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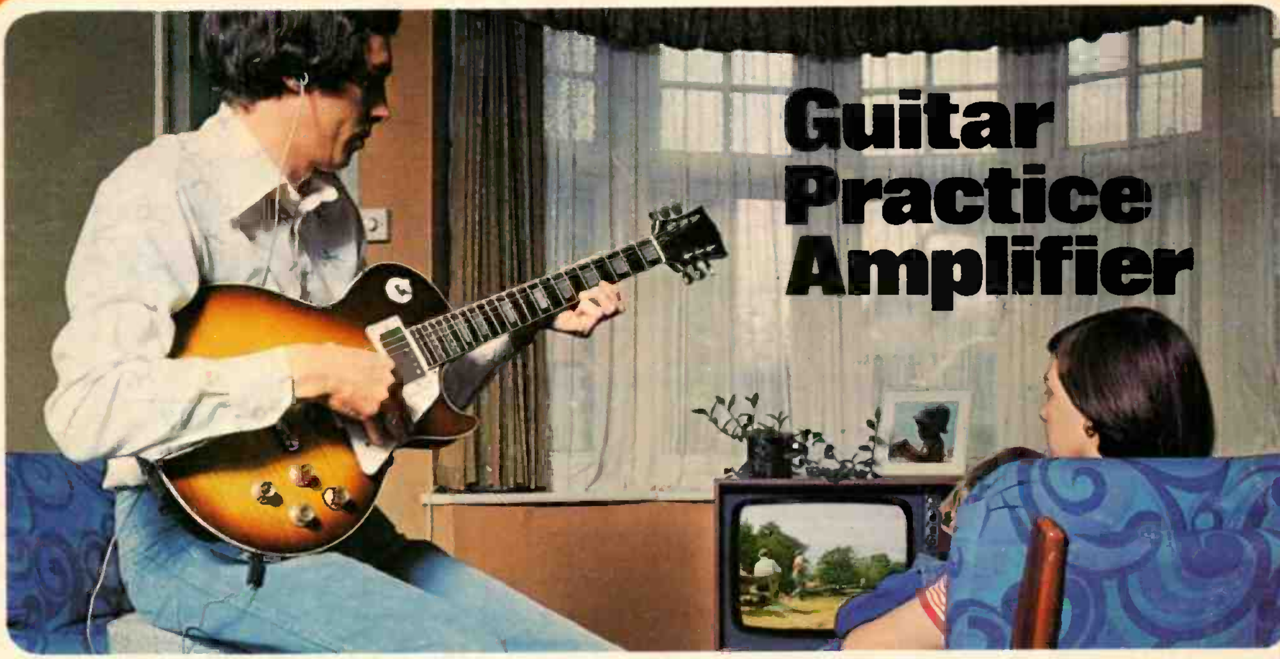
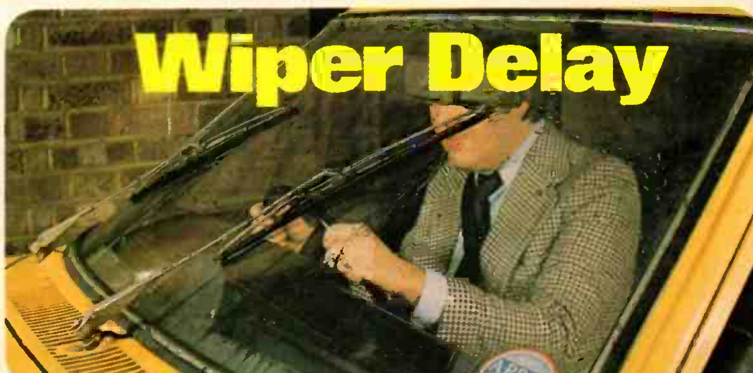


Guitar Practice Amplifier

Transistor Checker



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SS140

40 watts r.m.s. into 4 ohms using 45V supply such as SS345. Ideal for small discos and P.A. 101 × 76 × 19mm (4 × 3 × ¾in). **£3·95†**

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STIRLING SOUND policy is to ensure customer satisfaction by designing and making their products in their own factory in Essex and selling direct. Production control-checked throughout. All QV Modules are compatible within the range and with much other equipment.

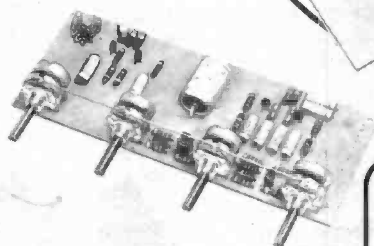
PRE-AMP AND CONTROL UNITS

UNIT ONE PRE-AMP/CONTROL

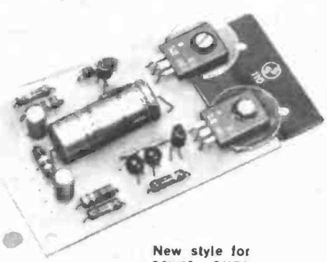
Combined pre-amp with active tone-control circuits. ±15dB at 10kHz treble and 30Hz bass. Stereo. Vol./balance/treble/bass 200mV out for 50mV in. Operates 10-16V. **£7·80**

SS100 Active tone control stereo. ±15dB on bass and on treble **£1·60**

SS101 Pre-amp for ceramic cartridges, radio, tape. Stereo. Passive tone control circuit shown in data supplied. **£1·60**



SS102 Stereo pre-amp for low output magnetic P.U.s R.I.A.A. corrected. Linear feedback facility. **£2·65**



New style for power amps SS105, SS110 and SS120

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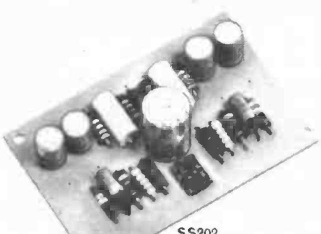
SS120 20 watts r.m.s. into 4 ohms, using 34V. Use SS324 for your power supply. **£3·00**

Modules SS105/110/120 all measure 89 × 50 × 19mm (3½ × 2⅞in). Suitable power supplies will be found in the accompanying range.



SS202 I.F. amp

FM TUNING MODULES

SS201 Front end tuner, slow geared drive, two gang A.F.C. facility. Tunes 88-108MHz. **£5·00**

SS202 I.F. amplifier. Metering and A.F.C. facilities. **£2·65**

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Appropriate technical details with all QV modules.

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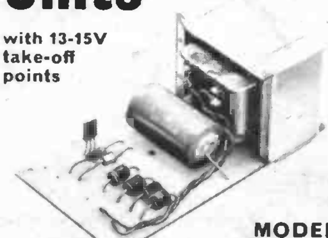
with 13-15V take-off points



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All the following are supplied assembled complete with mains transformers and low volt take-off points. Complete with mains transformers (except SS300). All at 8% VAT rate. Add 50p for p/p any model except SS300.

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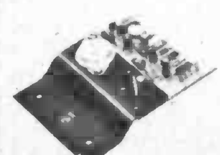
SS334	34V/2A	£5·20†
SS345	45V/2A	£6·25†
SS350	50V/2A	£6·50†

SS300 Power stabilising unit adjustable from 10V/2A to 50V/8A for adding to unstabilised supplies. With built-in protection against shorting (p/p 35p). **£3·25†**



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Complete with carrying case, test leads and battery.
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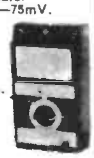

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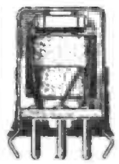

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With switched output and 4-way multi-jack connector. Type 1:3/4½/6V at 100mA £3·20. Type 2: 6/7½/9V at 150mA £3·30.
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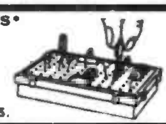

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Send sae for free leaflets on all kits. Post 30p on orders under £2·23, otherwise free. Prices include VAT. Overseas customers deduct 7% on items marked *, otherwise 11%. Official orders welcome.

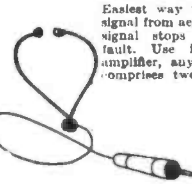
DRILL CONTROLLER

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.

MAINS TRANSISTOR PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: main transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only £1·50 VAT & Postage 50p.

RADIO STETHOSCOPE



Easiest way to fault find, traces signal from aerial to speaker, when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything. Complete kit comprises two special transistors and all parts including probe tube and crystal ear-piece, £2·95, twin stetho-set instead of earpiece. £1·00 VAT and postage incl.

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.

MOTORISED DISCO SWITCHES

With six 10 amp changeover switches. Multi adjustable switches are rated at 10 amp each so a total of 2000w's can be controlled and this would provide a magnificent display. For mains operating £4·25 post & VAT Paid. Ditto 9 switch £4·95 Post & VAT Paid. DITTO BUT 12 SWITCH £5·75 POST & VAT PAID.

AMMETERS

Ideal for chargers etc. 2" sq. full vision 8 amp 95p. 1½" *round* 2 amp 55p, 3 amp 65p. Post & VAT 25p each.

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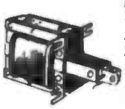

Model 772—small but powerful 1in. pull—approx. size 1½ × 1½ × 1¼in., £1·00
Model 4001/—¾in. pull. Size 2¾ × 2 × 14in. £1·50
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Prices include VAT & postage.

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

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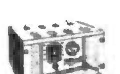
Type 600 relay with twin 500 ohm coils which may be joined in series or parallel thus relay will operate off voltages between 5 and 30 volts DC. Price 44p each, 10 for £4 post and VAT paid.

BATTERY CONDITION TESTER

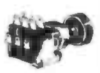
Made by Mallory but suitable for all batteries made by Ever Ready and others, most of which are zinc carbon types but also mercury manganese—nicad—silver oxide and alkaline batteries may be tested. The tester puts a dummy load on the battery and the meter scale indicates the condition depending upon which section the pointer rests. The section reads "replace" "weak" or "good". The tester is complete in its case, size 3¾" × 6¼" × 2" with leads and prod. £4·50 post & VAT paid.

BATTERY CHARGER



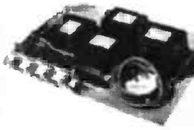
Famous Atlas in metal cas with meter, output lead terminated by crocodile clips. For 6 or 12V charging simply by changing plug on front panel. Ready built new and still £2·95 plus £1 Post & VAT

HONEYWELL PUSH BUTTON PANEL MOUNTING MICRO SWITCH



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

MULLARD UNILEX

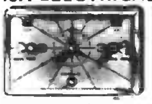


A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost any one in easy-to-assemble modular form and complete with a pair of Celestion speakers normally £8. This should sell at about £30—but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only £17 including VAT and postage.

TANGENTIAL HEATER UNIT

This heater unit is most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. Comprises motor, impeller. 2kW element and 1kW element allowing switching 1, 2 and 3kW and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only needs control switch. £5·83 plus VAT & post £1. 2kW Model as above £4·25 plus VAT & post 75p. Don't miss this. Control Switch 44p. P. & P. 40p.

ISA ELECTRICAL PROGRAMMER



Learn in your sleep; Have radio playing and kettle boiling as you wake—switch on lights to ward off intruders—have a warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp. on/off switch. Switch-on time can be set anywhere to stay on up to 6 hours. Independent 60 minute memory jogger. A beautiful unit. Price £2·95, VAT & Postage 60p, or with glass front, chrome bezel, £1·50 extra.

ROOM THERMOSTAT

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

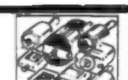
SMITHS CENTRAL HEATING CONTROLLER

Price £7·50 including VAT and postage.

RANDALL CENTRAL HEATING CONTROLLER

Price £6·50 including VAT and postage.

8 POWERFUL BATTERY MOTORS



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

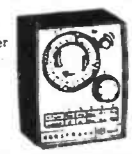
ROTARY PUMP

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, fertilizer, chemicals, anything liquid. Hose connectors each end. £2·00 Post Paid.

MAINS RELAYS

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.

HORSTMANN 24-HOUR TIME SWITCH



With 6 position programmer. When fitted to hot water systems this could programme as follows:

Programme	Hot Water	Central Heating
0	Off	Off
1	Twice Daily	Off
2	All Day	Off
3	Twice Daily	Twice Daily
4	All Day	All Day
5	Continuously	Continuously

Suitable, of course, to programme other than central heating and hot water, for instance, programme upstairs and downstairs electric heating or heating and cooling or taped music and radio. In fact, there is no limit to the versatility of this Programmer. Mains operated. Size 3in × 3in × 2in deep. Price £5·50. 80p Post and VAT. as illustrated but less case

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, 31, 29 metre bands. Kit contains chassis front panel and all the parts £1·90—crystal earphone 55p including VAT and postage.

PAPST MOTOR

West German make, these fine motors are noted for their performance and reliability. Special features are the rotating heavy outer which acts as a flywheel to eliminate wow and flutter and switchable reversing.
We have four types in stock, all 1350 revs., including starting capacitor.
(1) Reference No. KLZ 20.50-4, 230 volts 50HZ, price £5·50
(2) Reference No. KLZ 32.50-4, 230 volts 50HZ, price £6·50
(3) Reference same as above, 115 volts 50HZ, price £2·50
(4) Reference same as above, 110 volts 60Hz, price £2·50
Post and VAT 80p each extra.

CENTRIFUGAL BLOWER

Miniature mains driven blower centrifugal type blower unit by Woods. Powerful but specially built for quick running—driven by cushioned induction motor with specially built low noise bearings. Overall size 4½" × 4½" × 4". When mounted by flange, air is blown into the equipment, but to suck it out, mount from centre using clamp. Ideal for cooling electrical equipment or fitting into a cooker hood, film drying, cabinet or for removing flux smoke when soldering, etc. etc. A real bargain at £3·30. 60p post & VAT.

TERMS: Where order is under £6 please add 50p surcharge to offset packing expenses

J. BULL (ELECTRICAL) LTD.

(Dept. E.E.), 103 TAMWORTH ROAD, CROYDON CR9 1SG.

ITS 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—its an interesting list and its free—just send S.A.E. Below are a few of the Bargains still available from previous lists.

ARE WE GOING TO HAVE A HARD WINTER? We have already had some cold spells and by the law of averages a cold winter is due, so we take this opportunity to give you brief details of the heater and elements which we have available.

Tubular Heaters, 12ft. 720 watts nominal loading made by G.E.C., ideal for greenhouses, store sheds and other places where a low level of heating spread over a long distance is required. These are green enamelled tubes 3" dia. approx. The element runs right through them and the loading is 60w per ft. They keep just hot enough not to burn you if you touch them, similarly they will not scorch paper or rag so are not a fire risk even though curtains, etc., may touch. They are supplied complete with mounting brackets. Price £5·50 + 44p each. Carriage £2·50 + 20p each.

Heating Rods, contour following, mineral filled, metal clad, very pliable. 2000w approx. at 240v. Total element length 6ft., supplied in the form of a double U, but this is completely mouldable and may be straightened or bent to fit almost any shape. Ideal to fit into box to make a convector, to replace the element in an old convector, or to wrap around a pipe or cylinder or hang over the side into a tank, and generally to fit into places where straight elements will not go. Bend it as you put it in. Price £1·65 + 13p. Post 75p + 6p.

Ditto, but 1KW, 4ft. long. Price £1·65 + 13p. Post 50p + 4p.

Metal Clad Element, 1250w, 4ft. long but bent into 'U' shape. Ideal for convector or back heat radiator. £1·50 + 12p. Post 75p + 6p.

80w Tubular Elements, brass-encased with beaded flex ends. Standard replacement in most absorption type refrigerators, but also dozens of other uses. Price 85p + 7p. Post 20p + 2p.

1000w heat and light tube (Mullard) with special holder and terry clips for securing tube. Internally mirrored. Suitable for spit cooking or for general use or also useful under benches to prevent cold feet and legs. Price £3·30 + 26p. Post £1 + 8p.

1000w Fire Spiral, replacement in many fires. Also useful for dozens of other applications where Nichrome resistance wire is required. 35p + 3p. Post 10p + 1p.

750w Flat Element, made for Hotpoint Safety Kettle, this measures 5" long, 2½" wide and is about ⅛" thick—very useful for contact heating. Price 50p + 4p. Post 10p + 1p.

4 × 1KW Element Bank, a versatile bank of heaters. Relatively simple switching gives 8 heat outputs ranging from 250w to 4000w. The 4 × 1KW elements are welded through a 3" square iron plate. The heat part is a mineral filled nickel alloy clad loop which extends 17" from the plate. Contact is made by standard push on tag. Price £2·20 + 18p. Post £1 + 8p.

Replacement Elements, this is the old type 1KW spiral wire in clay refractory, bowed and size approx. 11" long and 3" wide. Standard replacement in many old type radiant heat fires. Price £1·25 + 16p. Post 40p + 3p.

400w Wire spirals in clay refractories, held in metal jacket, overall size 18" × k¾". Probably a replacement for some old type Jackson cookers. Price £1·25 + 16p. Post 40p + 3p.

Flexible heat; you have probably from time to time wanted to warm something by actually winding the heater around it. You can do this now for we have in stock flexible elements comprising glassfibre tape approx. ½" wide, approx. 1/16" thick, 15ft. long. The element is embedded into this, and fully insulated from the outside. The ends can be taken directly into a 13 amp plug or plastic junction box which we can supply at 30p + 2p extra. These are rated at 100 watts but you can reduce this if you wish by joining two in series. Price of element is £1·30 + 10p. Post 35p + 3p.

Cooker Elements, believe originally for the Baby Belling cooker—size approx. 10" × 8" 'M' shaped. 1350w. 230-240v. Price 90p + 7p. Post 40p + 3p.

Cooker Rings, radiant type as fitted to Tricity and similar cookers. 2000w. Ring size 6¾". Price £1·85 + 15p. Post 40p + 3p.

Waterproof heating element. This is blanket wire but other uses include, winding round water pipes to prevent freezing, under seed boxes to assist germination, in gloves or boots to help keep warm—13 yd. length gives approx. 30 watts at 230v., has self-regulating temperature control. Price 75p + 6p. Post 10p + 1p.

AM/FM Tuner with scale slow motion drive and pointer, Japanese made, six transistor, AM frequency 530-1600 KHZ, size approximately 5" × 3" for 12 volt operation. Price £10·25 + £1·25. Post 40p.

FM Tuner with nice clear scale and pointer, 8M drive six transistor 12 volt operation. Price £8 + £1. Post 40p.

Decoder designed for use with FM tuner but also effective with most other tuners, six transistor 12 volts, price £8·50 + £1. Post 40p unless ordered with the above tuner.

Equaliser for amplifying the output of magnetic cartridges tape heads, low output microphones, etc. gives 2·5v output with 30 mv input. Price £2 + 25p.

Stereo Equaliser similar to the above but with two separate inputs and outputs. Price £4·50 + 56p.

SMALL ADS

The prepaid rate for classified advertisements is 14 pence per word (minimum 12 words), box number 40p extra. Semi-display setting £9.00 per single column inch (2.5cm). All cheques, postal orders, etc., to be made payable to Everyday Electronics and crossed "Lloyds Bank Ltd." Treasury notes should always be sent registered post. Advertisements, together with remittance, should be sent to the Classified Advertisement Manager, Everyday Electronics, Room 2337, IPC Magazines Limited, King's Reach Tower, Stamford St., London, SE1 9LS. (Telephone 01-261 5918).

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Perhaps we can help you turn that old wish into reality

As all electronics constructors know, one of the secrets of happiness is to spend leisure time on work that is both interesting and constructive. Unfortunately, one's enjoyment of the hobby is soon spoilt if you can't obtain the right components. That's where Home Radio Components come in, and if you're a regular reader of these advertisements you'll know exactly what we three 'typical customers' recommend. Here it is—the first step is to invest in a Home Radio Components catalogue. This will enable you to locate quickly and easily the parts you need for the project you have in mind. Then, to buy the components you have a choice of three methods. 1, You can visit Home Radio's shop in Mitcham, above Tesco's almost opposite Mitcham Baths. 2, You can send a cheque or P.O. for the items you need, in the normal Mail Order way. 3, You can join Home Radio's Credit Scheme and settle your account monthly. Full details of this popular scheme are given in the catalogue.

Whichever method you use, you will enjoy the prompt, personal service Home Radio Components always strive to give. So, back to the first step, send off the coupon with £1·40 for your copy of the catalogue—it's a superb production!

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10/16	4p*		
10/25	5p*		
10/35	6p*		
10/64	6p*		
20/70	5p*		
22/6V3	5p*		
22/16	6p*		
25/25	6p*		
33/50	8p*		
47/6V3	5p*		
47/10	5p*		
47/16	5p*		
47/25	6p*		
50/10	5p*		
50/15	5p*		
100/18	6p*		
100/25	6p*		
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BC154	18p*	OA 47	14p	2926G	15p*	ZN414	1·60*

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Post & Packing 25p per order. VAT please add to total * 12½%, rest 8%.

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This kit contains all that the constructor will need to etch the circuits of his own design.
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Anhydrous ferric chloride in double sealed one pound Poly packs.
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Handy boxes for construction projects. Moulded extrusion rails for P.C. or chassis panels. Fitted with 1mm front panels.
1005 = 105mm × 73mm × 45mm = 60p
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"C100" 100 WATT AMPLIFIER

All built and tested, mounted on a plain aluminium chassis which measures 18" x 9½" x 4" and which you can mount into a cabinet of your choice.
Four Controlled Inputs, Master Volume, Treble, Middle and Bass Controls. S/C protected output. 100 watts Clean into 8ohm L/S. Ideal for Disco, Music Groups. PA and Clubs.
A Bargain at £42 + £1 carr. + 8% VAT.

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Ideal tester for everybody interested in electronics. Weighing less than 100 grammes and only 60mm x 24mm x 90mm.
Ranges: AC volts: 0·10v, 50v, 250v, 1,000v. DC volts: 0-10v, 50v, 250v, 1,000v. DC current: 0-1m/a, 0-100m/a. Resistance: 0-150K ohm.
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3 K'WATTS PSYCHEDELIC LIGHT CONTROL UNIT

Three Channel Bass, Middle, Treble. Each channel has its own sensitivity control. Just connect the input of this unit to the loudspeaker terminals of an amplifier and connect three 250V up to 1000W lamps to the output terminals of the unit, and you produce a fascinating sound-light display. (All guaranteed). £18·50 plus 75p P. & P. + 8%

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2½" 80 ohm 90p
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A plastic box with moulded extrusion rails for PC or Chassis panels with metal front plate fitted with four screws (all supplied).
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GARRARD 9V DC MINIATURE MOTORS, Type 31BM, 3200 RPM governed, size approx. 1¼in. dia. x 1¼in. high, with 2mm spindle. Brand New. **60p each or 2 for £1.**

SILICON HIGH VOLTAGE RECTIFIER STICKS, BY185 (new) 35kV 2·5mA **£1 each**, BY140 (ex-equip) 12kV 2·5mA **45p** each.

VARIABLE STABILISED POWER SUPPLY, mains input, 0–24V output, stabilised and current limiting at 500mA + 32V at 50mA. Brand new by British manufacturer. Size approx. 7½ x 2½ x 4in. complete with external 5kΩ 3-turn pot for voltage control. Connection data supplied. **£7.**

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2N3055 type Transistors. O.K., but unmarked, 5 for **£1.**

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SLOW MOTION MOTORS (suitable for programmers, displays, etc.) 230–240V a.c. input, rotation, 1 rev. every two to three minutes, **£1·25** each.

MINIATURE PLIERS. High quality "Crescent", made in USA. **£4·35 +VAT (35p).**

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

4MHz XTAL PACKS (10 assorted xtals between 4MHz and 5MHz), our selection only. **£1** Pack.

PROGRAMMERS (magnetic devices). Contain 9 microswitches (suitable for mains operation) with 9 rotating cams, all individually adjustable. Ideal for switching disco lights, displays, etc., or industrial machine programming. (Need slow motion motor to drive cams, not supplied.) 9 switch version **£1·50.**

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SPERRY 7-SEGMENT P.G.D. DISPLAYS, digit height 0·3in. red, with decimal points, 150V to 200V (nominal 180V) operation. These are high-volt industrial type and therefore brighter than normal displays. All brand new. AT THE BARGAIN PRICE OF **50p** PER DIGIT. TYPE 332 (two digits in one mount) **£1** each. (Sorry, no single digit available.) Data supplied.

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BC148 NPN SILICON, 4 for 50p.
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SMALL MAINS SUPPRESSORS (small chokes, ideal for radio, Hi-Fi inputs, etc.), approx. ½in. x 1½in., 3 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. x 1½in., 2 for **35p.**

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HEAVY DUTY RELAYS, 24V d.c. operated (will work on 18V) 3 heavy duty make contacts (around 10A rating) + 4 change over contacts + 1 break contact. New, complete with mounting bracket. (Ideal for switching HT on Linears.) Many uses for this high quality unit. **£1·50** each.

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

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Miniature earphones with min. jack plug, 2 for **50p** + 12½% VAT.

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TWIN I.F. CANS, approx. 1in. x ½in. x 1in. high, around 3·5–5MHz, 2 separate transformers in 1 can, internally screened. 5 for **50p + 12½% VAT.**

Dubilier Electrolytics, 50μF, 450V, 2 for **50p.**
Dubilier Electrolytics, 100μF, 275V, 2 for **50p.**
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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.
Plessey Electrolytics, 10,000μF at 63V, **75p** each.
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PLEASE ADD 12½% VAT TO ALL CAPACITORS.

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Plugs and sockets sold separately at **25p** each.

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EXPERT. Built-in-spotlight illuminates work. Pistol grip with fingertip trigger. High efficiency copper soldering tip.
EXPERT SOLDER GUN. £6·80 + VAT (54p).
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SP15D 15W **£3 + VAT (24p).**
SP25D 25W **£3 + VAT (24p).**
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Temperature controlled iron and PSU. **£20 + VAT (£1·60).**
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MOST SPARES AVAILABLE.

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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 SATURDAYS ONLY 9.30–12.00, 1.30–5.00.*

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PROJECTS... THEORY....

DOMESTIC AFFAIRS

Odd though it may seem, we want to start this month rather out of character for a technical magazine and talk about an important human problem. The subject is harmony in the home: a constantly occurring problem where accommodation is limited, as many will be bound to agree.

First of all, let us admit the root cause of some of today's domestic difficulties can be laid fairly and squarely at the door of electronics. (This is no indictment of do-it-yourself electronics, we hasten to make clear.)

Standing proudly in lounge or sitting room, the greatest gift electronics has given to man and his mate reigns supreme in most homes, dictating the family life style to a considerable degree. In the presence of the illuminated screen all other activities have to be curtailed or pursued in a subdued fashion. Where other rooms are available for non-viewers to carry on their various activities, there is no problem, save, maybe, a little inconvenience for the fugitive from the TV. But where no suitable alternative accommodation exists the situation can become critical—even explosive.

ACCOMPANIMENT

Suppose we digress for a moment, and consider another very remarkable social success of electronics—its leading part in the development of modern pop music. Which brings us to the ubiquitous electric guitar. The electric guitar is perhaps the most democratic of musical instruments, for more than any other it has brought the performance of live music within the reach of ordinary people. And naturally all these folk need to practise somewhere, sometime.

So, in relation to our main subject, have we reached an impasse?

Not really. The budding Mike Oldfield does not have to be banished entirely from the family viewing circle to do his practice on the electric guitar, regardless. One of the advantages of this instrument is that it is itself all-but mute, relying upon electronic amplification. This is where the solution is to be found. A simple low power amplifier feeding an earpiece gives the player all the sound he requires—and nought at all to anyone else.

Believe it or not, domestic bliss might well hang on this simple device. Could Marje Proops do better, in the circumstances, to keep a couple or a family harmoniously together?

Fred Bennett.

Our March issue will be published on Friday, February 18. See page 85 for details.

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VOL. 6 NO. 2 FEBRUARY 1977

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

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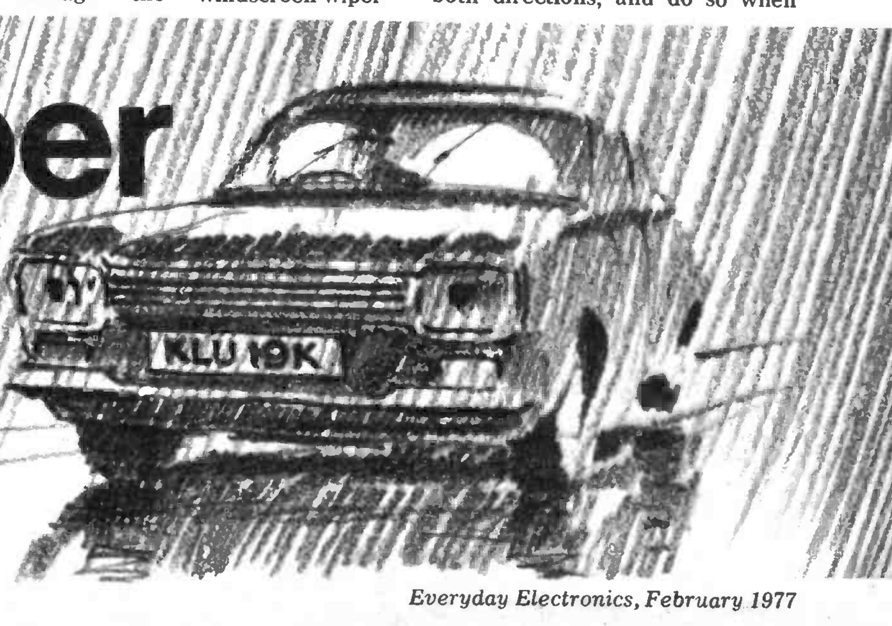
Wiper Delay

By ANDREW YEOMANS



WHEN driving through light rain or drizzle, one quickly realises that it would be desirable to have a unit which turned the windscreen-wipers on for a single sweep, then waited a while before turning them on again.

This design provides the necessary system and will suit all cars with self-parking wipers. It will work on cars with either field-coil wiper motors, or permanent-magnet motors as used on many modern cars. It will also work with both negative and positive earth cars.

The type of motor used can usually be determined by looking at the car's wiring diagram. However a quick check can be made by looking at the wiring. Cars with two wires going to the windscreen wiper switch have a field-coil motor, cars with three wires going to the switch have a permanent-magnet motor (or in the case of a two-speed motor, a field-coil motor), and four wires are used with a two-speed permanent magnet motor.

BASIC DELAY UNIT

The circuit of the delay unit used with a field-coil motor on a car with negative earth is given in Fig. 1. The unit is connected in parallel across the existing wiper switch. If Lucas car connectors are used for this purpose, the unit can be disconnected if it should go wrong, or for use in another car.

When the delay unit is turned on by S1 (which is ganged with VR1), capacitor C1 begins to charge through the motor, R1 and VR1 in series. As soon as the voltage across C1 reaches approximately half the supply voltage, the unijunction transistor TR1 will be triggered. The time taken for this to happen is determined by the resistance in series with C1; with the values as shown this time can be varied from about one to two seconds to about 30 seconds.

The equivalent circuit of a unijunction transistor is given in Fig. 2. Before it has been triggered, diode *D* is reverse biased, and R_A and R_B are both high in value, so little current can flow between bases b1 and b2, and emitter e. However as the voltage across C1 increases, *D* will eventually become forward biased, and then R_A suddenly drops in value. At that point C1 discharges through e, b1, and R3. The voltage pulse developed across R3 triggers thyristor CSR1 into conduction, and current flows through the windscreen-wiper motor and CSR1, the surge current being limited by R4 to a safe value.

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When the wipers have moved a short distance, the parking switch (which is mechanically operated by the motor) will close, thus shorting out CSR1 which returns to the non-conducting state, and also allows the motor to continue running until it reaches the parking position again, when the parking switch opens. The circuit is now in its original state, and the cycle repeats.

For use in cars with a positive earth, the same delay-unit circuit is used, however the leads marked positive and negative are reversed as in Fig. 3. No further changes are necessary.

GENERAL

If a potentiometer with only a single-pole switch is used, S1b may be omitted and the corresponding connections wired permanently together.

If the original windscreen-wiper switch is operated, it will override the delay unit.

A number of cars today are fitted with permanent magnet motors. This type of motor has to be short-circuited when it is switched off, to ensure that it stops quickly. This makes it difficult to design a reliable solid-state delay unit, since the short-circuit must be removed before the motor is operated, otherwise the car battery will be shorted out, and the short-circuiting path must be able to carry current in both directions, and do so when

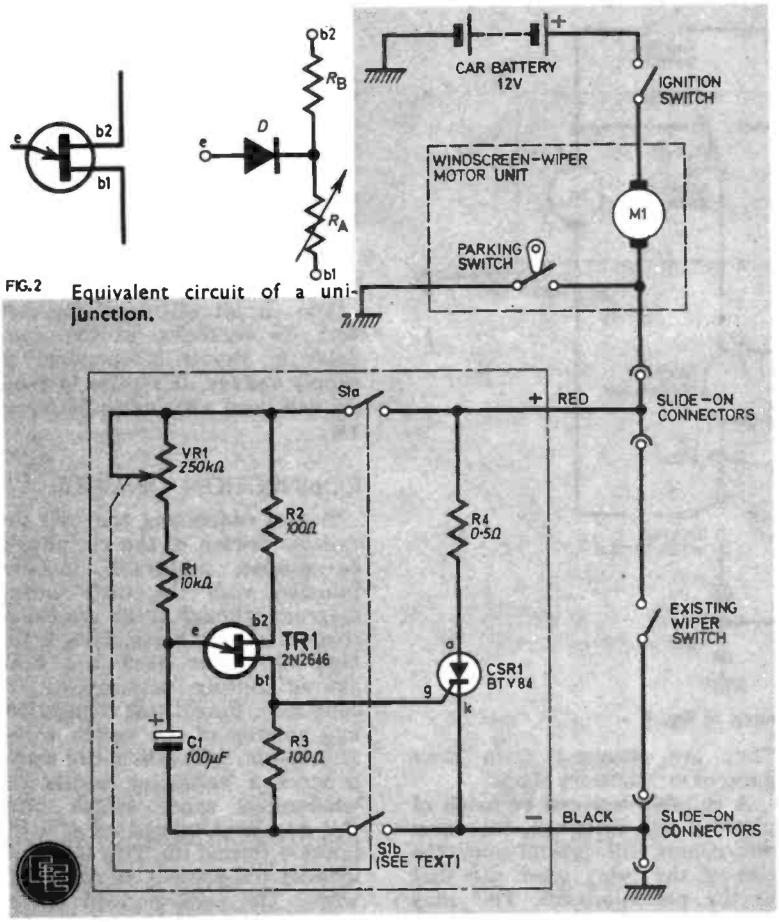


FIG.2 Equivalent circuit of a unijunction.

the delay unit is switched off. Therefore in this design a relay is used.

The actual type of relay is not critical: it should have a changeover contact (break before make) which can carry the motor current (up to about 10 amps), and the coil should operate reliably on 12V. Two sets of contacts may be connected in parallel to give the required current rating.

The circuit diagrams for positive and negative earth versions are given in Figs. 4 and 5 respectively. The unijunction TR1 triggers CSR1 as in the field-coil version. In this case R4 is unnecessary as the relay RLA will limit the current—however it will do no harm if included. When CSR1 turns on, it operates RLA which then starts the motor via contact RLA1. When the parking switch operates, it shorts out RLA coil and CSR1, so the relay releases and the motor completes one sweep, drawing current through the parking switch and RLA1 (normally closed) contact. On completion of the sweep, the parking switch shorts out the motor, which then stops, and the cycle repeats.

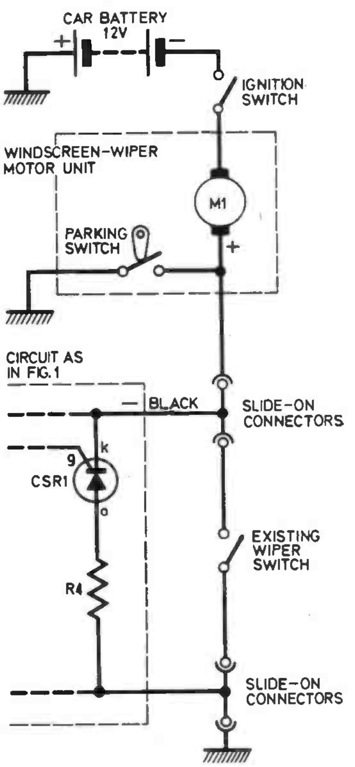
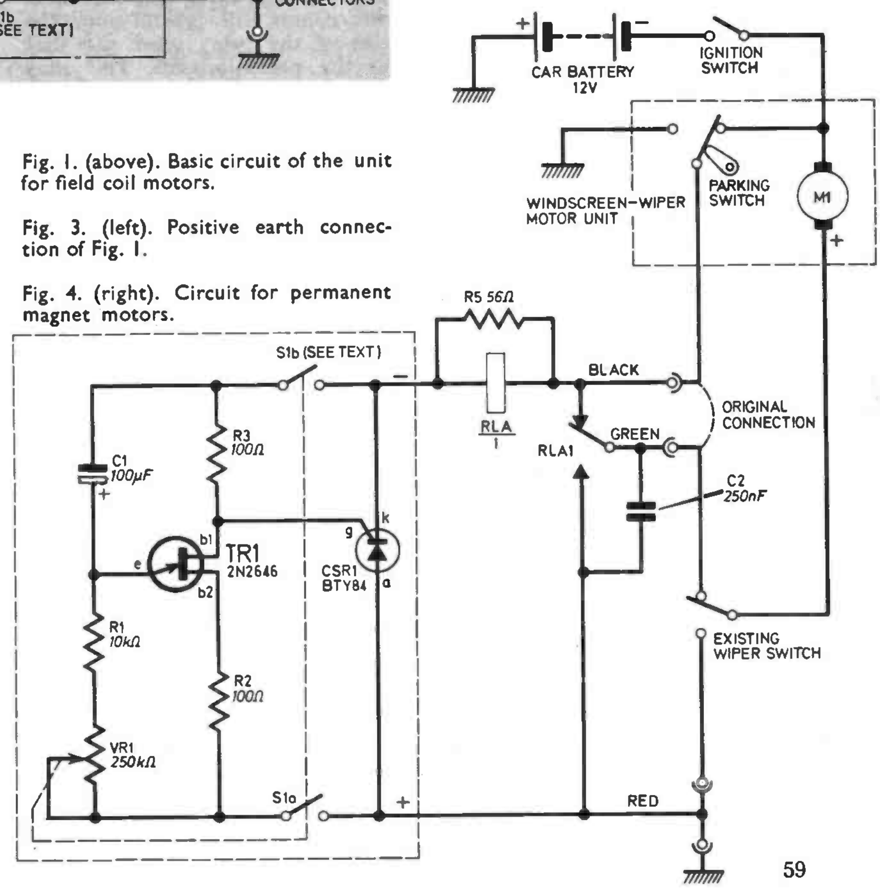


Fig. 1. (above). Basic circuit of the unit for field coil motors.

Fig. 3. (left). Positive earth connection of Fig. 1.

Fig. 4. (right). Circuit for permanent magnet motors.



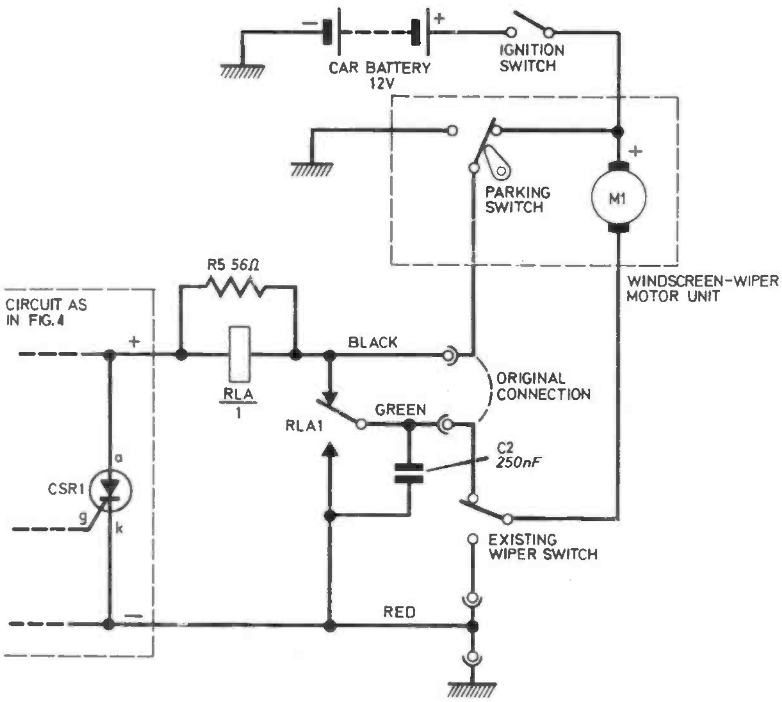


Fig. 5. Negative earth version of Fig. 4.

Capacitor C2 is included to suppress sparking at the relay contact, which could cause radio-frequency interference. Resistor R5 allows enough current to flow to hold the thyristor on until the parking switch operates; for low-resistance relay coils (less than about 100 ohms), the value of R5 may be increased or omitted, provided that the combined resistance of RLA and R5 in parallel is less than about 60 ohms.

CONSTRUCTION

Layout is not critical, however care should be taken to make strong soldered joints which can withstand the vibration of a car. A Veroboard layout is given in Fig. 6. The connections to the thyristor and the wires to the existing wiper switch must be capable of withstanding the motor current. For the field-coil version, wire of at least 3A rating should be used, and for the permanent magnet version, wire of at least 6A and preferably 10A rating should be used, as this has to be capable of carrying the full motor current continuously. It is best to terminate the cables with Lucas push-on insulated connectors, which are almost standard, as then the unit can be very quickly attached or removed.

They are obtained from most garages or accessory shops.

A suitable box can be made of plywood and softwood, the exact dimensions will depend upon the size of the relay used and that of the potentiometer. This may then be screwed under the dashboard, or mounted by the potentiometer spindle through a hole drilled in the dashboard.

TWO-SPEED MOTORS

Cars fitted with two-speed motors may have the delay-unit fitted to the lower speed connection; typical connections are given in Fig. 8. For positive earth versions, reverse the positive and negative wires as was done in Figs. 1/3 and 4/5.

6-VOLT CARS

The circuit will work for cars with 6V batteries, as the time-delay is almost independent of supply voltage. If a relay is used, R5 will need altering to 33 ohms, 1W.

CONNECTION OF UNIT

Before connecting the unit the existing wiring of the car should be studied, preferably in conjunction with the car's wiring diagram (though these are sometimes incorrect, particularly if the type of motor used has been altered during production), to determine the existing connections and polarity of the switch wires. If in doubt, with a field-coil motor connect a voltmeter across the windscreen wiper switch after this has been turned off and the ignition turned on. This will then identify the polarity of the switch wires. The positive lead of the delay unit should be connected to the positive terminal of the switch, and the negative lead to the negative terminal.

Components

SEE
SHOP TALK
page 63

Resistors
- R1 10kΩ
- R2 100Ω
- R3 100Ω
- R4 0·5Ω 3W (see text)
- R5 56Ω 1W (see text)

Capacitors
- C1 100μF elect. 25V
- C2 240nF 500V

Semiconductors
- TR1 2N2646 unijunction
- CSR1 BTY84 or similar thyristor

Miscellaneous
- VR1 250kΩ log. pot. with d.p.d.t. switch
- RLA1 12V relay with changeover contacts rated at 10A or more (see text).
- Veroboard 0·15 inch matrix 16 holes by 8 strips; connecting wire; 20 s.w.g. aluminium 65 × 30mm; Lucas car type connectors; materials for case (see text).

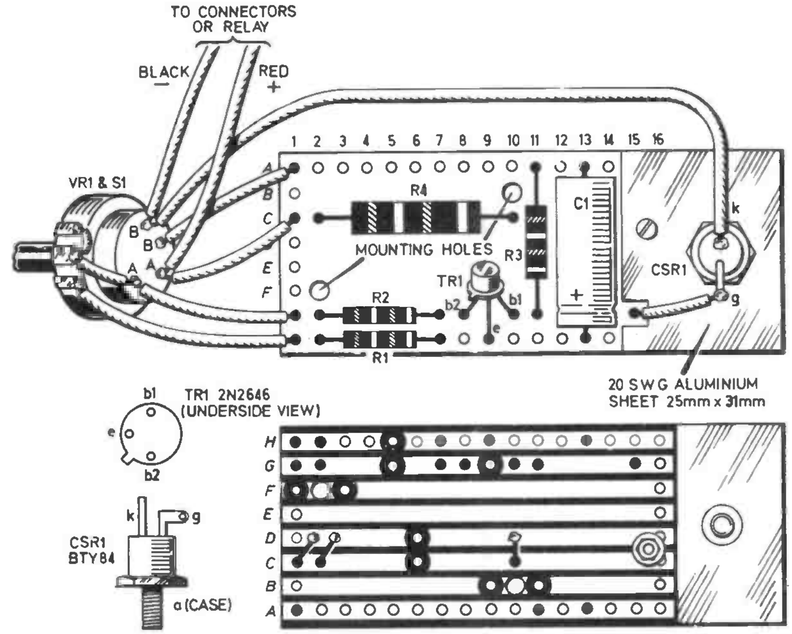


Fig. 6. Construction and wiring of the basic unit. For permanent magnet motors the relay of Fig. 7 is also required, Resistor R4 and the two breaks at 6C and 6D can be omitted when the relay is used (see text).

Wiper Delay

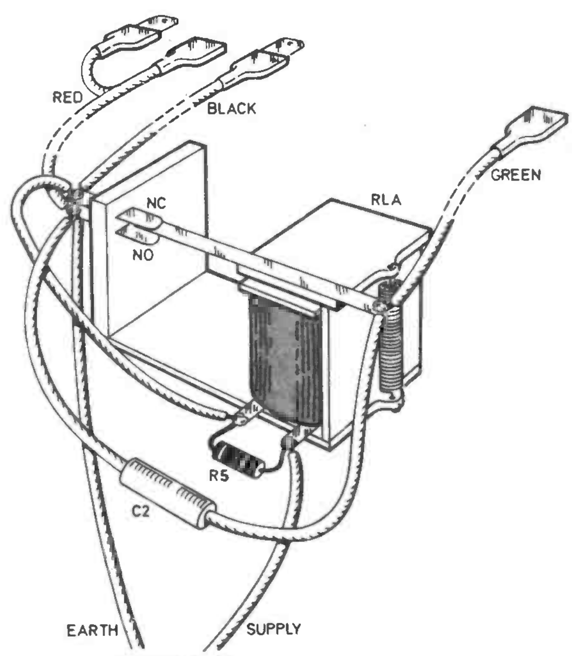


Fig. 7. Relay wiring for permanent magnet motors.

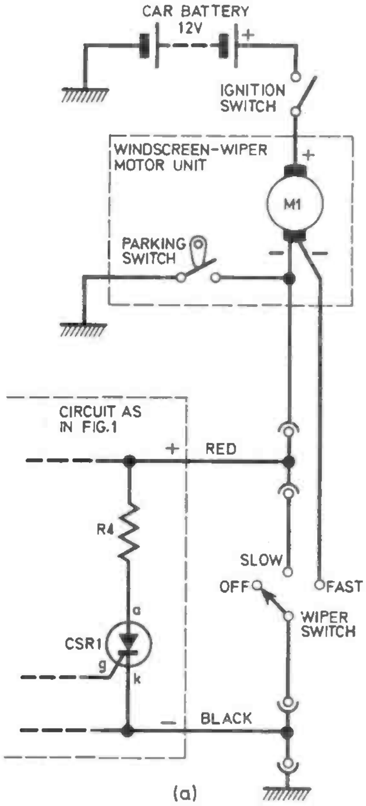


Fig. 8a. Wiring for a two speed field coil motor.

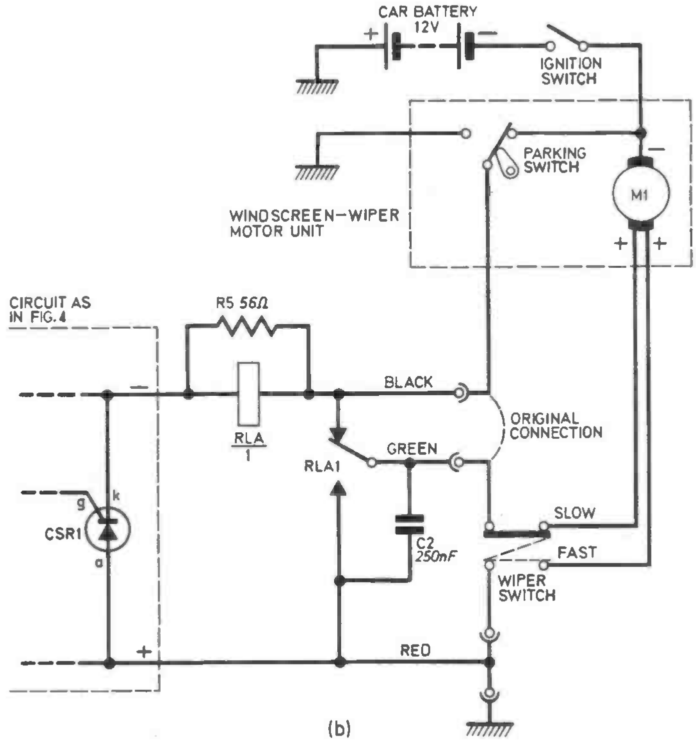


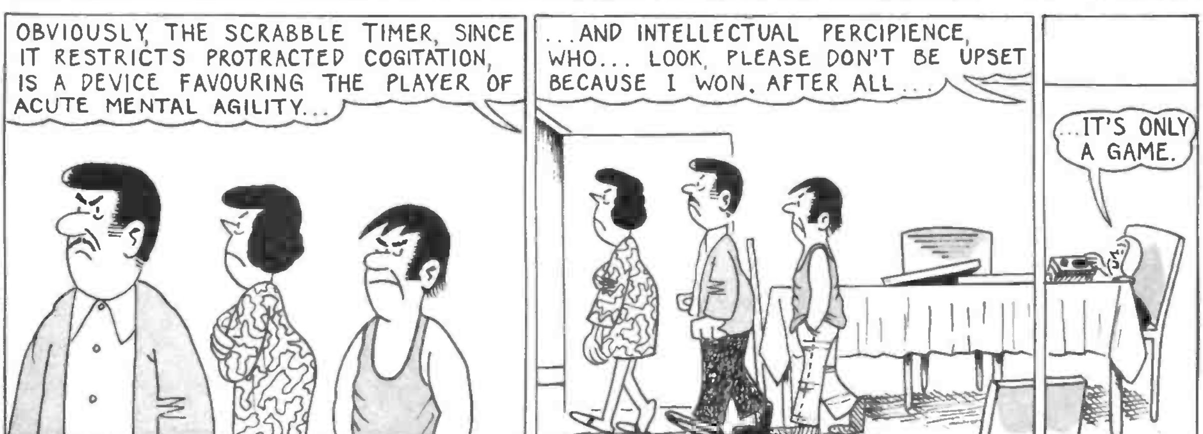
Fig. 8b. Wiring for a two speed permanent magnet motor system.

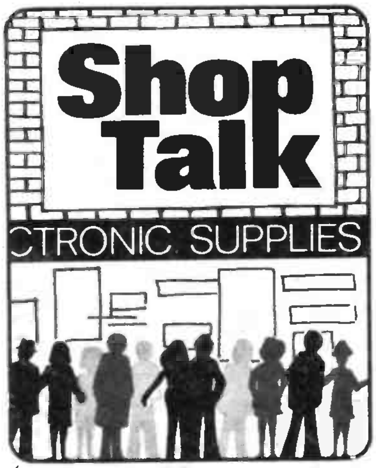
With permanent magnet motors, test the wiper switch with an ohmmeter with the ignition turned off. The lead to the normally-connected (off) switch terminal should then be disconnected and the green wire from the delay unit connected to the switch. The black delay-unit wire should then be connected to the wire just removed from the switch, and the red delay-unit wire connected to the normally-open (on) switch terminal.

Care should be taken in cars with a combined windscreen wiper/washer switch to identify the correct terminals.

If the ignition is now turned on and the delay unit potentiometer rotated until it just clicks on, the windscreen wipers should begin to operate, with a delay of about one to two seconds between sweeps. If the control is rotated further, the delay period should increase to a maximum of about 20-30 seconds at the most clockwise position. ⌑

JACK PLUG & FAMILY...





By Mike Kenward

New products and component buying for constructional projects.

WE often receive enquiries from readers asking where they can buy parts for our projects. Many of them say that their local small shop can supply some parts but not the full range. It all comes back to mail order and the firms that advertise in our pages.

Obviously it is not possible for people to list everything they sell in a small advert—some sell over 8,000 items—so they either advertise their catalogue or a few of the more popular items they sell. So, if you cannot get what you want locally, we would suggest you get in touch with one of the mail order firms or better still get a few catalogues.

As an extra aid for readers we are hoping to publish an Electronic Components Buyers Guide which will list all the firms who have advertised in our pages recently and cover the general range of components—about 200 categories. In this way every reader will be able to find a supplier for a particular range of items. However this guide will not replace anyone's catalogue because no prices or type numbers will be quoted—it will simply be a guide as to where to buy. Anyway that's a few months away yet so let's look at the catalogues we have received recently.

Catalogues

The latest catalogue from B. H. Components consists of 64 pages covering just about the whole range of items, most of which are illustrated with neat line drawings or rather poorly reproduced photographs. However, at 20p, and it includes two 10p vouchers which can be used against £1 minimum orders, you won't hear any complaints from us. Especially as we know only too well how the cost of paper rises with the falling pound. Size is 200 × 141mm and space is used to the fullest extent. B. H. are at 59 North St., Leighton Buzzard, Bedfordshire, LU7 7EG.

A new edition of the Arrow Electronics catalogue has recently become available. It is well reproduced on quite good paper with a good general range of components well spaced out through its 41 pages. Size is 208 × 150mm price 40p, available from Arrow at Leader House Coptfold Rd., Brentwood, Essex.

Perhaps the best produced catalogue available is that from Home Radio it measures 275 × 200mm and has 192 pages, almost every one with excellent photos or line drawings of various items. Perhaps the only items it does not list in great quantity are semiconductors, including i.c.s.—everything else is well catered for including test gear. However you must pay for this quality and the cost is £1 plus 40p postage and packing (that gives some idea of the size and weight of the catalogue). Home Radio are regular advertisers in our pages and you will find ordering details in their ad.

Tandy have produced a new catalogue—we did not realise the range they cover, particularly in the component area (2,000+ exclusive lines they claim). The best thing for us to do is tell you to get it and see for yourselves, catalogues are free from any of the 160 Tandy Stores.

Burglar Alarm

Another burglar alarm kit has been introduced recently, this one from Copydex.

The House Guard system includes a panic button which can be placed by the bedside or front door and can be used to set off the alarm if the home-owner is frightened, and a delay timing device for the entry/exit door. The system also contains an outside alarm bell with indicator light in steel housing, a control panel with a test light, two pressure alarm mats, five sets of magnetic contacts for doors or windows, an internal audible alarm, sufficient cable for the average home, all necessary fittings and a step-by-step instruction book.

The control unit is operated by a keyed switch, and the test light is provided for checking the circuit. The alarm is powered by a 6 volt battery, so as to be independent of the mains, and the entire kit offers professional standards by providing high quality components. Recommended retail price is £76 including VAT. Copydex Ltd., are at 1 Torquay Street, Harrow Road, London W2 5EL.

We also have news from another kit supplier—Josty. They have supplied us with a small kit, which is very professionally presented with an excellent p.c. board and good instructions, and with a list of their kits. The list entitled Electronic Construction Kits 1976/77 is available free from them or from component suppliers that sell the kits. Most of the kits should be easy to construct, work first time and represent good value for money.

Projects

Having said all that about catalogues we come down to buying for the projects in this issue and the first name to come forward is Maplin Electronics Supplies, reminding us that we are still waiting for a sight of their long expected new catalogue. The item that brought their name forward was the MC3360P i.c. amplifier of which we believe they are at present the only stockist in this country.

This item has replaced the MFC 4000 which was discontinued some time ago by the manufacturers Motorola. The i.c. can be obtained by sending 99p to Maplin, this includes V.A.T. and postage, you will find their ad. on the back of this issue.

Having looked through the components listed for the other constructional projects we can not forsee many buying problems and most items should be readily available if not from your local shop then from one of the mail order suppliers.

The meters used in the *Transistor Tester* and the *Electronic Stop Clock* are the two most expensive single items and you should watch the price when buying. There is no reason why surplus types of the correct sensitivity should not be employed. There are a few edgewise types, as used in the stop clock, available from some of the larger suppliers—in particular Henrys Radio and Doram—although they tend to be more expensive than the normal meters.

PLEASE TAKE NOTE

TEACH-IN 76

It has been brought to our attention that an error occurred in *Teach-In 76*, section 12.2. "*Example* Suppose resonant conditions are $R = 10$ ohms, $X_L = 100$ ohms" . . . should read $X_L = 1000$ ohms.

It has been pointed out to us by Doram that the relay specified for the *Light Flasher* December '76 is not designed to switch the load required. The use of a relay with contacts rated at 10A would ensure longer life. Open style type 12V (110Ω) is recommended.

Guitar PRACTICE Amplifier

By M. Feeney

A COLLEAGUE requested a tiny practice amplifier for an electric guitar; we agreed that the smallest commercial guitar amplifiers are 10 or 5 watt "combo's" with built-in loudspeakers, still too large for many situations. It was decided to build a unit based on an i.c. general purpose amplifier which would offer the following facilities:

(i) $\frac{1}{4}$ watt practice amplifier, ideal for budding stars still living at home.

(ii) Headphone listening for late night sessions or tuning up in noisy situations.

(iii) Pre-amp, with fuzz facility, with very low impedance output to reduce hum, drive long leads etc.

CIRCUIT

The circuit uses an MC3360P integrated circuit with a simple one transistor pre-amp., Fig. 1.

There is some leeway in component values depending on requirements. The input socket was used to switch the negative power on, a switch may be used if preferred, but the author found that this often leads to flat batteries through forgetfulness or inadvertent knocks moving the switch! Capacitors C1 and C2 determine the bass response, in practice the 50mm diameter speaker used has very little response below upper middle, but 10μF for each gives a solid sound through 'phones.

Any simple transistor pre-amp could be used before C2 and some quality guitars may not require one at all. Capacitor C3 must be at least 0·02μF. This can be raised if the reproduction through 'phones is too brilliant, 2μF should mute the treble sufficiently. Capacitor C4 also affects the bass response, a value of 10μF produced a very "light" sound in 'phones but later a 50μF was used to restore some body to the bass strings. Resistor R4 is only necessary if an 8Ω speaker is used. A 16Ω speaker is optimum and 25 or 30Ω speakers could be used with slight loss of volume.

The prototypes were built into old Japanese intercom cases which still contained loudspeakers. This permitted true pocket portability. Pocket transistor radio cases should be equally suitable; the larger and

Components

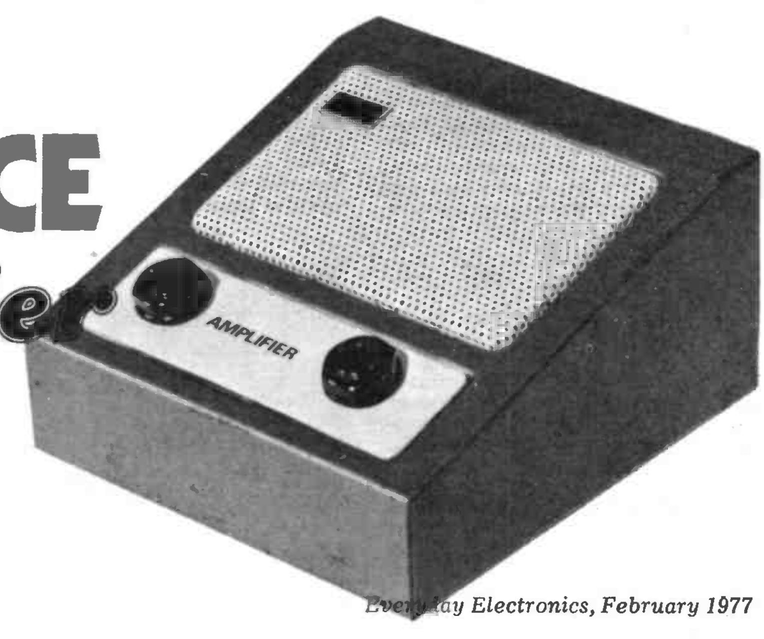
Resistors
- R1 2·2M Ω $\frac{1}{8}$W
- R2 10k Ω $\frac{1}{8}$W
- R3 10k Ω $\frac{1}{8}$W
- R4 8·2 Ω $\frac{1}{4}$W } see text
- R5 100 Ω $\frac{1}{4}$W } see text

Capacitors
- C1 0·1μF plastic or ceramic } see text
- C2 10μF 10V } see text
- C3 0·1μF plastic or ceramic } see text
- C4 10μF 10V } see text

Semiconductors
- TR1 BC108 *npn* silicon
- IC1 MC3360P 250 mW audio amplifier

Miscellaneous
- LS1 8 Ω miniature loudspeaker
- SK1 Standard jack socket with 1 set normally open contacts
- SK2 Stereo jack socket with 2 sets normally closed contacts
- B1 PP3 9V
- Stripboard 0·1 inch matrix 7 strips x 14 holes; Case to suit; battery connector; Screened cable.

See Shop Talk Page 63



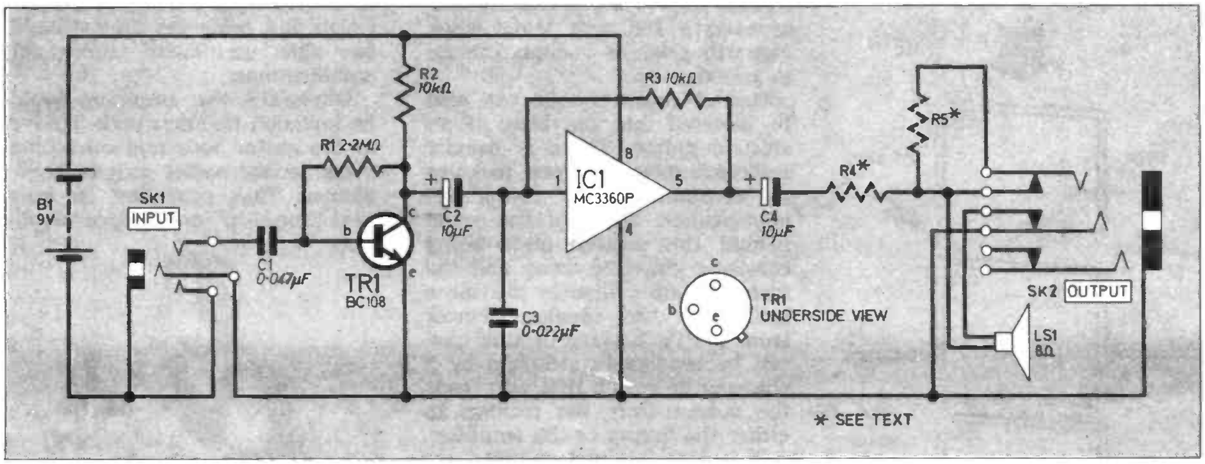


Fig. 1. Complete circuit diagram of the Guitar Practice Amplifier.

stronger the case, the better the tonal quality.

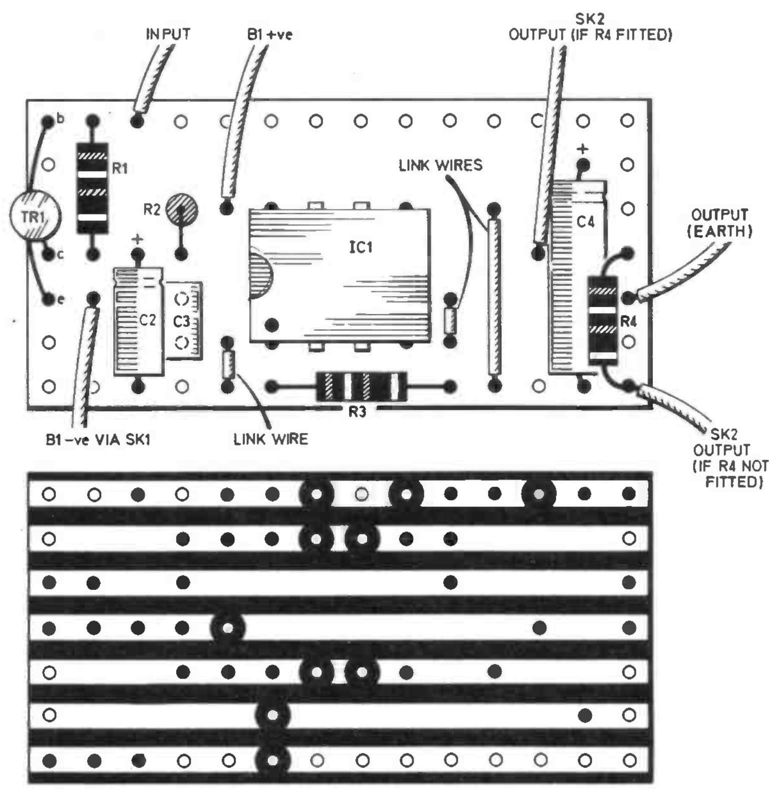
There are no controls in this circuit for the sake of simplicity and most guitars already have tone and volume controls. All the electronics were accommodated on a piece of 0·1 inch matrix Veroboard.

The layout used is as Fig. 2. Layout is somewhat critical due to the high gain employed, several versions of the layout began ultrasonic oscillations, audible as reduced volume output with a definite "fizz" to the sound. So long as output leads are kept short and well away from the input, all should be straight forward. Veroboard and battery were secured with double-sided adhesive tape.

A simple version needs no output jack, being a "pocket combo" that gives sufficient volume, albeit distorted, to allow an electric guitar to compete with acoustic instruments. The addition of a stereo jack gives the extra features mentioned above. This jack is wired in an unconventional manner, see Fig. 3., so that a stereo headphone plug will connect such that the two ear-pieces are series wired; while a mono jack will still make conventional contact. An optional resistor R5 may be added if 'phones reproduction is too loud. The prototypes gave around 90dB sound level with ordinary hi-fi headphones!

A standard guitar lead will allow the output to be fed into a larger guitar amplifier but will produce severe clipping (fuzz) on all but the minimum settings of guitar and amp. volume controls. The output may also be taken via

Fig. 2. Layout and wiring of the circuit board of the amplifier.



FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS excluding V.A.T.

£3.50
excluding case

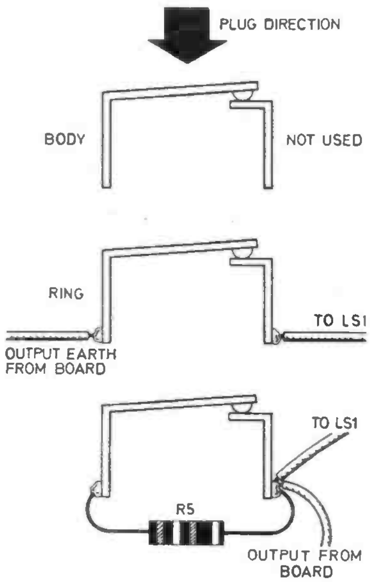


Fig. 3. Wiring of the output socket of the amplifier.

a mono jack to a hi-fi loudspeaker or even a 100 watt stage stack and will produce enough volume to practice by.

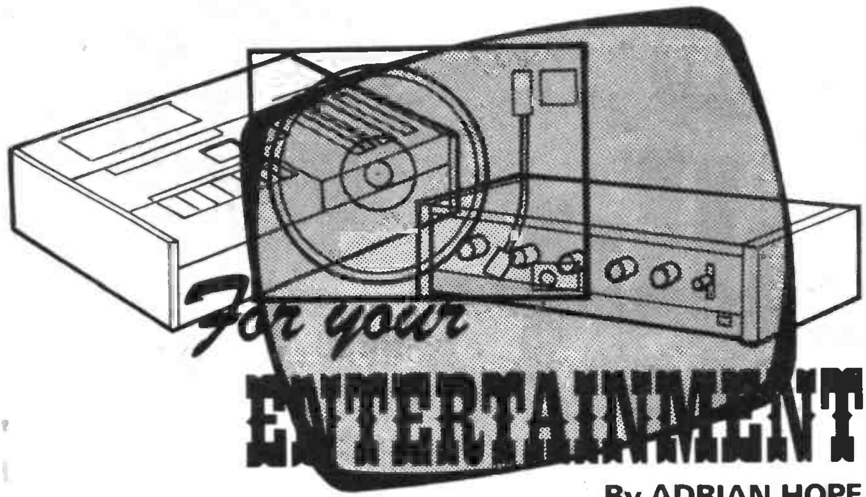
One of these circuits can also be inserted into the body of an electric guitar. There is usually sufficient room between pick-ups to accommodate a 50mm 8Ω loudspeaker. Some of the wood behind the scratch plate being carefully chiselled away and the scratch plate drilled to provide a grille for the speaker. Power from a PP3 battery in this case can be separately switched by a changeover switch that also feeds the output from the pickups to either the output or the amplifier.

This idea is given as "food for thought" because each guitar will be radically different and there are problems with feedback: layout is very important and there is some tendency to straight forward mechanical feedback through the strings. However, the author is very pleased with the resulting electronic (as opposed to electric) guitar and any roadie worth his soldering iron should be able to make successful modifications!

Obviously the amplifier could be installed together with battery in the guitar body and connected via a second outlet jack to headphones. Thus providing an integral "tune up" or practice amplifier. ⌑

...For Your Reference

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



For your ENTERTAINMENT

By ADRIAN HOPE

YOUNG people with an interest in electronics today really don't know how lucky and how safe they are. A decade or so ago, virtually all electronic gadgetry (be it audio, visual or motive) available to the home experimenter relied on valves, relays and rheostats, and required a mains or heavy duty battery power supply. Through blissful ignorance, my own parents let me play around with horrifyingly lethal mains powered gadgetry, even including water dimmers, and I was more than a little lucky to survive in one piece.

But nowadays almost everything electronic is available in solid state form, often needing only a couple of cells to power it. As a result, younger and younger enthusiasts can play safely with quite complicated electronics.

Free Charge

Recently a reader, still at primary school, came up with an interesting idea which might well trigger other thoughts in older brains. The schoolboy had recently bought a digital wristwatch and, like everyone who buys these fascinating gadgets, soon realised how expensive they can be to run. So his mind turned to the possibility of making an electrical wristwatch self-charging.

My initial suggestion would have been to build in a tiny mechanical generator with a pendulum operated by the natural movements of the wearer in the manner of a self-winding watch.

But the schoolboy's idea was an aerial to pick up off-air radio power, rectify it, and use it to charge the battery. Essentially it sounded a sound scheme.

There have long been apocryphal stories of farmers living near BBC radio and television transmitters (some of which pump out literally hundreds of kilowatts of power) and using massive grid aerials to pull in enough off-air power to light and heat their cowsheds. The snag, of course, is that the signal strength is only that strong in the close vicinity of a transmitter, and efficient power reception in most of the wavebands used for entertainment transmission would require an aerial several metres long. This would make a wristwatch somewhat clumsy!

But microwave transmissions up in the Gigahertz band, as used for radar, have wavelengths in the order of centimetres, so a dipole could fit neatly into the body or strap of a wristwatch. The snag here, of course, is that such radiations are directional and usually only found at high strength near radar transmitters or inside microwave ovens. Also, as witnessed by the safety interlocks which have to be provided on microwave ovens, these radiations can be hazardous to health.

Red Hot

The idea of powering wristwatches from off-air microwave radiation may sound rather fanciful, but if I am not very much surprised something very similar is in fact already being done!

Paris Match recently carried an article explaining how the American Embassy in Moscow had suddenly realised that it was saturated in Gigahertz frequencies.

The level varied during each day, but was often so high that the Ambassador had enough cause for concern to call his Embassy staff together and tell them that they had in fact been living in the equivalent of a low-power microwave oven for a matter of years. It turned out that radomes for radiating microwaves were strategically placed all round the Embassy.

The Americans are still reputedly scratching their heads on why the Russians should have soaked the Embassy and its staff in microwave radiation; but my guess is that they were using the power to recharge batteries in espionage equipment permanently installed in the very fabric of the Embassy building. Or do our readers have any other ideas for an explanation?

Design Features

I'll bet every reader has his own pet example of an Alice-in-Wonderland design feature.

I often wonder whether the people who design functional equipment ever actually use it. There is a small travelling "overnight" case with latch releases carefully positioned so that they automatically release and open the case every time it is rested in a railway luggage rack.

A friend bought a battery-powered photographic exposure meter with a zip case but found that closing the zip also closed the switch for the meter and thus drained the batteries. The otherwise excellent Ronson rechargeable razor does likewise. The on/off switch is on the side of the razor casing and tends to get a little loose and over-easy to switch after a while.

From a manufacturing point of view, it would be just as easy to have the switch move one way into the "on" position as the other; and for the user it is obvious that it makes sense to have the switch move into the "off" position as the razor is pushed home into the case. But no—the designer has constructed the razor so that when you push it home into the protective case the switch tends to turn itself on and when you pull the razor out of the case to use it the switch tends to turn itself off.

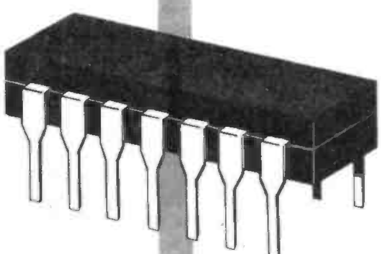
Incidentally I took the trouble to raise this point with the Ronson stand at the HEDA trade and press show in Birmingham. I was thanked for my interest and promised a considered comment the next week. But nothing has been heard—it will however be interesting to see if future Ronson shavers have the switches modified.

"This electronic machine says 'yes' at regular intervals, saving you the cost of a yes man."

Doing it Digitally...

Part 5

By O. N. Bishop



IT is very complicated to wire up a chain of flip-flops but fortunately there is an integrated circuit, type 7493, with four flip-flops already wired into a counting chain.

The pin connections to the i.c. are shown in Fig. 5.1 and it will be noticed that the first flip-flop is not connected to the others although it shares a common clear line. This flip-flop can be used separately for counting two's with the other three counting eights or the four may be used together for counting to 16. (There may be some confusion here as the maximum count of the i.c. is binary 1111 or 15 but if the zero state 0000 is included there are indeed 16 unique states.)

Follow the working of the counter by wiring it up as shown in Fig. 5.2. The clock input should come from the i.c. clock circuit as previously.

In the wiring diagrams of Fig. 5.2 output A has been wired to input B so that all four flip-flops are in series giving a count of 16.

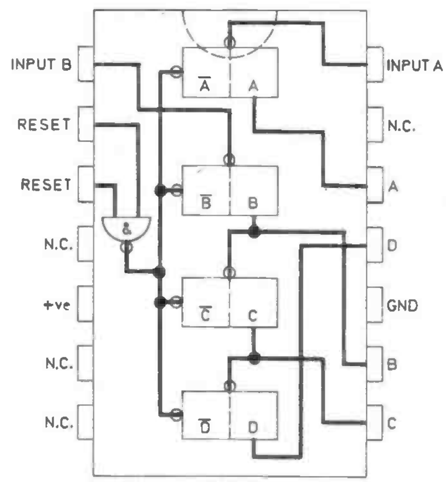


Fig. 5.1. The internal connections of the 7493 integrated four bit counter.

There are two reset inputs connected through a NAND gate. One of these is held high by being connected to 6V and the other is connected to ground when counting normally or 6V if reset is required—reset produces the 0000 state.

Check the counting sequence using the slowest clock rate and compare with Table 5.1.

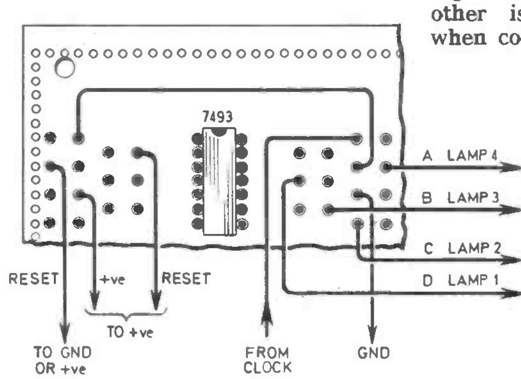


Fig. 5.2. Connecting the 7493 as a four bit counter. The lamps are used to indicate the states of the four stages.

HIGH SPEED COUNTING

To check out the counter at high speed, connect the $0 \cdot 1\mu F$ capacitors in the clock circuit and

Table 5.1: Count sequence of the 7493

Count	Outputs D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1
16	0	0	0	0
		etc		

use the earphone or loudspeaker unit to monitor the output from each stage.

Starting at the clock frequency itself, each succeeding stage will produce a note of half the frequency (an octave lower), so if the clock runs at, say, 240Hz (just below middle C) the outputs will be:

Clock	A	B	C	D
240Hz	120Hz	60Hz	30Hz	15Hz

Because the frequencies from stages C and D are so low, there may be a noticeable flicker of the lamps connected to these outputs.

The note from output C will be a very low frequency buzz—about the same frequency as the mains hum on some radios and amplifiers. The sound from stage D will be more a series of clicks.

What can this counting circuit be used for? It can be used to count up to 15 people passing through the door as described in connection with the two-stage counter earlier and even more if another 7493 were connected in series with the first!

If the light sensitive switch were connected across the lanes of a model racing car set the counter could be used to record the laps. Other uses include digital dice, reaction timers and digital thermometers.

INTERFACE

For digital circuits to become more than just electronic curiosities they must communicate with the real world. Somehow a way must be found of translating physical phenomena such as heat light and sound into a form which can be handled digitally. We call these circuits "interface" circuits.

LIGHT OPERATED SWITCHES

Light operated switches are designed to give an output which will operate integrated circuits so that they can be used to trigger all sorts of devices.

Two types of switch are described here: the first uses a "photo-transistor" and is very similar to the transistor switch which was described earlier; the second uses a light dependent resistor.

PHOTO-TRANSISTOR SWITCH

A photo-transistor is constructed like an ordinary transistor except that the top of the case is made of glass. When light falls on the transistor, a very small current is generated which is added to any currents already flowing through the transistor from the battery. If things are adjusted correctly this extra light-generated current will be enough to turn on the transistor.

The basic circuit is shown in Fig. 5.3. With a ten megohm resistor (R1) connected to the base, the transistor will turn on and off at the light levels encountered at twilight, so if the circuit is intended to switch on at dusk this is the best value to use.

With a 3·3 megohm resistor in the base circuit it will switch at a slightly brighter light and with 100 kilohms it will switch at higher light intensities such as a well lit room or bright sunlight. Try the circuit with various resistors noting the different switching levels.

Before setting up the circuit, work out what the output will be for bright light and dim light (output high or low), then check by connecting the output to one of the lamps on the experimental board.

The output from the photo-transistor can also be connected to the input of NAND or NOR gates. If it works the wrong way for the required purpose the output can be passed through an INVERTER first.

The photo-transistor is a very fast acting device, capable of responding to very short flashes of light or very brief shadows. It can, for example, detect the brief flash of a photographic flash bulb and is capable of being switched on and off several thousand times a second.

It is also a very interesting device to look at, for the tiny transistor chip can be seen through the glass. The drawback of the photo-transistor is its price and the following light operated switch can be made for about half the price.

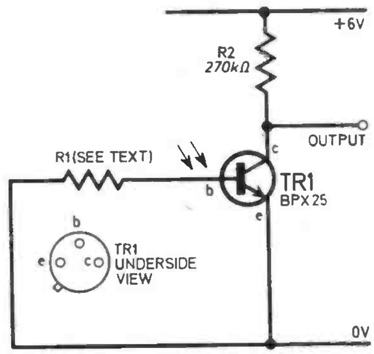


Fig. 5.3. A light operated switch using a photo-transistor as the light detector.

PHOTO-RESISTOR SWITCH

The second light-operated switch uses a special type of resistor (type ORP12) the resistance of which changes according to the amount of light falling on it. In the circuit of Fig. 5.4 the voltage at point *A* will be high (almost 6V) when the photocell (R1) is brightly lit, for then it will have a low resistance. In dim light or darkness the resistance will be very great and the voltage at point *A* will be near 0V.

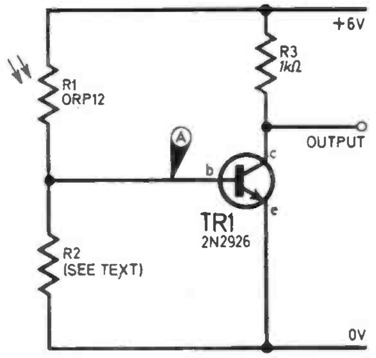


Fig. 5.4. A light detector using a light dependent resistor.

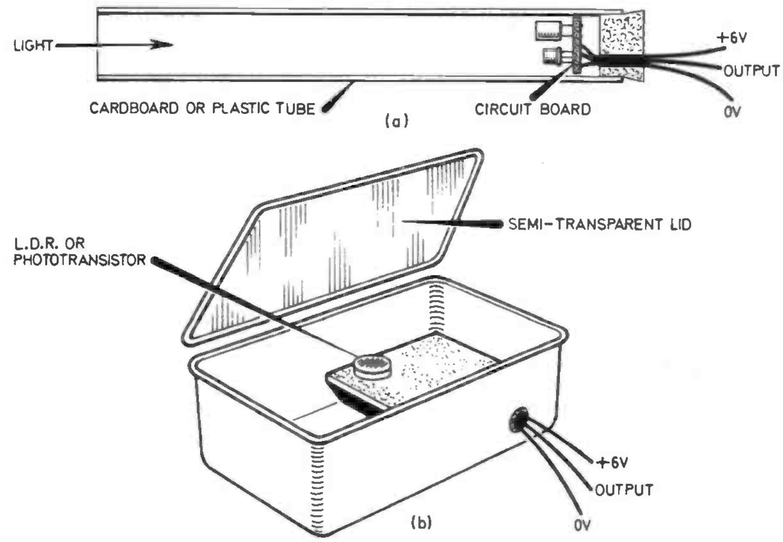


Fig. 5.5. Methods of mounting the light operated switches; (a) for interrupted beam devices, (b) for general light levels.

The voltage at point *A* cannot be used to operate an i.c. gate because an i.c. gate does not simply require a low voltage input, it requires an easy path of current to flow out of the input of the gate to ground.

In the circuit of Fig. 5.4, the voltage at point *A* is used to operate a transistor switch, the output of which can operate an i.c. gate, since it is easy for the current to flow to ground through the turned on transistor.

The circuit using the photoresistor is a little more complicated to build than that using the photo-transistor though it works out cheaper. The ORP12 does not respond as quickly as the phototransistor so it will miss sudden flashes or quick shadows but it is suitable for most purposes and has the advantage that it will switch at low light intensities. By using a five kilohm resistor (R2) in series with the ORP12 it will respond to light from a match struck in darkness or the headlights of a passing car.

It may be required to vary the level at which the switch will trigger and this can be achieved in both types of switch by replacing the fixed resistor by a variable one. For the photo-transistor it should have a value of one or two megohms and for the light dependent resistor the variable resistor should be about five kilohms.

It may be that the constructor wishes to make the light operated switch into a permanent unit and this can easily be done by placing the components on a small piece of circuit board inside a plastic box.

If one is interested in detecting the interruption of beams of light the photo-transistor or l.d.r. is best placed at the end of a cardboard tube (Fig. 5.5a). If one merely requires the detection of general light levels the device can be mounted on top of the box.

It is sometimes easier to mount the device inside the box on the circuit board and if the box is one of those semi-transparent food containers, the amount of light getting through the lid will be more than enough to operate the switch. A rough idea of the construction is given in Fig. 5.5b.

POWER SWITCH

A power switch is a different type of interface circuit from the light operated switch since it enables the *output* of an i.c. gate to operate other devices such as a bulb, a relay or a low voltage motor.

The circuit is based on the transistor switch and the chief difference is that it uses a transistor which is capable of carrying a much greater current than the 2N2926, BC107 or ZTX300.

There are two types of circuit as shown in Fig. 5.6a and b. The first. Fig. 5.6a, switches on when its input is high and the second switches on when its input is low. The "high on" switch is simpler to make, the "low on" having an extra (inverting) transistor before the switching transistor.

The load to be switched is connected across the two terminals marked "load". The switching transistor can be either a BD131 which can switch up to four amps or the BFY52 which can switch about one amp. Other transistors can be used providing the load that is to be switched does not take more than the maximum current rating ($I_{C\,max}$) of the transistor.

The switch can operate with voltage levels higher than the 6V logic supply voltage so things

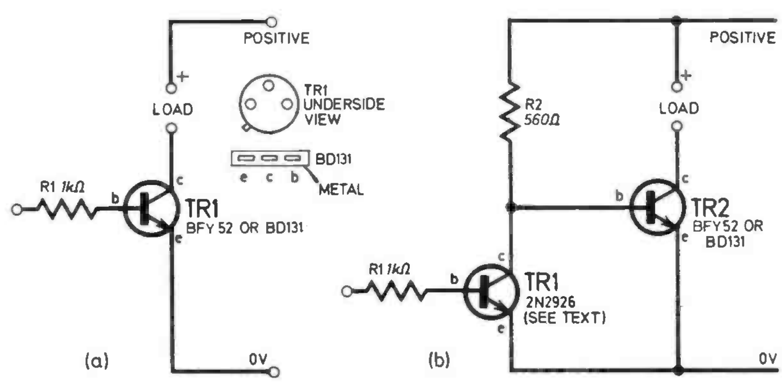


Fig. 5.6. Two types of power switch. The transistor should be selected according to the current consumed by the load; (a) "high-on" (b) "low on".

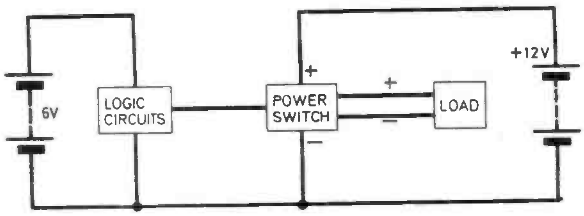


Fig. 5.7. Illustrates how the power switch can be used to control a load.

Components

Light Operated Switches
Type A
R1 see text
R2 270kΩ
TR1 BPX25 photo-transistor

Type B
R1 ORP12 l.d.r.
R2 see text
R3 1kΩ
TR1 2N2926

Power Switches
High on
R1 1kΩ
TR1 BFY52 or BD131 (see text)

Low on
R1 1kΩ
R2 560Ω
TR1 2N2926 (see text)
TR2 BFY52 or BD131 (see text)

Dual Function Power Switch
R1, R2 1kΩ 2 off
R3 560Ω
D1 1N4148
TR1 BC107
TR2 BFY52 or BD131 (see text)
0·15in matrix stripboard, 9 strips x 12 holes, metal box

like transistor radios with 9V or 12V supplies could be controlled (Fig. 5.7). **Do not use the switches with any equipment that is connected to the mains.**

For most applications including 6V 40mA lamp switching, small radios and tape recorders and model train motors, the BFY52 transistor will be perfectly adequate at voltage levels up to 20V. (Note that a BC107 or a ZTX300 and not a 2N2926 must be used in the circuit of Fig. 5.6b if a supply voltage of more than 18V is used.)

These switches can be made up permanently if they are to be used often and they can be wired into any larger unit as necessary. The main point to consider is overheating. If a large current is passed through the transistor it will get hot and too great a temperature can destroy the transistor.

To get rid of the excess heat a heatsink is used. Clip-on heatsinks are readily obtainable for the BFY52 (Fig. 5.8a) but they are easily constructed from scraps of aluminium or copper sheet (Fig. 5.8b). Make sure that the metal is in good contact with the can of the transistor but note that the can of the transistor is internally connected to the collector so do not allow the heatsink to touch any other part of the circuit.

The BD131 and similar high power transistors are bolted to the heatsink using the hole in the transistor. This may consist of a piece of aluminium sheet or a specially constructed finned type.

As well as the heatsink it is also necessary to allow the air to flow freely, so it is a good idea to put holes in the box which houses the current carrying transistor.

If only low power is being switched, or high power for only short periods, then a heatsink may not be necessary. If, during use, the transistor becomes too hot to touch then fit a heatsink which reduces the temperature.

DUAL FUNCTION SWITCH

If preferred, a dual function switch can be built i.e. one that has a "high on" and a "low on" input. The circuit is just a little more complicated than the previous two and can be seen in Fig. 5.9a.

Basically, it is the "low on" circuit with an extra input to the base of the BFY52 or BD131 transistor to give the "high on" input.

To stop this input affecting the previous stage the diode is fitted, though this does not affect the operation of the "low on" circuit.

One further point about this circuit: when used as a "high on" switch, the "low on" input must be connected to the positive supply.

If the switch is to be made up as a permanent unit then a suitable layout is shown in Fig. 5.9b. The power transistor is bolted to the lid of the metal box to act as a heatsink.

If heavy currents are to be used for fairly long periods then it is

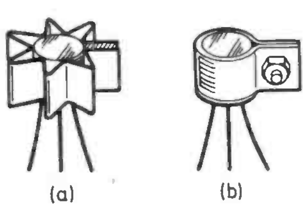
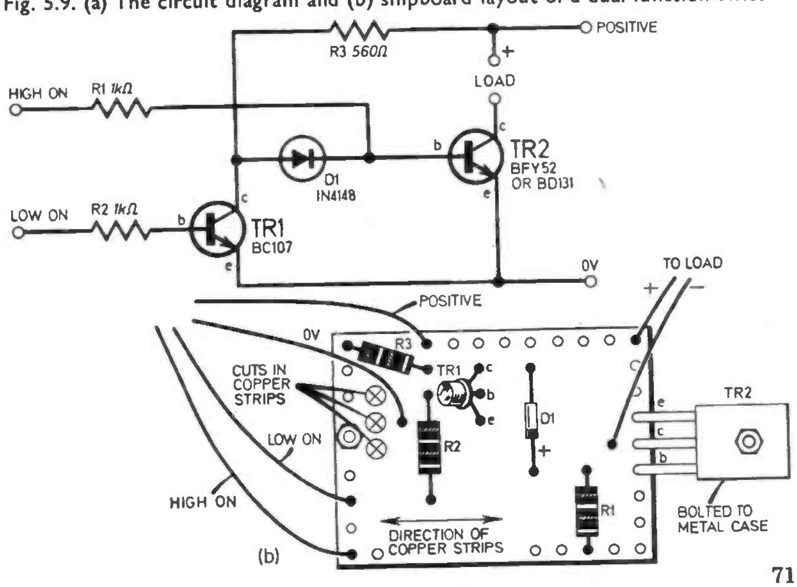


Fig. 5.8 (a) commercially available, (b) home-made transistor heatsink.

Fig. 5.9. (a) The circuit diagram and (b) shipboard layout of a dual function switch.



wise to make some ventilation holes in the box.

No wires or other contacts must touch the metal box since the metal plate of the BD131 is connected to the collector.

DESIGNING SYSTEMS

This series began by showing how components could be joined together to make gates. Then we saw how gates could be joined to make logic circuits. To make this simpler we used gates in i.c.s. instead of making them from individual components.

Various input devices such as a clock and light operated switch have also been described as well as output circuits such as loudspeaker units and power switches. We will now consider how some of these units can be joined to make systems able to perform quite complicated operations.

COMPATIBILITY

The circuits described in this series have all been designed to make the combining of such units a simple matter: they all operate on a 6V power supply line and all inputs and outputs are compatible. All outputs can be fed into i.c.s and all i.c. outputs can operate the output devices.

Some of the input devices can be connected directly to output devices if required, e.g. the clock can be coupled to the loudspeaker unit without any i.c. between. Thus the problem of designing systems is mainly that of deciding what the system is required to do.

DAWN SWITCH

As an example of a system here is a design for a unit which will make a noise when it gets light each morning. (It will also sound during the night if the house catches fire!)

The block diagram of Fig. 5.10 shows that the system consists of four sections: a light detector, a power switch, a clock to generate the alarm signal and a loudspeaker so that the signal can be heard.

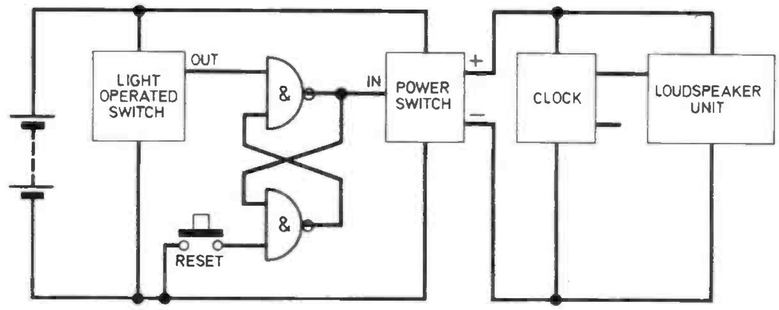


Fig. 5.11. By adding a bistable the power switch will stay on even when the light is removed.

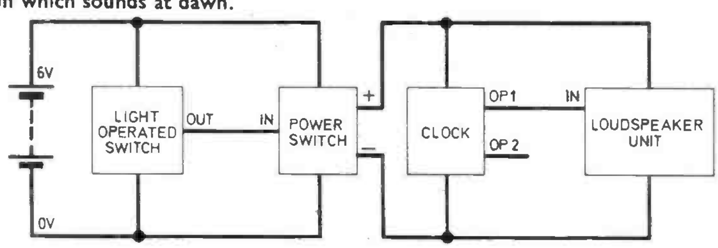
If the units have already been constructed then try connecting them as shown.

When the clock is switched on its oscillations are heard through the loudspeaker unit. The clock is to be triggered by the light operated switch, which is turned on as the light reaches a given brightness. Since this is a slow light change, the switch using the light dependent resistor rather than the photo-transistor would be most apt.

This gives a low output in the light, and a high output in the dark but the output of the switch is only capable of operating an i.c. gate. This output could be used to operate a gate in the clock circuit—it could be connected to one of the gates comprising the clock. This would cause the clock to operate in darkness and cease in light which is the wrong way round for our purpose.

One of the unused gates in the 7400 could be used as an INVERTER to overcome this problem but this approach is not a sound one for it means the clock and the loudspeaker unit would be consuming power all night, even when they were not producing any sound. It would be better if they could be switched on only when required. Hence we use a power switch after the light operated switch to switch the supply of the clock and the loudspeaker unit.

Fig. 5.10. Block diagram showing how simple units can be combined to form an alarm which sounds at dawn.



The switch only needs to be of the medium power, "low on" variety.

LATCHING ACTION

For some applications of this circuit it might be useful if, once triggered, the alarm kept sounding. For instance, it could then be used to detect the flash of a burglar's torch.

We have already met a circuit which stays in one state after being triggered and this is the BISTABLE. The BISTABLE would be triggered by the light operated switch whose output would go to the power station.

The BISTABLE can be made from NAND gates which will change states when the input goes low, that is when the light operated switch is illuminated. The two gates of the BISTABLE can be wired up on the experimental board and connected into the system as shown in Fig. 5.11. If the system is to be built as a permanent unit then the two spare gates in the clock i.c. could be used.

REMOTE CONTROL

Another example of a system which can be built using the units so far covered is a light operated remote control system. Using such a system the light from a torch can be used to switch on a piece of electrical apparatus such as a radio, model car or tape recorder.

The distance from which the control can be effective depends on the power of the torch. Car headlights from a car turning into a drive could be made to switch on a warning alarm in the house or a torch could be used to switch on a radio without getting out of bed.

To detect the light, a light

operated switch is needed and to control the load we need a power switch. There are several ways in which these can be joined together and the best thing to do is to build the system on the experimental board and when it performs correctly to make it into a permanent unit.

The photo-transistor light operated switch is best for this type of system: it needs a fairly high level of illumination to operate it so can be arranged not to respond to normal lighting but only to the extra light from a torch or lamp.

For a device which is to be triggered by a light shone on it at night use the ORP12.

The outputs from the light operated switches are not sufficient to power anything other than an i.c. input or the input to a transistor switch so some sort of circuit must come between the light operated switch and the load to be switched. There are many ways of doing this:

Direct operation

The output of the light operated switch goes direct to the power switch. The photo-transistor type goes low when illuminated so the "low on" power switch is necessary if the load is to be switched on when the torch is shone. The reverse effect can be obtained by using the "high on" power switch.

The ORP12 switch goes high when illuminated so for "light on = load on" the "high on" switch is needed, and for "light on = load off" the "low on" variety must be used.

In some cases the output from the photo-transistor switch will not go high enough to operate the power switch. This is because the amount of current available from its output is small. It is enough to operate an i.c. gate but is not quite enough to operate the power switch. If this happens try adding a pull up resistor as shown in Fig. 5.12. This raises the voltage level of the output up to the point at which it begins to operate the power switch. The value of the resistor used should be somewhere between 1·8 and 4·7 kilohms.

In fact, the added resistor is in parallel with the resistor in the light operated switch. Since the 270 kilohm resistor is so high compared with the pull up resistor, in a permanent unit the lower value resistor alone can be used.

For operating i.c. gates use only the 270 kilohm resistor, as the lower value will mean that the output will never go low enough to operate the i.c. input.

Using a bistable

The light operated switch is used to trigger a BISTABLE as shown in Fig. 5.13. The effect of this is that the device will continue to operate even when the torch is no longer shining on the light detector. A reset button is necessary for switching off.

If the photo-transistor light operated switch is used, make the BISTABLE from NAND gates so that it will be triggered from a low input from the light operated switch (Fig. 5.13a). With the ORP12 type use NOR gates which

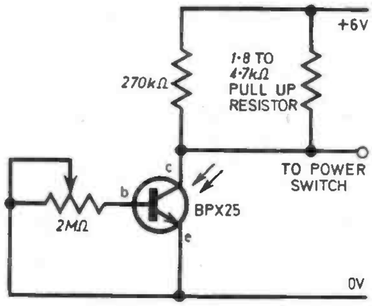


Fig. 5.12. Adding a pull-up resistor.

will be triggered by a high input (Fig. 5.13b).

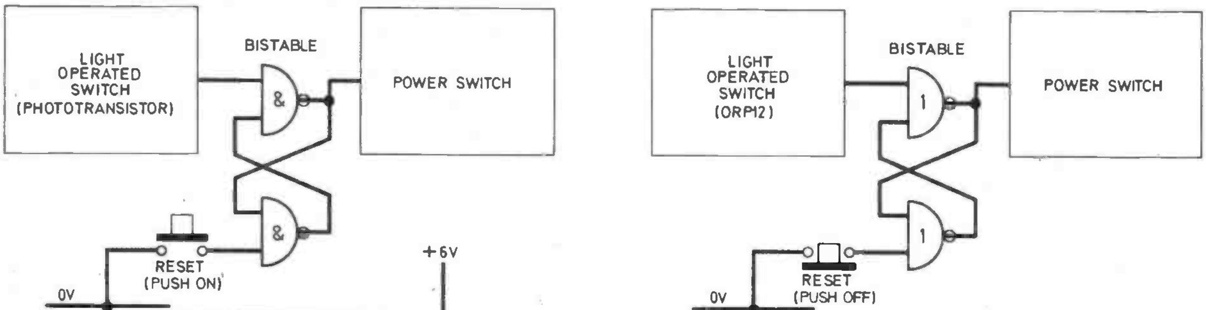
Using a flip-flop

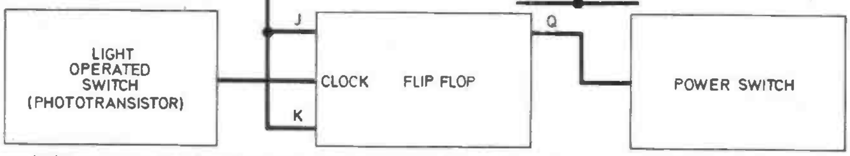
A 7473 (or more cheaply a 7472) i.c. can be used as a flip-flop. The output from the light operated switch is connected to the clock input and the *J* and *K* inputs are connected to 6V. With this wiring the flip-flop will change state whenever its clock input goes low. The simplest light operated switch to use is the photo-transistor type as this goes low when illuminated. If an ORP12 type is used an INVERTER will be necessary.

The effect of the flip-flop is that when the torch is shone for the first time the load will be turned on and will stay on until the torch is shone again when it will turn off. The advantage of this is that when you are in bed listening to the remote controlled radio, you do not have to keep the torch shining on the light detector. The circuit is shown in Fig. 5.14.

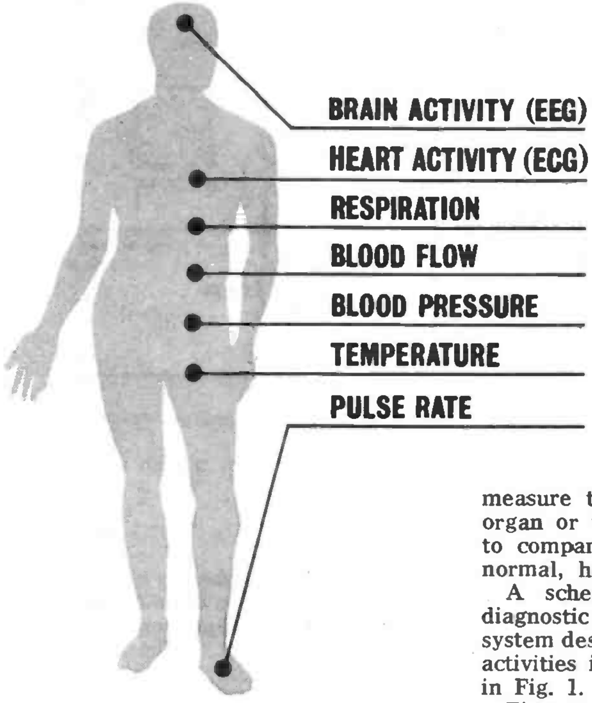
To be continued

Fig. 5.13. Remote control using a light operated switch. The bistable causes the power switch to latch on. (a) Using a photo-transistor, (b) a light dependent resistor.





Figs 5.14. By placing a 7472 or 7473 flip-flop between light operated switch and power switch, the light can be used to alternately turn the load on and off.



Electronics in Medicine

By S. McCLELLAND

A top ten league of the fastest-growing branches of electronics would, without doubt, include medical electronics—a subject which has mushroomed into a whole new technology in itself in little more than 20 years.

What is medical electronics? It is the application of electronics to medical and clinical problems—a huge domain encompassing developments from all types of patient monitoring equipment—E.E.G.s, E.C.G.s, blood pressure and flow meters and many more, to healing equipment such as heart pacemakers and defibrillators. And all are designed for more accurate, faster diagnosis of illnesses or more convenient and reliable methods to treat those illnesses.

In fact so much medical electronic equipment exists already—and more is being added to it year by year—that developments in the field may be hard to follow, but the rough and ready division into primarily *diagnostic* devices (ie. for patient monitoring) and primarily *therapeutic* devices (ie. for patient treatment) can serve as our starting point.

We will leave therapeutic equipment to a later article, but for now we will consider diagnostic equipment and particularly that with which you yourself—as a patient—might come into contact.

DIAGNOSIS

Diagnosis of an illness in the clinic depends on being able to measure the activity of a given organ or tissue in the body and to compare these activities with normal, healthy tissues.

A schematic diagram for a diagnostic medical electronics system designed to measure tissue activities in the patient is shown in Fig. 1.

First, whatever the system is designed to measure—the electrical triggering of the heart, the pressure in the arterial blood supply, the pulse rate—some sort of transducer will always be needed. This is the "business end" of the equipment, the part the patient sees, and it will convert these various biological measurements into electrical impulses the system can handle.

These electrical signals will be fed straight into the second stage of the system, the amplifier. It should be both sensitive enough to record biological signals which are in general very weak and also as noise-free as possible to discriminate the true measurement from spurious signals which may find their way into the equipment.

The third main stage of the equipment is usually some sort of display or recording device: perhaps just a meter, or a c.r.t. display, or where a permanent record is wanted, a chart or magnetic tape recorder.

SYSTEM TRENDS

Looking at the system as a whole we generally find most problems are at the transducer end. Getting the transducer into the correct position, and making sure it stays there can sometimes be difficult. In some perverse way, biological environments seem to resent electrical prying!

In fact, the trend today is to make the actual information sampling as quick, convenient and painless as possible, for often hard-pressed non-technical staff may have to administer it. This has resulted in a reduction in the surgery, which is very time-consuming, necessary to implant the transducer.

Similar comments can be made on the display of diagonstic information. It must be presented as conscisely and unambiguously as possible—in a matter of life and death a nurse has no time to squint at an electrocardiogram display and ponder on what it means!

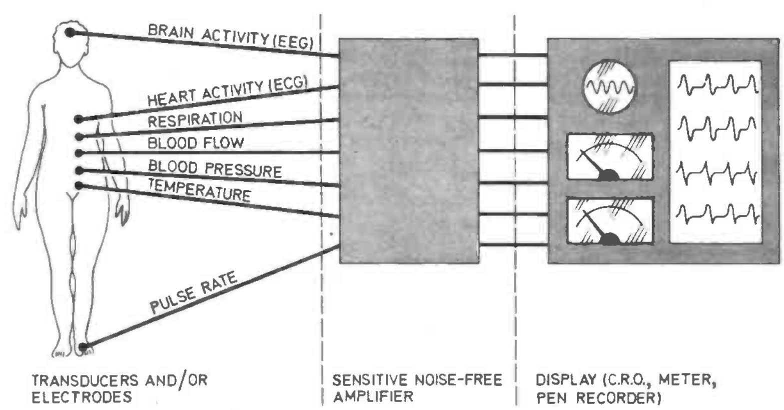


Fig. 1. Schematic diagram of a medical electronics system.

We can illustrate these features by discussing briefly some of the diagnostic equipment available. As we are electronics enthusiasts it might be appropriate to look first at how we measure the body's own electrical activity—bioelectricity, and start at the measurement which is, quite literally, closest to our hearts, the electrocardiogram.

BIOELECTRIC MEASUREMENTS

Most people will have heard of the two main bioelectric measurements; the electrocardiogram or E.C.G., which measures the heart's activity and electroencephalogram or E.E.G. which measures the brain's activity.

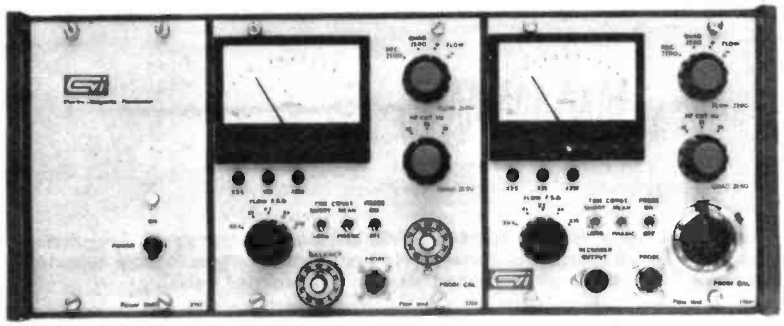
The E.C.G. arises directly from the pumping action of the heart. The human heart is basically a small, mechanical pump of four chambers. When pairs of these chambers contract in sequence, they squeeze blood into each other and round the body. Proper timing of these contractions is no less important in the heart than in the internal combustion engine and is in fact controlled by an electrical excitatory wave which sweeps across the heart in all directions about 70 times a minute. It is this electrical impulse which stimulates the muscular heart tissue into contraction.

THE E.C.G. MACHINE

The electrocradiograph—E.C.G. machine—picks up these electrical impulses using electrodes mounted outside the body on the skin. At this point they are only about 1mV in amplitude.

Since the E.C.G. pulses spread out across the heart tissue in an essentially 3-dimensional manner, these electrodes must be placed at different places on the patient's body so that a full picture of the E.C.G. can be built up. In practice, 3 E.C.G. amplifiers are used in parallel to get this picture with the capability to switch between several groups of electrodes. An electrode mounted on the right leg is normally used as a reference.

Most E.C.G. designs now employ some form of high impedance input, differential amplifier. The high impedance input cuts down the effects of the high (and variable) resistance of the E.C.G. electrode—skin boundary (moistening the skin with special lotions also helps to do this).



The Cardiocascular Instruments' electromagnetic flowmeter for measuring blood flow.

Differential amplifiers are preferred over single-input ones because they are designed to reject common mode spurious signals picked up from the mains by the E.C.G. leads or even by the patient.

Since the output must be of the order of volts to drive the display equipment, the total E.C.G. amplifier must have a voltage gain, of about 1,000, with a bandwidth of about 100Hz to give the accurate detail of the E.C.G.

E.C.G. INTERPRETATION

Having recorded an E.C.G., what can we deduce from it? The form of one E.C.G. signal (this corresponds to one complete heartbeat) can clearly indicate electrical activity. The E.C.G. trace peaks, which are associated with the heartchambers being electrically excited and then recovering their normal state, are assigned letters to ease identification (Fig. 2).

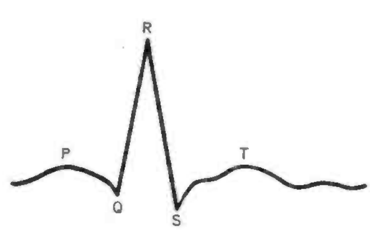


Fig. 2. Typical E.C.G. associated with one heartbeat.

As with most measurements, interest centres rather on abnormal E.C.G.s than normal ones, and they can often give an immediate indication of the patient's complaint. One of the first things which is studied, for example, is heart rate. For example, the pacemaker tissues of the heart may be driving it too quickly (tachycardia) or too slowly (bradycardia), both of which will be evident from the E.C.G.

RECORDING BRAIN WAVES

Both the electrical activity of the heart and that of the brain are, of course, bioelectric potentials, but the characteristics of each are very different.

To start with, if we measure the brain's electrical activity using electrodes taped to the head connected to an electroencephalograph or E.E.G., we find the amplitude is very small, about 50μV. E.E.G. activity is also far more complicated than, for example, E.C.G. activity—so complicated that the full significance of E.E.G. activity—dubbed "brain waves"—has yet to be understood. This is hardly surprising when we realise that the human brain contains some 10,000,000,000 nerve cells all capable of contributing to the electrical activity of the brain!

However the E.E.G. is still a very valuable instrument in medicine—for example it can indicate the presence of nervous diseases such as epilepsy which can cause highly irregular E.E.G. patterns.

E.E.G. analysis also reveals that depending on conditions one of four main frequency bands will be present. These bands are designated alpha, beta, theta and delta respectively. Alpha rhythm—with a frequency between 8Hz and 14Hz—is the major one and is associated with relaxation, which has led to the development of equipment designed to feedback alpha rhythm to a subject in order to induce relaxation (Fig. 3).

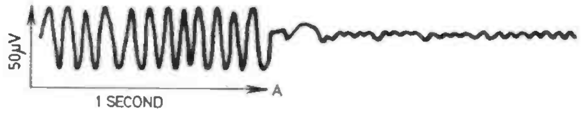


Fig. 3. Impression of one recorded E.E.G. channel showing signal irregularity and dominant frequency of about 11Hz (α rhythm) which rapidly subsided at point "A" when subject opened his eyes and stopped relaxing.

If we return to the actual instrumentation used in E.E.G. work we can see that because of the characteristics of the signals, high quality, noise-free equipment must be used.

We can take as an example of this the "Beckmann Accutrace 16" E.E.G. As in the E.C.G. measurements, building up a complete picture of E.E.G. activity requires several electrodes and the Beckman Accutrace has 16 instrumentation channels (8 channel models are also available). A chart recorder output provides a display area some 75cm wide for these channels.

Since after all we are dealing with the amplification of low level signals, sensitive amplifiers are needed. This instrument has a maximum sensitivity of 0·5µV/mm and buffered differential amplifiers are again used to eliminate spurious signal pickup.

BLOOD MEASUREMENTS

Apart from the E.C.G. and E.E.G., blood measurements (particularly pressure and and flow rate) are also important.

The pressure of the blood in our arteries varies through a minimum to a maximum over one heart beat cycle. It is measured usually by introducing a tube, filled with saline, into the blood vessel concerned. Blood pressure variations are transmitted through the saline medium to a transducer mounted externally on the tube. The transducer correspondingly modulates a carrier signal. After amplification and demodulation, the fluctuations can be displayed either as whole cycles or separated as maximum (systolic) and minimum (diastolic) blood pressure variations.

Blood flow rate, on the other hand, can now be measured without injecting anything into the blood vessel. This is achieved by using electromagnetic flow meters which depend on the fact that blood is a moving, electrically conducting liquid. This means that in the presence of a localised magnetic field, a small measurable voltage will be induced across the bloodstream which is proportional to its rate of flow. A plastic clip arrangement which fits round the blood vessel concerned carries both the pair of electrodes which detects this voltage, and the electromagnet used to produce the field.

OTHER MEASUREMENTS

Other physiological measurements which can be made include pulse rate, body temperature, and respiration.

Pulse rate is usually measured by attaching a photocell-lamp transducer to the patient's finger, toe, or ear-lobe, in such a way that the light from the lamp passes through the monitored blood vessel before reaching the photocell. The electrical output of the photocell varies with the blood pumping rate ie. pulse rate.

Body temperature is relatively easy to measure—the transducers used in this case being low thermal capacity thermistor probes which are small enough to be mounted anywhere on the patient.

Direct measurement of breathing (respiration) is obviously also very valuable. It can be measured rather ingeniously as the electrical impedance changes in a person's chest which accompany his breathing in and out. To detect these changes a small a.c. voltage of about 100kHz is applied to the chest, and the resulting current flow measured.

PATIENT MONITORING

Many of the various pieces of equipment previously discussed are often combined into a general patient monitoring system designed to continuously watch over the patient and inform the medical personnel if an emergency does develop.

The advantages are obvious: only an electronic system remains vigilant round the clock and is subject to none of the fatigue, to which even the best human personnel are prone. Also the

The Beckmann Accutrace—a modern electroencephalograph.

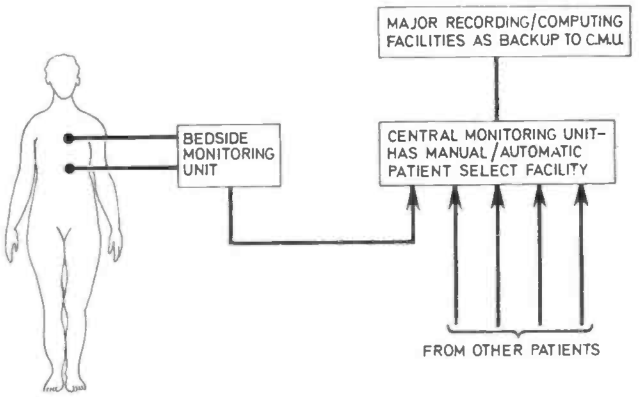


Fig. 4. A schematic diagram of a bedside monitoring system.

automatic monitoring system is probably in a better position anyway to specify "routine" abnormalities ie. those for which it is programmed, quickly.

In general, patient monitoring systems are of two types: bedside monitoring systems for intensive care units, and surgical monitoring systems for use in the operating theatre.

BEDSIDE MONITORING

The concept of bedside monitoring is quite simple: in an intensive care unit the system is arranged so that there are usually six to twelve patients in each section. The physiological parameters (for example E.C.G., pulse rate, temperature, blood pressure) of each patient are continuously checked by a bedside monitor next to him. The monitor contains these items of diagnostic equipment in one housing but each is often in a modular package making for maximum flexibility. The "Sirecust" system developed by Siemens Ltd. exemplifies this.

Each bedside unit is also connected to a permanently-manned central monitoring unit. The unit permits more detailed analysis of any one patient's condition (it has the capability to select individual bedside units) and usually has substantial facilities available to record it (Fig. 4).

The feature all bedside monitoring systems share is the provision of alarms—physiological parameters which cross preset values on each item of equipment will alert the medical personnel and automatically select the patient concerned for monitoring at the central unit.

RECORDING

In some units this alarm capability is further enhanced by the addition of a magnetic tape loop recorder to each bedside system. The tape loop is long enough so that one continuous revolution of it takes up to 1 minute and recording normally takes place continuously. In the event of an emergency, the loop is immediately played back through a chart recorder. In this way the physician is informed of the patient's physiological condition from 1 minute before the alarm was triggered and the development of the emergency.

Sometimes a normal, continuous recording is wanted, but hand in hand with its undoubted usefulness goes the problem of how to analyse effectively the enormous quantities of output which are produced.

One low cost convenient solution to this is the provision of a time compression magnetic recording system (for example, developed by Siemens Ltd.). By speeding playback time, one hour recording time takes one minute to analyse, naturally making for quick overall interpretation. In fact a compatible portable analogue recorder is available so that the subject doesn't even need to be inside the hospital while the E.C.G. recording takes place but can be leading a near-normal life.

SURGICAL MONITORING

In general, monitoring techniques in the operating theatre are very similar to bedside monitoring techniques: indeed the differences lie not so much with the electronic circuitry as with the external design of the system.

Often the medical electronics system will be in a modular form —built in a particular arrangement to suit the operating theatre layout and to minimise hindrance to personnel movement.

Of course, there is usually slightly more of an emphasis on speed of data processing and display so that everyone concerned can see the state of the patient's health at a glance. This kind of factor is often reflected in even larger screen c.r.t. displays than normal or slave c.r.t. displays scattered round the theatre.

COMPUTERS

This need for urgency has also spurred on the applications of that seemingly ubiquitous device —the computer. It is proving very useful in the operating theatre where E.C.G. information, for example, can be sent directly from the patient down a telephone line in analogue f.m. form to a remote computer centre, processed and sent back to the surgeon in the theatre.

No less are the applications to bedside monitoring—where data handling of this type (though in batch-input form) often takes place. In both applications, a computer system can be a valuable adjunct to the doctor in providing diagnosis. The trend obviously suggests that one day a completely electronic "doctor" will be developed. While this is probably possible in theory, at least, it is doubtful that it would ever be practicable without considerable technological advances. Whether it is at all desirable is, of course, another question.

However, the use of computers isn't restricted to purely diagnostic applications. A hospital based data-processing system is capable of making an extremely efficient match between patients requiring treatment and hard-pressed medical resources—both human and machine—so called "organisation optimisation". So in the future we can look forward to the computer extending more and more into every sphere of hospital activity — with the patient's every step from admission to eventual discharge being somehow involved with it. ⌑

Your Career in Electronics

by Peter Verwig

RADIO COMMUNICATIONS

WHEN thinking about a career the sensible approach is to seek a growth situation. An expanding industry will clearly provide more opportunities for career development than one which is stagnant or declining. Opportunities for promotion in a stagnant industry are stunted by the need to wait to step into "dead men's shoes", whereas in an expanding industry new jobs and therefore new job opportunities are being created all the time.

Electronics, as a whole, is in a growth situation but the growth is not uniform throughout all its specialist sectors. Domestic radio, for example, has suffered an enormous decline in recent years in the U.K. and other highly industrialised countries, not because people buy less radios but because production has been moved to the Far East where labour costs and other factors allow them to be manufactured very cheaply.

The same applies to items like cassette recorders and hifi equipment and, increasingly, to television receivers. There is a similar decline in home manufacture of low-cost electronic components. So, unless you want to be a service engineer, consumer electronics tends to be less attractive than many other industry sectors.

The young job hunter would do much better to concentrate his mind on getting employment in the professional and capital goods sectors where, because of the much higher level of technology involved, the design and production is in the U.K. and where companies with a good export performance are well-cushioned against trade recession in the home market.

One sector where exports are buoyant and look like staying so for many years to come is radio communications. This is the oldest sector of electronics stretching back to the beginning of the century when Marconi was conducting his early experiments and, until the 1930's, was virtually the whole of the electronics industry if we include public broadcasting. For sheer size it has long been displaced in economic importance by electronic data processing which has made such impressive growth in the past 20 years.

Nevertheless, radio communications is still an important and permanent sector of the electronics industry and, moreover, a sector in which Britain has always enjoyed a fine reputation for innovation and technical excellence.

A good guide to what the rest of the world thinks about a particular product sector is to look at the trade balance of imports and exports.

In the first nine months of 1976 we find that Britain imported £16·6 million worth of radio communications equipment but that exports of home produced equipment to other countries was £62·7 million, giving a surplus of £46 million. Exports showed a growth in those nine months of over 50 per cent compared with the same period in 1975. And if we look at the companies working in the field of radio communications quite a few export over 50 per cent of their total production and in some cases as much as 80 per cent.

Perhaps the most surprising aspect of radio communications over the past few years is that the h.f. band of the frequency spectrum, that between 2MHz and 30MHz, is still so active in medium and long distance communications. In theory the h.f. band should be slowly emptying as more and more long-distance traffic is absorbed by satellite communications and high capacity submarine cables. Especially so as the last two are inherently more reliable being completely free from the vagaries of the ionosphere and the restrictions of the present sun-spot minimum.

MICROWAVES

For short-haul work there has been tremendous growth in the use of v.h.f. and u.h.f. for both fixed point-to-point and mobile use, and terrestrial microwave links are now commonplace for high capacity trunk routes, a recent example being the completion of the microwave system in the Caribbean extending over 800 miles with a capacity of 960 voice channels.

Microwave technology has now advanced so much that it is a separate discipline embracing radar and a number of navigational systems as well as communications. This month we shall confine our remarks to what is often referred to by those working on super high frequencies as "steam radio", the implication being that communications systems operating at the lower frequencies are very old fashioned.

It is certainly true that the very first practical radio communications systems were on long waves, then medium waves and, by the 1920's, it was discovered that very long distances could be covered on remarkably low powers on short waves. Amateur radio experimenters were responsible for discovering that short waves were of real value. Hobbyists, like yourselves, but of an earlier generation, and they had been banished to what were then thought as being useless wavebands. But once the amateurs had demonstrated that, given suitable propagation conditions, they could communicate with each other over vast distances with only a handful of watts of radiated power the professionals, previously scornful, moved in.

IMPROVEMENT

So, in the sense of exploitation of the short waves, i.e. the frequency spectrum 2 to 30MHz generally known as the h.f. band, the basic system may be called old-fashioned. But so is farming. And while modern technology has transformed farming through the years and improved efficiency enormously, so has technology transformed the use of h.f. Just as the modern farmer gets a far greater yield of produce per acre today compared with 50 years ago, so do h.f. communicators squeeze more out of the available communications channels in the spectrum 2 to 30HMz.

The improvement has come from greatly improved frequency stability, far more selective receivers, far more use of directional beam antennas, and new methods of modulation, particularly single sideband suppressed carrier (s.s.b.) which doubles the number of voice transmissions for a given frequency occupancy. For Morse and other forms of data transmission there are high-speed keyers which means more traffic in a given time.

If we look to v.h.f. we again find that improved frequency stablity of transmitters and receivers has allowed channel spacing to be progressively reduced from 50kHz to 25kHz to 12·5kHz allowing more and more stations to operate in a given band of frequencies without mutual interference.

There are other great improvements. For example, selective calling systems by which a mobile station may be alerted to the fact that it alone is being called. And, of course, the advent of solid state technology and microminiaturisation have brought about the widespread use of the pocket radiotelephone for police, firemen and other public servants on v.h.f. and u.h.f. Even on h.f. where there is a physical limitation in reducing the size of inductances and certain other components it is possible to squeeze a 100 watt radiotelephone into a car dashboard. In the old days such a set would be housed in a six feet high equipment rack of considerable weight.

REDIFON

Regular readers of this series will recall that to illustrate career prospects I have frequently selected a company as a practical example. To illustrate radio communications I have chosen Redifon Telecommunications Ltd. I might have chosen Marconi who have been in the business for 75 years, or the much younger Racal Group who are performing so brilliantly year after year, or Pye Telecommunications Ltd., who have set such a cracking pace in mobile radio. Any of these companies can provide good opportunities for keen technicians and engineers interested in radio.

Of course you don't need to work for a manufacturer to be in radio communications. There are similar opportunities in the Post Office, all three armed services, air lines, shipping companies, in companies like Cable & Wireless and International Aeradio, in the electricity and gas supply industries, and a host of other user organisations.

But Redifon Telecommunications is currently of interest because it is working hard on expansion in total business activities and is broadening its product range. The company is a subsidiary of Rediffusion Ltd., well known for Cable TV, radio relay systems and TV rentals as well as for its stake in TV and sound broadcasting at home and overseas.

Bench testing a Powerpage transmitter as used by the Post Office for wide area radio paging.

Adjusting an HFA 125 100W solid state HF amplifier, an example of third-generation solid state equipment designed for the military and naval markets.

Redifon has its headquarters at Wandsworth where there are also production facilities, but main production has been gradually transferring to a new manufacturing plant at Cwmbran, Gwent, opened in June 1974. The present production area is 52,000 sq. ft. and there is provision for further expansion to double in size and also introduce research and development on the site.

MARINE EQUIPMENT

The company has a complete range of marine radio communications equipment in the catalogue and can not only supply all the requirements for a fully equipped ship's main radio station but can also supply sea-going operators.

A typical marine radio package will include a bench-mounted operator's console with main and reserve receivers, v.h.f. radiotelephone, two watch receivers for monitoring distress frequencies, a reserve transmitter, interface with the ship's telephone exchange, auto-keying unit for sending distress signals, radio selector panel, and loud speaker panels. The accompanying main ship's transmitter is floor-standing and capable of putting 1·5kW into the antenna.

All ship radio equipment has to be approved in facilities and quality by licensing authorities and Redifon claim to hold type approvals from more countries than any competing manufacturer. This, of course, helps enormously in selling on a worldwide basis and quite recently Redifon has had additional export successes with Japanese shipbuilders, with Red China and with shipping companies in India, supporting the existing trade with Europe in such countries as Germany, France, Norway, Greece and Italy, not to mention a special fit in a luxury yacht owned by a rich oil prince.

A year or so ago Redifon was hit by the world shipping recession. There was a big reduction in order intake but marine business is now reviving. The second half of 1976 showed a 34 per cent increase in orders over the same period in 1975, a good sign.

Wise companies try to overcome ups and downs of this nature by broadening their product lines. In marine communications this is done by selling to navies and by selling communications-related products. Redifon has important naval contracts and has recently achieved enormous success with the Omega navigator which uses a world-wide network of ground stations to provide a "fix" for any Omega-equipped ship. Nearly 1,000 systems have been sold which is far more than any other manufacturer.

Redifon also build satellite navigation systems which will give a "fix" anywhere in the world to within 400ft, compared with Omega's one or two miles. Yet another product is a radio beacon suitable for marine or aviation use.

RADIOTELEPHONE

The overall product lines are further broadened by land communications. Redifon is building a new business with the Routemaster v.h.f. radiotelephone specially designed to be fitted on buses. This product is a direct result of vandalism. If there is a disturbance on the bus the driver can be instantly in touch with a headquarters station by speech or automatically, in which case the transmission not only gives the alarm but also vehicle identification. The system also includes provision for fitting additional services at a future date for automatic data transmission of vehicle status and location.

C.E.R.E.S.

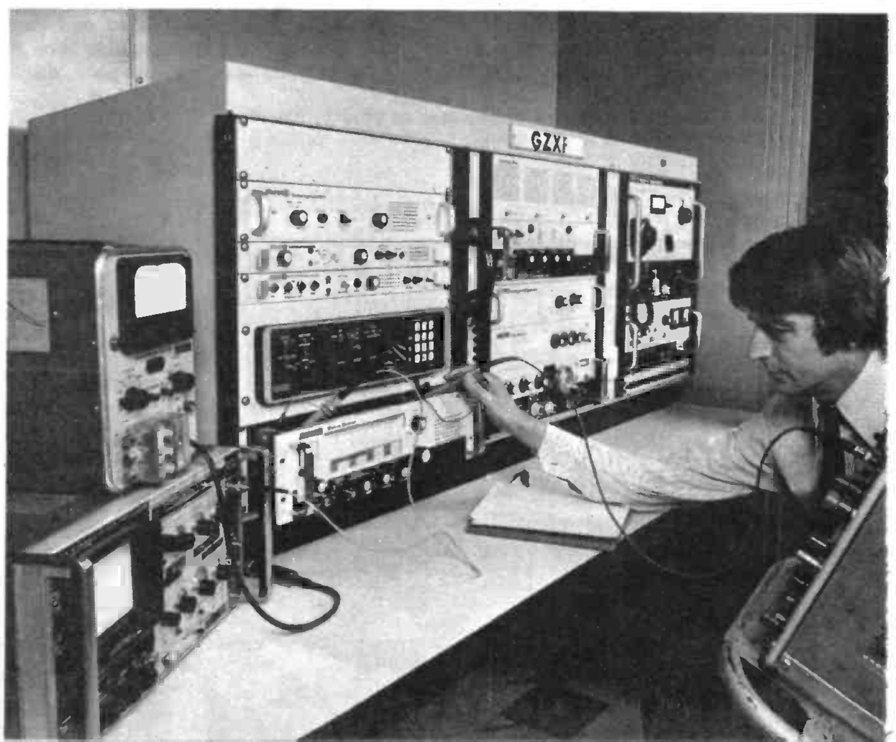
Last June Redifon announced entry into high level radio monitoring with a system called CERES (Computer Enhanced Radio Emission Surveillance). CERES came about through a British Government requirement. Monitoring stations are used by organisations such as the BBC and news agencies.

Less publicised are the secret monitoring services where transmissions are monitored on a regular or intermittent basis as part of a country's intelligence service, and especially to identify unauthorised transmissions, their operating frequencies and message content. As such transmissions are likely to be encrypted in secret code which will need to be broken, perhaps taking hours or days by experts even with the aid of computerised codesmashers, such transmissions are invariably recorded.

Two or more monitoring stations at different locations will also co-operate in a direction-finding exercise to pin-point the location of the unauthorised transmitter.

This work, 24 hours a day, seven days a week, has traditionally required a great number of highly skilled operators. CERES is a modern system in which, with computer assistance, a single operator can control up to four

Checking out units of a ship's main radio console.



receivers at a time with automatic search over the tuning ranges and automatic recording of one or more suspect transmissions while still searching for others. Six operators can thus control 24 receivers in a typical radio monitoring centre.

The computer is programmed to control many of the routine tasks which previously needed a separate operator. It can, for example, tune to spot-frequencies at pre-determined times, or maintain continuous watch, or continuous search ignoring all signals which have previously been established as legitimate.

This year Redifon will be extending its activities in the mobile radio market with new u.h.f. vehicle-mounted and personal-portable transceivers and is in the running for personal paging contracts from the Post Office. There is a suggestion that Redifon will enter the Citizen's Band market should CB be allowed in the UK.

It should now be clear that although I have not mentioned anywhere near all of Redifon's radio communications products, there is a great spread of activity including high technology systems, the sort that cannot be easily made in Hong Kong or Singapore or Taiwan. The products are also sold world-wide. In fact 80 per cent of production goes overseas.

In short, Redifon Telecommunications and similar companies offer a good career structure and a secure future. In Redifon's case there is also the prospect of rapid expansion, another desirable feature.

LOW ANNUAL INTAKE

As Redifon is still comparatively small the craft apprentice intake is proportionally low, currently running at 6 a year but, as expansion proceeds, there will be vacancies in all technical grades both inside the factories and laboratories and outside on commissioning new installations, and in servicing.

If you already have qualfications or are keen and willing to do on-the-job training with a view to qualifying and really getting ahead, then companies like Redifon will always give you a fair hearing.

A short final word on apprenticeship. Don't look down your noses at this method of getting a good start in life. Sir Raymond Brown, now managing director of Muirhead, started life as a Redifon apprentice. Bob Munton, operations manager at Redifon Telecommunications and responsible for all manufacturing activities, systems engineering and quality assurance, started life as a sheet metal apprentice with de Havilland. On the way up he obtained a degree in Business Studies and is a member of both the British and American Institutes of Management.

There are dozens of other examples of apprentices who got to the top, especially in electronics where brainpower and enthusiasm are the name of the game rather than the circumstances in which you may have been born. ⌘

THE long hot summer which is now a distant memory, had the effect of completely dis-orientating me. Let me explain, every year the thought is always at the back of my mind that come September, the weather gets colder, the days get shorter and there is bound to be a big influx of new recruits to our fascinating hobby. It is therefore old uncle Paul's pleasant duty to advise these novices on such things as buying their components.

Well you may be saying, that seems simple enough. Yes and so it is, but my copy has to be on the editor's desk about three months before it is published. In effect I should have it ready about June.

However on the principle of, "better late than never", here are a few of my well tried and trusted tips.

To-day we retailers all have to specialise in certain areas of electronics and so the first point is, you are not going to get all your parts from one source. I would reckon you will, on the average, have to deal with at least four suppliers, and since the "high street component shop" has disappeared from most towns, you will have to order the goods by *mail order*.

The second point is that most mail order houses are operating with very depleted staff for economic reasons so try and make it easy for them. For a start fill in their forms clearly using block capitals, (especially your name and address). Do not chase them if your goods do not appear in under a week (it will take longer than this even if they manage an immediate turn round).

I am always baffled by the customer (and fortunately they are a very small minority) who telephone to tell me that their order was a fortnight in coming and they consider it disgraceful. I usually tell them that on the few occasions I order goods by mail order, I usually wait two months before I see my parcel. These same people usually tell us we should acknowledge each order, without stopping to think what it would cost in labour and postage. The real answer to this problem is to plan well ahead.

If you are a real enthusiast (and I am sure you are at least one in the making) you are going to tackle more than one project, and therefore start ordering the parts for your second project while you are still busy on your first.

Lastly I must touch on a very real problem, one that is a nightmare for the retailer, "inflation".

Everyday Electronics does a splendid job, in trying to give guidance on the cost of a project. I naturally check my prices against their forecast prices, and I regret to say I can seldom match them. The two or three months gap between the forecast and the appearance of the article would easily account for it. To keep up with inflation, our prices (not all of them of course) are changing daily. You may tell me I ought to hold my prices if only for a month, but dear reader, suppose you offered me an article at £1.00 and just as I was handing you the money, you learned that the next time you are going to buy the self same article it will cost you £1.50. What would you do?

So to my final point, when you have totalled your order add on 10 per cent. for inflation. It will be much appreciated by your suppliers, and rest assured he will refund it if it is not required! To sum up:

★ Write clearly and use the suppliers order form. ★ Be Patient. ★ Plan ahead. ★ Make due allowance for inflation.

TRANSISTOR CHECKER

By A. J. Flind

THERE must be many constructors who, like the author, have accumulated a large number of assorted transistors of somewhat dubious origin. Some work, some don't, but a far greater difficulty is posed by those that "half" work, i.e. they function but have reduced gain, high leakage, etc.

There have been designs for testers which will give a comprehensive check to almost any type of semiconductor, but the instrument which would be of most use in the average workshop is one that will provide, in a few seconds, a simple functional check on the transistor or diode about to be used, together with a rough idea of gain. In addition such an instrument can be invaluable for trouble-shooting purposes on existing equipment.

The tester in this article is inexpensive to construct since it has been designed to use a surplus 1mA meter, which many constructors will already have in the "junk box". Meters of lower current rating can of course be used if a suitable shunt is fitted, but a scale calibrated in decade steps is to be preferred since it simplifies the reading of gain.

Instead of the more usual transistor holders mounted on the case the author has chosen to have three small crocodile clips hanging from the panel on short leads; holders are more expensive, prone to failure since they are not designed for continuous use and are in any case useless for components taken from equipment or "breadboards". The clips are cheap, robust and will accommodate practically anything.

CIRCUIT ACTION

The principle of operation is about as simple as possible, as can be seen from the circuit diagram of Fig. 1. Switch S1 selects OFF, PNP, or NPN; the circuit is the same in both cases but the battery and meter polarities are reversed. In the OFF position a short is applied across the meter terminals, always a good practice where possible as it provides heavy damping to the movement and thus helps to prevent damage in transit.

Switch S2 in position 1 connects the meter as a voltmeter in the collector circuit and leaves the base open circuit. Thus if the transistor under test is short circuit, a high reading will be obtained, but leakages up to 200μA or so can be read without too much loss of sensitivity due to the series resistance. Small transistors with a leakage higher than this will normally be useless.

Diodes can be checked in this position by connecting them between the *E* and *C* leads; S1 can then be used to apply forward and reverse current tests. In addition shorting *E* to *C* checks the internal battery voltage, though it should be noted that there is no appreciable load on the battery whilst this is being done.

Switching S2 to either test position connects the meter as a collector current monitor and applies a bias current to the base connection of approximately 10μA. The common emitter current gain (h_{FE}) of a transistor is given by its collector current divided by its base bias current, so a transistor with a gain of, say, 400 would give a collector current of $\frac{10 \times 400}{1000}$ mA, =4mA which can easily be read in the high gain position, where the meter is shunted to read 10mA full scale.

For a gain of less than 100, S2 should be moved to the low gain

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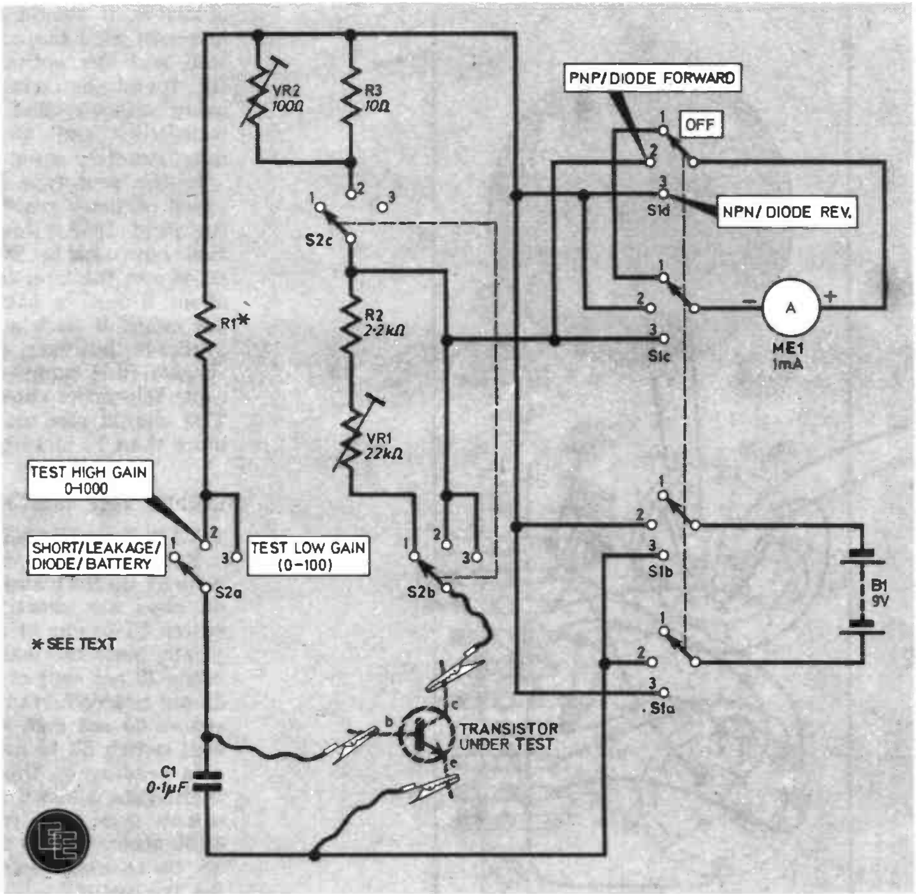


Fig. 1. Circuit diagram of the Transistor Checker.

position, where a full scale deflection of 1mA thus reads gains of 0 to 100. The capacitor C1 is included to prevent noise or stray hum fields, etc., causing errors in readings.

CONSTRUCTION

The unit is based on two 4-pole 3-way "wavechange" switches, only 3 poles of S2 being used. A 10-way tagstrip provides mounting for the two presets and anchorage for the three connector leads, see Fig. 2. Actual layout in the case will depend on the components available, particularly the meter, but should present no problems to the constructor. The prototype was built into a home-made aluminium box, approximate size 200 x 90 x 45mm, the front panel layout is given as a guide in Fig. 2. The wiring, particularly of the switches, can be a little tricky and the use of several different coloured wires is recommended. Tick off the wires on the diagram of Fig. 2 as they are connected.

SETTING UP

Potentiometer VR1 has to be adjusted to give meter full scale on the available battery voltage. Switch S1 to either "on" position, S2 to position 1, short leads *E* and *C* together and adjust VR1 for full scale.

Potentiometer VR2 is the 10mA shunt adjustment. Using the test arrangement shown in Fig. 3, switch S1 to PNP, S2 to position 2, adjust the 1 kilohm potentiometer to give a current flow of 10mA from *E* to *C*, and adjust VR2 for full scale on the meter. If the

Components

Resistors
- R1 See text
- R2 2·2kΩ
- R3 10Ω

Potentiometers
- VR1 22kΩ miniature skeleton presets
- VR2 100Ω miniature skeleton presets

Miscellaneous
- C1 0·1μF plastic or ceramic capacitor
- ME1 1mA d.c. moving coil meter
- S1, S2 4-pole 3-way switches (2 off)
- B1 9V type PP3

10-way tagstrip; pointer knobs (2 off); crocodile clips (3 off); 6BA fixings; coloured connecting wire; case. battery clips

See Shop Talk Page 63

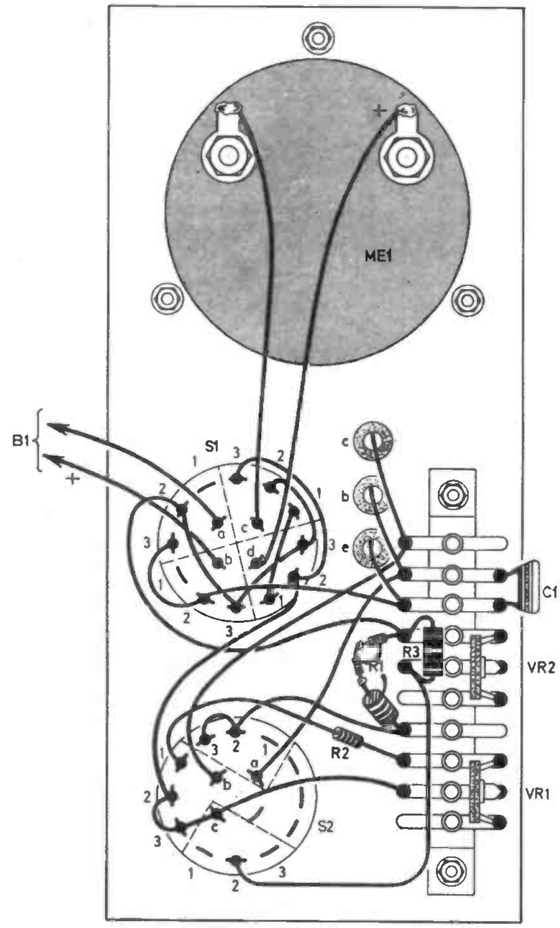
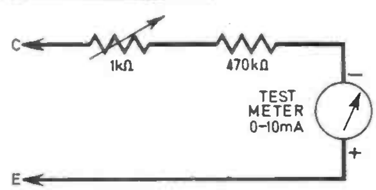
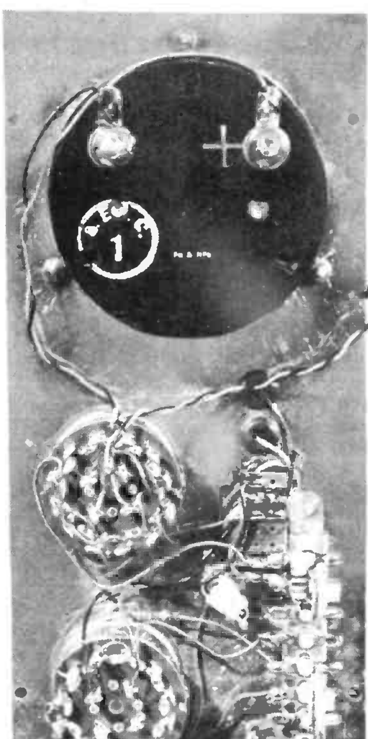


Fig. 2. Layout and wiring of the Transistor Checker.
Fig.3 (Right). Test arrangement.





adjustment proves tricky an increase in the value of R3 may prove helpful.

Finally the value for the bias resistor R1 has to be selected. The current through this should ideally be 10μA, but is dependent upon the voltage across it, which consists of the battery voltage less the base-emitter voltage drop of the transistor being tested. The latter differs a little according to the type of transistor, in particular whether it is a silicon or germanium variety, so the actual value of resistance used must necessarily be something of a compromise.

If a meter capable of reading 10μA with reasonable accuracy is available, it should be connected in series with the base connector lead and the optimum value of R1 found by trial and error, using silicon and germanium transistors and aiming for an approximately equal error.

In the prototype R1 was composed of three resistors in series (to yield 10μA); tests were carried out with a BC109 and an OC44 and the final error was only about 0·5μA in each case (or 5 per cent). If such a meter is not available, however, a 910 kilohm resistor (E24 range) of 1 or 2 per cent tolerance should be used. This should give an error of not more than 10 to 15 per cent.

USING THE INSTRUMENT

TO TEST A TRANSISTOR

Ensure S1 is OFF, S2 at LEAKAGE, connect up the transistor, ensuring no clips are shorting, and then switch S1 to PNP or NPN as appropriate. Note the leakage. If it exceeds 20 per cent of scale (200μA) do not proceed. Many silicon transistors do not leak at all. If all is well switch S2 to HIGH GAIN for a gain reading on the 0-1000 scale. If the gain is less than 100, switch to LOW GAIN for a reading on the 0-100 scale. Return S1 to OFF and S2 to LEAKAGE before removing the transistor.

TO CHECK A DIODE

Connect cathode to *E*, anode to *C* and ensure S2 is set to DIODE. S1 at PNP then applies forward bias and should give a fairly high reading; S1 at NPN gives a reverse leakage test.

The battery can be checked by switching S2 to BATTERY and S1 to either on position, the meter should read full scale.

Care must be taken to avoid shorting the *E* and *C* leads in either gain position as this could lead to damage to the meter.

This unit will test most small transistors and silicon power types, although the low collector currents used may lead to inaccurate gain readings with the latter. Early germanium power types such as the OC36 often have leakage currents in excess of 1mA and so cannot be checked.

Finally, purists may observe that to test an NPN transistor one has to pass the switch through the PNP position and thus subject it to a reversed supply; a separate supply switch could be used to avoid this if desired. ⌑

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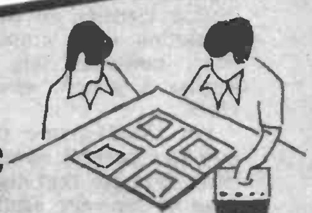

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MARCH ISSUE ON SALE FRIDAY, FEBRUARY 18

Electronic

STOP CLOCK

By R. A. PENFOLD

THERE are many sports, scientific experiments in schools, and other fields of interest where a simple stopclock can prove to be extremely useful. It is possible to produce an electronic equivalent of either conventional analogue or digital timing devices, admittedly digital circuits do offer greater resolution than simple analogue ones; however, this article describes a simple analogue stopclock.

For the beginner this type of unit has several advantages. The main ones are that digital circuits tend to be very easily damaged during construction, and they tend to be far more complicated and expensive even when using modern technology and components. The unit described here is based on a couple of very rugged and inexpensive operational amplifier integrated circuits, and a few discrete components.

Three ranges are covered, and these are 0 to 10, 25, and 100 seconds. The unit is completely portable with power being obtained from a couple of internal 9 volt batteries. These have an extremely long life as current consumption is only about 2 to 3 milli-amps. A battery check circuit is incorporated in the design.

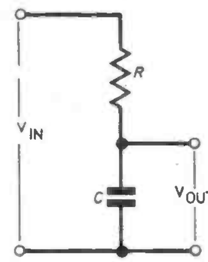
OPERATING PRINCIPLE

The circuit operates on the simple principle that if a capacitor is fed from a voltage source via a resistor, it will store the current that flows into it and the voltage across it will gradually increase. This basic set-up is shown in Fig. 1 (a).

If the voltage across the capacitor was to rise at a linear rate, by using a meter to measure the voltage across the capacitor, and calibrating the meter in seconds, a simple stopclock could be produced. Unfortunately the voltage across the capacitor does not rise in a linear fashion, but gives what is termed an exponential curve if voltage is plotted against time on a graph. This is shown in Fig. 1 (b).

This means that a stopclock based on this simple idea would have a non-linear scale, and each time division of the scale would have to be located and marked by the constructor. This is virtually an impossible task in practise.

The reason that the voltage across the capacitor does not rise linearly is that as the voltage across the capacitor increases, the remaining supply volts that are developed across the resistor decrease. Therefore as time passes the voltage across the resistor decreases, and so does the charge current to the capacitor in consequence. For the system to function properly some means of maintaining a steady voltage



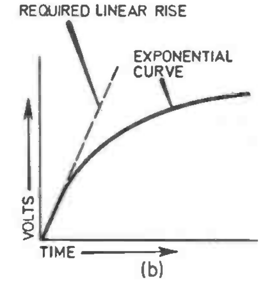
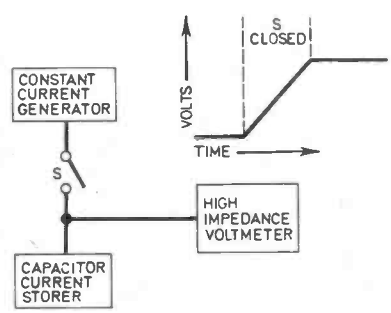


Fig. 1a. Basic circuit. (b) Exponential charge curve.

HOW IT WORKS

While switch S is closed a constant current is fed to a capacitor. The current is stored by the capacitor and in consequence the voltage across the capacitor increases as time elapses. The charge voltage is read by a high impedance voltmeter, and there is a linear relationship between elapsed time and charge voltage.

If the voltmeter is adjusted so that, for instance, S has to be closed for 10 seconds to produce full scale deflection of the meter, half f.s.d. will be reached after 5 seconds. The meter can thus be given a linear scale calibrated in seconds, and an electronic stopclock with a range of 0–10 seconds is produced.



across the feed resistor is required, so that the capacitor charge current remains constant and a linear scale is obtained.

OPERATIONAL AMPLIFIER

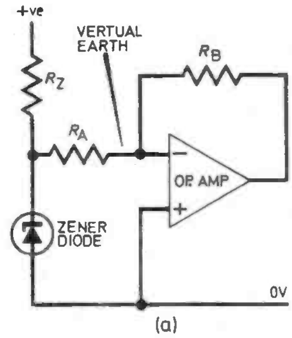
An operational amplifier can be used to provide the basis of a precision constant current generator, and the basic configuration for this is shown in the circuit of Fig. 2 (a).

An operational amplifier has two inputs, an inverting one (−) and a non-inverting one (+). It also has a very high voltage gain, this being typically 200,000 for the 741C devices used here. The output voltage is equal to the voltage between the inputs multiplied by the voltage gain of the i.c. Obviously only a minute voltage difference is required at the inputs in order to send the output fully positive or negative.

When the non-inverting input is positive of the inverting input the output goes positive of the OV rail, and when it is negative of the inverting input the output is also negative. For those who are unfamiliar with op. amp. circuits it is perhaps worthwhile mentioning here that the device is powered from equal positive and negative supplies, and that the output can have either polarity with respect to the OV supply line.

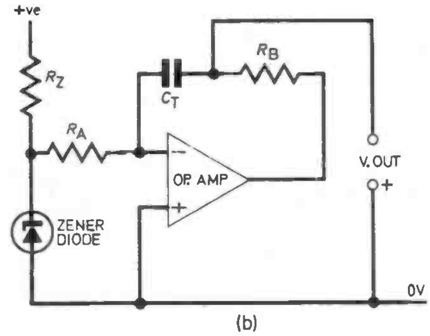
Resistor R_Z and D_Z form a Zener shunt rgeulator and a positive stabilised voltage is fed from the junction of these to the inverting input of the op. amp. The non-inverting input is connected to the OV line, and so this input is negative. With respect to the inverting one. This causes the output to swing negative of the OV rail, and a current will flow via R_B. This has the effect of counteracting the current flow via R_A, and brings the voltage at the inverting input to fractionally above the OV rail potential. The circuit will always try to balance with the inverting input at virtually the same potential as the non-inverting input, or at earth potential in other words. What is known as a virtual earth is formed at the inverting input, and this is encountered frequently in contemporary circuits.

A constant current is generated through R_B as, if its value is made small, the output will only be slightly negative of earth in order to balance the current through R_A. If it is given a large value a higher output voltage will be produced in order to maintain a balance. The level of the current through R_B is set by the values given to R_A and the Zener, and is in fact equal to the current flow through R_A.



(a)

Fig. 2 (a). Basic constant current arrangement.



(b)

Fig. 2(b). Circuit configuration to obtain a linear ramp.

RAMP GENERATOR

By inserting a capacitor between the virtual earth and R_B, a linear negative ramp output is obtained. This idea is shown in Fig. 2 (b). Here the output voltage will initially balance the circuit exactly as before, but as the voltage across C_T begins to build up, the voltage at the amplifier output will swing more negative in order to maintain a constant current through R_B. A linear ramp is thus produced across C_T.

PRACTICAL CIRCUIT

The circuit diagram of the stopclock is shown in Fig. 3. Components R1, R2, R3, and TR1 form a simple but highly effective regulator circuit that has an output voltage of approx. 3·6V. This voltage is fed to the i.c. by way of one of the switched resistors, R4 to R6. These are the equivalent of R_A of Fig. 2, and R7 to R9 are the equivalents of R_B. These give the unit its three timing ranges by producing three levels of charge current.

When S3 is in the right hand position, C1 is charging, and when it is in the opposite position one of the resistors R7 to R9 maintain the virtual earth at the inverting input. Switch S4 can be used to discharge the capacitor so that the charging process can be started from the beginning once again.

It is extremely important that the voltmeter takes a negligible current from C1, as otherwise it would noticeably discharge C1 and a steady reading would not be obtained at the end of the timing period.

Meter ME1 and one of the presets VR1 to VR3 form the voltmeter, a different preset is used on each range so that the unit can be separately calibrated on each range. Amplifier IC2 is wired as a unity gain buffer amplifier and is interposed between the output of the ramp generator and the input of the voltmeter in order to boost the input impedance of the voltmeter to an extremely high level.

Switch S2 is the function switch; in position 1 the unit is off, in position 2 it is on, and in position 3 the meter is connected to the positive supply line through R10. This last position enables the positive supply voltage to be measured as R10 converts the meter to a 0-10 voltmeter.

COMPONENT PANEL

Some of the components are wired up on a 0·1 inch matrix

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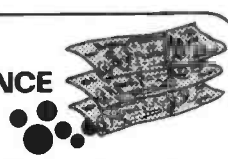

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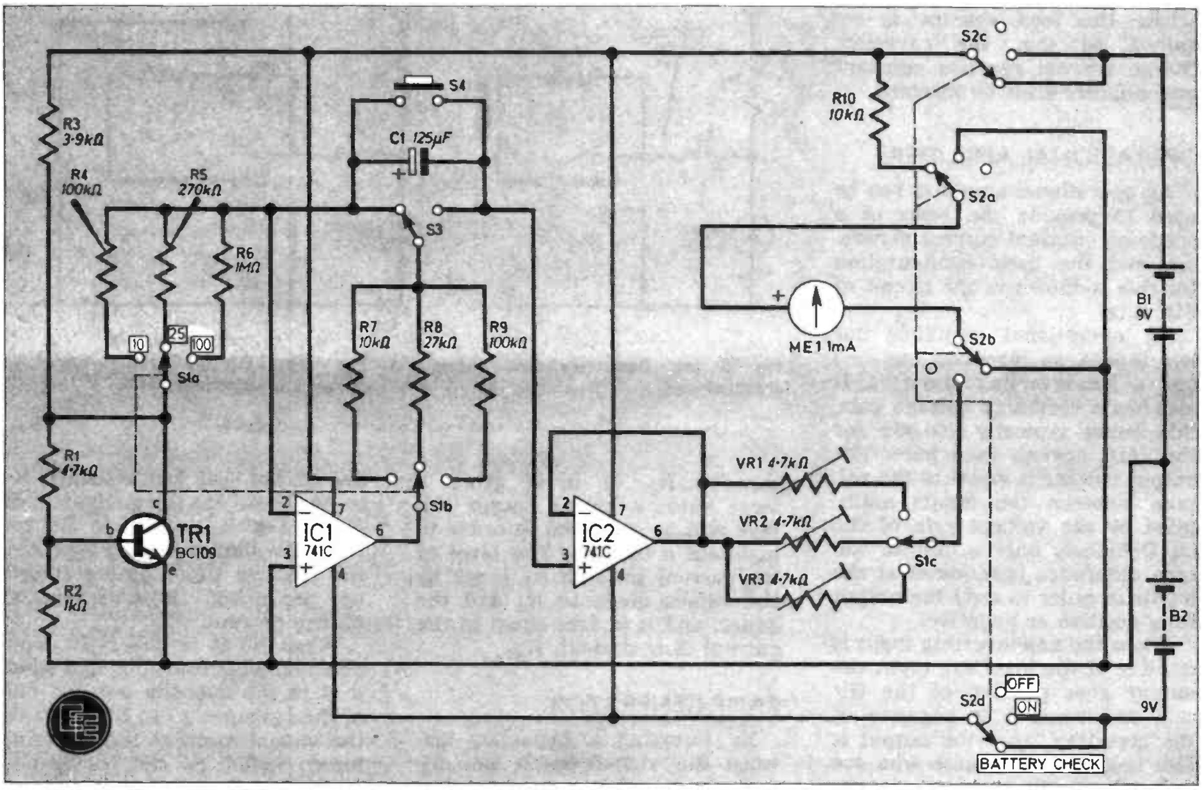


Fig. 3. Circuit diagram of the Electronic Stop Clock.

Veroboard panel. This has 34 holes by 18 strips, and Fig. 4 shows full details of the panel which must be cut down from a larger piece of board using a hacksaw. Then the two 6BA clearance mounting holes are drilled using a 3·2mm twist drill. There are 16 breaks in the copper strips which are made using the special tool or a small (about 4mm) hand held drill. Next the components and link wires are soldered in, starting with the link wires and leaving the i.c.s and transistors until last. Be careful not to bridge any of the copper strips with excess solder when soldering in the components, e s p e c i a l l y when working on the i.c.s.

CASE

A 205 × 140 × 75mm Verobox makes a very neat and attractive housing for the unit, but any case of about the same size can be used. The general layout of the unit can be seen by referring to the accompanying photographs; the layout is not critical. An edgwise meter is used on the prototype and this gives a long

Components

Resistors

R1	4·7kΩ
R2	1kΩ
R3	3·9kΩ
R4	100kΩ
R5	270kΩ
R6	1MΩ
R7	10kΩ
R8	27kΩ
R9	100kΩ
R10	10kΩ

All ¼W Carbon ± 5%

Potentiometers

VR1	4·7kΩ skeleton preset
VR2	4·7kΩ skeleton preset
VR3	4·7kΩ skeleton preset

Capacitors

C1	100μF 10V elect.

Semiconductors

TR1	BC109 silicon npn
IC1	741 differential op-amp 8 pin d.i.l.
IC2	741 differential op-amp 8 pin d.i.l.

Miscellaneous

ME1	1mA d.c. moving coil edgwise panel meter
S1	3 pole-3 way rotary switch
S2	4 pole-3 way rotary switch
S3	miniature s.p.d.t. toggle
S4	push-to-make release to break push button type
B1, 2	9V type PP3 (2 off)

Stripboard 0·1 inch matrix size 18 strips × 34 holes; Verobox type 1411 (205 × 140 × 75 mm); control knobs (2 off)

See Shop Talk page 63

ELECTRONIC STOP CLOCK

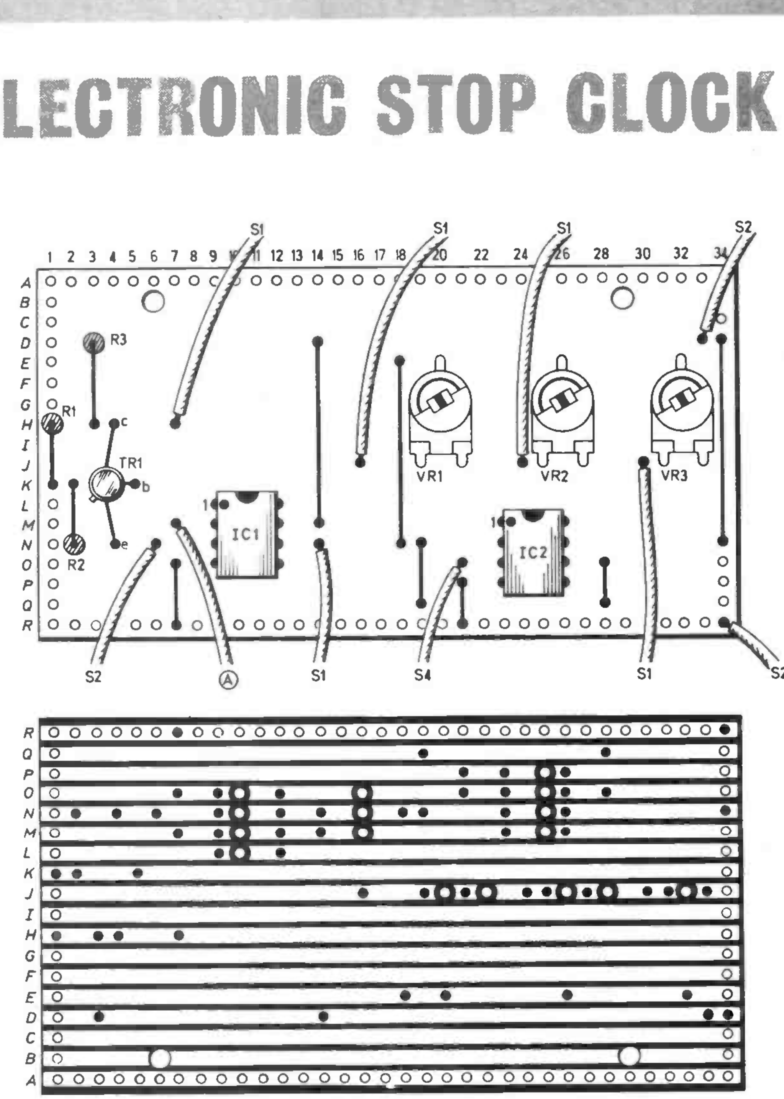


Fig. 4. Layout and wiring of the component board.

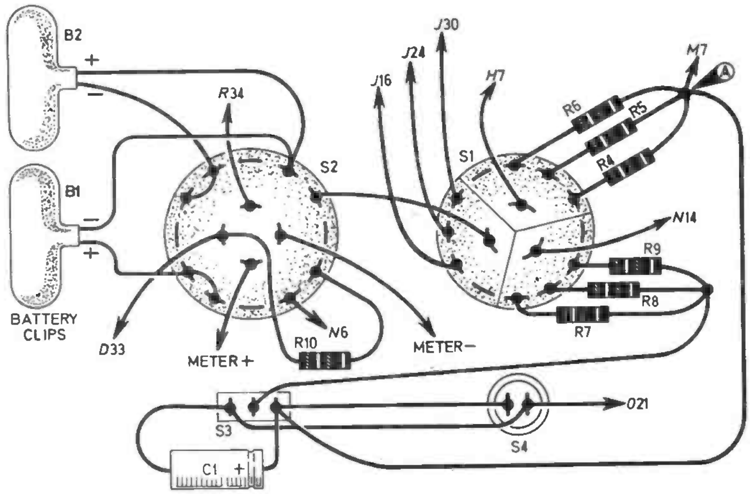


Fig. 5. Interwiring of the complete unit.

scale for the amount of panel space occupied by the meter. However, any 1mA moving coil meter can be used.

Veroboxes have a rather hard and thick front panel, and probably the easiest way of making the cutout for the meter is to drill a series of small closely spaced holes (about 3mm dia.) around the periphery of the required hole, just inside the line marking the border of the cutout. These holes are then joined up using a miniature round file, and finally a flat file is used to smooth and enlarge the edges of the hole, as required.

WIRING

Several of the components are mounted on the controls, and the wiring to these is shown in Fig. 5. This is all quite straight forward and should present no problems provided the ends of the leadouts and tags are well tinned with solder prior to attempting to complete a joint. Ensure that the leads to the component panel are long enough to enable it to be mounted in its intended position.

The component panel is mounted on the base of the case using two 25mm 6BA bolts with nuts. It is advisable to use a couple of short (6mm) spacers to hold the panel a little way clear of the case in order to prevent possible damage to the board as the mounting nuts are tightened. If a metal case is used these spacers are obviously essential.

The two PP3 batteries are placed vertically on a piece of foam rubber or a similar material, so that they are held firmly in place when the lid of the case is screwed on.

CALIBRATION

Before turning the unit on, give the wiring a thorough check and adjust the preset resistors to insert maximum resistance into circuit (turned fully clockwise).

A clock with a seconds hand is required for calibration, and with the unit turned on and switched to Range 1, S3 is put in the on position for 10 seconds, VR3 is then adjusted for precisely full scale deflection of the meter. Always press S4 to ensure that the meter is electronically zeroed before starting the unit. Some initial adjustment of the mechanical zero set screw may also be required.

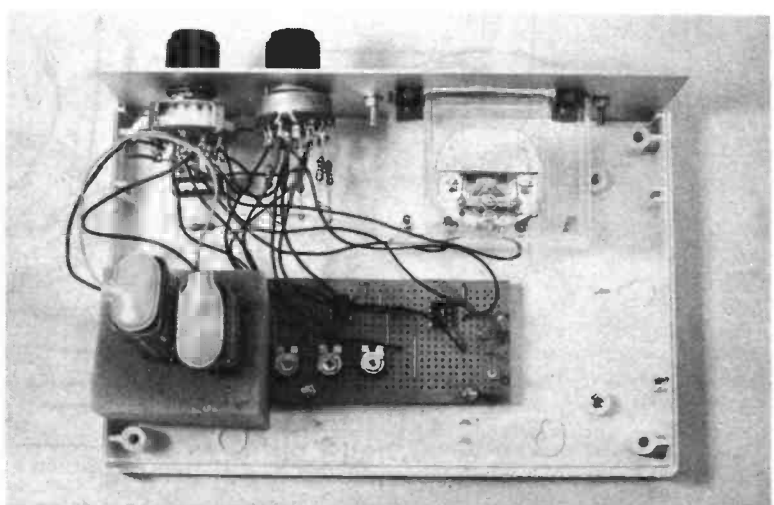
Ranges 2 and 3 are adjusted in much the same way as Range 1, except that S3 is held in the on position for periods of 25 and 100 seconds, and VR2 and VR1 respectively are adjusted for f.s.d. of the meter. Carry out the calibration process as precisely as possible, as the care taken here largely determines the accuracy of the finished unit.

A 0-25 scale can be added to the meter if desired, but this is by no means essential as it is quite easy to convert the obtained reading into seconds, since most 1mA meters have 25 scale divisions. If a new scale is to be added, take great care not to harm the delicate meter movement during this process.

Make a mental note of the battery voltage initially indicated by ME1 with S2 in the check position. The battery should be replaced when the indicated supply voltage has fallen about a volt or so below this figure.

Note that in some applications it is possible to operate the unit automatically via a microswitch or a photoelectric circuit/high speed relay combination: these being connected in place of S3. There is plenty of scope here for those who like to experiment.

Also the unit can be modified to operate over a quite short timing range. For instance, with R4 at 10 kilohms and R7 at 1 kilohm, Range 1 would cover 0 to 1 second f.s.d. ⌑

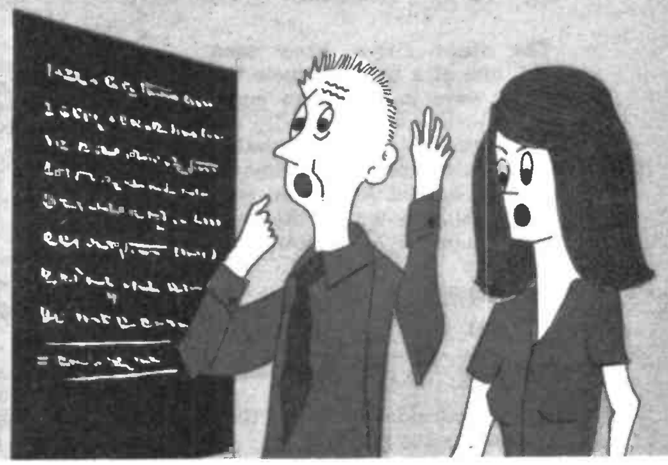


DO MATHS BOTHER YOU?...

LET'S FIGURE IT OUT

Part 3

By PHIL ALCOCK



LET us use some of the ideas presented and see if we can figure out a few problems.

TOLERANCE

A capacitor is checked on a component bridge and the value of 0·2μF is obtained. The capacitor is marked 0·22μF ± 20%. Is the component within the specified tolerance?

Answer

Yes. The tolerance of ± 20% means that the capacitor can be high or low by one fifth of the nominal value (20% equals "twenty hundredths" which is one fifth). The value should lie in the range 0·22μF ± 0·044μF, and so our component is well within the specified tolerance. We are assuming in this question that the result of the bridge test is sufficiently accurate for our purposes. A good bridge will usually give a result which is within about 1 per cent of the true component value. This degree of uncertainty in the component value is small compared to the tolerance being investigated.

PARALLEL RESISTORS

How can I work out the value of a resistor, to go in parallel with a given resistor, so that I get a particular value of effective resistance from the combination?

Answer

This is an interesting question and gives us a chance to use a simple equation. [Now then, don't run away—we have done all the work already.] First we work out the equation to use, so let us consider the circuit in Fig. 3.1.

Let *R1* represent the existing resistor (value known). Let *R2* represent the resistor whose value is to be found. Let R_e represent the effective value of *R1* and *R2* in parallel. If a battery is connected to *A* and *B* (positive to *A*, negative to *B*) current will flow as shown in Fig. 3.1. Using Ohm's Law and calling the voltage, between *A* and *B*, V_{AB}, we may write

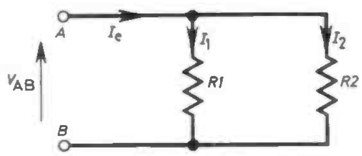


Fig. 3.1. Resistors in parallel.

$$I_1 = \frac{V_{AB}}{R1} \quad (\text{Current} = \frac{\text{Voltage}}{\text{Resistance}})$$

$$I_2 = \frac{V_{AB}}{R2}$$

Total current $I_e = I_1 + I_2$

$$\text{or} \quad I_e = \frac{V_{AB}}{R1} + \frac{V_{AB}}{R2} \qquad (1)$$

Since the current I_e must also represent the current that would flow in the effective resistance of *R1* and *R2* in parallel, which we are calling R_e, we may write

$$I_e = \frac{V_{AB}}{R_e} \qquad (2)$$

Comparing equations (1) and (2) which are identical on the left hand sides (both I_e) we see that

$$\frac{V_{AB}}{R_e} = \frac{V_{AB}}{R1} + \frac{V_{AB}}{R2} \qquad (3)$$

Every term on both sides of equation (3) can be divided by V_{AB} without changing the "balance" of the equation. This simplifies the equation by cancelling V_{AB} which is common to every term and gives

$$\frac{1}{R_e} = \frac{1}{R1} + \frac{1}{R2} \qquad (4)$$

Equation (4) is the equation we require, since it relates the values of *R1*, *R2* and R_e. An example will illustrate its use. Let us assume we require a resistance (R_e) of 5kΩ and *R1* is known to be 15kΩ.

From (4), with *all* values expressed in kΩ units

$$\frac{1}{5} = \frac{1}{15} + \frac{1}{R2} \qquad (5)$$

Multiply both sides of (5) by 15 to "remove" the fractions

$$15 \times \frac{1}{5} = 15 \times \frac{1}{15} + 15 \times \frac{1}{R2}$$

OR, more simply

$$3 = 1 + \frac{15}{R2} \qquad (6)$$

Subtract 1 from each side to give

$$2 = \frac{15}{R2}$$

Multiply both sides by *R2* to give

$$2\,(R2) = 15$$

Divide each side by 2 to get the required answer

$$R2 = \frac{15}{2} = 7{\cdot}5\text{k}\Omega \qquad (7)$$

The steps above have been listed, one at a time, to show the various ways in which an equation can be manipulated. We could have done the manipulation first and then put in the known values of R_e and $R1$ at the end. Doing it this way we get the same answer (hopefully) as follows.

Subtract the quantity $1/R1$ from *both* sides to give

$$\frac{1}{R_e} - \frac{1}{R1} = \frac{1}{R2}$$

Multiply both sides by R_e and then $R1$ (two steps) to get, first

$$1 - \frac{R_e}{R1} = \frac{R_e}{R2}$$

then $R1 - R_e = \dfrac{R1 \times R_e}{R2}$

Multiply by $R2$ on both sides

$$R2\,(R1 - R_e) = R1 \times R_e$$

Divide both sides by $(R1 - R_e)$

$$R2 = \frac{R1 \times R_e}{(R1 - R_e)}$$

This last equation gives a "formula" for solving this kind of problem since it gives us the required $R2$ value in terms of the known values of $R1$ and R_e. Putting in the figures (all in kΩ as before)

$$R2 = \frac{15 \times 5}{(15 - 5)} = \frac{75}{10} = 7{\cdot}5\text{k}\Omega$$

With practice these steps in manipulating an equation will become easier. Do not forget to think of the equation as a "balance." Practice with simple figures at first so that you do not confuse the issue with (doubtful) arithmetic.

POWER DISSIPATION

How can the power dissipation in a transistor be calculated?

Answer

The method may depend on the circuit arrangement. Let us consider the arrangement shown in Fig. 3.2.

With this kind of circuit (if it has been well designed) it is usually possible to assume that (a) the base-emitter voltage is steady at 0·6 volt (for a silicon transistor)

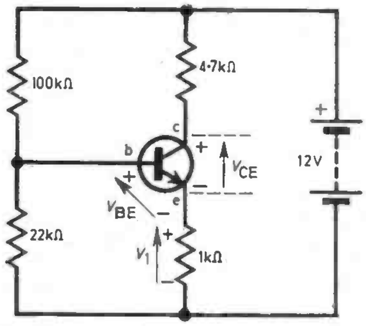


Fig. 3.2. Transistor arrangement devised for discussion on power dissipation.

and (b) the base current is negligibly small, since modern transistors usually have a gain of 50 or more. A gain of 50 would mean that the base current was about 2 per cent of the total emitter current.

Studying the circuit we see that the emitter current will produce a voltage drop V_1 across the 1kΩ resistor, and if we neglect the base current we can write:—

$$\left(\frac{22}{100 + 22}\right) 12 = V_{BE} + V_1$$

The term in the brackets on the left hand side, is the current flowing in the 100kΩ and 22kΩ series combination due to the 12 volt supply voltage and will be in milliamps, since the resistance values are in kilohms. Multiplying this current by 22 gives the voltage across the 22kΩ resistor and this must always be equal to the sum of V_{BE} and V_1.

Using our "rule of thumb" value for V_{BE} and writing $V_1 = (1 \times I_e)$ volts, where I_e is in mA, we get

$$\frac{12 \times 22}{122} = 0{\cdot}6 + I_e$$

Multiplying both sides by 122 gives

$$264 = 73{\cdot}2 + 122\,I_e$$

Subtract 73·2 from both sides and then divide by 122 to give

$$\frac{190{\cdot}8}{122} = I_e \simeq 1{\cdot}56\text{mA}$$

The voltage across the 4·7kΩ collector resistor is given by

$$1{\cdot}56\ (\text{mA}) \times 4{\cdot}7\ (\text{k}\Omega) \simeq 7{\cdot}35 \text{ volts.}$$

We can now work out the voltage "left" between collector and emitter.

$$V_{CE} = 10 - 7{\cdot}35 - 1{\cdot}56$$
$$= 1{\cdot}09 \text{ volts}$$

The transistor power dissipation is given by the product of $V_{CE} \times I_e$ and is approximately 1·7mW. With power transistors much higher values of dissipation will be obtained since current levels of several amperes are often involved.

RADIO COIL

A coil of wire is wound on a ferrite rod for a radio aerial circuit. How can the coil resistance be calculated?

Answer

To solve this problem we must know the size of wire, so that the resistance of a specific length can be obtained from wire tables, and the actual wire length. The wire length can be calculated by multiplying the length of one turn by the number of turns. Since the length of one turn is approximately $\pi \times$rod diameter, if the wire is thin, we can write

coil resistance = (coil wire length in metres)×(wire resistance for 1 metre).

To make the problem more interesting we will assume that our information comes from various sources and the units are mixed up!

Wire (old stock) 38 SWG, 283 omhs per 1,000ft

Ferrite Rod Diameter = 10mm

Number of turns equals 300

The wire length is

$$\left[\,300 \times \frac{22}{7} \times 10\,\right] = \frac{66{,}000}{7}\text{mm}$$

The resistance of the wire will be

$$\frac{283}{1{,}000} = 0{\cdot}283 \text{ ohms per ft}$$

But 1ft equals (12×25·4)mm. To change the length of wire from millimetres to feet we must divide by (12×25·4).

Hence length of wire

$$= \frac{66{,}000}{7 \times 12 \times 25{\cdot}4}\text{ft}$$

and the coil resistance is therefore given by

$$\text{resistance} = \frac{66{,}000 \times 0{\cdot}283}{7 \times 12 \times 25{\cdot}4}\text{ohms}$$

$$\simeq 8{\cdot}75 \text{ ohms}$$

In subsequent articles it may be possible to cover some other useful topics.

Physics is FUN!

By DERRICK DAINES

Calibrating a Meter

SO ONE day you're sitting there, staring at an unknown meter. Does it work? Can it be used? Perhaps it has some sort of calibration scale on it already, perhaps it has the maker's name and incomprehensible hieroglyphs, or perhaps it has no markings. Can you use it as the basis of an inexpensive multi-test meter? Take heart. If it works at all it can be used. Just read on . . .

One thing is sure—the meter itself is going to tell you nothing, no matter how long you stare at it. You must winkle out all its little secrets for yourself and the first one to be winkled out is the internal resistance of the meter.

There are various ways of doing this, but probably the best way is illustrated in Fig. 1.

It does not show a particular voltage for the battery supply because it is not important. Any voltage will do from (say) 2·5 volts to 50 volts.

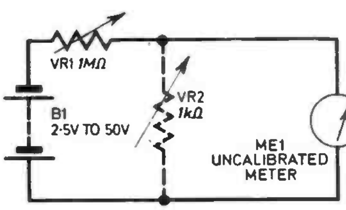


Fig. 1. Circuit for finding the internal resistance of a meter movement.

Wire up the circuit omitting VR2 altogether and wind up VR1 to maximum resistance before switching on. Now slowly turn VR1 down until the meter shows full-scale deflection (or f.s.d. for short). Do not touch VR1 again. Put VR2 into circuit and adjust it until the meter shows exactly half f.s.d. Switch off the battery supply. The resistance of VR2 can now be measured and it will be exactly equal to the internal resistance of the meter. Make a careful note.

Some readers may not have facilities for measuring the value of VR2 and indeed may be setting out to make a multi-test meter to do exactly that. Do not despair. Instead of VR2 we take a handful of 5 per cent resistors, substituting one at a time until we find one that gives us the requisite half f.s.d.

Now we know the internal resistance of the meter and the only other thing we need to know is the current consumed by the meter at f.s.d. A battery source of a known voltage is required and it is suggested that a fresh 9 volt battery is used. Wire up the circuit shown in Fig. 2. Start with VR1 at maximum and slowly wind it down until the meter shows f.s.d. Switch off and measure the resistance of VR1 (or use fixed resistors as before). Now comes the nasty bit—the arithmetic. Actually, it's not very difficult to do on paper, easier if you've got a pocket calculator and simplicity itself is there's a tame teacher hovering about!

The current used in the little circuit depends upon (a) the supply voltage, *E* (known), (b) the overall resistance,

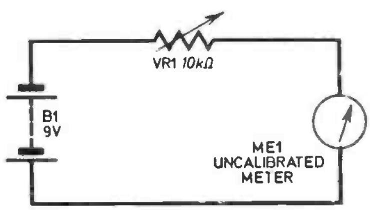


Fig. 2. Circuit for finding the sensitivity of the meter movement.

and that includes the resistance of the meter itself. So, add together the measured or known resistance (*Rs*) and the known resistance of the meter (*Rm*). Divide this total into the known supply voltage, giving the required current consumption of the meter at f.s.d.

Thus $\frac{E}{R_s + R_m} = I$. Looks familiar? It should!

If possible, repeat the experiment and calculations with different supply voltages.

Theoretically, all the results should be identical, but errors creep in at various places, which illustrates the advantage of repeating the work with different supply voltages, and the mean value taken.

Currents in excess of f.s.d.

Now we know all there is to know about the meter and we can consider what to do with it. Suppose we wish to use the meter to show current consumption. As long as the requirement is not greater than the meter is capable of carrying then all is well, but if I wish to measure larger currents I must have recourse to shunt resistors (Fig. 3), where some or most of the current is shunted through the resistor. The choice of resistor is another simple bit of arithmetic. First divide the *required* f.s.d. current by the *actual* f.s.d. current —this gives us the multiplier needed.

Suppose we have a 140μA 700 ohm meter and wish the meter to show ·001

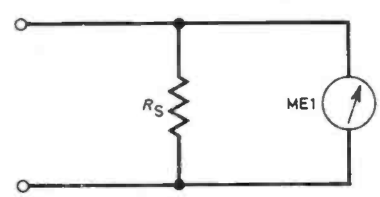


Fig. 3. Wiring of a shunt resistor to alter the sensitivity of the unit.

amp (1mA) at f.s.d., then 0·001 divided by 0·00014 gives 7·142. That is to say, we must somehow multiply the current consumption by that figure. The shunt resistor required is obtained by dividing the internal resistance of the meter by the multiplier *less* one, i.e.

$R_{shunt} = \frac{R_m}{(N-1)}$ where *N* is the derived multiplying factor. In the example (7·142 − 1) is 6·142 and if this is divided into the 700 ohm resistance of the meter, a shunt resistor value of 113·9 ohms (or 114 ohms) is derived.

The Extraordinary Experiments of Professor Ernest Eversure

by Anthony John Bassett

THE Prof. is being visited in his Laboratory by Tom and Maurice who have been asked to help organise a charity event. Bob has just helped the Prof. and the boys to assemble a loudspeaker impedance-converter in order to solve problems they were having with the sound-system, and the Prof. instructed his amazing electronic Robot to do some of the routine assembly work, so that now they have time for one or two more projects before the event opens.

GAME OF SKILL

From under the flap of Tom's large satchel projected about 100mm of wooden object, and as Tom opened the satchel, and removed this item, which had been crammed in with great difficulty, and proceeded to bend back into shape a piece of thick metal wire which followed an uneven zigzag course from one end of the wood to the other.

Bob exclaimed, "I know what that is, it's a *try your skill* game. You try to thread a small metal ring along the zigging wire from one end to the other without making contact. If you do make contact, this completes a circuit, and a bell rings and a lamp lights!"

"Yes," replied Tom, "and this is something else we had a problem with at the last Charity Fair. First we tried making one with a thick copper wire, but because the copper wire was soft, it did not keep its shape, and soon began to sag. Then we tried using brazing-rod, which was better than the copper because it is harder, but it has a tendency to snap easily after it has been bent. Now this one is made of 1·5mm mild-steel rod (available from a pet-shop, which sells it for the purpose of making birdcages).

"It amazes me that such a simple project should present such problems and require so much effort to solve them. I really admire the scientists who persist with great determination on much more difficult problems, and the technologists whose efforts and skills makes these inventions and designs into practical working projects which can be of great benefit to mankind.

"But would you believe, having tried copper wire, aluminium wire, which I could not solder, brass and various other metallic wires, although the steel birdcage-wire is the best so far, there is still a problem with it which I am trying to solve. I don't really suppose it could possibly be solved by electronics means, I thought I'd ask to see whether the Prof. could help in any way.

"You see, Prof., although this wire keeps its shape quite well and does not snap as easily as the brass, the problem is that, unlike the copper and brass wire, it makes large yellow sparks when the ring touches the wire and completes the circuit. Although the sparks are harmless, they are frightening to some people who would otherwise use the *test your skill* in aid of our charity.

"I was thinking of electrolytically copper-plating the wire to solve this problem, but I doubt if I could easily put on a layer of copper sufficiently thick to last for very long. I wonder whether you have any ideas which would help?"

"Yes, Tom. Because you are using both a bell and a lamp, this means that there is quite a heavy current through the wire, which is the cause of the sparking. The electrical energy released at the points of contact breaks away microscopic pieces of steel which burn up in a moment to produce yellow sparks.

"Bob and I have recently been discussing ways of using transistors to reduce current through electrical contact points to prevent sparking, sticking and burning of the contacts, and I think a similar type of circuit could be used with your *Steady Hand Tester* game."

TIME DELAY

The Prof. quickly thumbed his way through a notebook until he came to the circuit diagram shown in Fig. 1.

"This diagram shows a circuit which I tried about a year ago and it was quite successful. When the ring touches the wire, C1 charges rapidly through R1 and VR1, and when the voltage across C1 reaches about 1 volt the transistors conduct, the lamp lights and the bell rings for a period which is dependent upon the charge on C1 and its time constant together with the value of resistor R2.

"By increasing the resistance of VR1, the time delay before the bell rings is increased, which gives a handicap advantage according to the setting of VR1.

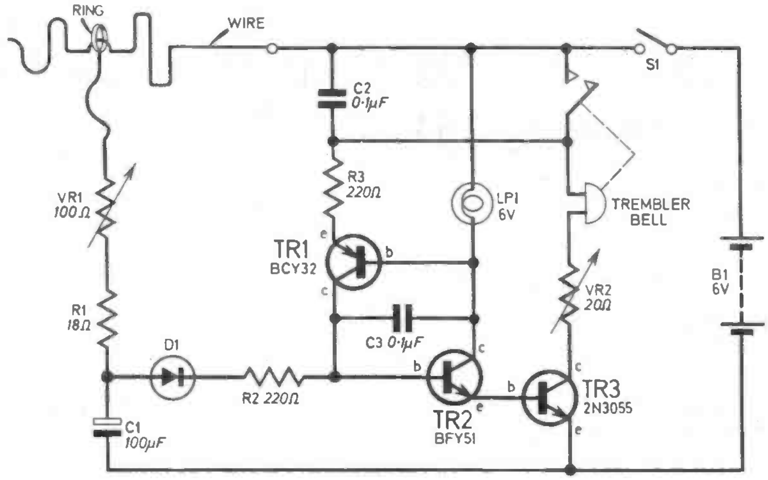


Fig. 1. The Prof's. circuit diagram for the Steady Hand Tester.

"But I am thinking of adding a couple more transistors to the circuit to give it 'hair trigger' sensitivity."

The Prof. began to sketch a small additional circuit which used a BC108 and a BC478 transistor.

To be continued

BOOK REVIEWS

ILLUSTRATED TEACH YOURSELF: RADIO
Author David Gibson
Price £1·60
Size 204 × 150mm, 96 pages, paperback
Publisher Hodder and Stoughton
ISBN 0 340 19608 4

UNASHAMEDLY aimed at the school boy (and girl), and one must look at it with that in mind. Having said that I must add that there is plenty of solid information in this that anyone just getting interested in the subject would find useful.

Well laid out with excellent illustrations and a few colour pages. If you want to start with radio and go on to be a ham, this book starts you off with components—takes you through basic transistor operation to crystal set operation and detailed construction. Includes four other radio circuits and construction details and finishes with a chapter on aerials and one on short wave listening.

Not too deep or too fast for the beginner and fulfills its obvious aim and title in every way. M.K.

110 COSMOS DIGITAL IC PROJECTS FOR THE HOME CONSTRUCTOR
Author R. M. Marston
Price £2·75
Size 215 × 135 mm 115 pages
Publisher Newnes-Butterworths
ISBN 0 408 00216 6

MANY readers will be familiar with the author's name as this is his seventh electronics book intended for the amateur electronic constructor, student and engineer.

There is a shortage of literature available to the amateur on the subject of CMOS (COSMOS) and this book is a welcome arrival.

The first chapter introduces the reader to the basic building block of CMOS devices and explains simple arrangements of these blocks to form NOR and NAND gates and compares their performance with the TTL family. This is followed by a chapter on inverter, gate, and logic circuits (15 in all) and shows the derivation of the five basic logic functions used in digital circuitry using NAND and NOR gates.

Multivibrator Circuits are the subject of Chapter three where 25 different circuits are described including a detailed account of a car Tachometer. There are 10 d.c. Lamp Control Circuits in Chapter four including such devices as lamp dimmers—suitable for dimming instrument panel or courtesy lights in cars—time controlled auto-turn off circuits, and lamp flashers.

Many Relay Switching Circuits (20 in fact) are discussed in the following chapter including time delay types and other activated by temperature, light and water.

The final two chapters are headed Sound Generator And Alarm Circuits, and Counting And Dividing Circuits, the latter containing details of a divide-by N counter where N can be any integer.

Sensible applications are provided for almost all the circuits in the book. One important point to note is that there are no construction details such as layout of the components on stripboard or p.c.b. or wiring up details (this is left to the constructor)—hardly surprising for a book of this size containing so many projects.

All of the projects in the book have been designed by the author, and have been built and tested by him.

There is a useful Appendix detailing semiconductor and i.c. pin identifications for those used throughout the book, six i.c.s and three transistors.

B.W.T.

THE OSCILLOSCOPE IN USE
Author Ian R. Sinclair
Price £2·50 (U.K. only)
Size 215 × 140mm, 129 pages
Publisher Fountain Press
ISBN 0 85242 471 X

THE aim of the author is to show how an oscilloscope works, and how it may be used in electronic measurement, and he does this very well. It will prove invaluable to the amateur constructor of electronics projects and should be on the shelves of college and school electronics laboratories.

The informative, concise text is supported by many excellent, generously captioned diagrams and photographs of equipment and more important, photographs of oscilloscope traces which forms part of the practical approach.

The book is split into ten approximately equal chapters each subdivided by use of bold sideheadings producing a neat and orderly layout.

The first two chapters are really intended for the newcomer and show how the oscilloscope works—basics only—and explains the use of the controls relating to simple measurements of voltage and time. Chapter three includes various measurements of phase difference (single and dual beam methods), frequency determination by Lissajou's Figures and input and output resistance measurements.

Gain, Power Output, Distortion, Frequency Response, and Equalisation measurements are among the headings of Chapter four, Testing Audio Amplifiers.

R.F. Testing, Power Supply Testing, and Pulse & Timebase Circuits are dealt with separately in Chapters five, six and seven respectively.

Chapter 10 is devoted to T.V. waveforms and is strongly supported by photographs of oscilloscope traces of these waveforms.

The final two Chapters are concerned with diagnosing faults on the oscilloscope itself, and 'scope accessories such as attenuating probe (construction details), calibration circuits and wobbulators. B.W.T.

HAND TOOLS FOR THE ELECTRONIC WORKSHOP
Author Harry T. Kitchen
Price £2·25
Size 216 × 138mm, 115 pages, soft linen finished cover
Publisher Angus Books
ISBN 0 85242 472 8

An excellent book by this respected author who covers the whole range from the basic minimum of tools and how to use them through micrometers, vernier protractors to drills, taps and dies. All the items are well covered and there are many excellent photographs for illustration.

After this comes a section on soldering which would be of assistance not only to any beginner but to many experienced constructors whose work one sometimes comes across. This takes us through a further 30 pages and once again carries some well reproduced photographs which, on this subject say more than words.

The final two chapters cover Miscellaneous Tools (such as pop-riveters, hammers, glue and aerosols of various types), and Tool Boxes and Work Benches.

In my opinion all electronics books are rather highly priced when compared with similar ones—for instance in cookery—however one must say that this book is value for money and it carries much that will be of interest not just to the newcomer but to everyone involved in the hobby. M.K.

SIMPLE CIRCUIT BUILDING
Author P. C. Graham
Price £1·99
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One of the Newnes Constructors Guide series and one of the few books I have come across that carries advertisements from suppliers and even *Practical Electronics* our companion magazine (the others in the series do too). Not an aptly named book and perhaps "Basic Circuits" or something similar would be a better guide to its contents.

This is in no way a practical guide to circuit construction—more a guide to application circuits with brief notes on how to wire some of them up. None of the recognised circuit boards are shown or used, a few printed circuit type layouts are given. Readers are referred to another book in the series for guidance on circuit board construction.

Useful if you want to learn a bit more about the actual circuits and how they work, not if you want to learn how to construct useful items. We wonder why P. C. Services get a mention as component suppliers when there are many many other firms who can supply parts and none are mentioned; not even advertisers.

No doubt the ads. help to reduce the cost of the book but I don't think I would buy this one—most of the circuits can be found in reference books or manufacturers literature. M.K.

GEORGE HYLTON brings it down to earth

Theory and Practice

ONE lesson which experience teaches is that there are times when theory is indispensible and times when a bit of experiment gets results faster. The question is, how do you know which is going to be better, in a particular case?

How do you answer the question: should I build a circuit to see if my idea will work or should I first try to prove the idea on paper? There's no simple answer. But the more experimenting and circuit building you do, the more you develop an "instinct" for making the right approach. It usually turns out that the best approach is to make sure, on paper, that what you are going to construct will do the job, but to optimise your circuit by experiment.

A simple example will illustrate this. Suppose you intend to build a simple radio receiver, to your own design, and you want to use a crystal earpiece to listen to the programmes. The first thing you need to know is: how much audio voltage has to be applied in order to produce adequate volume? Unless you know the answer to this question you are working in the dark, and running the risk of constructing equipment that won't do the job properly.

Suppose you check this with an oscillator and find that it is 2V r.m.s. The corresponding peak voltage is 2·8V and it swings both positively and negatively. So the voltage from the amplifier must, for undistorted signals, be able to swing up by 2·8V and down by 2·8V. In the kind of amplifier in Fig. 1, the collector sits at some steady voltage V_{CE}. Positive audio signals make the transistor take more collector current, producing a greater voltage drop in R2. Negative inputs have the opposite effect. This varying drop in R2 is the audio output and is applied to the crystal earpiece. (For the time being we'll assume that the impedance of the earpiece is infinite, so that its presence does not affect the voltage.)

Now, it follows from the way this circuit works that V_{CC} must be at least 5·8V. This is because the peak-to-peak (positive to negative) voltage swing in this circuit cannot exceed V_{CC}. In practice, the undistorted output is rather less, because of the imperfections of the transistor.

The nearest standard battery voltage is 6V but you will probably want to use 9V, which is all right. When the 9V battery runs down, say to 6V, the output should still be somewhere near 3V peak, if the circuit is properly designed.

Amplification Factor

The books tell you that for maximum output voltage swing R1 should be h_{FE} times R2, where h_{FE} is the d.c. amplification factor of the transistor. A particular type of transistor may have h_{FE} =100-300. Do you take the average (200) and risk an error or find the correct value by trial and error? Trial and error must give the best results here, since it tailors the circuit to suit the *particular* specimen of the transistor type which you are using.

Theory gives a good guide to where to start trying. For example, you may know or discover by tests that your crystal earpiece causes no significant loss of treble for values of R2 up to 10 kilohms. (A crystal earpiece, being a capacitor, bypasses R2 at high frequencies, causing treble cut). If h_{FE} is about 200 and R2 is 10 kilohms then R1 should be about 200 x 10k=2 megohms and you can start by trying a standard value such as 1·8 or 2·2 megohms.

Since there is a danger of inadequate volume with a flat battery you may decide to optimise R1 for a 6V supply rather than the full 9V. With a 9V supply the circuit will not be quite optimised, but will still give more output than at 6V. So if it works at 6V it also works at 9V.

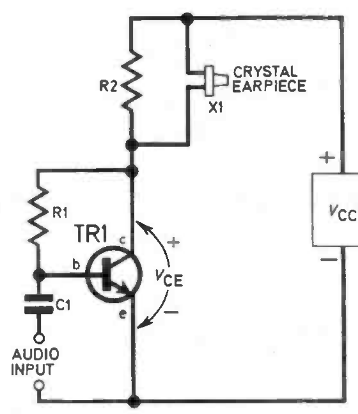
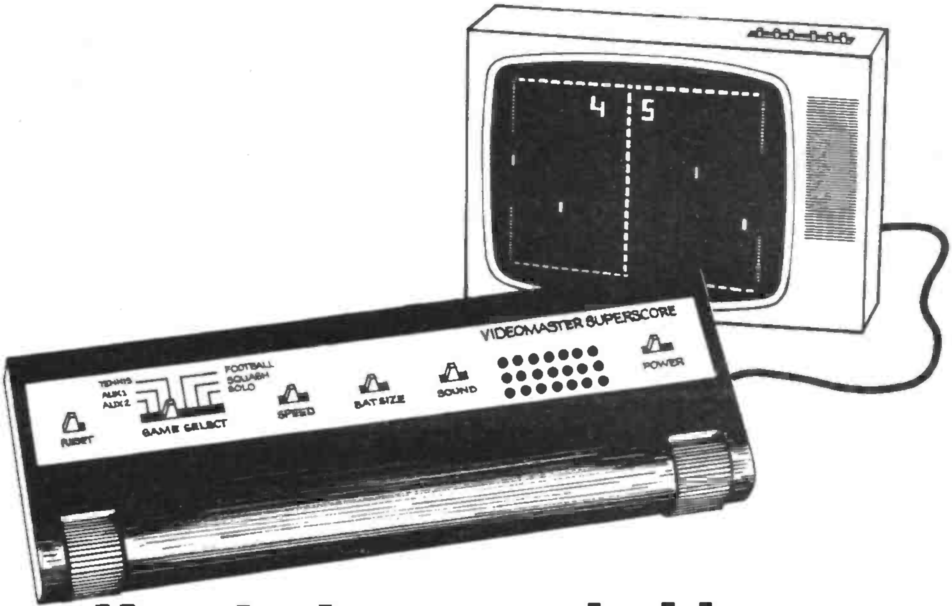


Fig. 1. The experimental amplifier circuit.

Tweaking

Looking back you can see how in this design, theory has been used to give some of the answers and trial and error for the others. In general, electronic engineers rely on theory to give a basis for a design and then use trial and error (sometimes called "tweaking") to get the optimum results.



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