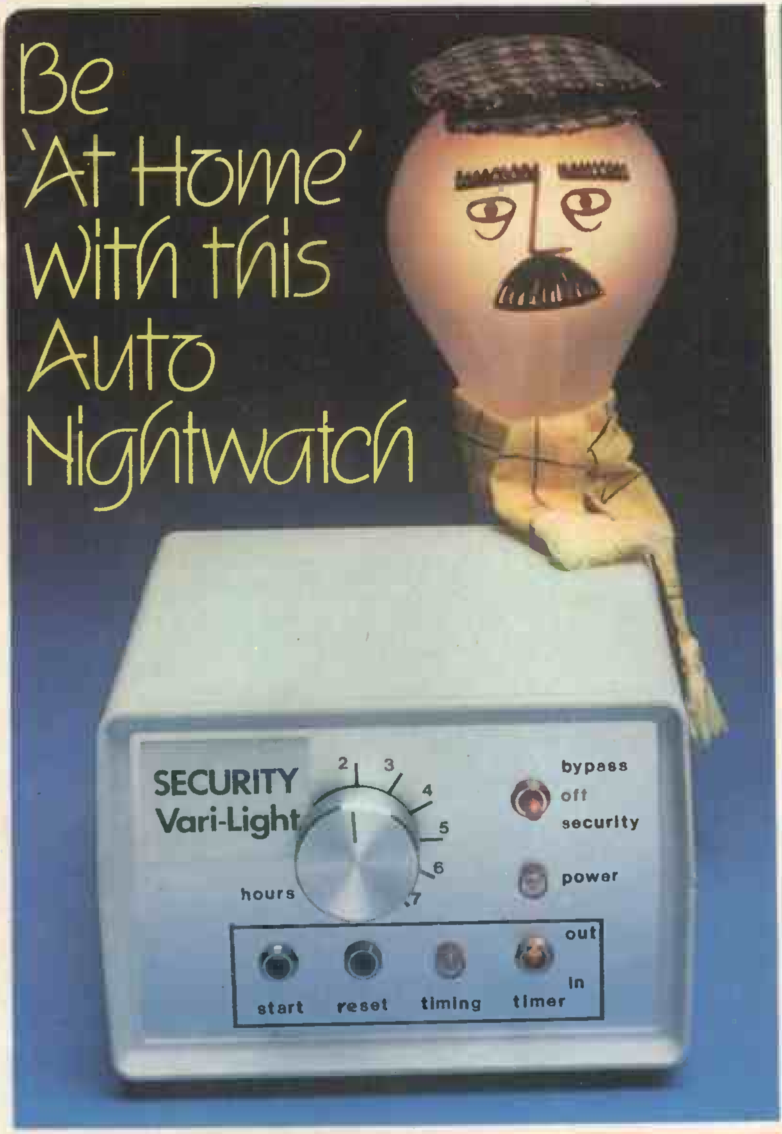
Easy to build projects for everyone

Everyday ELECTRONICS

DEC. 82
80p

Be 'At Home' with this Auto Nightwatch

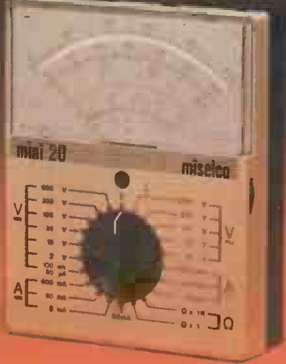


VELOCITY MEASURER

SEDAC Prize Winning Project

Extra Ram for the ZX81

SPECIAL OFFER



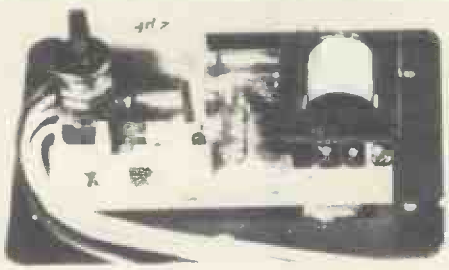
Mini 20 MULTIMETER

CAR INDICATOR ALERT

5V REGULATED SUPPLY

Australia $1·35 Malaysia $4·95 IR £1·19 (inc. V.A.T.)

ELECTRONIC IGNITION KIT



TOTAL ENERGY DISCHARGE electronic ignition gives all the well known advantages of the best capacitive discharge systems.

PEAK PERFORMANCE ——— higher output voltage under all conditions.

IMPROVED ECONOMY ——— no loss of ignition performance between services.

FIRES FOULED SPARK PLUGS no other system can better the capacitive discharge system's ability to fire fouled plugs.

ACCURATE TIMING ——— prevents contact wear and arcing by reducing load to a few volts and a fraction of an amp.

SMOOTH PERFORMANCE —— immune to contact bounce and similar effects which can cause loss of power and roughness.

PLUS

SUPER POWER SPARK ——— 3½ times the energy of ordinary capacitive systems — 3½ times the power of inductive systems.

OPTIMUM SPARK DURATION 3 times the duration of ordinary capacitive systems — essential for use on modern cars with weak fuel mixtures.

BETTER STARTING ——— full spark power even with low battery.

CORRECT SPARK POLARITY unlike most ordinary C.D. systems the correct output polarity is maintained to avoid increased stress on the H.T. system and operate all voltage triggered tachometers.

L.E.D. STATIC TIMING LIGHT for accurate setting of the engine's most important adjustment.

LOW RADIO INTERFERENCE fully suppressed supply and absence of inverter 'spikes' on the output reduces interference to a minimal level.

DESIGNED IN RELIABILITY an inherently more reliable circuit combined with top quality components — plus the 'ultimate insurance' of a changeover switch to revert instantly back to standard ignition.

IN KIT FORM

it provides a top performance electronic ignition system at less than half the price of competing ready-built systems. The kit includes everything needed, even a length of solder and a tiny tube of heatsink compound. Detailed easy-to-follow instructions, complete with circuit diagram, are provided — all you need is a small soldering iron and a few basic tools.

AS REVIEWED IN
ELECTRONICS TODAY INTERNATIONAL JUNE '81 ISSUE and EVERYDAY ELECTRONICS DECEMBER '81 ISSUE

FITS ALL NEGATIVE EARTH VEHICLES, 6 or 12 volt, with or without ballast

OPERATES ALL VOLTAGE IMPULSE TACHOMETERS
Some older current impulse types (Smiths pre '74) require an adaptor — PRICE £2.95

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BARCLAYCARD
VISA

DIMENSIONS:

Length	12.5 cm
Width	8.9 cm
Height	4.3 cm
Lead length	100.0 cm

TECHNICAL DETAILS

The basic function of a spark ignition system is often lost among claims for longer 'burn times' and other marketing fantasies. It is only necessary to consider that, even in a small engine, the burning fuel releases over 5000 times the energy of the spark, to realise that the spark is only a trigger for the combustion. Once the fuel is ignited the spark is insignificant and has no effect on the rate of combustion. The essential function of the spark is to start that combustion as quickly as possible and that requires a high power spark.

The traditional capacitive discharge system has this high power spark but, due to it's very short spark duration and consequential low spark energy, is incompatible with the weak air/fuel mixtures used in modern cars. Because of this most manufacturers have abandoned capacitive discharge in favour of the cheaper inductive system with it's low power but very long duration spark which guarantees that sooner or later the fuel will ignite. However, a spark lasting 2000μS at 2000 rev/min. spans 24 degrees and 'later' could mean the actual fuel ignition point is retarded by this amount.

The solution is a very high power, medium duration, spark generated by the TOTAL ENERGY DISCHARGE system. This gives ignition of the weakest mixtures with the minimum of timing delay and variation for a smooth efficient engine.

SUPER POWER DISCHARGE CIRCUIT A brand new technique prevents energy being reflected back to the storage capacitor, giving 3½ times the spark energy and 3 times the spark duration of ordinary C.D. systems, generating a spark powerful enough to cause rapid ignition of even the weakest fuel mixtures without the ignition delay associated with lower power 'long burn' inductive systems.

HIGH EFFICIENCY INVERTER A high power, regulated inverter provides a 370 volt energy source — powerful enough to store twice the energy of other designs and regulated to provide sufficient output even with a battery down to 4 volts.

PRECISION SPARK TIMING CIRCUIT This circuit removes all unwanted signals caused by contact volt drop, contact shuffle, contact bounce, and external transients which, in many designs, can cause timing errors or damaging un-timed sparks. Only at the correct and precise contact opening is a spark produced. Contact wear is almost eliminated by reducing the contact breaker current to a low level - just sufficient to keep the contacts clean.

TYPICAL SPECIFICATION

	TOTAL ENERGY DISCHARGE	ORDINARY CAPACITIVE DISCHARGE
SPARK POWER (PEAK)	140 W	90 W
SPARK ENERGY	36 mJ	10 mJ
(STORED ENERGY)	135 mJ	65 mJ
SPARK DURATION	500 μS	160 μS
OUTPUT VOLTAGE (LOAD 50pF EQUIVALENT TO CLEAN PLUGS)	38 KV	26 KV
OUTPUT VOLTAGE (LOAD 50pF + 500 KΩ EQUIVALENT TO DIRTY PLUGS)	26 KV	17 KV
VOLTAGE RISE TIME TO 20 KV (Load 50pF)	25 μS	30 μS

TOTAL ENERGY DISCHARGE should not be confused with low power inductive systems or hybrid so called reactive systems.

Everyday ELECTRONICS

VOL. 11 NO. 12 DECEMBER 1982

PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

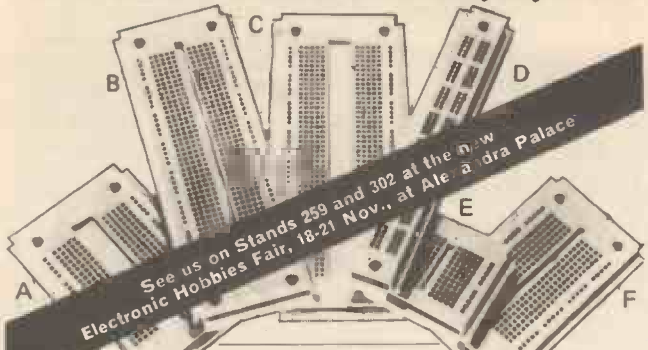
Our January 1983 issue will be published on Friday, December 17. See page 795 for details.

PROJECTS

SERIES

FEATURES

IT'S AS EASY AS A,B,C...



As used in the
Cambridge Learning Booklet

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- C **EXP 600** 6" centre channel makes this the Microprocessor Breadboard. **£6.60**
- D **EXP 4B** An extra 4 bus-bars in one unit. **£2.40**
- E **EXP 325** Built in bus-bars accepts 8, 14, 16 and up to 22 pin ICS. **£1.65**
- F **EXP 350** 270 contact points, ideal for working with up to 3 x 14 pin DIPS. **£3.30**
- G **PB6** Professional breadboard in easily assembled kit form. **£9.75** (Not illustrated.)
- H **PB 100** Kit form breadboard recommended for students and educational uses. **£12.50** (Not illustrated.)

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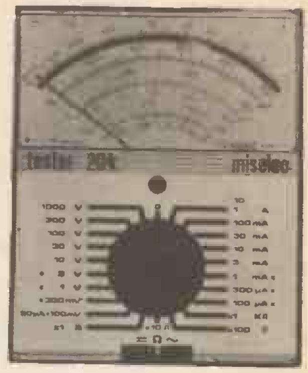

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d.c. I 50μA, 100μA, 300μA, 1·0mA, 3mA, 10mA, 30mA, 100mA, 1A, 10A.
a.c. V 10V, 30V, 100V, 300V, 1000V.
a.c. I 3mA, 10mA, 30mA, 100mA, 1·0A, 10A.
Ω 0–5·0kΩ, 0–50kΩ, 0–500kΩ, 5MΩ, 50MΩ.
dB from −10 to +61 in 5 ranges.
Dimensions: 105 × 130 × 40mm.

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a.c. V 10V, 30V, 100V, 300V, 1000V;
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0-2-20-200-1000V. Acc: 0.8%
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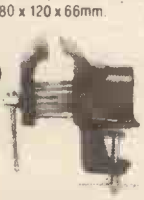

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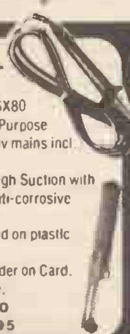

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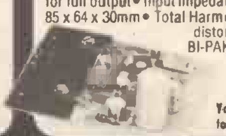

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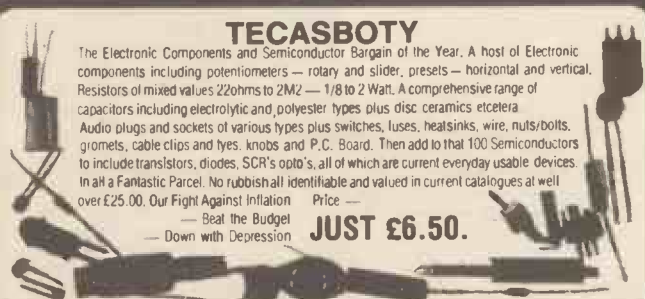

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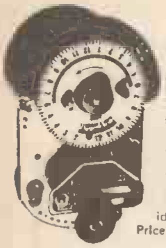
VENNER TIME SWITCH



Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only £2.95. These are without case but we can supply a plastic base £1.75 or metal case £2.95. Also available is adaptor kit to convert this into a normal 24 hr. time switch but with the added advantage of up to 12 on/offs per 24 hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is £2.30.

THERMOSTAT ASSORTMENT

10 different thermostats. 7 bi-metal types and 3 liquid types. There are the current stats which will open the switch to protect devices against overload, short circuits, etc., or when fitted say in front of the element of a blow heater, the heat would trip the stat if the blower fuses; appliance stats, one for high temperatures, others adjustable over a range of temperatures which could include 0 – 100°C. There is also a thermostatic pod which can be immersed, an oven stat, a calibrated boiler stat, finally an ice stat which, fitted to our waterproof heater element, up in the loft could protect your pipes from freezing. Separately, these thermostats could cost around £15.00 - however, you can have the parcel for £2.50.

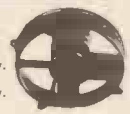
TREMENDOUS OFFER!

Your Chance of a lifetime

We have to clear a big store. 100 tons of stock must go. 10 kilo parcel of unused parts. Minimum 1,000 items includes panel meters, timers thermal trips, relays, switches, motors, drills, taps and dies, tools, thermostats, coils, condensers, resistors, etc. etc. Individually these must cost in excess of £100.

YOURS FOR ONLY £11.50 plus £3.00 post.

EXTRACTOR FAN



Mains operated – ex-computer
5" Woods extractor £5.75, Post £1.25.
5" Plannair extractor £6.50. Post £1.25
4" x 4" Muffin 115v. £4.50. Post 75p.
4" x 4" Muffin 230v. £5.75. Post 75p.

SEAT BELT REMINDER

Buzzer sounds when you switch on ignition – stops when you handle seat belt – Complete kit £3.00.

8 POWERFUL BATTERY MOTORS

(all different)

For models, maccanos, drills, remote control planes, boats, etc. £2.95.

INSTRUMENT BOX WITH KEY

Very strongly made (ply-wood sides with hard board top and bottom). This is black grained effect, vinyl covered, very pleasing appearance. Internal dimensions 12½" long, 4¾" wide, 6" deep. Ideal for carrying your multi range meter and small tools and for keeping them in a safe place. £2.30. Post paid if ordered with other goods, otherwise £1.00.

COMPUTER DESK

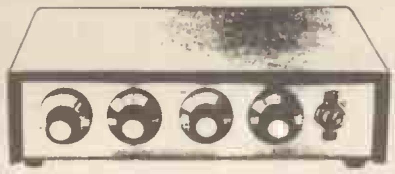
Size approx 4'x 2'x 2'6" high. These were made for hard work, the top being formica covered. Suitable for housing instruments or for use as office desks. Beautifully made, these cost over £100 each, our price only £11.50 each, however, you must arrange to collect.

MINI MONO AMP on p.c.b., size 4"x 2"

approx. Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amplifier. Brand new, perfect condition, offered at a very low price of £1.15 each, or 10 for £10.00.

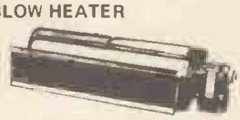
TERRIFIC VALUE KITS!

3 CHANNEL SOUND TO LIGHT KIT



Complete kit of parts for a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four-pin plug and socket facilitate ease of connecting lamps. Special price is £14.95 in kit form or £25.00 assembled and tested.

TANGENTIAL BLOW HEATER



2.5 Kw quiet, efficient instant heating from 230/240 volt mains. Kit consists of blower as illustrated, 2.5 Kw element, control switch and data all for £4.95. post £1.50.

CAR STARTER AND CHARGER KIT

In an emergency you can start car off mains or bring your battery up to full charge in a couple of hours. The kit comprises: 250 watt mains transformer, 40 amp bridge rectifier, start/charge switch and full instructions. You can assemble this in the evening, box it up or leave it on the shelf in the garage, whichever suits you best. Price £12.50 + £3.00 post.

6 WAVEBAND SHORTWAVE RADIO KIT

Bandspread covering 13.5 to 32 metres. Based on circuit which appeared in Radio Constructor. Complete kit includes case materials, six transistors and diodes, condensers, resistors, inductors, switches, etc. Nothing else to buy if you have an amplifier to connect it to or a pair of high resistance headphones. Price £11.95.

MEDIUM & 2 SHORT WAVE CRYSTAL RADIO

All the parts to make up the beginners model. Price £2.30. Crystal earpiece 65p. High resistance headphones (gives best results) £3.75 kit includes chassis and front, but not case.

TRANSMITTER SURVEILLANCE

Tiny, easily hidden but which will enable conversation to be picked up with FM radio. Can be made in a matchbox – all electronic parts and circuit. £2.30. (not licenceable in the U.K.)

RADIO MIKE

Ideal for discos and garden parties, allows complete freedom of movement. Play through FM radio or tuner amp. £6.90 comp. kit. (not licenceable in the U.K.).

FM RECEIVER

Made up and working, complete with scale and pointer needs only headphones, ideal for use with our surveillance transmitter or radio mike. £5.85. or kit of parts £3.95.

3 - 30v VARIABLE VOLTAGE POWER SUPPLY UNIT

With 1 amp DC output, for use on the bench, students, inventors, service engineers, etc. Automatic short circuit and overload protection. In case with a volt meter on the front panel. Complete kit £13.80

INTERRUPTED BEAM

This kit enables you to make a switch that will trigger when a steady beam of infra red or ordinary light is broken. Main components – relay, photo transistor, resistors and caps, etc. Circuit diagram but no case. Price £2.30

IONISER KIT

Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder – complete mains operated kit, case included £11.95 plus £2.00 post.

RADIO STETHOSCOPE

Easy to fault find start at the aerial and work towards the speaker – when signal stops you have found the fault. Complete kit £4.95.

MUGGER DETERRENT

A high-note bleeper, push latching switch, plastic case and battery connector. Will scare away any villain and bring help. £2.50 complete kit.

MORSE TRAINER Complete kit for only £2.99.

DRILL SPEED CONTROLLER Complete kit for £3.95.

INVISIBLE AND SILENT SENTINEL

Ultra sonic beam when broken could warn you of visitor – two complete kits – transmitter & receiver & relay, to operate light or bell £9.50.

BURGLAR ALARM

Complete kit includes 6" external alarm bell, mains power unit, control box with keyswitch, 10 window/door switches, 100 yards of wire. With instructions £29.50.

J. BULL (Electrical) Ltd.

(Dept. EE), 34 - 36 AMERICA LANE, HAYWARDS HEATH, SUSSEX RH16 3QU. Established 30 YEARS

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £10. add 60p service charge. Monthly account orders accepted from schools and public companies. Access & Barclaycard orders phone Haywards Heath (0444) 454563. Bulk orders: Write for quote. Delivery by return.

Shop open 9.00 – 5.30, mon – friday.

STEREO HEADPHONES

Very good quality, 8 ohm, padded, terminating with standard ¼" jack plug. £2.99 plus 60p post.

TIME SWITCH BARGAIN

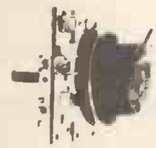
Large clear mains frequency controlled clock, which will always show you the correct time + start and stop switches with dials. Complete with knobs FOR ONLY £2.50.

ROPE LIGHT

4 sets of coloured lamps in translucent plastic tube arranged to give the appearance of a running or travelling light. With variable speed control box, ideal for disco or shop window display. Complete, made up, ready to plug into mains. £36.00 + £2 post.

ZX81 OWNERS

Make yourself a full size keyboard! Key switches complete with plain caps. 6 for £1.15. Easily divisible.



DELAY SWITCH

Mains operated – delay can be accurately set with pointers knob for periods of up to 2½ hrs. 2 contacts suitable to switch 10 amps – second contact opens a few minutes after the 1st. £1.95.

ROTARY WAFER SWITCHES

5 amp silver plated contacts. ¼" shaft. 1" dia. wafer.

Single wafer types, 29p each. as follows:

1 pole 12 way	2 pole 6 way	3 pole 4 way
4 pole 3 way	6 pole 2 way	4 pole 3 way

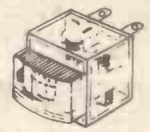
Two wafer type, 59p each, as follows

2 pole 12 way	4 pole 5 way	4 pole 6 way
6 pole 3 way	8 pole 3 way	12 pole 2 way

3 wafer types 99p each,

9 pole 4 way	6 pole 5 way	6 pole 6 way
	12p 3 way	18p 2 way

LEVEL METER



Size approximately ¾" square, scaled signal and power but cover easily removable for rescaling. Sensitivity 200uA. 60p

WATERPROOF HEATING WIRE

60 ohms per yard, this is a heating element wound on a fibre glass coil and then covered with p.v.c. Dozens of uses – around water pipes, under grow boxes in gloves and socks.

COMPUTER PRINTER FOR ONLY £4.95

Japanese made Epson 310 – has a self starting brushless drive motor. Complete with electronics – uses plain paper. Brand new with data. ONLY £4.95 plus £1.25 Post.

12v MOTOR BY SMITHS

Made for use in cars, these are series wound and they become more powerful as load increases. Size 3½" long by 3" dia. These have a good length of ¼" spindle – price £3.45.

Ditto, but double ended £4.25.

Ditto, but permanent magnet & various spindle sizes £3.75.

STROBE LIGHT

Bright flash ideal for disco, speed variable 1 to 20 flashes per sec. Mains operated – made up ready to work £14.95 + £1.50 post.

EXTRA POWERFUL 12v MOTOR

Made to work battery lawnmower, this probably develops up to ¼ h.p., so it could be used to power a go-kart or to drive a compressor, etc. etc. £6.90 + £1.50 post. (This is easily reversible with our reversible switch - Price £1.15).

GO KART MOTOR

24 Volt operated easily vary speed and reverse – terrific power. Price £9.50 + £1.50 post.

SPIT MOTORS

These are powerful mains operated induction motors with gear box attached. The final shaft is a ½" rod with square hole, so you have alternative couplingmethods – final speed is approx. 5 revs/min, price £5.50. – Similar motors with final speeds of 80, 100, 160 & 200r.p.m. same price.

REVERSIBLE MOTOR WITH CONTROL GEAR

Made by the famous Framco Company this is a very robust motor, size approximately 7½" long, 3½" dia. 3/8" shaft. Tremendously powerful motor, almost impossible to stop. Ideal for operating stage curtains, sliding doors, ventilators etc., even garage doors if adequately counter-balanced. We offer the motor complete with control gear as follows:

1 Framco motor with gear box
1 manual reversing and on/off switch
1 push to start switch
1 x 100w auto transformer
2 limit stop switches
1 circuit diag. of connections.

£19.50 plus postage £2.50.

FREE OUR CURRENT BARGAIN LIST WILL BE ENCLOSED WITH ALL ORDERS.

Everyday ELECTRONICS

VOL. 11 NO. 12 DECEMBER 1982

ELECTRONIC HOBBIES FAIR

WHEN THIS issue of EVERYDAY ELECTRONICS appears the Electronics Hobbies Fair will already be in full swing. Even so, there is probably time to alert the new or casual reader to what promises to be the greatest exhibition of its kind ever staged in the UK.

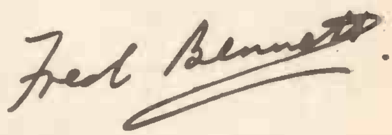
The Electronic Hobbies Fair runs for four days: Thursday 18th through to Sunday 21st November. The venue is Alexandra Pavilion—a unique and remarkable structure first opened in December, 1981. It is set in the midst of beautiful parkland on a high prominence in North London. British Rail are offering special rate return tickets inclusive of admission, and these can be obtained from main line stations throughout the UK. A free bus service operates between the Alexandra Palace BR station and the exhibition complex. The London Underground station Wood Green on the Piccadilly Line is nearby.

Inside the Alexandra Pavilion visitors will have much to explore among the stands occupied by component and equipment suppliers and other traders. There will be names familiar to readers of this magazine, also some perhaps not so well known, but all catering for the needs of the hobbyist, whatever his or her particular field of interest.

Visitors will find the EVERYDAY ELECTRONICS stand and those of our fellow sponsors *Practical Electronics* and *Practical Wireless* in the rotunda located towards the back of the hall. Don't fail to look us up.

Encircling the rotunda are a score or more stands housing a variety of special attractions. These include displays by well-known amateur organisations devoted to particular aspects or applications of electronics. In contrast to this mix of essentially hobbyist activity the Royal Signals add an impressive and highly professinal display of the modern army's communication equipment (and specialist personnel) while several commercial organisations provide demonstrations of exciting developments, including reception of USSR TV via satellite, electric cars and holography.

A further link between the hobbyist area and the electronics industry is well illustrated at the SEDAC stand, where this year's prizewinning projects designed and built by school pupils are on display. The generosity of our co-sponsor Mullard Ltd., has resulted in doubling the value of prizes for the 1983 Schools Electronic Design Award Competition. In order to allow visiting school children or teachers who might not have been previously aware of this national competition, the closing date for registration has been extended to December 15th, 1982. The absence of school girls from the previous contest finalists has been remarked upon before. May we now urge members of the fair sex to show that electronics is not exclusively for males, by submitting their entries in strength this time!



EXTRA RAM FOR THE SINCLAIR ZX81

BY K. DEPLEDGE (G3 PAN)

IT IS possible to add a further 3K of RAM to your ZX81 using the *2K Ram Pack* published in *EE* April 82 plus one more chip, two diodes, one resistor, a run of the mill *npn* transistor and a 24-way d.i.l. socket. Conservative cost about £7 but with, for many, a potential additional saving of two of the 2114 memory chips specified for the *2K Ram Pack*.

A quick scan of the April issue and, having long ago given best to the professionals in PCB production, off went the order for a board and 2 x 2114 RAM Chips. Why only two, read on and all will be revealed.

THE ZX81

The ZX81 internal 1K of RAM comes in one of two types, one using a 4118 1K x 8 bit RAM chip, the other as two 1K x 4 bit 2114 memory chips. The writers experience is that most kits contain the 2114. However, the p.c.b. is printed and drilled for both.

Now, the 2114s cost about £1 each retail (if you shop around) and the 4118 about £4. (Maybe Sinclair were looking after the pennies when they designed in 2114 i.c.s but needed the protection of dual type sourcing and therefore kept the ability to also use the 4118). Now the 6116 CMOS RAM chip is available. This is a 2K x 8 bit device which is pin compatible with the 4118 and can be purchased at around £6. With minor modifications to the ZX81 board, £6 can give you a 2K RAM computer.

GETTING IT TOGETHER

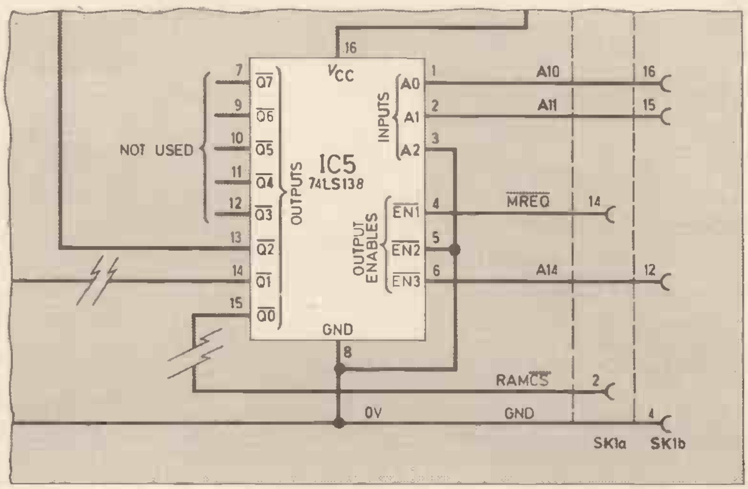
The 6116 modification had been built into the author's ZX81 for some months, replacing 2114 chips, but the April issue of *EE* got the cogs meshing—why not 2K more and use up those redundant 2114s. Surely it couldn't be too difficult. It wasn't.

The first thing to do was build the *2K Ram Pack* and check it was working. This done, after a long wait for the 23-way connector, power up and RAMTOPS: Print Peek 16388+ 256* Peek 16389 NEWLINE—sure enough the answer came back 19456—it worked first time.

Just a moment though, something amiss, the modified ZX81 had 2048 bytes (actually slightly less but this was a Ramtops test) giving 18432—add 2048 bytes from the *2K Ram Pack* and the answer should have been 20480. Some memory had been paralleled!

Re-reading the April project shows the *2K Ram Pack* starting address is 16384 (that's normal enough) and "the decoding is required to enable the Ram Pack to be positioned 1K beyond this address"—we need the position to be 2K beyond 16384—so how?

Fig. 1(a). Circuitry around the decoder i.c. in the *2K Ram Pack* showing lines to IC5 to be interrupted.



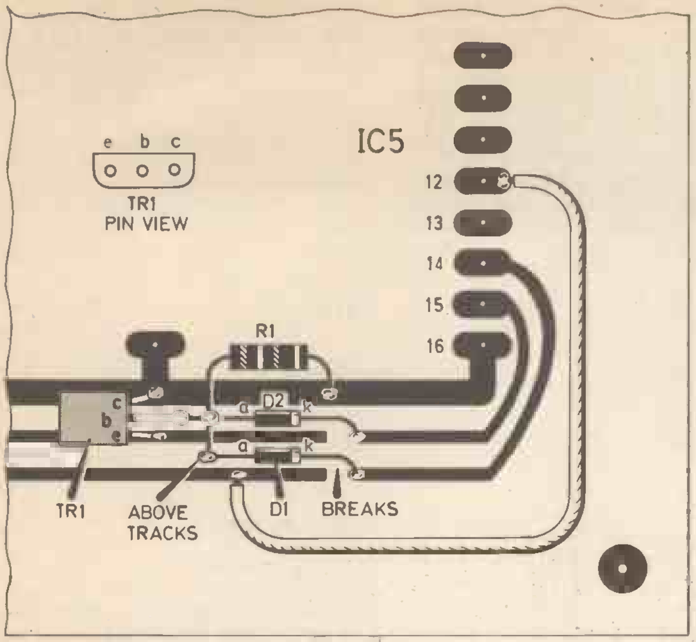


Fig. 2. Where the additional components are to be mounted on the trackside of the p.c.b. of the *2K Ram Pack*. Note the breaks made in the tracks.

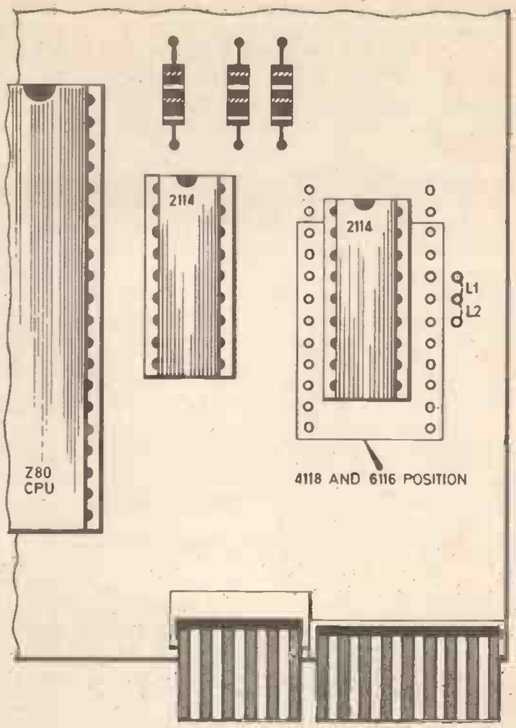


Fig. 3. The ZX81 Ram area. The 6116 (2K × 8 static RAM) is to be fitted in a socket sited at pin locations 1 to 24 (in box shown) with the 2114s removed.

MODIFYING THE 2K RAM PACK

Reference to the 74LS138 control chip shows Q0 directly controlling $RAM_{\overline{cs}}$ to ZX81 internal memory and Q1 and Q2 controlling input to the two 1K stores in the Ram Pack.

To allow for the expanded internal (6116) memory we need use Q2 and Q3 for the Ram Pack memory and ensure Q0 *and* Q1 control (inhibit) $RAM_{\overline{cs}}$ in the 16-18K address fields.

To reach this end Q2 (pin 13) needs no alteration, but Q3 (pin 12) needs to feed $\overline{cs}$ (pin 8) on IC1 and IC2 and the Q1 (pin 14) disconnected from these $\overline{cs}$ pins.

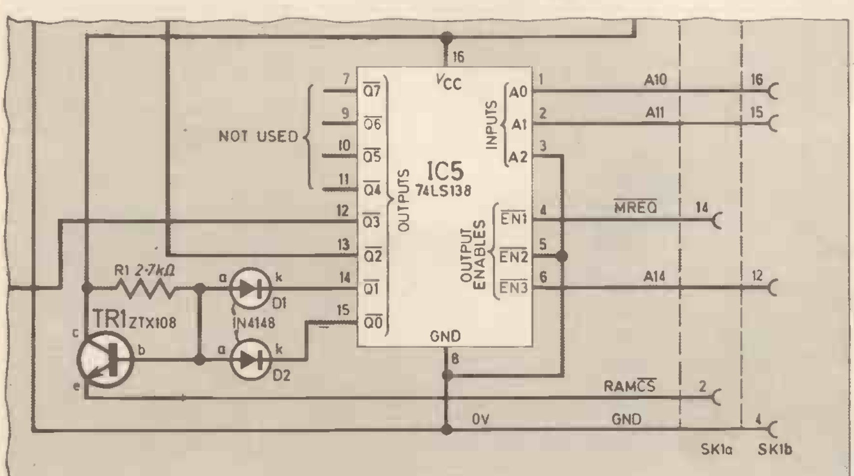
This leaves Q1 and Q0. Q0 needs to have direct $RAM_{\overline{cs}}$ control removed and, together with Q1, brought under sequential control, that is, Q=1stK, (internal) Q1=2ndK (internal) Q2=3rdK and Q3=4thK. This can be effected with two diodes, a resistor and an *npn* transistor wired in the emitter follower mode.

The resultant changes can be seen clearly by comparing Fig. 1a (original circuit) and Fig. 1b (modified) with required track cuts.

To carry out the mod carefully refer to Fig. 2 where, for clarity, IC5 (74LS138) is reproduced with pins 1 to 8 blanked out and pins 12, 13, 14, 15 and 16 identified. Trace pin 15 track and cut where shown. Next trace pin 14 track and likewise cut as shown. Before proceding further check with an ohmmeter that each cut has really open circuited the tracks—don't leave it to an eyesight test.

Next, using a fine tipped soldering iron solder an insulated wire link from pin 12 to the far side of the pin 14 track. Then solder the cathodes of the 1N4148 diodes (banded end) to the tracks of pins 14 and 15 respectively. Now form the leads of the transistor (any of the ZTX108/BC108 family will do as long as the lead configuration matches the board requirement — the author used BC457). Solder the collector to the +5 volt rail, solder the emitter to the $RAM_{\overline{cs}}$ side of the Q0 cut track. Now solder in the resistor, one side to the +5 volt rail and the other to join with the commoned anodes of the diodes and the transistor base lead, made above and clear of the

Fig. 1(b). Decoder circuitry with the additional components added to allow the *2K Ram Pack* to be used with a 2K (internal) ZX81.



COMPONENTS

For 2K Ram Pack Modifications

R1	2·7kΩ ⅛ to ⅓W carbon ±5%
D1, 2	1N4148 small signal silicon (2 off)
TR1	ZTX108, BC108, BC457 or similar *npn* silicon type

For Modifications to ZX81

IC1	6116 2K × 8 bit RAM

24-pin d.i.l. open type i.c. socket or 2 × 12-way Soldercon pins.

Guidance only
Approx. cost **£7**
See page 826

board. Make sure all components are located parallel with the p.c.b. so as not to interefere with the fit of the case. It is also a good idea to insert p.v.c. insulating tape on the board below the main "bridge" of components to prevent accidental shorting to the tracks.

That completes the modification to the Ram Pack and for those who already have the 6116 modified ZX81, all that remains is to plug in, power up, enter Ramtops and read 20480. For others who wish to incorporate the 6116 modification read on.

6116 MOD TO ZX81

First undo the ZX81 case following the instructions given in the May issue of *EE* (why not add the worthwhile *Keyboard Beeper* (May 1982, *EE*) whilst you're at it).

Check the RAM chips for type, refer to Fig. 3.

4118 RAM

If the 4118 is soldered directly to your ZX81 p.c.b. we do not advise you to remove it. The on-board 2K upgrade is unfortunately, not possible for you to implement.

First remove the 4118 chip from its i.c. socket (preferably using an i.c. extractor or with careful, gentle leverage from a thin screwdriver). Avoid touching the pins or work on an earthed plate ensuring at least one hand is in contact with the plate—this is expensive CMOS you're handling and it doesn't like bodystatic. Immediately transfer the chip to the piece of conductive foam or conductive plastic tubing—which is what your 6116 and 2114s should have been packed in.

Now locate both ends of the link marked L1 on the board and cut off. Solder a new link at the position marked L2. Re-assemble into the case, power up, run the Ramtops test to read 18432.

2114 RAM

If your ZX81 is fitted with 2114s then you have saved the cost of half the 2114s for your *2K Ram Pack*. The ZX81 IC4a position has an 18-way d.i.l. holder containing one 2114 inside the drilled and marked 24-way area that is there to take a 4118. Carefully extract the two 2114s. Do not attempt to remove the holders. Offer up a skeleton 24-way d.i.l. socket to position IC4. Some holders only need the centre bar removed to fit around the 2114 18-way socket, others may require cutting into two strips. Solderon pins could be used instead. Locate the holder into the position on the board marked IC4 making sure you are within the 24-pin socket area and not the 28-pin area also marked. The old 2114 holder will now be framed within the 24-pin socket. Solder the socket, cut the L1 link and solder in the L2 link. Plug in the 6116. Reassemble into the case, power up, run Ramtops test to read 18432.

All that now remains is to bring the modified *2K Ram Pack* to the modified ZX81, check RAMTOPS to read 20480.

THE FUTURE

For many who need more than a 4K memory, have another look at the original *2K Ram Pack* control chip (IC5). Q4, Q5, Q6, Q7 are unused. By lifting input A2 from ground and taking to address line A12 you could control a further 4K of RAM—or even, with a little flair, inlet/outlet ports.

NOTE

You will find that these additions to your ZX81 enable you to use many programs written specifically for use when 16K Rampacks are attached. However some clever games programs use a mixture of BASIC and machine code. In these cases it is as well to remember the machine code will have been allocated to specific addresses which may not fit unmodified to your 4K machine. ⌘

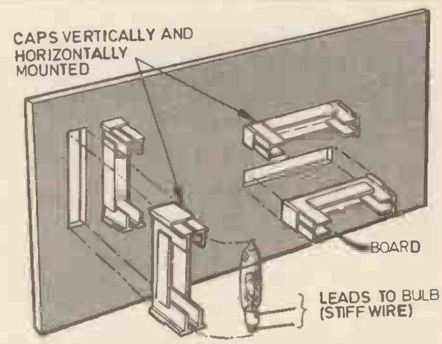
PANEL LAMP COVER

Bearing in mind the cost of commercially made panel lamps, I have devised a simple substitute.

A cap off a Bic disposable razor is the basis of the cover, see diagram. To mount it on a panel or board it is simply pushed or snapped into a rectangular hole.

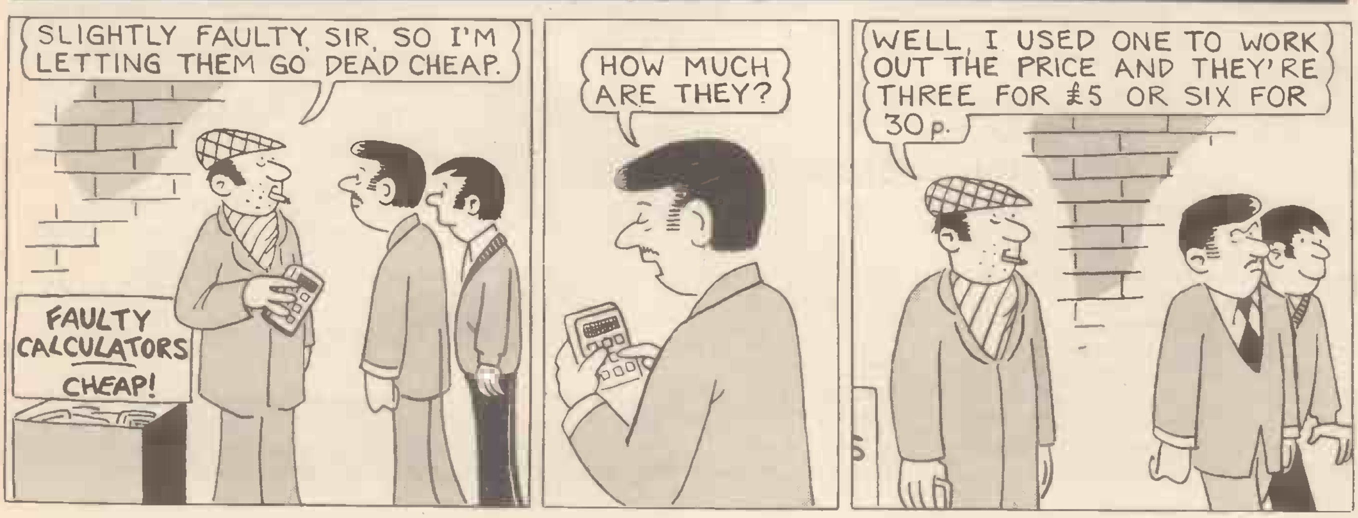
This idea has the advantage that the lamps may be mounted vertically or horizontally.

I. Petrie-Brown, Birkdale, Southport.



JACK PLUG & FAMILY...

BY DOUG BAKER



BE 'AT HOME'

WITH THE

SECURITY VARI-LIGHT

BY A.R.WINSTANLEY

WE ARE constantly reminded that burglaries on private homes seem to be continuously on the increase. Everyone can take obvious precautions like locking doors and windows, but the device to be described here offers a more subtle means of combating casual prowlers and burglars.

It does this by tricking the would-be prowler into believing that the house is occupied at night, even though the occupants are out.

The Security Vari-Light is a unit designed for use with floor-standing standard lights or table-top lamps, therefore installation is very simple. The Security Vari-Light operates the lamp on a random cycle which has been carefully designed to give a realistic effect.

A timer circuit is incorporated so that the system will switch on after a predetermined delay of between two to seven hours. Having lights flashing on and off at four o'clock in the morning could be deemed counterproductive, as this may draw attention to the house. The timer will help to overcome this and can be switched out if it is not required.

REPEATER

The system has been further developed and although this unit is designed to control just one lamp, by adopting a system of optical links, "repeater" units can be employed to operate lights throughout the house. The object in this respect, is to avoid having to alter any of the house's existing lighting and wiring, in order to make installation an easy matter.

Furthermore, by employing optically-coupled repeater units to drive other lights, mains wiring is avoided. Instead, a light sensitive cell connected to the repeater unit detects when the "main" security light is illuminated, and causes a second lamp to light up. Indeed, by making several photo-resistors "look at" the main Security Vari-Light, almost any number of secondary lamps could be controlled in this manner.

CIRCUIT DESCRIPTION

Fig. 1 is the circuit diagram for the Security Vari-Light and it can be divided into two distinct sections, the Timer/Power Supply section and the Logic Control section, the latter to be described first.

IC3 comprises two four-bit shift registers, a CMOS 4015 is used, and by connecting the Q4 output of the first shift register to the D input of the second, a single eight-bit shift register is formed. The CLOCK and RESET pins for both registers are connected in parallel for this application.

IC1 is a simple 555 astable multivibrator which provides a low-frequency clock signal, approximately one clock pulse every ten minutes is passed to the shift registers. An EXCLUSIVE-OR gate, a CMOS 4070 is the only other logic element and this device contains four separate gates, all of them utilised in the circuit.

LOGIC CONTROL

The circuit operation is as follows. Upon initial application of power, a reset pulse is delivered by IC2d to the shift registers, the outputs of which are then cleared to zero.

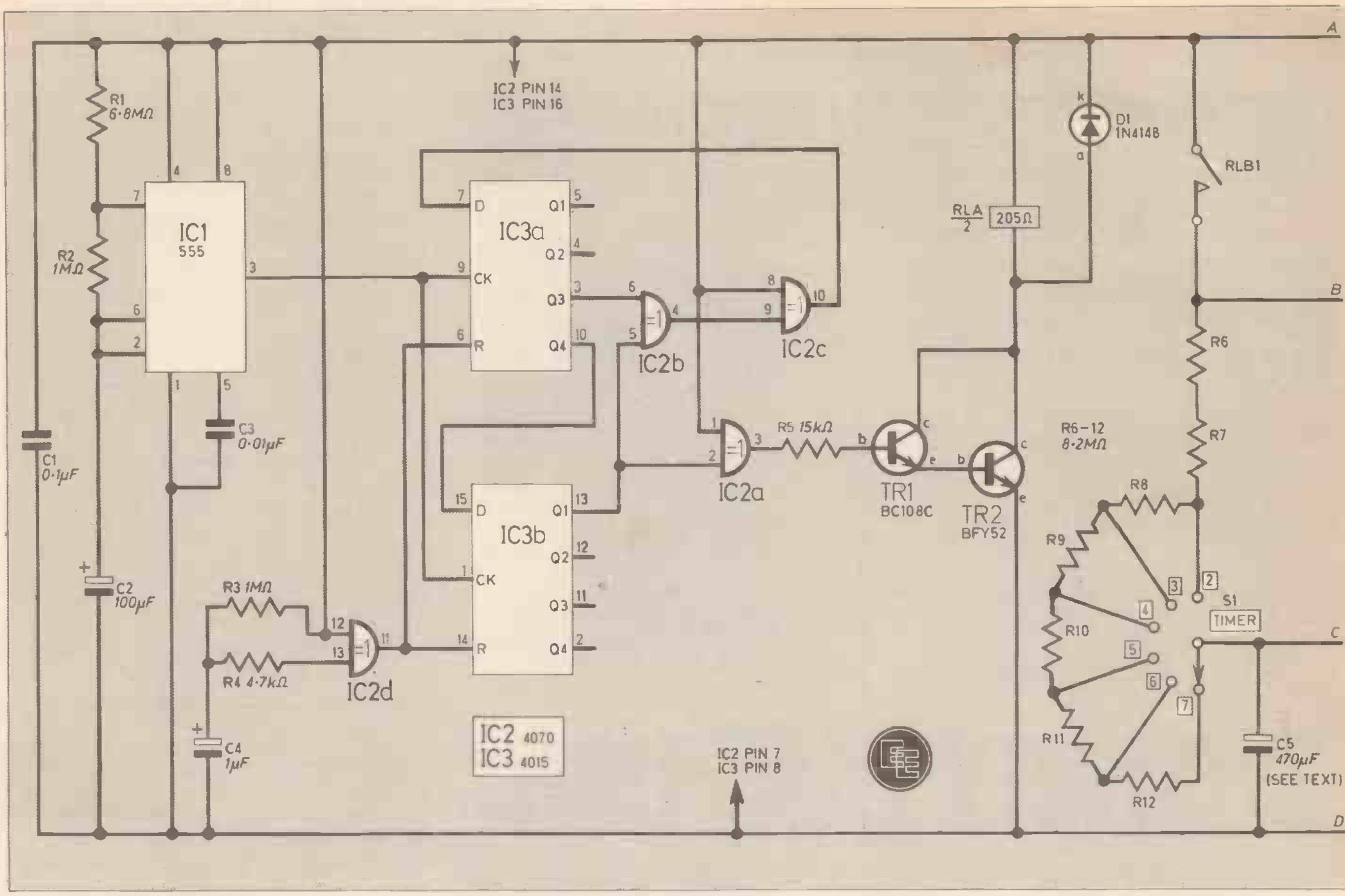


Fig. 1. Circuit diagram of the Security Vari-Light.

Simultaneously, the first positive clock transition is despatched by IC1 but the effect of this upon the logic circuit is cancelled by the switch-on reset pulse.

Since the inputs of IC2b are at logic zero, the output of IC2b is also zero, remembering that IC2 is an EXCLUSIVE-OR function. However, IC2c is connected as an inverter since one input is permanently wired to logic 1. The logic 0 generated by IC2b, then, is inverted by IC2c to generate a logic 1 which is injected into the DATA input of IC3a.

In effect, IC2b and IC2c have combined to form an EXCLUSIVE-NOR gate which serves to "start up" the shift registers and prevent them from remaining at logic zero, as detailed earlier. The pseudo-random sequence will then follow on with each successive positive clock pulse.

SHIFT REGISTER

The output from the shift register is taken from the Q1 bit of IC3b (pin 13) and it is here that the pseudo-random pattern will be observed. This is inverted by IC2a and drives a high-gain transistor switch comprising of TR1 and TR2, which themselves complete the circuit to the mains relay RLA.

Thus when the output of IC3b (Q1) is low, which it is for the first five steps of operation, then this is inverted by IC2a to form a logic one. This high signal activates the relay RLA through the transistor switch, so that the contacts RLA1 close and power is applied via the mains socket SK1 to the mains lamp, so the lamp illuminates.

Since the logic 0 output of the shift register (Q1 of IC3b) is inverted by IC2a to form a logic 1, this means that the lamp will illuminate immediately upon power switch on. It will extinguish when a logic 1 eventually reaches pin 2 input of IC2a.

After ten minutes or so, the clock generator will deliver another positive-going pulse which will advance the shift registers by one step. The logic circuit will now generate the pseudo-random sequence, the lamp switching on and off accordingly.

TIMER CIRCUIT

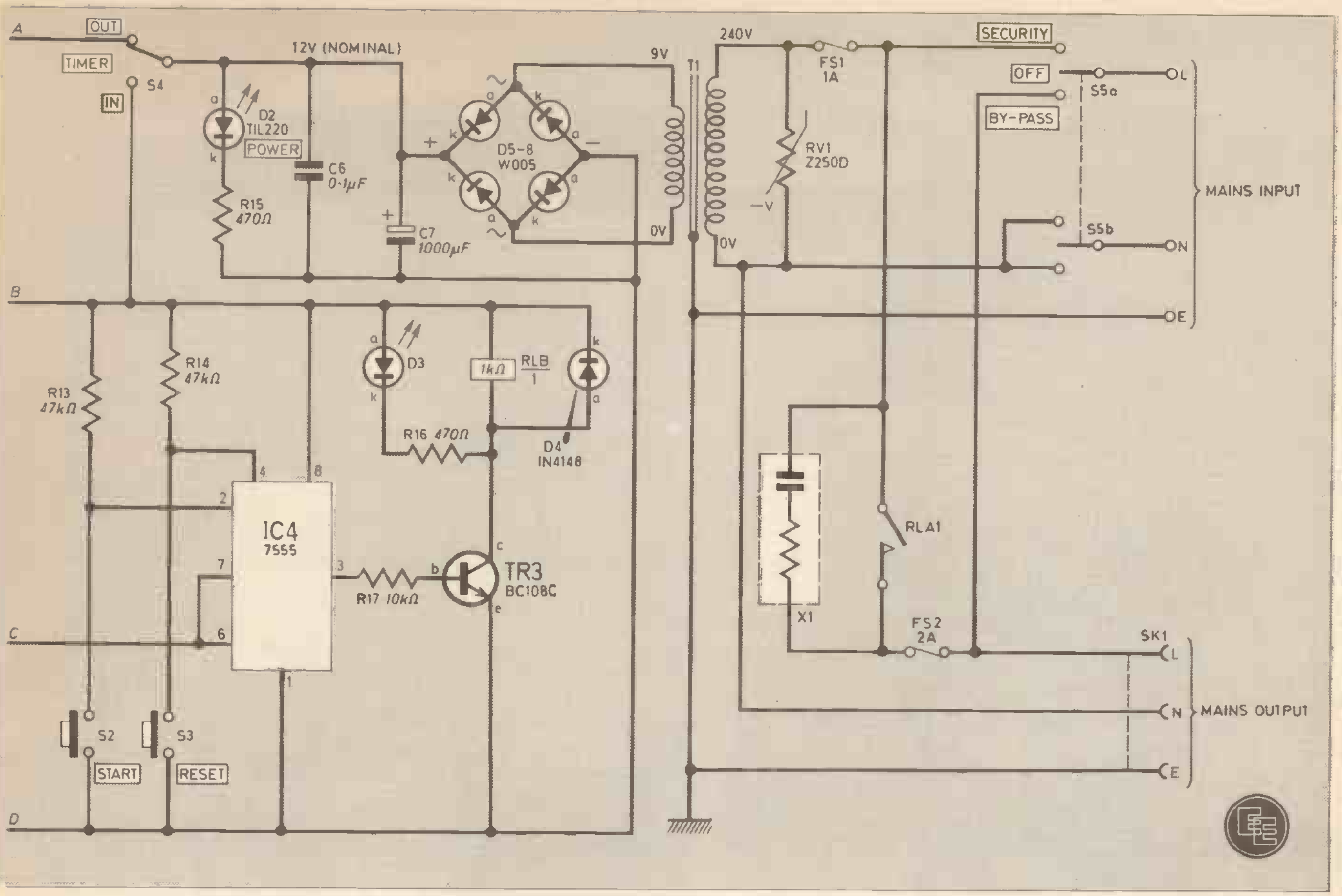
A timer has been incorporated which will operate the logic section for a predetermined period, between approximately two to seven hours, and will then disconnect the lamp. Thus the user can set the Security Vari-Light to operate randomly for a suitable period while he is away, the device will then turn off automatically.

The timer is formed by IC4, a CMOS 7555 connected as a monostable. Timing is initiated by closing S2 temporarily and the timer can be reset by closing S3, if required.

TIMING PERIOD

The timer period is controlled by resistors R6-12, and C5. By rotating S1 one may adjust the value of the timing resistor network and thus the timer period can be altered as required. One problem with a simple circuit of this type is the leakage current through the timing capacitor C5. The long time constants which are required imply that a large-value capacitor is needed, specifically, an electrolytic type. These have high leakage currents which greatly affect the accuracy of the timer. With C5 at 470µF, each 8·2 megohm timing resistor corresponds to a delay of one hour.

When the timer is initiated, pin 3 of IC4 goes high, and this is buffered by TR1 to drive the reed



relay RLB and the TIMING l.e.d. indicator, D3. The reed contacts RLB1 then close and supply power to the logic section.

This in turn activates the switch-on reset circuit (IC2d) and then the logic sequence starts up in the manner described, causing the mains lamp to operate in a pseudo-random fashion.

If the timer is not needed, it can be bypassed by setting S4 to OUT which disconnects the timer circuitry and provides power straight through to the logic.

POWER SUPPLY

The power supply is a standard type in which 240V a.c. is stepped down by T1 to about 9V a.c., and subsequently full-wave rectified by D5-8 and smoothed by C7 to give about 12V d.c. at no load. D2 is the POWER l.e.d. and illuminates when the Security Vari-Light is switched in.

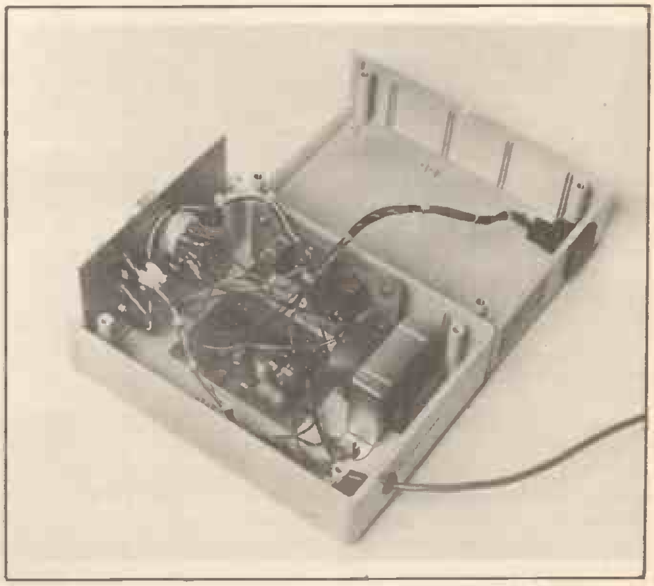
In the SECURITY mode, S5 (the mode switch) passes mains current through to T1 primary winding and then the random logic sequence will operate the mains lamp, and this can then be timer-controlled if desired. However, S5 can be moved to the BYPASS mode and this will supply power to the lamp continually, bypassing the electronics.

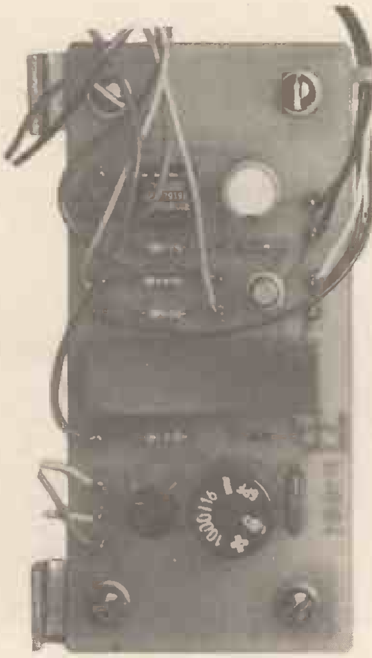
S5 is actually a centre-off type so when in middle position, both the electronics and the lamp will be completely disconnected from the mains supply.

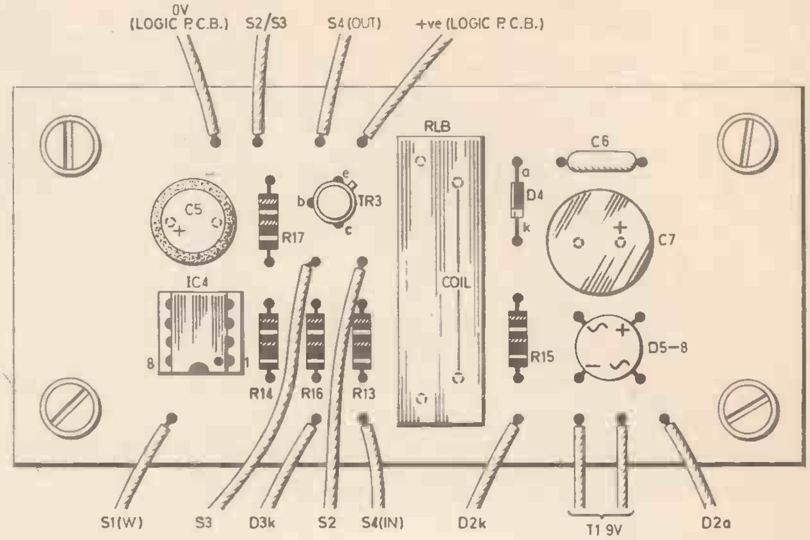
MAINS SUPPRESSOR

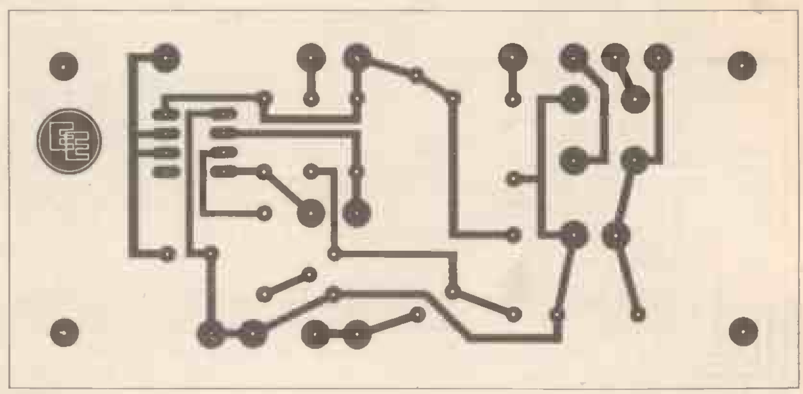
Finally, the mains contacts of RLA1 are protected by a suppressor network, X1. This reduces contact wear and prevents mains transients from working through the power supply causing the logic section to malfunction. Protection of this nature is increased by the mains transient suppressor, RV1.

However, the presence of X1 provides a route for mains power when S5 is in the BYPASS mode, so even though the electronics are disconnected, enough power may be transmitted through X1 to operate the CMOS. As a result of this the light-emitting diodes glow very dimly.









CONSTRUCTION starts here

PRINTED CIRCUIT BOARDS

Construction is relatively straightforward, because nearly all components, including the mains relay, are mounted on two specially-designed printed circuit boards.

The first p.c.b., which carries the power supply and timer section. is shown in Fig. 2. This is mounted vertically using metal brackets or plastic vertical p.c.b. guides. Assembly of components is as indicated in the diagram, noting that Veropins should be used where flying leads are taken off the board. Also an eight-pin d.i.l. holder is used for IC4 to prevent damage occurring to the i.c. when soldering. The reed relay used is a Maplin type FX51F, other makes may not be compatible with the holes in the p.c.b.

The arrangement of components on the second board is illustrated in Fig. 3. The relay for this layout is a Maplin 5A mains relay type YX98G, this will solder directly to the circuit board. FS2 is a 20mm p.c.b. mounting type, rated at 2A.

The integrated circuits IC2 and IC3 are CMOS devices and are particularly sensitive to static electricity. Do not remove the devices from their conductive packing until they can be inserted into their respective holders on the board.

CASE

The case used on the prototype was a plastic Verobox type 202-21311 which has dimensions 138 x 190 x 91mm. As mentioned earlier, it is recommended to fix the timer p.c.b. vertically to obtain the most compact arrangement, layout is otherwise not too critical. Keep the lengths of mains wire to a minimum and away from the mains interwiring, this will ensure that no problems are caused by mains interference.

The timing resistors R6-12 are soldered directly to the tags of S1, in accordance to Fig. 4. This diagram details all necessary interwiring and must be followed closely.

The earth input is connected to the mounting frame of the transformer, and this is accomplished by

SECURITY VARI-LIGHT

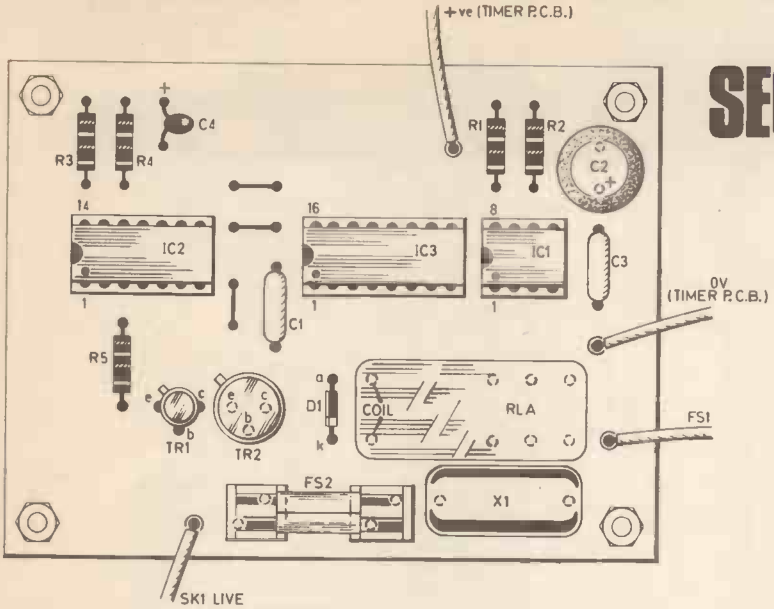
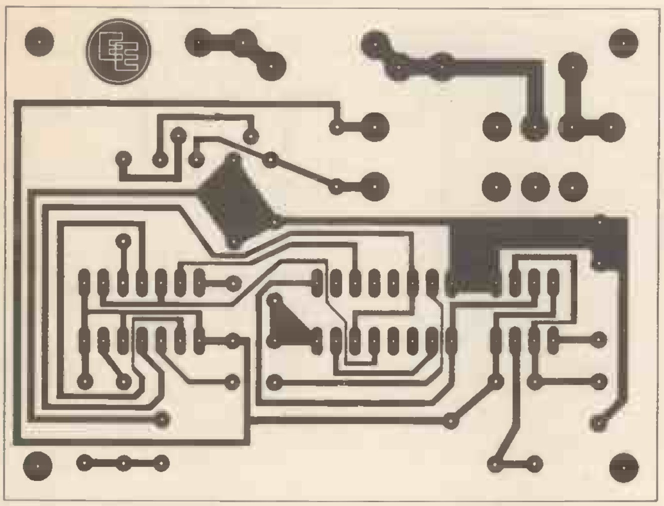
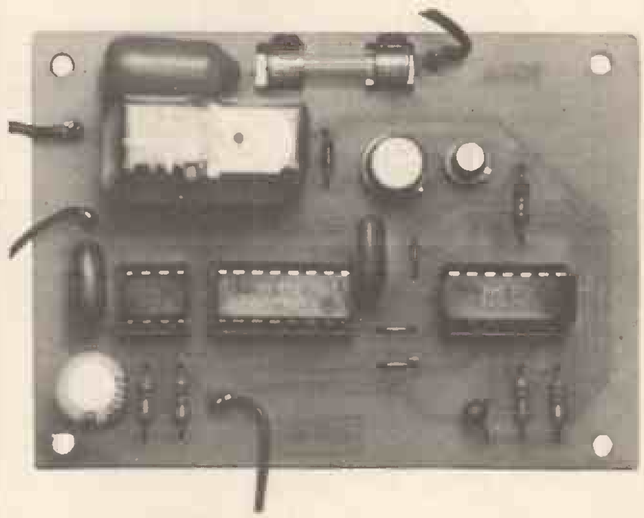


Fig. 2. (opposite page) The component layout and full size track artwork for the timer/power supply printed circuit board. The four mounting holes are for securing the board to the p.c.b. brackets. These can be seen in the photograph of the prototype also shown.

Fig. 3. (left) The Security Vari-Light main control logic board component layout and full size track artwork. This board is mounted on spacers off the bottom of the case. Photograph (below) shows the finished p.c.b. assembly from the prototype model.





using a solder tag fixed under one of the transformer mounting bolts. It is essential that the front panel, which is made of aluminium, is also soundly earthed, remembering that it is anodised, so this must be removed at the earthing point.

It is of prime importance that the three-core mains cable is properly secured so that it will not pull out and for this, a cable retention clip and grommet are utilised.

SK1 is a "Euro-Facility" 6A 250V mains socket and is a clip-in type. A suitable cutout (28 x 23mm) is made in the top half of the case, at the rear. It may be necessary to secure the socket with an adhesive, since the rather thick case wall may prevent the socket from clipping into position properly.

MAINS WIRING

All mains interwiring should be completed using 24/0·2mm 6A wire. This is thick enough to carry the required current but can be soldered to the small tags on the rear of the mains ON/OFF switch, S5. Insulate each mains joint with 2mm bore p.v.c. sleeving for additional safety.

The remainder of the interwiring can be completed with standard 7/0·2mm wire. Use of several colours assists with checking, later on.

There are two light - emitting diodes to be fixed to the front panel, and this can be achieved with two transparent lens-clips or the standard black bezel clips.

To label the controls on the front panel after the panel has been drilled, use rub-down lettering (available from stationers and some component suppliers), after which carefully apply several light coats of protective clear lacquer. This will help prevent the letters from lifting off.

CHECKING

Check out very carefully all wiring and soldering, prior to switching on. Ensure that the mains plug is fitted with a 3A fuse and then plug a lamp (500W maximum power) into SK1. With S5 at OFF (centre) and S4 to TIMER IN, plug into the mains and switch on by moving S5 to SECURITY. This should cause the POWER l.e.d. to light up. The TIMING l.e.d. may or may not be alight, but either way, pressing S2 will activate the timer and the mains lamp should also light up. Pressing S3

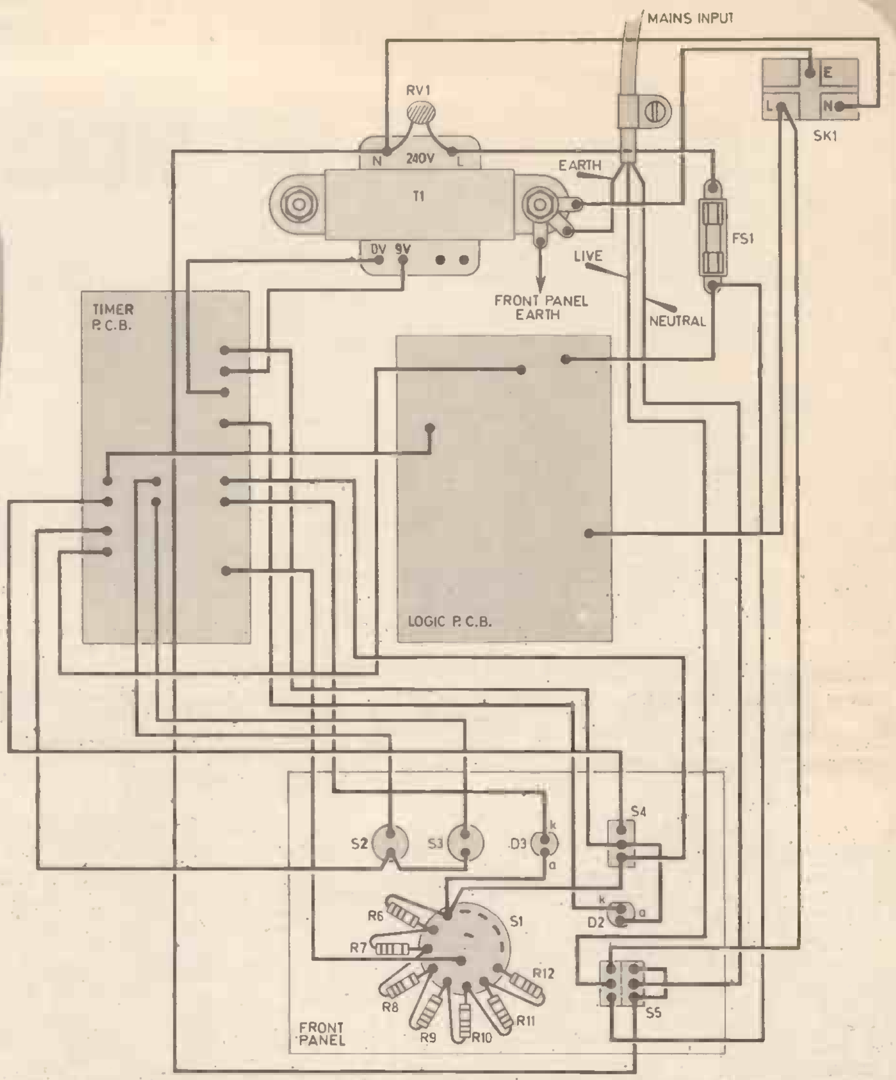


Fig. 4. Interwiring diagram. Note that resistors R6 and R7 are soldered onto two unused switch tags on the unused half of S1. The front panel earth wire was soldered to the metal case of S5.

COMPONENTS

Resistors
- R1 — 6·8MΩ
- R2, 3 — 1MΩ (2 off)
- R4 — 4·7kΩ
- R5 — 15kΩ
- R6-12 — 8·2MΩ (7 off)
- R13,14 — 47kΩ (2 off)
- R15, 16 — 470Ω (2 off)
- R17 — 10kΩ
- All ¼W carbon film ±5%

Capacitors
- C1, 6 — 0·1μF polyester C280 (2 off)
- C2 — 100μF 25V elect, radial lead
- C3 — 0·01μF polyester C280
- C4 — 1μF 35V tantalum bead
- C5 — 470μF 25V elect, radial lead
- C7 — 1,000μF 25V elect, radial lead

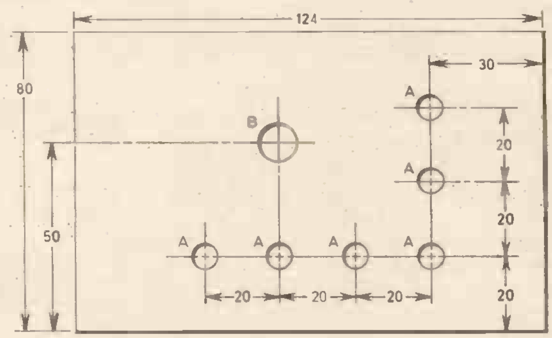
Semiconductors
- D1, 4 — 1N4148 silicon (2 off)
- D2, 3 — TIL220 0·2in. red l.e.d. (2 off)
- D5-8 — W005 50V, 1A bridge rectifier
- TR1, 3 — BC108C silicon *npn* (2 off)
- TR2 — BFY52 silicon *npn*
- IC1 — 555 timer
- IC2 — 4070B CMOS quad 2-input EXCLUSIVE-OR gate
- IC3 — 4015B CMOS dual 4-bit shift register
- IC4 — 7555 CMOS timer

Switches
- S1 — 2-pole, 6-way rotary
- S2, 3 — push-to-make momentary action (2 off)
- S4 — s.p.d.t. miniature toggle
- S5 — d.p.d.t. centre off miniature toggle

See Shop Talk page 826

Miscellaneous
- RV1 — 240V mains transient suppressor Z250D
- X1 — mains R-C contact suppressor
- RLA — miniature mains relay, 12V, 205Ω coil, contacts rated at 240V, 5A
- RLB — encapsulated reed relay, 9-12V, 1kΩ coil, 50V, 200mA contacts
- FS1 — 20mm, 1A fuse with chassis mounting holder
- FS2 — 20mm, 2A fuse with p.c.b. mounting clips
- T1 — miniature mains transformer, 9V, 250mA secondary
- SK1 — mains panel mounting socket
- PL1 — shrouded pin mains plug (for SK1)

Case, Verobox 202-21311 size 138 × 190 × 91mm; single sided p.c.b.s. size 86 × 65mm and 105 × 50mm; 16-pin d.i.l. holder; 14-pin d.i.l. holder; 8-pin d.i.l. holder (2off); 24/0·2mm wire (for mains wiring); 7/0·2mm wire; P-clip; grommet; knob; 3-core mains cable; standard 3-pin mains plug with 3A fuse; self adhesive feet (4 off); Veropins; solder tags; mounting hardware (nuts, screws, washers and p.c.b. bracket or guide).

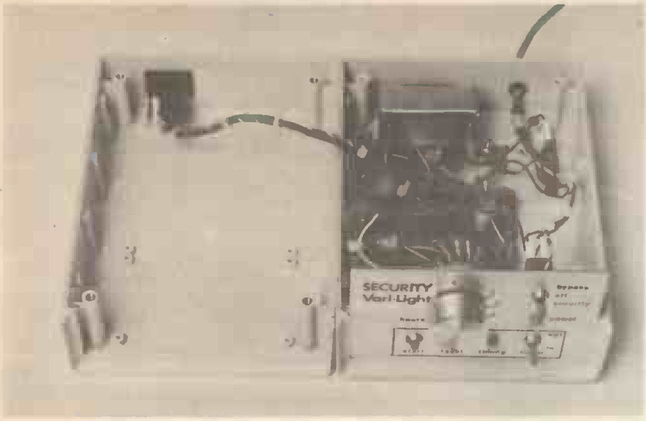


HOLE SIZES
A = 6·4mm
B = 10mm

ALL DIMENSIONS IN mm

Fig. 5. Front panel drilling details.

COMPONENTS approximate cost £28



View inside the finished prototype model clearly showing the mounting of the mains socket SK1, and how the mains wiring is separately held together with cable ties.

should extinguish the lamp and the TIMING indicator. This indicates that the timer functions correctly. Follow on by testing other functions.

Using a stopwatch, check the time period obtained with the timer set to the two hour delay setting. The result obtained will give a good indication of the accuracy that can be expected on other settings.

If the timer is discovered to be unacceptably inaccurate, the simplest remedy is to change the value of C5 accordingly. With the prototype, the theoretical two hour delay came out actually as more than 50 per cent over this; C5 was reduced to 220µF. The delay then was about one and three-quarter hours, which is more acceptable.

APPLICATION

With the model suitably tested and functioning it can be pressed into service. It is possible to use the device with any mains lamp (or number of lamps) totalling not more than 500 watts.

Floor-standing spotlight units work well as a deterrent if located in the hallway or near to the entrance of a room. ☐

COUNTER INTELLIGENCE

By PAUL YOUNG

Component Buying

Following on from my October article, I would like to add a few more, I hope helpful, ideas on the subject of buying components for various projects.

Many customers come into a shop clutching their copy of EVERYDAY ELECTRONICS open it at the required page, point to the list of components and say "I would like that lot". If this happens on a busy Saturday, then the retailer, who is probably understaffed and has a shop full of people to serve, will most likely ask you to leave your list and come back later.

One cannot altogether blame him, because a list of perhaps thirty or forty varied items can take up to twentyfive minutes to assemble, and if he stops to do this, it is quite likely that several customers will walk out. Remember, today is a buyers market and the poor retailer does not wish to lose a single customer.

Let me suggest how you can help him. First of all, take your magazine and write out your desired list again, re-arranging the order. The reason for this is simple enough, if you look at any list you will soon notice that, for example, resistors might be as follows: R1 1kΩ, R2 10kΩ, R3 47Ω, R4 1MΩ, R5 1kΩ, R6 3·9kΩ, R7 10kΩ and R8 47Ω.

It is not difficult to see how time consuming this is, because the assembler has to keep returning to the same box. The list should be set out as follows: (2) 47Ω, (2) 1kΩ, (1) 3·9kΩ, (2) 10kΩ, (1) 1 MΩ. The same treatment applies to capacitors and other discrete components.

It is also helpful if the list can be priced, if only approximately. In addition, make sure you have enough money! Many is the time I have spent half an hour compiling an order, only to be informed that he or she is short of the required amount by £1·62, and would I please suggest what should be taken out of the parcel to make the amount right!!! Perhaps I am getting touchy (put it down to age) but this behaviour tends to irritate me.

Lucky Dip

Still on the subject of components, I would like to touch on values, because the average reader is inhibited against altering values even by the smallest amount. Quite understandable, as the designer is pictured as a chap in shirt sleeves with an ice bag on his head, working a slide rule which is red hot, until he finally deduces that a certain capacitor should be 0·02µF.

In practice, Mr. Designer is sitting at his bench lashing the project together and finds he needs a capacitor. He dips his hand into his junk box pulls out a 0·02µF tries it, and *Eureka*—it works alright, so a 0·02µF it shall be.

The Reader than asks his supplier for a 0·02µF, only to be told "I am sorry Sir, the nearest I have is 0·022µF". The reader quickly backs out of the shop, horrified at the idea of altering Mr. X's design.

Don't be worried kind reader, it will not make any difference. If the designer wants you to stick closely to his values he will make them close tolerance.

If you bear this in mind, you will find you can substitute ¼ watt resistors for ½ watt and vice versa. With capacitors, you can choose from electrolytics, tantulum, polyester, polystyrene, polycarbonate, paper and silver mica. The governing factors here are physical size, and in the case of close tolerance (1 per cent or 2 per cent) you may be limited to polystyrene of silver mica.

With capacitors, a higher voltage can always be used, and I can best illustrate the veracity of my facts by a true story. Several years ago I asked a friend to design a signal tracer and asked him to make the tolerances as large as possible so that I could select a component I had in quantity.

When I received the design, the parts list looked like this: C1, anything between 0·01µF and 0·1µF, any material, voltage no lower than ten. C2, 0·01µF to 0·1µF. R1, 10 to 100Ω, any wattage from ⅛ watt upward. R2, 47kΩ to 470kΩ, again any wattage, and so on through the list.

Obviously, the constructor will pick the nearest value, but there is no need to be worried about small deviations, and this makes it much easier for your retailer to supply your wants.

Computer People

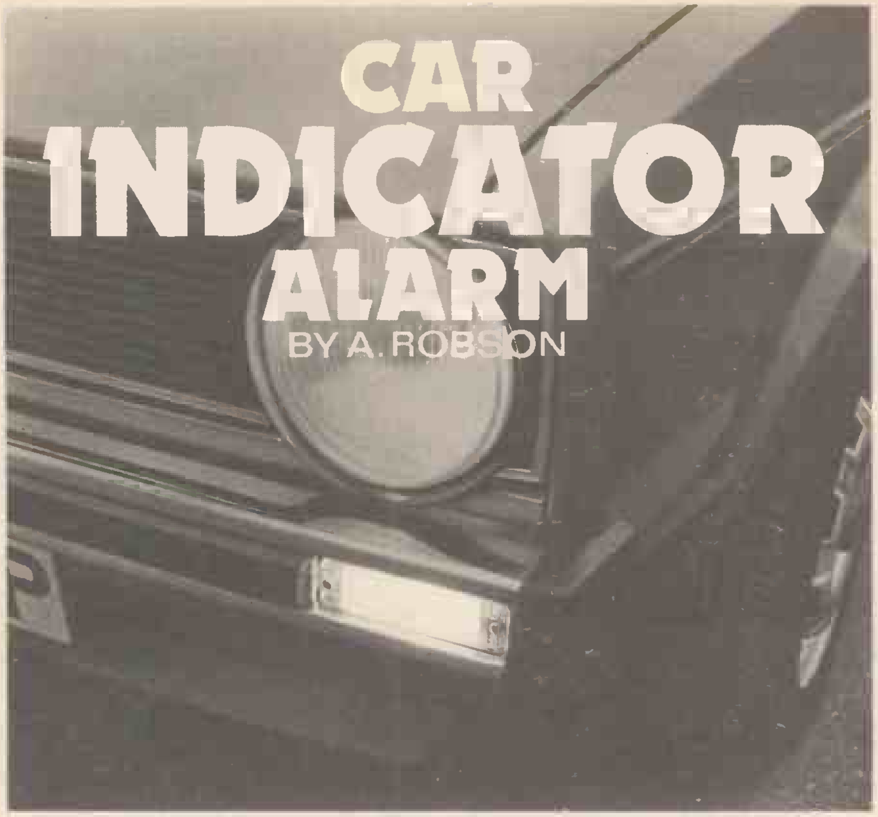
I have been told by many people that if you sit sipping a coffee outside the Cafe de L'Opera in the Rue de la Paix in Paris, the whole world will pass by. I thought I would try it last year, until I found that the coffee cost over £1 a cup!!

However, I have been helping a friend whose shop is not a million miles from London W2, and I have found that the "all the world" idea applies here. Every nationality seems to pass by the door, many of them would-be customers.

Unfortunately, until recently this shop sold only computers and spares, and computer language is quite unknown to me. If a "floppy disc" walked right up to me and looked me straight in the eye, I wouldn't recognise it. In fact, I picture it as a soggy grey pancake.

Even when asked for items we stock, the language or accent makes for difficulty. This is further compounded by being slightly deaf (a legacy from the last War and after, when I was trundling noisy piston engined aircraft around the sky for some ten years). The other day I was asked for something which sounded like "have you any spacer hooks" asking him to repeat the question he said "No, Data Books, you dummy"—Paul Young sinks slowly to the floor.

All the same, it has been an invigorating experience.



CAR INDICATOR ALARM

BY A. ROBSON

THE direction indicator warning buzzer/clicker on some cars is so feint that it cannot always be heard above the engine and road noises. The result is that the indicator is sometimes left on, creating a driving hazard.

The circuit described here uses only a single i.c. (555 timer) in its design to provide an audible signal when the indicators are operated, of sufficient loudness to be heard in most driving conditions.

CIRCUIT DESCRIPTION

The full circuit diagram of the Car Indicator Alarm is shown in Fig. 1. It uses a 555 timer i.c. in a rather unconventional way. There are no timing components in the circuit. The threshold input (pin 6) is strapped to the positive supply line.

When the car indicator is not operating, PCC1 assumes a very high resistance in its dark environment inside the case. PCC1 and R1 form a potential divider across the supply lines to feed the trigger input on IC1 (pin 2). With the value for R1 as shown, this makes the trigger voltage level low which causes the output, pin 3, of IC1 to go to approximately 12V. The relay is thus not energised.

If the car indicator is now operated, LP1 lights up in sympathy with the indicator dash-mounted pilot lamp. Light from LP1 reaches PCC1 and causes its resistance to substantially reduce removing the trigger on level from pin 2. IC1 output drops to 0V and so the relay becomes energised; RLA1 opens, the relay becomes de-energised resulting in RLA1 contacts (normally closed type) closing again.

If LP1 is still on, the above cycle repeats, and the relay contacts "chatter". Thus there are bursts of chatter each time LP1 illuminates. The chatter rate is controlled by the value of C1, sometimes called a slugging capacitor.

ASSEMBLY

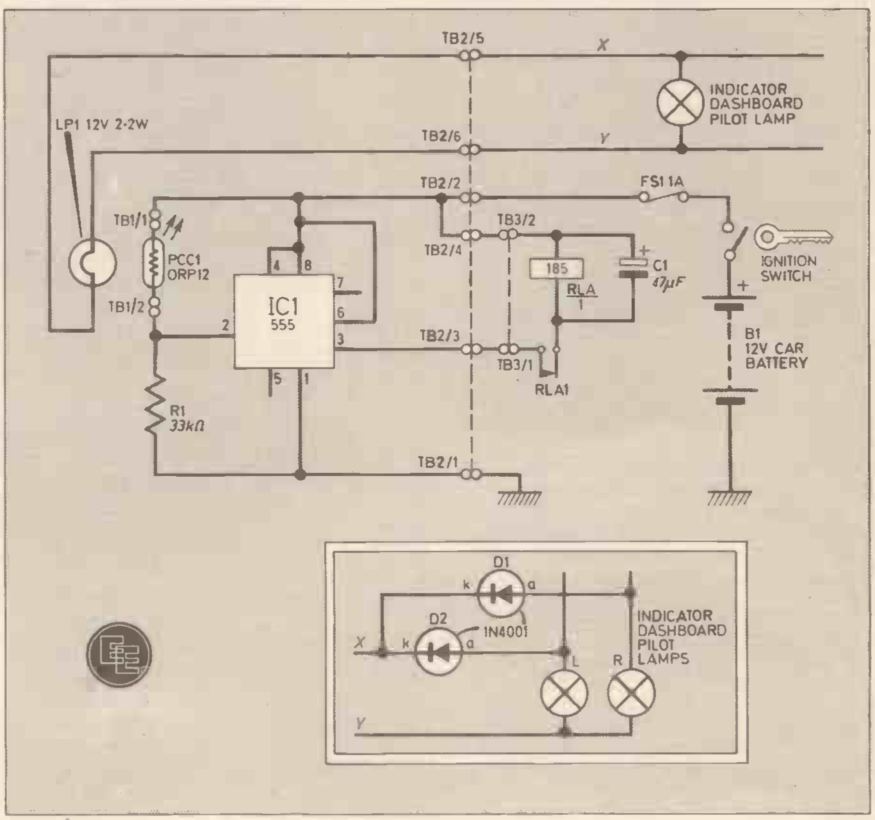
Full assembly and interwiring details are provided in Fig. 2. Any small plastic box may be used for containing the circuit board and other components. The container for a 35mm film was found by the author to be ideal for this.

Prepare the case to accept the chosen lampholder and fix in place on the blank end of the case as near to the side as possible. Make a small hole in the same end to allow the four leads from the circuit board to pass through to reach TB2.

Cut the 0·1in matrix stripboard to size and make the necessary breaks on the underside using a spot face cutter or small drill bit (about 3mm dia.). Assemble and solder IC1, R1 and the link wires. Attach suitable lengths of flying leads — use insulated stranded wiring. The insulation colours of the wires from the board to TB2 should be of different colours for easy identification when wiring up.

The l.d.r. is secured near to the edge of the lid inside by a terminal

Fig. 1. The circuit diagram for the Car Indicator Alarm. The inset shows circuit modification for use on cars fitted with two (Left and Right) dashboard indicator pilot lights.



block. The leads from the terminal block are threaded through the lid, loop over the outside and pass inside to connect to the circuit board.

Blu-Tak or Plasticene may be used to hold the board in position so that it does not interrupt the optical path between LP1 and PCC1.

Feed the four wires through the case end and gently pull them through while pushing the board into the case. Apply some Blu-Tak to board/case to hold the board firm in the correct position.

Thread the remaining two board wires through the lid of the case and connect to TB1 as shown. Screw PCC1 to TB1 and attach this assembly to the lid using glue or Blu-Tak. Clip the lid in position with PCC1 aligned with LP1. Plug the holes at either end of the case. Connect the six leads from the case to the terminal strip, TB2.

The other case should be of metallic material to help "amplify" the relay chatter. Some brackets will need to be constructed to securely hold the relay and capacitor. The size, shape and fixing will vary according to the components and box used. Always use shakeproof washers with nuts and bolts for fixings on cars as the vibrations produced could otherwise loosen nuts/bolts. A rubber grommet must be used fitted in the hole carrying wiring to TB3. The latter should be screwed to its case.

Fit the components and wire up as shown using stranded wiring.

You should now have two units each fitted with terminal blocks, ready for installation in the car.

The metal box containing the relay should be placed (not fixed) close to the driver's seat. The other unit can be mounted anywhere in the car. The steering column was found to be a convenient position in the designers car. Insulating tape was used to hold it secure.

Trace the leads of the indicator pilot light(s) on the dashboard and connect a pair of leads in parallel with the existing lamp. Run these leads to positions 5 and 6 on TB2. If there are two pilot lamps, one for each Left and Right, two diodes will need to be included as shown in the inset in Fig. 1. The diodes are more conveniently attached at TB2. This then requires three wires to connect to TB2, see Fig. 3.

A good earth (chassis) connection is required to connect to TB2/1. This may be found under the dashboard; any metal screw into the metalwork will do, under which a wire, or wire with solder tag may be fitted.

Finally connect the positive supply lead +12V to TB/2. This must be made via an in-line fuse or a spare fuse position that may be available in the car fuse box. Fit a 1A fuse. The ignition switch is a convenient place to pick up the +12V using a spade terminal; there is usually a free position to be found on the switch that is "live" only when the ignition switch is turned on.

COMPONENTS

R1	33kΩ ¼W carbon ±5%
C1	47µF 16V elect.
IC1	555 timer i.c.
PCC1	ORP12 light dependent resistor
RLA	180 ohm 12V relay with at least one set of normally closed contacts
LP1	12V 2·2W filament lamp
FS1	1A, to suit holder (see text)
TB1, 2, 3	cut from 12-way 2A screw terminal strip

Stripboard size 0·1 inch matrix, 10 strips × 16 holes; miniature panel mounting lampholder for LP1; aluminium for brackets; metal box size 70 × 50 × 25mm approx.; rubber grommet; solder tag; nuts, bolts, shakeproof washers, 6BA; plastic case—35mm film case.

Approx. cost Guidance only £6

See page 826

Wire the two units together to almost complete the project. Use lightweight automotive wiring for all long runs of wiring between unit and car/unit and sleeve or wrap any exposed connections.

Operate the indicators with the engine running. A chattering noise burst should be heard to come from the metal box each time the indicator pilot lamp flashes on. Fix the box in a suitable position for loudness and convenience. ⌑

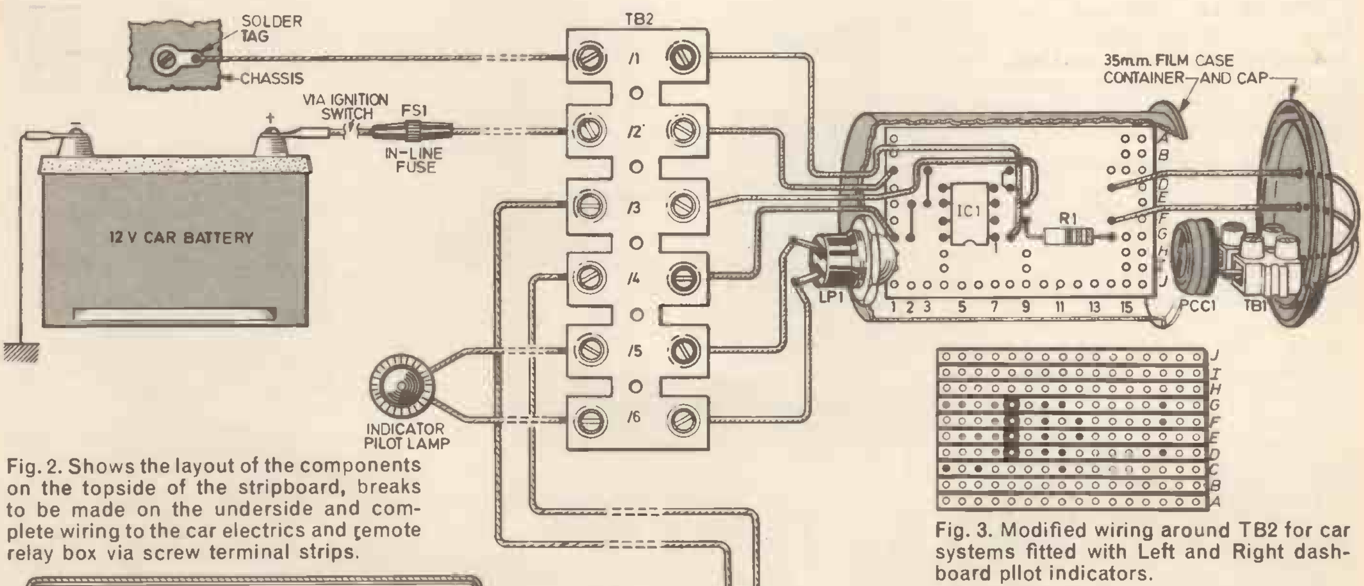
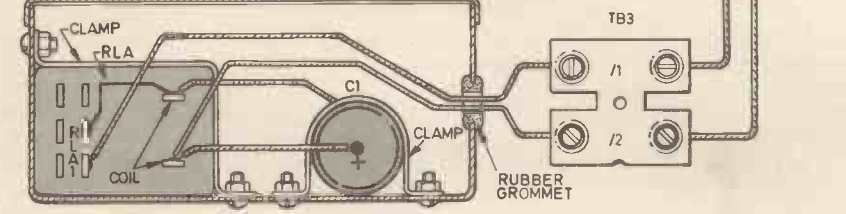
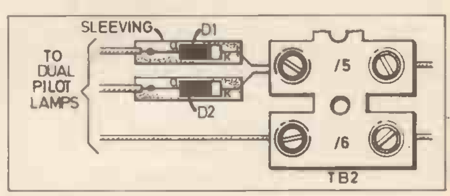



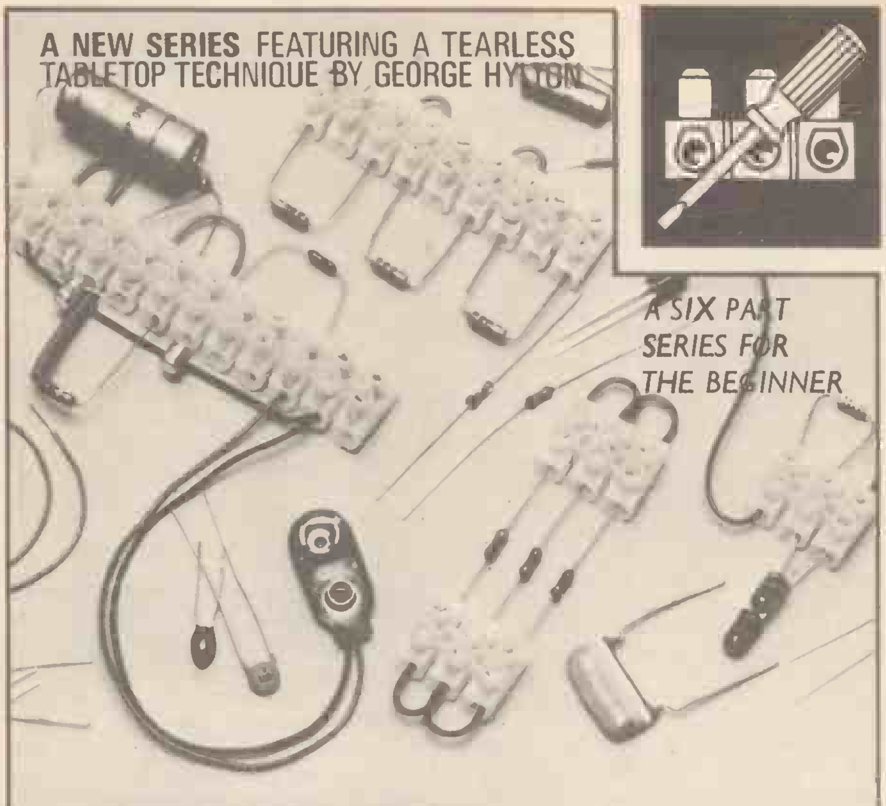
Fig. 2. Shows the layout of the components on the topside of the stripboard, breaks to be made on the underside and complete wiring to the car electrics and remote relay box via screw terminal strips.

Fig. 3. Modified wiring around TB2 for car systems fitted with Left and Right dashboard pilot indicators.



A NEW SERIES FEATURING A TEARLESS TABLETOP TECHNIQUE BY GEORGE HYLTON

A SIX PART SERIES FOR THE BEGINNER



INTRODUCING ELECTRONICS

Part 3 COILS & INDUCTANCE

IN 1819 the Danish physicist Oersted discovered that electric currents produce magnetic fields. To be precise, he placed a compass near a wire and found that the compass needle moved when a strong current was turned on.

It was soon realised that the magnetic effect of the current could be multiplied by coiling the wire so that the current passed through many turns. A compass placed at the centre of such a coil could then indicate by its movement how much current was flowing. This provided researchers with a current indicator or galvanometer.

Clearly, electricity and magnetism, two apparently quite different things, meet and interact in such electromagnetic circuits.

The trick of coiling up the wire to intensify the magnetic effect is exploited in a vast range of devices, including dynamos, motors, alternators and of course electromagnets. Loudspeakers and microphones commonly contain both coils and magnets. The "search heads" of metal detectors contain coils; radio and TV sets contain coils and so do electric bells and telephones.

ELECTROMAGNETISM DEMONSTRATED

Let's do some experiments. You'll need a magnet. Any kind will do, but if you have a choice a bar magnet is the most convenient. It should be as powerful as possible.

You'll need a tube made of some sort of insulating material, and wide enough to let your magnet, or part of it, pass inside. A cardboard tube will do, or a plastic or glass one. I borrowed a plastic hair roller for my experiments.

You'll also need some iron nails or bolts — about the same length as your tube — and two lengths of insulated wire each about three metres.

The rest of the parts are leftovers from earlier experiments.

Wind one length of wire into a coil at one end of your insulating tube. Leave a few inches of loose wire at each end for connecting up, see photograph. My coil has about thirty turns on it but the exact number is not important. The more the better.

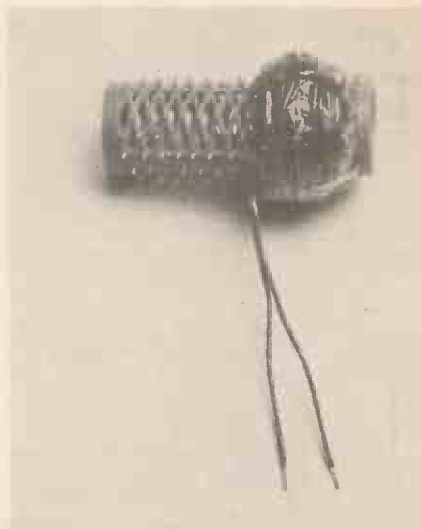
You are going to generate electricity by moving your magnet about in and around the coil. How do you know that you've succeeded? The simplest way would be to connect an electric lamp to the coil and watch it light.

AMPLIFIER

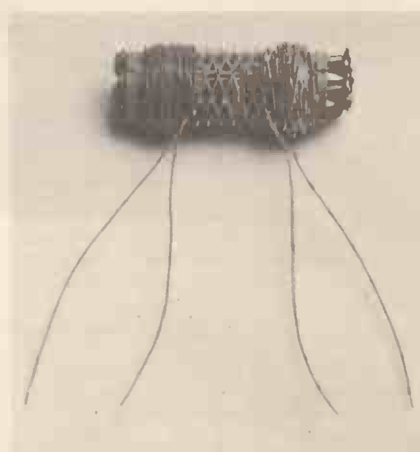
Unfortunately the amount of energy created by our very inefficient arrangement is much too small. It will result in a few thousandths of a volt at the coil ends. We must amplify it.

To do so we adapt the two-transistor amplifier used last month for our experiments with capacitance. Fig. 3.1 shows the new circuit. One resistance is changed and the polarity of the 1000μF is reversed.

One l.e.d. in the Indicator will light all the time. Electricity generated in our coil will produce changes in current which will make the l.e.d. flicker.



A home made coil for the experiment in Fig. 3.1 made from 7/0·2 stranded p.v.c. covered wire and a plastic hair roller.



Adding a second coil to the above and an iron core in the form of 4 inch long nails.

Plunging the end of a bar magnet (or one leg of a horseshoe magnet) into the coil quickly should produce this effect. (With weak magnets the flicker is small so watch carefully.) If your magnet won't go into the coil then move it quickly to and fro past the outside, as close as possible.

Note that the flicker goes in step with the movement, and that there is no flicker when the magnet is stationary, however close to the coil it may be.

Now hold the magnet steady in the coil and remove the coil quickly. Again, the l.e.d. flickers. Evidently it doesn't matter what we move — coil or magnet — so long as we move something.

Michael Faraday, who discovered this electromagnetic effect, deduced that the key factor was to have an electrical conductor (the coil) in a changing magnetic field. Varying the distance between coil and magnet produces changes while the movement is going on.

COIL CORES

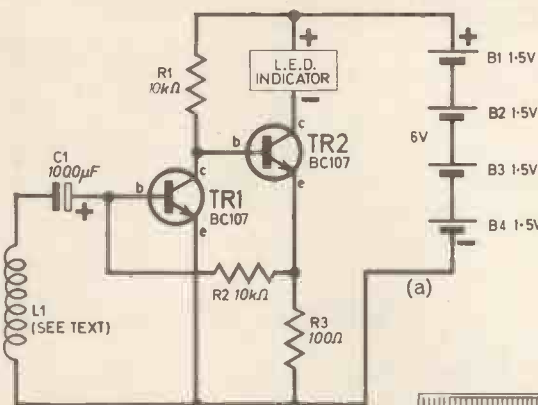
Magnetic fields can pass through the air but they prefer to pass through iron. To concentrate the field fill the tube with iron nails. It doesn't matter if they are a bit too long and stick out at the ends. Moving the magnet near the coil or the nails will produce an enhanced flicker of the Indicator l.e.d.

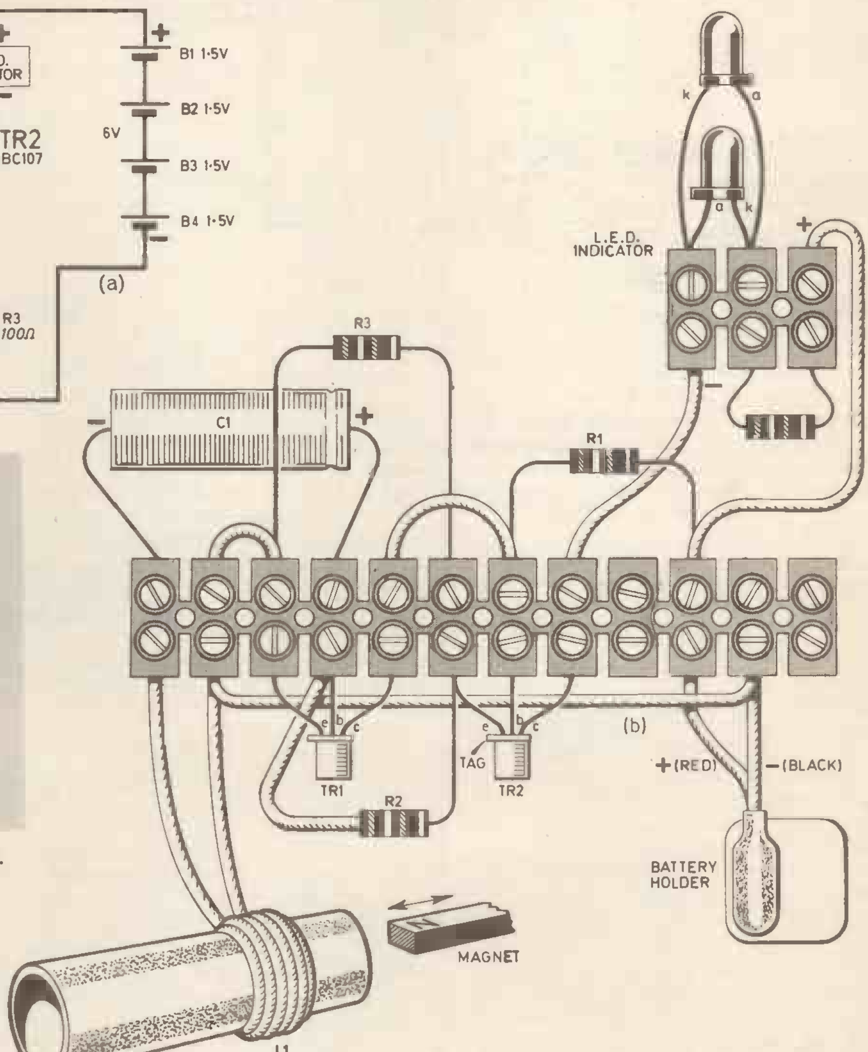
ELECTROMAGNETIC COUPLINGS

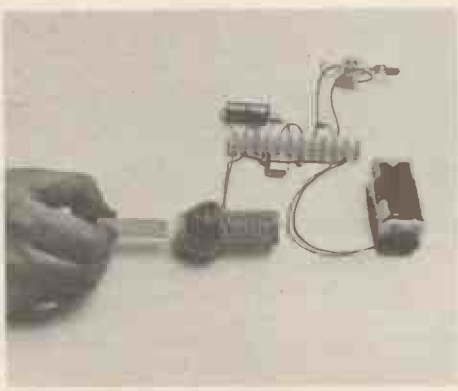
It would be quite feasible to use an electromagnet instead of the permanent magnet, and wave it around near the coil. However, there is a more interesting possibility. If you wind a second coil round the same tube you can turn it into an electromagnet by passing a current through it (Fig. 3.2). The iron core which you have given your coil will conduct the magnetism from one coil to the other.

Since the positions of the coils are fixed it is no longer possible to make electricity by movement, but the essential condition — a changing field — can be produced in another way.

At the instant the electromagnet is switched on its field starts to build up and to travel outwards. The second coil feels this sudden build-up of field and produces a little pulse of voltage which can be amplified to make the Indicator flicker. As soon as the field has built up to its steady value with full current flowing in the electromagnet coil — which happens very quickly in the present case — the voltage pulse ceases. Steady fields have no effect.







Moving the magnet in and out of the coil.

Fig. 3.1 (a) top. Circuit diagram of an amplifier for demonstrating electromagnetism and (b) right, the suggested screw terminal block assembly. Tiny voltages produced by a moving magnet near the coil cause the Indicator lamp to flicker.

The easiest way to energise your second coil is to connect a battery to it. If you have an old, but not dead 1·5V cell you can try it. But **don't use your 6V supply!**

Your coil has a resistance of perhaps a tenth of an ohm. Applying 6 volts should produce a current of 60 amperes, in theory. In practice it will damage the battery, which is not designed for such currents.

What's to be done? You could, instead of connecting the coil directly across the battery, interpose a safety resistance big enough to limit the current to a reasonable amount such as 100mA. But there is a neater way which gives bigger currents.

We know that energy is only transferred from one coil to the other at the instant of switching on.

How to construct a single 1·5V cell holder with terminal block and paper clips.

It hardly matters for how short a time the coil is switched on.

Let's charge a capacitor (C2) to 6V via a resistance (R4) (Fig. 3.3) and then discharge it through the coil. This way we can apply the full 6V, very briefly, without damaging anything. The resistance can be left connected so that the capacitor recharges every time the coil is disconnected.

Carrying out the experiment of Fig. 3.2.

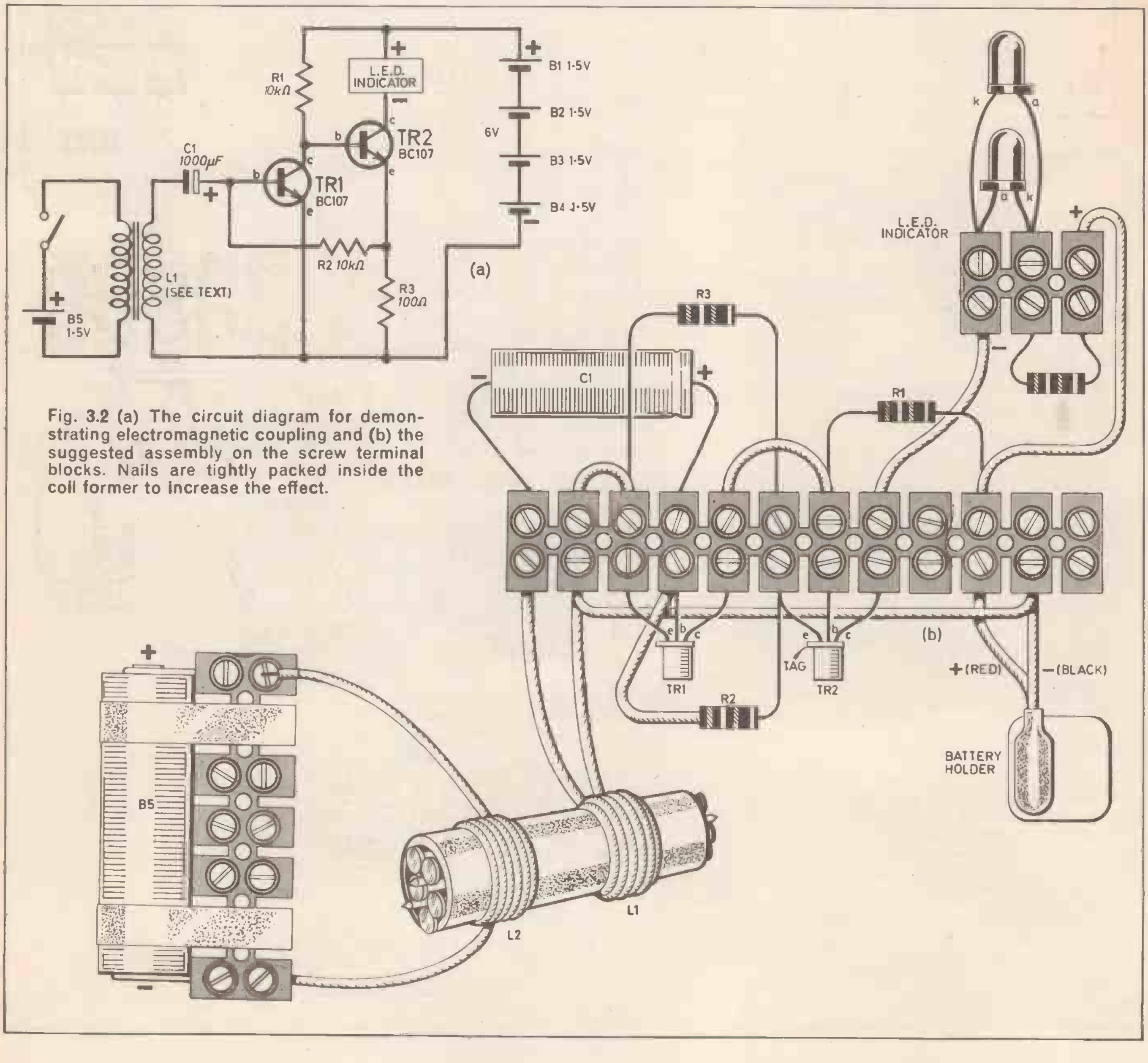


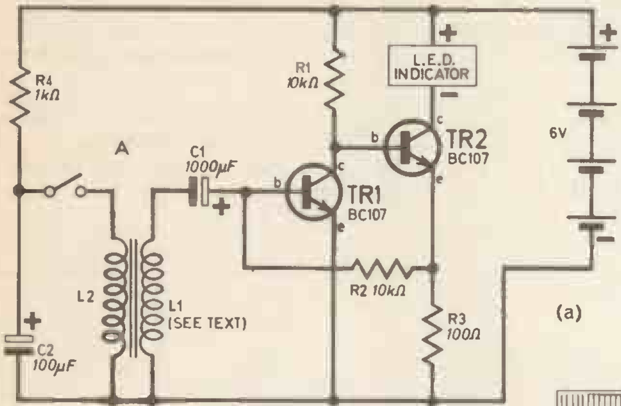
Fig. 3.2 (a) The circuit diagram for demonstrating electromagnetic coupling and (b) the suggested assembly on the screw terminal blocks. Nails are tightly packed inside the coil former to increase the effect.

If we use a capacitance of 100μF and a resistance of 1kΩ the time constant of the circuit is a tenth of a second so we don't have to hang about waiting for the capacitor to recharge before we can have another go with the coil. Every time you touch the free end of the coil on point *A* you should see a flicker. Remove the nails and the flickers cease, showing that the iron core of the coils really does couple them together.

TRANSFORMERS

Our two-coil arrangement is a crude form of electrical transformer. If the "electromagnet" coil is supplied with a changing current, the resulting changing magnetic field induces a voltage (an electromotive force) in the other coil. If the electromagnet coil were supplied with a current that changed continually, for example, with alternating current, then energy would be transferred to the other coil all the time.

Common sense tells you that the arrangement is reversible. You could change your transformer connections, driving your first coil and taking energy out of your second one.



Making and breaking the supply to L2.

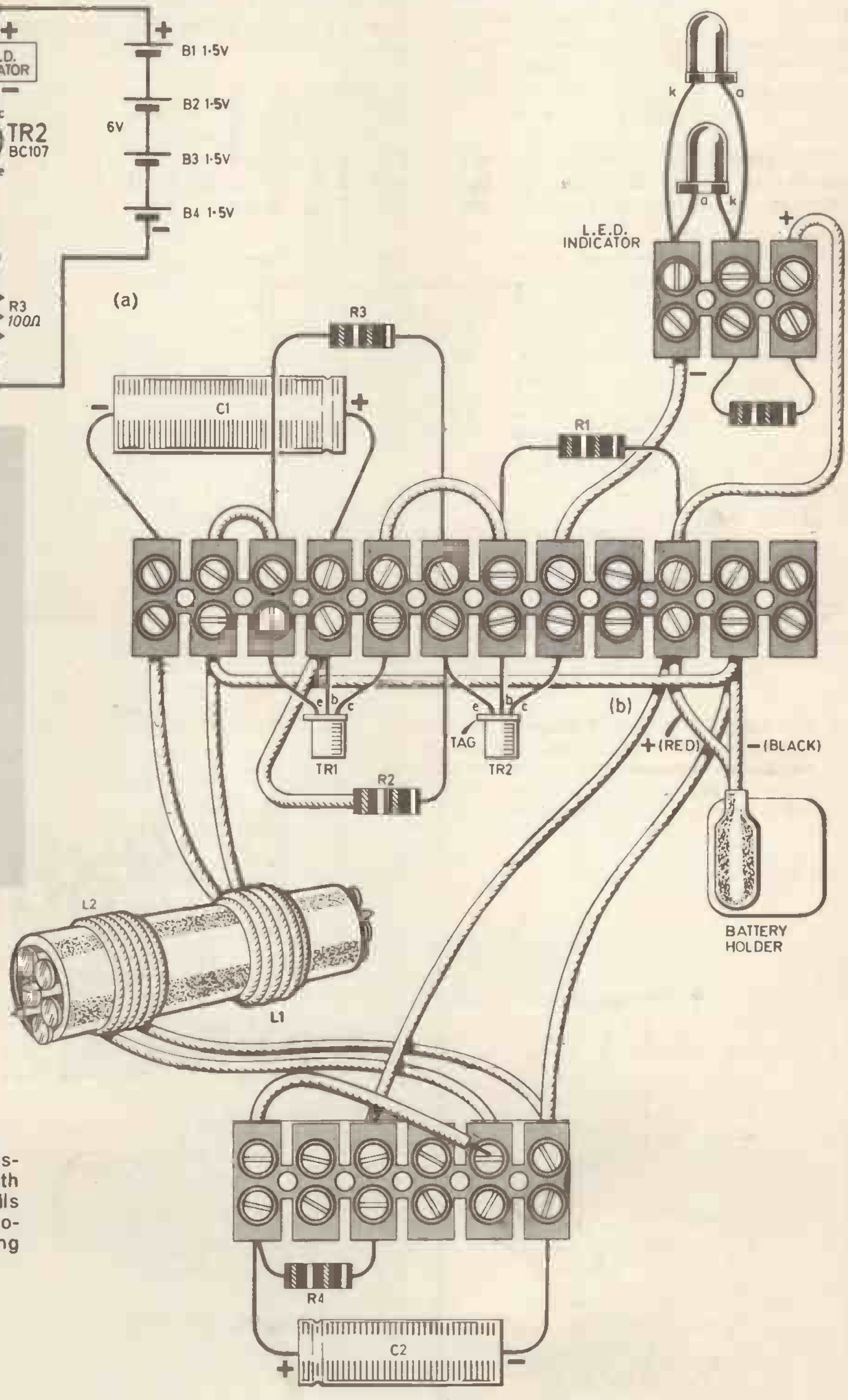


Fig. 3.3 (a) The circuit diagram for illustrating the working of a transformer with (b) the suggested layout and wiring details on the terminal blocks. The electromagnetic coil is energised by discharging a capacitorhrough it.

This transformer is very inefficient. One reason is that nails are not a good core material. I've been calling them iron but they are really mild steel. Real transformers use special alloys.

Another reason is that our sort of core is the wrong shape to conduct magnetism well. A cylindrical core gives the equivalent of a bar magnet (Fig. 3.4 a and b). The magnetic field flows from North pole to South pole through the air. It would much rather flow through some more iron (Fig. 3.4c).

Magnetism doesn't flow round and round like a current but it is still desirable to have a complete magnetic circuit of iron to couple the coils more effectively.

In transformers the driven winding is called the **primary** and the pickup winding is called the **secondary**. The voltage induced in the secondary depends on the number of turns. If the secondary has ten times the turns of the primary it produces ten times the voltage (but only one tenth of the current).

To supply transistor circuits from the mains a **step-down transformer** is often used. This reduces the voltage from, say the 240V a.c. of British mains to the 10V or so needed by a small transistor radio.

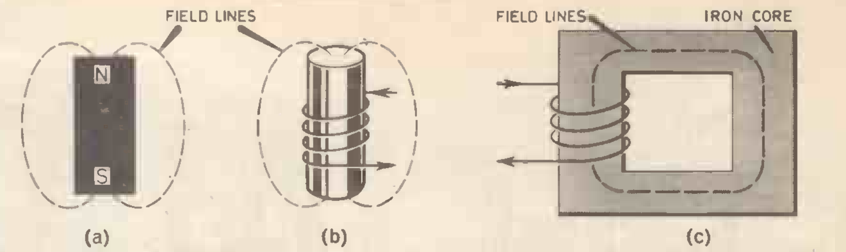


Fig. 3.4. Coil cores. In (a) and (b) coil and bar magnet produce similar fields. In (c) the iron core gives an easy path from pole to pole. Little field now goes through the air.

INDUCTANCE

The magnetic field round a coil which is carrying a current is a store of energy. If the current is switched off the field collapses back into the coil. As it does so, the coil itself, being a conductor in a changing field, generates a voltage. The size of this voltage depends on how quickly the current falls: the faster the greater.

In a motor car this fact is exploited (together with a step-up action) to generate the tens of thousands of volts needed for the ignition of the fuel.

When the current is turned off the polarity of the self-induced voltage pulse is always in the direction which tends to keep the current flowing. In other words, the coil resists any attempt to alter the current. The effect is seen not just with abrupt switch-offs but also when the current changes more slowly and smoothly. The voltage across the coil always changes in the way needed to keep the current going.

This property of a coil is called **self-inductance** — usually abbreviated to plain "inductance". To be able to compare inductances, a unit of inductance has been agreed upon. The current is somehow made to change at the rate of one ampere per second. If the coil then generates an opposing voltage of one volt it has *one* unit of inductance. This unit is called a *henry* after an American physicist.

The primaries of mains transformers have inductances of several henries. Most other inductances are much smaller. Your coils have inductances of a few millionths of a henry (microhenry, μH). Thousandths of a henry are millihenries (mH) and thousand-millionths are nanohenries (nH).

When a.c. flows through a coil the inductance continually opposes the changing current. It behaves a bit like a resistance. The effect can be quoted in ohms but is actually called an **inductive reactance**. The reactance increases both with the inductance and the frequency of the current.

L/R TIME CONSTANT

It takes time for current to build up or fade away in an inductance. The time depends on how much resistance there is in the circuit. Unlike *RC* circuits, where the resistance increases the charging time of the capacitance, in *LR* circuits (*L* is the usual symbol for inductance) the resistance reduces the time constant; that is, more resistance gives faster charging and discharging. The time constant is *L/R* seconds; for example, 10H and 5ohms give 2 seconds.

DEVICES

A coil suspended in a magnetic field moves when energised by current. In a loudspeaker the movement is arranged to move a diaphragm. In a moving coil meter it turns the pointer.

The system works in reverse. Moving the diaphragm generates a voltage in the coil. This is the principle of the dynamic or moving-coil microphone. In relays the movement operates switch contacts.

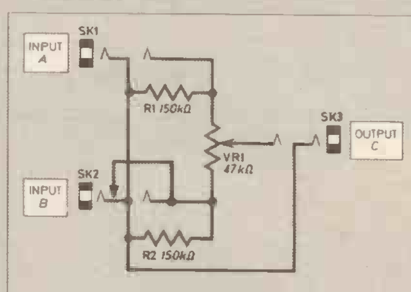
To be continued

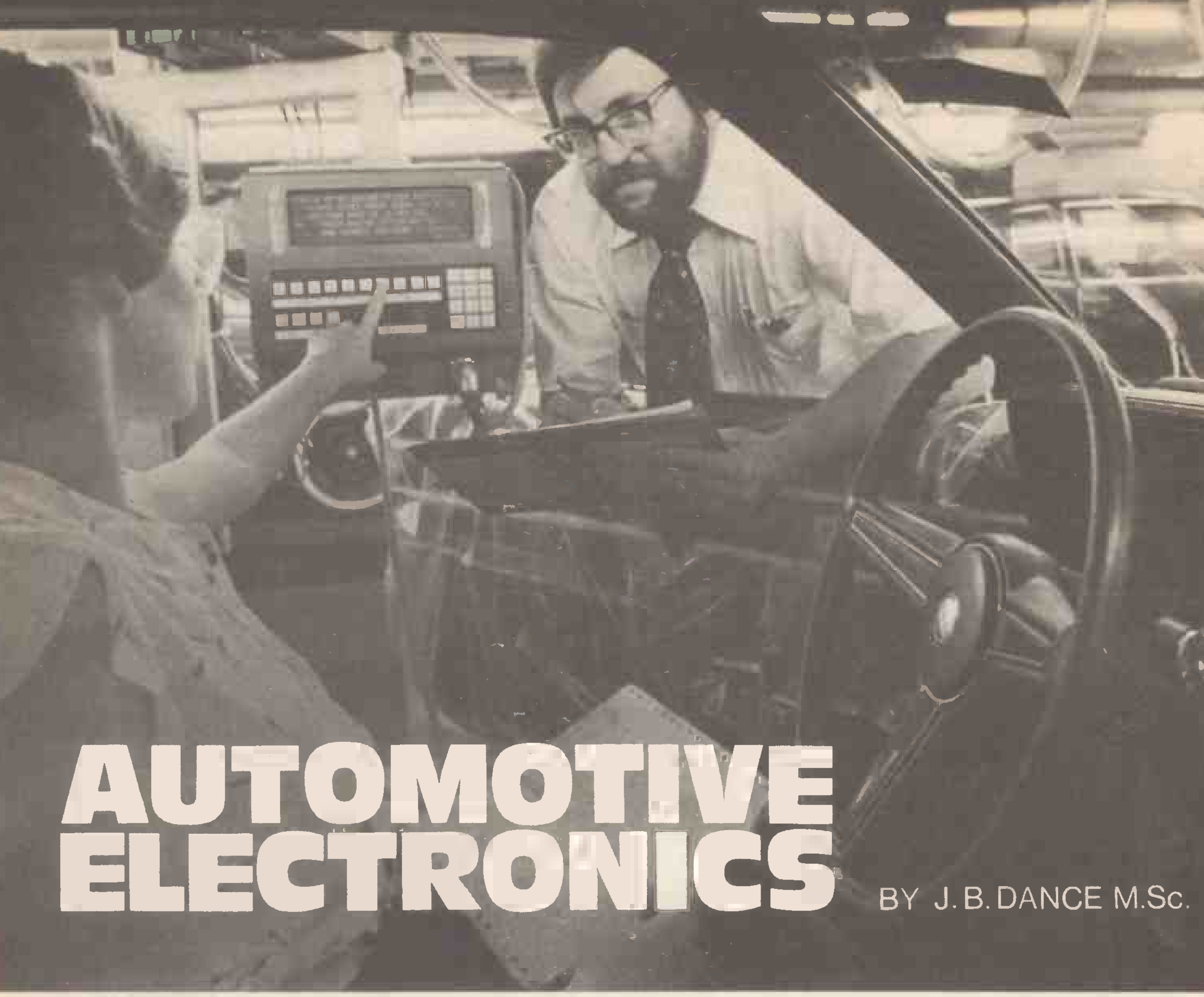
PLEASE TAKE NOTE

PUBLIC ADDRESS SYSTEM
(May to August 1982)
June 1982, page 402. The resistor R23 10 ohm should be rated at 2 watts.

COMBINATION LOCK
(October 1982)
Resistor R3 in Fig. 1 (page 700) should be 820 ohms not as shown. A 1N4001 diode should be inserted between switch S1 and battery positive. Cathode (k) to switch S1 and anode (a) to battery positive.

SOUND SPLITTER
(September 1982)
The circuit diagram, Fig 7, for the Remixer Box shown on page 565 should be replaced with the circuit below.
The wiring diagram Fig. 8 for this unit is correct.





AUTOMOTIVE ELECTRONICS

BY J. B. DANCE M.Sc.

THE widespread use of complex electronics in vehicles has not come about nearly as rapidly as in the case of some other products, such as watches and cameras. Although quite simple circuitry is adequate for vehicle burglar alarms, ignition systems and other useful systems, very rapid developments have taken place within the past year or so involving the use of far more complex electronics in cars. Many manufacturers are already competing with one another for a share of what is already becoming a lucrative market—estimated at £1,500 million by 1985.

DEDICATED MICRO SYSTEMS

It seems certain that dedicated microcomputer systems designed especially for vehicle use will take over from the general purpose microprocessor chips which are already being employed in some cars.

Microprocessors can be used to provide near-optimum control of the fuel-air mixture for maximum economy and minimum dangerous exhaust emission together with automatic advance and many other functions. Electronically controlled anti-lock braking systems are available, whilst radar controlled monitoring of the distance of the vehicle in front is possible with either the operation of a warning indicator or the automatic application of the brakes under conditions which may cause a collision; external temperature indicators can automatically provide for a greater braking distance when external temperature is below freezing point.

DASHBOARD SYSTEMS

Microprocessors are also used in some advanced dashboard systems which continually inform the driver of the number of miles-per-gallon being achieved by his vehicle in digits (with an alternative display of km per litre), the temperature outside the vehicle, and automatically monitor many functions such as the oil pressure for guidance of the driver.

A microprocessor controlled monitoring system has even been developed which actually tells the driver in electronically generated spoken words if a fault is present (such as a low brake fluid level) or if a potential problem is developing (such as a low fuel level in the petrol tank).

OVERCOMING RESISTANCE

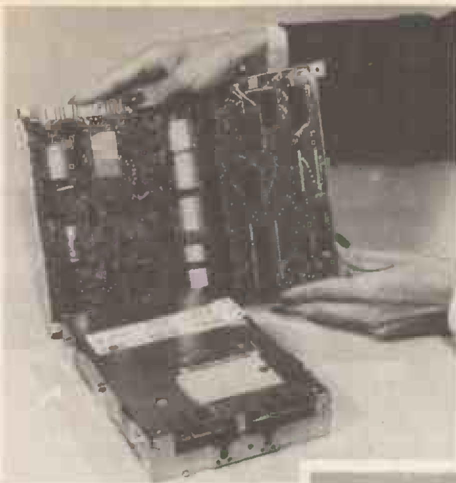
There has been some considerable resistance to the use of complex microelectronic systems in vehicles where traditional systems are not easily changed and where reliability of complex equipment is a vital consideration. Strangely enough much of the incentive for the recent development of microprocessor control systems has come from the controls to be introduced by many countries on exhaust gas emission and on fuel consumption as petrol becomes more precious. Future legislation is most easily met by the microprocessor control of vehicle engines.

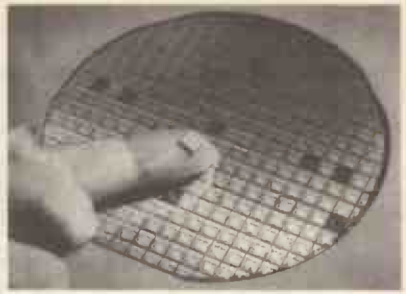
COMPUTER, COMMAND, CONTROL

One of the most amazing recent developments was the announcement by General Motors just over a year ago that virtually all of their petrol-driven cars built in the USA will be fitted with a small digital computer about the size of a textbook. General Motors produce Chevrolet, Pontiac, Oldsmobile, Buick and Cadillac cars; their Delco Electronics Division has now become the largest manufacturer of computers in the world with a production of over 20,000 electronic vehicle control modules per day at its Kokomo and Milwaukee plants.

The electronic control module or on-board computer is known as the "brain" of the computer, command and control system used by General Motors. It receives inputs from various sensing elements in the system and provides commands to numerous actuator devices which control many operations in the vehicle, such as the ignition timing, the idle speed motor, the electro-mechanical carburettor and so on. The sensing elements update the computer every 100 milliseconds, while every 12·5 milliseconds the system monitors the vehicle for critical emissions and driveability information.

In addition, the electronic control module has a limited system-diagnostic capability. If certain system malfunctions occur, the diagnostic



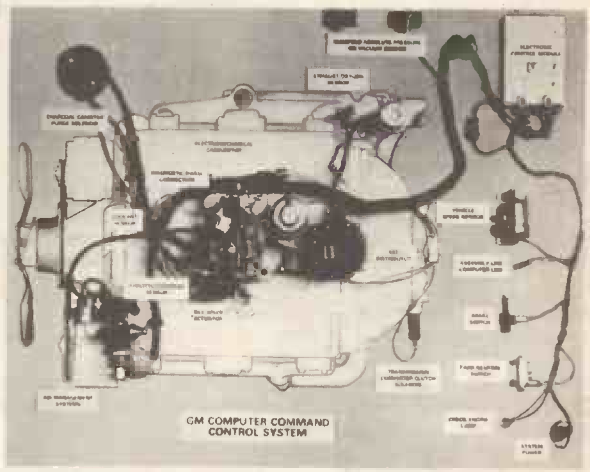


This is the "heart" of an Electronic Control Module (ECM), or micro-computer, which commands the functions of GM's 1981 emission control system. This chip is programmed to receive input from engine-mounted sensors throughout the Computer Command Control (CCC) system.

(above) The brain of the General Motors Computer Command Control (CCC) emission system is this Electronic Control Module (ECM).

Slightly larger than a paperback book, this micro-computer receives data from engine mounted sensors at a rate up to 160 times per second. The ECM will perform up to 350,000 calculations per second.

(right) General Motors Computer Command Control System



(Heading Photo) Each 1981 model General Motors automobile equipped with the Computer Command Control system receives a final check at the end of the assembly line. The automobile's on-board computer is connected to the assembly plant's computer to check engine function operations in the Computer Command Control system.

The "shape of cars to come" is how Roger B. Smith, GM Chairman, describes the new experimental Aero 2000 four-seater car. The driver need not take his eyes from the road to see car speed, fuel supply and similar readings reflected in the windshield (top left). Road maps can be called up on a television screen (top right). Possible vehicle trouble spots are analysed in a console diagnostic centre (lower right). A 180 degree rearward projection replaces the three rear view mirrors that are on most cars.

"check engine" light in the instrument panel will be illuminated, alerting the driver to the need for a service. The computer also assists the service technician in returning the system to its normal operating condition by isolating the general area of the system where the malfunction has occurred.

However, we shall see that in certain cars the computer, command and control system can carry out many other functions.

EXHAUST-OXYGEN SENSOR

About six years ago General Motors introduced a catalytic converter emission controlling device; this has no moving parts, requires no owner-attention, but is designed to control the amount of oxides of nitrogen in the exhaust gas emissions as well as the carbon monoxide and hydrocarbons. The catalytic converters contain platinum, palladium and rhodium —all precious metals.

An oxygen sensor having a cone-shaped zirconia ceramic body, coated inside and outside with platinum, is now mounted in the exhaust manifold ahead of the catalytic converter. The sensor inside surface is open to the atmosphere and the outer surface is exposed to exhaust gases.

The difference in the amount of oxygen on these inner and outer surfaces generates a voltage signal which is related to the engine air/fuel ratio and this voltage is passed to the computer system. The latter produces an output signal which directs the carburettor to deliver a richer or leaner mixture to the engine to optimise the catalytic converter performance.

The computer system also receives information about the cooling system temperature, the crankshaft rotation rate (r.p.m.), the throttle position and the manifold pressure. In some models an electronically controlled exhaust gas recirculation system further reduces the exhaust gas emissions.

ELECTRONIC TIMING

General Motors employ electronic spark timing systems in most of their petrol-driven cars. The microprocessor system is used to optimise the ignition timing and dwell angle which are programmed functions of the engine speed, the mechanical load on the vehicle at the time, the coolant temperature and various other sensor signals.

The electronic ignition timing system is said to improve spark control flexibility and accuracy and this results in improved fuel economy while still maintaining the stringent exhaust emission requirements and providing good driving performance.

The ignition advance weights and the vacuum advance mechanisms employed in conventional petrol engines are not required in the electronically timed engines. The distributor used in the system contains a new module developed especially for the purpose.

Even the idle speed is electronically controlled to compensate for transient load changes (such as air conditioning, power steering and transmission engagement) which require power under idling conditions. The control system maintains low engine idling speeds so as to minimise fuel consumption under urban driving conditions.

In addition, the idle speed controller will automatically compensate for altitude-sensitive speed changes, and will increase the engine speed when this is needed to compensate for hot engine conditions or too low a battery charging rate.

TORQUE CONVERTER CLUTCH

In 1981 General Motors introduced microcomputer control of their torque converter clutch which receives commands for engagement or disengagement as a function of the gear select, vehicle speed, engine load, coolant temperature, throttle position and brake status.

It is claimed that this system provides the convenience of automatic transmission with the engaged efficiency of manual transmission. It allows more operating regions where the clutch can be engaged so as to reduce fuel consumption.

FOUR, SIX OR EIGHT CYLINDERS?

Perhaps the most remarkable development using the General Motors Computer, Command and Control System is available in a 6 litre Cadillac V8 engine. This can be automatically converted into a 6 cylinder 4·5 litre or into a 4 cylinder 3 litre engine when the full power of the 6 litre engine is not required for the particular driving conditions being encountered at the time. The number of cylinders is selected so as to minimise fuel consumption while providing the performance demanded by the driver.

This type of variable capacity engine is known as a modulated displacement engine and is the first of its type in the world. Digital fuel injection is employed with an electromechanical system of inlet and exhaust valve control under computer command.

The change from one mode of operation to another is stated to be so smooth that the occupants of the car are unaware that it has happened and there is no lag or drag. The change is effected by a valve selector unit which employs a single solenoid to simultaneously deactivate both valves of a cylinder. Both valves then stay closed so that the piston operates as an almost ideal spring with the resultant losses virtually zero.

Cadillacs fitted with this V8-6-4 engine have a digital mile-per-gallon readout which displays on demand the instantaneous and average fuel consumption accurate to 0·1 mile-per-gallon, together with the anticipated range based on the average fuel consumption and the amount of fuel remaining in the tank.

The number of cylinders being actively used at any time is also displayed. This display enables the driver to learn to optimise the fuel economy of the vehicle and to learn to be a more efficient driver, while he is free to use full power when he is in a hurry!

SELF-DIAGNOSIS

The computer, command and control system also provides a diagnostic system for monitoring the engine control system sensors and actuators for proper operation. It will memorise any malfunctions (including temporary ones) and alert the driver by means of an instrument panel warning light.

If necessary, the system will substitute nominal values for the signals from critical sensors so as to allow the car to be driven until repairs can be made.

It also enables a service department to "interrogate" the microprocessor and obtain answers from a digital display on the instrument panel. When a serviceman grounds a 'trouble code' test lead terminal under the dashboard, a light will flash a unique code indicating the fault code and the problem area. The serviceman can then use his trouble-shooting chart to find the defective component.

RELIABILITY

Many people think—often quite rightly—that the more complex the system, the more there is which is likely to develop a fault. This is especially important in vehicles where a failure is far more of an inconvenience than the failure of, say, a domestic television receiver.

Each completed computer is therefore put through a complex eight hour test extending over a wide temperature range, with sample tests from −40°C to +85°C. The warranty on the computer, command and control system is for 50,000 miles or five years, whichever occurs first.

Each vehicle produced receives its final check at the end of the assembly line with its own "on-board" computer connected to the assembly plant's computer, when many tests are carried out and any necessary adjustments made.

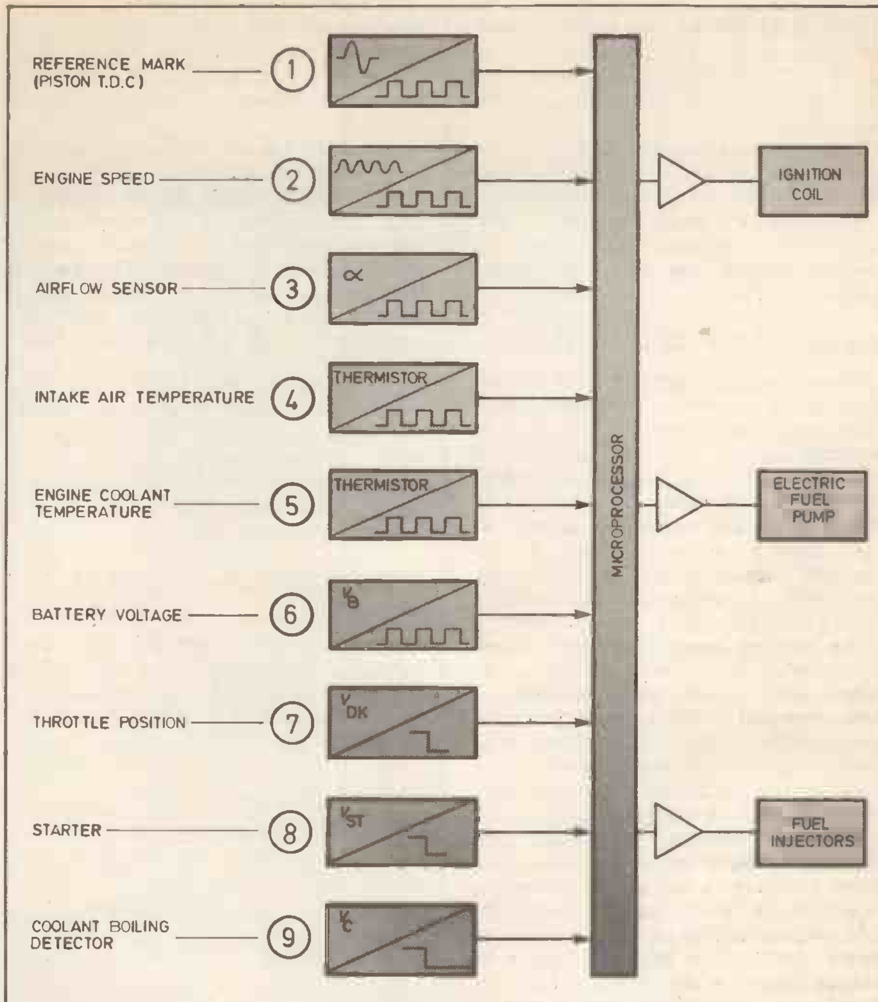


Fig. 1. The Bosch L-Jetronic system used in the BMW series 5 models.

EUROPEAN DEVELOPMENTS

In Europe the use of electronics in cars has been relatively modest when compared to the complex computer, command and control system just discussed. This is not really surprising, since European cars are generally considerably smaller, more efficient and more economical—apart from the fact that the USA semiconductor industry is more highly developed.

Bayerische Motoren Werke AG (BMW) of Germany has introduced a microprocessor in its 55 series of cars. They claim two unique developments, namely their service interval indicator and the energy control display. The service interval indicator was developed in order to replace the conventional idea of servicing a vehicle at fixed mileage intervals.

Sensors provide information about the engine speed, the engine temperature and the distance travelled since the last service together with the time since the last service. The service indicator remembers the load and operating conditions of the engine since the last service and computes whether it is time for the car to be serviced again.

As an example, one may mention that the time during which the oil is at a temperature of less than +55°C is important, since there is extra wear during this warm up period and during this time the oil is degraded more quickly than in a fully warmed-up engine. Similarly extra wear occurs at over 4,000r.p.m.

One type of display involves the use of five green l.e.d.s, one yellow l.e.d. and three red l.e.d.s on the instrument display. These indicators advise the driver when an oil change is required and when the vehicle requires servicing.

IMPROVING DRIVING HABITS

The calculation is performed according to a special formula derived through extensive testing and which gives a good indication of the actual demands placed on an engine. It was found that most drivers can expect to have longer intervals between servicing with this system which offers the driver the first opportunity of influencing his car's service times through his own driving habits.

When the car has been serviced, the service interval indicator is reset with a special key. The unit has a back-up battery which will support the indicator for a period of four months, such as when the car is not used and its battery has been removed for charging.

The car uses an electronically controlled injection system in which the amount of fuel entering the cylinders is accurately measured. This is compared with the distance travelled (using pulses derived from the speedometer system) to give the instantaneous fuel consumption.

FUEL INJECTION SYSTEM

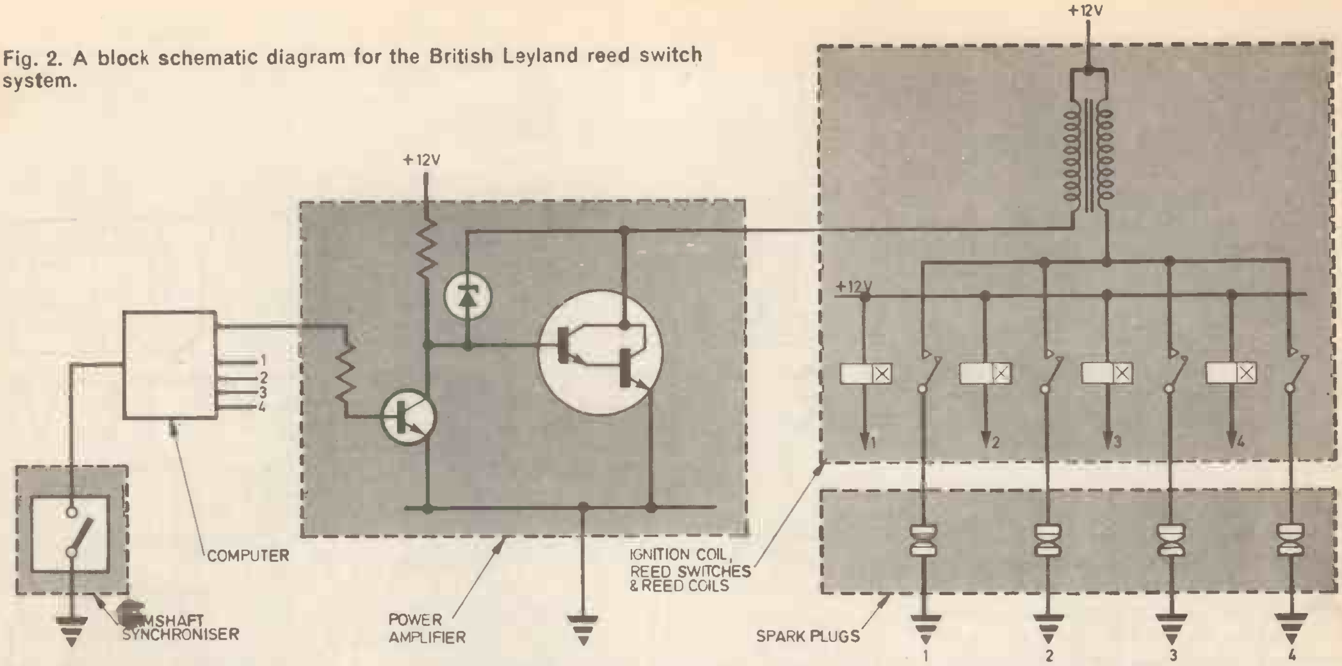
In some of the BMW series, the Bosch L-Jetronic system of fuel injection is used (Fig. 1). Engine speed is detected by a sensor adjacent to the flywheel, the passage of each tooth on the flywheel generating two pulses. Thus the 232 pulses per revolution using 116 teeth enables the crankshaft angle to be determined to within 1·55 degrees. The load on the engine is found by a sensor which measures the volumetric air flow into the cylinders and the required timing angle is calculated accurately. The fuel injection time is calculated from the air intake and engine coolant temperatures, the throttle position and the engine speed.

The control system can modify the engine performance at certain speeds using pre-programmed instructions. For example, the engine speed sensor can be used to shut off the fuel when the engine speed exceeds 1200r.p.m.

The system will also provide a mixture enriched by a factor of two for cold starts, but as soon as the engine fires, the mixture composition is returned to its normal level during warming up. Only when the engine temperature reaches its normal working value is the normal air-to-fuel ratio employed.

The on-board microcomputer: the SAB 80215 is a key device in providing the driver with a variety of information. Such as actual fuel consumption, as well as time and average speed. It can be so programmed that warning signal sounds when a set speed is exceeded.

Fig. 2. A block schematic diagram for the British Leyland reed switch system.



BRITISH LEYLAND

In the UK British Leyland has been developing distributorless ignition systems. One such system is shown in Fig 3 in which pulses from a camshaft synchroniser are fed to a computer which in turn drives two power amplifiers. The primary current flows through the split-primary of the ignition coil in a direction which is dependent on the particular power amplifier which is conducting at the time.

According to the direction of the primary current, two of the diodes in the ignition coil secondary circuit are biased to conduction. Two of the sparking plugs are fired in series, but only the one causes ignition of the mixture. A disadvantage of this system is that energy is wasted in the firing of the second plug. At the next part of the ignition cycle, the other power amplifier conducts and the other two plugs fire.

Fig. 2 shows another system in which high voltage reed switches are employed to control the firing of the sparking plugs. Reed switches which must withstand 30kV to 50kV are not cheap and their life is not unlimited. However, only one power amplifier is needed. In this system the ignition coil current is first turned on, the selected reed switch is then closed and the spark occurs when the ignition coil current is interrupted. The reed switch opens only after the spark.

SPEAKING CAR

Toyota of Japan has introduced what is said to be the first talking car which contains a speaking monitor system that tells the driver if his seatbelt is unfastened, the lights are left on or if any similar faults or potential faults are present.

The system, developed jointly by Toyota and Matsushita, employs the latter's MN1599 microcomputer together with their MN2332 memory and digital to analogue converter.

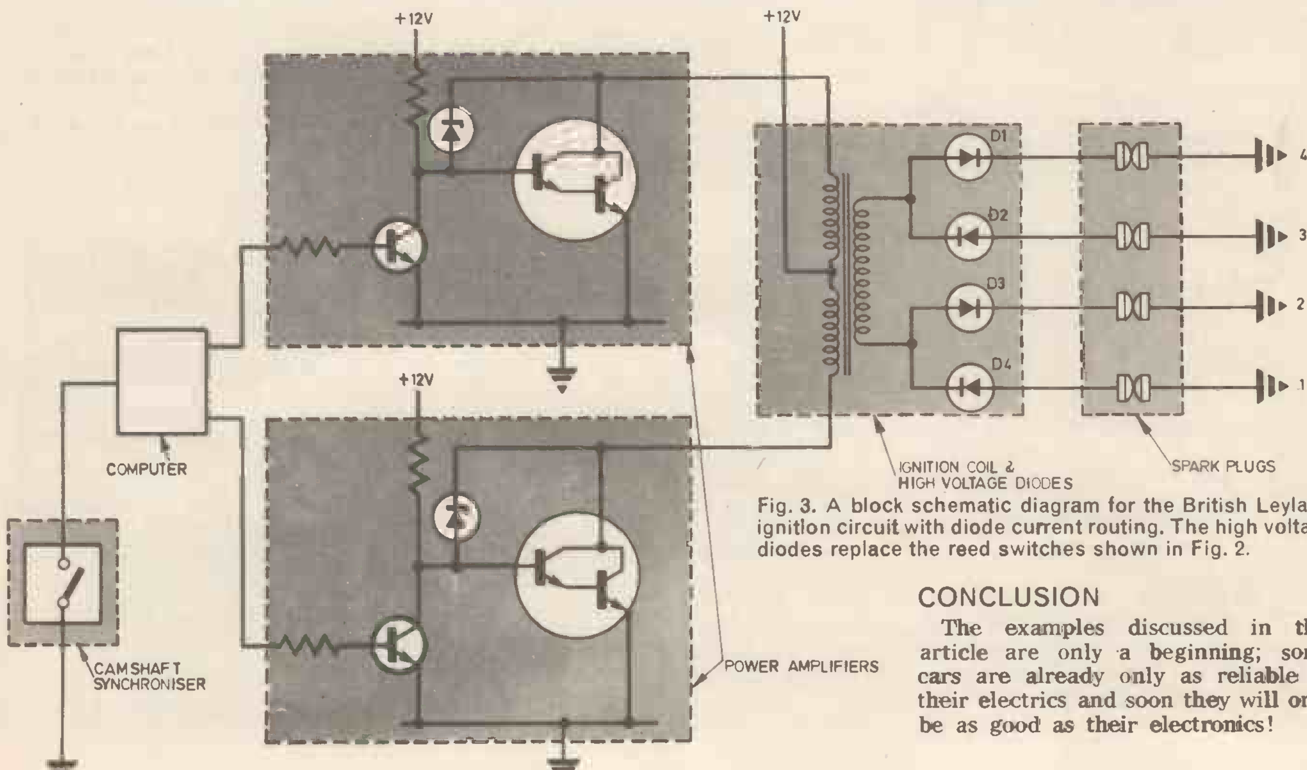


Fig. 3. A block schematic diagram for the British Leyland ignition circuit with diode current routing. The high voltage diodes replace the reed switches shown in Fig. 2.

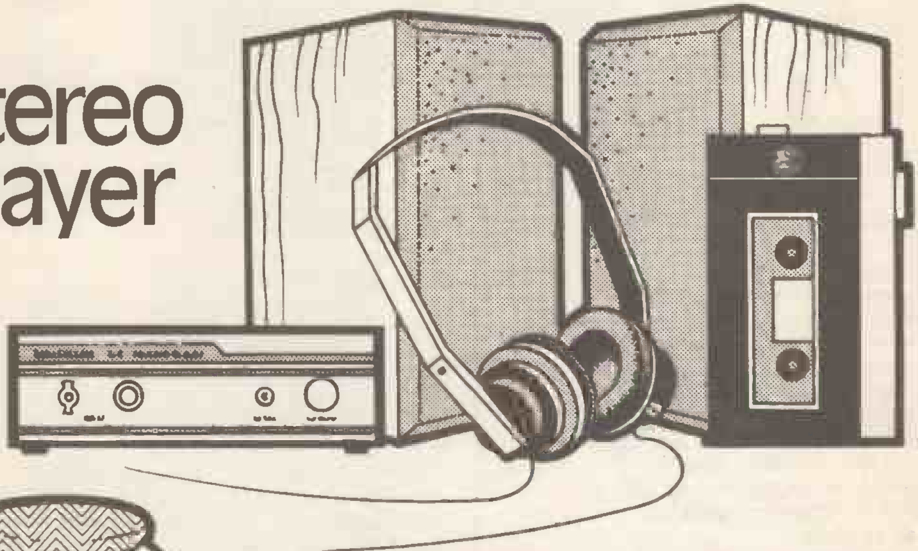
CONCLUSION

The examples discussed in this article are only a beginning; some cars are already only as reliable as their electrics and soon they will only be as good as their electronics! ⌑

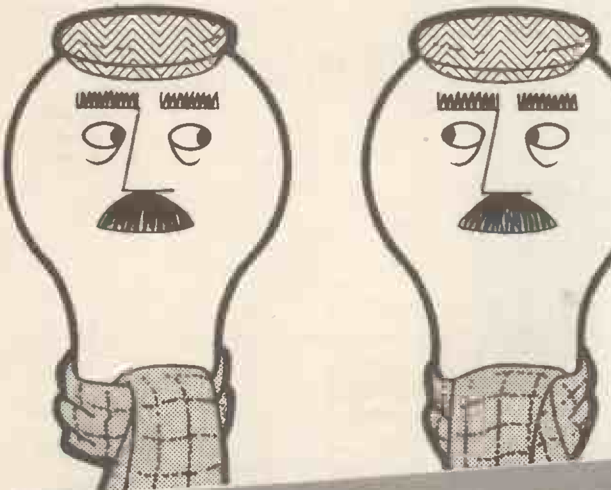
Everyday ELECTRONICS

JANUARY ISSUE

LOUDSPEAKER AMPLIFIER SYSTEM for Personal Stereo Cassette Player



When at home you can now enjoy loudspeaker reproduction from your Personal Cassette Player. This 5-watt stereo amplifier is fed from the headphone outlet socket to provide adequate output for the bedsitter, teenager bedroom or private den. Built-in power source to power the player and save your batteries.



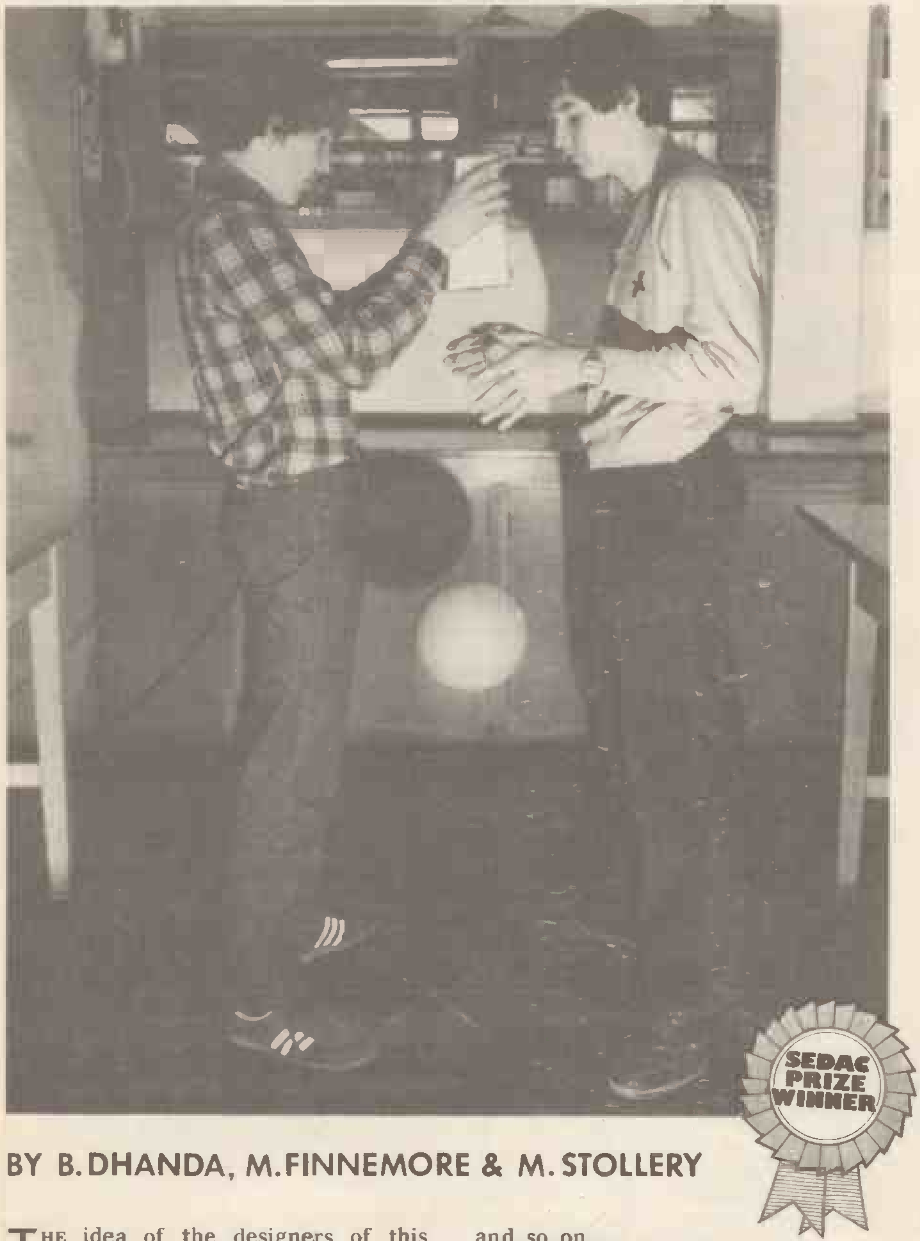
OPTO REPEATER

To complement the Security Vari-Light featured in the December issue, this unit enables further lamps to be optically coupled to the main control lamp, thus creating the effect that more than one room is occupied. The whole system is simple to install and requires no complicated mains wiring.

PLUS 2 MORE
SEDAC Prize Winning Projects
Analogue to Digital Converter
Coulomb Meter

JANUARY 1983 ISSUE ON SALE FRIDAY, DECEMBER 17

VELOCITY MEASURER



BY B. DHANDA, M. FINNEMORE & M. STOLLERY

THE idea of the designers of this project was to build an accurate, cheap and practical piece of equipment that would repeatedly measure the velocity of a moving object, and store the results in a semiconductor memory to be displayed later on a seven-segment readout. This information would then be useful for plotting velocity-time graphs for many moving objects such as moving trolleys, falling spheres and so on.

It was decided to use an ultrasonics beam, and for this to be reflected off the moving object back towards the transmitter. The received ultrasonic signal would be at a slightly different frequency. The faster the object is moving, the greater the difference between transmitted and received frequencies. This phenomenon is known as the Doppler Effect.

TICKER TIMER METHOD

The Velocity Measurer described here was designed to take over the role of Ticker Timer method of determining velocity of moving objects, which is in common use in school laboratories.

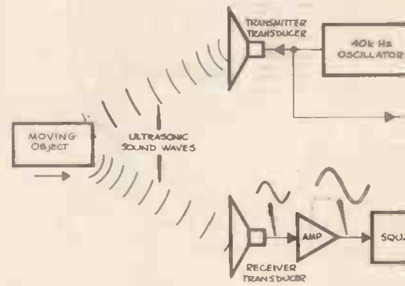
The Ticker Timer is a small electromechanical device. A velocity recording can be obtained by threading one end of the paper ribbon through the Ticker Timer, and sticking the other end to the moving object. When the object moves it pulls the paper through the Ticker Timer which is printing 50 dots every second.

When the object moves faster the paper also travels faster, which means the dots are spaced further apart. This ribbon of paper is later cut up into 10 dot segments which are stuck side by side onto a piece of paper to form a velocity-time graph.

Some of the major drawbacks of the Ticker Timer method are:

1. The object which is being measured must be connected to a long strip of ticker-tape which introduces a certain amount of friction. This means that any results obtained may be affected by this friction.
2. Cutting up the Ticker Timer tape and constructing the velocity-time graph takes a long time to produce.

HOW IT WORKS



THE Velocity Measurer can be used in the laboratory with greater ease and accuracy than with conventional methods of taking velocity measurements, such as with the electromechanical ticker timer. It is capable of measuring small changes in velocity at selectable sampling rates, and to store this data in a semiconductor memory. After the experiment, the data may be read out in single steps to allow a velocity-time graph for any moving object to be plotted.

The project uses ultrasonics for determining velocity of the object based on the Doppler effect. The unit emits a constant frequency 40kHz sound wave. This reaches the object and is reflected back to an ultrasonic transducer mounted on the unit. The

3. The Ticker Timer cannot be used to take measurements on oscillatory motion nor movements towards itself.

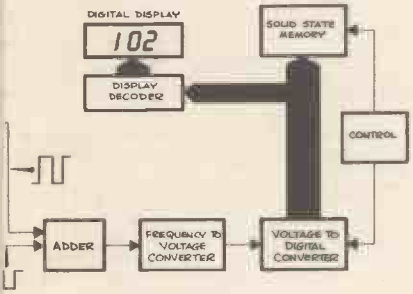
The main advantage of Measurer is that there is no physical contact with the object, which in turn, means there is no friction to affect the readings. According to the designers the only significant disadvantage of their unit, compared with the more conventional Ticker Timer is that the user has very little idea how the device obtained its velocity readings, though on the other hand, it could be used to demonstrate Doppler shift and ultrasonics in the laboratory.

DOPPLER SHIFT

This project has been designed to make use of an effect known as the "Doppler Shift". Consider a stationary source of radiation at frequency f_1 being aimed at an object moving directly towards the source at velocity v. The waves rebounding from the object to reach a receiver adjacent to the source will be found to be at a different frequency f_2 to the transmitted waves. This difference in frequency $(f_2 - f_1)$ is called the Doppler shift and is given by the formula:

$$\text{Doppler shift} = (f_2 - f_1) = \left(\frac{2 \times v}{c}\right) f_1$$

where c is the velocity of propagation of the transmitted wave.



moving object causes the reflected sound waves to apparently increase in frequency in proportion to its velocity. The circuitry computes the difference in transmitted and reflected frequencies to calculate the speed of the object.

Sixteen spot velocity measurements are made during the motion of the object on release of the START switch, 5 per second, 10 per second or 50 per second depending on the setting of the Speed Selector Control Switch.

Outputs exist on the unit (1) to allow connection to a proprietary memory bank to store the results of many experiments which is able to feed a chart reader to automatically produce velocity-time graphs; (2) for connection to an oscilloscope to display velocity directly.

COMPONENTS

Resistors

R1	220kΩ	R11	10MΩ	R21	100Ω
R2	220kΩ	R12	10kΩ	R22	82kΩ
R3	10MΩ	R13	100kΩ	R23	8·2kΩ
R4	4·7kΩ	R14	1kΩ	R24	680kΩ
R5	4·7kΩ	R15	100kΩ	R25	390Ω
R6	1MΩ	R16	2·2kΩ	R26	to
R7	100kΩ	R17	100kΩ	R51	220Ω (22 off)
R8	100kΩ	R18	5·6kΩ	R52	1·5kΩ
R9	27kΩ	R19	12kΩ	R53	10Ω 10W 5%
R10	3·3kΩ	R20	10kΩ	R54, 55	4·7kΩ (2 off)

All ⅓W carbon ±5% except where stated otherwise

See **Shop Talk** page 826

Capacitors

C1	100nF ceramic	C16	100nF ceramic
C2	22pF ceramic	C17	10nF ceramic
C3	2·2nF ceramic	C18	1nF ceramic
C4	22pF ceramic	C19	4·7nF ceramic
C5	10nF ceramic	C20	10nF ceramic
C6	10nF ceramic	C212,	2nF ceramic
C7	1µF 35V tantalum bead	C22	100nF ceramic
C8	100nF ceramic	C23	1µF 35V tantalum bead
C9	1µF 35V tantalum bead	C24	10µF 16V tantalum bead
C10	0·47µF 35V tantalum bead	C25	15pF ceramic
C11	0·22µF 35V tantalum bead	C26	220nF polyester type C280
C12	100nF ceramic	C27	220nF polyester type C280
C13	10µF 16V tantalum bead	C28	470nF polyester type C280
C14	22µF 16V tantalum bead	C29	470nF polyester type C280
C15	47µF 16V tantalum bead		

Potentiometers

VR1, 7, 8	10kΩ (3 off)
VR2	10kΩ horizontal mounting preset
VR3, 6	5kΩ (2 off)
VR4	100kΩ
VR5	50kΩ
VR9	1MΩ

All ¾ inch long 20 turn cermet types except where stated otherwise

COMPONENTS approximate cost £60 excluding p.c.b.s & case

Semiconductors

D1, 2, 3	1N4148 small signal silicon (3 off)
D4, 5, 6, 7	TIL209 red l.e.d.s (4 off)
D8	1N4001 1A 50V rectifier diode
D9	Integral part of S4 or TIL209 red l.e.d.
IC1, 2	NE531 op-amp (2 off)
IC3, 4	741 op-amp (2 off)
IC5	9400CT frequency-voltage converter i.c.
IC6, 7	555 timer i.c.
IC8	74LS393 TTL low power Schottky dual 4-bit binary counter
IC9	7493 TTL 4-bit binary counter
IC10	74LS42 TTL low power Schottky b.c.d./decimal decoder
IC11	7413 TTL dual 4-input NAND
IC12	7400 TTL quad 2-input NAND
IC13	ZN427E 8-bit analogue-to-digital converter
IC14	7400 TTL quad 2-input NAND
IC15	7493 TTL 4-bit binary counter
IC16, 17	7489 64bit bipolar RAM configured 16 × 4 bits (2 off)
IC18, 19	7404 TTL hex inverters (2 off)
IC20-22	74185 TTL binary-to-b.c.d. encoder (3 off)
IC23-25	7447 TTL b.c.d./7-segment decoder/driver (3 off)
IC26	7805 5V 1A voltage/regulator monolithic (TO-220)
IC27	7905 −5V 1A monolithic voltage regulator (TO-220 case)
LED1, 2, 3	MAN72 or other common anode 7-segment l.e.d. display (3 off)

Miscellaneous

X1	40kHz ultrasonic receiver transducer
X2	40kHz ultrasonic transmitter transducer
S1	4-pole 3-way rotary switch
S2, 3	1-pole 2-way momentary action push button switch (2 off)
S4	double-pole on/off latching push button switch with integral l.e.d. indicator (D9)
PL1	4mm plug red
PL2	4mm plug black
SK1	4mm socket green
SK2	4mm socket yellow

The above list contains only a description of the items appearing in the circuit diagrams. Hardware is not itemised as this will vary with requirements and layouts of individual constructors. We recommend the use of d.i.l. sockets for all the i.c.s.

The shift is seen to be proportional to the velocity v of the object and the transmitted frequency, f_1. Thus by keeping f_1 constant, the object velocity may be determined by measurement of the "shift".

When the above equation is applied to a trolley at 10 cm/sec, and an ultrasonic frequency of 40kHz aimed at the object, the Doppler shift is found to be quite small, approximately 24Hz, (c=33,000 cm/sec).

CIRCUIT DESCRIPTION

For convenience and clarity, the circuit diagram for the Velocity Measurer has been divided into several sections.

Consider the stages shown in Fig. 1. This contains the ultrasonic transmitter, ultrasonic receiver and other analogue signal processing circuitry and timing signals to provide an 8-bit wide digital signal of magnitude numerically equal to that of the velocity of the moving object being measured.

The output of IC6, a 555 timer i.c. in an astable configuration, feeds X2, an ultrasonic transmitter transducer operating at 40kHz. The frequency of operation is determined by C18, VR6, R18 and R19. It may be adjusted to the required 40kHz resonant frequency of X2 by means of VR6.

Some of the radiated ultrasonic beam from X2 is reflected by the moving object to reach X1, the ultrasonic receiver transducer. The received signal generates a very small voltage across X1. Amplification of this signal is provided in two stages by high-frequency op-amps IC1 and IC2.

The amplified received signal is mixed with the transmitted signal, taken from IC6 pin 3, across VR1. The mix reaching the following stage is variable by means of VR1 wiper position. The effect of the diode D1 is to act as a demodulator to provide sum and difference frequencies of the transmitted and received signals. This will give the low frequency Doppler shift component and a much higher frequency.

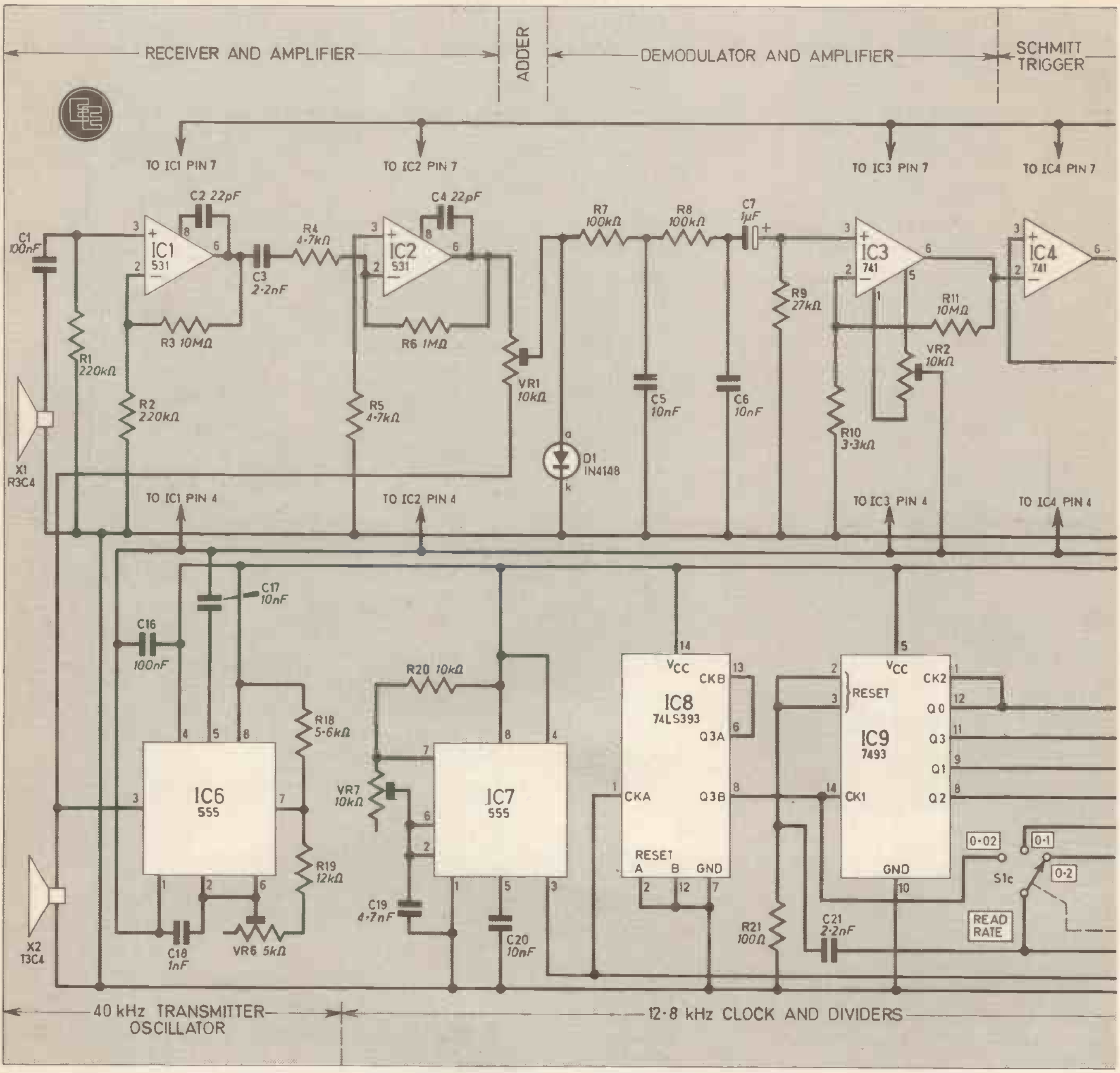


Fig. 1. Circuitry of the ultrasonic transmitter and receiver, analogue signal processing and timing stages of the Velocity Measurer.

The latter is removed by the cascaded low filters composed of R7/C5, R8/C6 allowing the low frequency to reach IC3, a further op-amp connected as a high gain (×3000) voltage amplifier. VR2 is the off-set null control.

SCHMITT TRIGGER

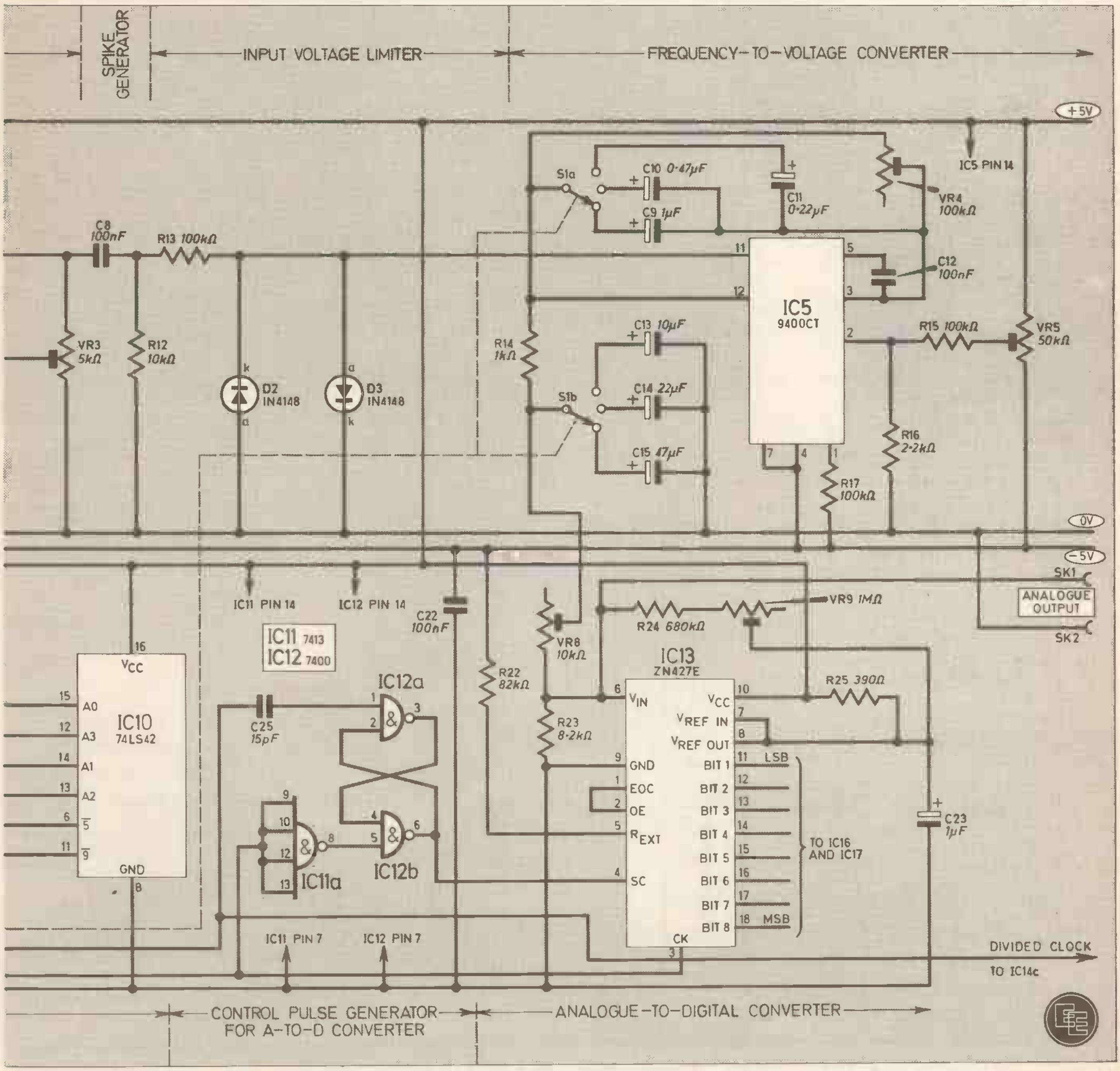
Op-amp IC4 is wired as a Schmitt trigger with reference voltage set by VR3. The action of a Schmitt trigger is to clean up a waveform by producing a well-defined square wave at the same frequency. The square wave produced here is further processed by the differentiator circuitry C8 and R12 to produce negative and positive going spikes, limited in amplitude by diodes D2 and D3 to keep the input level to IC5 within acceptable limits.

FREQUENCY-VOLTAGE CONVERTER

It can be seen that the spikes are produced by the moving object and are of a frequency equal to the Doppler shift. IC5 is known as a frequency-to-voltage converter i.c. It produces an output voltage, pin 12, which is linearly proportional to the input frequency.

VR4 in conjunction with C9, C10, or C11 as selected by S1a forms part of the scaling circuitry required to cater for the three different sampling periods. R14 with either C13, C14 or C15 as selected by S1b form simple low pass filters to reduce the voltage fluctuations that appear at the output.

To provide an output voltage level that was in direct relationship to the velocity of the moving object, in cm/sec, the output from the frequency-to-voltage needs to be reduced by a factor of 0·41. This is achieved using a potential divider composed of VR8 and R23. The analogue output between SK1 and SK2 may be connected to an oscilloscope to give a graphical representation of the moving object, or a Harris Data Memory Unit for storage of many results.



ANALOGUE DIGITAL CONVERTER

The scaled down analogue voltage reaches pin 6 of IC13 the input of an analogue-to-digital converter. This produces an 8-bit wide binary number proportional to the magnitude of the input voltage. By suitable scaling the digital output may be made to represent the actual numerical value of the velocity (in cm/s) of the moving object being measured.

IC7 is a 555 timer i.c. connected in the free-running mode adjustable by VR7. It is set to oscillate at 12·8kHz which provides the clock for IC13. This frequency is also input to IC8, a dual 4-bit binary counter i.c. The two counters have been series connected to provide a divide-by-256 counter. The resulting 50Hz clock from IC8 is available at one position of S1c and also feeds the clock input of IC9 connected as a 4-bit binary counter.

IC9 outputs reach the binary inputs of IC10 to yield at outputs "5" and "9" further division of the clock frequency by factors of 5 and 10 respectively. These are available at S1c. At the end of each timing period, that is 20ms, 100ms or 200ms, a pulse is generated to reset IC9 to zero output.

IC11a, a spare gate connected as an inverter and IC12a and b wired as an R-S bistable, control the periods when IC13 converts the analogue input at pin 6 to digital data, pins 11 to 18.

CONTROL LOGIC AND MEMORY

The next stage of the circuit to be described is shown in Fig. 2. Here we can see the logic circuitry associated with the Start and Step switches which control the data written to and

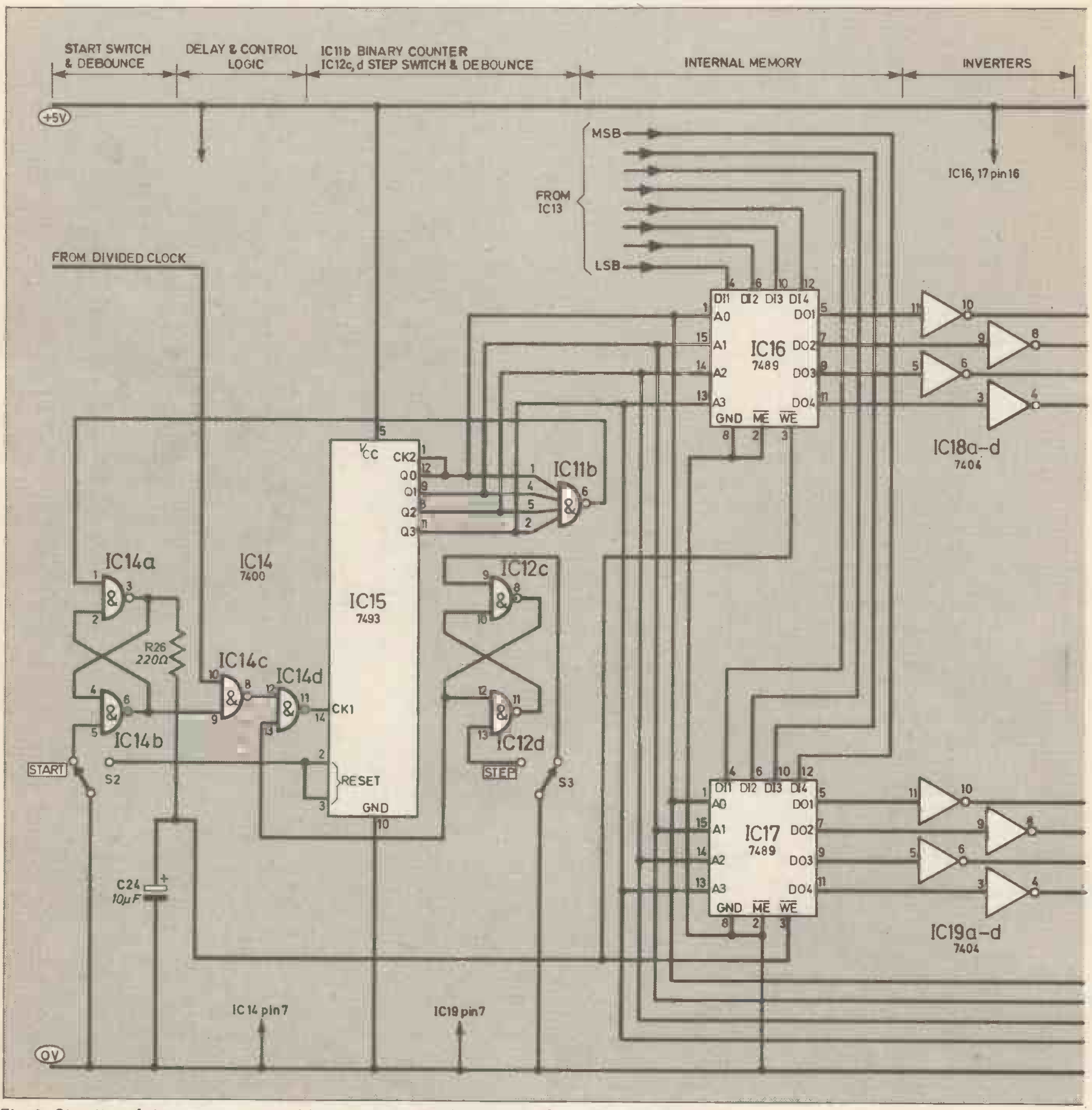


Fig. 2. Circuitry of the memory control logic and the display stages of the Velocity Measurer.

read from the memory (RAM) chips IC16 and 17.

Mechanical switches such as those specified for Start and Step are liable to produce contact bounce when operated which would severely interfere with the successful function of the unit. To eliminate this possibility, debounce circuitry has been included for these switches. This is provided by cross coupled NAND gates, IC14a and 14b for S2, and IC12a and 12b for S3.

One output from S2 debounce circuitry controls the memory read/write pins on IC16 and IC17. The other output controls the clock pulses to IC15 whose outputs provide addressing information for the memory. After all 16 memory locations have been addressed by IC15, a low pulse is generated by IC11b to reset S2 latch.

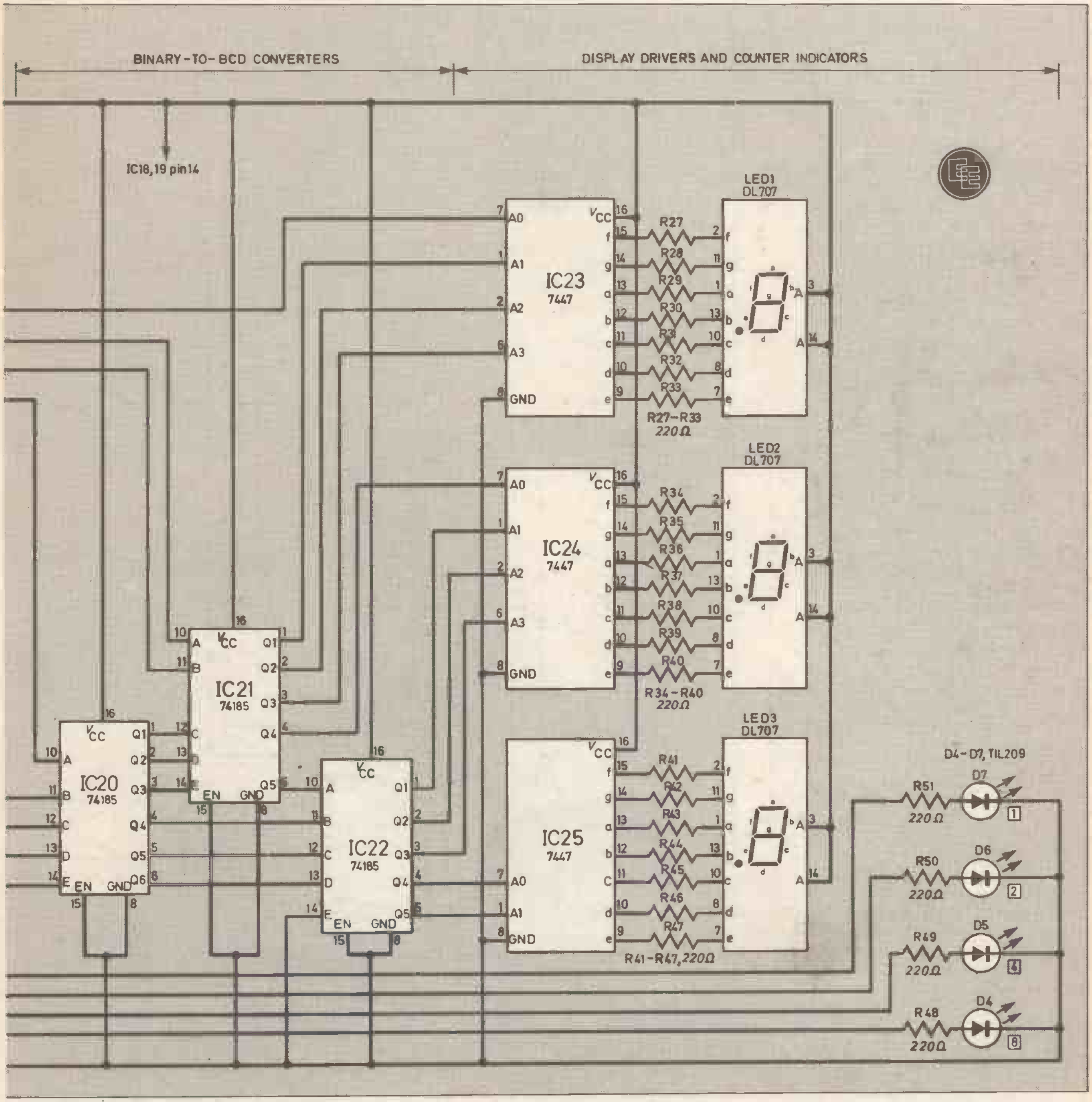
The delay given by R26 and C24 holds the memories "open" briefly to enable them to take in the last reading.

Single stepping through the memory can be accomplished using S3. This facility allows the user to read and record memory contents displayed on the 7-segment read-out. Each time S3 is pressed, a debounced level enables the divided clock pulse to advance the address counter, IC15.

The data to be written into memory when Start is pressed is that at the output of IC13. The least significant 4-bits are written into IC16, with the most significant bits into IS17.

BINARY TO B.C.D.

The binary from the memory chips needs to be encoded to allow the information to be displayed on three seven-segment read-outs. The circuitry to accomplish this is shown in Fig. 2. The eight data lines from



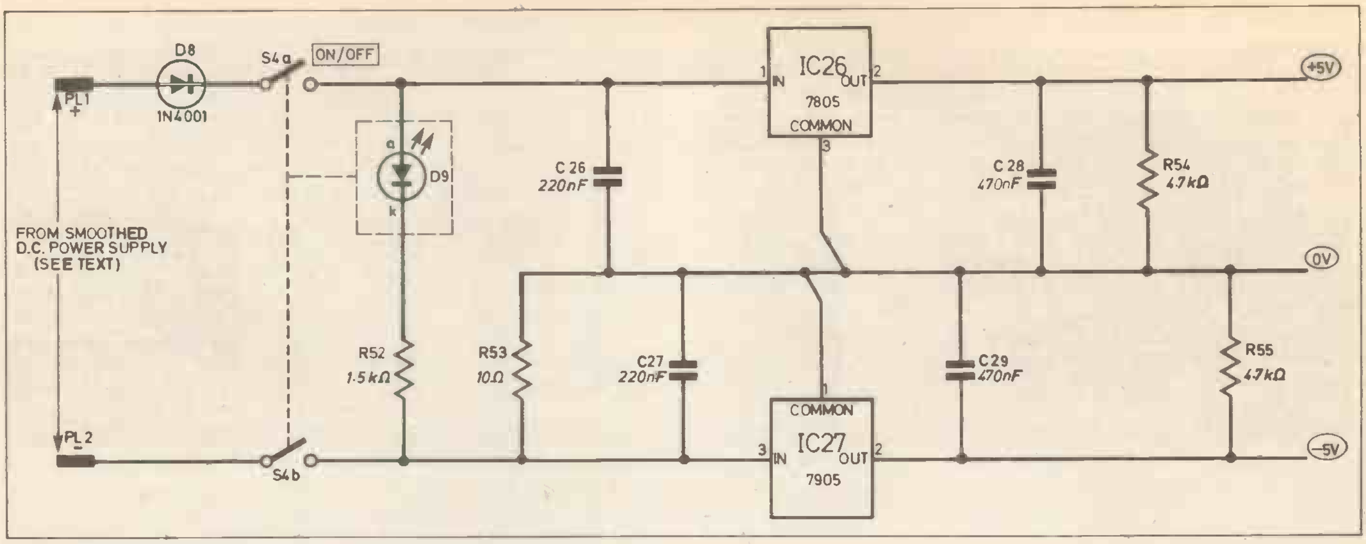


Fig. 3. The power supply used in the prototype Velocity Measurer.

memory are buffered and inverted by IC18 and 19 before reaching the various inputs on IC20 to 22. These i.c.s are derived from custom 256-bit ROM i.c.s type 7488. The 74185 will provide binary-to-b.c.d. conversion as required by the display circuitry.

The binary input forms the address to the cell containing 8-bits of data. The result is two 4-bit wide digits for the two least significant display digits, and one 2-bit wide digit for the most significant display digit. This information reaches the input of 7-segment decoder i.c.s, IC23 to 25 to appear on l.e.d. displays LED1-3.

The four lines to the memory address inputs also reach the display panel to light up combinations of four l.e.d.s, D4 to D7, in binary format. This provides the user with the necessary visual indication of the precise memory location being addressed. Position in the memory bank is time related and will, with knowledge of the position of S1 allow velocity-time graphs to be plotted.

POWER SUPPLY CIRCUITRY

The final part of the circuit is the power supply circuitry built into the prototype Velocity Measurer. This appears in Fig. 4.

The circuitry was found to need a smooth and low noise power supply. This was found available in the designers school laboratory and consisted of a Radford Labpack with Smoothing Unit attached and was operated with the Selector set to 14V.

The basic requirement for the "electronics" is a +5V, 0V, −5V split rail at 0·5A, and may be realised in a number of ways, and without the need for the above mentioned or similar equipment.

To produce the required voltages from the mentioned school equipment, fairly conventional circuitry was employed as shown in Fig. 3. Diode D8 is included for protection should the input supplies be reversed in error. Switch S4 on to supply power to the circuitry. This is indicated by D9 lighting up.

IC26 and 27 are monolithic voltage regulators able to supply a smooth and stabilised voltage of +5V and −5V respectively at currents up to 1A. Input voltage may be as high as 35V, but the devices will need to be mounted on substantial heatsinks for such input voltages. Capacitors C25 to 28 are included for reasons of stability.

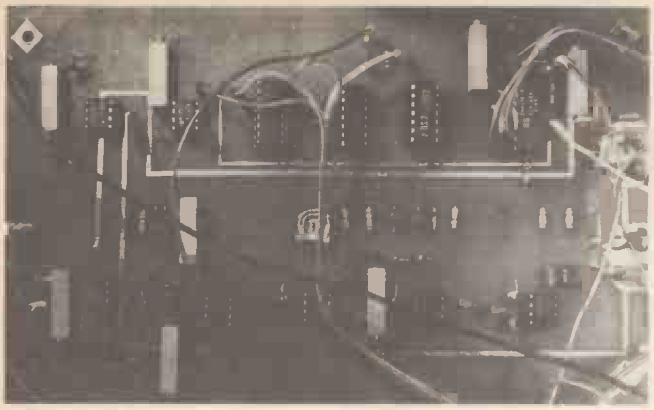
This part of the circuitry gave problems to the designers of the system which have not been fully overcome. The power supply section runs very hot after about 20 minutes use. Constructors are advised to seek or design alternative power supply circuitry.

The completed prototype with lid removed showing interboard wiring.

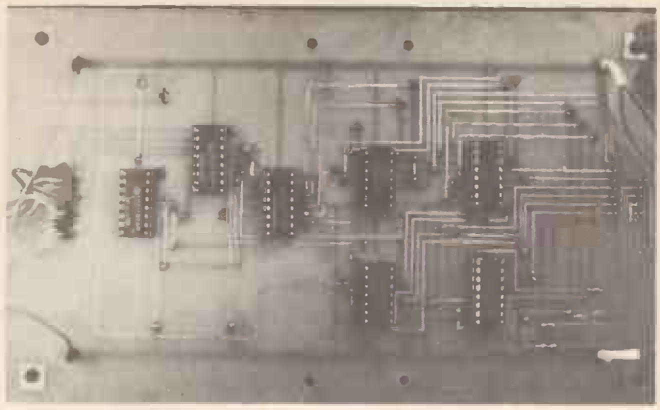
SETTING-UP CALIBRATION

Transducer Resonance

The running frequency of the transmitter oscillator, IC6, is adjustable using VR6 and this should be set so that both transducers resonate. To



The p.c.b. containing most of the circuitry shown in Fig. 1.



Top view of the p.c.b. which contains the memory i.c.s and display decoder i.c.s in the prototype.

find this setting, place a hard, flat-faced object about 20cm in front of the transducers and adjust to find the position resulting in the strongest signal at the output (pin 6) of IC1.

Setting Adder and Schmitt Trigger

Move a flat object, for example a book, to and fro in front of the transducers and adjust the adder, VR1, so that movement of the object results in a strong signal from IC3. Next adjust the Schmitt trigger, using VR3, so that any noise or mains hum in the signal from IC3 is rejected. A clean, square wave should emerge from IC4 when the object is moving, and no signal when the object is stationary.

Zeroing Converter

VR5 gives the zero adjustment of the Frequency to Voltage Converter (IC5) and this should be set so that with no incoming signal the output (pin 12) is at zero. VR9 gives the zero adjustment of the Analogue to Digital Converter (IC13) and this should now be adjusted, with the Start button held down, so that the seven-segment displays are just reading zero.

Calibrating Converter

Using a signal generator, inject a square wave of frequency 600 Hz and amplitude 5V at pin 6 of IC4. (Signal generator ground should be connected to some point at 0V, for example, SK2). Adjust the scaling resistor, VR4, of the Frequency to Voltage Converter so that the output (pin 12) is just 4·0V. (Check that this falls if the signal generator frequency is slightly reduced).

With the Start button held down and the 600 Hz signal injected, adjust the input scaling of the Analogue to Digital Converter using VR8 so that the seven-segment displays just read 255. Again, check that this figure falls if the signal generator frequency is slightly reduced.

Calibrating Read Rate

The read rate is controlled by the frequency of oscillation of IC7. Adjust VR7 until the frequency is 12·8kHz.

FEATURES

The Velocity Measurer when started will automatically take 16 readings of velocity at equally spaced intervals (a) 50 times per second (b) 10 times per second or (c) 5 times per second depending on the setting of the Read Rate switch, S1.

There are three controls sited on the front panel of the prototype:

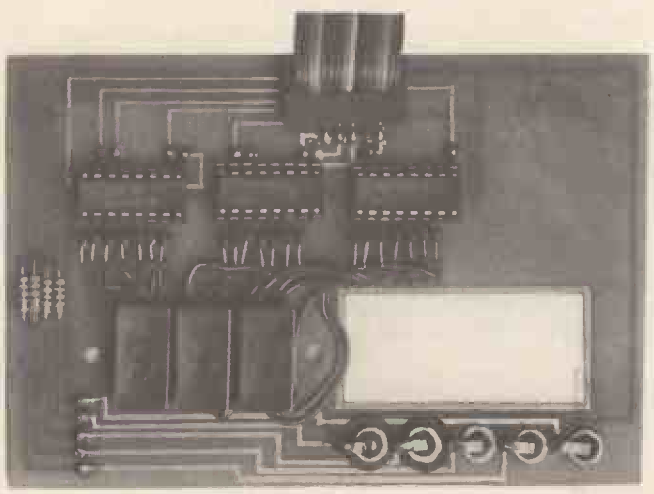
START This control is used to reset the system and when released starts the Measurer recording. If this button is held depressed, the device gives a direct reading of the velocity of the moving object:

STEP This control allows the user to step through each of the 16 memorised velocities, the memory location being indicated by one display and the velocity displayed on the seven-segment read-outs.

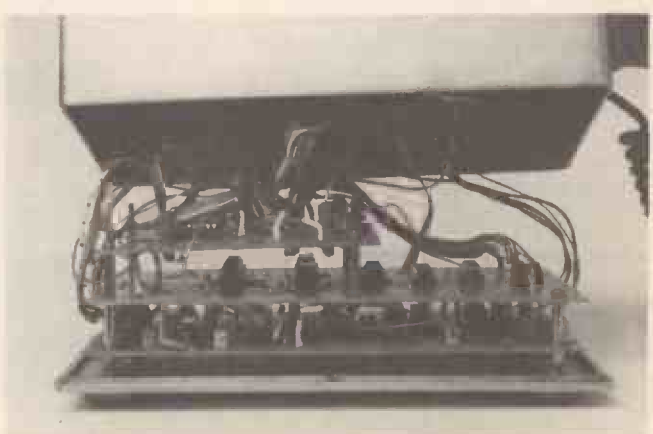
READ RATE This rotary control sets the rate at which the Measurer takes its spot readings of velocity—every 0·02s, every 0·1s or every 0·2s. Also, if the unit is being used as a direct reading velocity meter, Read Rate controls the rate at which the display is updated.

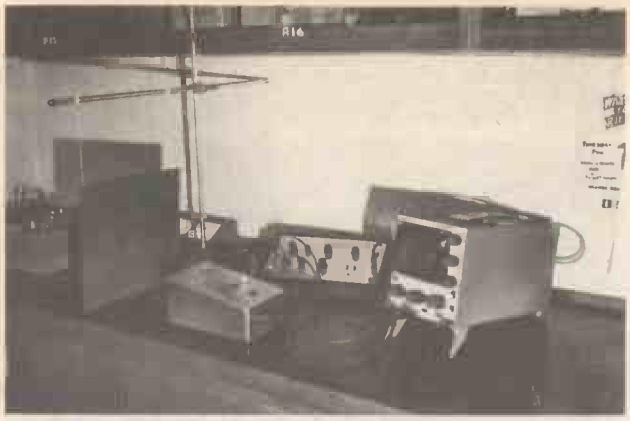
There are two displays. One gives the velocity reading in cm/second on a 3-digit l.e.d. segment display. The second is a row of four discrete l.e.d.s which shows the location of memory

Close-up view of the prototype display board,



The tier arrangement of the p.c.b.s in the prototype unit.





Measuring the oscillatory motion of a swinging aluminium plate.

Using Measurer to determine velocity of a trolley on incline.

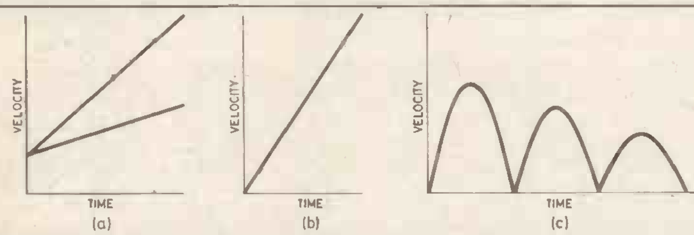


Fig. 4. Velocity/time graphs plotted using the Velocity Measurer (a) small trolley down incline (b) free-falling object (c) an oscillating object (pendulum bob).

being displayed. This read out is in binary.

LIMITS

At about 2 metres from the device reflected sound becomes weak from small objects, and this means at distances further than 2m, a large surface (a sheet of aluminium for example) is needed to reflect the sound. The device cannot read velocities higher than 2·55 metres per second.

TYPICAL USES

Some applications in which the device has proved effective are:

(i) Taking the necessary velocity and acceleration measurements of the small trolleys used in school dynamics investigations. (Acceleration is shown by the gradient of the velocity-time graph which emerges).

(ii) Measuring the acceleration of freely-falling objects. For example, using a football falling about 1 metre the resulting figure for acceleration was in close agreement with free-fall theory.

(iii) With the Harris Data Memory attached, recording velocity against time for oscillating objects. For example, reliable readings were obtained using a piece of wood about 20cm square swinging pendulum-fashion on 0·5m of string.

(iv) Taking direct measurements of speed in the laboratory where normally the use of a stopwatch and metre rule would prove necessary. For example, it was able to measure the speed of a water wave running along a trough.

OTHER FACILITIES

The Velocity Measurer can be connected to a "Harris Data Memory Unit" by connection at SK1 and SK2. The ability to do this greatly increases the number of velocity readings that can be handled. Then later, by simply connecting the Data Memory to a Chart Recorder, an automatic velocity time graph can be plotted.

Furthermore, if an oscilloscope is connected at SK1 and SK2 then it will display directly the speed being sensed and does so independently of the Start switch.

Three levels of filtering are selected at the output using the Read Rate selector. In the 0·02s setting, it enables the output to change at up to 100 cm/s^2 at the expense of "bobbling" at low speeds; in the 0·2s setting, the "bobbling" is sufficiently low that speeds as low as 10cm/s may be accurately measured.

OPERATING INSTRUCTIONS

1. Connect a suitable power supply at PL1 and PL2.
2. Turn on the Velocity Measurer at S4.
3. Point the ultrasonic transducers at the object whose velocity is to be measured.
4. Turn the Read Rate control to the appropriate reading rate for the experiment in mind. You are now ready to take measurements.
5. At the appropriate time in the motion of the object, press and *release* the Start switch. When this switch is pressed the memory is prepared to receive readings. When the switch is released readings will be taken and stored.
6. When all the memory locations have been filled, no more readings will be stored in the system, and the system, will be ready to display its results. To obtain these results press the Step switch. The first reading will then appear. Press again to obtain the next stored reading. This will continue up to a total of 16 readings and will then repeat. The memory location being read will be displayed on the discrete l.e.d. read-out in binary format.
7. Repeat from 4 above for same or next experiment.

Measuring the speed of a water wave.

Everyday News

Scimitar

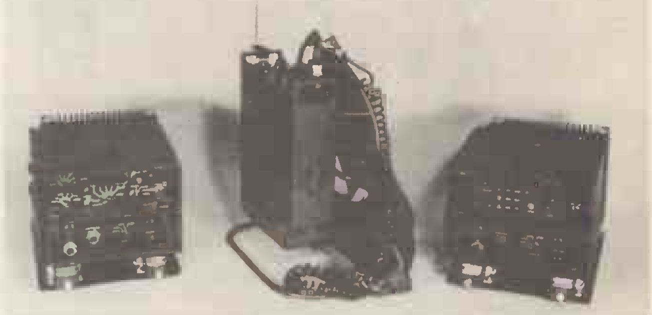
The most advanced radio system in the World

MILITARY necessity can have valuable spin-offs for everyday purposes. The classic modern examples were radar and computers, whose development was accelerated by the needs of the Second World War. It now seems to be the turn of radio.

A new radio system, developed to provide reliable military communications, proof against eavesdropping and jamming, shows promise of helping the users of some civil radio bands.

The new system has been developed in several NATO countries as a result of an American government requirement. In the UK, Marconi and Racal have both developed their versions. A large contract for the Marconi version, which is called Scimitar, has been placed by the Swedish government.

UNJAMMABLE, SNOOPER-PROOF RADIO



Line-up of some of the Scimitar communications equipment which features built-in digital cryptographic security.

Frequency Hopping

How does it work? Basically, these radio systems, which are known as frequency - hopping or frequency-agile radios are just electronic versions of commonsense radio operating techniques.

One traditional way to avoid jamming or eavesdropping is to keep changing frequency. Every time you do so your enemy has to search for your new frequency and retune. Your friends don't have to, because your frequency changes follow a prearranged pattern which they know.

If you have four channels, *A*, *B*, *C* and *D*, you may change on some apparently random basis, such as *B*, *A*, *D*, *C*, *D*, *A*, *B* and so on. With manual operation these changes must be relatively slow, say once every minute. But with modern digital electronics they can be very rapid indeed.

The exact rate of change used in Scimitar is a secret, but it is probably well over 100 times a second. Moreover, the number of channels can be very large. In the v.h.f. version ordered for the Swedish army selections can be made from over 2000 possible channels, spread over the band 30 to 88MHz.

Each receiver contains an electronic memory into which programs of instructions for frequency-tracking can be fed from outside. To enable the next frequency hop to be anticipated each set contains two frequency synthesisers. The "spare" one is set electronically to the next frequency, ready for instant changeover, and so on.

Interference

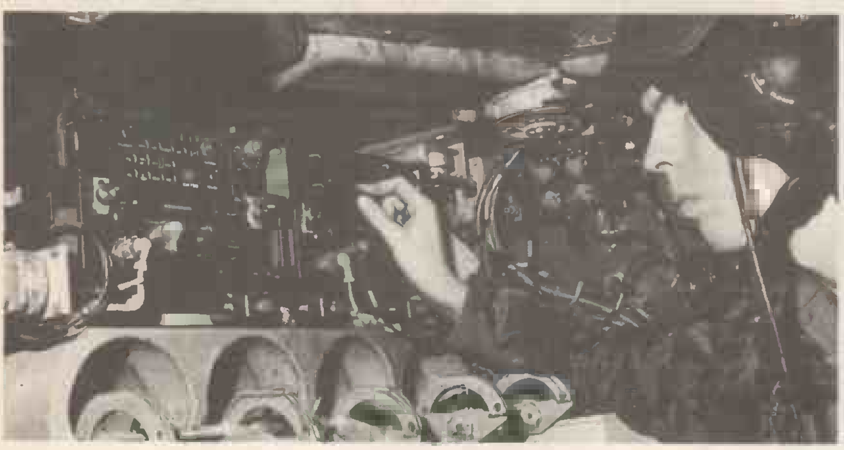
If numerous transmitters operate simultaneously, each hopping from channel to channel at random, then from time to time it must happen that two transmissions take place at the same time on the same channel. They interfere with one another—but only for the few milliseconds that the overlap occurs.

To the ear, this is just a tiny bit of noise and has little effect. If more and more transmissions are packed into the band more such short bits of interference occur. It turns out, however, that the ear can tolerate a surprisingly large number before the intelligibility of speech is seriously impaired.

The consequence is that for the price of a little noise more stations can be packed into a given frequency band than with the normal system of giving each station a fixed frequency channel. This would seem to make frequency-hopping attractive to such civil users as the police.

Not only would it make eavesdropping virtually impossible but it would make more channels available, too. But would the price be too high? Apparently not. Marconi say that despite the complexity of frequency hopping it adds only about 10 per cent to the cost of the radio equipment.

The frequency "hopping" equipment installed in an armoured vehicle.



Pocket version being used to demonstrate its usefulness to civilian authorities.

ANALYSIS

NEW AGE OF LEISURE

The most optimistic of our political leaders touting the most reflationary economic programme promises only to "create" a million new jobs over a five year period. At best this still leaves two million in Britain technically available for work and registered as such.

Forecasts and projections of this type are nowadays made by computer using an economic model rather than employing a small army of statisticians and mathematicians. Similarly, on the industrial front, Ford at Dagenham have just fielded a whole regiment of robots to build car bodies. People are still invaluable but fewer are required for any given task, not a new phenomenon but continuation of a trend which has been accelerating for a century.

Assuming high unemployment to be a catastrophe we lay blame elsewhere, on politicians, organised labour, foreign imports, the welfare state, automation, electronics. Never on ourselves for wanting and grabbing more while giving less, constantly fuelling ourselves on greed and envy.

And yet, viewed correctly and sensibly managed, ours could be the Utopian age of visionaries through the ages. Work sharing alone, albeit swapping income for leisure, could provide employment for all those who want to work while simultaneously providing the extra time for developing those interests which so many now trapped in the rat-race are too exhausted to pursue before retiring age, when it is often too late.

Electronics, positively viewed, is a liberating more than a destructive force. It releases millions from tedious tasks at work and brings instruction and entertainment to even more millions at home.

Electronic hobbyists with time on their hands might well encourage friends or acquaintances to share their enthusiasm. A modest home circle rather than a full-blown club.

Think about it. To wean a youngster from adolescent vice or relieve an oldster's boredom could be the most worthwhile project you have ever started.

Brian G. Peck

Computing Cuts

A Department of Health and Social Security scheme for massive expansion of data processing could eliminate more than 20,000 jobs in local DHSS and Unemployment Benefit offices.

But the whole scheme, if implemented, will not be completed until 1994 allowing natural wastage rather than staff redundancies.

Breakfast News

BBC TV's breakfast programme will be aided with hot news by £250,000 worth of Hewlett-Packard electronic office equipment enabling staff to access news agencies and prepare and edit copy on word processors.

The computerised system will need agreement from the unions before the programmes start next Spring.

CAR-PROOF

The new Avo 2000 Series of digital multimeters includes the model 2002 vehicle test set. It has already become standard dealer equipment for Ford cars.

A big feature is its ability to withstand being run over by a car or even a truck!

The Ministry of Defence is to install a new communications network for UK air defence compatible with the US Joint Tactical Information Distribution System (JTIDS). Total cost is estimated at £225 million with Marconi and Plessey having the bulk of the development work.

Euro Scanner

A new medical electronics company, Meditech, founded by a group of ex-EMI employees, has produced a whole-body diagnostic scanner aimed at the European market and at much lower cost than scanners currently available.

MULLARD VISIT FOR SEDAC PRIZEWINNER

Simon Rainey, who came second in the 1982 SEDAC Schools Competition, spent a day as guest of Mullard Magnetic Components Division, Crossen, Southport.

(For details of how to enter the 1983 SEDAC Schools Competition see page 811.)

Colin Smith (Electronic Engineer) discusses the PC20 Microprocessor with Simon (right) during his visit to the electronic section of the Mullard Magnetic Components Division, Southport.

Our picture shows left to right, Simon Rainey, Mr. Earnshaw (teacher), Mr. Stone (headmaster) and Jim Stitson (Manufacturing Manager) looking at the Power Plants Mimic Panel.

New Standards

Direct Broadcasting by Satellite (DBS) ideally should be on one agreed technical standard of TV transmission. National pride, however, will probably lock countries into their existing systems based on PAL, SECAM or NTSC with the problems of standards conversion for international programme exchange remaining.

An entirely new standard would also mean huge investment in new transmission and reception equipment which many countries could not afford.

Enough videotape to fill two million T120 cassettes a year is being produced at a new plant at Wrexham, North Wales. The company is Intermagnetics and the tapes are sold under the brand name Zimag.

THE ELECTRONICS OF IT INFORMATION TECHNOLOGY

PART TWO

BY T.E. IVALL C.Eng., M.I.E.R.E.

ALTHOUGH we may have got used to the idea of self-sufficient apparatus operating under automatic control, and even computers "talking" to each other, we find in fact that all IT systems have some means of connection to the outside world. They receive and put out information as changes in physical quantities as explained in Part 1.

These changes may be phenomena meaningful to human beings, such as sounds and images, or they may be physical changes that are detected or generated only by hardware. An automatic weather station, for example, does both. It receives information directly from the environment as measurements from various sensors but puts out information designed for presentation to human beings.

INFORMATION CONVERTERS

To make these connections with the world an IT system needs converting devices. The converters we use in domestic electronic equipment — pickups, microphones, keyboards, loudspeakers, cathode - ray tubes, alpha-numerical displays and the like — are only a few of the devices that are available.

Many of these devices are transducers.* Some convert mechanical or other energy directly into electrical energy and are called passive transducers, Fig. 2.1(a). One example is the moving-coil microphone, another the photo-voltaic cell as used in camera exposure meters.

Active transducers, on the other hand, use the mechanical or other energy to *control* electrical energy coming from a separate source, Fig. 1(b). Examples of these are the carbon microphone and the photoconductive cell.

ON/OFF SWITCH

A common type of information converter is the on/off switch or key switch. It uses a mechanical movement to control abruptly the current in a circuit. This allows a binary choice — between on and off, or current and no current — which is, in fact, the basic unit in the measurement of all information (Fig. 2.2).

When an array of key switches, each with its own label, is used as a keyboard, the important information at any moment is: which particular switch in the array has been operated. There are various methods of obtaining this information electrically but a common one is shown in Fig. 2.3.

This method is analogous to the principle that any point on a map can be identified by the grid lines which intersect at that point. Closing any one of the six switches makes a circuit between one horizontal and one vertical conductor: this circuit uniquely identifies the key switch because no other switch in the array will connect that pair of conductors.

Fig. 2.4 sums up the process of information conversion. A device either receives some physical quantity from the outside world (a) and converts it into an electrical quantity, or it receives an electrical quantity (b) and converts this into another physical quantity. The quantities change but the information they carry does not. But this is not the whole story.

ANALOGUE OR DIGITAL

The information in its electrical form may be represented in two ways: analogue or digital.

To illustrate this let us return for a moment to Part 1. In the electronic counting system described, the number of objects was represented by that number of pulses of electrical energy. In fact the exact form of their energy-time graph did not matter very much: the pulses could equally well be triangular or some other shape provided their number was correct.

This type of representation, in which the number of electrical events gives the essential information, is a digital representation. (The term itself comes from the Latin *digitus* for finger — the link with counting is obvious.)

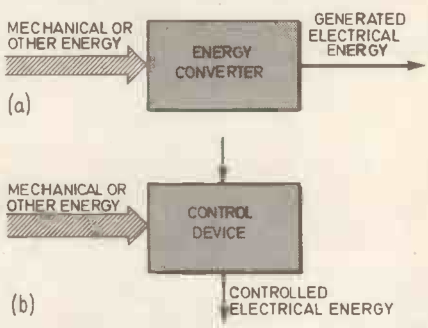


Fig. 2.1. Two ways of obtaining information in electrical form from information carried by some other kind of physical energy: (a) passive transducer giving direct conversion of energy; (b) active transducer controlling electrical energy from a separate source.

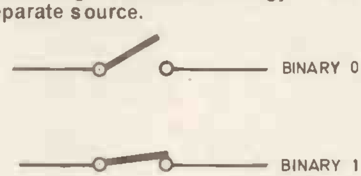


Fig. 2.2. Because an on/off switch can make or break a circuit carrying current—allowing a binary choice—it can convert mechanically represented information into electrically represented information.

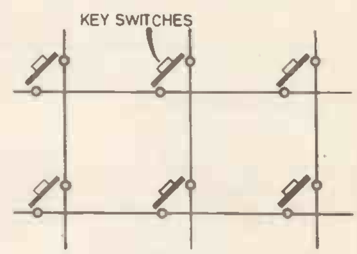


Fig. 2.3. Array of key switches used as a keyboard. Each switch connects a unique pair of conductors, and this provides electrical information on which switches are operated in the keyboard.

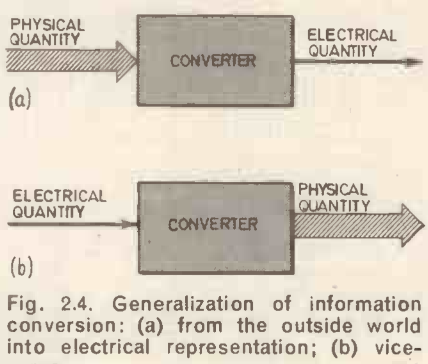


Fig. 2.4. Generalization of information conversion: (a) from the outside world into electrical representation; (b) vice-versa.

* One dictionary defines the transducer as a device which receives waves from media or transmission systems and supplies related waves to other media or transmission systems.

Another type of representation shown in Part 1 was a continuously varying electrical quantity obtained from a microphone responding to a sound wave. The successive values of electrical energy were proportional to the successive values of sound energy. In other words the time graph of electrical energy was similar in form to the variation with time of the sound energy. As such the electrical variation is a model, or analogue, of the sound variation. This, then, is an analogue representation.

ANALOGUE AND DIGITAL METHODS COMPARED

So some information converters are analogue and others digital in the way they work. To illustrate this, Fig. 2.5 compares two transducers, both of which are electrically representing the rotation of a shaft.

At (a) is an analogue transducer giving a proportional electric current (3mA per degree of rotation), while at (b) is a digital transducer giving a related number of pulses of current (one pulse per 10 degrees).

Both transducers use current as the electrical quantity, but the analogue type does it directly while the digital type uses current merely as a medium for denoting number. In some digital transducers for use on rotating shafts the angular information is translated directly into a binary code, such as the Gray code.

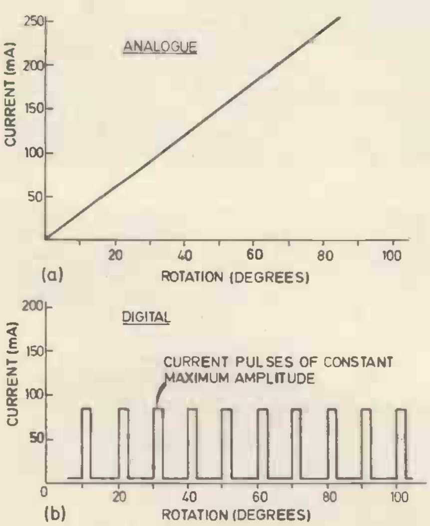


Fig. 2.5. Graphs illustrating the action of (a) an analogue transducer and (b) a digital transducer, both of which respond to the rotation of a shaft and use current, in different ways, to represent shaft rotation in degrees.

STEP-BY-STEP, OR INFORMATION BY NUMBERS

The above heading might suggest a dancing lesson out of a book. In fact what we are discussing is rather similar, in so far as it involves a sequence of steps identified by numbers. The subject is the conversion of analogue signals — coming from some device which might be anything from a strain gauge to a television camera — into the digital form that many IT systems require. This means that the successive values of the signal (Part 1) have to be represented by numbers.

A practical problem here is that any analogue-to-digital conversion device needs a certain amount of time to produce each number. Electronically each number is represented by a pattern, either in time (for example, a sequence of pulses) or in space (for example an array of electrical states in a memory). Some interval of time, however small, is necessary to allow each pattern to be formed and distinguished from those preceding and following it.

Clearly such a converter cannot operate directly on the whole of an analogue signal, which is a sequence of values infinitely close together in time. The best that can be done, to keep the digital representation as close as possible to the continuously varying quantity, is to convert values of the signal at a very high rate.

In practice engineers use the rate necessary for the job. And this depends on the accuracy of digital representation they need for a particular application. (Any clock with an escapement mechanism doesn't indicate time continuously, but it's near enough to continuous for most human purposes.)

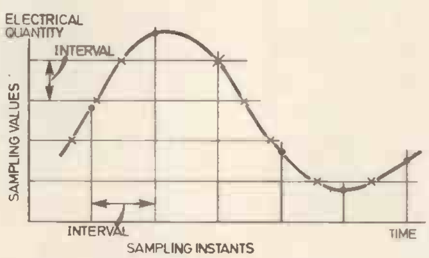


Fig. 2.6. How a continuous electrical signal can be sampled at regular intervals of time (dots on graph) or regular intervals of the value of the electrical quantity (crosses on graph).

This modern telephone, British Telecom's Sceptre 100, uses both analogue transducers (in the handset) and digital information converters (in the keyboard and the liquid-crystal digital display). It also has a memory for storing telephone numbers—but we come to that subject later in the series.

SAMPLING

So the continuously varying signal is "sampled" at intervals. The sampling could be at regular intervals of time or at regular intervals of value of the electrical quantity forming the signal, as shown in Fig. 2.6.

This process is the basis of quantization. What was originally varying continuously is now represented as a series of discrete quantities, or quanta.

A simple analogy is a man climbing up a slope. If the slope is continuous, as in Fig. 2.7(a), then his upward movement is continuous. If the slope is cut into a series of

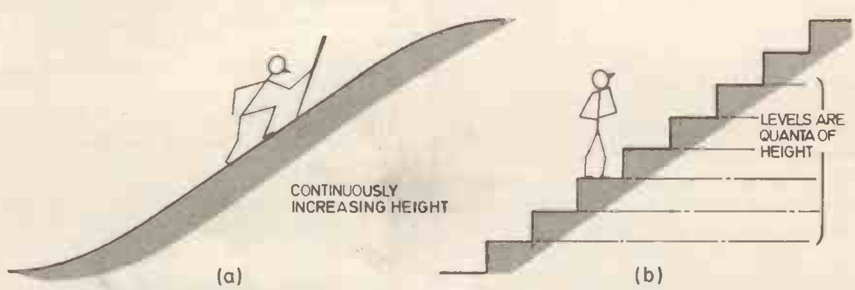


Fig. 2.7. Simple analogy of the principle of quantization. At (a) the man moves continuously up the slope. At (b) the slope has been cut into a series of steps and the man then moves abruptly from one quantum of height to the next quantum, and so on.

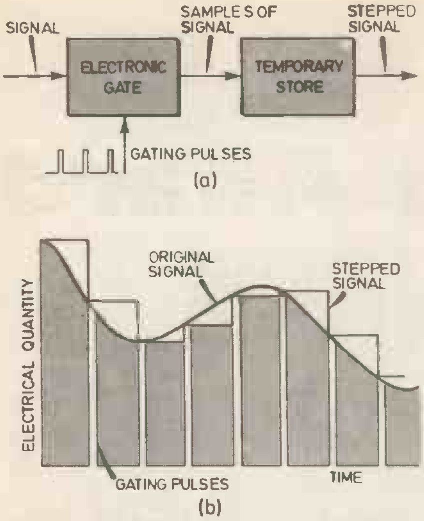


Fig. 2·8. Electronic method for quantizing a continuously varying signal, using a gate and a temporary store (a). The samples obtained from the gate and the steps from the store are shown at (b). Amplitudes of the samples, or levels of the corresponding steps, are the quanta.

steps, as at (b), his upward movement is discontinuous: he moves abruptly from one quantum of height (level) to the next quantum and so on.

One method for quantizing a signal is shown in Fig. 2.8. The signal is passed through an electronic gate which is opened for short periods by very narrow pulses occurring at a regular rate, (a). What emerges from the gate is a train of pulses of different amplitudes — thin "slices" or samples of the original signal. These samples are usually of too short a duration to be usable in IT equipment, so their values have to be prolonged.

SAMPLE AND HOLD

The initial value of each sample is held in a temporary store until the next sample is taken. As a result the information available from the temporary store takes the form of a series of steps roughly following the graph of the original continuous signal, as shown at (b). This is the "sample-and-hold" method.

How accurately the quanta — the samples or steps — follow the original continuous signal depends on the fineness of quantization — that is, the intervals between samples. In general it is more difficult to sample rapidly than to sample slowly, so engineers use the slowest rate of sampling (longest intervals between samples) that will define the signal to the accuracy needed.

To obtain the highest possible accuracy of signal definition the sampling rate required is given by a simple formula based on mathematical (Fourier) analysis of the waveform.*

ENCODING

The final requirement of analogue-to-digital conversion is that it must represent the quanta by numbers suitable for use in IT systems. This is done by an encoding device. The technique is used, for example, in pulse code modulation (p.c.m.), a transmission system employed for trunk telecommunications throughout the world. Fig. 2.9 shows the general principle.

At (a) is part of an electrical waveform which could be a speech signal. This is sampled at a regular rate, typically 8,000 times per second, to give a sequence of discrete amplitudes, shown as the heights of the vertical lines in (b). Each of these amplitude samples falls within a quantizing interval, identified by a decimal code number on the vertical (signal amplitude) scale.

The quantitizing-interval number in which the amplitude sample falls is then generated in binary coded form. In this binary coded version the two digits 0 and 1 are generated as a sequence of two voltage values, (c) — here a low voltage for 0 and a higher voltage for 1. In effect the result is a train of pulses representing binary numbers.

For this simplified explanation we have used decimal code numbers in (b) and directly converted them into the equivalent binary numbers, but other forms of encoding could be used.

To be continued

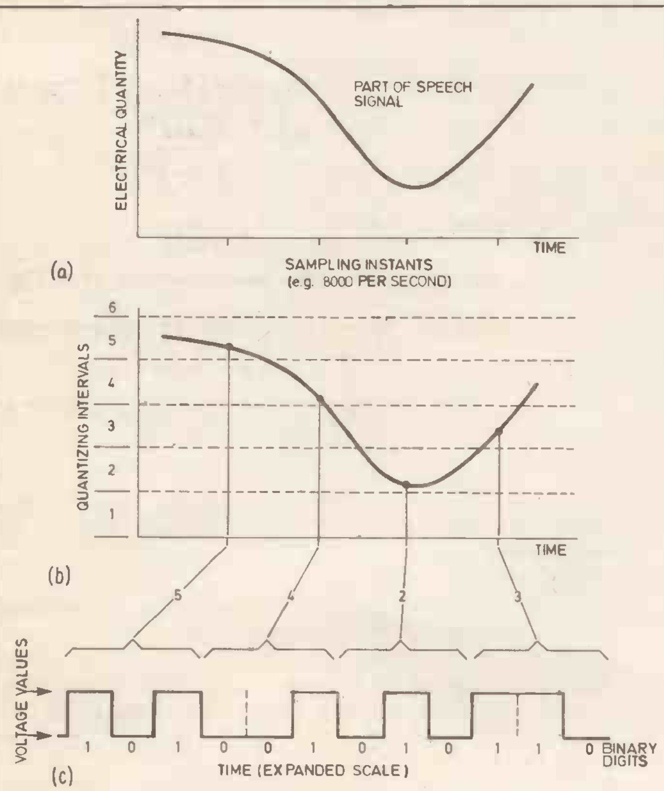
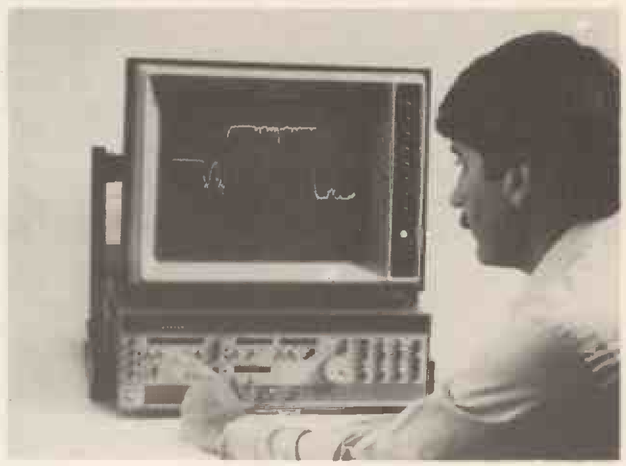


Fig. 2·9 Principle of analogue-to-digital conversion. The continuous electrical signal at (a) is sampled at regular intervals of time and the samples are represented by a sequence of numbers corresponding to the quantizing intervals in which the samples fall (b). At (c) is a binary coded version of the sequence of numbers in the form of high (1) and low (0) voltage values. (Note: in this illustration the least significant digit of each binary number occurs first in time and the most significant digit last.)



(above) Analogue-to-digital conversion, as described in the article, is at the heart of this Hewlett-Packard waveform recorder. Incoming signals are sampled at 20 million times a second and are stored in a memory. This digital data can be read out from the memory when required to construct a graph on the cathode-ray tube, as shown.

* For full accuracy of definition the sampling rate must be at least twice the frequency of the highest frequency sinewave component of the signal, as given by Fourier analysis.

1983 SCHOOLS
Electronic Design Award
COMPETITION

over £2,000 in Prizes

REGISTRATION CLOSES DECEMBER 15 1982
This is a four-week extension on previously announced date.

Mullard Ltd—the largest electronic components company in the UK—and Everyday Electronics join forces to present this rewarding challenge to Secondary Schools....

DESIGN A PIECE OF ELECTRONIC EQUIPMENT HAVING A DIRECT PRACTICAL APPLICATION IN A SCHOOL'S SCIENCE LABORATORY

This competition is open to any United Kingdom Secondary School, State or Independent. Pupils of either sex in the age group 11-18 are eligible to participate in a team representing their school.
The competition will be conducted in two stages.

STAGE 1
Submission of Papers describing the proposed project with full circuit details.
Papers will be judged for novelty, ingenuity and viability. Particular attention will be given to originality and good circuit design technique.
Schools whose designs are adjudged to be the most promising will be asked to produce a working model.

STAGE 2
Models will be examined and prize winners selected on the basis of mechanical design, neatness of wiring and general assembly, plus operational performance.

All models will be exhibited at Mullard House, London, where the official presentation of prizes will be made at the end of June 1983. Representatives of finalists will be invited to stay overnight in London as guests of the SEDAC sponsors.

FIRST PRIZE The SEDAC Trophy and £300*

SECOND PRIZE £200*

THIRD PRIZE £100*

*** Plus a selection of components valued at £200**

NINE RUNNERS UP a selection of components valued at £100

In addition, all twelve finalists will receive a certificate and one year's subscription to Everyday Electronics.

Science teachers of Secondary Schools are invited to apply for a Registration Form which contains full details of this competition.

Write to: Schools Competition, Room 2130, Kings Reach Tower, Stamford Street, London SE1 9LS.

Secondary School Pupils—make sure your school accepts this challenge and enters this contest. So bring this announcement to the attention of your science teacher or the head of your school.

Closing date for Registration: December 15 1982

Closing date for submission of Papers: January 31 1983

SCHOOLS ELECTRONIC DESIGN AWARD COMPETITION (SEDAC) SPONSORED BY MULLARD LTD AND EVERYDAY ELECTRONICS

ELECTRONIC

BY D.J.EDWARDS

V/I METER

ONCE it used to be true that it was pointless trying to build your own multimeter. It was difficult to match the price and accuracy of manufactured units. Today, with integrated circuits and close tolerance resistors, it has become easier to match conventional multimeters.

The unit described here has seven voltage ranges with minimum input impedance of one megohm and two low resistance current ranges. Accuracy, simplicity of construction and cheapness are all features of this design.

DESIGN CONSIDERATIONS

The main design feature of a good voltmeter is a high input impedance, this must be placed before accuracy in priority, because impedance directly affects accuracy. Multimeter voltage ranges are usually described as being so many ohms per volt and this ohm/volt figure is known as the meter's sensitivity, the larger this figure, the better the meter.

A typical cheap meter has a sensitivity of 1,000 ohms/volt, that is, on the 10V range its input resistance is $10 \times 1{,}000 = 10$ kilohms. This may sound high, but in practice it means that such a meter cannot accurately measure a voltage across a resistance larger than, say, 1 kilohm.

Here's why. The 1,000 ohm/volt meter on the 10V range is placed across a 1 kilohm resistor. In effect a 10 kilohm resistor is connected in parallel with the 1 kilohm resistor, causing the in-circuit resistance to drop to 909 ohms (using $1/R_T = 1/R1 + 1/R2$).

This means that the voltage across the 1 kilohm resistor must also fall (voltage is directly proportional to resistance) so an inaccurate reading is obtained and the performance of the circuit may be affected. Bearing in mind that the majority of resistors in electronic circuits are over 1 kilohm, the problems a user will experience can be envisaged. These meters are suitable for *electrical* circuits, however, where resistances are usually small.

ELECTRONIC METERS

The next step up is usually a 20 kilohm/volt meter and these are probably the most common. On the same 10V range, its resistance is 200 kilohms, which is a little more respectable. After this come the 100 kilohms/volt and electronic meters.

This meter has a fixed input impedance of either 1 megohm or 2 megohms, depending on the range selected. This is *not* an ohm/volt figure and cannot be due to its construction. This is quite impressive when you realise this gives sensitivities of 10 kilohm/volt on the 100V and 200V ranges, 100 kilohm/volt on the 10V and 20V ranges, 1 megohm/volt on the 1V and 2V ranges and 10 megohm/volt on the 0·1V range. This is a sound arrangement because it gives you the highest sensitivities where you need them, on the lower voltage ranges.

On current ranges, the requirements are exactly the opposite. Because an ammeter is placed in series with a circuit, its resistance should be as low as possible, so as not to affect the reading or the circuit. On both current ranges this meter only drops 0·1V, an acceptable figure (from Ohm's law $V = I \times R$).

THE CIRCUIT

The circuit diagram of the Electronic V/I Meter is shown in Fig. 1. The heart of the design is a 741 operational amplifier IC1. Normally its open loop gain (the gain measured with no feedback applied) is typically 200,000 times. This tends to be rather large for most applications, but can be reduced by making it closed loop by feeding part of the output back to the inverting input via a resistor. This is negative feedback, which as well as reducing the gain, also improves the performance of the op amp in respect of stability, noise, drift and frequency response.

When the desired closed loop gain is much smaller than the open loop gain, it can be set accurately using two external resistors, R_F and R_I (see Fig. 2). In this mode the gain of the op amp is given by:

$$\text{Closed Loop Gain} = \frac{R_F}{R_I}$$

and the input resistance equals R_I. In this design, R_I is constant and R_F can be selected to give gains of 1, 0·1, 0·01, and 0·001. As the f.s.d. of the meter is 0·1V, we need inputs of 0·1V, 1V, 10V and 100V respectively to obtain this. Now the op amp is not amplifying at all, but attenuating or negatively amplifying.

Now the basic principles of operation of the circuit have been explained, the practical details can be taken into consideration.

The capacitor, C1, between input and output ensures that the meter does not respond to any a.c. signals at the input.

DUAL POWER SUPPLY

The 741 is designed to be used with a dual power supply. This has been simulated here by using R13 and R14 as a potential divider across the battery, giving +4·5V at their junction. This is made the earth, and so we have a ±4·5V supply.

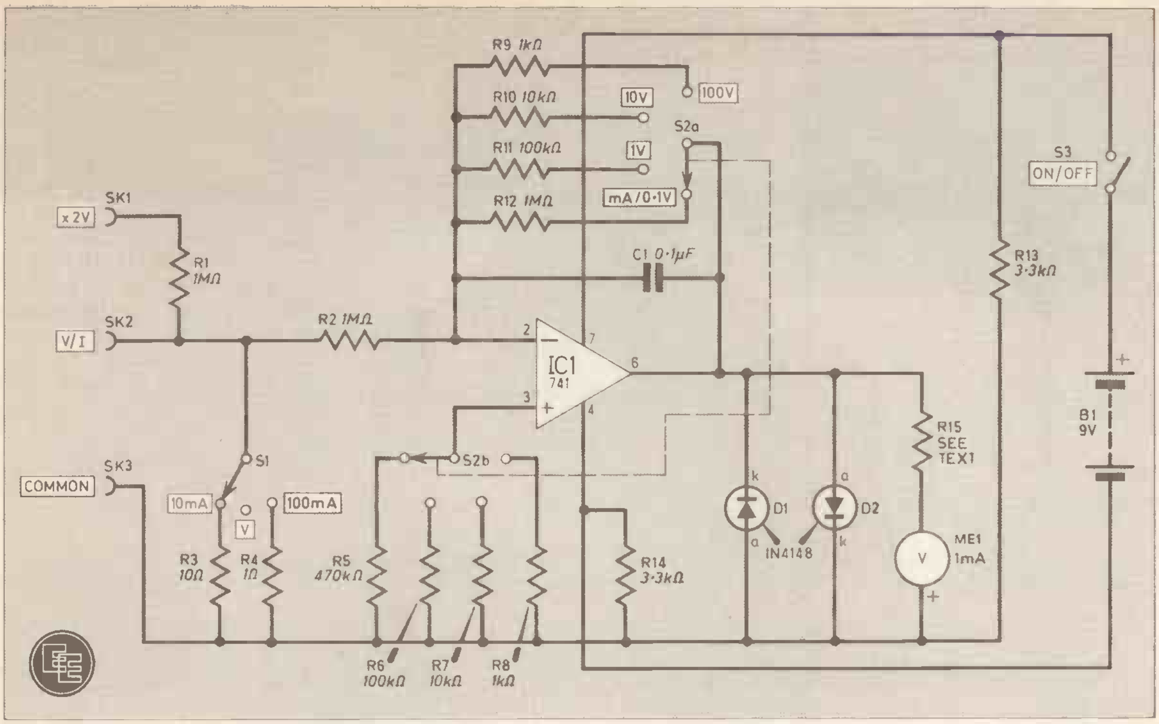


Fig. 1. The complete circuit diagram of the Electronic V/I Meter. Note that for current measurement, S2 must be in the 0·1V position.

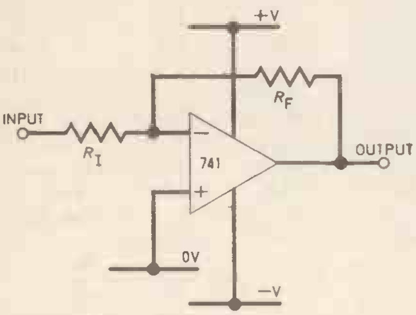


Fig. 2. Theoretical circuit of an op-amp with negative feedback.

In the no input condition, it is arranged for the 741 output to be at earth potential, by earthing the +ve, or non-inverting input. If the other side of the meter is connected to earth, there is no reading. As we are using the inverting input as the +ve probe terminal, the output will fall below earth in response to a d.c. voltage and so the −ve terminal of the meter is connected to the output of IC1, and the +ve terminal to earth.

In practice it is difficult to obtain a zero (with respect to earth) output for no input, due to input bias current and input offset voltage. In this case, input offset voltage has negligible effect because the gain of our circuit is too low to amplify it into a significant output offset voltage.

The effects caused by input bias current are increased as the value of the feedback resistor is increased, which is why the 0·1V range with its 1 megohm feedback resistor is most in need of attention. The effects can be minimised by introducing a resistor between the + (non-inverting) input and earth. Its value is given by:

$$R = \frac{R_I \times R_F}{R_I + R_F}$$

This is catered for in the switch bank of S2b by resistors R5 to R8.

Diode D1 provides some protection to the meter if the voltage being measured is too large for the range selected, and diode D2 provides a similar function in case the input polarity is reversed.

CONSTRUCTION starts here

CASE

The construction should begin with the case, drilling details of which are shown in Fig. 3. The meter can be used as a template for its fixing holes, taking care not to damage it. The case used for the prototype meter was a simple aluminium case with lid, measuring 155 × 80 × 50 mm and any enclosure of similar dimensions can be used.

COMPONENTS

Resistors

R1, 2, 12 1MΩ (3 off)
R3 10Ω
R4 1Ω
R5 470kΩ ±5%
R6 100kΩ ±5%
R7 10kΩ ±5%
R8 1kΩ ±5%
R9 1kΩ
R10 10kΩ
R11 100kΩ
R12 1MΩ
R13, 14 3·3kΩ ±5% (2 off)
R15 See text
All ¼W carbon ±1% unless otherwise stated.

See Shop Talk page 826

Capacitors

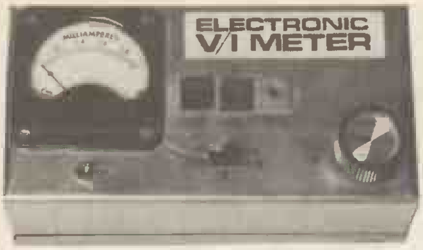
C1 0·1µF polyester

Semiconductors

D1, 2 1N4148 silicon (2 off)
IC1 741 operational amplifier

Miscellaneous

S1 s.p.d.t. centre off slide switch
S2 2-pole, 4-way rotary
S3 s.p.s.t. miniature toggle
ME1 Moving coil meter, 1mA f.s.d. 100Ω coil
B1 9V PP3 battery
SK1 4mm banana socket yellow
SK2 4mm banana socket red
SK3 4mm banana socket black
Aluminium case, 155 × 80 × 50mm; 0·1in. matrix stripboard, 24 strips × 12 holes; battery connector; knob; 8-pin d.i.l. holder; 7/0·2mm wire; solder tags (2 off); probes on 4mm banana plugs (2 off, one red, one black).



COMPONENTS
approximate cost £9 excluding case

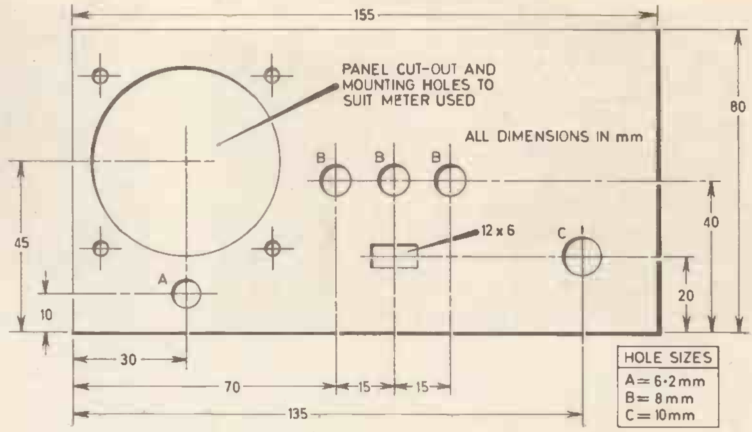


Fig. 3. Panel drilling details for the Electronic V/I Meter. The slot for slide switch S1 may require two additional mounting holes, one at either end.

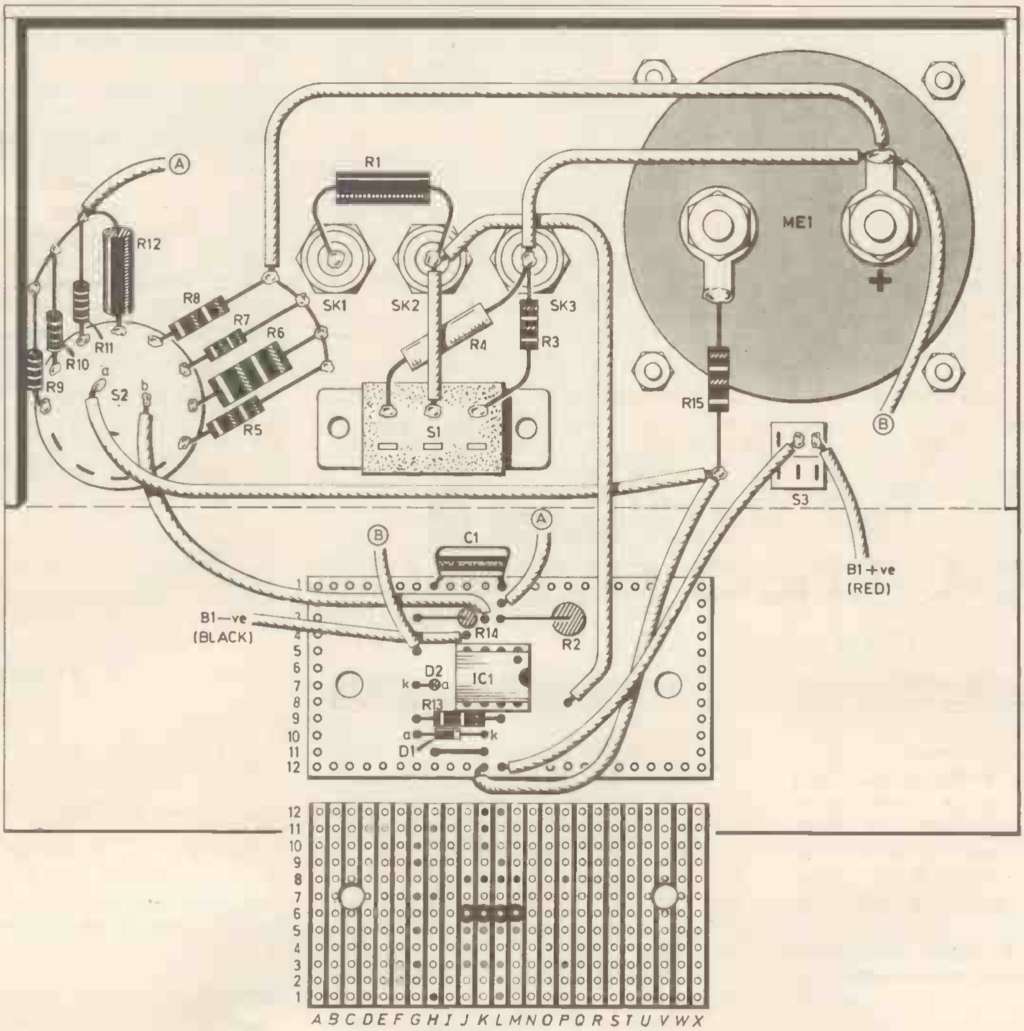
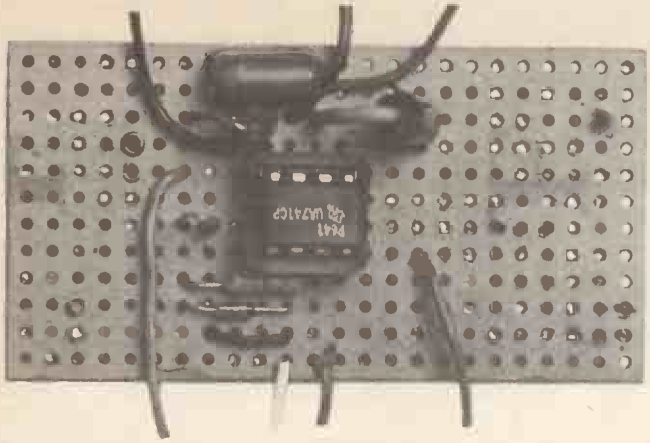
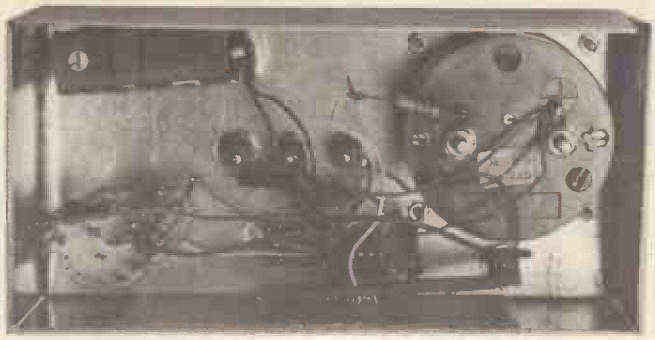


Fig. 4. Wiring diagram and stripboard layout. Many components are mounted directly onto the switches and sockets and this must be done with care to avoid leads shorting on the aluminium case. The finished board assembly is mounted onto one side of the case (shown folded flat for clarity) with short spacers.





The circuit board and wiring of the prototype model.

Fig. 4 shows the layout of components on the circuit board and the breaks on the underside. A piece of 0·1in matrix stripboard is used, size 24 strips by 12 holes. An 8 pin d.i.l. holder is recommended for IC1. When the board assembly is complete, it is fixed to the side of the case and the wiring can be carried out.

When all the case mounted components have been affixed, solder R1 across sockets SK1 and SK2, and R3 and R4 from their respective switch contacts to SK3. Resistors R5 to R12 are mounted directly onto S2.

SETTING UP

There is no calibration as such required. However, it may be necessary to insert a small value resistor (R15) in series with the meter movement to give an f.s.d. of 1V, this being due to meter tolerances. In the prototype, R15 was 10 ohms.

To find the value required insert a 50 ohm preset resistor in series with the meter, select the 10V range and connect the probes to a 9V battery (whose exact value has been measured on a multimeter). Adjust the preset until the reading on the Electronic V/I Meter agrees with this. Remove the preset, measure its resistance and replace it with the nearest value fixed resistor. The meter is now ready to use.

IN USE

To measure voltage, put S1 in its central position (v) and select the range required with S2. With the probes in SK3 (COMMON) and SK2 (V/I), the input resistance will be 1 megohm. If, on the same range, the +ve probe is placed in SK1 (x2V), the input resistance will be 2 megohms and the voltage required for f.s.d. will be doubled. This x2 input cannot be used on the 0·1V range due to input bias current problems because R5 is calculated for a R_i of 1 megohm. For 2 megohms input impedance, it would need to be 666 kilohms, and R5 could be replaced by a 680 kilohm resistor if a 0·2V range is preferred to a 0·1V range.

To measure current, select the 100mA range on S1 and switch S2 to the 0·1V position. Sockets SK2 and SK3 are used for the current measurement probes.

For *all* measurements, always start on the highest range and then switch down as necessary. Diodes D1 and D2 will *never* protect the meter as well as common sense. ⌑

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5 VOLT REGULATED SUPPLY

BY F. G. RAYER

CONSTRUCTION starts here

THIS VERY simple Power Supply Unit provides a 5V output ideal for TTL logic circuit and other small low voltage projects. It eliminates the need for batteries, an important factor since there is no suitable battery generally available for TTL devices.

The component count has been kept low and the construction is straightforward using chassis mounted tag strips.

CIRCUIT DESCRIPTION

The basic circuit diagram is shown in Fig. 1. The mains transformer, T1, has a 9V secondary rated at 0·5A, although a 6V output would be sufficient provided that it was also rated at 0·5A.

The a.c. output from the transformer is full wave rectified by the bridge rectifier D1 to D4 and then smoothed by reservoir capacitor C1. This electrolytic can be any value in the range 1,000 to 2,200μF at 16V.

The regulator i.c., a 5V, 0·5A device provides the stabilised output and is decoupled by C2. The output at the terminal block is duplicated, but it must be remembered that it is *not* dual supply and cannot be used as such, for instance to provide a +ve and −ve 5V supply.

Note that the author has not included a switch in either the mains input or the d.c. output but the constructor can add one if this is thought to be necessary.

CHASSIS PLATE

The general layout of the components is shown in Fig. 2. Please note that the prototype model shown in the photograph was assembled on a flanged chassis plate without a cover. However, as there are potentially lethal mains voltages present on exposed solder tags, it is essential that the project is assembled in a fully enclosed case.

If a metal case is chosen, the point of entry for the mains cable must be protected with a grommet

COMPONENTS

C1	1,000µF to 2,200µF 16V elect, radial lead
C2	0·1µF polyester or polycarbonate
D1-D4	1N4001 silicon diode (4 off)
IC1	LM341P5 or 78M05 5V, 0·5A regulator
T1	mains transformer, 9V or 6V, 0·5A secondary
TB1	4-way terminal strip

Miscellaneous
Tag strip, 3-way and 6-way; grommet (2 off); P-clip; 7/0·2mm interconnecting wire; p.v.c. sleeving; mounting hardware—M2·5 screw (9 off), M2·5 nut (9 off), M2·5 washer (9 off), spacer; 3-core mains cable; 3-pin mains plug with 2A or 3A fuse; case to suit, typically 120 × 60 × 60mm.

Guidance only Approx. cost £4 excluding case
See page 826

and all metalwork *must* be earthed. Remember that if it is an aluminium case protected with an anodised coating (which has the appearance of a dull sheen), the anodising must be scraped away from the earthing point as it acts as an insulator.

MAINS INPUT

A three core mains lead must be used, fitted with a normal three pin plug with a 2A or 3A fuse. The lead is fed through the grommet and securely clamped to the base with a P-clip. The three cores are soldered to a three way tag strip, with the earth core (yellow/green) going to the earthed tag.

The 240V primary of T1 is then connected to the live and neutral tags as shown. The transformer must be fixed to the base plate with two screws and nuts.

The secondary winding of T1 is taken to a six way piece of tag strip onto which the bridge rectifier is assembled with diodes D1 to D4. Capacitor C1, a radial lead electrolytic, is soldered across the tags as shown, taking care with the polarity. Note that the two end tags of the tag strip are the earthed tags and are securely screwed to the chassis.

The 5V regulator, IC1, is fixed directly to the chassis with a nut and screw and a small spacer to clear the plastic body of the component. In this way, IC1 uses the case as a heatsink. The remainder of the wiring is carried out as shown with the output terminating at the four way terminal block, TB1.

Capacitor C2 is added across the output of IC1. Any component leads that could accidentally short out on

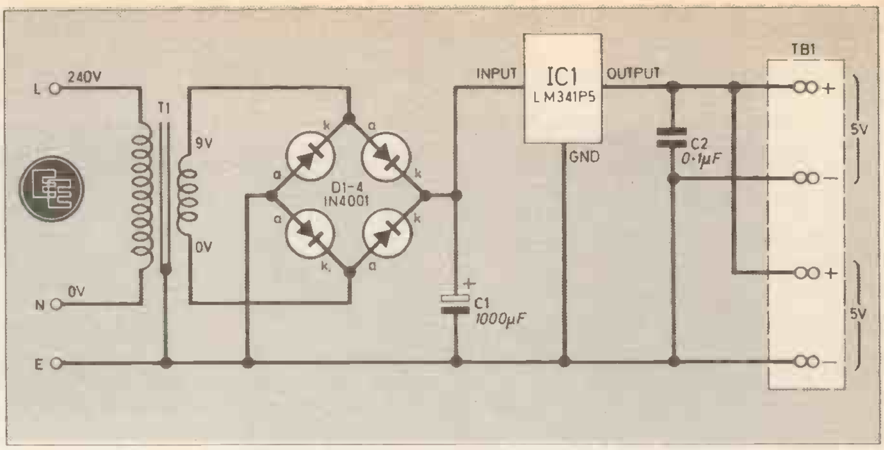


Fig. 1. Circuit diagram of the 5 Volt Regulated Supply. Note that the output is duplicated on TB1.

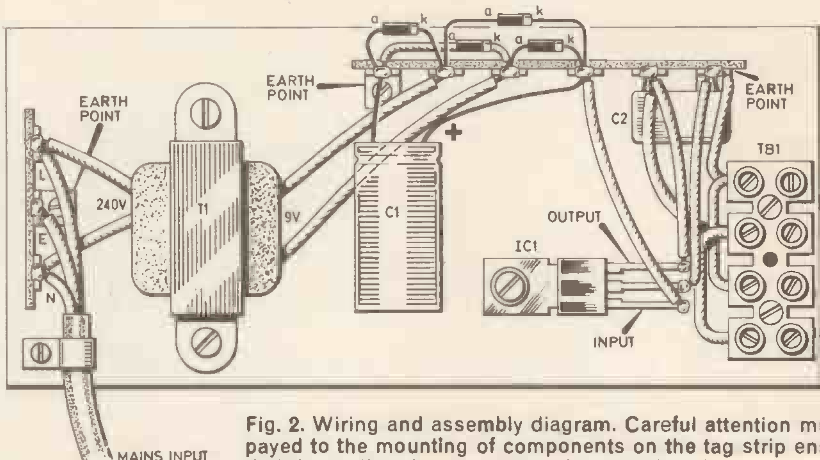
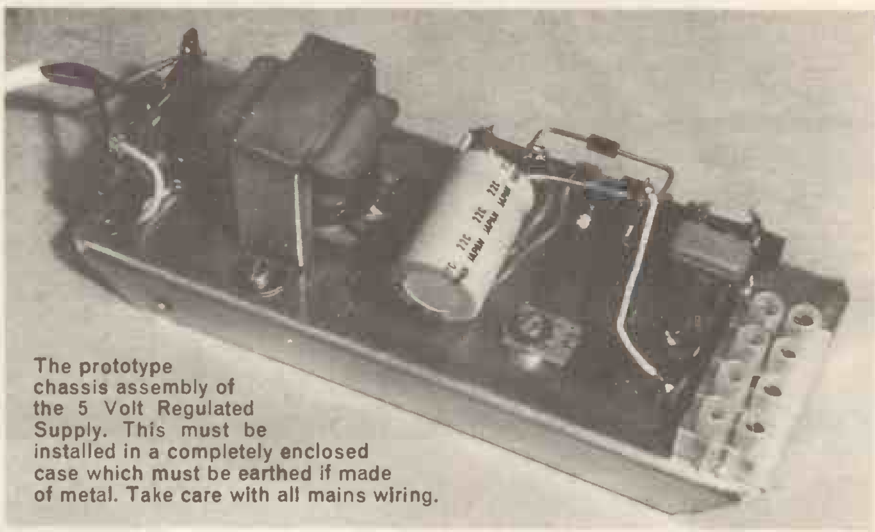


Fig. 2. Wiring and assembly diagram. Careful attention must be payed to the mounting of components on the tag strip ensuring that the earth points are secured to the chassis.



The prototype chassis assembly of the 5 Volt Regulated Supply. This must be installed in a completely enclosed case which must be earthed if made of metal. Take care with all mains wiring.

an adjacent component or tag should be sleeved with p.v.c.

As has been already stated, the 5V Power Supply Unit must be mounted inside a case and the case, chassis, front panel (if fitted), cover and negative terminal are *all* earthed.

It is advisable to mount the terminal block on the outside of the case, and to do this, the output wires must pass through another grommet.

No setting up is required, and after a thorough visual check of all wiring, solder joints and component polarity and orientation, the unit can be replaced into its case and plugged into a mains output—and the output measured with a voltmeter.

Once again, the dangers of working with mains voltages must be stressed and at no point should the mains be connected to this unit whilst the terminal strips are exposed. Do not take chances and if in doubt, seek the guidance of an experienced constructor or electrician.

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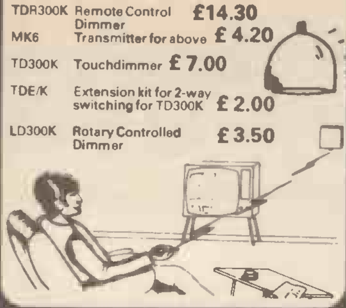

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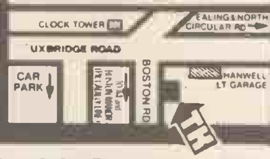

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PART 2—PRACTICAL ASPECTS OF CIRCUIT DESIGN AND PROJECT BUILDING

CIRCUIT DESIGN is a somewhat circular process, which is best learned by doing it rather than by reading about how to do it. You can however gain an insight into the process by reading through the descriptions of how the projects published in magazines work.

The other attributes needed are patience and a basic ability, aided if necessary by a suitable calculator, to manipulate the basic electronics formulae.

THE CIRCUIT

Ideally the circuit should be drawn so that the action of the circuit (input to output, cause to effect) progresses from left to right across the diagram.

Some of the component values will be dictated by the device data or input/output conditions. Other component values will require the use of standard formulae like Ohm's law. When using formulae it is important to remember the standard units of the various components and where they differ from those used in the formulae (such as capacitance which is expresed in Farads (F) whilst we work in microfarads which are $F \times 10^{-6}$.

POWER SUPPLY RAILS

A useful starting point is to set a suitable voltage for the power supply rails since this will dictate a number of the resistor values.

When working with time delay or oscillator circuits and some other types of circuits the formulae will require you to select two or more component values (usually a resistance and a capacitance). When faced with this dilemma it is best to start by selecting an economic value for the capacitor and then applying the formulae to set the resistor values.

Some new circuit designers may become alarmed when they find that the calculated values for resistors are not readily available. This is because resistors are manufactured only in a range of standard values. For most purposes the actual value of the resistance is not over critical and there will be one of the standard values within 10 per cent of the required value which will be adequate.

In the event of your having to substitute a different value it will be necessary to consider the effect of increasing or decreasing the value on the action of the circuit and to choose the correct course.

FIXED AND VARIABLE RESISTORS

If the value of the resistance is critical the problem can be overcome by using one or two fixed value resistors in series with a suitable variable resistor. The values should be chosen so that the total resistance can be adjusted over a range between about 90 per cent and 110 per cent of the calculated value. The variable resistor can then be adjusted when testing out to give the required effect.

This will generally allow for variations in component values including those of associated components such as capacitors which can vary as much as 50 per cent to 200 per cent of the stated value.

Once the design has been completed and the component values calculated the whole lot should be checked over to make sure that there are no omissions. It is particularly important to check that *all* the pins of any integrated circuits used are connected to the correct points in the circuit including connecting any unused inputs of logic circuits to the correct power rail.

PROTOTYPE CONSTRUCTION

The circuit should be tested out on a prototype board to check that it functions as you intended that it should. If any problems arise it is easy to alter the design by changing the connections or component values on the prototype board, but this will not be so easy when the circuit is made up in a more permanent form.

How you need to approach the final construction of your project will depend on the nature of your circuit and how it is to be housed. If your circuit consists of solely panel mounted components linked together with wires, then the most convenient method of construction is to simply mount the components on the panel in the appropriate places and link them together with wires.

It will be a great help when testing out the system if the wiring is done with wires of different colours. If the wiring is laid out with care taking the trouble to group the cables together, except where this might cause hum or other interference, they can be laced together neatly after the unit has been tested.

P.C.B. OR STRIPBOARD

If your circuit incorporates a number of small components, these can be mounted either on a printed circuit board or on stripboard. In general the more simple types of project lend themselves to being constructed on stripboard whilst the more complex circuits are best made up onto printed circuit boards, providing that you have access to the necessary materials and tools.

If either of these two methods of construction is used, it will be necessary to literally sit down with pencil and paper to work out how to arrange the components and connections on the boards. If you can obtain a supply of one-tenth inch graph paper this will be a great help since most components are constructed to fit on such a matrix.

Once the p.c.b. design has been finished it can be transferred to the board and the board etched and drilled as normal. After preparation the board can have the components inserted starting with the smallest components.

MOUNTING COMPONENTS

At this stage *all* the integrated circuits should be catered for by providing sockets into which the i.c.s will be inserted later. This will greatly ease any subsequent fault finding.

Care must be taken to ensure that all polarity sensitive components are correctly oriented since some spectacular faults, such as capacitors exploding, can occur if errors are made in the polarity.

It is also important to ensure that the soldered joints are all correctly made without their failing to make contact or shorting out adjacent tracks. The most common reasons for projects failing to work are associated with poor soldering.

If the circuit uses a mains driven power supply, it is advisable to check that it is in fact producing the correct output voltage before connecting it to the rest of the circuit. After giving the board a final check over, with the aid of a magnifying glass if necessary, the integrated circuits can be inserted and the unit switched on.

TESTING AND FAULT FINDING

Fault finding is a skill that is improved by practice but there are certain approaches which are valid for most types of project.

If, on switching on, the unit is completely dead it is advisable to check that the required voltage is available across the power supply connections. If this voltage is not present when the power supply is connected to the unit but is produced by the power supply when disconnected then the fault is likely to be caused by a short circuit occurring across the power rails. This might be a faulty connection, faulty component or incorrectly polarised component.

If the correct voltage occurs at the power supply rails, it will be necessary to work steadily through the circuit, preferably from the input to the output, checking with suitable test instruments to see where the circuitry fails to work as it should. This process is aided by fitting the i.c.s into sockets since they can easily be removed and replaced as the testing proceeds.

When the point at which the circuit fails to work is detected it is necessary to think carefully as to what might cause the symptoms to appear.

Before looking for more complex causes it is worthwhile giving the board a close inspection, with the aid of a magnifying glass, to check for board faults such as broken or short circuited tracks. If short circuits are found these can be cut out with a modelling knife. Broken tracks can be repaired by soldering wire connections across the breaks and incorrect tracks can be cut off and the correct connections made with insulated wire soldered to the ends of the tracks.

PACKAGING THE PROJECT

Whilst a beautifully presented but non-working project will not impress an examiner a well presented and correctly functioning unit is bound to impress. It will also be less likely to fail at a critical time than the ball of string assembly that is sometimes presented to examiners.

Ideally your project should look like the sort of thing that you could buy in a shop. Although you are probably not going to be able to produce a specially moulded case just for your project, there is no reason why it cannot be mounted either in one of the cases which can be bought from electronics shops or in a good home made case.

Lettering can be applied to the case by using rub-down lettering protected by several layers of spray-on clear lacquer.

WRITING THE REPORT

If your project is for an examination, it will be necessary to write a comprehensive report describing the design and the construction. This report will be used by the examiner as part of the marking operation and is also used at later stages of the process to check that the marks given by all examiners are consistent.

For this reason the report must give details of all the stages of the project. You must include your specification, details of the alternative solutions considered, details of how the unit was constructed and tested. You will need to be honest about any faults you found since the examiner will expect that you will have had to spend some time finding faults.

If you were lucky enough not to have had any problems when testing out the unit you must say so since this omission could lose you marks.

You must also include a complete circuit diagram and a detailed description of how it works. Here you would be well advised to read the appropriate sections of any of the projects described in this magazine to see the right approach.

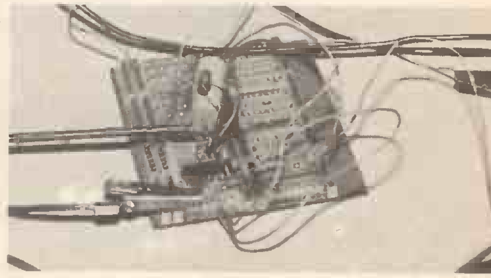
You should also include photographs of your project which should be as clear as possible. It is well worth taking the trouble to present both your project and the report as neatly and professionally as possible since this shows that you are proud of what you have achieved.

DEMONSTRATING

The final hurdle is that you will be expected to give the examiner, who will probably be a teacher of some sort, a demonstration of your project. You need not fear this part of the process since the examiner will almost certainly be a fellow enthusiast and he or she will certainly be interested to hear what you have to say about YOUR INVENTION. You should actually enjoy telling about your work and showing someone else how it works. ☒

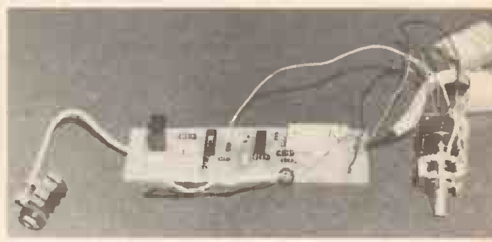
The photos show a pupil of the authors working on her project.

Susan Whitley of Finningley checks out her prototype Guitar Tuning Aid.



Testing the "breadboard" circuit prior to designing a printed circuit board.

Etching the printed circuit board.



Board ready for insertion into case.

Applying "rub-down" lettering to case.

The completed tuning aid which won Susan the Individual project prize in the Yorkshire Regional Final of the "Young Engineer for Britain 1981".

By BARRY FOX

Advertorial

I've always had an aversion to "advertorial". That's an article which is sponsored by a manufacturer or retailer for advertising purposes.

Sometimes advertorial is blatant; a page of puff for a new product dressed up to look like an independent appraisal. The manufacturer pays for the page to be published and the magazine preserves its integrity by publishing a note at the top which identifies the page as advertising. A more subtle kind of advertorial is a puff article on a firm and its products which a journalist manages to sell to a magazine as editorial copy.

Some Japanese firms have been very successful at this. They take a tame journalist with good connections in Fleet Street to Japan, show him (seldom her) all kinds of exciting new gadgets and impressive factories, provide extravagant entertainment and then wait confidently for a predictably sycophantic piece to appear in print.

In this respect the European electronics press is often a bit of a disappointment to the Japanese. They are duly impressed by what they are shown, because it's always truly impressive, but have a nasty habit of asking awkward questions and writing objectively. That's why some Japanese firms don't waste their time on the European electronics press!

Booklets

For obvious reasons, advertorial material often isn't worth reading. This is why many journalists won't write it. Perhaps this is also why there has been a trend over recent years towards a new kind of advertorial, that isn't really advertorial at all. It's a free booklet, that's sponsored by an advertiser.

The booklet contains hard technical facts written subjectively, with advertising puff for the sponsoring firm kept clearly separate. As publications of this type are free, and contain useful information, they can be well worth watching out for when you visit exhibitions or specialist shops.

Watch out, for instance, for the Sennheiser brochures. These contain much more than a list of Sennheiser microphones and headphones; they also contain some very useful general information on microphone and headphone technology. Kef, one of the most successful British loudspeaker manufacturers, produces a series of technical bulletins, called Kef Topics. You can learn a great deal about loudspeaker technology from these.

The tape manufacturer, 3M, has produced some good information sheets, called Pulse, on audio and video tape technology. British Telecom have some useful publications on a wide range of telecommunication topics.

Bang and Olufsen in Denmark has published a series of White Papers on tape and gramophone design philosophy and technology. Although the emphasis is heavily on B and O products, there is still a good deal of background information to be gleaned.

The First

One of the first firms to put out a booklet of general information on the whole topic of hi fi, with the company's products referred to only as specific examples, was Pioneer of Japan. It's nearly ten years now since the Pioneer HIFi Handbook "an introduction to the terms and technology of serious sound reproduction" was published.

Although it contained silly errors (like a discussion of tuner specifications under the heading for turntables) it was a brave effort, and good for the company's image. Unfortunately I haven't heard a squeek from Pioneer for nearly two years now.

Almost the same fate has befallen another Japanese company, Teac. Five years ago Teac published two very good free booklets. These explained the technology and techniques of multi-track recording, with special reference to their home four- or eight-track systems.

But Teac has also been hiding its light under a bushel recently. In fact domestic Teac multitrack recording equipment is now being seriously challenged by Fostex, a new Japanese firm started by ex-Teac engineers.

Fostex multi-track equipment is handled in Britain by Turnkey, of New Barnet, Herts. The Turnkey mail order catalogue advertises a whole range of electronic gadgetry, and has a lot of useful technical information in lay terms, for instance on cables, noise gates, signal processing and special effects like echo.

The Microcomputer Boom

The Laskys "Buyers Guide" contains a very good description by Guy Kewney of how the home microcomputer boom got underway. It's something I've watched with jaundiced interest, because it's exactly like the hi fi boom of a decade ago, and the video boom which began in the late 70's and is still continuing.

In each case the people selling high technology equipment often know as little about it as the first time buyer. Their only advantage over the customer is a vocabulary of buzz words that cow the unfortunate newcomer into puzzled submission.

There are, of course, some genuinely knowledgeable dealers who really know their subject. But often they can't express themselves in plain English.

Computer Hobbyists

The computer market is still booming and buoyant because there are still enough latent hobbyists around to support sales of "Heath Robinson" hardware, with instruction manuals which are as thick as an encyclopaedia and as readable as a telephone directory. But both here and in America there is a largely untapped reservoir of people who have neither the time nor the inclination to start another hobby, especially a hobby as demanding as computer technology.

What I, and many other people want, is a memory bank and word processing system, that will make my business life easier. Unfortunately, it's taking a very long time for this message to get through to the people who are making and selling computer systems.

Frightening Choice

I know of a weekly magazine in London which recently asked a string of large, and small, computer firms to tender for the supply of a word processing and data storage system for the magazine office. The ignorance and incompetence of many of the firms was frightening. Some of them didn't even know enough about their product to be able to put in a coherent tender.

An American journalist told me how he'd been sold a word processor, and immediately been confronted with an utterly incomprehensible manual. I know of two British journalists who have bought expensive microcomputer systems, but not found the time to learn how to program them.

Even if a businessman gets a sound system, and a manual clear enough to let him get it working, there's still the problem of getting the system to do exactly the job it was bought for.

A businessman with no knowledge of computer programs will be completely stymied. As sure as night follows day, someone then says it's the wrong system for the job and the only solution is to start again!

No wonder so many small businesses are doing as I am now doing, and that's hanging on until the computer market has shaken down. I'm waiting until it's as easy to buy, use and maintain a computer system as it is to buy, use and maintain any other electronic leisure or labour-saving device.

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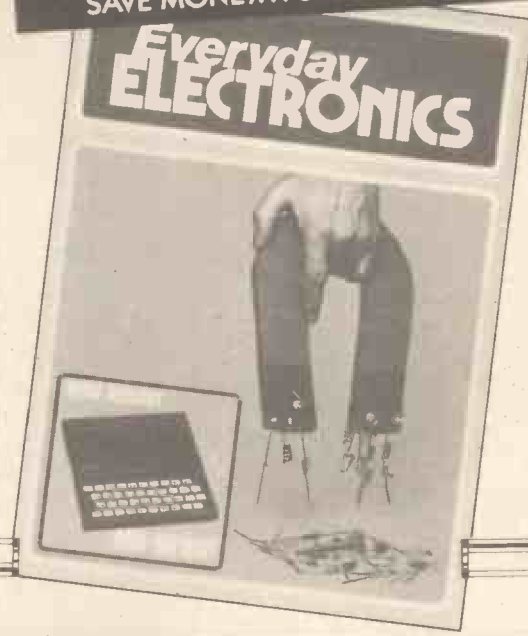

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RADIO WORLD

By Pat Hawker, G3VA

Racalex 82

Radio communications equipments are tending to become ever more complex and more dependent upon advanced technology. The recent exhibition and symposium of the Racal Group of companies underlined this with its impressive assortment of military communications systems and those appendices that threaten to become ever more important.

This includes ECM or electronic counter measures which basically means jamming enemy systems, ECCM or electronic counter-counter measures which involves making your system able to defeat the enemy's ECM; and ESM or electronic support measures than can include the most sophisticated techniques for surveillance, analysis of incoming signals and much else besides.

The search to make communications reliable and secure while denying such facilities to the enemy is reflected in the emphasis placed on digital encryption of speech and telegraph traffic. A further aim is often to conceal the very existence of radio traffic—a classic form of cryptography or more correctly "steganography".

One approach to this is the use of frequency-hopping techniques in the crowded h.f. band using s.s.b. rather than f.m. type signals. It is then very difficult indeed to detect the signals even with a spectrum analyser.

Yet *Racalex 82* provided evidence that the oldest mode of radio communication, manual morse transmission, still has a valuable role. Racal for instance were showing a new morse code training system for classroom use—but it was talking to Lady Virginia Fiennes that provided the most convincing proof.

Transglobe communications

Lady Virginia Fiennes was the base radio operator for the three-year *Transglobe* expedition during which her husband, Sir Ralph Fiennes, and co-explorer Charles Burton successfully completed the first ever circumnavigation of the globe following mostly the Greenwich Meridian and travelling via both South and North Poles.

When the party sailed from Greenwich in September 1979 they carried some £200,000 of modern radio equipment loaned by Racal Electronics. As communications chief, Lady Fiennes, had two main radio tasks. To keep in touch from a series of base camps, including eight lonely months in a reinforced cardboard hut in the Arctic, with the explorers. Also, to keep in touch with Cove Radio at the Royal Aircraft Establishment, Farnborough, Hampshire or the Portishead Radio long-distance coast station.

Using 400-watt and 1kW h.f. single-side equipment she usually spoke directly to the high-power UK stations. But in the extremely difficult radio propagation conditions for which the Arctic and Antarctic are noted (including severe polar cap absorption and multipath conditions that make even strong signals difficult to copy) the links with the explorers, who were using man-pack type equipment, was often a matter of finding that slow morse will get through when other modes find the going altogether too tough.

Portable power

With portable equipment the main problem, particularly in extremely cold climates, tends to be keeping the batteries charged and in good shape. While petrol-electric generators can be carried in vehicles, for truly portable operation it comes down to a question of batteries and/or hand generators—and neither of these sources of power are exactly lightweight. There is increasing interest in high-energy lithium batteries for such applications.

Unique experience

I asked Lady Fiennes whether she was writing a detailed account of the Transglobe radio communications. She admitted that she had been asked to do this but seemed rather diffident in that her experiences as a radio operator did not mean that she regarded herself as a communications expert.

Personally, I hope she is persuaded to provide us all with a detailed account of this unique experience. Radio operators often provide a more valuable report of the problems—and suggestions on how they can be overcome—than the engineers and the radio propagation experts who so often wish to justify their designs.

I recall, some 35 years ago, reading a long typescript report of the radio communications of the original *Kon-Tiki* expedition. The operator was a former Norwegian Resistance clandestine operator and the most successful equipment carried on the raft proved to be the wartime "B2" suitcase set.

Unfortunately, so far as I know, this report was never published, presumably because publishers felt there was little demand for such semi-technical information. Yet it was a fascinating account of the practical problems of communicating from a small balsa-wood raft in the middle of the Pacific Ocean.

Exit v.h.f. television?

The interim report of the Merriman Committee recommends that the British 405-line v.h.f. television on Bands I and III should end in 1984 rather than 1986 and that no further television broadcasting should be permitted on these bands.

While this recommendation will not surprise many people it does seem remarkable that only in the UK will viewers lose what are in every other country the prime television bands. It would have been very much easier and cheaper to have put new 625-line channels on v.h.f. than to develop cable or direct satellite broadcasting.

In the end it is the viewer who pays.

Top speed

In the January 1982 *Radio World* I referred to the claim in the "Guiness Book of World Records" that the highest known speed of sending on a purely manual morse key was the 35 words per minute (w.p.m.) clocked up by Harry Turner, W9YZE in 1942. This has resulted in a most interesting letter from Tom Laidler of Glandore, South Australia, who has been VK5TL since 1937 and who was trained as a Post Office telegraph operator in 1918 by a Mr. Thomas Morris.

Although no written records exist, Mr. Morris once told Tom Laidler that he had been able to get his sending up to 39 w.p.m. and "that it took a lot of hard practice to get the extra five characters in to make it 40 w.p.m." The date when this happened is unknown but the claim rings true as many Post Office operators reached high speeds in the days before the development of the teleprinter.

Still an active morse enthusiast at the age of 78 years, Tom uses a home-built key he made in 1938 based on the wooden patterns for a standard Post Office type key, but for which he then had several bits cast in a brass foundry. He also owns one of the rare "three paddle Automorse" key designed by a Mr. N. P. O. Thomas, also of the Australian Post Office, about 1922 that makes both dots and dashes automatically.

In the years before the development of electronic keyers some extremely ingenious mechanical keys were developed and marketed in a number of countries. The automorse key was sold for £5, which at the time was more than a week's pay for a telegraphist. Even today, as my earlier story shows, manual morse is far from obsolete.

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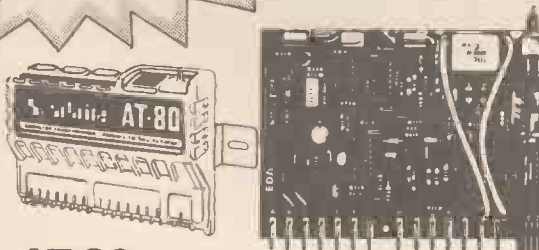

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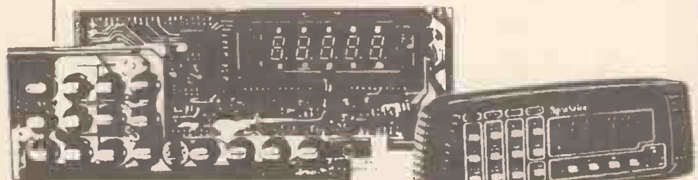

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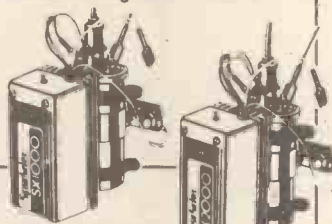

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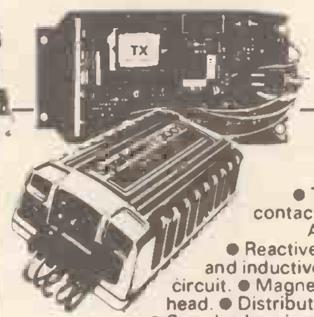

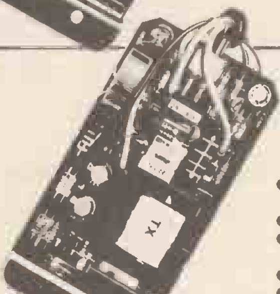

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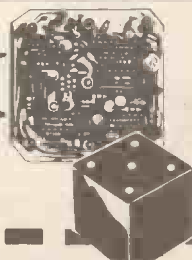

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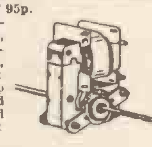

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SQUARE ONE FOR BEGINNERS

HAVING studied the fixed value resistor earlier this year, this month's *Square One* will take a look at the **variable resistor** or **potentiometer**. The resistance value of a variable resistor is measured in ohms, but by means of rotating a shaft or slot on the component, this value can be varied between zero and the predetermined maximum resistance.

Potentiometers (or "pots" as they are sometimes known) are three terminal devices, one terminal at each end of the resistive track and a third terminal on the wiper. This is the terminal that "wipes" along the resistive track and so varies the resistance at the wiper.

The circuit symbols are shown in Fig. 1. There are two main types of variable resistor, the **control potentiometer** and the **preset potentiometer** and as can be seen, the symbol differs for each in the way the wiper is represented.

CONTROL POTENTIOMETERS

The control potentiometer is the type used for volume controls on amplifiers and in other situations where frequent adjustment is required. The adjustments are made by means of a knob attached to the rotating shaft on the component, and the full range of adjustment is made through three-quarters of a turn of the shaft.

Also available are **dual ganged** (or tandem) potentiometers, this type having two variable resistors mechanically linked on one spindle. The most obvious application for tandem pots is controls for stereo equipment, whereby both channels can be simultaneously adjusted with one control knob.

A further type of control potentiometer is the **slide pot**, where the resistive track is produced lengthways and the wiper "slides" along it thus varying the resistance. These are most commonly found on graphic equalisers and mixer units and are generally available as both single or dual ganged types.

PRESET POTENTIOMETERS

The preset potentiometer is for the situation where, once set, the value will be left. They are not intended for continuous adjustment. The main use of the preset is therefore in the setting up and calibration of electronic equipment.

A whole range of types and sizes of preset are available, including precision multiturn trimmers (trimmer being another name for a preset) which require anything up to 25 full rotations for the wiper to go from one end of the resistive track to the other, facilitating very accurate settings.

Among the other types are skeleton presets of which there are two sizes, miniature and standard, and both of these can be supplied as either horizontally mounted or vertically mounted components. Almost all preset resistors are intended for direct mounting into a printed circuit board compared to the control potentiometers which are designed for mounting onto a front panel, by means of a threaded bush and nut.

Adjustment of preset potentiometers is usually by a screwdriver slot although some types do have a small integral knob which can also double as an enclosure for the component.

MATERIALS

A number of different materials are used for the resistive tracks of both types of potentiometer. Small presets usually have a carbon or cermet (a conductive plastic) resistive track, the cermet type being of higher quality and more durable.

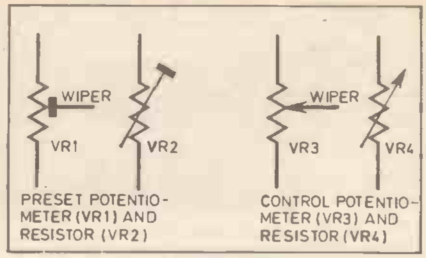

Fig. 1. Circuit symbols of variable resistors. Note that where the wiper is drawn as a diagonal stroke through the symbol, the component is a two terminal device and adjustment simply varies the resistance between the two terminals.

The multiturn trimmers are of a wirewound construction as are the higher power control potentiometers.

The dual ganged, slider and standard control potentiometers have carbon tracks with the higher quality versions again having the cermet track.

Further to all the different types of variable resistor so far discussed, there is an additional two categories into which they will all fall; that is **linear track** or **logarithmic track**. The linear type, abbreviated to *lin*, has a varying resistance which responds linearly with the rotation of the wiper and includes all wirewound and most carbon or cermet potentiometers.

However, the logarithmic response, abbreviated to *log*, has a larger proportion of the resistance at one end of the track, so rotation of the wiper at this end of the track causes a greater variation in resistance than at the other end. Log tracks are available on most carbon control potentiometers.

A selection of variable resistors. Clockwise, from bottom left corner: a wirewound control pot; a carbon control pot with integral switch; a dual ganged control pot; three different sizes of control pot. In the foreground, a selection of preset potentiometers including a multi-turn in the bottom right, and finally a cermet control potentiometer.

By Dave Barrington

Heating Controller

Now that the winter months and cold weather are about to hit us, readers may be interested in a new controller unit from Vellerman (UK).

The Vellerman Heating Controller Kit, K2583, is designed to control the temperatures inside buildings enabling central heating systems (oil, gas, electricity) to work more economically and therefore save energy.

The unit is claimed to replace conventional thermometer units and provides four programmes daily controlling the temperature at any given period. These programmes are totally independent and therefore it is possible to select day and night temperatures separately.

The digital display readout also functions as a clock as well as a thermometer. It is also possible to control the unit manually without disturbing any of the pre-selected programmes.

It is claimed that savings are obtained by a more accurate measuring of time and temperature and precise on and off switching, eliminating mechanical tolerances.

The K2583 Heating Controller is available in kit form for £75 plus VAT or as a ready built and tested unit for £98·90. More details and specification can be obtained from Vellerman (UK) Ltd., Dept EE, P.O. Box 30, St. Leonards-on-Sea, East Sussex TN37 7NL.

Combination Lock

Readers who are constructing the *Combination Lock*, published in our November issue, and looking for a suitable latching mechanism for this project may care to investigate the device from TK Electronics.

This electrically operated latch mechanism, stock No. 701 150, is specified for use on 12V a.c. However, we understand that it will work reliably from a 9V d.c. source. Also, it is claimed, it may be used with any existing Yale or Chubb type lock, replacing the catch or "box" that normally mounts on the door frame.

A 20-page booklet on Remote Control kits is also available from TK and contains circuits for remote switching of lights, television and model control. The booklet cost 30p plus a stamped addressed envelope.

End of an Era

Finally, on a sad note before we discuss the problems of component buying we must report the demise of Home Radio.

With Sir Freddie Laker's Airways plummeting to earth with a loss of £230 million, and now old history, it is unlikely that the disappearance of Home Radio (Components) Ltd., caused a tremor in the City.

Even so, it is sad to relate that a firm that had been going for over thirty years, and much appreciated by the amateur constructor, has had to close. There may not be a single answer as to the cause, but rising costs and diminishing sales, the result of the recession, were probably major factors.

The Managing Director, Alan Sproxton, said that in his opinion the enthusiasm of the amateur constructor was as great as ever, with numbers still growing, but many had not the money to spare for their hobbies. He also said that at one time Home Radio received large orders from schools, colleges, and training centres, but during recent years the orders had dropped drastically.

Home Radio will chiefly be remembered for the large well illustrated catalogue which was produced at yearly intervals. The first, printed in 1959, set a trend and standards that have been copied ever since.

On a personal note, I should like to thank Alan Sproxton for all the help that he has given whenever we have been searching for elusive components. Readers will never know the amount of research and time Alan has spent on their behalf. We hope, in fact we are sure, that Alan will always make available to us his vast knowledge of the components industry.

The K2583 Heating Controller from Vellerman.

CONSTRUCTIONAL PROJECTS

Security Vari-Light

Although identically rated components are available for the *Security Vari-Light*, they may not be compatible with the printed circuit board and could cause purchasing problems.

The mains relay RLA used in our model is the Maplin 5A Mains Relay, stock No. YX98G. If an alternative relay is used it may prove necessary to connect it to the logic board by means of suitably rated flying leads. The coil resistance should be about 100 ohms minimum.

The 9 to 12V reed relay RLB used in the prototype was the Maplin FX51F. An alternative is the Electrovalue encapsulated relay type LPS12, but this is *not* pin-compatible.

Only one of the secondary windings of the mains transformer are used, but a transformer with a single secondary winding could be substituted here. Although the twin winding version is rated at 9V 500mA, it is quite in order to use a mains transformer with the secondary rated at 9V 250mA.

It should be pointed out that the twin secondary winding version seems to be a more popular item amongst our advertisers.

The mains transient suppressor, Z250D, and the contact suppressor are available from Maplin and should be ordered as: HW13P (Mains Trans Supp) and YR90X (R-C Network).

The R-C or "snubber" network X1 consists of a resistor and capacitor connected in series across the relay contacts and is used as a contact interference suppressor, when switching reactive loads, for RLA1.

The mains transient suppressor RV1 is used to dissipate any "spikes" on the power supply line when the peak level of the mains is exceeded.

The suppressor components are not absolutely necessary but, particularly in view of the mains supply variations and fluctuations in some areas, it is probably wise to adhere to the design.

5 Volt Regulated Supply

The components list for the *5 Volt Regulated Supply* calls for a LM341P5 5V regulator. Any 5V 500mA positive regulator may be used here, but check that the pinning details are the same. The 78M05 regulator seems to be more readily available from advertisers.

The transformer used in this power supply can be practically any type rated at 240V primary and 9V 500mA secondary.

The final choice and size of case will be determined by the physical size of the mains transformer used.

Car Indicator Alarm

The relay for the *Car Indicator Alarm* can be any 185 ohm coil type with at least one set of normally closed contacts. In fact, any relay with a coil resistance down to about 110 ohms, with suitable contacts, may be used.

Electronic V/I Meter

A suitable meter for the *Electronic V/I Meter* is available from Ambit, Electrovalue, Greenweld or Magenta Electronics.

Extra Ram

The 6116, 2K × 8 bit RAM, called for in the *Extra Ram for the Sinclair ZX81* project should be readily available from most semiconductor suppliers, but in case of difficulty it is listed by Ambit and Cricklewood Electronics.

This article is a modification to the *2K Ram Pack* published in our April 1982 issue. The printed circuit board for the original design is available from Proto Design, Dept EE, 14 Downham Road, Ramsden Heath, Billericay, Essex CM11 1PU, price £2·21 (including VAT and p/p).

Velocity Measurer

The ultrasonic transducers for the *Velocity Measurer* are sold in pairs and we suggest readers purchase the type terminated with pins rather than phono sockets.

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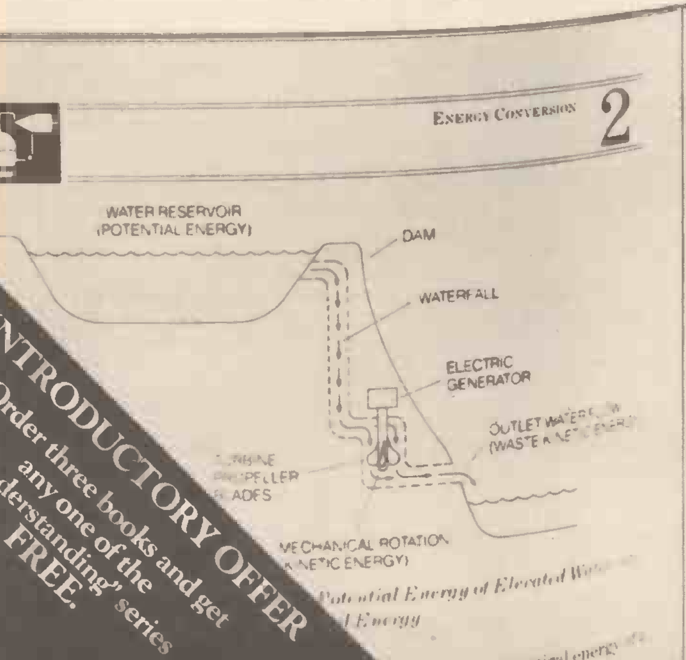

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Your ZX Spectrum comes with a mains adaptor and all the necessary leads to connect to most cassette recorders and TVs (colour or black and white).

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- Sinclair 16K extended BASIC–incorporating unique 'one-touch' keyword entry, syntax check, and report codes.

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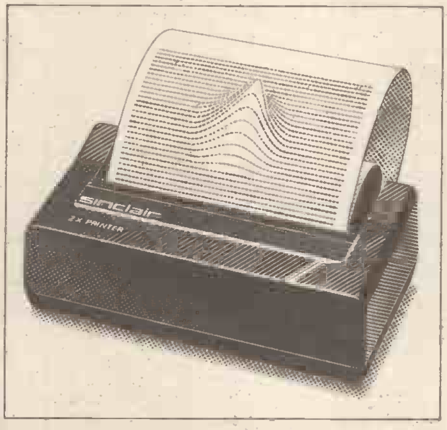
The ZX Printer – available now

Designed exclusively for use with the Sinclair ZX range of computers, the printer offers ZX Spectrum owners the full ASCII character set – including lower-case characters and high-resolution graphics.

A special feature is COPY which prints out exactly what is on the whole TV screen without the need for further instructions. Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your ZX Spectrum. A roll of paper (65ft long and 4in wide) is supplied, along with full instructions. Further supplies of paper are available in packs of five rolls.



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The new Microdrives, designed especially for the ZX Spectrum, are set to change the face of personal computing.

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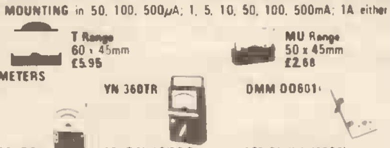

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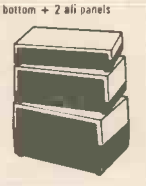

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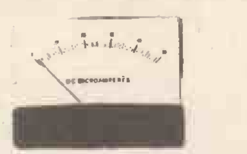

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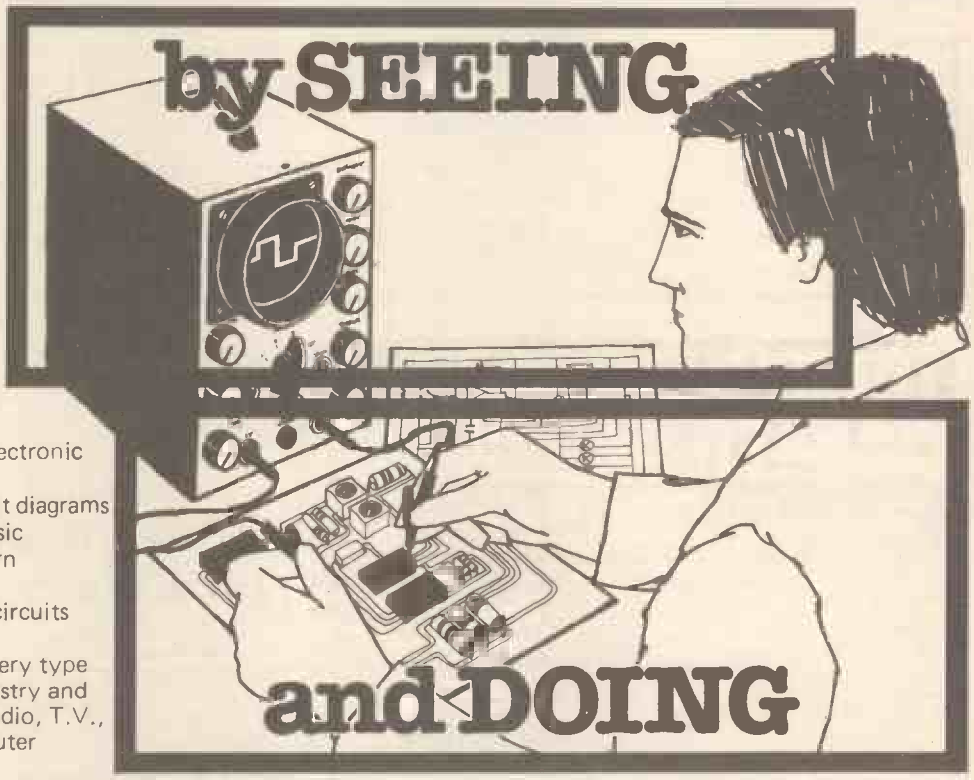

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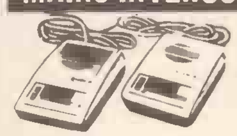

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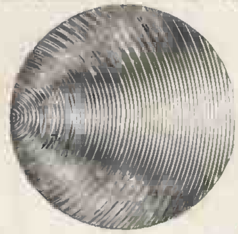

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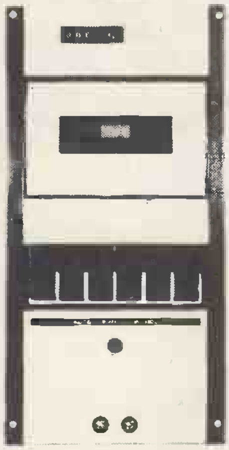

6 piano type keys

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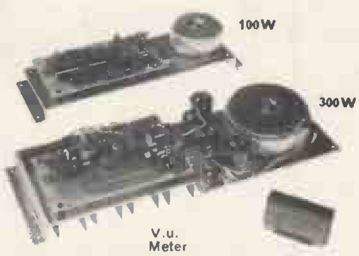

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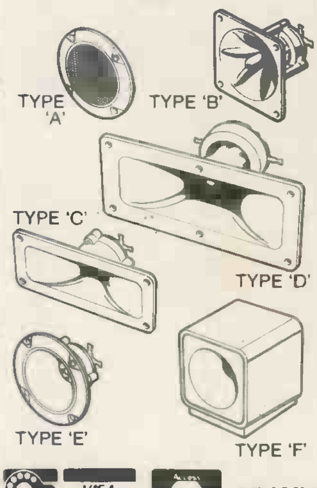

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