE

"Resistance" is not quite the right name, however. Once the capacitor is fully charged *no* current flows, and its resistance is then infinite. In addition, the term "resistance" is reserved for circuit elements which use up energy. The capacitor itself uses up no energy. It stores it. Only the resistors in our present circuit dissipate energy. If R1 is short circuited so that current can flow unimpeded into C no energy is used up when C charges. The energy is merely transferred from one place (the battery) to another (the capacitor). It will then stay put until something happens which lets it out, such as discharging through R2.

The "resistance" of circuit elements which store energy is called **reactance.** The energy-storing circuit elements in electronics are capacitance and inductance. Inductance stores energy in a different form, a magnetic field. We will look at it later.

There is also a general term for the current-resisting properties of *any* circuit elements. This is **impedance.** Resistors, capacitors, inductors and any combination of them offer impedance to the flow of current. You can see from our present circuit that the impedance of a capacitor depends on the frequency with which it is charged and discharged.

The higher the frequency the more current flows in a given time, so the lower the impedance.

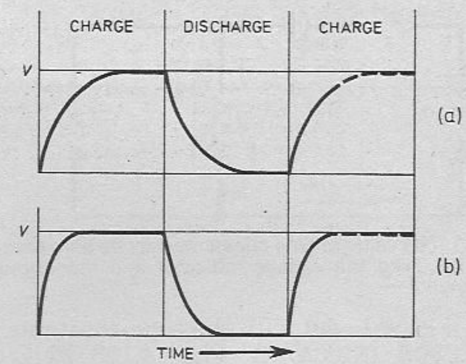


Fig. 4.10. Typical graphs obtained by varying the value of capacitors in Fig. 4.9.

TIMING CIRCUITS

So far the fact that it takes time to charge a capacitor has just been a nuisance. But it can be put to use. Timing is an operation which frequently has to be carried out.

Circuits in which capacitors are charged or discharged through resistances are used a great deal in electronics, as timing circuits. In printing photographs, for example, you might arrange for the lamp which projects the image on the printing paper to stay on only when a capacitor is charging. By using different combinations of resistance and capacitance, the printing/exposure time can be set to whatever suits the particular photograph and paper. Once the timer has been set, the photographer can make as many enlargements as he likes, getting the same exposure every time.

By the water-vessel analogy (Fig. 1.4) the time it takes to charge a capacitor depends on the driving voltage V, the circuit resistance R and the capacitance C. As the water analogy shows, the rate at which the capacitance fills is fast at first but slows down all the time because of the back pressure of the charge already accumulated. In theory the capacitor never quite fully charges, though if you are prepared to wait long enough it charges as nearly completely as you wish. To avoid the embarrassment of this situation, in which all capacitors take for ever to charge fully, the charging time is usually talked about in terms of the time taken to charge to about $\frac{2}{3}$ of the full charge. We say about $\frac{2}{3}$ because the actual amount used is 63·2%. The reason for choosing 63·2% is that it keeps the arithmetic easy.

The time to reach 63·2% of full charge is just: Resistance × Capacitance.

If R is in megohms and C in microfarads the answer comes out in seconds. Thus if R=1MΩ and C=10µF it takes 10 seconds to reach 63·2% of full charge. This means that if the battery voltage is 100V the capacitor charges to 63·2V in 10 seconds. If the battery voltage is only 10V, then it takes 10 seconds for the capacitor to accumulate 6·32V, and so on. You can see from this that the time to reach 63·2% charge does not depend on the battery voltage, the *amount* of charge does; 10µF charged to 63·2V has ten times the charge if 10µF is charged to 6·32V. But the *charging* time is the *same*. This 63·2% charging time is called the **time constant** of the circuit.

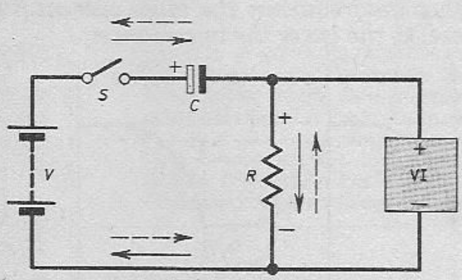


Fig. 4.11. The value of time constants may be demonstrated easily by using the voltage indicator and few additional components.

You can experiment with the time-constants using the VOLTAGE INDICATOR Fig. 4.11. Remember, however, that the VOLTAGE INDICATOR itself has an input resistance which cannot exceed 100kΩ (the resistance of the input pot). Adding an extra R as shown reduces the charging time by providing an extra path for charging current. When C is connected, the VOLTAGE INDICATOR lights for a time, then goes out. Now, to light the VOLTAGE INDICATOR, its live input terminal must be driven positive. This means that the voltage difference between the ends of R must also have the polarity shown. This implies that charging current must flow through R in the direction shown by the solid arrow. So as current flows from the positive terminal of the battery into the positive plate of the capacitor, current must also be flowing *out* of the negative plate, through R, into the negative terminal of the battery. This is quite the normal state of affairs as far as the battery is concerned, and it is also exactly what would happen if C were shorted and only R were in circuit. But we know that C is an insulator. So the fact that the current seems to flow through C must be an illusion.

The situation becomes clear if you forget about water pipes and think about electrons instead. The positive terminal of the battery attracts electrons from the positive plate of C. The negative terminal repels electrons, driving them to the negative plate. So electrons flow in the direction of the dotted arrows. Each electron carries a negative charge. When the charge of all the accumulated electrons at the negative plate is equal to the battery voltage no further movement of electrons can take place and the capacitor is fully charged.

The *scarcity* of electrons at the positive plate constitutes a positive charge, equal but opposite to the negative charge. If the capacitor is now removed from the battery and discharged the electrons travel back to their original plate.

R/C timing circuits such as these can be conveniently used for timing relatively short periods. By "conveniently" we simply mean that the values of R or C needed for long periods (over about a minute) become inconveniently large. Of course, you *can*, in theory, time periods of *any* length but for very long periods it is necessary either to use electrolytic capacitors (which are not very precise or stable) or very large (and therefore expensive) paper or plastic-film capacitors, or especially high-value resistors.

If you try to use R/C timing circuits for extremely short periods, you find that the component values become inconveniently small. But between "too large" and "too small" lies a wide and very useful range of timing periods, from a few seconds to a few nano-seconds.

Most practical applications call for periods from a few milliseconds to a few microseconds. In a 625-line European-style TV receiver, for example, there are timing circuits for the "frame" period of about 20mS and the "line" period of about 70µS.

OSCILLATION

For practical work, assemble the oscillator shown in Fig. 4.12. In this circuit, the transistors act as switches which operate in such a way that C1 is continually charged, discharged, charged, discharged . . . etc.

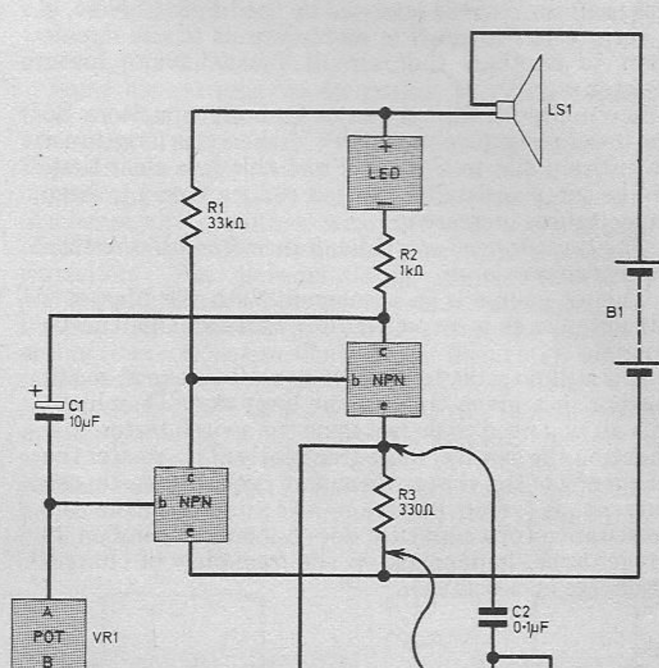


Fig. 4.12. Using the modules as shown construct this simple oscillator. By using the VOLTAGE INDICATOR, the impedance of C2 can be checked.

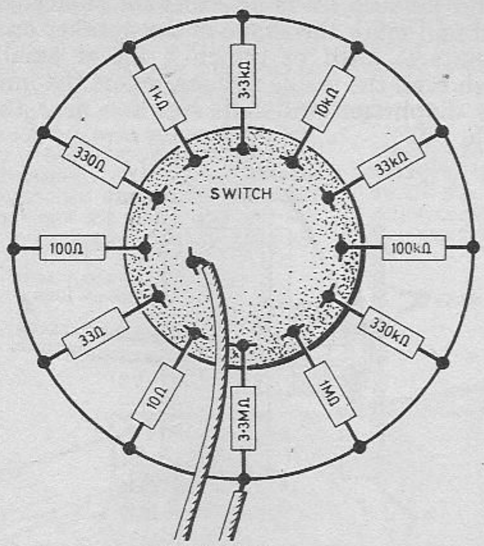


Fig. 4.13. The switch for the RESISTOR BOX is wired according to the method as shown.

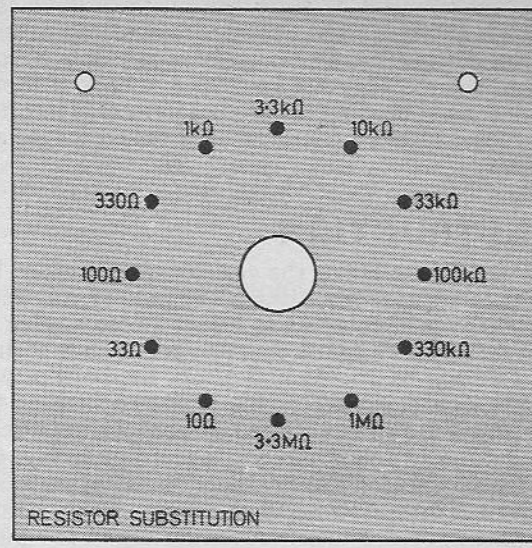


Fig. 4.14. Covercard, shown full size required for the RESISTOR BOX.

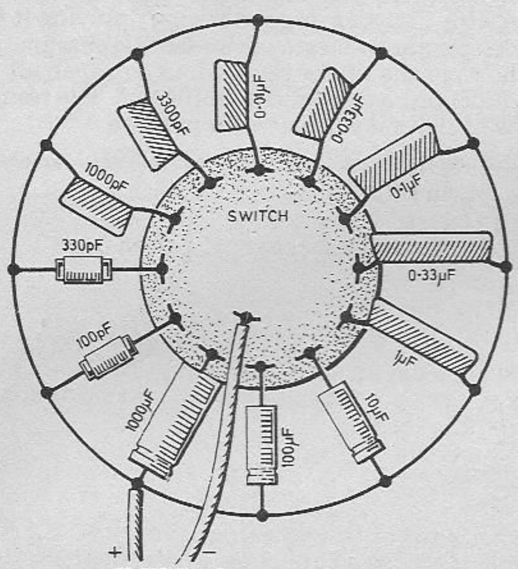


Fig. 4.15. The wiring for the CAPACITOR BOX. Observe the polarity of the electrolytic capacitors.

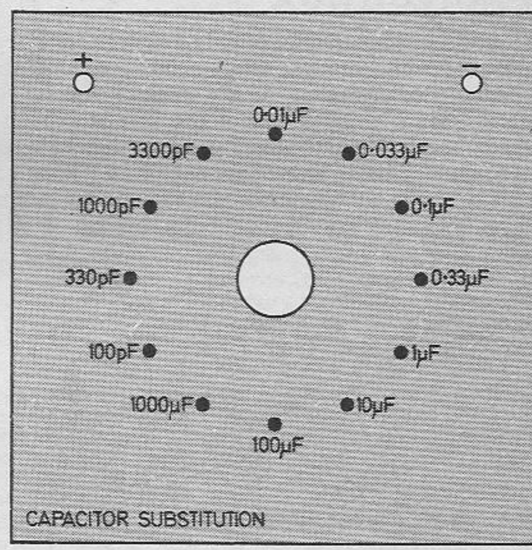


Fig. 4.16. Covercard required. This is also shown full size and may be traced.

Every time it happens, the LED flashes and a click is heard in the loudspeaker. With the values of VR1 and C1 shown the result is a ticking sound. If you experiment with other capacitors you happen to have you should find that increasing C1 slows down the rate of ticking (increases the period) while reducing C1 speeds up the rate. At very slow rates you should see the LED go on and off, and at high ones the sound will be a buzz, whine or whistle. At extremely high rates you will hear nothing, because the pitch of the sound is too high. It is ultrasonic, that is, "beyond sound".

In this case, how can you tell that the circuit is still oscillating? Bring a transistor radio close to it and you should be able to pick up interference noises (whistles, etc.). If the noise disappears when you switch off the oscillator, this proves that it is coming from the oscillator. You are using the radio as a means of converting the ultrasonic frequency to a sonic one.

By using this oscillator as a source of voltage which changes at different frequencies you can check, by using the VOLTAGE INDICATOR as shown, that the impedance of C2 is reduced (letting more voltage get to R4) as the frequency is increased (i.e. the pitch of the sound rises).

R AND C SUBSTITUTION BOXES

By now you will have come to see the need for some handy way of making rapid changes of *R* or *C* for experimental work. This can be arranged very easily with the help of rotary switches. A rotary switch is a multi-position rotary switch which is made very thin by using sheets of insulation (plastic, resin-bonded paper, or ceramic) to carry the contacts. The usual types have twelve fixed contacts, connected to solder tags round the edge. The number of movable contacts (tags in the middle) can be 1, 2, 3, 4 or 6. If there is only one, then turning the shaft connects it in turn to each of the 12 fixed contacts. It is called a 1 pole, 12 way switch.

CONSTRUCTION

We shall first make the resistor substitution box. As you can see we are using a one pole 12 way rotary switch which enables us to select up to twelve different resistors. Construction can commence with the box. This has four sides and a top, the bottom being omitted. Dimensions for this is shown in Fig. 4.17. Shown in Fig. 4.14 is the cover card to be stuck to the top. The switch is wired up according to Fig. 4.13, and then mounted inside the box. The protruding spindle is then cut off and a small pointer knob fitted. Two pins/nails are then located on top of the box to act as terminals which will connect to any external circuits you might use.

CAPACITOR BOX

The same sequence of events is followed for the construction of the capacitor box, only capacitors are used instead of resistors. The wiring of the switch is shown in Fig. 4.15. The size of the box is exactly the same as for the resistor box, only a different cover card is used. This is shown in Fig. 4.16. This is also drawn full size. By spraying the two boxes with different colours they may be identified easily.

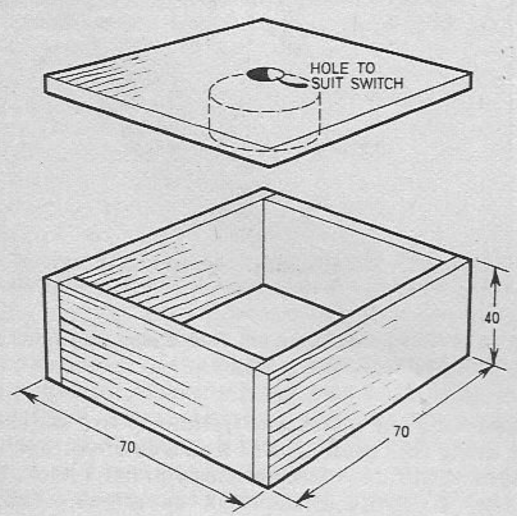


Fig. 4.17. Dimensions of the two boxes. Plywood can be used to construct them.

LOUDSPEAKER CABINET

In one of our previous experiments (Fig. 4.12, the oscillator) a loudspeaker was called for. No doubt you just wired the circuit direct to the loudspeaker with insulated wire, this is of course perfectly correct. However, since the paper diaphragm is rather delicate and easily damaged, continual soldering and desoldering and general rough handling may damage the diaphragm beyond repair. To overcome this problem we shall mount it in a simple cabinet (Fig. 4.18).

A round tobacco tin is an excellent choice. Remove the lid and mark the shape of the speaker on the inside surface. Drill or punch a lot of small holes through from the inside surface, where the inner part of the diaphragm will fall. Not too near the edge though.

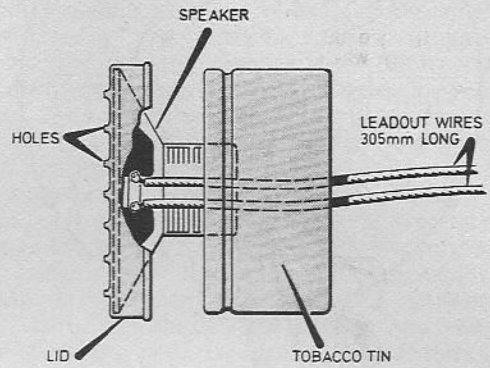


Fig. 4.18. Our simple cabinet. This is made from a discarded round tobacco tin.

Make sure there are no pieces sticking up which might penetrate the diaphragm. Glue the speaker in place with Copydex or similar glue applying it to the rim, keeping it well away from the diaphragm. Make two holes in the tin for the leadout wires, about 12 inches (305mm) long would be sufficient. The result will not be hi-fi but it will serve our purpose.

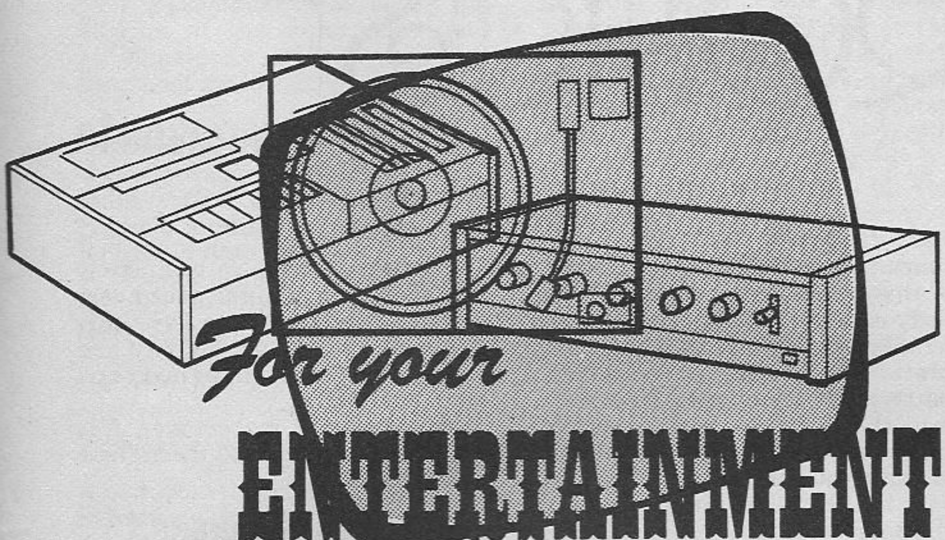
Next month we shall embark on a new subject — amplifiers.

QUESTIONS

1. The current passed by a resistor of 1kΩ is:
   a. 1mA per volt
   b. 10mA per volt
   c. 0.001mA per volt
2. One 10μF capacitor is charged to 8V and another to 3V. They are then connected "series opposing". The net voltage is:
   a. 5V
   b. 11V
   c. 24V
3. A sine wave of 1V and a frequency of 100Hz is applied across a capacitor, a current of 3mA flows. If the frequency is increased to 300Hz, what is the current now flowing?
   a. 900mA
   b. 9000μA
   c. 9mA
4. A circuit contains a resistor of 10MΩ and a capacitor of 100μF. The time constant is:
   a. 10 seconds
   b. 1 second
   c. 1000 seconds
5. Television in the USA has a frame frequency of 60 frames per second. Each frame lasts for about:
   a. 17 milliseconds
   b. 60 milliseconds
   c. 20 milliseconds

ANSWERS *To Part three*

1. 2 ohms.
2. 10 ohms.
3. 50 volts.
4. 4 amps.
5. 500 milliamps.



For your ENTERTAINMENT

By ADRIAN HOPE

THE hi fi and home entertainment shows held in London last autumn were something of a disappointment, largely due to the policy adopted by their organisers of deliberately holding two similar shows within a mile of each other at the same time. Some potential exhibitors were so confused over which show to back that they compromised, and backed neither.

Others supported one but not the other; whilst some went the whole hog and exhibited at both shows, thereby tying up massively expensive quotas of staff. If one thing in this world is certain it is surely that there won't be two simultaneous shows next autumn. For the press, the shows were surprisingly dull, there being very little on show in London that hadn't already been shown at Harrogate. In fact for me there were only three points of interest at Olympia.

TV Games

Firstly, buried in a corner, one exhibitor was giving us a foretaste of video games for the future. The Fairchild game system uses plug-in solid state memory boards in the manner of a computer, to programme it for different games. So far around a score of games can be programmed, and more will follow. The Fairchild system will be launched on the UK market as soon as supply in the USA has satisfied demand, and as soon as the British public has become tired of TV ping-pong and is looking for something more exotic.

Video Recording

Behind the scenes at the JVC stand, not on view to the public, was a prototype version of the new VHS videocassette recorder, developed by JVC and Matsushita in Japan. Similar in size and appearance to a large but otherwise ordinary audio cassette recorder, the VHS can record two hours of video on a single cassette, also similar in appearance but somewhat larger than an audio cassette.

Future modifications of the machine will provide for four hours of recording on a single cassette – if anybody can be found who actually wants four hours of continuous video recording! The VHS machines will come onto the UK market during 1978, and will without doubt cause a sensation. Apart from how they look and what they offer, the machines and tape will probably be cheaper than for the two hour cassette system now available from Philips. A two hour system from Sony, the Betamex, will be launched here soon after the VHS machines and the Sony tape may prove cheaper of all, around £6 an hour. But more of all this when the machines and tape are actually available.

Film Loops

Finally, on the Wireless World stand there was to be found a lifelike wax model of John Logie Baird talking about television. This talking head system, which originates from the USA, relies on a waxwork dummy sculpted to look like the subject. A sound film of a human head physically resembling and sounding like the subject is then shot and formed into a continuous loop.

A special film projector then "screens" the talking head film on the head of the waxwork, to make it look as if the waxwork has mobile features and is talking. As proved by the Olympia demonstration, which ran continuously all week, the result can be very impressive. The first experiments in this area date back to Walt Disney Studios before the War, and the particular film loop system used was invented by Conkling Chedister of New Jersey twenty-five years ago.

It was suggested that use of the system at Olympia was "a UK first", but I distinctly remember seeing a talking head at a specialist photo exhibition three or four years ago. Be that as it may, the Olympia talking head was impressive and I suspect we shall be seeing many more, similarly eyecatching displays at future exhibitions.

In the meantime, owners of the increasingly popular Super 8 sound film cameras can now play around with the idea for themselves, for instance by shooting a film of dad talking and projecting it on mum's skull-like polystyrene wig stand.

Telephone Tones

Continuing briefly on last month's subject of spies, how many times have you seen Secret Agent Number One, phone Secret Agent Number Two using the time-honoured identification code, "I'll let the number ring twice, then hang up, then ring again so that you know it's me"? Well if in real life spies worked like this they would very soon come unstuck. Why? Because when you dial a number on the telephone, the ringing tone you hear at your ear does more often than not, bears no relation to the way the phone rings at the other end. Here's why. The bell of a telephone is driven by pulses of 50 volt a.c. current. These current pulses are produced by a generator at the telephone exchange local to the number being called. This generator is switch in to the called line by low level pulses initiated from the calling number.

In other words, when a Birmingham subscriber dials a London number, he is switching a London generator into circuit with the London number, to ring its bell.

All this, of course, makes sense, because it would be an inelegant solution to send heavy current ringing pulses down the line all the way from Birmingham to London. The ringing tone the Birmingham caller hears in his earpiece is simply a locally generated low-level signal which, as likely as not, is totally out of sync with the ringing pulses in London.

So two rings from Birmingham may well be one or three rings in London. Incidentally, this also explains why sometimes a number you are calling can appear to pick up the phone before it has even rung.

TEACH-IN 78 REPRINTS

Owing to great demand the October and November issues of EVERYDAY ELECTRONICS have completely sold out. To help those readers who wish to follow the *Teach-In 78* series but have missed parts 1 and 2 that appeared in these issues, reprints of *Teach-In Part 1* and *Part 2* are available at a cost of 35p each, inclusive of postage. Orders (specifying Part required) with remittances should be sent to: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF.

IMPLANTABLE MEDICAL ELECTRONICS

By S. McClelland

IT IS A tribute to electronic engineering that some of the most spectacular and exciting advances in modern medicine have taken place because of it. We have already looked at some of the electronics available to help doctors diagnose illness in an earlier article.

Electronics can also be used directly in treatment, and possibly the most exciting of these devices today is the range of so-called "spare parts" or prostheses which can be implanted directly into the patient.

HEART PACEMAKERS

The best known of these electronic prostheses is probably the heart pacemaker which enables the human heart to beat normally even when critical parts of it may be defective or diseased.

The human heart, although it is basically a mechanical pump is electrically controlled by a small region of specialized "natural pacemaker" tissue which 70 or so times a minute sends out signals across the organ causing sequential contraction of its individual chambers.

However, it is when these signals are incorrectly produced or perhaps even blocked altogether that doctors need to restore correct heartbeat action by implanting an electronic pacemaker which provides electrical signals similar to those produced naturally.

In basic terms, this pacemaker is an oscillator producing short-lived pulses of 5V amplitude about 70 times per minute. Although some of these units are mounted on the body externally it is generally preferable to surgically implant complete pacemakers (oscillator, battery and stimulating electrode) into the body. In fact it usually takes the form of a package placed in the right hand side of the chest with the electrode leading across to the heart (see Fig. 1).

The fact that the units are implanted does raise some extra considerations on their design, particularly as regards reliability.

FIXED RATE

Earlier pacemaker designs used pre-set oscillators that would supply output all the time regardless of actual heart condition. While these fixed rate pacemakers are highly desirable for patients who have completely lost their own natural pacemaker activity, many patients have only a partial loss of such activity and only require intermittent electronic pacing.

The *demand pacemaker* was therefore developed to meet these requirements.

DEMAND PACEMAKERS

The demand pacemaker design can sense the wave of electrical excitation sweeping across the heart and regulate its own output accordingly. When the heart is beating normally, it will shut down its own output, only triggered into action again when some beat irregularity occurs.

The demand pacemaker is usually designed to sense the major, or QRS, component of the

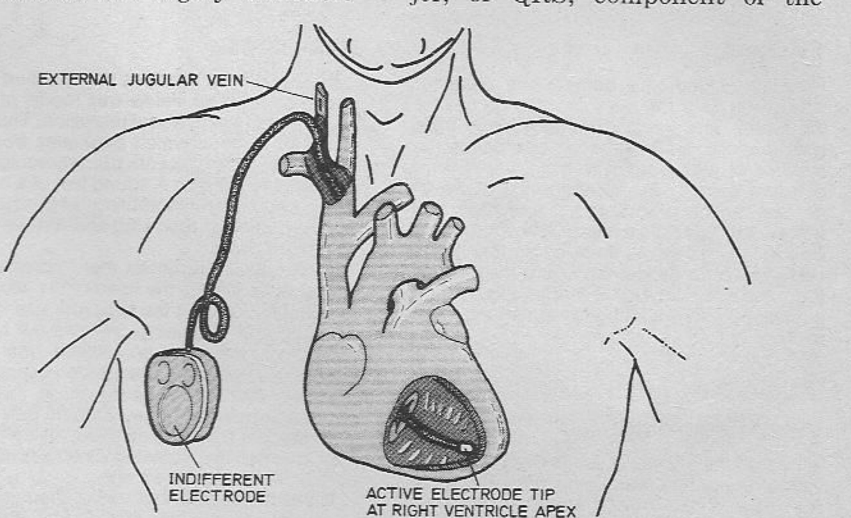


Fig. 1. Location of a heart pacemaker within the human body. *(Courtesy of Devices Implants Ltd.)*

electrical heartbeat: the appearance of such a wave will cause the pacemaker to shut down for the length of time between two *normal* heartbeats.

If the heart is beating normally, the QRS component of the next beat will again shut the pacemaker down, and so on.

If however the heart is beating irregularly for example, more slowly than it should, the QRS component will be late in arriving. The pacemaker will sense its absence at the correct time and automatically trigger the next heartbeat itself.

DESIGN CONSIDERATIONS

So far we have looked at the two main types of pacemaker but have not said anything about the problems their designs raise.

The first, and probably most important consideration which must be made is that the pacemaker must perform reliably – producing the specified electrical output in the response to specified conditions throughout its lifetime.

This means that the circuit design and its components must behave in a very stable fashion over a long period of time. It also means that the device must be completely sealed up. For example in epoxy resin so that the body tissues cannot cause it to malfunctions. At the same time, its presence must not adversely affect the body tissues themselves.

THE BATTERY

The pacemaker's power source must be completely self-contained and usually has been a mercury cell, which while being a good constant voltage source it has a short lifetime, of between two and three years in practice. When the cells wear out, re-operations are necessary to replace them.

So, ideally, medical engineers would like to use cells with similar characteristics to the mercury cell, but with lifetimes of some ten years and preferably more so that a lot of surgery time can be saved.

This has meant the development of more exotic cells – nuclear powered ones, in fact, and at the time of writing the full production of pacemaker cells using the plutonium isotope 238 is expected shortly in this country. In this cell, electricity is produced by thermocouple conversion of the heat from the radio active decay of the plutonium. Naturally, the sealing for a cell which contains such poisonous agencies must be of of the very highest quality so that even under all the stresses a human being can possibly encounter in life, the cell will remain intact.

OTHER IMPLANTS

In clinical practice, the results of the heart pacemaker have been so successful, with many hundred thousand around the world now implanted, that the development of other such prostheses has been encouraged. These include devices to aid patients suffering from incontinence difficulties and electrically controlled limbs.

But to show how rapidly developing this field is and how much promise it holds for the future, we've chosen to devote the major part of this article to one project, carried out at the Medical Research Council's Neurological Prostheses Unit: the development of artificial vision for blind people.

Although this work is still in experimental stages, the results certainly encourage the hope that in the future blind people can be given satisfactory sight by transmitting suitable electrical signals directly into their brains.

REQUIREMENTS

How is such a marvellous idea possible in practice? Before discussing the Unit's work, it may be helpful to review the general background to designing such a *visual prosthesis.*

We, as human beings, see with our eyes but interpret vision with our brains, specifically in a two-lobed region of nervous tissue lying at the base of the brain known as the visual cortex.

When people who are sighted and become blind, this tissue, for the most part stays functional, usable, but of course, unused.

If suitable electrical stimulation is applied to the tissue, for example through small implanted electrodes placed on the cortical lobes, the patient experiences small bright dots of light, usually one per electrode, called *phosphenes,* and these remain fixed in the visual field. The position of these phosphenes in the visual field is related to the electrode position, and their appearance, to the state of the nervous tissue at the time.

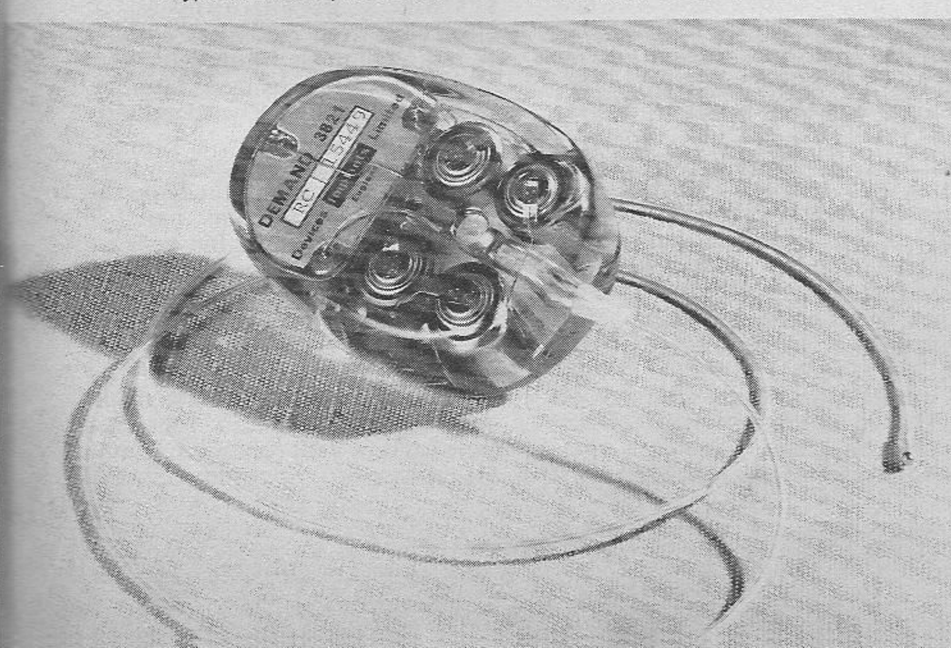
It is the aim of the project to build an implant that will stimulate enough cells in the cortex to build up a phosphene picture, like the way ink dots build up a newspaper photograph. To do this, there must be a way of transmitting the required signals into the implant and some means of receiving them and directing them to the correct electrode.

VISUAL PROSTHESIS

Actually the Unit, with Mr. P. E. K. Donaldson as project leader, have been developing an implanted device physically consisting of three separate sections:

1. A *main silicon-rubber cap* about the size of an outstretched hand containing the radio receivers and electronics of the system, which is secured below the patient's scalp but above his skull.

A typical demand pacemaker. *(Courtesy: Devices Implants Ltd.)*



2. *Two smaller caps* fitting side-by-side over the two lobes of the visual cortex, which contain the stimulating electrodes connected by cable to the main cap.

3. The *transmitters* for the system are mounted in a helmet arrangement worn on the patient's head and they are linked to the implanted receivers by a 10MHz carrier waveform. A signal or combination of signals from these transmitters activates the receivers in the implant beneath them, which provide power for the stimulating electrodes. Thus, unlike the heart pacemaker, no implanted battery is needed.

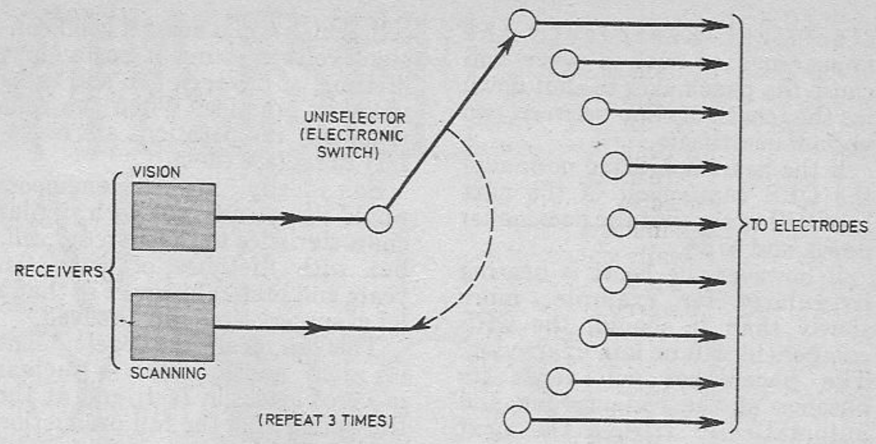


Fig. 3. Proposed future uniselector system for visual prosthesis implant (highly schematic).

At present, most effort is devoted to perfecting the implant half of the system and (as we shall see) to increasing the number of electrodes. So most of the transmitter inputs are used for experimental purposes, although in the future they will probably come from a closed-circuit TV camera. Indeed, one patient has already successfully "read" Braille from signals fed to this implant from a punched tape reader.

RADIO CHANNELS

We shall now go on to discuss some of the details of the system, particularly the number of radio channels that are needed to make a useful prosthesis.

Estimating the prosthetic facilities required to enable a blind person to read, Prof. G. S. Brindley, F.R.S., Director of the Unit, decided that to recognize one printed letter at a time needs 60 operational prosphenes, and to read at a normal speed, the patient would require ten times that number.

All this means that the better the picture required, the greater the number of electrodes that are needed to produce it.

The first prosthesis implanted in 1967 was an 80 electrode system. It was a "linear" design, i.e. one transmitted radio channel used one receiver to produce one phosphene.

It became clear that a design of this type could just not be used if anything like a 600 electrode system was wanted. A prosthesis containing 600 radio receivers would be just too bulky to implant and, of equal importance, the radio channels would be so crowded together that cross-talk between them would inevitably result and spuriously stimulate electrodes.

How could the prosthesis be made to have a high electrode number but at the same time a low radio channel number?

The answer lay in a new ingenious type of system design.

SYSTEM DESIGN

The main limitations of the above "linear" design can largely be overcome if an "array" system of radio receivers is used instead to address each electrode. Fig. 2. symbolizes a small portion of such an implanted array.

If column radio receiver *P* and row receiver *C* both receive a signal then only electrode *P/C* and no other electrode has the power to produce a phosphene. On the other hand if receiver *P* and receiver *A* are activated instead only electrode *P/A* will produce a phosphene. The intersection units at each row/column crossover point are AND logic gates which ensure that electrode *P/A* (say) is stimulated only when receivers *P* and *A* output.

For simplicity only a small array has been shown, but the important point to note is that with this system a given number of electrodes need a smaller number of radio channels to operate them and with a large electrode number, this reduction is correspondingly great.

This ingenious design was used in the second implant made by the unit in 1972 which had 75 stimulating electrodes but because of this array system needed only 20 radio receivers (arranged in a 15 column × 5 row array).

At present the Unit are working on an implant having 304 stimulating electrodes but again only needs 35 radio receivers (arranged in a 19 column × 16 row array)

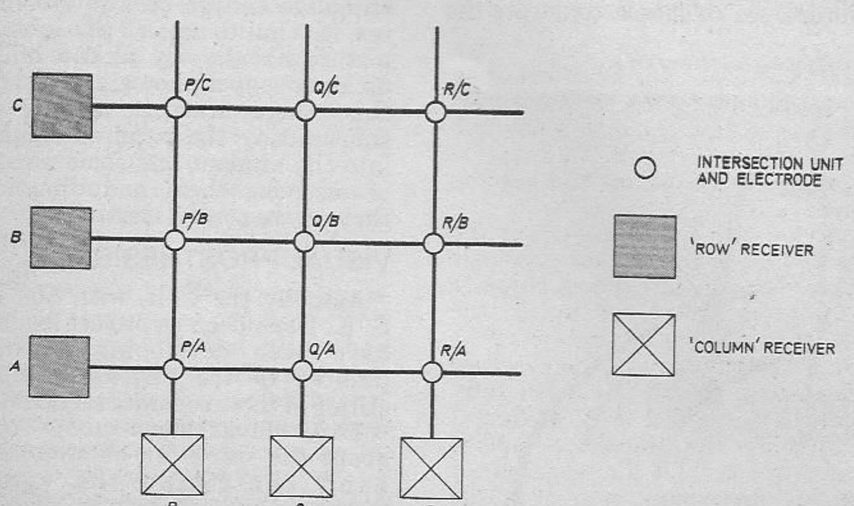


Fig. 2. An implanted "array" system used for present prostheses.

UNISELECTOR

The above system is capable of operating quite large numbers of phosphenes but in the future where a very high phosphene capacity is demanded, an electronic uniselector system will probably be used instead, Fig. 3.

This will basically consist of an implanted solid-state (not electromechanical) uniselector or switch, which will be fed by a few radio receivers and which will in turn feed all the electrodes in the implant. Under the control of these receivers it can switch continuously between all these electrodes and supply them with suitable stimulating signals. In practice, three of these switches will be connected together in parallel for greater reliability.

MICROELECTRONICS

Some form of integrated electronics is necessarily called for in a project like this where site of implant is a prime consideration.

In fact the implant does not use monolithic silicon i.c.s. the type that are familiar to most of us, but thick film hybrid circuits instead.

This is far cheaper for the relatively small quantities of circuits the project requires, and more importantly, these circuits are easier to design, and once designed are easier to change should that become necessary.

Basically thick film hybridization is a technique whereby circuits can be made by depositing wiring and passive components (like resistors) onto a substrate using special conducting links and ceramic materials, and then made permanent by firing. Other components e.g. transistors and diodes are soldered on to the circuit afterwards.

Two of the three main electronic "building blocks" used in the implant, the column and intersection units, are made in this way.

The third package, the row coils, are merely free standing tuned circuits pre-set to the implant operating frequencies.

SEALING

The sealing of all these circuits from the warm, watery environment into which they would be implanted probably presented the biggest engineering problems of the whole project.

At first sight, it might appear that these sealing problems were solved once and for all with the successful development of the heart pacemaker.

In fact, the conditions in which a visual prothesis and a pacemaker have to work are considerably different, but even so epoxy resin similar to that used in pacemakers provided a starting point from which to conduct the search for a suitable sealant. The bulky ceramic packages also reminiscent of pacemakers were used for sealing the second implant circuits but have now been dispensed with in the third implant in favour of a flexible sealant which would make better use of the space available in the implant.

The best sealant appears to be silicon rubber adhesive. This keeps out liquid water (this would cause short circuit and electrolytic damage) and unlike most of the other potential sealants, also deals effectively with the water vapour that will always permeate in from the outside.

This material is remarkably adhesive so that with special techniques, it can be made to literally "stick like glue" when applied to circuitry. No gaps are left in the circuits, and in spite of water vapour being present in the sealant after the prothesis is implanted, it cannot condense and harm the circuits underneath.

VACUUM CENTRIFUGE

Indeed these techniques called for the development by the unit from scratch of a vacuum centrifuge, for only the simultaneous application of a vacuum and a great "*g*" force during the sealing operations will free air bubbles that will otherwise be trapped in the sealant and become such gaps.

Even with the discovery of the usefulness of the sealant problems have by no means ended. Stresses still seem to be set up in the sealant capable of detaching it from the circuitry in the presence of electric fields. The novel solution to this seems to be to mount the thick film transistors upside down on the think film substrate or as Mr. Donaldson puts it rather more graphically, "like beetles on their backs".

TESTING

All the developments described above could not have been made without prolonged testing to discover just how each modification would affect the body tissue and how indeed the body tissue would affect each modification.

Many perfectly suitable materials exhibit altered, or indeed totally different, behaviour, inside the body. Consequently each implant component is submerged in saline test baths at blood temperatures for many months on end to simulate a physiological environment. Each is electrically loaded and connected to an alarm indicator so that if, and when, it fails, the time and manner of its failure can be determined.

The effects (toxic or otherwise) these materials might produce over a prolonged period in the body, could only be assessed by implanting them into rabbit and baboon living tissue, and these trials suggested that it was safe to proceed with a human prosthesis.

Nor did the experiment end when the prosthesis was finally implanted into the patient, for more trials were needed to "map" the phosphenes, that is to determine the position of each phosphene in the patient's visual field and compare it with the position of the electrode that produced it.

FUTURE PROSPECTS

In all, three prostheses have been implanted, the most advanced to date having 304 electrodes.

Judging by the success of this very exciting project so far, it can surely only be a matter of time before blind people, even those with irreparably damaged eyes or optic nerves, can be given satisfactory sight by this method.

Indeed there seems to be nothing in principle against replacing any defective organ in this way. Such is the very exciting future for this subject. □

ACKNOWLEDGEMENTS
The author would like to acknowledge the help given to him by the following:
Mr. P. E. K. Donaldson of the MRC Neurological Prostheses Unit;
Devices Implants Ltd;
Sierex Ltd.

SQUARE ONE ...FOR BEGINNERS

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

WIRING ON MATRIX BOARD

IN A previous SQUARE ONE we described how to build circuits on stripboard, showing in particular the similarity between a photograph of the actual board and the components drawn on the physical layout. Stripboard is of course very widely used in EVERYDAY ELECTRONICS projects. A second type of board often used is plain stripboard, or sometimes called matrix board. It consists of a sheet of s.r.b.p. less the copper strips, but is punched with a matrix of holes on either 0.1 or 0.15 inch spacing.

CIRCUIT DIAGRAM

Refer to Fig. 1. This shows the first stage of a complex amplifier. The drawing is of course in accordance with normal practice and style.

The first thing to do when using matrix board is first to cut it to size. The size is normally given as so many holes by so many holes, not, as with stripboard which is given as so many strips by so many holes. Alternatively

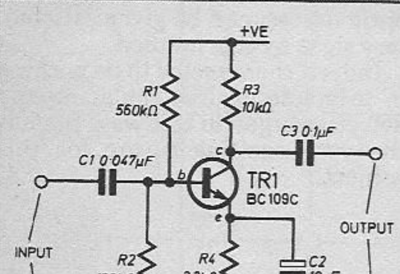


Fig. 1. Circuit diagram of the first stage in a complex amplifier.

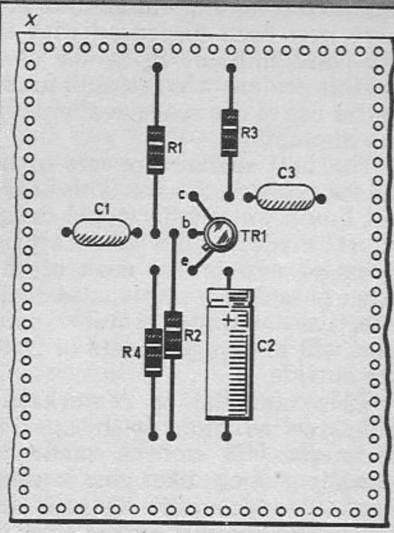


Fig. 2. The physical layout of the circuit in Fig. 1. Shown here is the top with the locations of the components. Note the correct orientation of the polarized components.

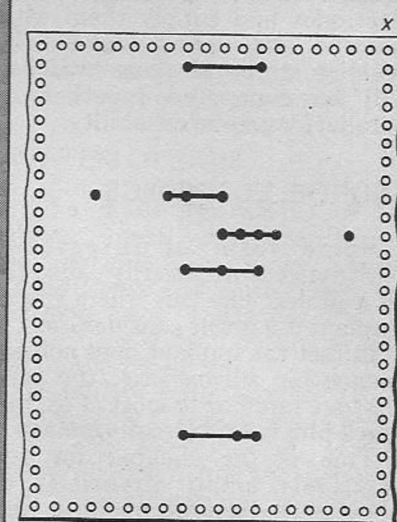
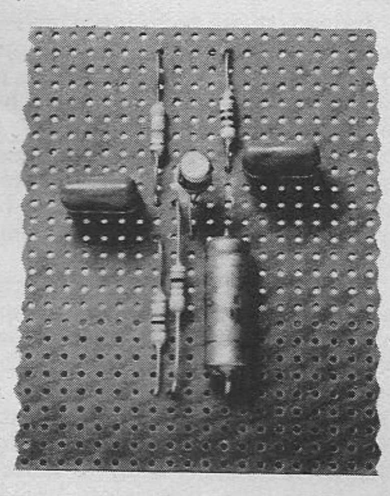
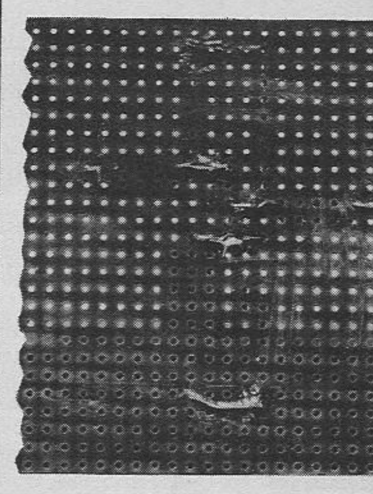


Fig. 3. Underside view of the board. The wire links are shown by the solid lines, the position where the component leads pass through the board as solid dots.



This photograph shows how the components of Fig. 2 actually appear on the board.



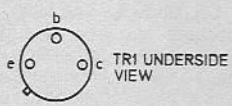
The underside view of the board is shown in this photograph. Note particularly how the leads of the components form the links.

the actual size in millimetres may be given.

Now look at Fig. 2. This is the physical layout of the board showing the components on the top side. At this point it might be worth mentioning that although the layout is similar to the circuit diagram this is not always the case.

Underneath this layout is a corresponding photograph showing how the components really look in practice.

Refer now to Fig. 3. this is the underside of the board and shows the required links to be made between the various components on the board. The corresponding photograph details how the wire links will look on the board.



In all constructional projects the underside view of the semiconductors are given as shown here.

WIRING

Perhaps the first thing you will have noticed about the photograph is that the leads of the components actually form the links. This is perfectly in order and is normal practice for this type of board. Where the links are spaced a fair distance away then ordinary tinned copper wire is used.

When mounting the components on the board the lead-out wires are pulled tightly to anchor the component in place, after which the soldered joint provides the necessary mechanical anchorage.

One advantage of this type of board is that mistakes or any rearrangement of the wiring is easily carried out, whereas with stripboard if a break has been made in the wrong place then a wire link must be used to effect a repair. This is nearly always rather messy looking and spoils the appearance of the board.

LAYOUT

That then is how to wire a circuit on matrix board. You may have noticed that the layout has been "spread out", this has been done deliberately to show clearly the soldered joints, and the use which has been made of the component leads. In practice of course circuits such as these are normally built as close together as possible in order to save space on a crowded complex board. Incidentally if the circuit *is* constructed a very valuable preamplifier will be the result.

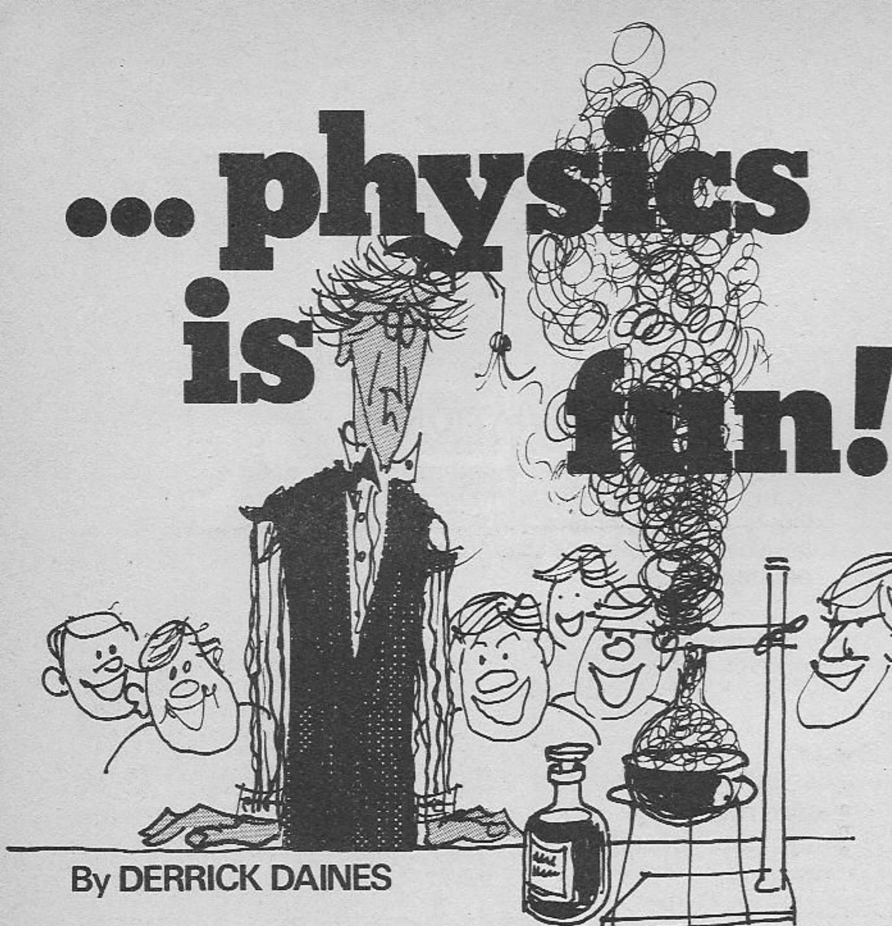
...For Your Reference

ABBREVIATIONS

Listed here are the more common terms used widely in EVERYDAY ELECTRONICS. Although the list is comprehensive it is by no means exhaustive. A few terms may therefore have been omitted.

a.c.	alternating current
a.f.	audio frequency
a.f.c.	automatic frequency control
a.g.c.	automatic gain control
a.m.	amplitude modulation
BA	British Association (nut and bolt sizes)
cm	centimetre
d.c.	direct current
d.p.d.t.	double-pole double-throw
elect.	electrolytic
e.h.t.	extra high tension
e.m.f.	electromotive force
f.e.t.	field effect transistor
f.s.d.	full scale deflection
f.m.	frequency modulation
g.	gram
h.t.	high tension
i.c.	integrated circuit
l.e.d.	light emitting diode
l.d.r.	light dependent resistor
lin.	linear
log.	logarithmic
m	metre (measurement of length)
mm	millimetre
m.w.	medium wave
npn	transistor structure
pnp	transistor structure
oz	ounces (avoirdupois)
p.i.v.	peak inverse voltage
p.v.c.	polyvinyl chloride
r.f.	radio frequency
r.m.s.	root mean square
s.p.s.t.	single-pole single-throw (switch)
s.r.b.p.	synthetic resin bonded paper
s.w.g.	standard wire gauge
t.r.f.	tuned radio frequency
u.h.f.	ultra high frequency
u.j.t.	unijunction transistor
v.h.f.	very high frequency
%	per cent
X	reactance
Z	impedance
A	ampere (amp)
dB	decibel
F	farad
H	henry
Hz	hertz (cycles per second)
Ω	ohm
V	volt
W	watt
p	pico (÷ 1,000,000,000,000)
μ	micro (÷ 1,000,000)
m	milli (÷ 1,000)
k	kilo (× 1,000)
M	Mega (× 1,000,000)

... physics is fun!



By DERRICK DAINES

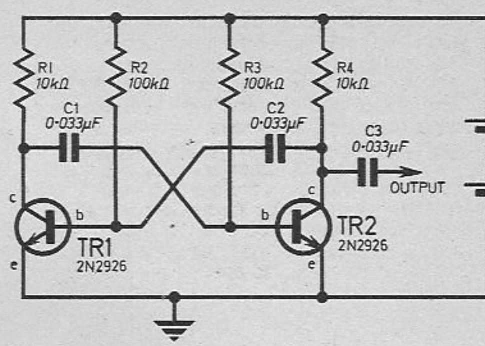


Fig. 1. Basic circuit for a simple organ which may be used with voicing circuits.

Organ Voicing

As any organ builder will tell you, the most fascinating part of building an electric organ is the voicing – that is, devising circuits to produce different tones. To the novice, a glance at any electronic organ may produce feelings of bewilderment and awe. How *do* they manage to produce so many tones? The answer is basically very easy. What *is* the difficult part is to produce tones that blend well and are pleasant in themselves; as someone once said, that do not sound like Uncle 'Arry playing a marforgun under the tablecloff!

There is no need to go to the trouble and expense of building a whole organ in order to sample some of the great fun to be had in voicing; a very simple little circuit will suffice, while if you have a Stylophone or something similar, why, it's luxury itself! Suitable designs frequently appear in the pages of this and similar magazines and Fig. 1, shows a design that is quickly and easily made. Make it up on a piece of stripboard or, if you prefer, tap a few brass pins into a lump of wood and solder your components to that. An additional refinement will be a stage or two of amplification, but it's not absolutely necessary.

For the rest of this article I will assume that the reader has a Stylophone with a small external amplifier and speaker, but it is all applicable to any other simple organ design. The Stylophone output is a sinewave with a spiky component, while other designs usually have a square-wave, as does the circuit of Fig. 1. Take the output to an S-Dec or other breadboarding system, as per Fig. 2, and then to the final amplifier or speaker. Now you are all set to fiddle about and enjoy yourself.

Voicing circuits

You will need a few capacitors, several resistors and if you can manage it, a small inductance such as a tiny transistor output transformer. Winding coils is not recommended at this stage, although you can if you like to throw a few hundred turns of fine wire round a small nail!

Organ voicing circuits fall into three main types; *RC; CR;* and *LC*. The latter get to be very complicated and can be further subdivided into band-pass, band-stop and resonant circuits, so for the time being let's confine ourselves to the simple ones.

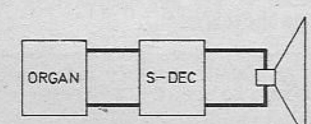


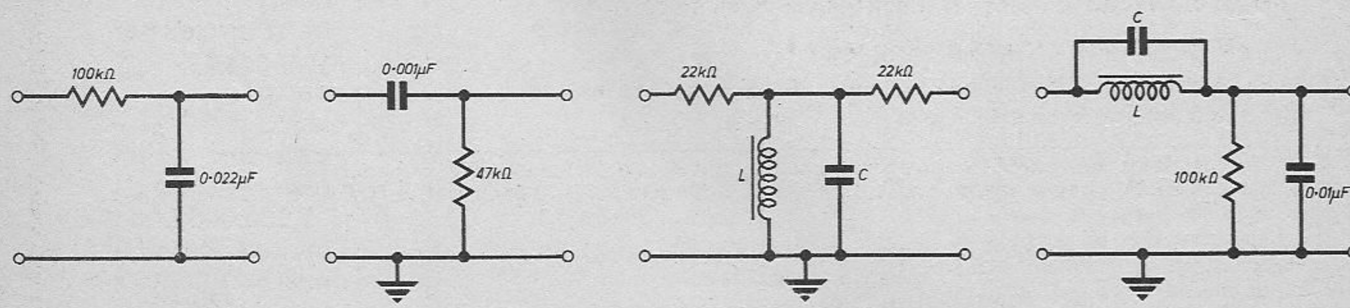
Fig. 2. Suitable breadboarding system using an S-Dec.

The diagram of Fig. 3 shows the basic *RC* circuit, which produces smooth fluty tones. Just one component of each is sufficient to significantly alter the tone, although in practice there are typically three resistors and three capacitors. There is sufficient room for experimentation to keep anyone happy for years. Start with the values shown and *listen*.

If you have an oscilloscope, so much the better. Change one value, then another. Keep changing the values and note the difference in tone. Note how the waveform will not only become smoother as you increase the value of *C*, but will decrease in volume after a while and eventually disappear. If you increase *C* but decrease the *R*, what happens? What limits are there on this process?

Referring to Fig. 4 this shows the reverse – a *CR* circuit, which produces thin, stringy tones. Again, typically such a circuit will have three or more pairs of components, although even one is enough to affect significant changes.

The bigger the *C*, the "fatter" will be the tone, while a small *C* will make a very thin,



Four examples of voicing circuits. From left to right; Fig. 3. A simple *RC* filter; Fig. 4. A *CR* filter; A band-pass filter is shown in Fig. 5 and uses an inductor; Lastly, the filter of Fig. 6 is a band-elimination filter.

violin sound. Some can set your teeth on edge! Alter and experiment as much as you like, starting with the values given.

When you have produced a couple of circuits that you like, one fluty, one stringy, breadboard both circuits and try them together and separately. Neither should predominate over the other and you will then need to experiment to find the right value *R* to put in series with the louder one. What is more likely, you will find that one or the other is not so good as you had first thought, throwing you back into another series of experiments.

Band-pass filter

The band-pass filter involves an inductance, as shown in Fig 5, which is a very basic configuration. I have not shown a value for the *C* since this will depend upon the inductance, but for experimentation a value of 0·01μF is a good place to start. At the right value resonance will be observed and the tone will take on the qualities of an oboe or trumpet. All values are subject to experiment.

The band-elimination filter is the reverse of the above, and is shown in Fig. 6, it surprisingly has a very similar effect on the ear.

Finally, as an example of a commercially-produced tone filter, a Baldwin Vox Humana filter is shown in Fig. 7. This shows how complicated a double-tuned band-pass filter can be. It will also be seen that it includes a small *RC* element, which shows how the basic configurations can be combined to produce the desired effect.

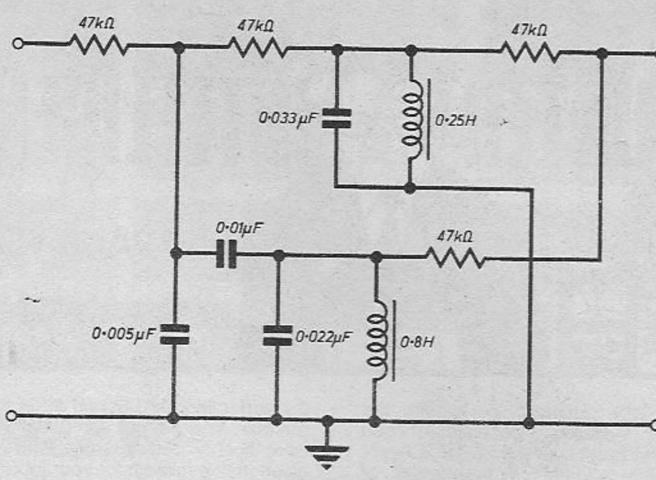


Fig. 7. An example of a commercially made filter; The Baldwin Vox Humana.

Voice Range

One factor in voicing an organ that has never been satisfactorily resolved in any organ (to my knowledge) is the question of voice range. A viola for example does not have the upper range that a violin has, while a piccolo cannot get so far down as a trombone. This poses an interesting question; on an organ keyboard there are a finite number of keys, so what happens to the viola voice when the organist keys above that instrument's range? In an ideal world, the viola voice should cut out, but that would make the organ even more complicated to build than it is.

Perhaps there is room here for a microprocessor?

I REALLY look forward to writing the "Christmas number" because I can indulge in reminiscences. And what is every writers favourite subject? Why, himself of course! I will talk about my electronics career from the time I started (about 1931) until the outbreak of World War II. It reads rather like Stephen Leacock's story *The History of John Smith.* John Smith started as an errand boy in a haberdashery store and over the years worked his way up to be chief buyer and then as he grew old and senile, came down the ladder again, and was finally replaced by another errand boy who did twice the work for half the money! But as they say in some of the lurid paperbacks, we are anticipating.

Let it suffice to say I started with the old Marconi Company in Dagenham and after a few months' training I was considered trustworthy enough to blow up a few customers' sets. It was about that time, that the Marconiphone Company joined forces with HMV and we were all shunted across to Hayes, Middlesex. There was such a glorious muddle during this move, that we became very much behind with customers' repairs, and consequently were put on a long stint of overtime. I have no intention of making this article a social comment on the thirties, but I feel I should just remind you good young people, of the conditions we worked under then.

I was regarded as a skilled technician and was the only one considered skilled enough to repair the new ten-valve superhets. For this I was paid the princely sum of seven and a halfpenny an hour. Work started at 7.30a.m. and if you were a total of three minutes late during the week you were hauled up before the supervisor and ticked off in no uncertain manner. You did not complain, after all there were twenty other people who would have given their eye teeth for your job.

Having said all that, I must in all fairness, say that we were no less happy than our counterparts today, and probably more contented with our lot on the whole. And we had no television!

I left HMV finally, because having put in for a penny an hour rise, it was turned down and even the supervisor was flabbergasted. Unofficially he suggested I look elsewhere. Fortunately I obtained a job with Ultra Electric in much the same capacity. This was a fairly uneventful period in my career and I finally left them after eighteen months in the hope of obtaining more wages.

I went to a firm called Sunbeam Radio, and it is true my salary reached the dizzy heights of three pounds per week, but unfortunately they folded up after six months. My next employment was with Alexandra Black the Wireless Doctor, but my hair-raising adventures of how I pretended I could drive a car, in order to get the job and the nail biting time I had going round with a repertory company providing their sound effects, have already been told in an earlier Christmas number.

I believe the Wireless Doctor fired me, I am not quite sure on that point, but I next found myself in a Radio Shop in Edgware Road. Only one event occurred here, which I like to boast about, I repaired a radio at a house in Kensington Palace Gardens, the residence of Mr. Ivan Maisky, the Soviet Ambassador and was actually introduced to the great man himself. He was probably the best of the Russian Ambassadors we ever had and very pro-British.

About this time there was one firm, whose skill in radio engineering I had always greatly admired, Messrs. Philips, and so I applied for a job as a technical assistant, and was accepted. I worked for them for three years, until I was finally lured away by the prospect of big money at Radio Rentals.

One way I used to augment my income was repairing radios for a Mr. Mack, who had a Radio Shop in Garrett Lane, Tooting. He knew nothing at all about radio, and used to save all his repairs up for me to do on Saturdays, at half a crown a time! (That's about twelve and a half pence in today's money). I worked for about a year with Radio Rentals and working conditions were still very harsh. We worked six days a week, starting at 9.00a.m. and finishing around midnight, and if you were five minutes late you were fined a shilling (five new pence).

After leaving Radio Rentals I had several jobs of fairly short duration, finally finishing up back with the EMI Group (which included the combined firms of Marconiphone and HMV). We were now within a year of the start of World War II and I was badly bitten by the flying bug, having been given a trip in a Leopard Moth by one of my Radio Rentals friends, and so I applied to join the Royal Air Force Volunteer Reserve. This was the only way I could see of getting free flying.

I always remember on the entrance form you had to list all the firms you had worked for, stating why you had left. I duly wrote them all down and in each case the reason I gave for leaving was to better my position. This posed a problem, because I finally finished up with the same firm I started with. I solved this by naming the first one "The Marconiphone Company" and the last one "His Master's Voice Company". No one knew it was one and the same.

I think you can see there is a slight similarity with the life of John Smith. In case you wonder what finally became of John Smith, at the age of sixty-five he became useless and his children had to look after him. They did not want to, but they had to. At seventy, he became ill and after being given the proper treatment he died. They buried him, and over his grave erected a marble signpost pointing to the North West, but I doubt if he ever got there. He was too much like you and me!

Happy Christmas

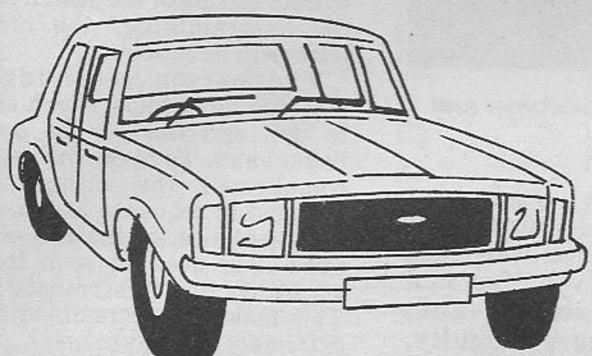
JACK PLUG & FAMILY...

NEXT MONTH

Light on the Disco & Pop scene

CHASER LIGHT DISPLAY

A four channel sequential lighting display that will produce a sensation of movement. The unit incorporates speed, direction, and freeze effect controls and can handle up to 1 kilowatt per channel. The master unit contains an l.e.d. monitor display to show the status of the cycle.



CAR SYSTEM ALARM

This easy to build unit gives a sound and visual warning if the side or headlights, or any other chosen accessories are left switched on when the ignition is turned off.

PLUS

STEREO/MONO LEAD TESTER

Designed primarily for the pop group to give rapid check-out of jack-to-jack connecting leads, but can be adapted to cope with any other plug types. It can detect short, open and crossed leads.

A.C. METER CONVERTER

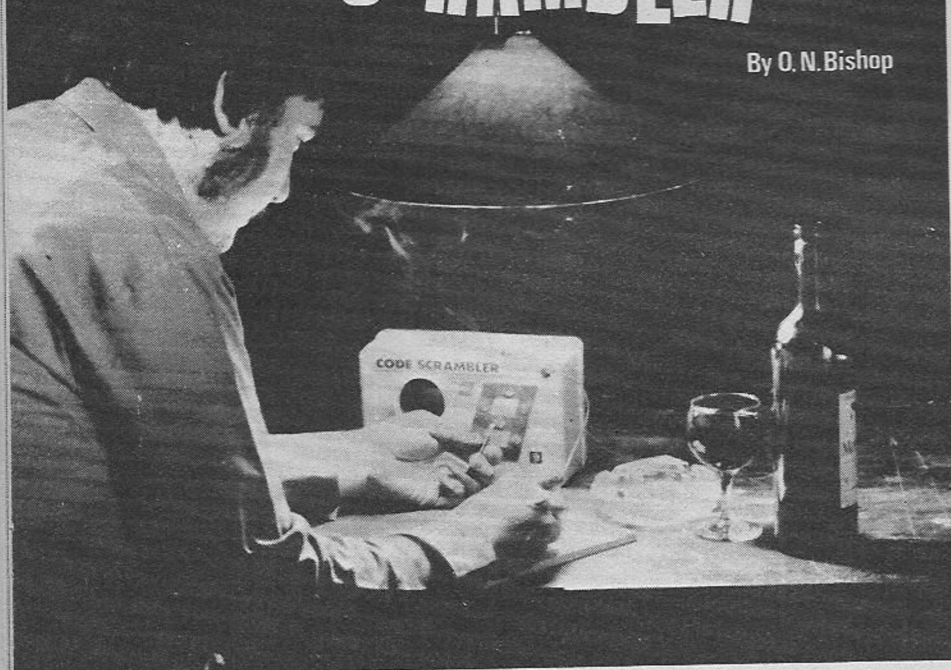
Extends the range of a standard a.c. voltmeter by converting the chosen scale to read one-tenth or one-hundreth f.s.d. Ideal for measuring low level audio signals.

Everyday ELECTRONICS

FEBRUARY
ISSUE ON SALE
FRIDAY, JANUARY 20

CODE SCRAMBLER

By O. N. Bishop



Why not build this novel code game in time for Christmas and amuse your party friends?

INTRODUCTION

THE CODE SCRAMBLER turns ordinary letters and figures into code symbols (or, more correctly, *cipher* symbols, but "code" is a shorter, more familiar word). If we think of a letter as being made up from segments arranged in the pattern of the seven-segment displays used in electronic calculators, we can scramble the segments according to some pre-arranged system, and produce a symbol which looks nothing like the original letter. For example, in Fig. 1 the letter *'t'* can be made up from four segments; segments *d, e, f,* and *g* of the standard seven-segment display. If we interchange the segments of the display in pairs, we get a new symbol. In this example, the symbol includes the decimal point (we shall refer to this as segment *h,* for convenience). We write the scrambled symbol with rounded-off corners to conceal the fact that it is derived from a seven-segment display and, since there is no ambiguity, we can write the decimal point wherever we like.

A person unscrambling this symbol performs the same operation of interchanging segments, and recovers the original letter *'t'*.

Strictly speaking you do not need an electronic device to scramble letters in this way but, as the author found when he was trying to work out a system *before* he had built the prototype, scrambling is a tedious business and very subject to error.

OUTLINE OF THE CIRCUIT

The scrambler operates on one letter or figure at a time, so only one l.e.d. seven-segment display is required, see Fig. 2. This is controlled by a keyboard, which is an array of metal contacts set out on an outline of the seven-segment grid. There is also a "reset" contact.

A wander plug connected by a flexible wire to the ground rail of the circuit is touched against the segments which are part of the letter that is being scrambled (or unscrambled). Grounding a contact causes a bistable to change state and this switches on one of the segments of the display.

The connections between keyboard and display are arranged so as to scramble the segments. In the diagram the wiring is shown as in the prototype, in which the permanent interchanges are **a-c,** and **d-h,** and there is also a switch which allows all three possible sets of interchanges for the remaining four segments. We can have **b-g** and **e-f,** or **b-f** and **e-g,** or **b-e** and **f-g.** This means that the scrambler can produce three differently scrambled versions of the same letter. The three versions of letter **t** are shown in Fig. 3. As long as the correct setting of the switch is used for unscrambling, the original letter will be recovered.

The person receiving the message must know which setting to use, and this can be decided beforehand. To make things really complicated, the setting can be changed in sequence at the end of each sentence, or the end of each word – or even at each letter – according to a prearranged plan. This makes the scrambled cipher extremely difficult to break.

CHARACTERS

With a little twisting and ingenuity the seven-segment format can be used to display all the alphabet (lower-case letters), all the figures and a few punctuation marks, see Fig. 4. As we are dealing with only one letter at a time, it does not matter that in some letters the writing-line comes at the bottom of the keyboard, while on others it comes half-way up.

Letter **i** has a dash above instead of a dot; this letter can also be written using the lower-right segment instead of the lower left segment, giving an entirely different symbol when scrambled, but coming back to **i** again when unscrambled. The letter **l** can also be written on right or left, and all this helps make cipher-breaking more difficult. Letters **m** and **w** have

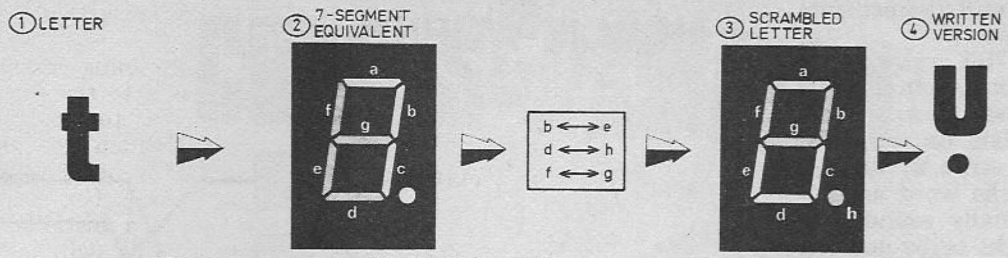


Fig. 1. The principle of the Code Scrambler.

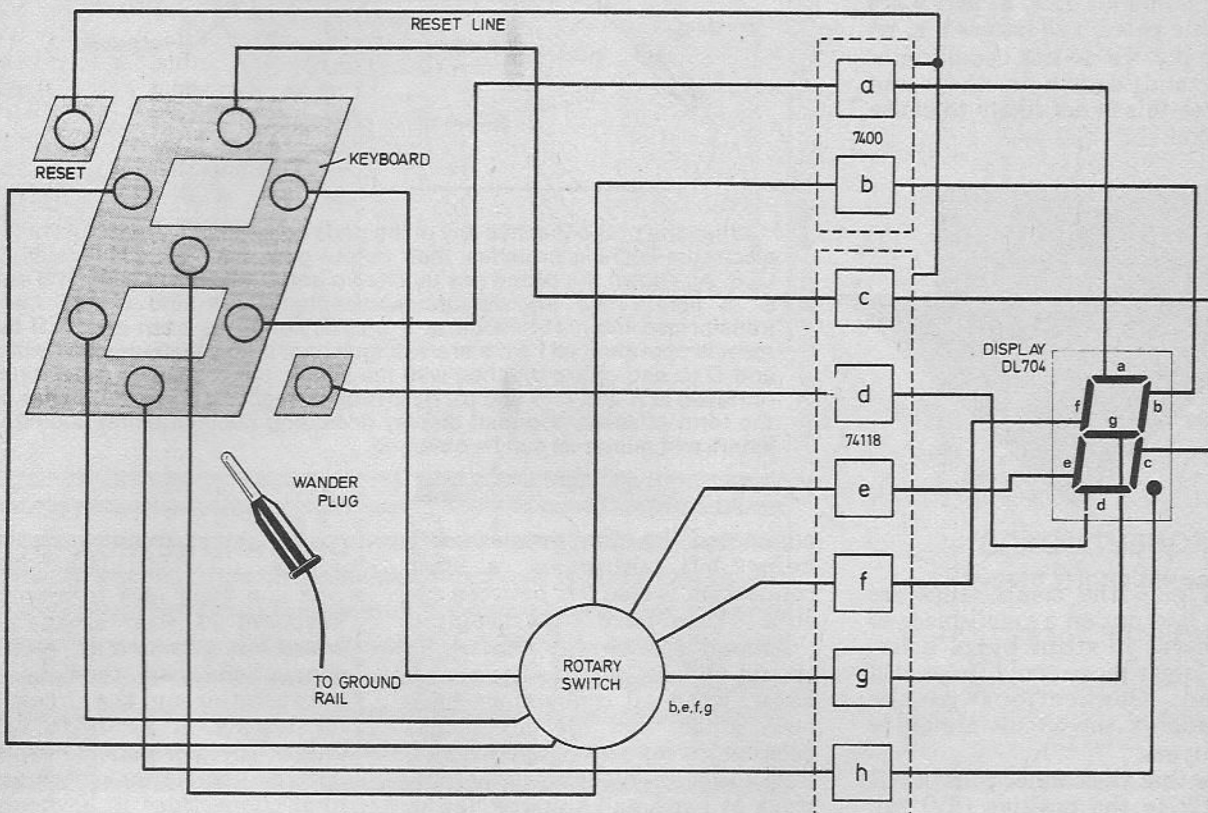
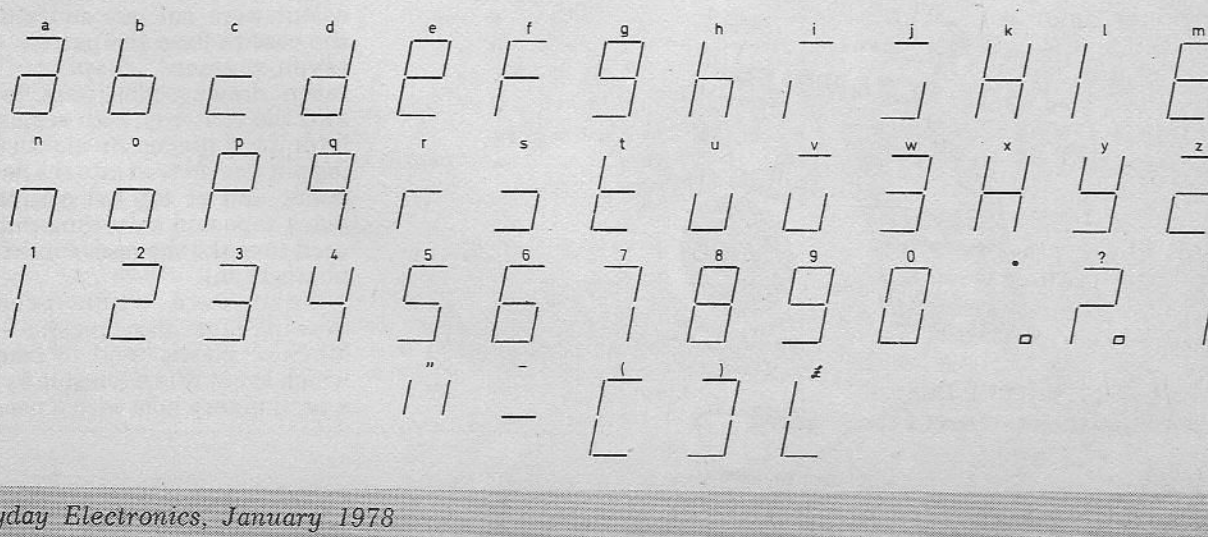


Fig. 2. The way the circuit operates.

Fig. 3 (left). Three versions of the letter "t".

Fig. 4 (below). Characters for the Code Scrambler.

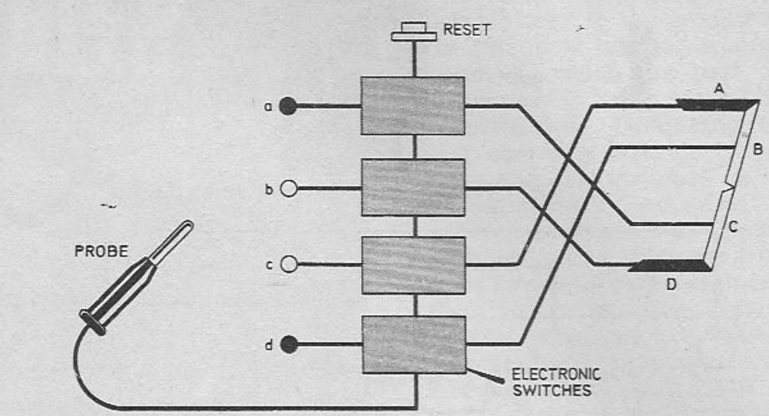


had to be turned sideways to make them fit, but are still distinct from any of the other *letters*.

Letter **k** is a bit awkward in shape, but distinct from **h.** The same pattern is used for **x**, but this gives little problem on unscrambling for, if you write **x**, when it ought to be **k**, the word as pronounced will usually sound very much like it ought to be and the correction can be made.

The numerals **1, 2, 3,** and **9** are the same pattern as letters **l, z, w,** and **g**, but we do not usually mix letters and figures in the same group so this is not likely to cause confusion

HOW IT WORKS...



When the probe touches any of the pads connected to the inputs of the electronic latching switches, their output goes high and illuminates its l.e.d. As shown the probe has touched *a* and *d* which has caused *B* and *C* to light. Thus information represented by *a* and *d* has been transformed into information at *B* and *C*, i.e. it has been coded. If the reset is operated, all l.e.d.s are extinguished. If now the equivalents of *B* and *C* (*b* and *c*) are touched with the probe, the original information is retrieved at *A* and *D* (*a* and *d*). By arranging eight l.e.d.s and switches, in the form of seven-segment display (including decimal point) coding of letters and numerals can be obtained.

START HERE FOR CONSTRUCTION

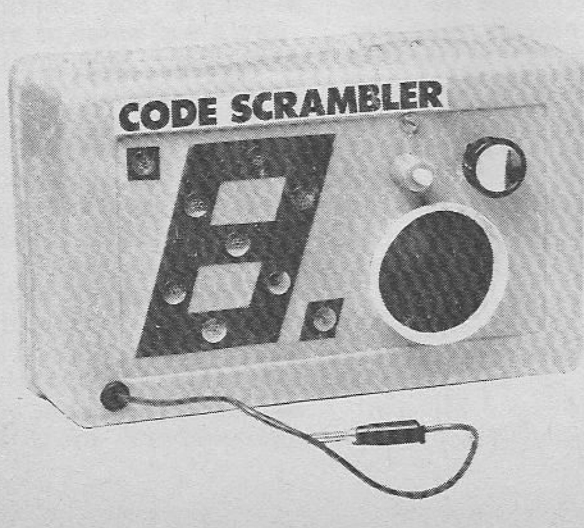
COMPONENT BOARD

In Fig. 6 the components are shown laid out on a small piece of stripboard, 10 strips by 24 holes, but a larger piece could be used if desired. Connections to the remainder of the circuit are made to Veropins.

Note that the connections of IC1 and IC2 to the positive (6V) rail and the connection of IC2 to the negative rail are made by short lengths of tinned copper wire on the topside of the board; Pins 3 and 12 and pins 6 and 9 of IC1 are connected by the copper strip being left unbroken; a strip connection is also left between pin 10 of IC2 and pin 6 of the display.

Around the display the wiring should be kept close to the board. Later, when all connections have been made, and the circuit has been tested for correct operation, a thin mask of black cardboard is stuck by two small drops of glue on the top surface of the display to hide the adjacent wiring. This card has an opening cut in it just big enough to allow the digit to be viewed.

Exterior view of the finished unit. Note the viewing window, probe and keyboard.



CASE AND KEYBOARD

It is a good idea to prepare the keyboard as soon as the circuit board is completed; temporary connections can then be made between this and the circuit board for testing. If all is in working order, the permanent supply to battery, the rotary switch and the final connections to keyboard can then be made.

The prototype was fitted into a plastic lunch-box which besides being a cheap case suited to the purpose of this project is of insulating material and makes the construction of the keyboard much more simple. Strips of plastic insulating tape in an attractive blue colour were cut out and stuck to the case to form the pattern of the seven-segment display. Then seven drawing-pins were pressed into the centre of each segment to form the contacts. An eighth drawing pin was pressed into the decimal point, and at top left a square of black tape and a drawing-pin were used to make the reset contact (see photograph).

Take care when pressing drawing-pins into plastic—some kinds of plastic tend to crack, in which event it is advisable to make a preliminary hole with a needle or

CODE SCRAMBLER

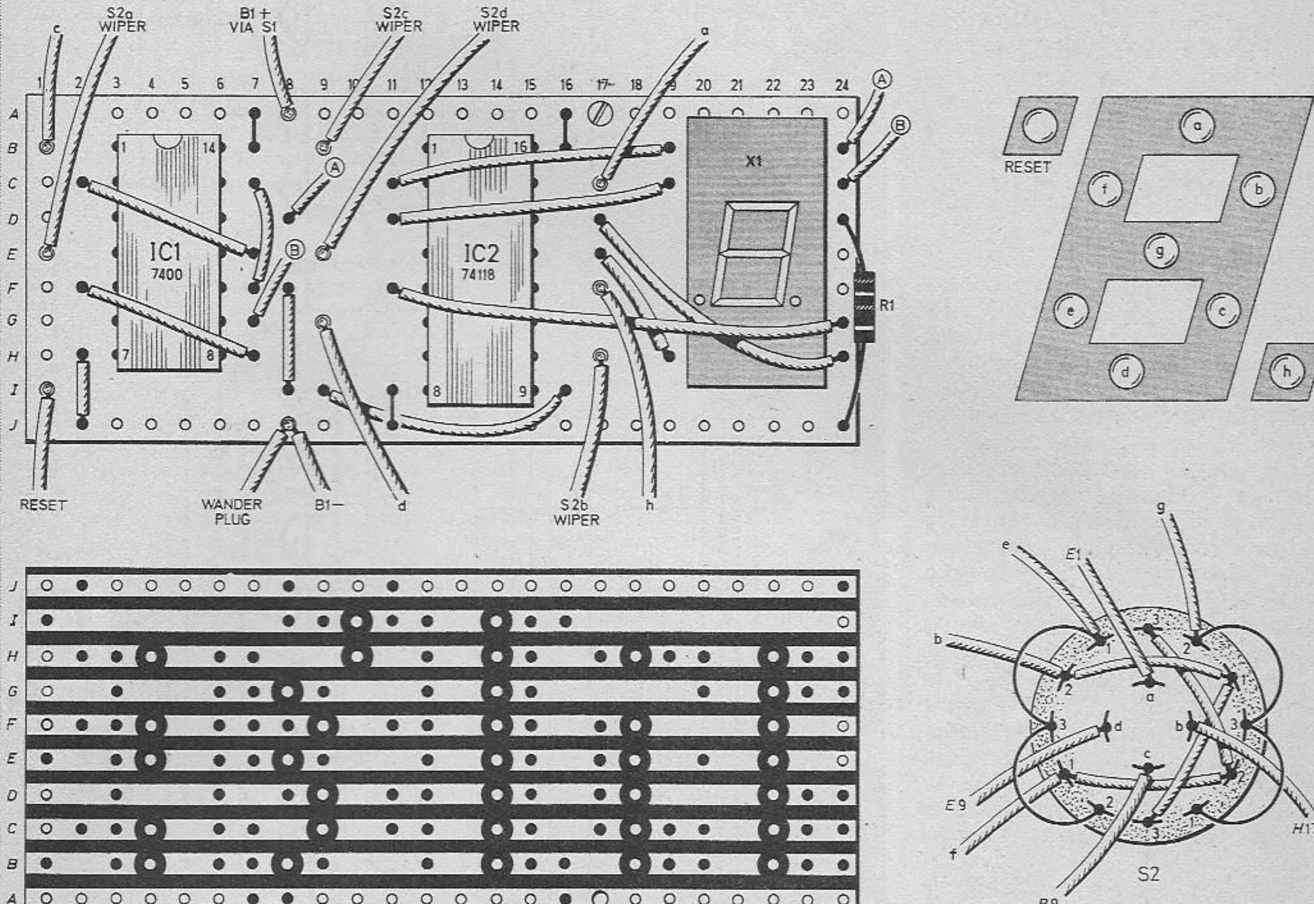


Fig. 6. Component layout and wiring of the stripboard. The breaks in the copper strips are shown above and the wiring for the switch S2 is given on the right.

COMPONENTS

Resistor
R1 270Ω ¼ watt carbon ± 10%

Semiconductors
IC1 SN7400 TTL Quad 2-input NAND gate
IC2 SN74118 TTL Hex S-R latch
X1 DL704 seven-segment l.e.d. display

Miscellaneous
S1 push-on push-off button switch
S2 4-pole 3-way rotary wave change switch
B1 6 volts HP7 1 5V (4 off)
Stripboard: 0 1 inch matrix size 10 strips × 24 holes; Veropins (11 off); battery holder for 4 × HP7's; battery connector to suit; knob; drawing pins (9 off); plastic case; connecting wire; probe (wander plug, metal rod or similar); 6BA fixings; Formica mounting plate 120 × 50mm; coloured tape; solder.

See Shop Talk Page 207

FOR GUIDANCE ONLY
ESTIMATED COST OF COMPONENTS
£4.50
excluding case

The project described in this article is the subject of a Provisional Patent.

CIRCUIT DESCRIPTION

The circuit requires only 3 active devices: the seven-segment display (DL704 or similar), and two TTL integrated circuits which are used for the bistables. Six bistables are contained within the 74118 Hextuple bistable latch, and the two other bistables are wired up from the four NAND gates of the 7400 quadruple 2-input NAND gate i.c.

The circuit diagram is shown in Fig. 5. The connections shown are those used in the prototype, but the reader is free to vary the connections between keyboard contacts and the rest of the circuit. There are 210 different ways of connecting the keyboard to the rest of the circuit, and each of these gives 3 different scrambling patterns, so the reader can copy the prototype circuit exactly or vary the connections and have a cipher that cannot be unscrambled except by his own machine or another one wired *exactly* like it.

The outputs of the bistables are connected directly to the input pins of the display. In the reset condition the output of each bistable is a low voltage, close to zero, and very little current passes to the display which remains blank.

When the input to a bistable is momentarily connected to ground by the wander-plug being touched against the appropriate contact on the keyboard, the output of that bistable immediately goes high (almost 6 volts) and stays high. A current then flows to the corresponding segment of the display, and is returned to ground through the common cathode pin (pin 12) and the current-limiting resistor R1. By touching the required contacts in turn, the corresponding bistables are made to change state, and the display pattern is built up.

After the pattern has been copied on paper, the wander-plug is touched against the reset contact. The reset inputs of the bistable are thus all grounded, and any bistables that have been triggered are now returned to their original condition. All outputs are low and the display is completely blank, ready for scrambling the next character.

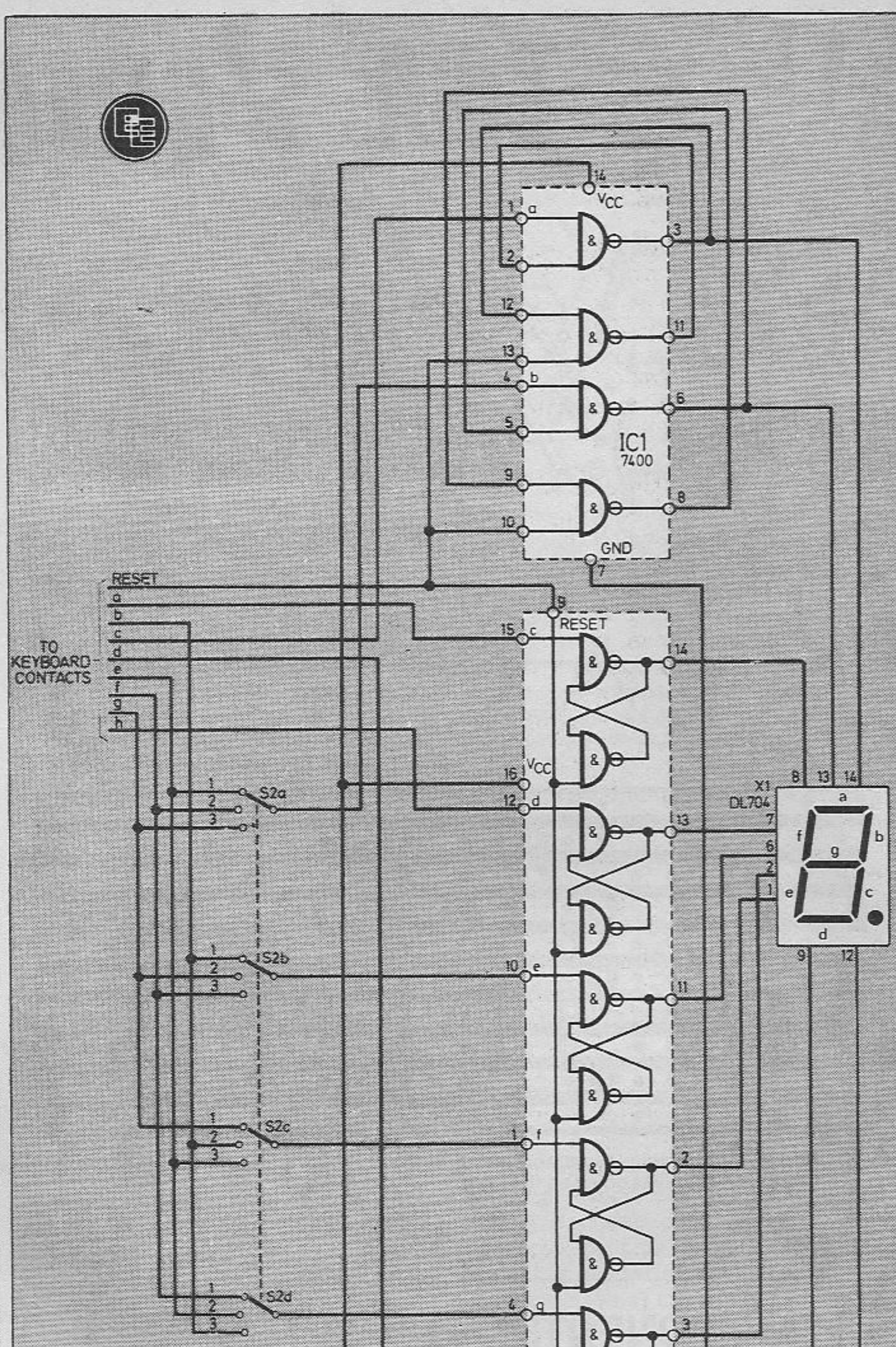
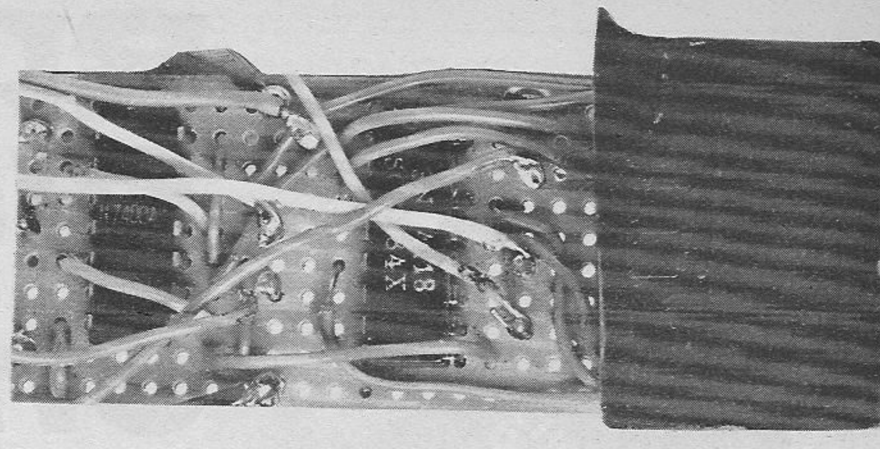


Fig. 5. Complete circuit diagram for the Code Scrambler.



The completed circuit board showing the cardboard mask.

ordinary pin before inserting the drawing-pin. The PVC box used for the prototype caused no trouble in this respect. Holes are also cut in the front panel (actually the *bottom* of the lunch-box) for the power switch S1, the rotary switch S2, the wander-plug lead, and the viewing window.

The viewing window was designed to present an attractive appearance, and also to shade the display from light to help visibility (see photo.). The cap from an aerosol fly-spray was painted matt black inside and a rectangular opening about 20 × 15mm cut in the cap.

To keep out the dust (and fingers) a piece of thin glass was fixed over the rectangular opening in the cap, using Sellotape.

The circuit board was bolted to a mounting strip of Formica held across the interior of the case on brackets bolted to the side walls. The strip was positioned so that the display came central in the hole, about 3mm from the glass. The cardboard mask on the display was large enough to prevent any of the interior "works" or wiring from being seen through the window.

Power supply was from four penlight cells contained in a battery-holder, which was retained in position in the case by bolts passing through the walls of the case. In fact, the construction of the case and the layout of the components is not at all critical, and can be suited to whatever case is available cheaply, and modified according to the ingenuity of the constructor.

TESTING

Before making connections to the board, test the operation of the flip-flops and display. Connect the battery; no segments should light. Then with a free wire connected to battery negative, touch pin *a*—segment *a* should light—and remain lit until the reset pin is touched with the free wire. It should then remain unlit. If this does not happen, the operation of the bistable (or possibly the display segment) is at fault and must be checked. Similarly, test the other bistables and display segments.

If it has been decided to copy the prototype wiring exactly, the wiring from contacts to the board and S2 can then be added as shown in Fig. 6.

Some care is needed when soldering to the drawing-pins. For one thing, excessive heat might melt the plastic case. It is wise to use a heat-sink of the kind used when soldering transistors. Attach this to each pin while it is being soldered to. The other thing to note is that drawing-pins are often corroded at the tips and do not accept solder easily. It is best to scrape the point and around the point with a file to expose the uncorroded metal. Then tin the tip by heating it with the iron and adding a little solder. After this, no difficulty should be experienced in soldering a wire wrapped firmly round near the point of the pin.

If it is decided to make a scrambler with your own personal scrambling system, make temporary connections between the contact pins and the board and S2. Choose any two pairs of contacts, and run wires from these direct to the board, interchanging the wires on the way so that if, for example, the pair are from contacts *g* and *c* the wire from *g* goes to *c* on the board and the wire from *c* goes to *g* on the board. Then choose another pair, and swap these in the same way. The remaining four contacts are wired to S2, and from the switch four wires go to the vacant four pins on the board. It's well worth while connecting the wires temporarily and then running through the alphabet to see what sort of patterns you get. We defy you to work it out on paper first!

Some systems of wiring give symbols that consist of too many disconnected segments, which are not good for making a cipher that is satisfactory to write. Play about with the wiring until you hit on something that gives reasonable symbols in all three settings of the rotary switch. Switch on at S1 and you are ready to scramble (Fig. 7). □

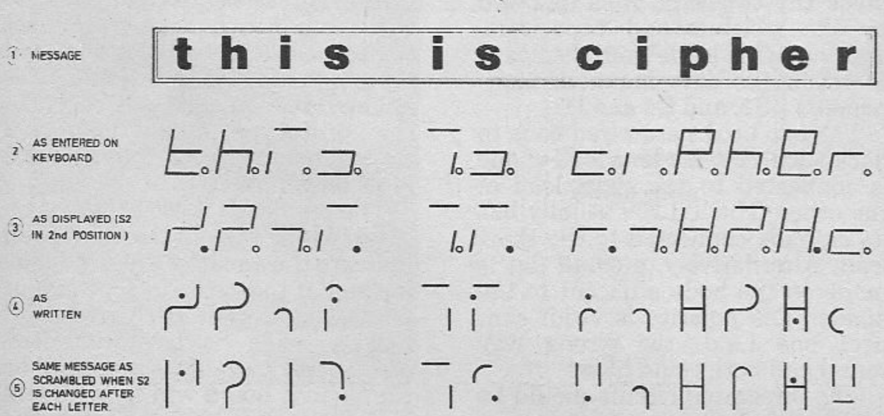
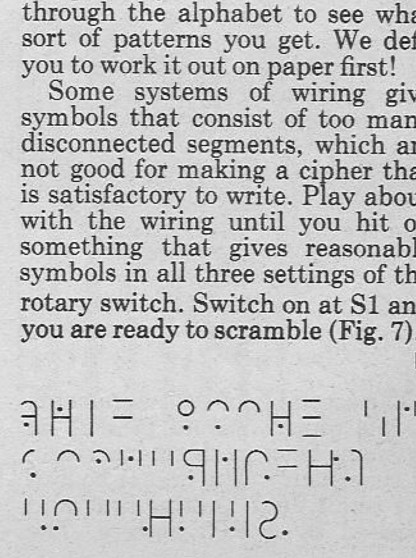
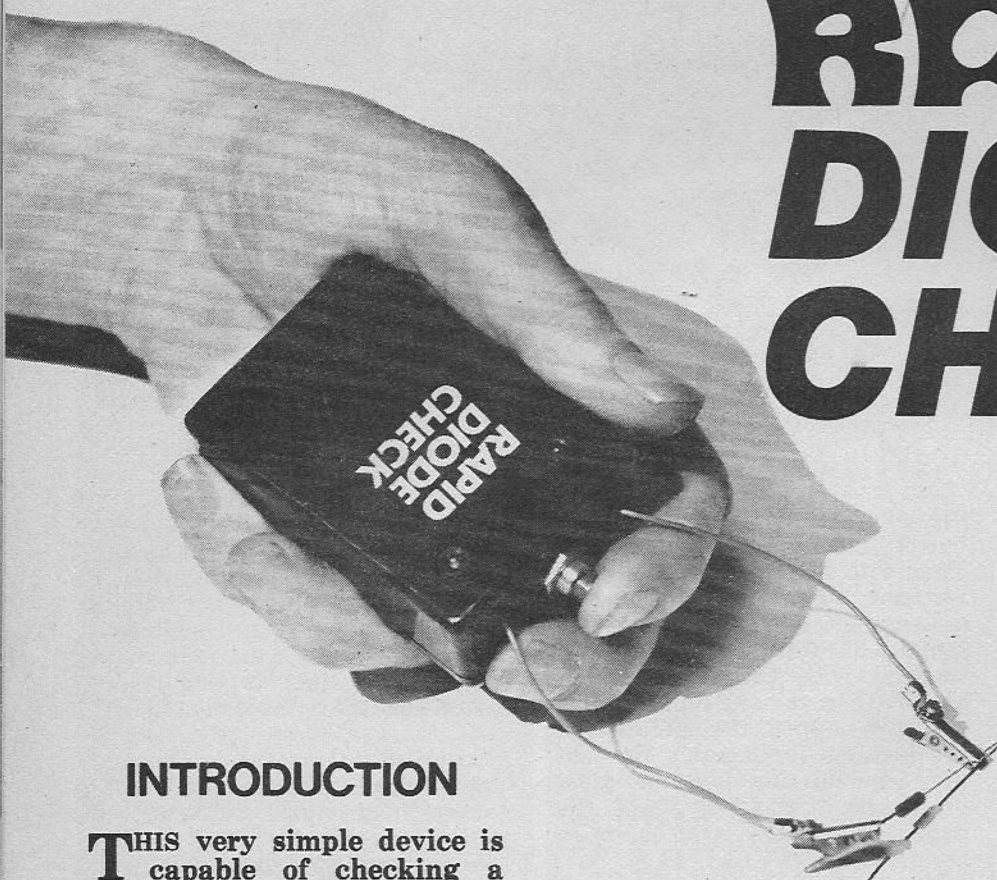


Fig. 7. Some messages in scrambled cipher. Note how the full stop at the end of the sentence is combined with the "r" to make a single symbol.





RAPID DIODE CHECK

By R. Dudley

Build this simple GO/NO-GO diode checker and test those unmarked cheap surplus devices.

INTRODUCTION

THIS very simple device is capable of checking a silicon or germanium diode for polarity in half the time required to test the same diode with a multimeter set to the ohms range. In addition to ascertaining whether a diode is in working order or not, this device also identifies the cathode lead of the component by illuminating a light emitting diode adjacent to this particular lead.

START HERE FOR CONSTRUCTION

The assembly of the components in this project should present no problems even to the inexperienced constructor. The unit is housed in a small Vero "potting box" and powered by a PP3 battery. The case should first be drilled to take the two l.e.d.s, the pushbutton and the test leads. Care is necessary here as the drill bit can easily slip and scratch the case. Ideally the holes should be started by hand with a sharp implement before drilling.

The layout of the components on the topside of the stripboard is shown in Fig. 2; begin by making the necessary breaks in the copper strips on the underside. Solder in place the two wire links followed by the resistors and capacitors, and the flying leads from the board to reach the case mounted components – S1, and D1 and D2.

The two l.e.d.s are wired back to back such that the long lead of one is connected to the short lead of the other. The TIL209 usually has its cathode connected to the short lead. Alternatively, a small flat is made on the body adjacent to the anode. The polarity is vital: connect one l.e.d. the wrong way round and both could blow!

The integrated circuit should be fitted with some care as it can be damaged by the application of high voltages due to static at its pins. It should be kept in its protective foam or foil until needed and then soldered without undue heating having checked its orientation beforehand. Also it may be a good idea to unplug the soldering iron immediately prior to soldering this component in place, to eliminate the possibility of damage from leakage currents through the iron to the mains.

Fix S1, D1 and D2 in position on the case and connect the flying leads from the component board to the components. Finally connect the test leads to the unit and feed these out via the two small holes situated one on each side of S1. In the prototype small insulated crocodile clips were found to be ideal terminals.

The test leads must be wired up as shown or the checker may well indicate the anode of the test diode instead of the cathode. The layout of the component board and battery inside the case can be seen in the photograph. So that the component board will fit it should be positioned in the case before the battery as there is only just enough room for both.

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS

£2

COMPONENTS

Resistors
R1 1MΩ
R2 220kΩ
Both $\frac{1}{8}$ watt carbon ± 10%

Capacitors
C1 10nF ceramic
C2 10nF ceramic

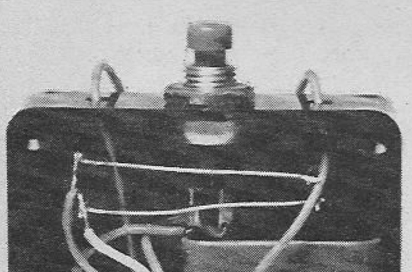
Semiconductors
IC1 CD4069BE CMOS hex-inverter
D1 TIL209 or similar light emitting diode
D2 TIL209 or similar light emitting diode

Miscellaneous
S1 push-to-make, release-to-break type switch
B1 9 volt type PP3

Stripboard: 0·1 inch matrix 7 strips × 11 holes; crocodile clips (2 off); battery clip to suit B1; case, Verobox (potting case) or similar, size 70 × 50 × 25mm or larger; connecting wire, solder.

See Shop Talk page 207

RAPID DIODE CHECK



Interior of tester showing positioning of the board, battery and test switch S1.

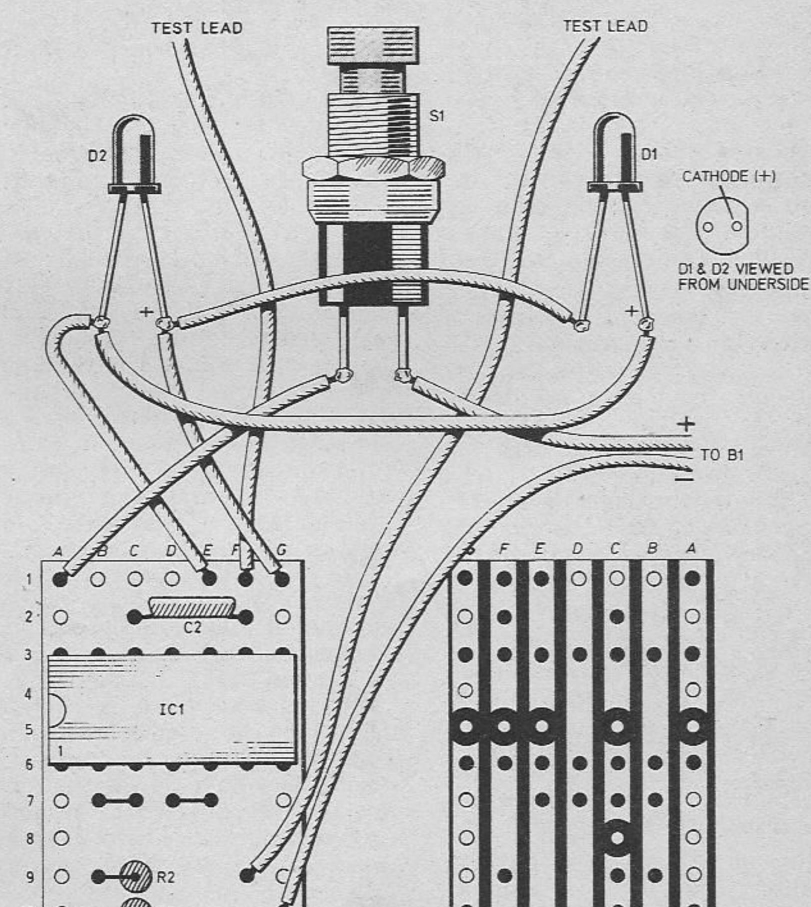


Fig. 2. Component layout and interwiring details for the Rapid Diode Check. The breaks to be made along the copper strips on the underside of the stripboard are shown on the right.

CIRCUIT DESCRIPTION

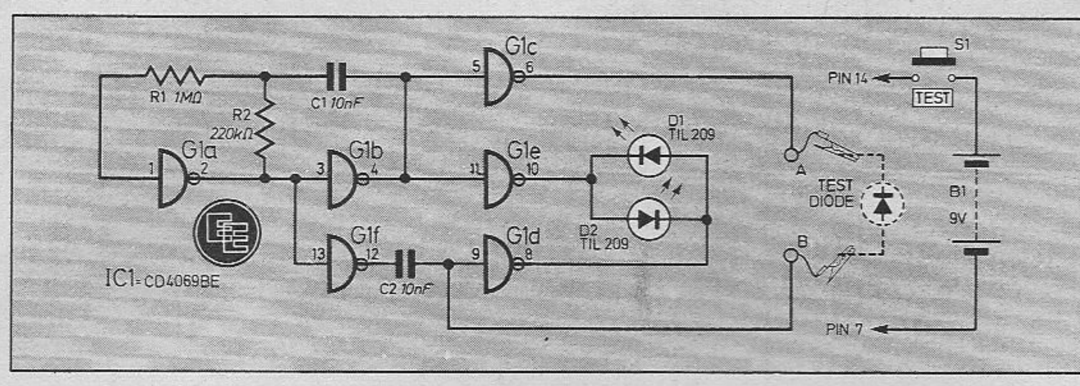


Fig. 1. The complete circuit diagram of the Rapid Diode Check.

The complete circuit diagram of the Rapid Diode Check is shown in Fig. 1. It can be seen that the whole circuit is based on a single integrated circuit IC1, a CMOS logic device. This i.c. consists of six inverters, each comprising two complementary transistors connected as a push-pull pair. Each inverter has an extremely high input impedance, of the order of thousands of megohms, and a relatively low output impedance of around 500 ohms.

The i.c. can operate from a supply voltage of between 3 and 15 volts and has very low power consumption. Hence it is ideally suited to battery operation. A supply of 9 volts was chosen as this gave good brightness to the l.e.d.s used without the need for any external series resistors as the 500 ohms output impedance limits the current available.

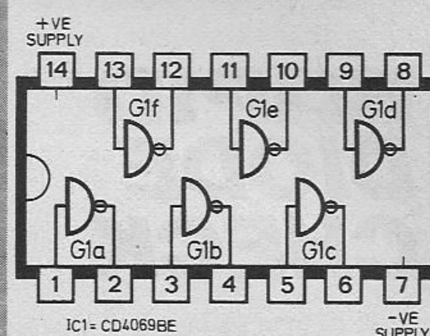
Gates G1a and G1b form a standard CMOS oscillator with R1, R2 and C1 that produces a square wave output of approximately 150 hertz. Resistor R2 together with capacitor C1 controls the frequency of the oscillator whilst R1 provides some degree of stability against falling battery voltage.

The two out of phase outputs from G1a and G1b (pins 2 and 4) are buffered with two other gates in the i.c., G1c and G1f to prevent loading of the oscillator. The outputs of these two gates (pins 6 and 12) drive the diode to be tested with an a.c. current of about 50 microamps via C2. This is insufficient to damage the most sensitive diodes. The remaining two gates G1d and G1e are available to drive the two l.e.d.s D1 and D2.

The polarity of the two test points terminals changes 300 times per second thereby alternately forward and reverse biasing the diode under test. When the diode is forward biased, the two terminals will be at virtually the same potential. Consider the state when the diode is forward biased with current flowing through the diode from terminal *A* to terminal *B*. This requires that the potential at *A* is high. Therefore the input to G1c must be low (action of an inverter) producing a high at G1e output. At the same time terminal *B* is high (only 0.6V less than *A* for a silicon diode) and so the output of G1d is low. This causes D2 to be forward biased and hence to be illuminated. Therefore the cathode is connected to *B* as indicated by D2 adjacent to *B*.

When the test diode is reversed biased then the potentials at *A* and *B* are opposite (one high and the other low) which causes the outputs of G1e and G1d to be both high or both low. Therefore both l.e.d.s are not illuminated.

A good test device will alternately become a closed then open circuit with the a.c. applied voltage and so one l.e.d. is pulsed on and off. However, this occurs so fast that the eye interprets it as being continuously lit. Modulating the intensity of the l.e.d. in this way has the added advantage that for the same brightness, significantly less power is consumed than if it were powered by direct current.

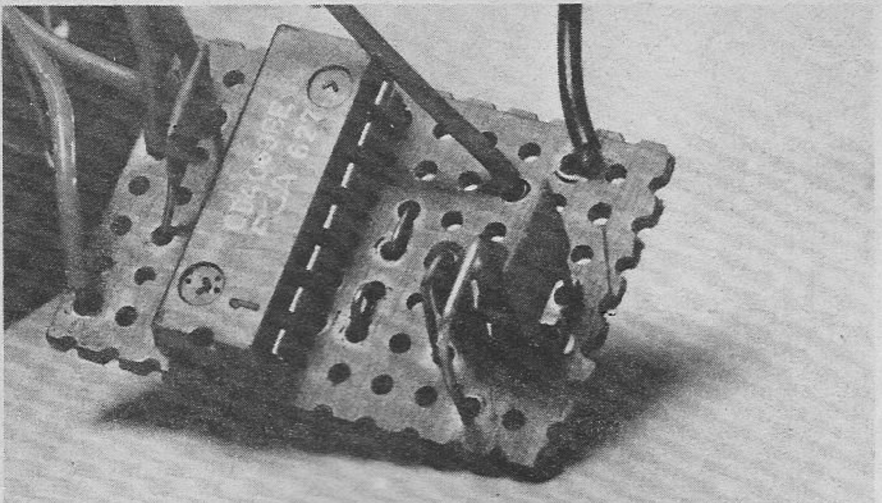


Pin configurations for the CD4069BE.

Now let's look and see what happens when a faulty diode is connected. If it is a complete short then both l.e.d.s will light up since this is the same as two diodes connected parallel opposing across the terminals which will cause both cathodes to be identified. The l.e.d.s will be flashing alternately, but so fast that they will appear to both be constantly lit.

If the diode is an open circuit then the condition mentioned earlier for a reversed biased diode will apply to both cycles of the oscillator and so neither l.e.d. will light.

This unit gives us a go/no go indication of a diodes condition as well as lead indentification of a good one.



The prototype component board. It would be wise to purchase an integrated circuit holder to save any possible damage to IC1 through soldering.

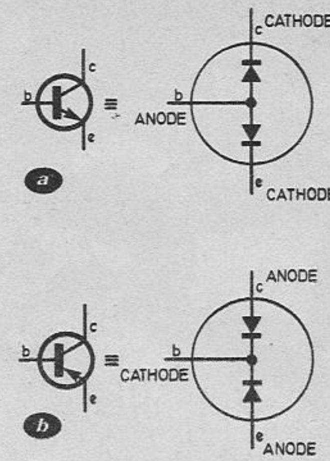


Fig. 3. Representation of transistors in terms of diodes. (a) *npn* type of transistor (b) *pnp* type.

QUICK TEST

To check that the unit functions, depress S1. The l.e.d.s should not light, indicating an open circuit. Now connect a good diode and see that the l.e.d. adjacent to the cathode is lit. Reverse the diode and the other l.e.d. should light. Both l.e.d.s should light when the probes are shorted.

IN USE

The prime use of the checker is to speed up and simplify the checking of packs of untested and unmarked diodes, which if you have the time to check them, are usually good value for money.

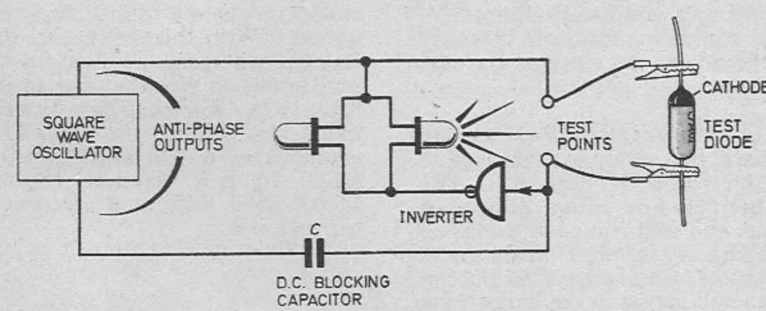
In selecting a good diode, one of the l.e.d.s should be fully on whilst the other does not glow at all. Should both glow, however dimly, the diode should be discarded. Similarly if neither glows, the diode is an open circuit.

The checker can also be used to perform a rudimentary test on a transistor. This will show up excess leakage and blown junctions but give no clue to the gain of the device.

Transistors can be thought of as two diodes in a single case, and it is these diode junctions that should be tested i.e. base/emitter and base/collector, see Fig. 3. However some small signal silicon transistors have a low base/emitter reverse voltage and so this junction may show up as a short circuit if its Zener voltage is appreciably less than 9 volts.

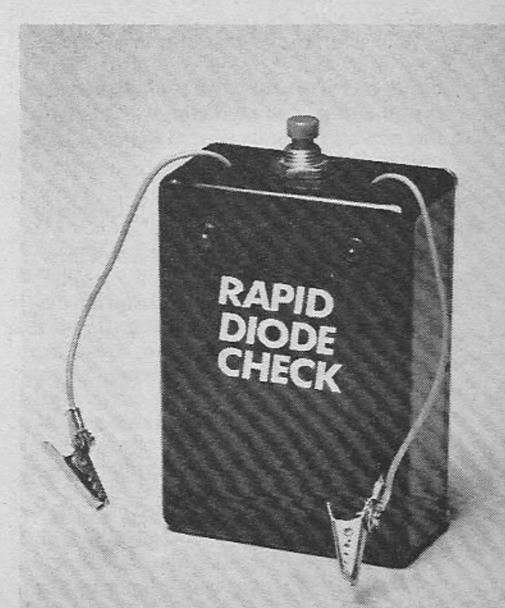
□

HOW IT WORKS...



The unit utilises the two anti-phase outputs from a square wave oscillator. One output is directly coupled to one test point while the other is via d.c. blocking capacitor *C*. Thus an a.c. current is available to pass through the test diode. Two parallel opposed connected diodes are connected at one end to one test point and at the other end via an inverter to the other test point. When the polarity of the oscillator is such that the diode is forward biased, both test points will be at approximately the same potential. The inverter action causes one of the l.e.d.s to be forward biased and light. This l.e.d. is situated along-side the cathode end.

The completed unit ready for use.



EE SPECIAL REPORT

The Electronic Workshop

A NEW ARRIVAL to our offices just recently was the *Electronic Workshop* as sold by Home Radio of Mitcham. Our particular model arrived complete, that is the power supply and necessary plugs were all pre-wired. In fact all we had to do was to wire a mains plug up and the Workshop was ready for use.

SPECIFICATION

As you can see from the general specifications the unit is supplied with its own internal power supply. This is located in the right hand compartment on the rear panel and is the black front panel seen in the photograph above. Located in the left hand compartment there is a 35 ohm speaker with its own volume control.

Between these two compartments a spacious tool box is available. One very good feature of the tool box is that it is lockable, a nice thought considering nowadays tools seem to sprout legs and walk off on their own!

On the narrow strip in front of the compartments there are a number of small holes and terminals.

Two terminals are for the speaker, the next three holes are for solder, tinned copper wire, and stranded insulated wire or other wiring to your choice. Moving along, the next two terminals are for an external aerial and earth; connection to earth and aerial can be made via sockets on the rear panel. The remaining three screw terminals are the power supply output terminals.

A rubber mat is provided for the working area, this provides a non-slip surface for constructing those projects which slide all over the place on the kitchen table.

SPECIFICATION

Overall size: 70cm x 70cm x 18cm.
Power supply: variable from 0 to 20 volts up to 1 amp.
Speaker: 35 ohm with volume control.
A generous size tool compartment is located in the centre of the back section. Two flush 13 amp sockets are also available on each side.

Two pieces of thick pine, 2.5cm high form the outer edges; in addition the upper face of these edges have slots provided for use as tool racks. The general arrangement can be seen from the photograph.

Two flush 13 amp sockets are provided for any additional equipment, such as a soldering iron, and these are to be found on the sides of the rear section.

USING THE WORKSHOP

Perhaps the greatest advantage of the *Electronic Workshop* is the portability. For most people a spacious and well equipped workshop cum laboratory is only a dream. Most constructors usually have to put up with a small corner in the living room or kitchen. This not only can cause friction between other members of the family when they are say, watching the TV but is a nuisance if the room is required for some other purpose and you have to pack up and move somewhere else.

The power supply is easy to use, a rotary control provides the necessary variation in the output voltage. The use of the speaker will be quite obvious to most people.

The *Electronic Workshop* has now been in use in our office for the past six weeks during which time we have found it most valuable in checking out the constructional projects published in EVERYDAY ELECTRONICS. In fact it could be used as the working area when conducting experiments from the *Teach In '78* series.

Perhaps the most important part of the unit is the power supply. Considering the simple nature (compared with i.c. types) the regulation is very good. On tests we carried out we loaded the output so that a current of well over 1 amp was drawn. The voltage drop at the full rated output of 20V was only 1.5V.

At lower currents the regulation was even better, the voltage did not drop at all when a current of 900mA was drawn at a voltage of 20V.

The supply thus lives up well to the specification.

One minor fault we did find was that the carrying handle was on the small size, but we are assured that a larger cut-out will appear on future models.

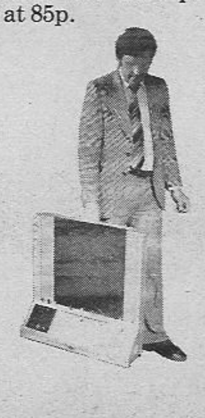
All in all the *Electronic Workshop* is a very good idea. It is surprising in fact why someone has not thought of it before. Now that Christmas is almost upon us it would make an ideal gift for someone whose interest is in electronics.

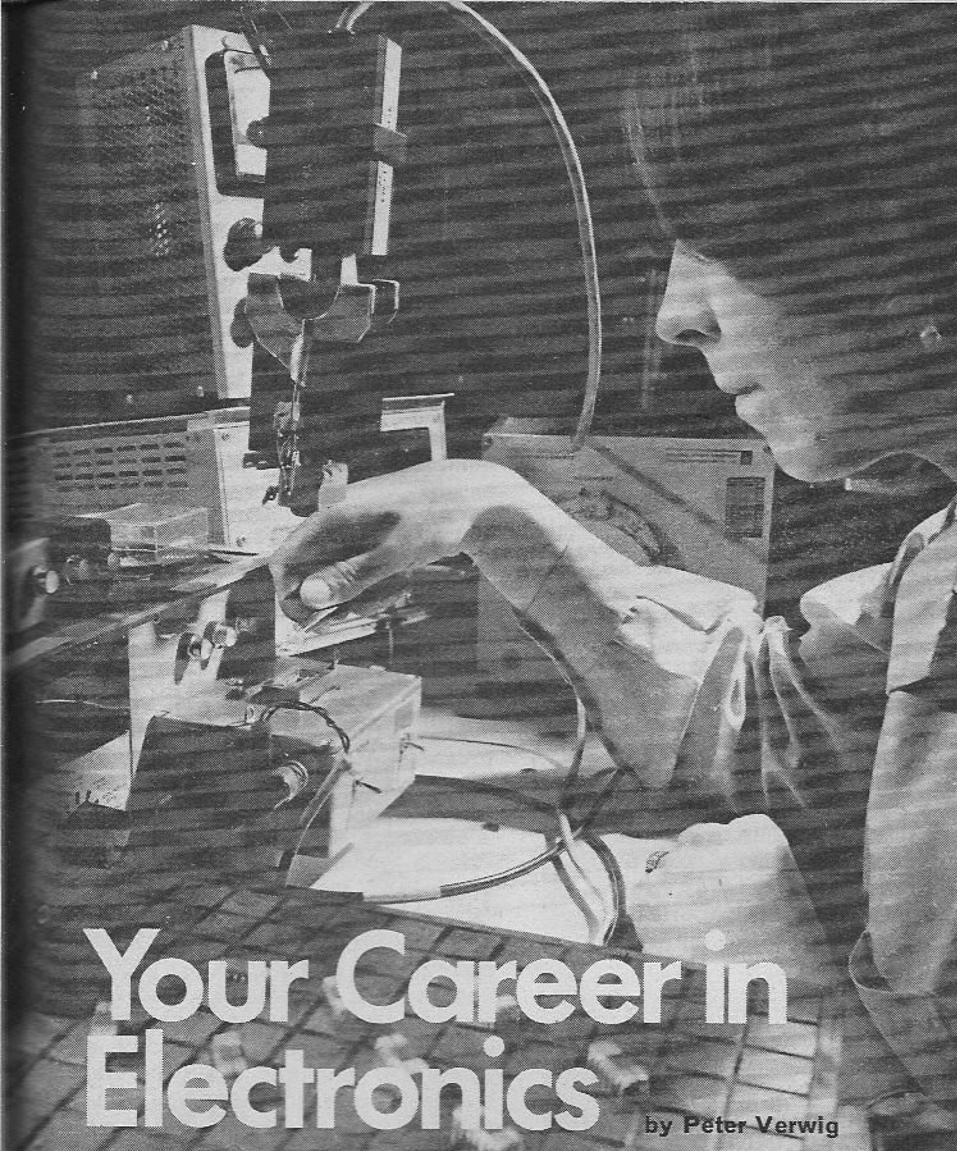
Orders for the unit should be sent to: Home Radio (Components) Ltd., Dept. EE, 240 London Road, Mitcham, Surrey. The cost is £39 for the complete unit but requires wiring up (full details supplied) or £46 complete and ready for immediate use.

An extra £2.06 must be added for VAT, and £2.50 for carriage.

HANDY VICE

A valuable piece of equipment for any workshop is a vice and a small one is particularly useful in electronics for such jobs as soldering cable to a plug or socket where a "third hand" is required. With this in mind, Home Radio have made available a small multi-position vice that can easily be fitted to the *Workshop* base by a single fixing bolt through the base. This is available at a special offer price of £4.60 to E.E. readers (normally £5.60). Add VAT at 8 per cent and carriage at 85p.





Your Career in Electronics

by Peter Verwig

This is the first of a new series of articles on careers in the electronics industry. From time to time, Peter Verwig will explain what the electronics industry is all about and the career structures which are open to young enthusiasts. – Editor.

DURING the past three years, since the first of our careers articles appeared in EVERYDAY ELECTRONICS, the electronics industry taken as a whole has prospered while other industries have stagnated or dropped behind. We have only to look at steel or shipbuilding to see how a recession in world trade can affect employment and no young person today is unaware that jobs are difficult to find. The figures for unemployment among young people speak for themselves.

The fact that electronics has relatively done so well in a period frequently described as the worst trade recession of the century emphasises its underlying strength as a growth industry. If it can do well in bad times, it will do even better when times are good. So I have no reservations in recommending electronics as a career to any readers who are willing to apply themselves to the challenge.

The key words are "career" and "challenge". To fashion a career for yourself is far more satisfying than just having a job. The challenge is in the fast-moving nature of the electronics industry which is one of perpetual change.

You need a bright and flexible mind and plenty of enthusiasm to keep abreast of technological change, not to mention the ebb and flow of world trade for the goods and services the electronics industry supplies. Here we find another key word – "world".

Electronics is a world industry with its main manufacturing centres in North America, Europe and Asia and its services penetrating the remotest areas of the globe.

MULTINATIONAL

Because electronics is a world business, nearly all the major organisations are international in character. Even those with manufacturing based in only the home country have sales offices or agents in overseas markets.

When a company or corporation has manufacturing plants in more than one country it becomes multinational. Don't let the word multinational worry you. It is fashionable to sneer at the multinationals these days because it is said that the great multinational organisations wield more power than some nation states. But without their enormous financial strength the industry could not support the level of research and development needed to sustain technological advances. Last year, for example, Britain's GEC (150,000 employees in the UK and 36,000 overseas) spent £150 million on R & D.

Without the multinational corporations many third world countries would have no electronics industry at all. Philips, the Netherlands based multinational has 400,000 employees of more than 70 different nationalities of whom only about 25 percent actually work in the Netherlands, the rest being elsewhere in Europe (including the UK) or in other continents.

At the other end of the scale there are hundreds of small and medium sized companies, many of them specialising in narrow sectors of the industry. So there is plenty of choice. Even if you work for a giant corporation it doesn't mean that you will cease to be an individual.

There are, for example, some 50 operating companies in the GEC Group, each working independently as a profit centre in its own business, but able to draw on the financial and technological strength of the Group as a whole.

Marconi with his original apparatus soon after his arrival in England in 1896. He died in 1937 and as a mark of respect every radio station in the world closed down for two minutes. (Courtesy: The Marconi Co. Ltd.)

FROM SMALL BEGINNINGS

The founder of the industry was Guglielmo Marconi, a young hobbyist, an amateur. He was only 22 when he filed the world's first patent for wireless telegraphy in 1896. Earlier experimenters and, indeed, scientists of note like Heinrich Hertz had observed and recorded the phenomenon but Marconi was the first to realise that the possibility of being able to communicate from one point to another without the use of wires was something more than a scientific novelty – properly exploited and developed, wireless communication could be of great service to mankind and also, as it turned out after years of struggle, become a gold mine.

The term electronics didn't come into general use until after the second world war. In the period from Marconi's early experiments at the turn of the century right through to the mid-30s all the developments were in the area of wireless communication, or radio as it came to be called. Broadcasting started in the 1920s and high definition television started in the late 1930s.

The 1939-45 war was a forcing ground for technology, most notably in microwave techniques and radar, but it was only after the war that the electronics industry as we know it today started its great growth. A broadening of applications came with the first fumbling attempts at building digital computers and the beginnings of the application of electronically controlled automation in industry.

What transformed the whole science of electronics and led to explosive growth was the work of Bardeen, Brattain and Schockley of Bell Telephone Laboratories in the late 1940s in developing the point contact transistor and, in 1949, Schockley's invention of the junction transistor.

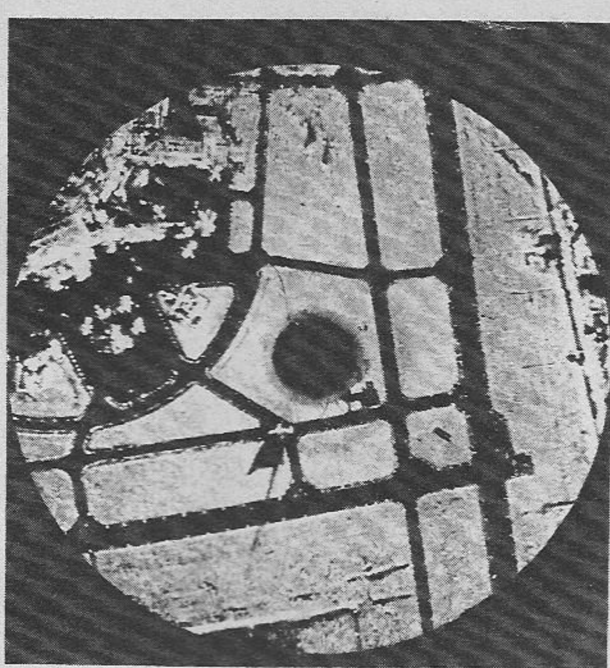
It was a few years before techniques were perfected so that transistors and later developments such as integrated circuits, large-scale integration and today's microprocessors could be produced in commercial quantities; and now the thermionic valve, except for some special applications generally involving high power, has all but been replaced by solid-state devices.

PRINTED CIRCUIT BOARDS

Another post-war development was the printed circuit. This, together with the monolithic integrated circuit has changed the whole nature of electronic equipment production. Solid state technology and the printed circuit have together substantially reduced the labour content in assembly of electronic equipment.

It is not necessary to employ armies of workers to wire up separate components with cable and soldering iron. Unskilled assemblers "stuff" the naked boards with components and the complete assembly can be soldered in one operation. And today a single LSI package may include hundreds, even thousands, of components on a single solid-state chip.

The printed circuit board revolutionised electronics assembly methods.



High-definition surface movement radar at Rome Airport built by Decca Radar. An aircraft can be clearly seen moving along the taxi-way.

SIZE OF THE INDUSTRY

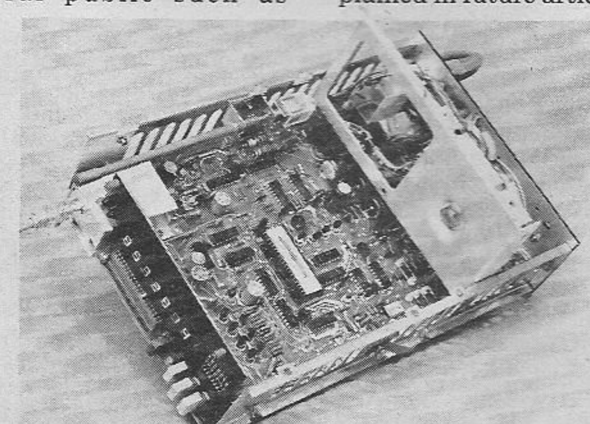
The British electrical and electronics industries today employ over 800,000 people and have a combined sales volume of over £800,000 million of which about one third is exported. Some £500 million is spent annually on R & D. I have grouped electrical and electronics sectors together because the electronics engineer is just as common in a power station today as in a broadcasting station. In fact electronics has penetrated into almost every human activity.

If we take the mainstream activity in electronics it subdivides into two main sectors, professional and consumer. The consumer sector designs and builds goods sold to the general public such as domestic radio and television, hi fi equipment, tape recorders, low-price calculators, electronic watches and clocks, TV games etc.

Although relatively few workers are required to assemble modern electronic equipment the need for engineers and technicians in R & D, testing, installation, commissioning, and maintenance is as great as ever and because of the ever-increasing complexity of the equipment they need to be of high calibre.

Ideally, to become a professional electronics engineer you should aim at acquiring a university degree but there are other channels through which equivalent qualifications can be acquired.

These will be described and explained in future articles.



A modern counter/timer instrument manufactured by Marconi Instruments Ltd. Note the l.s.i. circuit (Large Scale Integrated circuit – centre) and the 14 i.c.s, as well as numerous transistors.

The professional sector includes capital equipment such as long-range communications (including satellites), radio and t.v. broadcast transmitters and studio equipment, mobile radio for marine, police, fire service and commercial use, computers (a whole industry in itself), industrial automation, medical electronics, radar and other navigational aids, defence electronics and a fast-growing sector of security electronics.

The manufacturers of electronic equipment buy large quantities of components from other manufacturers so there is a large component sector needed to support the industry. Another large sector is in instrument manufacture, either for inclusion in equipment or for testing and servicing it.

In the UK about half of all electronics production is in the South East but the industry is slowly becoming more geographically dispersed. The East and West Midlands are prominent and so is the North West of England while Scotland has quite a concentration of manufacturers.

In activities such as radio and t.v. servicing and field servicing of professional equipment there are opportunities in practically all geographical areas.

THE FUTURE

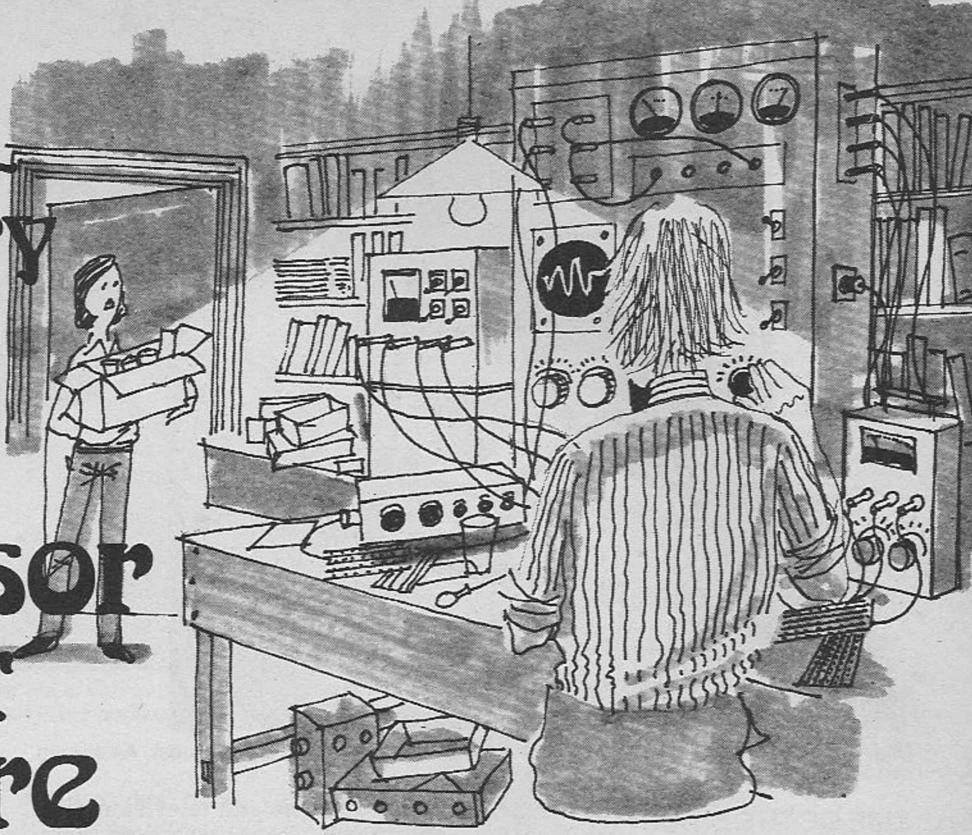
In this first article we have merely glimpsed at the electronics industry, an industry which is so young that thousands of people are around today who have seen it developing from its birth less than 80 years ago. No other industry shows more vigour or more excitement.

The brief historical outline given above shows that the biggest growth in technology and in trade has taken place in the past 40 years. Above all it is an industry of change and progress. We are now entering yet another phase of development, the age of the microprocessor with its almost unlimited possibilities.

This is just one of the great challenges which lie ahead for the engineer or technician just starting out on his *career in electronics.*

Next time we shall be looking at the various sectors of the electronics industry in a little more detail.

The Extra-ordinary Experi-ments of Professor Ernest Eversure



by Anthony John Bassett

THE PROF. has been consulted by a certain experimenter working on a magnetic line-of-force communicator. The Prof. is now explaining to Bob some of the problems this experimenter has come up against.

LINES OF FORCE

"One is that his concept of lines of force arranged neatly in a pattern around the poles of a magnet has been considerably disturbed. They are not arranged in a neat, stationary pattern but whipping around frenziedly in highly complex ways, so that each line of force in its frenzied motion scans through a particular volume of space. This has severely upset his original notion of linking point *A* to point *B* by means of a line of force, as the observer at point *B* would have to detect the line of force, as it went sweeping by rapidly, loaded with its complement of speeding magnetic quanta!

Of course, the greater the distance the greater the difficulty in detecting a particular line of force as it sweeps by. So my friend's adoption of this particular line of force theory does not appear to have helped him in his battle against the *Inverse Square Law!* But this has not discouraged him – not a bit. He has become even more fascinated by the problems, and has asked for my assistance."

"What can you do, Prof.? If there are so many of these lines of force whipping around at such high speeds, how will it be possible to distinguish the one which is supposed to link point *A* to point *B*, from all the others? Wouldn't you need a very special transducer at each point?"

"Yes indeed, Bob. I have discussed this with him and he wants me to label a bundle of lines of force which pass through the apparatus stationed at point *A*, in a distinctive way so that these particular lines may be pushed out from any others which may be incident at and around point *B*."

"How can you label a bundle of lines of force, Prof.? If they are so fine that mostly people aren't even sure they really exist, and in addition they are continually whipping around like frenzy? It sounds impossible to me. What kind of label could you tie on?"

NEW ARRIVALS

"Ah! Now regardless of whether magnetic fields really consist of lines of force or not, there are certain people who claim to be able to detect these and other fields, by means of a set of transducers which are the subject of a lot of controversy and interest. One of these people is due to visit the laboratory at any moment now. She is Lilian Whiteley, a beautiful young woman otherwise known as 'Lily the Queen of the Pendulum', and she is coming along with her friend, Dr. Angus R. Paterson whom you have already met. Now although they are the best of friends, Lily and Angus have profound professional disagreements.

"Angus as a professionally qualified doctor does not agree with Lily's methods of detection of fields, as they are not in accordance with conventional scientific theory. So do not be surprised if there are some arguments when they arrive, although I hope there will be one or two interesting practical experiments too."

Just at that very moment the door opened and two visitors appeared in the doorway. After the customary greetings between one another, Lilian presented to the Prof. a small box with an input socket, output socket and an on/off switch.

STRANGE PREAMPLIFIER

"Here is my Radiaesthetic Preamplifier, Prof., I lent it to someone, and I think that whilst he was investigating it, he looked inside it and probably damaged it in some way. Then when I tried to demonstrate it to a group of people it would not work, so that now they are highly sceptical."

"They're not the only ones!" growled Angus.

"But Prof.", she continued, "you've been so helpful in the past with my investigations, I wonder whether you could have a quick look at this preamplifier now for me, regardless of whether Angus believes that the human nervous system can detect fields, or not!"

The Prof. quickly opened the small box and examined the preamplifier. He handed it to Bob, who saw a small circuit board with a few resistors, capacitors and transistors.

"The soldering looks very rough, Prof.", Bob remarked, "just here on the leads of this transistor it does not look like ordinary solder at all!"

PLASTIC SOLDER

"I think you're right, Bob", the Prof. agreed. "It looks like plastic solder, which is a kind of glue with metallic colouring. It does not conduct electricity. Maybe Lilian's friend broke off the transistor in his investigations, and did his best to fix it again, not knowing that this 'plastic solder' would be unsuitable".

"Yes," said Lilian, "I think he wanted to see how it worked, and possibly build one for himself. If he still wants to build one I'll have to tell him to do it properly and use the correct type of solder."

"Can I fix it, Prof.?" Bob asked eagerly, "Then I'll be able to tell my friends that I've just repaired a Radiaesthetic Preamplifier, whatever that is!"

Using a craft knife Bob carefully scraped away the plastic solder, and the transistor came away from the rest of the circuit. He applied a soldering iron to the plastic solder to see what would happen, and instead of melting, it charred!

"Just as I thought!" exclaimed the Prof., as he caught a whiff of the pungent vapour from the charred plastic, "Cellulose acetate

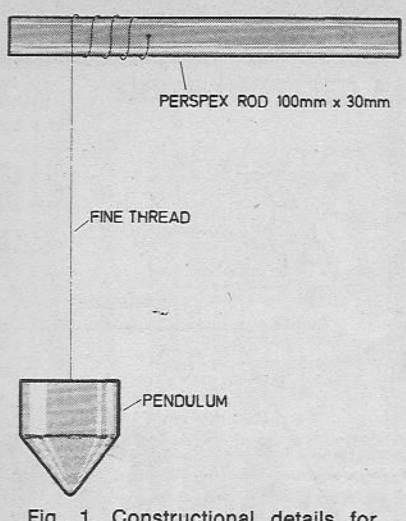


Fig. 1. Constructional details for the pendulum. Perspex is used throughout.

with a low volatility ester plasticiser! Many varieties of plastic can be quickly identified by the smell of the vapour produced by touching the plastic with a hot soldering iron! But this should be done with care, as large quantities of such vapour can be harmful to health."

Using resin-cored solder, Bob carefully replaced the transistor in the circuit. The Prof. switched it on and after checking a few of the voltages in the circuit handed it back to Lilian.

"This should be okay now," he told her, "Would you like to try it?"

Lilian plugged a jack plug into the input socket, which carried a small copper plate attached to the centre terminal. Onto this tiny copper plate she placed a small heap of white powder from a tiny jar.

PENDULUM

Next she produced a small pendulum consisting of a piece of cylindrical Perspex about 3cm diameter and about 3cm in length, the lower end of which was tapered to an obtuse point. Fig. 1. The top end was attached to about 30cm of fine strong thread; at the other end of the thread was tied a piece of plastic rod about 3mm diameter and 10cm long made by cutting a section from a plastic knitting needle.

Lilian carefully wound the thread onto the plastic rod until the pendulum had an effective length of only about 8cm and began to swing it back and forth so that the bob swung 3 or 4cm above the powder on the copper plate. The pendulum swung back and forth in a straight line, and she gradually unwound the thread, a few millimetres at a time, by rotating the plastic rod. At a certain length, the mode of oscillation of the pendulum changed abruptly and it began to gyrate, moving in a horizontal circular path instead of its previous straight swing back and forth.

Lilian kept the pendulum adjusted at this length, and plugged into the output socket of the preamplifier a length of screened cable of about 1 metre long, at the end of which was another small copper plate attached to the centre wire. Once again she began to swing the pendulum back and forth, still adjusting the length at which gyrating had previously occurred.

Now as she gradually brought the swinging pendulum over the second copper plate, it abruptly began to gyrate again, swinging in a horizontal circle, but much more strongly than it had gyrated over the input plate.

"Hooray, it's working again! Oh!, thank you, Bob, Prof., I'm so grateful!" Lilian explained with a happy smile.

"Rubbish," growled Angus, "You're deliberately swinging that pendulum in a circle instead of back and forth, and it's only because you're such a charming and beautiful young lady that you're able to get away with it."

"Ah, Tut! Tut! and Tsk Tsk Angus!" Lilian turned to Bob and the Prof. "How do I deal with this guy Angus?" she appealed "in one breath he both passes the most gorgeous compliments, and also tells me that I'm a fake!"

"Maybe it's not entirely deliberate my dear," Angus remarked, "maybe it's a subconscious psychological reaction!"

"Well we've got to settle this!" said Lilian decisively, "Prof., can I borrow a black screen and a few samples of various chemicals or specimens of various substances?"

RADIAESTHETIC PREAMPLIFIER

The Prof. gave some instructions to the experimental Robot, and in a few minutes it had rigged up an opaque black screen to separate one of the workbenches into two areas each of which was hidden from the other.

Lilian arranged her Radiaesthetic Preamplifier so that the box and the input plate were on one side of the screen, and the output was on the other side, liked by the wire which passed underneath the screen, Fig. 2.

Meanwhile the Robot returned with five jars each of which contained a different substance, and placed a small heap of each substance on separate sheets of clean paper on another workbench within reach of the output plate, but out of sight of the input plate. It now delivered the five jars with the remainder of their contents, to the other side of the black screen, adjacent to the input plate.

"Now, Bob," the Prof. explained, "as you can see, the jars are marked 1, 2, 3, 4, 5 and the papers are also marked 1, 2, 3, 4, 5 according to the substance which each carries. If you secretly tip a little heap of the substance from any of the five jars onto the copper plate which is connected to the input of the preamplifier and do not tell Lilian the number on that jar, she will be able to tell you which jar you have chosen, by referring to the sample heaps on the numbered sheets of paper, and swinging the pendulum above the copper plate which is connected to the output of the preamplifer.

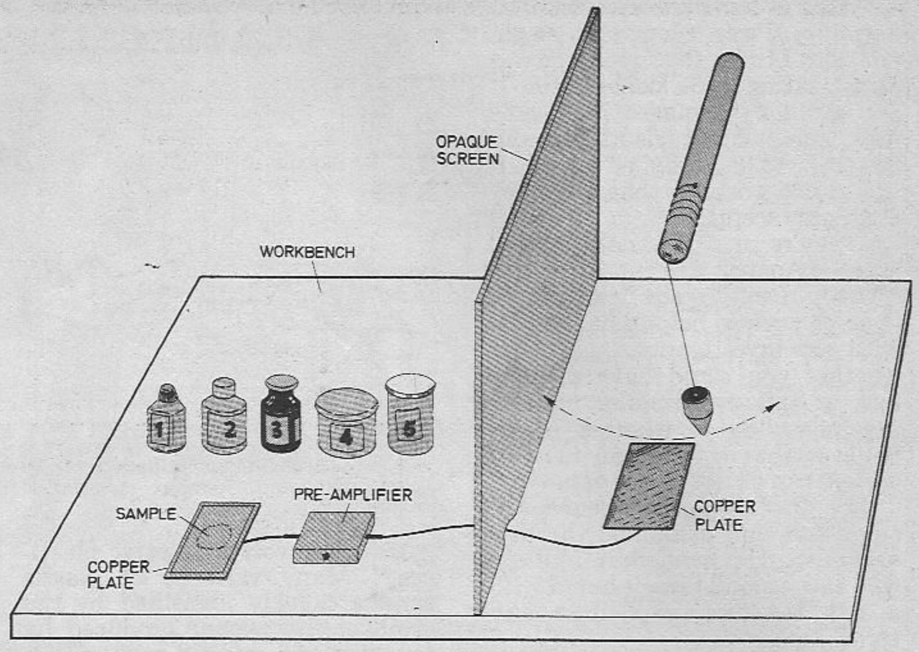
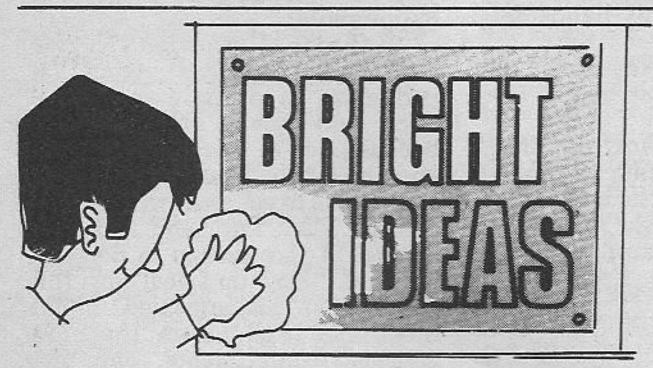


Fig. 2. The various parts of the Radiaesthetic Amplifier are positioned on any convenient surface, a workbench is ideal.

"Oh, Wow," exclaimed Bob, "how could that be possible, I don't see how that could work at all!"

To be continued



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

STORAGE BAGS

I recently tidied up my workbench and in the process thought up an efficient yet simple and cheap method of storing components.

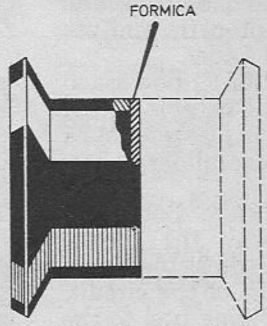
Items are put in plastic bags (4 × 6 inches are a good size), preferably of the press to seal variety, using a marker pen to identify the contents. A hole is punched through the unused plastic above the seal, and then a hook passed through this so that the bag may be attached to a length of string across and above the workbench. One length of string can easily hold dozens of bags, all readily removeable and independent of each other.

J. Fleming, London E7.

PLASTIC KNOB

When constructing any type of project on a limited budget, it is essential to keep costs to a minimum. As a consequence, I have made a very passable substitute for a control knob, two in fact, from a plastic cotton reel.

Carefully cut the cotton reel in half and then file the ends straight. Now glue an oversize piece of Formica or similar material to the cut ends and then file flush with the edge of the reel. Next the "knob" should be smoothed down and then given a couple of coats of gloss paint.



The knob can be attached to the control spindle by means of glue and packing (since the hole is slightly oversize for standard spindles). The more ambitious constructor may wish to install some type of grub screw, so that the knob can be removed when required.

J. Healy, West Midlands.

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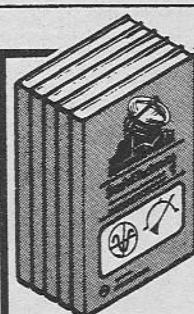

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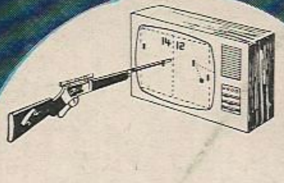

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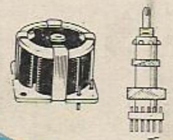

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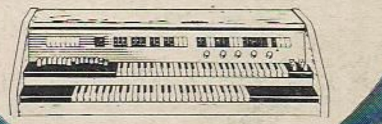

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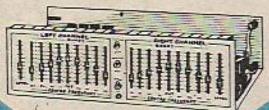

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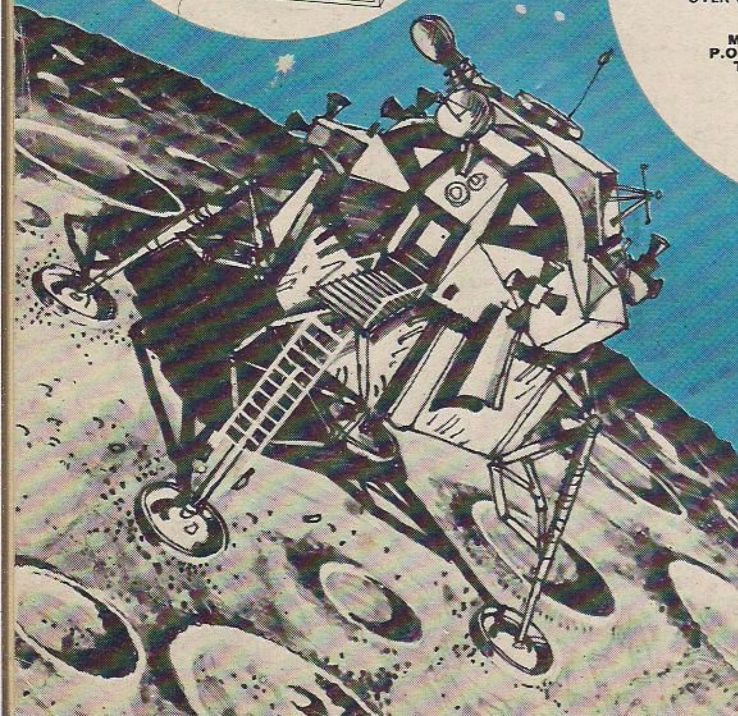

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