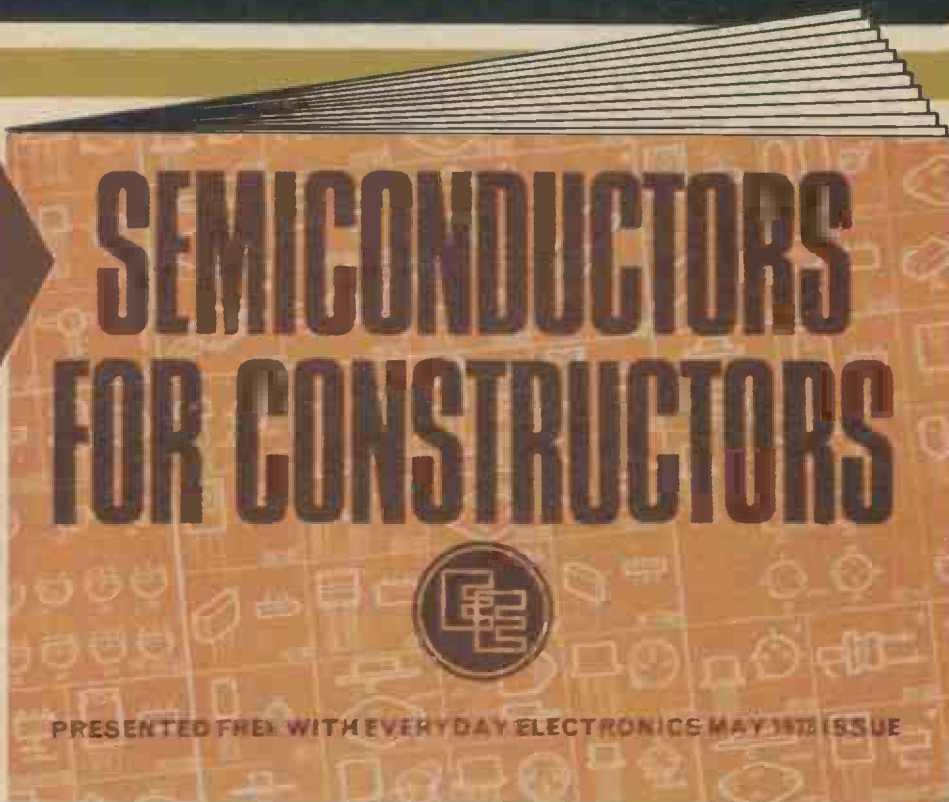
Easy to build projects for everyone

Everyday ELECTRONICS

MAY 78
40p

FREE
24 PAGE BOOKLET


SEMICONDUCTORS FOR CONSTRUCTORS

PRESENTED FREE WITH EVERYDAY ELECTRONICS MAY 1978 ISSUE

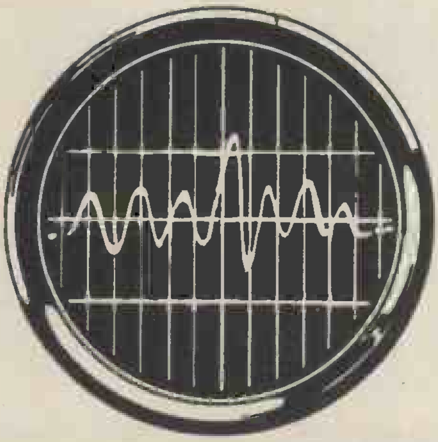
E E TELEPLAY STUNT CYCLE

IT'S THE LATEST!

MAINS TESTER

LOOK! Here's how you master electronics.

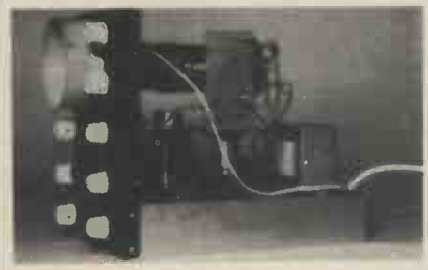
....the practical way.

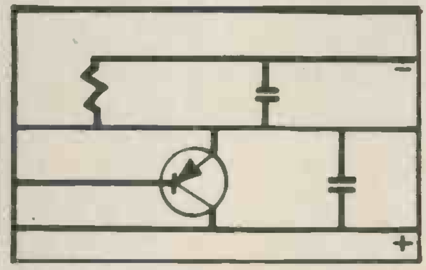


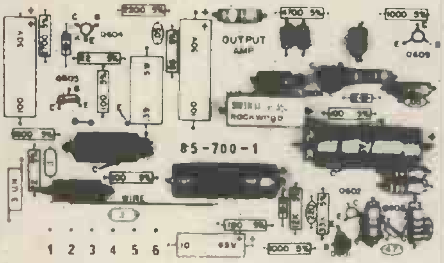
This new style course will enable anyone to have a real understanding of electronics by a modern, practical and visual method. No previous knowledge is required, no maths, and an absolute minimum of theory.

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

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







1 Build an oscilloscope.

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

2 Read, draw and understand circuit diagrams.

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

3 Carry out over 40 experiments on basic circuits.

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

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

Free!

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

British National Radio & Electronic School

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

NAME ______________________

ADDRESS ______________________

EE B5 Block caps please

ROOM THERMOSTAT

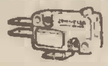
Famous Satchwell, elegant design, intended for wall mounting. Will switch up to 20 amps at mains voltage, covers the range 0.30 C. Special snip this month £3·00.

ROD THERMOSTAT—£3·00.

WINDSCREEN WIPER CONTROL

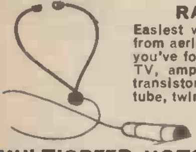
Vary speed of your wiper to suit conditions. All parts and instructions to make £3·75.

MICRO SWITCH BARGAINS



Rated at 5 amps 250V, ideal to make a switch panel for a calculator and for dozens of other applications. Parcel of 10 (two types) for £1.

RADIO STETHOSCOPE



Easiest way to fault find, traces signal from aerial to speaker when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything. Kit comprises transistors and parts including probe tube, twin stetho-set. £3·95.

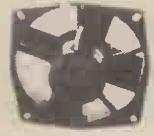
MULTISPEED MOTORS

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

12V MINIATURE RELAY

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

EXTRACTOR FAN



Ex computers—made by Woods of Colchester, ideal for fixing through panel—reasonably quiet running—very powerful 2500 rpm. Choice of two sizes 5" or 6½" dia. £4·43.

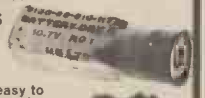
MAINS RELAYS

With triple 10 amp changeover contacts—operating coil wound for 230V a.c. Chassis mounting one screw fixing, Price £1·25

MICRO AMPLIFIER

Ex. behind the ear hearing aids complete with volume control. £2·16. Case not supplied.

MERCURY BATTERIES



Bank of 7 Mercury cells type 625 which are approx. ⅝in. diameter by ¼in. thick in plastic tube giving a total of 10.7V. Being in a plastic tube it is very easy to break up the battery into separate cells and use these for radio control and similar equipment. Carton of 25 batteries £1·60.

PP3/PP9 REPLACEMENT

Japanese made in plastic container with leads size 2in. × 1½in. × 1½in., this is ideal to power a calculator or radio, it has a full wave rectifier and smoothed output of 9V suitable for loading of up to 100mA. £2·53.

SWITCH TRIGGER MATS

So thin is undetectable under carpet but will switch on with slightest pressure. Ideal for burglar alarms, shop doors, etc. 24in. × 18in. £2.50. 13in. × 10in. £1.95.

MAINS TRANSISTOR PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6V, 9V, 12V for up to 500mA (class D working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: main transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only £2.00.

DRILL CONTROLLER

Electronically changes speed from approximately 10 revs to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. £3.45. Made-up model £1 extra.

8 POWERFUL BATTERY MOTORS

For models, Meccanos, drills, remote control planes, boats, etc. £2.

ROTARY PUMP

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

SHORTWAVE CRYSTAL SET

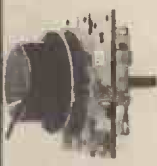
Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 19, 25, 29, 31 metre bands. Kit contains chassis front panel and all the parts £1·94—crystal earphone 55p including VAT and postage.

MULLARD UNILEX

A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone in easy-to-assemble modular form and complete with a pair of Plessey speakers this should sell at about £30—but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only £15·00 including VAT and postage.

HUMIDITY SWITCH

American made by Ranco, their type No. J11. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch adjustable by a screw, quite sensitive—breathing on it for instance will switch it on. Micro 3 amp at 250V a.c. Overall size of the device approx. 3¾in. long, 1 in. wide and 1¾in. deep. 75p.

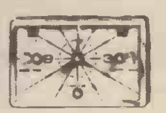


DELAY SWITCH

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 few minutes after 1st contact 95p.

25A ELECTRIC PROGRAMMER

Learn in your sleep. Have radio playing and kettle boiling as you wake—switch on lights to ward off intruders—have a warm house to come home to. All these and many other things you can do if you invest in an electrical programmer Clock by famous maker with 15 amp. on/off switch. Switch-on time can be set anywhere to stay on up to 6 hours independent 60 minute memory jogger. A beautiful unit.

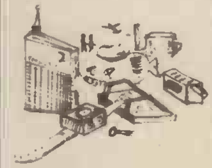


MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied. Model 1153 500mW. power, output £1·69.

Model 1172—10 watts power output £3·94
Model 1172 1W, power output £2·25
Model EP9000 4 watt power output £2·90
EP 9001 twin channel or stereo pre-amp £2·90

PRINTED CIRCUIT KIT PROJECTS



CONTENTS: (1) 2 Copper Laminate Boards 4½in. × 2½in. (2) 1 Board for Matchbox Radio. (3) 1 Board for Wristwatch Radio, etc. (4) Resist. (5) Resist Solvent. (6) Etchant. (7) Cleanser/Degreaser. (8) 16-page Booklet Printed Circuits for Amateurs. (9) 2 Miniature Radio Dials SW/MW/LW. Also free with each kit. (10) Essential Design Data Circuits, Chassis Plans, etc. for PROJECTS. £1·50.

SOUND TO LIGHT UNIT

Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450W). Unit in box all ready to work. £9.95.

MINI-MULTI TESTER

Amazing, deluxe pocket size precision moving coil instrument—jewelled bearings—1000 opv—mirrored scale.

11 instant ranges measure:—
DC volts 10, 50, 250, 1000
AC volts 10, 50, 250, 1000
DC amps 0-1 mA and 0-100 mA
Continuity and resistance 0-150K ohms.

Complete with insulated probes, leads, battery, circuit diagram and instructions.

Unbelievable value only £5·50p + 50p post and insurance.

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

TERMS: Cash with order—but orders under £6 must add 50p to offset packing etc.
BULK ENQUIRIES INVITED. PHONE: 01-688 1833

IT'S FREE

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

MAINS TRANSFORMERS

All these have 230/240v 50hz Primary

VOLTAGE	CURRENT	REF.	PRICE
1v	2 amp	TM 1	£1·94
2·4v	5 amp	TM 2	£1·62
4v	7 amp	TM 32	£2·70
6v	¾ amp	TM	50·85
6·5v	½ amp	TM 37	£0·85
6·5v	200 mA	TM 21	£1·62
6·5v–0–6·5v	100 mA	TM 21	£1·62
6·5v–0–6·5v	750 mA	TM 7	£2·16
6·3v–0–6·3v	100 mA	TM 33	£1·62
6·3v	2 amp	TM 4	£1·89
8·5v	1 amp	TM 12	£1·62
8·5v + 8·5v sep winding	½ amp	TM 12	£1·62
9v	1 amp	TM 5	£1·62
9v	1 amp 'c' core	TM 6	£1·80
9v	3½ amp	TM 11	£2·70
9v	5 amp	TM 38	£3·24
10v	25 amp	TM 15	£4·86
10v–0–10v	12½ amp	TM 15	£4·86
12v–0–12v	4 amp	TM 27	£4·32
12v	½ amp	TM 9	£1·05
13v	¾ amp	TM 7	£2·16
12v	1 amp	TM 10	£1·89
12v–0–12v	50mA	TM 19	£1·62
12v–0–12v	1 amp	TM 41	£3·24
15v tapped 9v	2 amp	TM 11	£2·70
15v	7 amp	TM 27	£4·32
15v–0–15v	3½ amp	TM 27	£4·32
15v–0–15v	3½ amp	TM 35	£4·86
17v	½ amp	TM 12	£1·62
18v	¾ amp	TM 13	£1·90
20v	½ amp	TM 14	£1·62
20v	5 amp	TM 27	£4·32
20v	12½ amp	TM 15	£4·86
20v–0–20v	6 amp	TM 15	£4·86
13v	100 mA	TM 21	£1·62
24v	1½ amp	TM 16	£2·12
24v	2 amp	TM 17	£2·70
24v + 2v 7 amp	2 amp	TM 39	£2·97
24v	4 amp	TM 40	£3·78
25v	1½ amp	TM 18	£2·43
26v	2 amp	TM 39	£2·98
30v tapped 24, 20, 15 & 12	3½ amp	TM 27	£4·32
30v	8 amp	TM 15	£4·86
37v	37 amps	TM 34	£31·86
40v tapped @ 30v, 20v & 10v	6 amp	TM 15	£4·86
50v–2 amp with 6·3v shrouded		TM 22	£, ·86
50v	8 amp	TM 29	£11·65
60v	5 amp	TM 24	£7·02
75v–3 amp with 6·3v shrouded		TM 23	£8·10
75v	4½ amp	TM 24	£7·02
80v tapped 60v & 75v	4 amp	TM 24	£7·02
100v	1 amp	TM 25	£7·02
100v–0–100v	½ amp	TM 25	£7·02
130v tapped 120v	½ amp	TM 28	£3·78
200v	½ amp	TM 25	£7·02
250v–0–250v with 6·3v 2A	50 mA	TM 36	£3·78
250v	100 mA	TM 36	£3·78
500v	50mA	TM 36	£3·78

350mA 6 VOLTS MAINS UNIT

Ideal for power 6 volt equipment, cassettes, tape recorder or amplifier or other appliances requiring more than the average mount of current. This is a really well made unit in plastic case made for Crown Radio intended originally to clip into position, this has external battery type contacts but it is a simple matter to solder leads straight on to these contacts and this unit employs full wave rectification and is recommended in every way. Price £4·30.

CALCULATORS

By famous makers like Texes, intended originally to be sold at quite high prices new and unused. **Type 1.** Basic functions—add, subtract, multiply, divide etc. Price £5·15. **Type 2.**—again basic functions but with rechargeable nicad batteries. Price £7·02p. Battery chargers for same £2·70. **Type 3**—basic functions but with memory and rechargeable batteries, price £11·34p + 84p.

AM/FM RADIO

Complete chassis, has turning scale with pointer volume control, on/off etc. Controls have edgewise knobs. These radios can be mounted on or just inside extension speaker, then you have a first class "music while you work" receiver. Reception on both AM-FM is better than average and even in areas where FM is notoriously bad, good results have been obtained. The output also is above average, the speaker power is probably around 1½ — 2 watts. They can be powered by 6v batteries or 6v power supply, in fact the Crown Radio One mention above is ideal, would no doubt function as an AM/FM Tuner—real bargain @ £5·50 + 69p.

UV TUBES (PHILLIPS ATINIC)

Useful for bringing out water marks in stamps and special colours in rocks, similar specimens. We have these in two sizes 9" 6w price £1·50 + 12p. Post 50p + 4p. 2ft 20 watt £2·00 + 16p. post 75p + 6p.

1 POLE 10 WAY SWITCH

For digital displays the 10 positions being evenly spaced through the 360 turn, and there is no stop. Silver plated contacts are rated @ 5 amps, normally an expensive switch but offered @ 86p each.

LIGHT PIPES

We offer a light pipe switch kit. This consists of everything except the plastic tube and lamps. We give instructions on how to wire up. The plastic tube for the lamps we cannot supply at present—in fact if any reader knows where there is a stock of this we shall be glad to hear of it. We can supply the lamps, these are 6·3v 0·3 amp made by Philips or similar good makers. Price £5·40 per 100. Alternatively we have coloured bulbs, these are wire ended price £6·36 per 100 (assorted colours).

SKELETON PRE-SET

Miniature size 2·2k, 10 for £1·00 + 12½p.

RELAY BASE

14 pin standard for many plug in relays 50p + 4p.

MECHANICAL GEAR BOX for coupling to electric drill for motor, gives a reduction and the final drive shaft which is approximately ⅜" diameter comes out at right angles to the drive. The gear box which is flange mounted is approx. 2¼" high 2¼" deep and 1" thick plus fixing flanges which protrude approximately ⅜" making the total depth approximately 3¾". This gear box has undoubtedly hundreds of uses. Price £2·16.

J.BULL (ELECTRICAL) LTD
(Dept. EE), 103 TAMWORTH RD.
CROYDON CR9 1SG

MK14-the only low-cost keyboard -addressable microcomputer!

The new Science of Cambridge MK14 Microcomputer kit

Just £39.95 (+ £3.20 VAT, and p&p)

The MK14 National Semiconductor Scamp based Microcomputer Kit gives you the power and performance of a professional keyboard-addressable unit – for less than half the normal price. It has a specification that makes it perfect for the engineer who needs to keep up to date with digital systems, or for use in school science departments. It's ideal for hobbyists and amateur electronics enthusiasts, too.

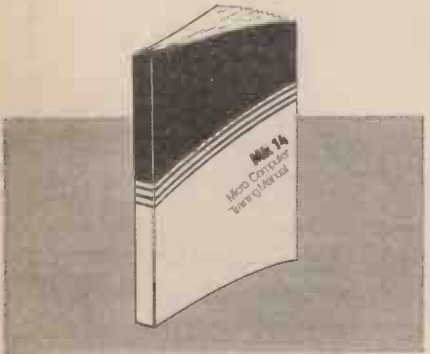
But the MK14 isn't just a training aid. It's been designed for practical performance, so you can use it as a working component of, even the heart of, larger electronic systems and equipment.

MK14 Specification

* Hexadecimal keyboard
* 8-digit, 7-segment LED display
* 512 x 8 Prom, containing monitor program and interface instructions
* 256 bytes of RAM
* 4MHz crystal
* 5V stabiliser
* Single 6V power supply
* Space available for extra 256 byte RAM and 16 port 1/0
* Edge connector access to all data lines and 1/0 ports

Free Manual

Every MK14 Microcomputer kit includes a free Training Manual..It contains



operational instructions and examples for training applications, and numerous programs including math routines (square root, etc) digital alarm clock, single-step, music box, mastermind and moon landing games, self-replication, general purpose sequencing, etc.

Designed for fast, easy assembly

Each 31-piece kit includes everything you need to make a full-scale working microprocessor, from 14 chips, a 4-part keyboard, display interface components, to PCB, switch and fixings. Further software packages, including serial interface to TTY and cassette, are available, and are regularly supplemented.

The MK14 can be assembled by anyone with a fine-tip soldering iron and a few hours' spare time, using the illustrated step-by-step instructions provided.

Tomorrow's technology – today!

"It is not unreasonable to assume that within the next five years . . . there will be hardly any companies engaged in electronics that are not using micro-processors in one area or another."

Phil Pittman, Wireless World, Nov. 1977.

The low-cost computing power of the microprocessor is already being used to replace other forms of digital, analogue, electro-mechanical, even purely mechanical forms of control systems.

The Science of Cambridge MK14 Standard Microcomputer Kit allows you to learn more about this exciting and rapidly advancing area of technology. It allows you to use your own microcomputer in practical applications of your own design. And it allows you to do it at a fraction of the price you'd have to pay elsewhere.

Getting your MK14 Kit is easy. Just fill in the coupon below, and post it to us today, with a cheque or PO made payable to Science of Cambridge. And, of course, it comes to you with a comprehensive guarantee. If for any reason, you're not completely satisfied with your MK14, return it to us within 14 days for a full cash refund.

Science of Cambridge Ltd,
6 Kings Parade,
Cambridge,
Cambs., CB2 1SN.
Telephone: Cambridge (0223) 311488

To: Science of Cambridge Ltd,
6 Kings Parade, Cambridge,
Cambs., CB2 1SN.

Please send me an MK14 Standard Microcomputer Kit. I enclose cheque/ Money order/PO for £43.55 (£39.95 + 8% VAT and 40p p&p).

Name ____________________

Address (please print) ____________________

____

____________________ EE/5

Allow 21 days for delivery.

Science of Cambridge

SEMICONDUCTORS—COMPONENTS

BABANI BOOK OFFER

Purchase books to the value of £5·00 from the list below and choose any 60p pak from this page *FREE*.

BP2	Handbook of Radio, TV & Industrial & Transmitting Tube & Valve Equivalents	60p
BP3	Handbook of Tested Transistor Circuits	40p
BP6	Engineers and Machinists Reference Tables	40p
BP7	Radio & Electronic Colour Codes and Data Chart	15p
BP10	Modern Crystal and Transistor Set Circuits for Beginners	35p
BP14	Second Book of Transistor Equivalents	95p
BP15	Constructors Manual of Electronic Circuits for the Home	50p
BP16	Handbook of Electronic Circuits for the Amateur Photographer	60p
BP18	Boys and Beginners Book of Practical Radio and Electronics	60p
BP22	79 Electronic Novelty Circuits	75p
BP23	First Book of Practical Electronic Projects	75p
BP24	52 Projects Using IC741 (or equivalents)	75p
BP26	Radio Antenna Handbook for Long Distance Reception and Transmission	85p
BP27	Giant Chart of Radio Electronic Semiconductor and Logic Symbols	60p
BP29	Major Solid State Audio Hi-Fi Construction Projects	85p
BP32	How to Build Your Own Metal & Treasure Locators	85p
BP34	Practical Repair & Renovation of Colour TVs	95p
BP35	Handbook of IC Audio Preamplifier & Power Amplifier Construction	95p
BP36	50 Circuits Using Germanium, Silicon & Zener Diodes	75p
BP37	50 Projects Using Relays, SCR's and TRIACS	1·10
BP39	50 (FET) Field Effect Transistor Projects	1·25
129	Universal Gram-motor Speed Indicator	8p
160	Coil Design and Construction Manual	50p
161	Radio, TV and Electronics Data Book	60p
196	AF-RF Reactance—Frequency Chart for Constructors	15p
202	Handbook of Integrated Circuits (ICs) Equivalents and Substitutes	75p
205	First Book of Hi-Fi Loudspeaker Enclosures	60p
213	Electronic Circuits for Model Railways	85p
214	Audio Enthusiasts Handbook	85p
216	Electronic Gadgets and Games	85p
217	Solid State Power Supply Handbook	85p
219	Solid State Novelty Projects	85p
220	Build Your Own Solid State Hi-Fi and Audio Accessories	85p
222	Sold State Short Wave Receivers for Beginners	95p
223	50 Projects Using IC CA3130	95p
224	50 CMOS IC Projects	95p
225	A Practical Introduction to Digital IC's	95p
226	How to Build Advanced Short Wave Receivers	1·20
RCC	Resistor Colour Code Disc Calculator	10p

THYRISTORS

600mA TO18 CASE

Volts	No.	Price
10	THY600/10	£0·15
20	THY600/20	£0·16
30	THY600/30	£0·20
50	THY600/50	£0·22
100	THY600/100	£0·25
200	THY600/200	£0·38
400	THY600/400	£0·44

1 AMP TO5 CASE

Volts	No.	Price
50	THY1A/50	£0·26
100	THY1A/100	£0·28
200	THY1A/200	£0·32
400	THY1A/400	£0·38
600	THY1A/600	£0·45
800	THY1A/800	£0·58

3 AMP TO66 CASE

Volts	No.	Price
50	THY3A/50	£0·28
100	THY3A/100	£0·30
200	THY3A/200	£0·33
400	THY3A/400	£0·42
600	THY3A/600	£0·50
800	THY3A/800	£0·65

5 AMP TO66 CASE

Volts	No.	Price
50	THY5A/50	£0·36
100	THY5A/100	£0·46
200	THY5A/200	£0·50
400	THY5A/400	£0·57
600	THY5A/600	£0·69
800	THY5A/800	£0·81

5 AMP TO220 CASE

Volts	No.	Price
400	THY5A/400P	£0·57
600	THY5A/600P	£0·69
800	THY5A/800P	£0·81

7 AMP TO48 CASE

Volts	No.	Price
50	THY7A/50	£0·48
100	THY7A/100	£0·51
200	THY7A/200	£0·57
400	THY7A/400	£0·62
600	THY7A/600	£0·76
800	THY7A/800	£0·92

10 AMP TO48 CASE

Volts	No.	Price
50	THY10A/50	£0·51
100	THY10A/100	£0·57
200	THY10A/200	£0·62
400	THY10A/400	£0·71
600	THY10A/600	£0·99
800	THY10A/800	£1·22

16 AMP TO48 CASE

Volts	No.	Price
50	THY16A/50	£0·54
100	THY16A/100	£0·58
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Projects... Theory...

and Popular Features...

Here we are again with another great selection of projects for the constructor.

The *Stunt Cycle* television game deserves special mention on a number of counts. It happens to be the first television game we have published. It is also one of the very latest to be devised. So our readers will be right up to date with *Stunt Cycle*, and will be able to amaze and enthral their family and friends with this exciting home amusement. It is compelling once you start playing and the seemingly impossible goal of jumping 36 buses is incentive for persevering once the throttle control is handled.

That it is a one-player game is another point in its favour. Television games for two contestants are common whereas the person living alone probably has a greater need for an amusement or something to exercise his skill upon.

The complex circuitry that forms the basis of this game is contained within a single integrated circuit. This particular device is larger than any we have previously used in our projects. It is also, not surprisingly, more expensive. Being a MOS type of device, this games chip does require special care when handling. Otherwise, this component should not offer any problems to those already experienced in handling i.c.s. The use of a socket for mounting this i.c. also helps by eliminating possible hazards that might arise if soldering directly to the pins. For the rest, careful study of the instructions and diagrams should ensure that all goes according to plan and success is achieved without any hitches.

After this "big one", something quite different. The *Mains Tester* is as simple as they come. Only three neons, three resistors plus a 13A mains plug are involved. But it all adds up to an extremely valuable little device. For it permits one to see at a glance the "healthy" or otherwise state of the mains sockets. An essential exploratory tool, we reckon, when moving into a new house.

Apart from our bumper contents, there is a bonus this month for our readers. The free booklet *Semiconductors for Constructors* is designed for the pocket, so wherever you go the vital facts about the more common transistors, diodes, thyristors and triacs can be close at hand. Over 700 devices in all are listed. The leadout diagrams will prevent frustration (and possible damage) when dealing with some unfamiliar device.

Fred Bennett.

Our June issue will be published on Friday, May 19. See page 453 for details.

Readers' Enquiries

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

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

Component Supplies

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

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VOL. 7 NO. 9 MAY 1978

CONSTRUCTIONAL PROJECTS

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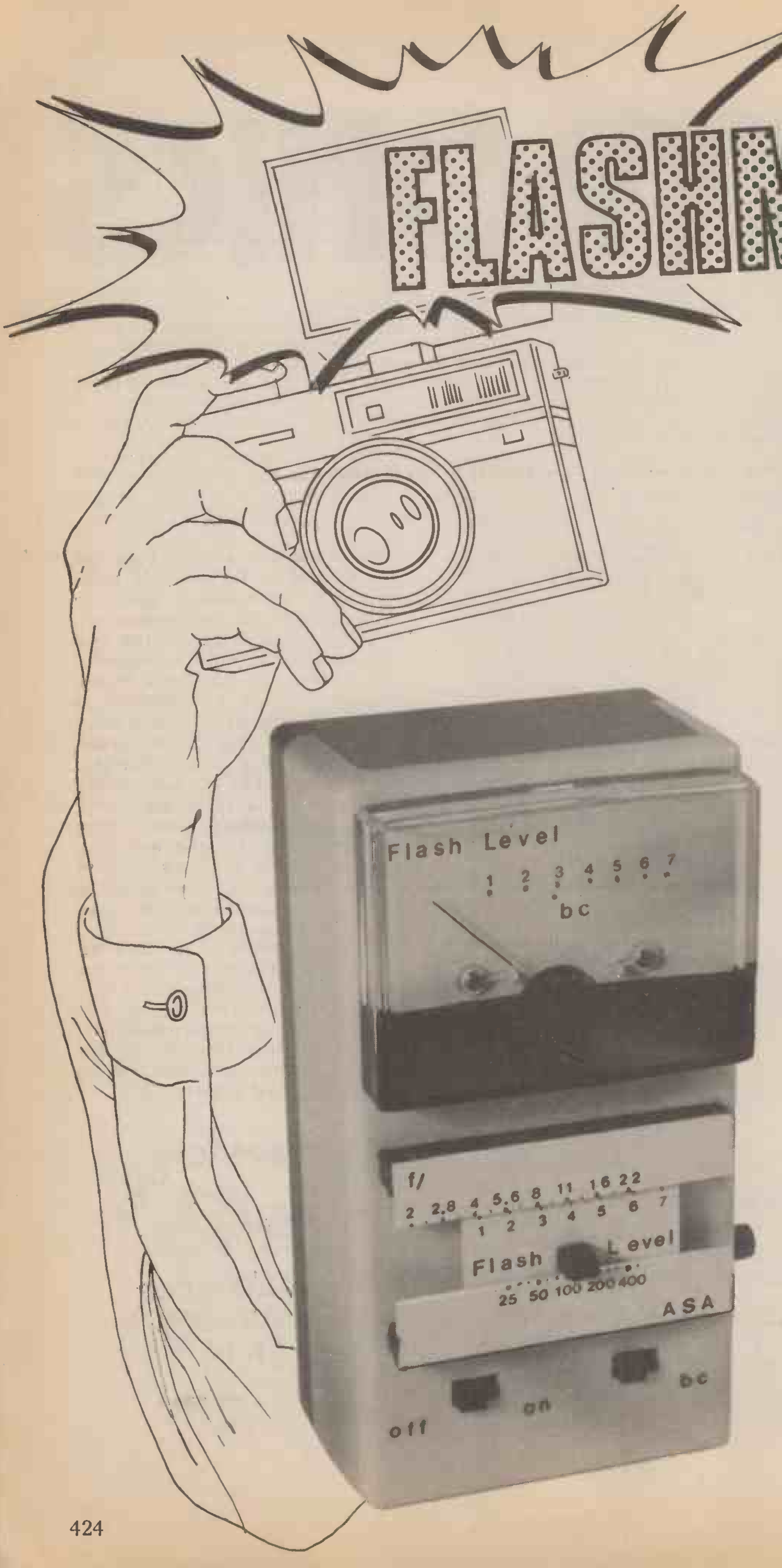
FLASHMETER

By R. A. Penfold



ELECTRONIC flashguns are currently available at quite low prices and are extremely popular. When in use there is the problem of obtaining the correct photographic exposure, and this is not completely solved by the use of guide numbers. These numbers relate the power of the flashgun to film speed and the distance between the camera and the subject.

This is not entirely satisfactory as in a practical situation the exposure will also be affected by the surroundings. There is a likelihood of under-exposure out of doors or in a large dull room, and over-exposure in a small room having light coloured walls. The problem is especially acute when using bounced flash, and also for colour or close-up work.

One way around the problem is to take each shot several times using different lens apertures. A much better alternative however is to use a flashmeter to measure the effective amount of light produced by the flashgun under the particular circumstances. The correct aperture setting for any particular film speed is then easily calculated from this information.

Flashmeters tend to be rather expensive to buy ready made, with prices starting at about £50 for a simple instrument. This high cost is presumably due to the relatively small number of units that are produced, and it is possible to build one's own flashmeter for a fraction of this cost.

OPERATING PROPERTIES

The block diagram of Fig. 1. shows the basic arrangement of the flashmeter. A photosensitive circuit is used to produce an output voltage which is proportional to the level of light falling on the photocell. Normally the output potential will be fairly low, but when the photocell receives the light from a flashgun a voltage spike will be produced.

The amplitude and length of the voltage spike will depend upon the intensity of light received by the photocell, and the length of the flash.

HIGH PASS FILTER

The voltage spike is fed to a storage circuit via a high pass filter and rectifier circuit. The storage circuit is merely a capacitor which is charged up by the voltage spike, and the rectifier circuit ensures that the charge on the capacitor cannot leak away back into the photocell circuitry.

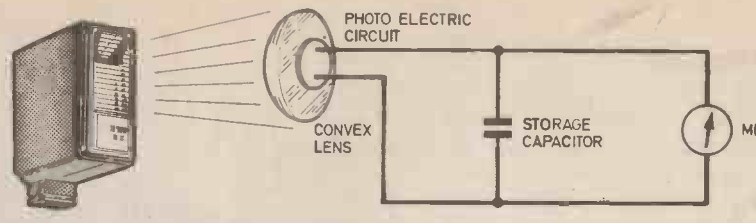
The high pass filter is needed to filter out signals produced by natural changes in the ambient light level. These changes are relatively slow and are easily filtered out. They must be filtered out as they would otherwise gradually *pump* up the storage capacitor to virtually full charge.

VOLTMETER

A voltmeter is used to measure the voltage produced across the storage capacitor, but an ordinary voltmeter is not suitable for use here as it would take a significant amount of current from the capacitor, and would discharge it almost the instant the voltage spike had decayed away. It is therefore necessary to use an electronic voltmeter that consumes no significant input current.

Although it may seem that this circuit measures the intensity of the light from the flashgun, and does not take into account the length of the flash, this is not in fact the case, and simple flashmeters of this type perform satisfactorily in practice.

The reason for this is that the circuit will not respond instantly to the light pulse, and this introduces the necessary time element into the unit.



HOW IT WORKS

The effective output from any flashgun is affected by the surroundings as well as by the output power of the gun, the flash-to-subject distance, etc. The Flashmeter contains a photo-electric circuit which collects the light and transforms it into a *voltage spike*. This spike is proportional to the light level received from the flashgun. This voltage spike is fed to a storage capacitor, the charge on this component being measured by the meter circuit.

The meter thus indicates the amount of light received, the correct aperture for the camera can then be calculated from the meter reading.

START HERE FOR CONSTRUCTION

Except for the meter, photocell and controls, all the components are mounted on a piece of 0·1 inch stripboard which has 18 strips by 24 holes. This must be cut from a standard size piece using a hacksaw, and any rough edges are then filed flat. Then the six breaks in the copper strips are made and the two 3·2mm diameter mounting holes are drilled before the components are soldered into position. Fig. 3.

CASE

The unit is built into a 120 x 65 x 40mm plastic Verobox, or a similar case. Do not attempt to use a case any smaller than the size quoted as there would probably not be sufficient space to accommodate all the components.

The general layout of the unit can be seen from the accompanying photographs, and for a similar reason it would be advisable to keep to this general arrangement.

The meter used in the prototype required a 38mm diameter cutout, this can be cut using either a fretsaw or a miniature round file. It also requires four 3·2mm diameter holes for the mounting screws, and the positions of these can be located using the meter as a sort of template once the large cutout has been made.

The two switches, S1 and S2, are sub-miniature slider switches, and they each require a small rectangular cutout. This can be produced by first drilling a small hole, and then filing this out to the appropriate size and shape using a miniature flat tapered file.

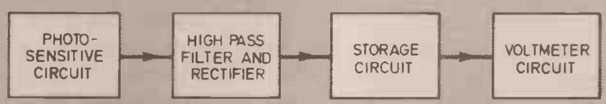


Fig. 1. Block diagram of the Flashmeter. This high pass filter (HPF) also contains the rectifier.

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PHOTOCELL

The photocell is mounted on the rear panel of the case, and its leadout wires are threaded through a couple of small holes which are drilled slightly above the centre of the panel. The photocell is then glued into position. Its leadout wires must be cut quite short so that they cannot accidentally come into contact with the component board when the rear panel is fitted into position.

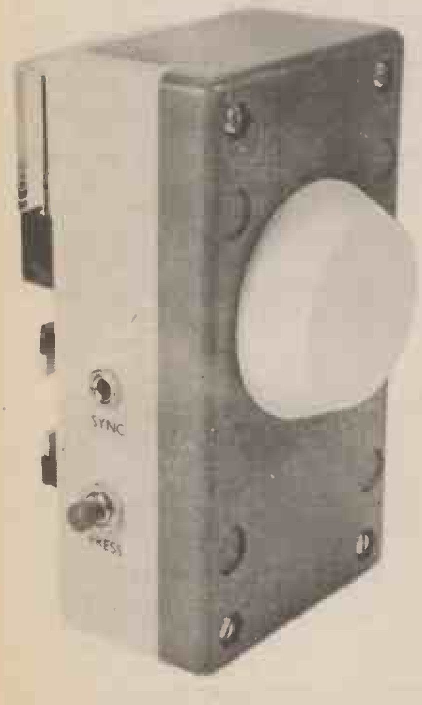
Finally the remaining wiring can be completed, all of which is shown in Fig. 3. The component board is then mounted on the meter terminals.

There is just sufficient space for the PP3 battery below the component board.

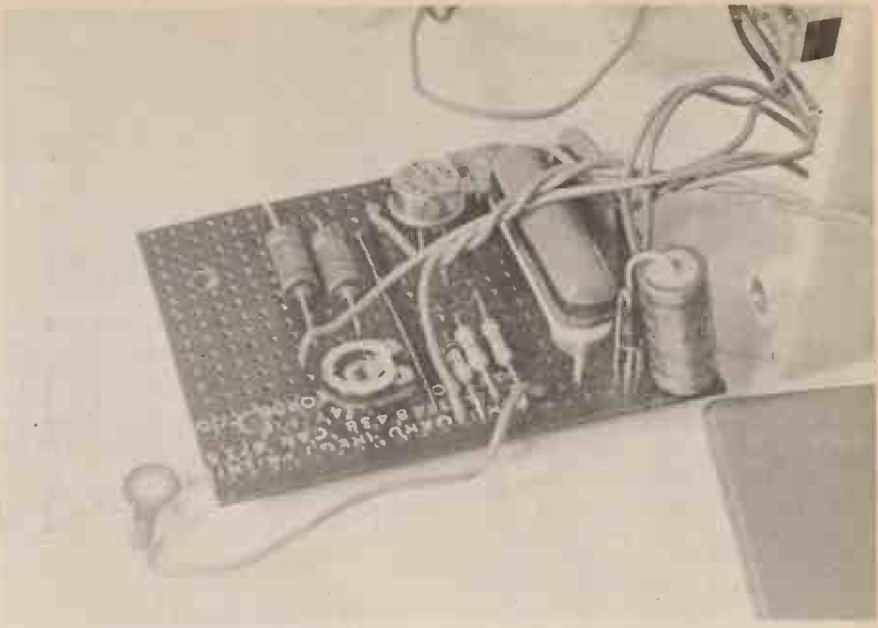
LIGHT RECEPTOR

A piece of thin white plastic roughly dome shaped is fitted over the photocell. Its purpose is to act as a light collector and diffuser. On the prototype a piece cut from the bottom of an empty yoghurt container is used, but anything similar, such as half a table tennis ball, should also be suitable.

The light receptor is glued into position using a good quality adhesive such as Bostik or an epoxy glue.



Rear of the finished unit showing the light diffuser.



The Flashmeter circuit board removed from the case showing the layout of components.

CALCULATOR

Constructional details of the calculator used on the prototype are provided in Fig. 4.

The two blocks that support the fixed scales are made from layers of thick card glued together, and then covered with insulation tape to provide a neat finish. Alternatively, small blocks of wood could be used.

The aluminium parts are made from 16 to 20 s.w.g. material, the exact gauge being unimportant. The foam is of the self-adhesive strip variety, and this is sold in DIY shops as draught excluder. Its purpose is to hold the sliding part of the calculator in place so that it does not simply fall out.

On the prototype the knob is one that has been cut from a miniature slider switch using a small hacksaw.

It is preferable to use some form of thin white plastic as the basis for the three scales as this will give a neat and hard wearing finish. However, white card can be used instead. Details of the scales are provided in Fig. 4.

These are produced using rub-on transfers such as Letraset. A good quality adhesive must be used when fixing the parts together as otherwise the calculator will not stand up to prolonged use.

METER

It is ideally necessary to remove the scale which is fitted to the meter (except for the zero marker) so that a new scale can be marked on by the constructor.

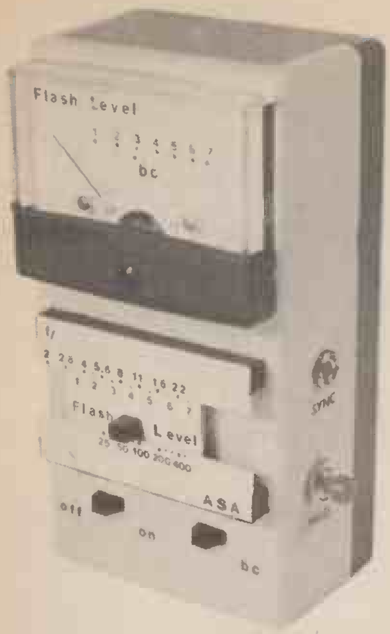
The front part of the meter simply pulls off to permit access to the scale, and then the markings can be carefully scraped off using the sharp point of a compass, or something similar. Great care must be taken not to damage the delicate meter movement while doing this.

It is *not absolutely essential* to the recalibrate the meter, as will be explained more fully later on.

CALIBRATION

The calibration should be carried out in an average-sized furnished room, this being the conditions for which flashgun guide numbers are determined. Initially VR1 is set for about half maximum resistance, and VR2 is adjusted for maximum resistance (fully clockwise).

Find from the calculator dial or guide number the flash-to-subject distance which would require an aperture of F/16 for a film speed of ASA 25. Set up the flashgun at this distance from the light receptor of the Flashmeter. Fire the flashgun and adjust VR2 for virtually f.s.d. of the meter.



FLASHMETER

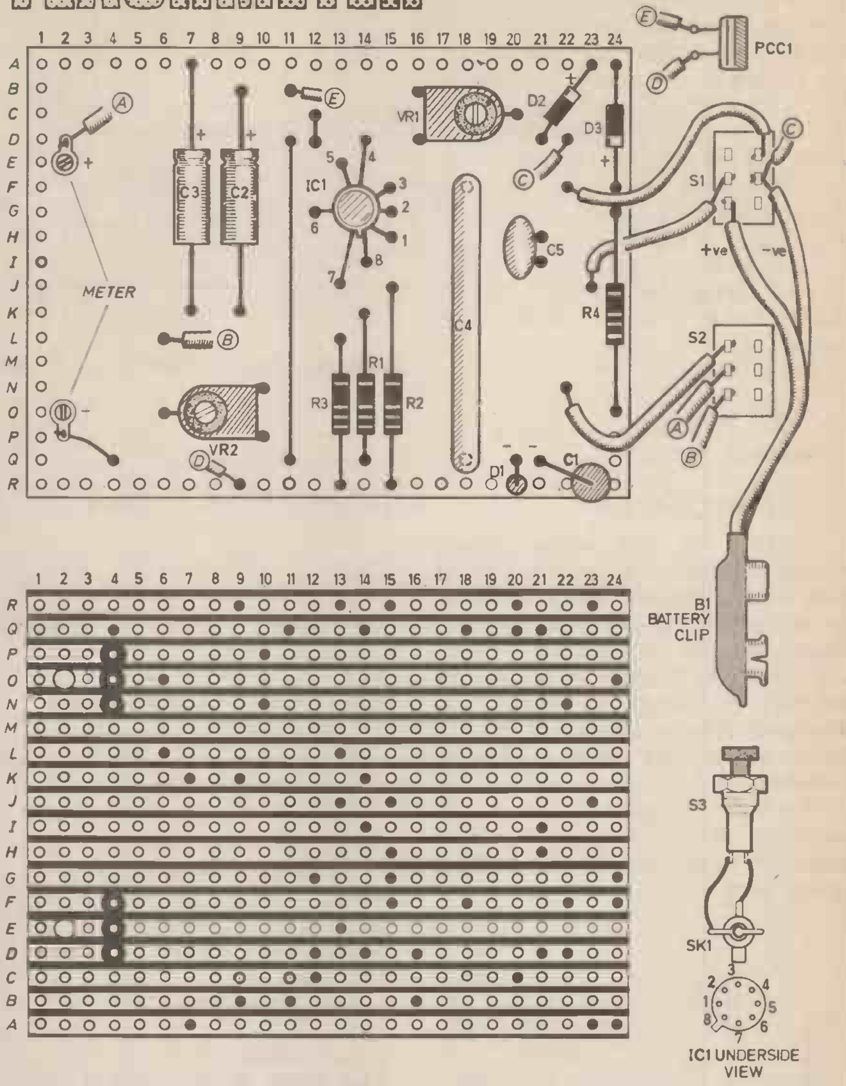


Fig. 3. Wiring details for the unit. Take extra care when soldering the i.c. as a socket cannot be used in this particular layout.

COMPONENTS

Resistors
- R1 330Ω
- R2 680Ω
- R3 100kΩ
- R4 22kΩ

All are ⅛W carbon ± 5%

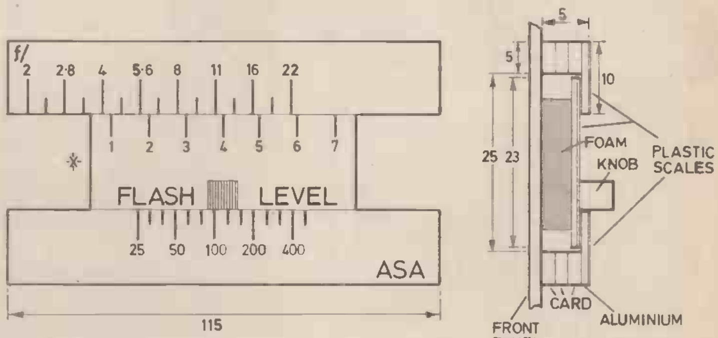
Potentiometer
- VR1 220Ω subminiature horz. preset
- VR2 22kΩ subminiature horz. preset

Capacitors
- C1 220μF 10V elect.
- C2 10μF 10V elect.
- C3 10μF 10V elect.
- C4 1μF polyester
- C5 82pF disc ceramic

Semiconductors
- IC1 CA3130T CMOS op amp
- D1 BZY88C5V1 5·1V 400mW Zener diode
- D2 BAY31 or similar silicon diode (OA200, OA202)
- D3 BZY88C15V 15V 400mW Zener diode
- PCC1 ORP12

Miscellaneous
- B1 PP3 9V battery
- S1 d.p.d.t. slide switch
- S2 d.p.d.t. slide switch
- S3 push-to-make release-to-break push switch
- SK1 3·5mm jack socket
- ME1 100μA f.s.d. moving coil meter. 59 x 46mm front. Stripboard 0·1 inch matrix, 18 strips by 24 holes; Verobox or similar case as required; material for light receptor and scale (see text); connecting wire; battery connector; small slide type control knob; solder.

See Shop Talk page 433



* CENTRE SCALE IS 35 x 23
ALL DIMENSIONS ARE IN mm.

Fig. 4. Constructional details for the calculator. Note that the scale is in three sections. The middle section being slightly deeper than shown so as to fit under the two outer scales. All three are drawn full size and may be used as templates. The general arrangement can be seen in the photographs.

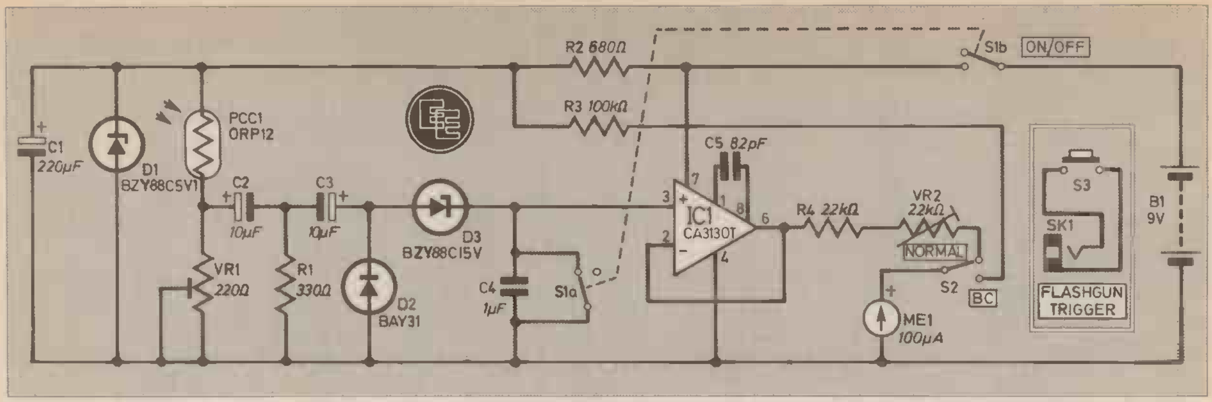


Fig. 2. Complete circuit diagram for the Flashmeter. Socket SK1 (Flashgun Trigger) and switch S3 are used to fire the flashgun.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Flashmeter appears in Fig. 2.

The voltage spike is generated across the simple potential divider circuit which is comprised of the l.d.r., PCC1 and potentiometer VR1. Under normal lighting conditions PCC1 has a fairly high resistance, and very little voltage will be produced across VR1.

When subjected to very bright conditions PCC1 exhibits a resistance of only a few tens of ohms, and so virtually the full supply potential appears across VR1.

Zener diode D1 is used to stabilise the supply voltage fed to the photocell circuitry, R2 is the zener load resistor.

HIGH CURRENT

Quite a high current is consumed by the photocell circuit for the short time that the flashgun is firing, and C1 ensures that this current requirement can be met.

Capacitor C2 and resistor R1 form the high pass filter. At high frequencies C2 will have an extremely low impedance, and signals will readily pass through to C3. At low frequencies the impedance of C2 will be high in comparison to that of R1, and so low frequency signals are blocked by a potential divider action.

PUMP CIRCUIT

The network comprising C3, D2, and D3 forms a diode pump circuit, C4 being the storage capacitor. Ordinary silicon diodes were initially tried in the position of D3, but results were not good as a significant amount of current leaked away from the capacitor through these diodes. Using Zener diodes of adequate operating voltage seemed to provide perfect results, and so a Zener type is specified for D3.

VOLTMETER

The electronic voltmeter part of the circuit is based on a CA3130T operational amplifier i.c. This is used as a non-inverting unity gain amplifier. Resistor R4, preset VR2 and the meter form a conventional voltmeter circuit which is connected across the output of the i.c.

The voltage at the non-inverting input of the i.c. will be matched by an almost identical output voltage. Thus the voltmeter circuit will indicate the voltage present across C4. Although the meter is not actually calibrated in terms of voltage, of course. The CA3130T has several unusual properties, one of which is an input impedance of 1·5T ohms (1,500,000,000,000 ohms)!

It therefore draws no significant current from the storage capacitor.

OPERATING PROPERTIES

Two other important properties of the CA3130T is its ability to operate with inputs down as low as the negative supply rail voltage, and the ability of the output to swing to virtually the negative and positive supply rail potentials. This enables the circuit to function without using the dual balanced positive and negative supply voltages which most other op amp i.c.s would require.

Capacitor C5 is the compensation capacitor for the i.c., and this component prevents it from becoming unstable. Switch S1 is the ON/OFF switch and it also acts as a reset switch by discharging C4 when it is set to the OFF position.

BATTERY CHECK

The second switch, S2 is the battery check switch, and when this is set to the BC position, the meter is connected across the stabilised supply rail by way of R3. The latter converts the meter to a voltmeter so that the stabilised voltage across D1 can be monitored.

After the unit has been in use for some time, the meter will indicate a fall in the supply potential, and that the battery needs to be replaced.

FLASHGUN TRIGGER

The last switch, S3 and the socket SK1 are not an essential part of the unit but are included for convenience. The flashgun can be connected to SK1 and then triggered by operating S3. This enables the flashgun to be fired while the Flashmeter is held near the subject which is to be photographed. An extension lead could be tried here.

After resetting the Flashmeter, double the distance between the flashgun and the Flashmeter, and fire the flashgun again. Temporarily mark the pointer position, then reset, double the distance again, fire the flashgun, and mark the pointer position. This will give scale positions corresponding to flash levels of 5 and 3.

A further doubling of the distance will give the position for a flash level of 1.

If the scale is cramped at either end, or if the flash level 1 position is less than 10mm from the zero point, try VR1 at various other settings and repeat the procedure at each setting until a scale similar to that in the photographs is obtained. The scale positions can then be permanently marked with paint or indian ink.

These points represent 2 stop intervals. Flash-to-subject distances corresponding to the intermediate 1 stop intervals (flash levels of 2, 4 and 6) can then be determined from the calculator dial or guide number, and these points marked in.

Note that during this procedure the Flashmeter and flashgun should be at least 2 foot (0·6m) from any wall or other reflecting surface. It is best to use a flashgun of fairly low power or the distances necessary will be too great. It is vitally important that the flashgun be fitted with fresh batteries, or be fully charged before commencing the calibration.

If one does not wish to modify the meter scale, then note the original scale readings corresponding to the flash level positions, and transfer these readings to the slider of the calculator.

In use, the pointer on the slider knob is set to the film speed in use. The required aperture (F/No.) can then be read off opposite the flash level indicated by the meter. ⌑

PLEASE TAKE NOTE

The Audiotest (*March '78*)

Resistor R17 in the components list should be 47kΩ not as shown.

On the stripboard layout Fig. 3 capacitor C2 should be relabelled C1, electrolytic C6 labelled as C7 and C7 as C8. C13 lead *16R* should go to *16Q*. Capacitor C2 (elect.) in the circuit of Fig. 1 should be C1 not as shown.

C-R Substitution Box (*March '78*)

Capacitor C14 in the components list should of course be 4·7μF 35V Tant, not as shown. In Fig. 2 the drawings for C14 and C15 should be transposed.

Mains Delay Switch (*April '78*)

In the components list S4 should be described as a "single pole push-on push-off push switch, not as given.

The author of the article has pointed out that the *Delay Switch* should only be used with tape machines that possess an "auto stop" mechanism. The reason for this is to avoid in certain cases pinchwheel distortion which may be the result of turning the machine off before the tape has actually stopped.

Teach In Part 7 (*April '78*)

In question 7.2. a figure has been left out, the h_{fe} should be 100 not 10 as quoted. Question 7.4. should read 'Noise can be thermally generated in:'

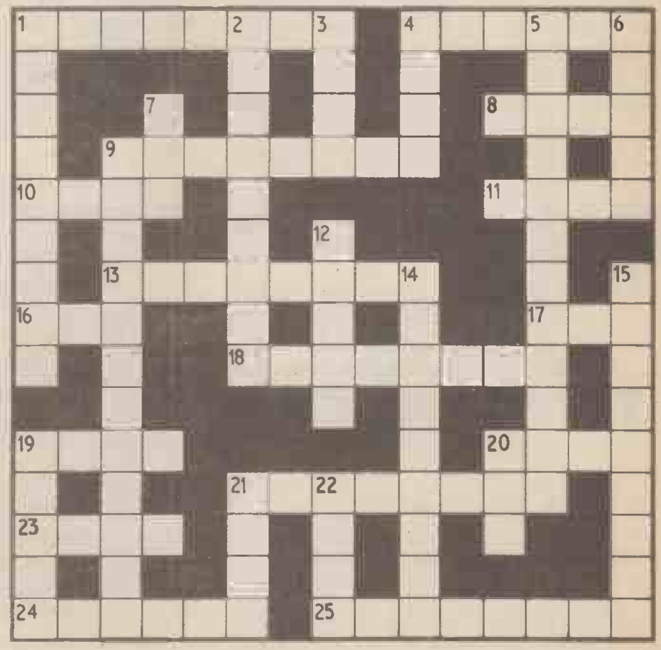
CROSSWORD No 3 BY D.P. NEWTON

ACROSS

1 Room to room communication.
4 It spans the gap in our knowledge of unknown resistors.
8 Chum about a lot. (Anag.)
9 Linked side by side across the power supply.
10 A volt makes a fool.
11 To speak obscurely.
13 The hard centre of some magnets. (4,4).
16 A hair of this animal could prove of use in detection.
17 Brown ring number.
18 A circuit in which there is no theoretical limit to the current.
19 Lift a plug.
20 Highly explosive.
21 Least receptive time. (4,4).
23 Once red now brown.
24 A fast flasher.
25 Even without material connection, communication is easy by this.

DOWN

1 Holds back the ball?
2 A storage jar.
3 You can't fence with this post.
4 Ring out the praise for his inventive genius.
5 This natural fibre dons another coat to prevent current loss. (6,6)
6 The elusive vapour once thought to propagate radio waves.
7 Head apparel.
9 Organically a good insulator, overall. (7,5)
12 In part, the motor sweeps clean.
14 Some variable resistors have this tendency to deviate from the straight and narrow.
15 Loop the loops for plenty of regenerative meals.
19 High volts could give the 10 across this.
20 Although black and unknown, it can be useful.
21 An unwary electron might fall into this trap.
22 Increase in size.



Solution on page 454

By J. C. May

MAINS TESTER

TO CHECK a mains socket or multiway adaptor for faults or incorrect wiring can be quite troublesome and will in general require the removal of the socket from the wall; in itself dangerous as well as awkward. This simple and inexpensive easy-to-build device is merely plugged into the socket and tells at a glance if anything is wrong.

START HERE FOR CONSTRUCTION

The circuit is built on a small piece of stripboard 10 strips by 15 holes and then mounted into a standard 13 amp plug. After mounting in the plug base (top not used) the whole assembly is potted in opaque and transparent resin, for safety, protection and good visibility (see photograph and Fig. 1).

The layout of the components on the stripboard is shown in Fig. 2. You will see that components are mounted on both sides of the board.

The resistors are mounted on the unclad side of the board in a suitable position to hang down into the plug cavities. The neons are mounted on the copper side and these lay uppermost in the final assembly.

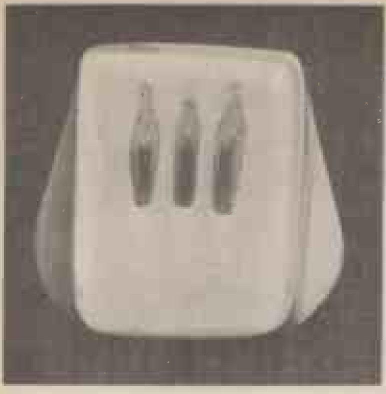
Begin construction by assembling and soldering the components to the stripboard. Do not attach the flying leads at this stage. The plug pins will need to be modified as shown in Fig. 3, the regions to be removed (using a hacksaw and file) shown dotted.

The live pin will differ in design from the other two pins (and from plug to plug) since the top of this is one half of a fuse-holder. Discard the fuse and holder and modify the pin top in a similar manner to the other pins so that when seated in the plug its top sits well into its allotted recess.

CHOOSING A PLUG

When choosing a plug for this project, inspect the live pin to ensure that the pin retaining flange can be maintained after modification, otherwise the pin will slip out of the plug. *It is imperative that this pin can never come adrift from the plug otherwise the possibility of a live pin in the mains socket exists which is highly dangerous and potentially lethal.*

The next stage is to solder a short length of insulated wire to each of the three pins. For this you will need a very hot iron to



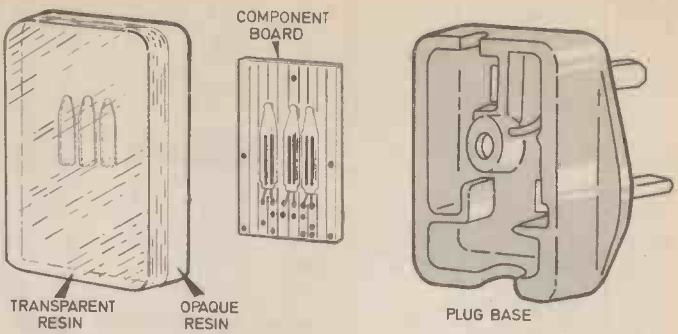


Fig. 1. Exploded view of the Mains Tester showing the two layers of resin and the component board.

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS

£2·20

excluding resin

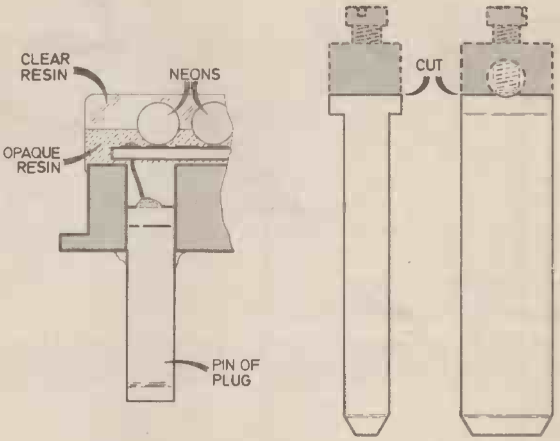


Fig. 3. Method of modifying the 13A plug pins.

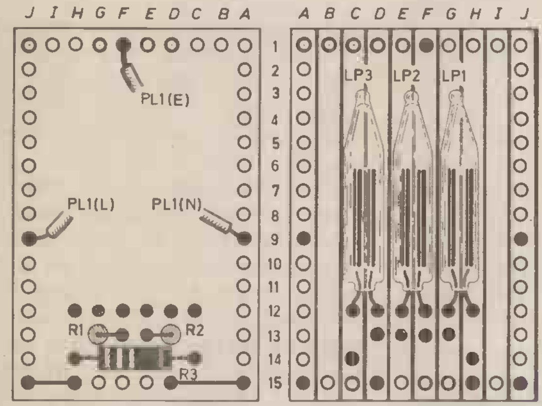


Fig. 2. Layout of components on the stripboard.

MAINS TESTER

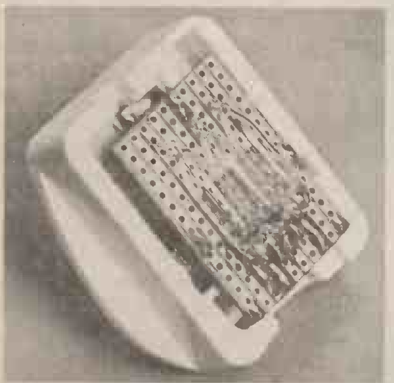
COMPONENTS

Resistors
R1, 2, 3 330kΩ (3 off)
All ¼W carbon ± 10%

Lamps
LP1, 2, 3 70 to 90 volt wire ended neons (3 off)

Miscellaneous
PL1 13 amp mains plug
Stripboard: 0·1 inch matrix 10 strips × 15 holes; potting resin as required (Plasticraft or similar); insulated connecting wire.

See Shop Talk page 433



Circuit board mounted in the plug prior to setting in resin.

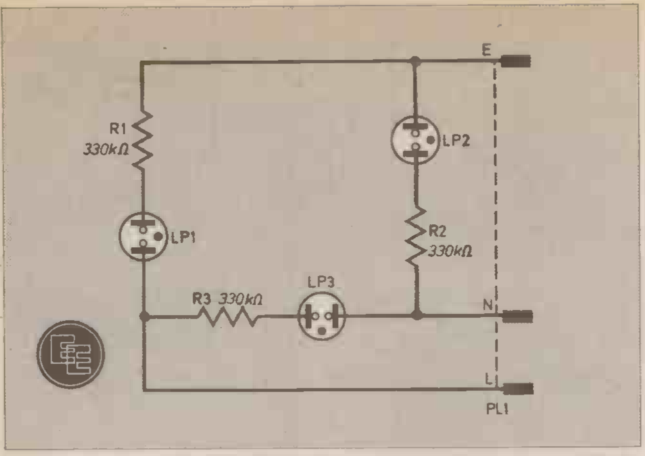
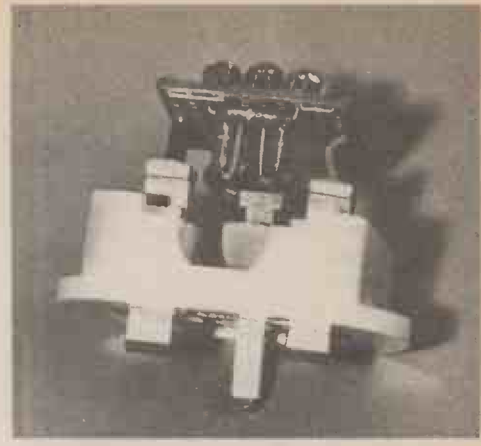


Fig. 4. The complete circuit diagram for the Mains Tester.



Attaching the circuit board to the plug pins.

CIRCUIT DESCRIPTION

The circuit diagram of the Mains Tester is shown in Fig. 4. The circuit consists of three neon lamps connected across the terminals of a plug, each with its own current limiting resistor.

Under normal conditions the lamps connecting live to neutral and live to earth should light. The other one connecting neutral to earth should not light because there should not be sufficient voltage on the neutral wire (60 to 70 volts is required to cause the neon to strike or light).

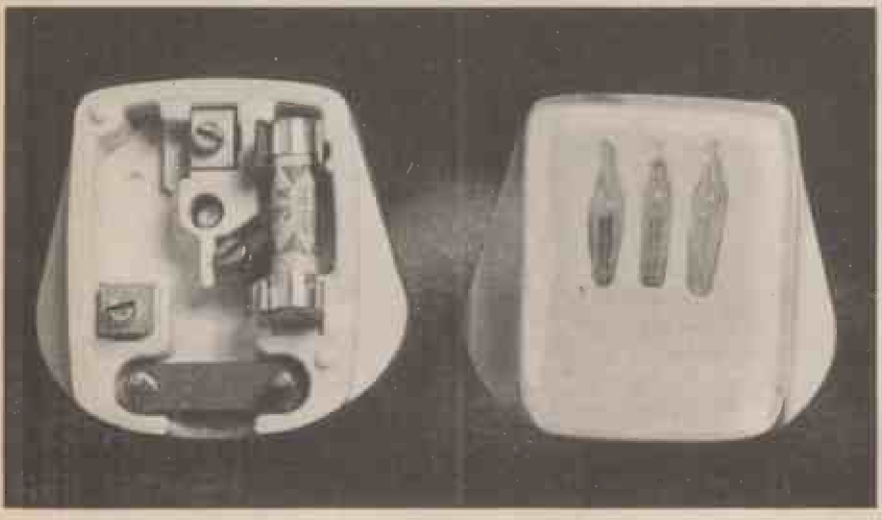
If the earth is open circuit, all three will light because there are two paths from live to neutral. These are live to neutral (LP3) and live to earth to neutral (LP1 and LP2 in series). The neon series resistors are in circuit to limit the current flowing through the neon to a safe level. If omitted, the neons will be destroyed.

avoid dry joints. Make sure that the tops of the pins are thoroughly cleaned before attempting to solder. Tin each pin first. A bad thermal-conductor such as wood needs to be used to sandwich the pins in the jaws of a vice while soldering. Alternatively, a piece of wood with holes drilled in it to hold the pins when laid on the bench can be used.

Insert the pins (with leads) back in the plug and secure with a drop of Araldite or similar adhesive.

Now place the board in position and solder the wires from the pins to the appropriate board positions, see photographs.

The 13A plug before modification is shown on the left and the completed Mains Tester on the right.



RESIN

Next press Plasticine around the pin where it emerges from the plug. This will prevent loss of resin before it sets. Make a wall of Sellotape around the top of the plug, mix and pour in the resin and allow to set. When completely set the Sellotape can be peeled off.

In the prototype both opaque and transparent resin was used, opaque to cover the board and lower half of the neon lamps, and transparent to completely cover the neons. Time must be allowed for the lower resin to set before adding the upper layer. The resin used in the prototype was that available from a Plasticraft kit obtainable from hobby/modelling shops.

USING THE UNIT

When the unit is plugged into a correctly wired mains outlet socket, the outer two neons should light, LP1 and LP3. If all neons light, the live and neutral connections to the socket have been transposed. If the socket incorporates a switch, turn it off. Both neons should go out. If only one does, this indicates that the switch is on the neutral side instead of the live. This situation is more dangerous than no switch at all.

Similar tests can be carried out on multiway adaptors, with the adaptor plugged into a socket known to be correctly wired. The author found that three out of four multiway adaptors in use in his house had faulty earths. ⌑

By Dave Barrington

New products and component buying for constructional projects.

Case

A new type of ready–made case is now being sold by Amatek. The case is mainly designed for digital type projects, e.g. clocks, frequency counters, voltmeters and the like.

It is finished in red vinyl covering and includes a smart removable front panel finished to give the appearance of brushed aluminium. The front panel is already drilled for two sets of push-switches, sockets and various different holes, any unwanted holes being covered by the front panel label.

At the top left hand corner there is a rectangular cutout which allows a four digit display to be used, (the display is not included in the price). However, a specially designed multiplexed display is available complete with a printed circuit board. A red filter is provided in front of the display, which can be removed if required. There is plenty of space inside for mounting printed circuit boards.

Overall the case seems very smart and versatile (within the realms of digital equipment at least), and should make any constructional project look professional. With this in mind we hope to publish in a future issue a design using such a case.

The basic case costs £8·50 and further details may be obtained from; Amatek, Dept. E.E., 22 Bardsley Lane, Greenwich, London SE10 9RF.

Board Mounting Adaptor

It is not always convenient to mount circuit boards vertically in the slots that are moulded in most of today's cases, and in some instances a particularly attractive case has to be discarded for this reason alone.

With this in mind Boss Industrial Mouldings are now producing a plastics p.c.b. guide adaptor for flat mounting circuit boards.

By simply pushing one Bimdaptor on to each corner of the p.c.b., or at closer intervals if weight or vibration could cause problems, the whole assembly can be slid into position on the slots that are normally reserved for vertically mounting circuit boards.

Being plastics, they can be fixed to any part of the board without fear of shorting tracks. Once the board is fully seated in the enclosure the adaptor is simply snipped to the correct height which, if you are wise, should be just below the level of the lid so that the lid will hold the adaptor and circuit board firmly in position.

Each adaptor has ten slots and is sold in packs of 25 for 85p per pack. Available direct or from component stockists, further information can be obtained from Boss Industrial Mouldings Ltd., Dept E.E., Higgs Industrial Estate, 2 Herne Hill Road, London, SE24 0AU.

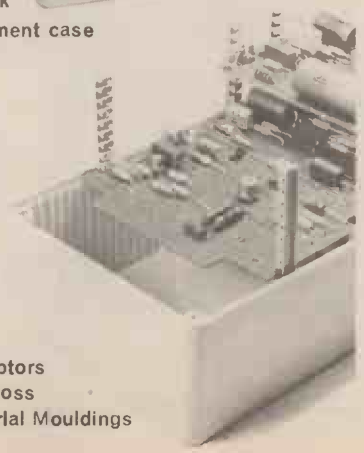
Cordless Soldering Iron

A new version of the Engel Model B.50 rechargeable soldering iron is now being marketed by Kelgray Products.

Complete with charger unit, the iron now incorporates a built-in spotlight to illuminate the working area. Using rechargeable nickel-cadmium batteries, the iron will give up to 100 intermittent operations (350 continuous) without recharging. Recharging time is approximately 8 hours.

A claimed advantage for this iron is that no stray eddy currents, which might damage an integrated circuit, are generated when the iron is being used.

Amatek Instrument case



Bimdaptors from Boss Industrial Mouldings

For price list and further information readers should contact Kelgray Products Ltd., Dept E.E., Kelgray House, Sandy Lane, Crawley Down, West Sussex, RH10 4HS.

Catalogue

We have just received the new Spring 1978 Components catalogue from Marshall's. This years edition contains 40 pages crammed with a vast variety of components from the simple r.f. choke to complete microprocessor evaluation kits.

For 45p post paid (35p to callers) readers will certainly, in the words of this firm, "Get a great deal from Marshall's".

Constructional Projects

This month there are only one or two items that could prove troublesome and need further mention. Otherwise there should be no difficulty in obtaining components, provided, of course, readers check through our advertisement pages first.

Looking at the *Mains Tester* project, any 70 to 90V wire-ended neons, available from many sources, will suffice for LP1-3. This article also calls for a special type of resin obtainable from Plasticraft kits at most model shops. If readers find this material hard to come by you can use Araldite which is available from most good hardware stores.

One point worth mentioning about the *Flashmeter* is the use of an extension lead. The article gives details of making your own extension lead. However, readers can, of course, purchase ready made leads from most photographic shops. The rest of the component for the *Flashmeter* should be readily available.

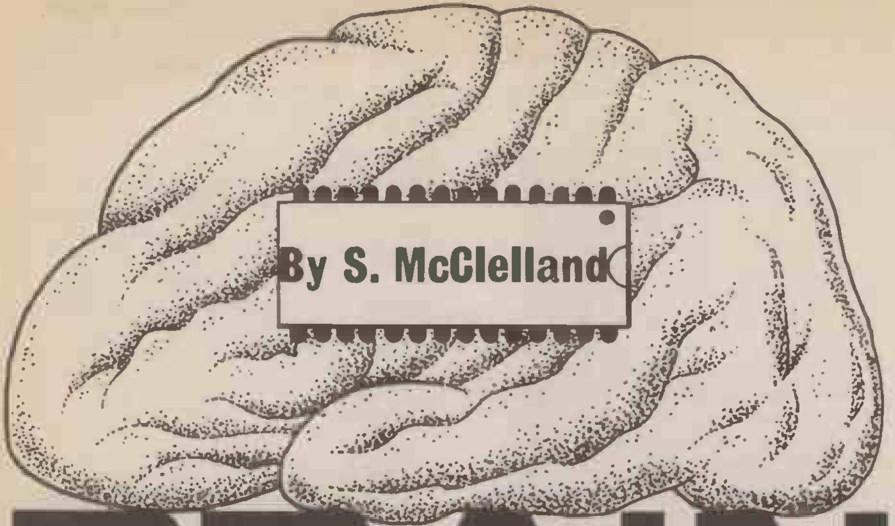
For the *9V d.c. Power Pack* the mains transformer used in the prototype was rated at 12–0–12V 100mA but carried no type number. A suitable transformer is available from Electrovalue, Dept. E.E., 28 St. Judes Road, Englefield Green, Surrey. The cost is £1·57 inclusive of V.A.T. and post/packing. Order as type 1200.

Our star project this month is the *EE Teleplay Stunt Cycle* and there are a few special components called for.

The special modulators, printed circuit board, oscillator coil, front panel and the AY-3-8760-1 integrated circuit are available from Teleplay, see advertisement in this issue.

The case for the t.v. game is a Bimbox type 1005 also available from Teleplay or direct from Boss Industrial Mouldings mentioned elsewhere on this page.

The game selection switches are special anti-bounce types and although any pushbutton types could be used here, we feel that the extra cash outlay is well worthwhile. Teleplay seem to be the only stockist of these switches.



BRAIN ON A GRAIN PART 1

ELECTRONICS will never be the same again—or so the pundits would have us believe. Why?

Because of a device that is finding its way onto the commercial market right now. It's a device so versatile that it will probably affect the design of everything from space satellites to sewing machines in future.

You may even find yourself programming one soon!

It's called a *microprocessor*: a whole computer brain shrunk in size to fit on a silicon chip—quite literally the most integrated of all integrated circuits.

MICROPROCESSOR

Indeed the microprocessor (MPU for short) is not something totally new. It has been brought about by applying existing large scale integration (or LSI) techniques to computers. LSI which gave us pocket-size calculators and electronic clocks has now moved on to give us a computer brain or processor made up of several *thousand* transistors on a silicon-chip less than 0·5 centimetre square!

The cost of this amazing piece of technology? A few pounds only —for like the calculator chips they will be produced in their millions.

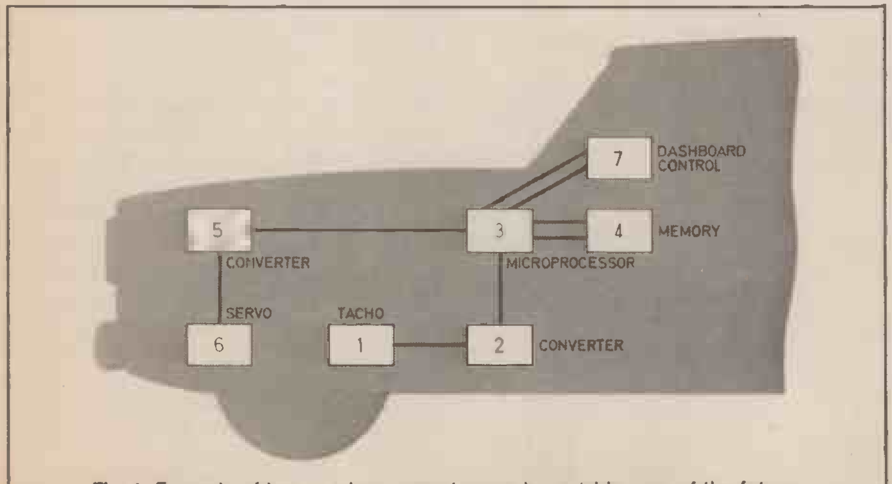


Fig. 1. Example of how a microcomputer can be used in cars of the future.

Although MPUs are made in a similar way to calculator chips, they function quite differently. A calculator chip, once made, is a calculator chip for life (it has a *dedicated* function) but the use to which a microprocessor is put is set by its program and not by its internal circuitry.

You can change its function merely by changing its program, i.e. the set of control instructions supplied to it that tell it to do as we wish with the information (or *data*) at hand.

APPLICATIONS

Here are just a few applications envisaged for the MPU: Traffic Control, Taxi Meters, Petrol Pumps, Cash Registers, Minicomputers, Multi-function Test Gear.

But with the expected drop of MPU prices over the next few years we are likely to see a very wide application for it, even in areas at present little touched by electronics.

How about microprocessors to drive your car when road conditions become hazardous? Or a central heating control system that can function just as well as a burglar alarm, a calculator or even a TV game: in fact a cheap home computer limited only by the ideas of the programmer!

It is not that far-fetched, either. Singer Ltd. have already marketed the world's first microprocessor-controlled sewing machine, the "Singer Futura". And other manufacturers are following suit.

Simpler to use, and more reliable than its mechanical counterpart (the microprocessor replaces 300 mechanical parts), this electronic sewing machine can handle difficult and intricate embroidery with relative ease. Its memory is capable of storing over 500 stitch patterns, 25 of which are available at the touch of a button.

COMPUTER ORGANISATION

All microcomputers, whatever they do, will be organised in basically the same way. Take, for example, the microcomputer speed control in an (admittedly) futuristic car which might well appear on our roads in the not-too distant future (Fig. 1).

The car's actual speed is measured by a tachometer, say, (1) which passes its information in the form of electrical signals through a converter (2) which talks to the MPU in the only "language" it can understand—*binary digital language.* (3)

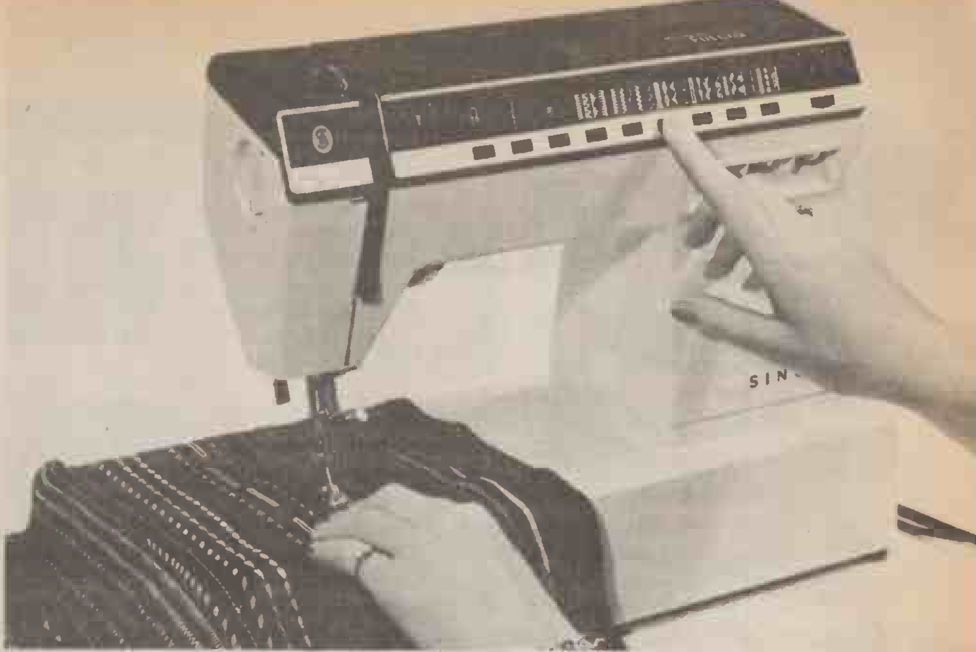
Using this data, the MPU consults the program stored in its memory (4) and compares the car's actual speed with its programmed speed. If the car is travelling too fast, the MPU activates an output device, e.g. a servo (6), to decelerate it via another data converter (5), to keep speed steady.

Data is not fed into the MPU continuously but in samples. The MPU is quite capable of sampling the car speed many times a second if need be, and acting on the result.

Even then, its abilities would not be exhausted, because it works so fast that in the split seconds between doing all this it could be controlling several other systems say, for example, automatically retuning the car radio for best reception, or optimising performance of the car's engine.

It could even be interrupted in the middle of a program if something urgent cropped up and could still return to where it left off in the program when the situation became normal, without any problems.

On top of all this, the driver could probably oversee and override the MPU activities from entirely external controls, mounted on his dashboard, and would have the option of being able to reprogram the MPU if he so wished, (7).



Microcomputer in action, inside the Singer "Futura" sewing machine.

BINARY

To understand what goes on in the MPU itself, however, we first have to understand binary. For the benefit of readers who are not familiar with this we will briefly explain it.

All digital computers—including microcomputers—handle numbers not in decimal form but in binary. In other words, they count in two's rather than tens.

This system, rather cumbersome for humans, is quite convenient for a computer because it needs only two signal levels to operate.

One voltage level (typically a few volts positive or negative) represents the level "1" (or "high" state); the other (usually about 0V) represents the level "0" (or "low" state).

We can use a string of these "1"s and "0"s as *binary digits* (called "bits" for short) to represent a number, where each bit, working leftwards in the string, represents an ascending power of two.

The system works like this. The binary number 1101 is a 4-bit number. The righthandmost bit (called the least significant bit, or LSB) has the lower value of all (1). The second bit position has the value of 2 if high, but the bit is low so its actual value is 0. The third and fourth bits are both high and have the decimal values 4 and 8 respectively while the lefthandmost bit is designated the MSB, or most significant bit. So the decimal value of 1101 is (8+4+0+1) or 13.

The 4-bit binary number can represent absolute values from decimal 0 (binary 0000) to decimal 15 (binary 1111).

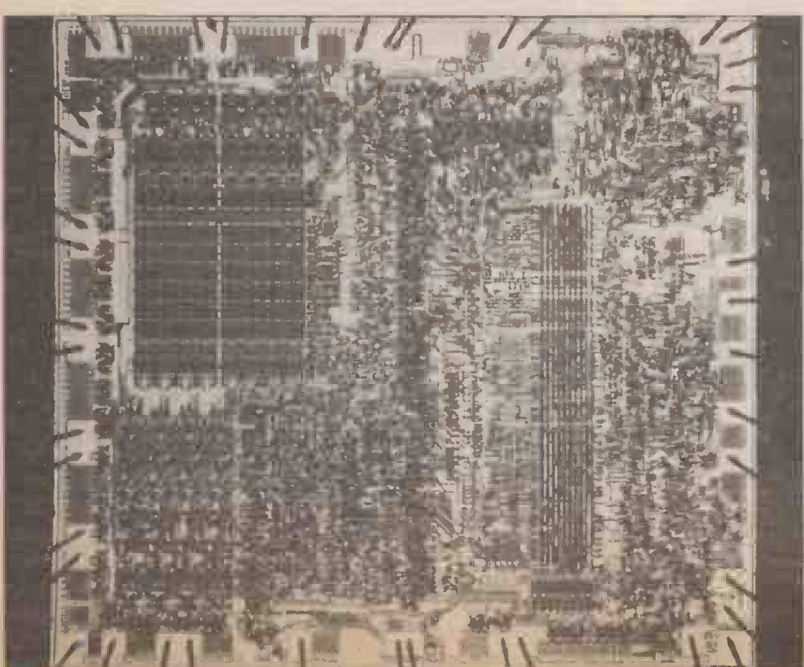
BYTES

Although the 4-bit number-range may seem rather small, there are several 4-bit minicomputers on the market. They overcome the limitations of 4-bit operation by "doubling up" their 4-bit "blocks".

For general purpose use, however, 8-bit MPU's are becoming popular. In computer jargon 8-bit blocks are known as "bytes". The memories of 8-bit MPU's are thus organised into 8-bit bytes. The registers (intermediate storage cells inside the MPU itself) are also either 8- or 16-bit.

To be continued

The complexity of a microprocessor. The actual size of the chip is 0·5 centimetre square!



TEACH-IN 78

Part 8

BY GEORGE HYLTON

POWER—WAVEFORMS—AMPLIFIER MODULE

THIS month the subject of amplifiers will be concluded. A new subject this month concerns power, with particular reference to amplifiers. As power is another essential subject, much the same as voltage, impedance and Ohm's law, a good deal of theory will be discussed. It is therefore essential that this part of the series is really understood and the information presented well and truly digested.

THE OHMS LAW OF POWER

When an electric current flows through a resistance, the temperature of the resistance is raised. An electric lamp is a familiar example. The flow of current through its thin filament raises the temperature to "white" heat.

The resistors in your experimental circuits generate so little heat that you do not notice it. We have deliberately kept the current down in all the designs, to avoid wasting battery power. But heat is being generated on a small scale, whenever current flows.

The heat is a measure of the work which the battery has to do to drive a current through the resistance in a circuit. If the resistance is low, a given voltage can drive a greater current, than through a high resistance. If the resistance is infinitely high, no current flows and no work is done.

It follows that heating goes up in proportion to current. However, if you have a particular resistance, say 100 ohms, so that current does flow, and then double the voltage, the current also doubles. So the heating is proportional to voltage, too.

The amount of heat being produced at any instant is proportional to current times voltage.

POWER

This quantity, current times voltage, is called power. Power is not just an electrical term. It is a mechanical term, too. We say a car engine develops so many horsepower. Or rather we used to, in these metric days we talk of watts, or in the case of cars kilowatts. The watt is a unit named after James Watt who improved the steam engine.

Power means the rate at which work is being done. If a machine works very hard for 10 minutes it may manage to do as much work as another machine would do in say 30 minutes. The first machine has three times the power of the second.

The total amount of work depends of course on how long the power is being produced. This is why your household electricity bill is for, not kilowatts, but kilowatts times hours.

The "unit" of electricity is the kilowatt-hour. An electric fire which consumes 1kW uses one unit in one hour. An electric lamp which consumes 100 watts uses one unit in ten hours.

The ways in which mechanical energy, heat, and electrical energy can be regarded as equivalent to one another in terms of the amount of work they can do were investigated in the 19th century by a physicist, James Prescott Joule. (Pronounced JOOL.)

He showed that mechanical work generates an equivalent amount of heat. Electrical energy also generates heat. For any rate of mechanical working (mechanical power) there is an equivalent rate of electrical working (electrical power).

FORMULAE

Actually the size of the electrical units amperes and volts have been fixed so that the electrical power in watts is:

$$\text{watts} = \text{volts} \times \text{amps}$$

You could hardly have anything simpler than that. If you remember the Ohm's law relationship: Volts $=$ amps $\times$ ohms you will see a certain similarity. And like Ohm's law, the power relationship can be expressed in three ways;

$W = V \times I$ power = volts × amps
$V = W \div I$ volts = power divided by current
$I = W \div V$ current = power divided by volts

Let us now work out the power produced in a 2Ω resistor when 10V is applied. The current is 10V ÷ 2Ω = 5A. So the power is 5A × 10V = 50W.

In electronics we are more likely to be concerned with milliwatts and microwatts.

$V \times mA = mW$: volts × milliamps = milliwatts
$V \times \mu A = \mu W$: volts × microamps = microwatts
$mV \times mA = \mu W$: millivolts × milliamps = microwatts

Engineers do not usually work out power the way we did in the example above. We started with the voltage, worked out the current and then the power. $W = V \times V \div R$ where $V \div R$ is the current.

You can see from this that voltage and resistance are really all that is necessary;

Power = voltage × voltage ÷ resistance =

$$W = V^2 \div R$$

This leads to:

$$V^2 = R \times W$$
$$V = \sqrt{(R \times W)}$$
$$R = V^2 \div W$$

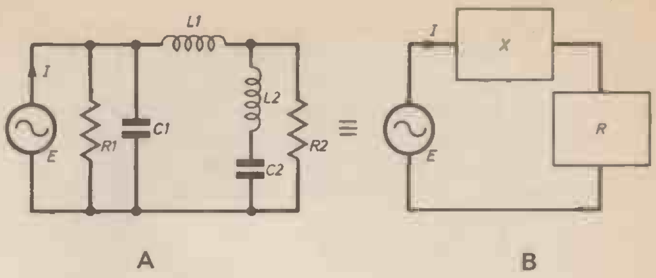
You can also calculate the power if you begin by knowing the current and the resistance. The slow way is to work out the voltage first, from $V = I \times R$ then multiply by the current I. The quick way, without calculating the voltage, is;

$$W = I^2 \times R$$
$$I^2 = W \div R$$
$$I = \sqrt{(W \div R)}$$
$$R = W \div I^2$$

Knowing any two quantities (watts, ohms, amps, or volts) you can work out the third.

POWER FACTOR

In circuits which contain only resistance, the power is calculated as shown above. In circuits which contain only reactance, i.e. are made up entirely of inductance, capacitance, or both, there is in theory *no* power.



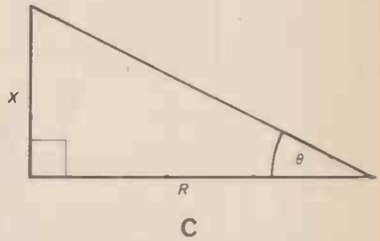


Fig. 8.1a. In this circuit which contains a mixture of resistance, inductance and capacitance, an equivalent circuit can be drawn which will simplify to just one reactance and one resistance as in (b). The cosine of a right angled triangle is represented as in (c).

Inductors and capacitors store energy. They do not dissipate it as heat. However, practical inductors have resistance and practical capacitors have imperfect dielectrics. Both lead to energy absorption, so some power is used up. But ideal coils and capacitors would absorb no power at all.

Life gets complicated when circuits contain mixtures of resistance and reactance, Fig. 8.1a. By some complicated maths, circuits like (a) can be shown to be equivalent to (b) which has *one* reactance X and one resistance R. The power in (b) is not simply $V \times I$ but $V \times I$ times another number which depends on how big the reactance is compared with the resistance.

If the reactance is large compared with the resistance then the circuit is almost a pure reactance which can not absorb power. If X is small compared with R, the circuit is almost a pure resistance which can absorb power very easily. So the extra number has to fix things in such a way that the reduction in power absorption caused by X is allowed for. It is a number between 0 (pure reactance circuit) and 1 (pure resistance circuit).

It is in fact called the **power factor** and is the cosine of the angle θ in a right-angled triangle (c). The cosine is 1 when the angle is zero, i.e. when the circuit contains only pure resistance.

PHASE ANGLE

The angle is called the phase angle because it describes how far the current is out of step with the voltage. You will remember from your work on RC time constants that when you charge C through R the current into C starts high then tails off, while the voltage in C builds up.

In an a.c. circuit this effect leads to a situation where the voltage and current never reach their maximum values at the same instant. One always lags behind the other. In RC circuits the *voltage* lags, in RL circuits the *current* lags.

GENERATOR

A simple a.c. generator produces one cycle of a.c. for every revolution of its spindle. One revolution takes it through one complete circle, which is 360 degrees. You can therefore take one complete period of a waveform such as a sinewave and label it with the angle through which the generator spindle has turned, Fig. 8.2.

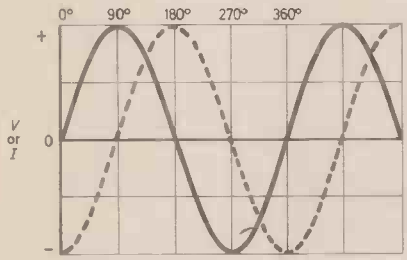


Fig. 8.2. Illustrating phase difference. Here the dotted line lags the wave shown solid by 90 degrees.

This enables you to talk about the phase in terms of angles instead of time.

If another generator is producing voltage or current as shown by the dotted line it can be said to be 90 degrees out of phase with the first one. In the same way, in a.c. circuits, voltages and currents can be out of phase with one another by some angle.

PHASE SPLITTER

One point which should be made is about something more familiar. If an *npn* transistor is driven by a signal of the polarity shown here, Fig.8.3, the collector current i_c flows as shown. This produces voltage drops in R1 and R2. The collector goes less positive and when the d.c. collector voltage is removed by C1 the resulting output is negative.

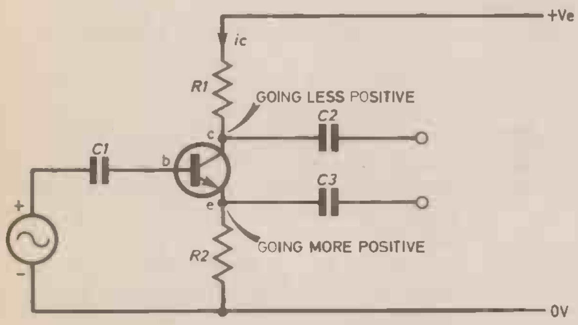


Fig. 8.3. A simple circuit for a phase splitter. If the values of R1 and R2 are equal then equal voltages but 180° out of phase will appear at the respective outputs.

The drop in R2 makes the emitter go more positive, leading to a positive output. The output at the collector is inverted, the output at the emitter is not inverted. In the terminology of phase angles, the emitter is *in phase* with the input, phase difference 0 degrees. The collector is in *anti-phase,* that is, it is 180 degrees *out of phase* with the input.

Note, however, that this 180 degree phase difference is not a true phase difference in one respect. There is no time-lag between the signal going into the transistor and the signal coming out. Actually there is, but it is so small that it is negligible at audio frequencies.

Circuits like this are sometimes called phase-splitters because they produce outputs of opposite polarity. If R1=R2 the output voltages are also equal. Opposite but equal voltages are sometimes needed in electronics. This is a cheap way of producing them.

POWER AMPLIFIERS

Power amplifier usually means an amplifier capable of producing an appreciable amount of output power. It does not mean that power is needed at the input. In general, power amplifiers for audio frequencies have high input impedance and are voltage-driven. There must be some power at the input, of course, but it is very small.

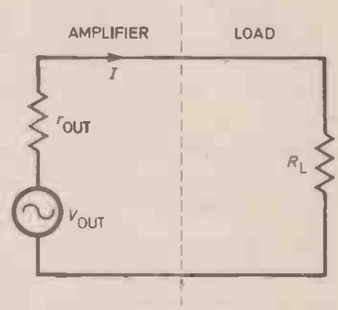


Fig. 8.4. For calculating the output current from an amplifier a simple equivalent circuit as here can be used.

Audio power amplifiers are rated to deliver a specified power to a specified load resistance. The load is usually to all intents and purposes the resistance of a loudspeaker, which is commonly somewhere between 3 and 16 ohms. The correct resistance should be used.

A lower resistance may take more power than the amplifier can safely deliver. A higher resistance receives less than full power. The reason is that nearly all transistor audio power amplifiers have very low output resistances, much less than the proper load resistance. This improves speaker performance. The current drawn from the output, Fig. 8.4, is:

$$I=\frac{\text{Output voltage with no load connected}}{\text{Output resistance}+\text{speaker impedance}}$$

$$=V_{out}\div(r_{out}+R_L)$$

If r_{out} is small compared with R_L, then R_L is what controls the current and therefore the power output. A power amplifier is really a combination of a voltage amplifier and a current supplying stage.

RATINGS

The voltage amplifying section raises the input voltage to the output voltage. The current-supplying source allows this output voltage to appear at the low-impedance load. If, for example, the amplifier delivers 8V to 8Ω, then the current is 1A. The power is 8W. If the input voltage is 100mV a voltage gain of 80 must be provided by the voltage amplifying section.

The limit on output power is often fixed by the maximum ratings of the output transistors, that is the current they can safely deliver and the voltage they can safely withstand. In amplifiers the output transistors, i.e. the current-supplying source, are usually driven by signals so large that on one peak, say negative, they are almost cut off, collector current nearly zero, and on the other peak fully on, collector/emitter voltage nearly zero.

Maximum voltage across a transistor then occurs when its current is zero and maximum current passes through the transistor when its collector/emitter voltage is zero.

The maximum ratings of a power transistor usually refer to these two separate conditions. Ratings of V_{CE}(max) = 100V and I_c(max) = 10A do *not* mean that the transistor can handle this voltage and current *simultaneously*. If it did, the power would be 1000W, or one bar of an average electric fire. In practice a large transistor, fitted with a large cooling plate, can dissipate perhaps 30W. So 1kW, even briefly, would be lethal to it.

WAVEFORMS

A special trick used in most transistor power amplifiers is to reduce the heat generated inside the output transistors to a minimum. The trick is called class B operation. The essence of it is to ensure that when there is no signal an output transistor passes no collector current.

This means that the transistor is not biased on in the usual way. Now, it is inevitable that a transistor operated like this will distort the signal waveform. In the example shown here, Fig. 8.5, only the positive half-cycles of input voltage produce any output current curves (a) and (b).

In an audio amplifier this produces extremely unpleasant distortion. Nothing can be done about this, as far as the transistor we are considering is concerned. But we can have a second transistor, identical with the first, but driven by an anti-phase version of the signal voltage.

The second transistor then passes current, the shaded part, curve (c) during half-cycles when the first is cut off. This still does not reproduce the shape of the input signal and distortion is still very bad.

What must be done is to invert the output of the second transistor and then add it to the first, as in curve (d). This is a fairly close copy of the input. The difference lies at points where the input is nearly but not quite zero, where little "flats" appear in the output wave.

The reason for them is that, as you know, a transistor passes no current until its base voltage is above a certain value. So small input voltages are lost.

This may not seem important, but it is. Speech and music consists very largely of small sounds mixed up with the bigger ones. In speech, for example the consonant sounds are mostly of low intensity, it is the vowels that make the noise. Removing these low-intensity portions has a quite disastrous effect. This is called crossover distortion.

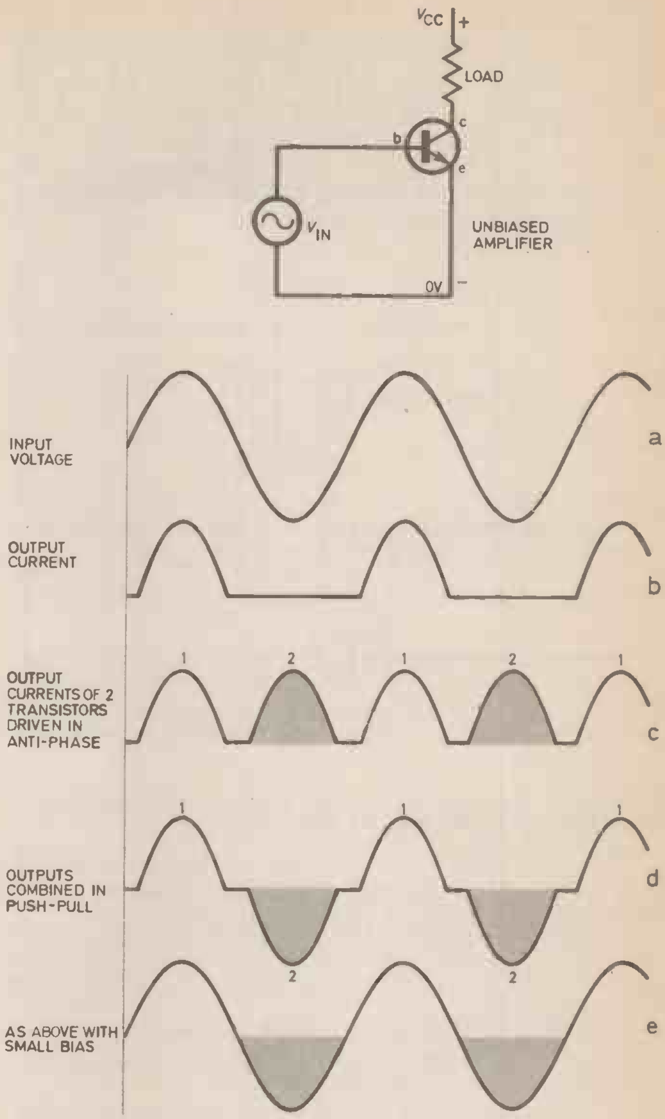


Fig. 8.5. A simple class B amplifier with an input waveform as shown will only produce the positive half cycles as in (b). If two similar transistors are used and their outputs added the waveform in (c) is produced. If however one of the outputs is inverted and added, the waveform shown in (d) will be the result. With a small bias a satisfactory output as in the last curve will be produced.

The remedy is to bias the transistors so that they normally just conduct all the time, passing a few milliamps. The smallest signals are then amplified satisfactorily.

PUSH-PULL STAGES

Output stages in which two output transistors, or other devices for that matter, such as valves, operate alternately in this way are called push-pull output stages. Early transistor amplifiers used germanium *pnp* transistors for the output, and transformers to do the phase splitting of the input voltage and combination of the outputs in the required way.

Such an amplifier but using *npn* transistors, is illustrated in Fig. 8.6.

All the resistances except the load R_L (the loudspeaker impedance) are concerned with biasing and can be ignored. Suppose the input signal has the polarity shown, Fig. 8·6. The transformer T1 produces two outputs as shown. Here V1 turns on TR1 and V2 simultaneously turns TR2 off. The resulting phase-inverted a.c. output currents are as shown. The windings on the output transformer are arranged so that opposite changes of current in TR1 and TR2 produce same-direction currents in the load.

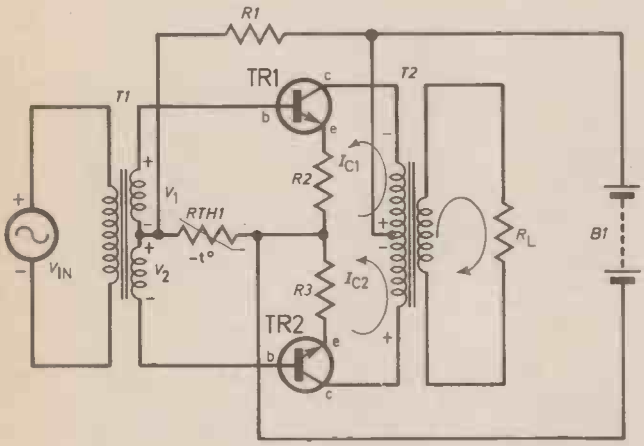


Fig. 8.6. Although this circuit seems complicated, the operation is quite easy to understand providing note is taken of the direction of currents.

For a large input, TR2 is cut off but TR1 goes on working. On the next half cycle all polarities of signal are reversed, TR2 conducts and the load current is reversed, as required to reassemble the signal waveform correctly.

The bias arrangement should remind us whether biasing a transistor with a voltage is a good idea or not. The answer is, generally no.

A small error in the voltage produces a large change in the current through the transistor. Also, different specimens of transistors of the same type have slightly different base/emitter characteristics, so a fixed base bias of say 600mV will not set up the same collector current in different transistors.

Also, the effect is temperature-dependent. As the temperature rises the same V_{BE} produces more current.

BIASING

Despite these snags voltage biasing is used for power amplifiers, because it has one crucial advantage. It puts very little resistance in the base/emitter circuit. This is important in power stages where the base currents due to the input signals have to be large. Resistance uses up signal voltage. Current biasing cannot be used, either because it involves high resistances or because the associated capacitors charge up when signals are applied. The result is always to bias the transistor the wrong way, beyond cut-off.

To reduce the effect of temperature it is usual to derive the bias voltage from a source, RTH1, which itself varies with temperature in the right way to keep the current constant. This source can be a negative temperature coefficient (n.t.c.) thermistor (a resistance which goes down as its temperature rises) or a transistor or semiconductor diode.

This system only works properly if the bias source is warmed by the output transistors, so that it is at the same temperature. Small-value emitter resistances, R2 and R3, are also used, partly to provide some d.c. negative feedback for stability and partly to provide a.c. negative feedback which reduces the effects of differences between the two transistors.

There is a real danger that if R2 and R3 are too small the transistors may "run away". That is, get warm, take more current, get warmer, take still more current and so on, until they are destroyed by internal heating.

Transformer-coupled push-pull amplifiers are not used much nowadays, partly because transformers are expensive and create problems in using negative feedback.

Nearly all low power amplifiers use a clever kind of output stage which dispenses with transformers.

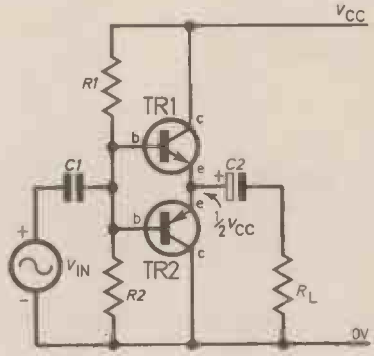
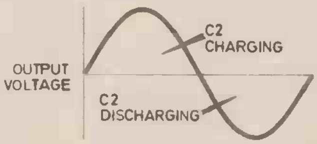


Fig. 8.7. A basic complementary output stage. Although both transistors should be identical with respect to their ratings, one should be *npn* and the other *pnp*.



Forgetting for the moment about biasing, the basic circuit Fig. 8.7, has two transistors in series across the power supply. The transistors should be identical in current gain and ratings, but one is *npn* and the other *pnp*. The load is connected via a large capacitance C2 which allows free passage to a.c. to the speaker and also charges up to half the supply voltage as shown.

COMPLEMENTARY STAGES

An *npn* transistor is turned on by a positive voltage on its base and off by a negative voltage. The reverse is true for a *pnp* transistor. Here the signal is applied simultaneously to both bases.

In the half cycle whose polarity is marked, TR1 is turned on and TR2 off. This allows C2 to charge to something near V_{cc}. The charging current flows through the load R_L.

On the reverse half cycle TR1 is off and TR2 on, capacitor C2 then discharges via TR2 and R_L, the current now going in the opposite direction through R_L, as required. So this **complementary output** stage (*npn* plus *pnp*) does the work of both the transformers in the earlier circuit.

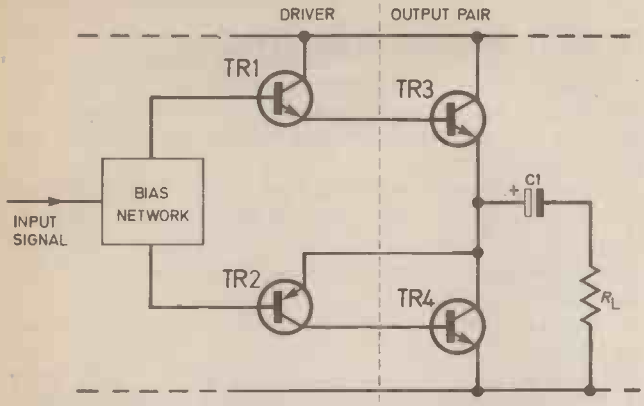


Fig. 8.8. If higher power is required from a complementary stage it is usual to use a circuit similar to that shown here. In this instance the circuit is called a quasi-complementary stage.

Amplifiers for higher power often use a **quasi-complementary circuit** in which both **output transistors** have the same polarity but are driven by a complementary pair. Fig. 8.8. Many variations exist but the basic principle is the same.

PRACTICAL POWER AMPLIFIER

For your power amplifier we shall use the low-power transistors with which you are familiar. Consequently the power output will be low, but enough to drive your speaker.

The circuit Fig. 8.9 looks complicated, but will yield to analysis.

First, the bias conditions. All the transistors are connected directly (collector of one stage to base of next) so a d.c. input to the first transistor is amplified by all stages. But the d.c. voltage at the output is fed back to the input as negative feedback (via R6).

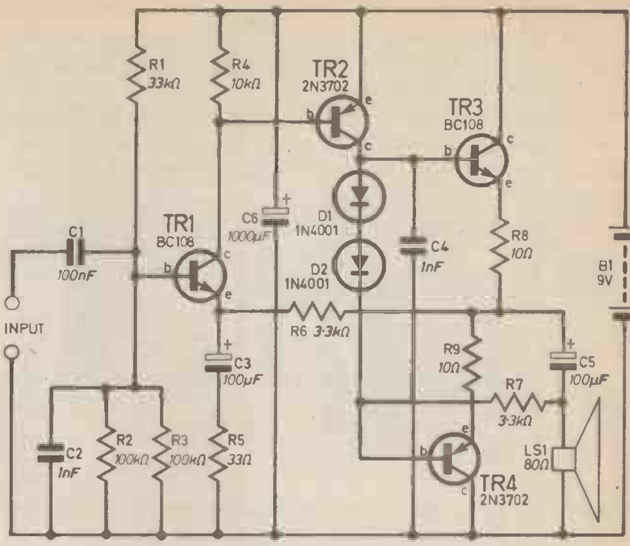


Fig. 8.9. The complete circuit for a practical amplifier. Again the circuit may look complicated but if thought about carefully can be broken down into sections quite easily.

When all the output is fed back like this the gain of the amplifier is 1. This means that the output voltage is the same as the input voltage. Actually there is a slight difference because there are two voltage drops in the feedback path; the base/emitter of TR1 and the drop in R6 due to the emitter current of TR1. So to adjust the d.c. voltage at the output stage emitters to $\frac{1}{2}V_{cc}$, the voltage at TR1 base must be more than 4·5V.

If all the a.c. output voltage were fed back the a.c. gain would also be 1. In practice a higher gain is required, say about 100. So R5 is added to form an a.c. voltage divider with R6, feeding back about 1/100 of the output.

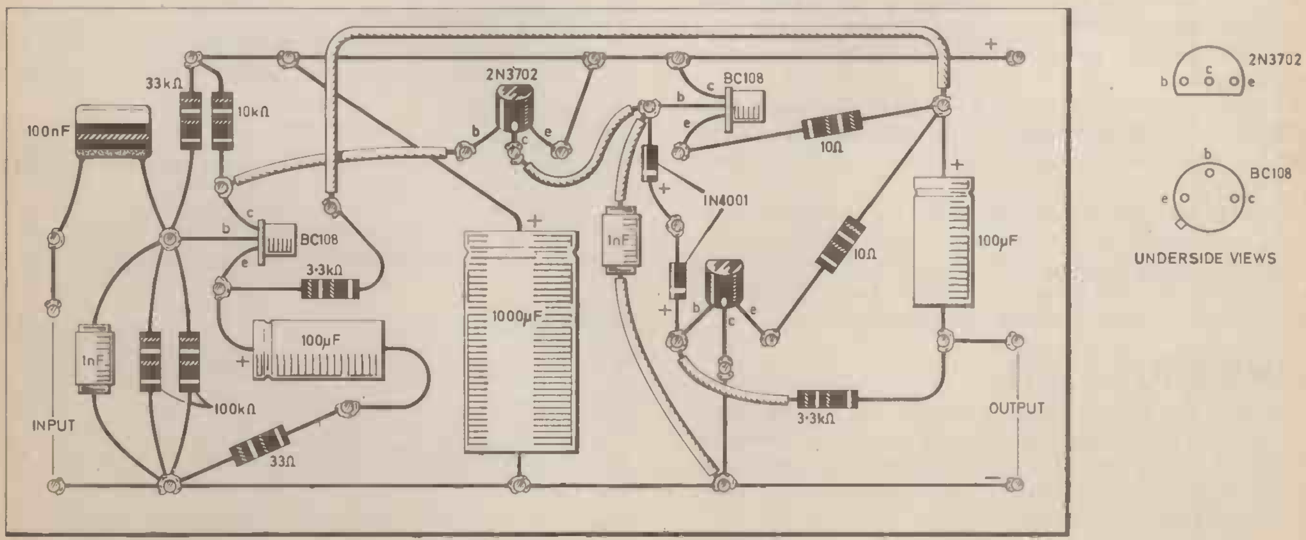
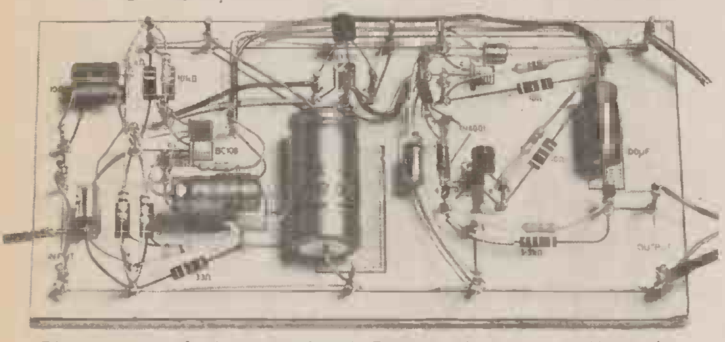


Fig. 8.10. Covercard required for the POWER AMPLIFIER. This is reproduced full size and may be traced directly.

The way in which R7 is connected to the loudspeaker is another sort of feedback. If the bases of the output transistors are driven positive, the output across the speaker also goes positive. This takes the lower end of R7 positive.

We now have the curious situation that *both* ends of R7 are driven positive by the signal. If both ends were *equally* positive there would be no a.c. voltage



Photograph of the completed POWER AMPLIFIER. Note the screened lead used for the input connection.

across R7 at all, therefore no a.c. current flows through it. Thus, the a.c. current of TR2 must all be going into TR3 and TR4, where it is wanted. This sort of feedback is called **bootstrapping** and is used in various forms in most amplifiers.

The output current must pass through a 10Ω resistor on its way to the speaker. So the real load is 90Ω, and the speaker therefore receives 80/90 of the output power. If the output voltage is 4·5V peak the total power $V^2 \div R$ is $4{\cdot}5 \times 4{\cdot}5 \div 90 = 0{\cdot}225$W, of which the speaker receives 200mW.

You may have wondered what C2 and C4 are for. These capacitors have no audio frequency function. They are there to prevent high-frequency instability.

In a previous part of the series you built a phase-shift oscillator in which the output of an inverting amplifier was fed back through a triple *RC* phase shift network which inverted the phase at one frequency and so turned negative feedback into positive feedback.

Well, this can happen by accident in *any* amplifier with negative feedback, especially a multi-stage amplifier. Phase shifts happen in transistors and couplings, largely because all circuits contain stray capacitance.

To counteract this it is helpful to connect one relatively large capacitance C4 to attenuate the high frequencies at which the stray phase shift is near 180 degrees.

The capacitance across the input C2 prevents oscillation when nothing is connected to the input.

It also attenuates stray high-frequency signals, such as signal from the local TV transmitter, which can get "detected" and cause audio interference.

CONSTRUCTION

We have purposely given the theory of the amplifier first, so that when constructing the amplifier a clearer idea is obtained of what each component does and why it is used, rather than just soldering the components in place because it says so.

In this way it is hoped that you will develop a mind which questions even the most simple of circuits and the credibility of each component. If you think like this, then understanding a complex 100W amplifier will be no problem after the series has ended.

The layout and card required for the amplifier is shown in Fig. 8.10. Once completed it can be used in future experiments and kept for further use after the series has ended.

ROOT MEAN SQUARE

At this point forget about amplifiers for a while and think again about power. In an a.c. circuit the voltage and current are periodically varying, so the power is varying too.

What we worked out just now was the *peak* power. But in practice we may want to know average power. One way of dealing with this problem is to find out what amount of purely d.c. power would have the same heating effect as the a.c. power.

This d.c. power is then equivalent to the average a.c. power. This particular approach leads, for sine wave signals, to the conclusion that the average power is half the peak power. In amplifier specifications peak or average power may be quoted. The average power is called the r.m.s. (root mean square) power.

If you are using the formulae for power which have voltage or current separately then the r.m.s. sine-wave power is obtained by taking V and I to be 0·7 of their peak values. Also to find the peak value of V or I sine waves when you know their r.m.s. value, multiply by 1·414.

QUESTIONS

8.1. A 10 ohm resistor passes a current of 2 amp. The power is;
a. 5W
b. 20W
c. 40W

8.2. An amplifier delivers 100W into a 4Ω load. The output voltage of the amplifier is;
a. 25V
b. 20V
c. 400V

8.3. If voltages are in anti-phase their phase difference is;
a. 180°
b. 360°
c. 90°

8.4. A transistor can safely dissipate 8W when mounted on a particular heatsink. If the supply voltage is 40V d.c. what is the maximum permissible direct current;
a. 5A
b. 200mA
c. 320A

8.5. A mains transformer delivers 100V r.m.s. Its peak output is approximately;
a. 140V
b. 70V
c. 200V

ANSWERS

7.1. 1000μF (a)

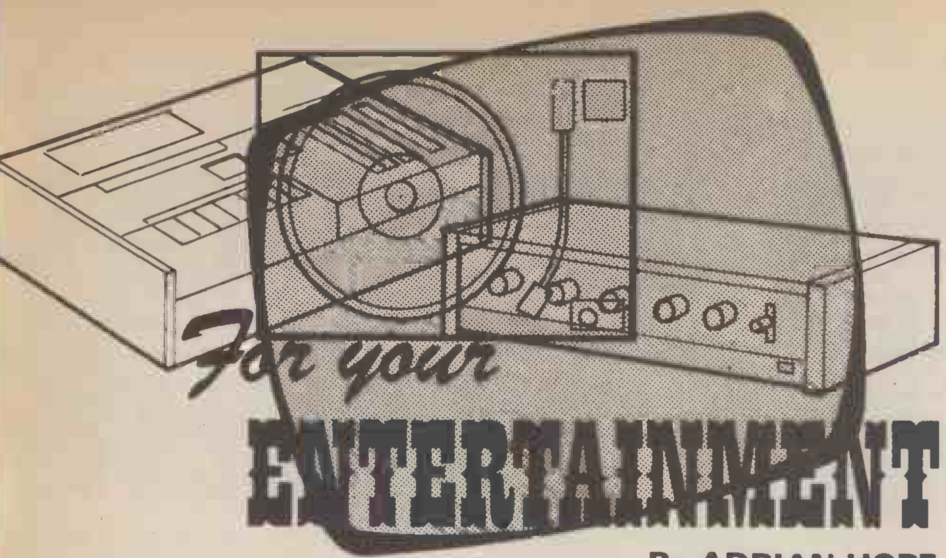
7.2. 25Ω (a)

7.3. an electric current (b)

7.4. resistors (c)

7.5. a high *Q* and small bandwidth (a)

Next month a new subject will be introduced, that of RADIO.



For your ENTERTAINMENT

By ADRIAN HOPE

Videotape

Have you ever noticed why some commercials on television look "cheaper" than others? It's almost always because they were made using videotape rather than film. But is it really necessary for videotape to look cheaper than film?

It's all to do with lighting. When you use film you have to use a great deal of light and everything looks very, very crisp, sharp and bright. But a lot of light costs a lot of money, and it's easy to shoot videotape with rather less light.

In fact using minimum lighting has become something of a tradition, some of the TV companies having mains load limit warning systems. These flash and sound if sufficient light is used to take them over the level agreed with the local electricity company as maximum load. And over that level they start paying a good deal more than the negotiated cut rate for their electricity. But if you shoot videotape using as little light as you can get away with, then it quite simply looks that way—cheap.

As one London agency has already proved with a test film, if you pile enough money and light into a videotape production it can be indistinguishable from film. The trouble is that a vicious circle has been created. Videotape has been thought of as a cheap medium, so it's been used as a cheap medium and looks like a cheap medium.

It will be interesting to see who has the guts to break the vicious circle, by spending enough money on a videotape programme or commercial to conceal the fact that it is in fact videotape.

A Passive Switch

A trend in professional sound studio equipment may well be of interest to amateur electronics enthusiasts.

As studio sound mixing desks get more complicated, so the number of switches needed inevitably increases. Although it is obviously useful to have each switch signalling its on/off state visibly, a very real problem arises if signal lamps are used.

They cost a lot of money, drain a great deal of current from a desk supply, and sooner or later need replacement. If you have a thousand or more switches and lamps (which is normal) then statistics say that almost every day you will need to change at least one lamp.

The answer which is now being adopted by studio equipment designers is to install *Schadow* "passive" illuminated switches. These take the form of ordinary, push button switches which, instead of incorporating a lamp, have a coloured reflector and a lens that focuses light onto the reflector whenever the switch is in an "on" position.

Usually pushing the switch "on" opens a shutter window to achieve this. The result is highly impressive. As the window opens the coloured reflector comes into view to signal the change of switch position.

They use no power, and generate no heat. There is no lamp to burn out and no extra wiring at the time of installation.

Although Schadow is a German firm, it is closely allied to British ITT, whose switch division is at Rhyl, North Wales. Prices per batch of 1,000 work out at about 35p per switch.

You can't buy direct from the factory, of course, but it's worth watching out for a component dealer who stocks them.

Identi-clips

In studios it's absolutely crucial that cables be readily identified, for instance if one of a whole bunch of microphones suddenly starts giving trouble.

Different studios use different identification techniques, and the one most readily adaptable to domestic use, for instance for labelling the leads into and out of a hi fi system, is that marketed by Critchley Bros of Brimscombe, Stroud, Gloucester.

These take the form of C-shaped clips that are embossed with a code letter or number and come in a variety of sizes, so that they are a tight snap fit over audio or mains cables.

To identify a cable, you simply snap-fit two clips, each with the same identifying letter and number, on a cable, one over each end. It's a delightfully simple way of doing a necessary job.

Light Help

At the time of writing there is much cufuffle over light bulbs and the discrepancy between their rated and actual life. But everyone seems agreed on one thing, namely that to over-run a lamp by just a few voltage per cent can shorten its life dramatically.

This prompted a colleague to check the voltage in his home. Although rated at 240 volts he found he was consistently getting 247 volts. This is of course quite legal under the 6 per cent deviation laws but in the light of the light bulb controversy, highly significant. He is now hunting for a regular supply of 250 volt bulbs.

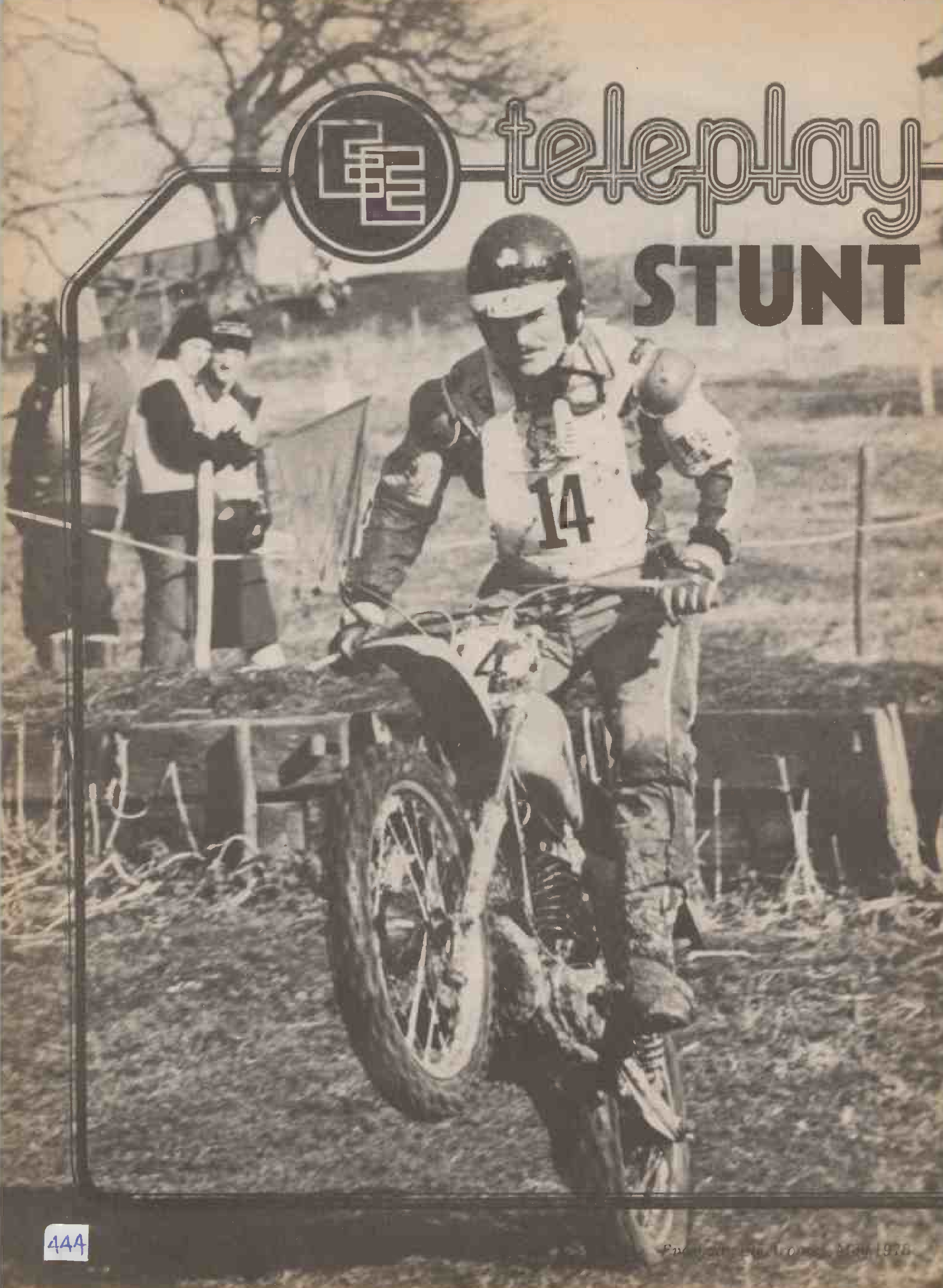
It occurs to me that readers of EVERYDAY ELECTRONICS might like to help each other on this. I'll bet that quite a few readers have voltmeters and can thus quite easily check their mains voltage a few times over the next week or so, and so find out how the actual supplied voltage compares with the rated supply. If readers will let me have any results c/o our editorial address, I'll collate and publish them.

First impression is that the electricity authorities find it easier to stick within the 6 per cent limits if they tend to average an excess of about 3 per cent which "soaks up" any drops due to heavy loading during peak periods. But if this is so, and the claims relating drastically reduced lamp life to slight over-running are justified, then we would all do better to buy only bulbs which are intended for a voltage in excess of our rated supply.

Finally

Thanks to Sharp (best known for it's calculators but now moving into the hi fi area) for brightening my day. The instruction book which comes with the CT-550 calculator helpfully explains what all the little symbols on a calculator readout means. AM it seems means anti-meridiem—I assume they mean meridian but let's not nit-pick. It's PM that fascinates me. This, say Sharp "indicates that the time displayed is post-mortem".

teleplay STUNT



IT'S THE LATEST!

CYCLE

By C. Cary

ONE of the very latest TV games, Stunt Cycle is really four games in one. It is for one player and will provide endless fun. It offers a challenge to the individual's reaction and skill without any dependency upon a co-player as required in many other TV games.

Stunt Cycle is based on the microcircuit chip AY-3-8760—one of the latest second-generation designs from the leaders in this field, General Instrument Microelectrics Limited.

This article describes a complete unit based on this chip which can be assembled in a small plastic case. A 9V d.c. supply is required. A suitable design for a mains operated unit is included elsewhere in this issue. Alternatively, a readily available commercial mains adapter can be used.

THE CONTROLS

Connection is made to the television receiver at the aerial socket. The output from the Stunt Cycle is on the Channel 36 frequency. This has been chosen because it is not used in Europe by broadcasters.

Four pushbuttons are provided for game selection. An easy or *amateur* mode of play, or a hard or *professional* mode of play can be selected by a toggle switch.

The game is played using the Throttle Control. Authentic motorcycle noises are reproduced over the television speaker, varying as the "throttle" is adjusted. Other sound effects indicate hits, crashes and successful jumps. The score is displayed near the top of the screen.

GAME DESCRIPTION

At the start of each game, the motorcycle and rider are stationary at the upper left-hand side of the TV screen. As the player turns the throttle, the motorcycle and rider move across the screen on track 1.

The motorcycle sound starts with the movement and as the cycle and rider accelerate, the motorcycle sound reflects these speed changes. The motorcycle wheels have an appearance of rotating at a speed also related to throttle setting.

At the end of track one, the cycle and rider reappear on track 2, at the left-hand side, and likewise at the end of track 2 the cycle appears on track 3 at the left-hand side of the screen.

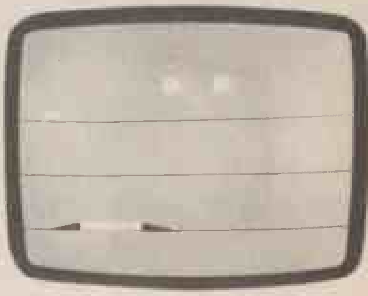
The movement of the cycle and rider on track 3 to the right edge of the screen will cause a reinitialisation of the cycle and rider at the left of the screen on track 1. There will be no movement until the throttle is reset to a slow speed and then increased.

The four games are now described.

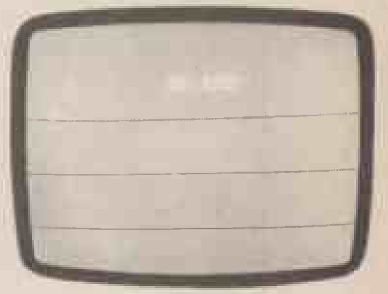
STUNT CYCLE

The basic game is Stunt Cycle. The object of this game is to control the throttle speed so as to jump properly the ramp and buses located on track 3. The game begins with 8 buses. With each successful jump over the ramp and buses, an additional bus appears.

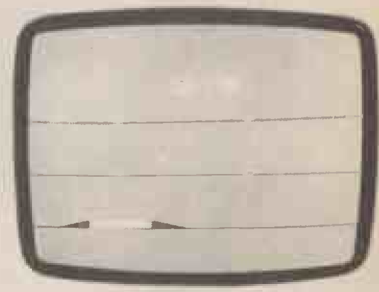
The game is over when the maximum number of errors has been exceeded, which is 3 or 7 errors depending on the position of the



STUNT CYCLE



DRAG RACE



SUPER STUNT CYCLE

MOTOCROSS

◀*Norman Barrow in action at ITV MotoCross—photographer Nick Nicholls*

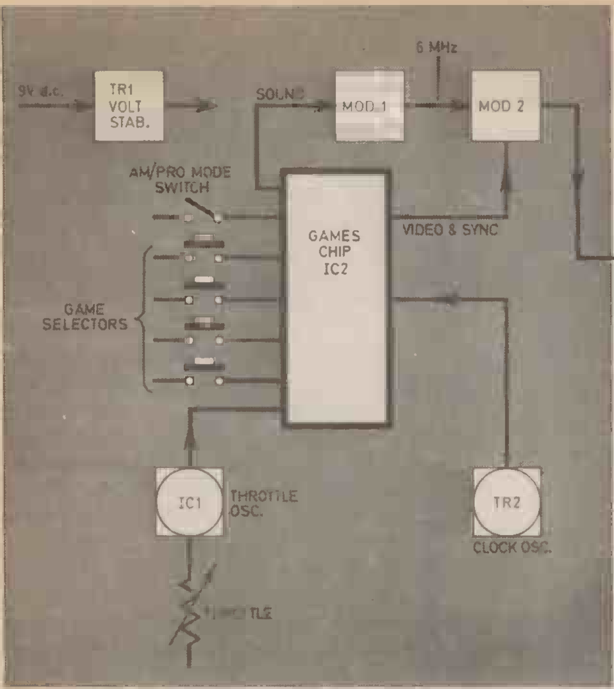


Fig. 1. Block diagram of the EE Teleplay Stunt Cycle Game.

AM/PRO switch or when 36 buses have been jumped, in which case the screen will fill up with buses. The game is then started by pressing the Stunt Cycle game button.

Errors are caused by accelerating too rapidly, insufficient speed to clear the buses, or landing too far past the back ramp after the jump. The cycle and rider flip upside down and a screeching sound indicates an error. The score records the errors in the first digit and the number of displayed buses in the next two digits.

DRAG RACE

The object of Drag Race is to reach the end of track 3 in the shortest time. The three-digit score is automatically reset as the rider first begins to move on track 1 and the score is incremented until the game is over. The score appears centred on the screen above track 1, and the score remains until the start of the next game.

Drag Race requires a speed shifting to achieve the lowest time scores. As the throttle speed is increased and the rider begins to move, the cycle object is in speed one and moves at a set rate across the screen.

The only way to accelerate the cycle object motion is to return the throttle to a "slow" position and then turn to a "fast" position. This shifting procedure will move the cycle into speed 2 and the object will go across the screen at a faster rate. Another "shift" will allow speed 3.

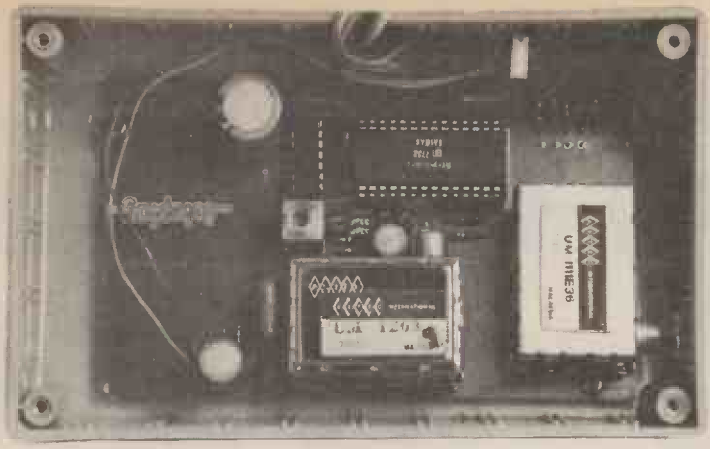
The AM/PRO option switch provides a difficulty factor. In the hard mode, a crash occurs if the player tries to increase the throttle speed too rapidly. A crash will flip the cycle and rider upside down and the sound will be a high-pitch screech. At the end of the crash, the cycle and rider are reinitialised on track 1 and the score reset. In the easy mode, no crash is allowed.

SUPER STUNT CYCLE

The third game is similar to Stunt Cycle with the addition of obstacles on track 1 and track 2. The object of Super Stunt Cycle is to do a "wheelie" over each obstacle and then adjust the throttle for the correct speed to jump the buses on the track 3.

The AM/PRO option switch selects one obstacle per track and allows 7 errors per game in the easy mode, and 2 obstacles per track and 3 errors per game in the hard mode.

Errors are caused by accelerating too rapidly, not in wheelie position over the obstacles, insufficient speed to clear the buses, or landing too far past the back ramp after the jump. The score records the number of errors and the number of buses displayed the same as in the game of Stunt Cycle.



The completed p.c.b. assembly.

COMPONENTS

Resistors

R1	15kΩ	R10	2·2kΩ
R2	100kΩ	R11	2·2kΩ
R3	100Ω	R12	2·2kΩ
R4	1kΩ	R13	220kΩ
R5	1kΩ	R14	1kΩ
R6	100Ω	R15	1kΩ
R7	100Ω	R16	2·2kΩ
R8	220kΩ	R17	2·2kΩ
R9	2·2kΩ	R18	470Ω

All resistors are carbon $\frac{1}{8}$W ± 5%

Potentiometer

VR1 10kΩ lin. carbon

Capacitors

C1 220μF single-ended elect. 10V
C2 100pF ceramic plate
C3 33pF ceramic plate
C4 820pF ceramic plate
C5 33pF ceramic plate
C6 220μF single-ended elect. 10V
C7 0·18μF met. polyester film, 20%
C8 100pF ceramic plate
C9 100μF single-ended elect. 6V

Semiconductors

IC1 CD4069 CMOS hex inverter
IC2 AY-3-8760-1
TR1 BC182 *npn* silicon
TR2 BC182 *npn* silicon
D1 BZY88C Zener diode 8·2V 400mW

See Shop Talk page 433

Miscellaneous

L1 100μH tunable choke in can (Weyrad)
SK1 miniature jack socket
SK2 part of MOD1
SK3 part of MOD2
S1 Miniature s.p.s.t. toggle switch
S2–5 pushbutton switch (4 off)
MOD1 Sound modulator UM1263 (Astec)
MOD2 Vision modulator UM1111E36 (Astec)

Printed circuit board, (Teleplay, 14 Station Road, New Barnet, Herts.); i.c. sockets: 28-way (1 off), 14-way (1 off); 5in length 10-way ribbon cable; length Systoflex 1mm sleeving; knob; aerial connecting lead; plastic case (Bimbox No. 1005); panel; mains adaptor unit 9V 100mA output. Screws: 6BA × $\frac{3}{8}$in (4 off); Self-tapping No. 4 × $\frac{1}{4}$in. (2 off).

MOTOCROSS

The object of Motocross is to traverse the three tracks in the shortest time, doing a wheelie over each obstacle. The score counters record the run time in the same manner as the Drag game.

As the throttle is increased, the cycle and rider move across track 1, at a rate determined by the throttle control setting. Motocross has no speed shifting. Located on each of the three tracks are obstacles. The AM/PRO option switch selects the number of obstacles per track. The easy mode has one obstacle per track and the hard has two obstacles per track.

In Motocross, the crash is not caused by accelerating too rapidly. The crash is caused by not doing a wheelie over the obstacle. In the wheelie position, the cycle will have the front wheel lifted off the track. A crash into an obstacle will flip the cycle upside down and produce the screech sound. The score is reset at the end of the crash.

START HERE FOR CONSTRUCTION

IMPORTANT

The Games Chip and the hex inverter chip are normally supplied mounted on a piece of foam polystyrene and wrapped in metal foil. This protects these devices from mechanical and electrostatic damage. Do not remove or handle these components until ready to fit into sockets (see later).

PRINTED CIRCUIT BOARD

The main assembly is built on a p.c.b. A full-size drawing of this is given in Fig. 4. The overall dimensions of this board should not be exceeded if the suggested plastic case is to be used.

Mount and carefully solder into their correct positions all circuit components. It is advisable to double check components and locations before soldering. The following sequence of operations is suggested.

teleplay STUNT

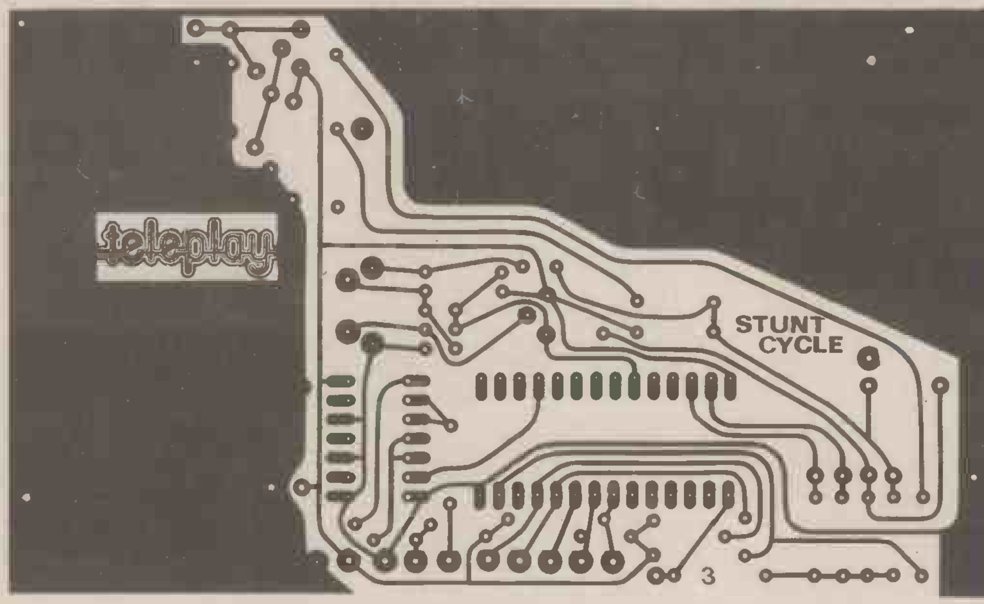


Fig. 4. Full size diagram of the Stunt Cycle printed circuit board (copyright).

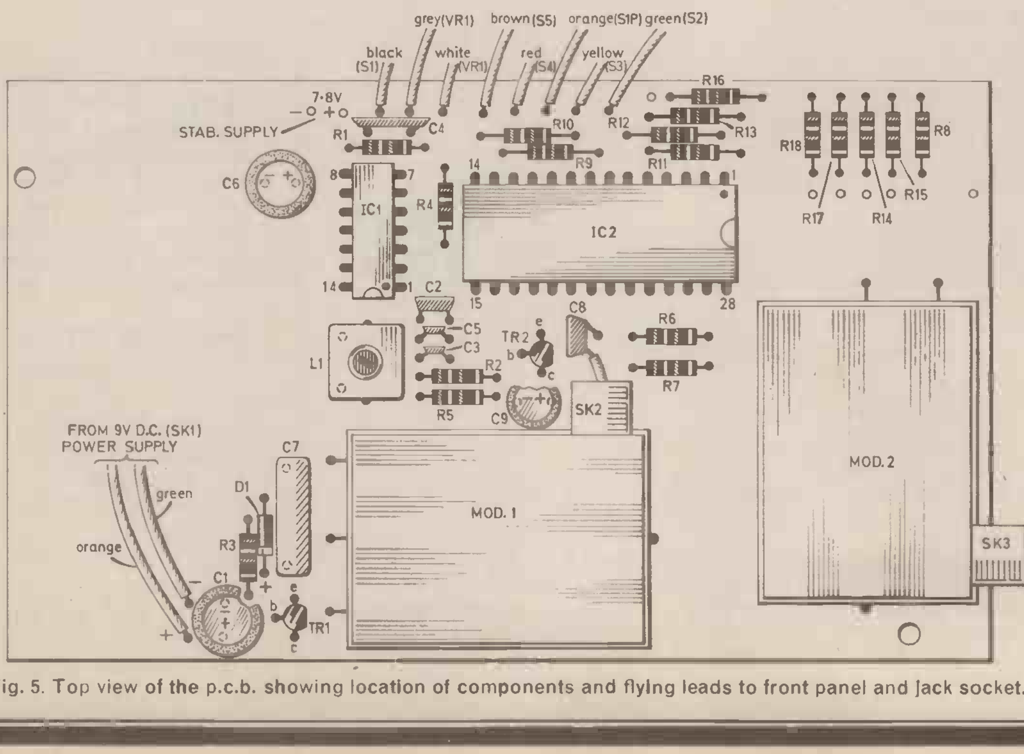


Fig. 5. Top view of the p.c.b. showing location of components and flying leads to front panel and jack socket.

IT'S THE LATEST!

CYCLE

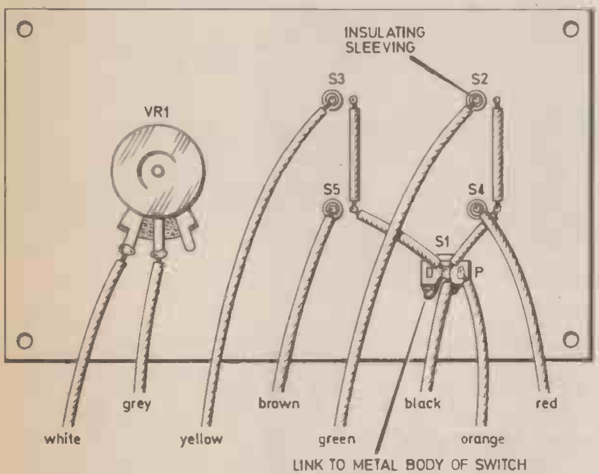


Fig. 6. Front Panel wiring. Note that one pin of each push-button switch is fitted with an insulating sleeve.

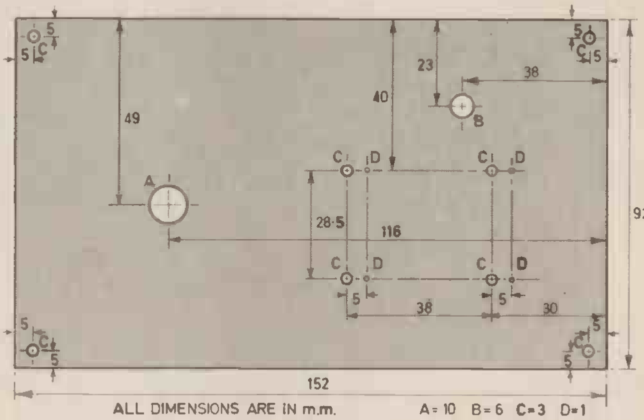
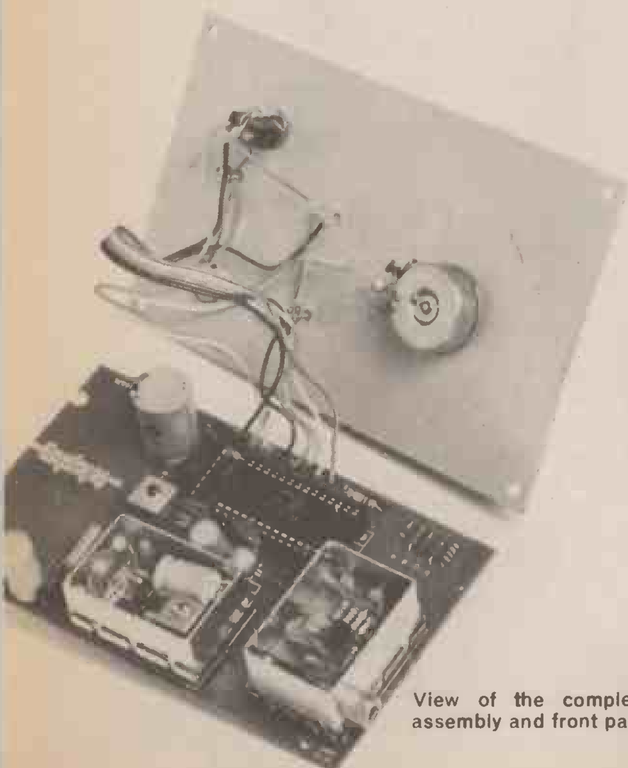


Fig. 7. Front Panel drilling details.



View of the completed p.c.b. assembly and front panel.

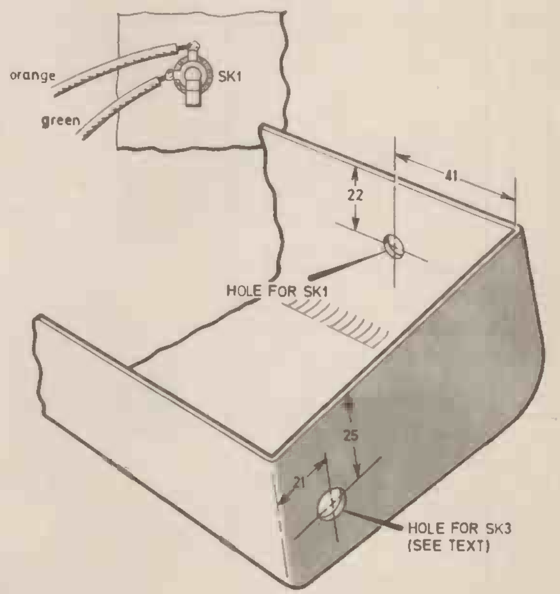


Fig. 8. Case drilling details. Locate p.c.b. assembly and check alignment of output socket SK2 before drilling hole for aerial lead connector.

CIRCUIT DESCRIPTION

The block diagram Fig. 1 shows in simplified form the overall system.

The heart (or perhaps rather, the brain) of this project is the G I Cycle Games chip AY-3-8760. This 28-lead dual-in-line microcircuit is IC2. It is a highly complex device, and contains a multiplicity of circuitry used to generate, modify and process logic signals for the operation of this game; it receives input signals from external sources, i.e. throttle control, clock generator; and it provides output for feeding to the TV receiver (via the modulators).

Other major items are the two ready-assembled modulator units MOD 1 and MOD 2. One digital i.c. and a pair of transistors complete the list of active components involved in this project.

For the following more detailed description, reference should be made to the circuit diagram Fig. 2.

POWER SUPPLY

An external 9V d.c. supply is fed in via jack SK1 and applied to the voltage stabiliser TR1. This *npn* transistor is employed as an emitter follower. The base of TR1 is held at 8·2V by R3 and the Zener diode D1. The output at the emitter is about 7·8V. This supply is smoothed and filtered by C6 and C7 respectively; it is then fed to IC1 (pin 14), IC2 (pin 28), TR2 (collector); and via dropping resistor R6 to MOD 2, and via R6, R7 to MOD 1.

The 7·8V line is also fed via resistors R9-R13 to pins 7, 8, 10, 11 of IC2 for game selection.

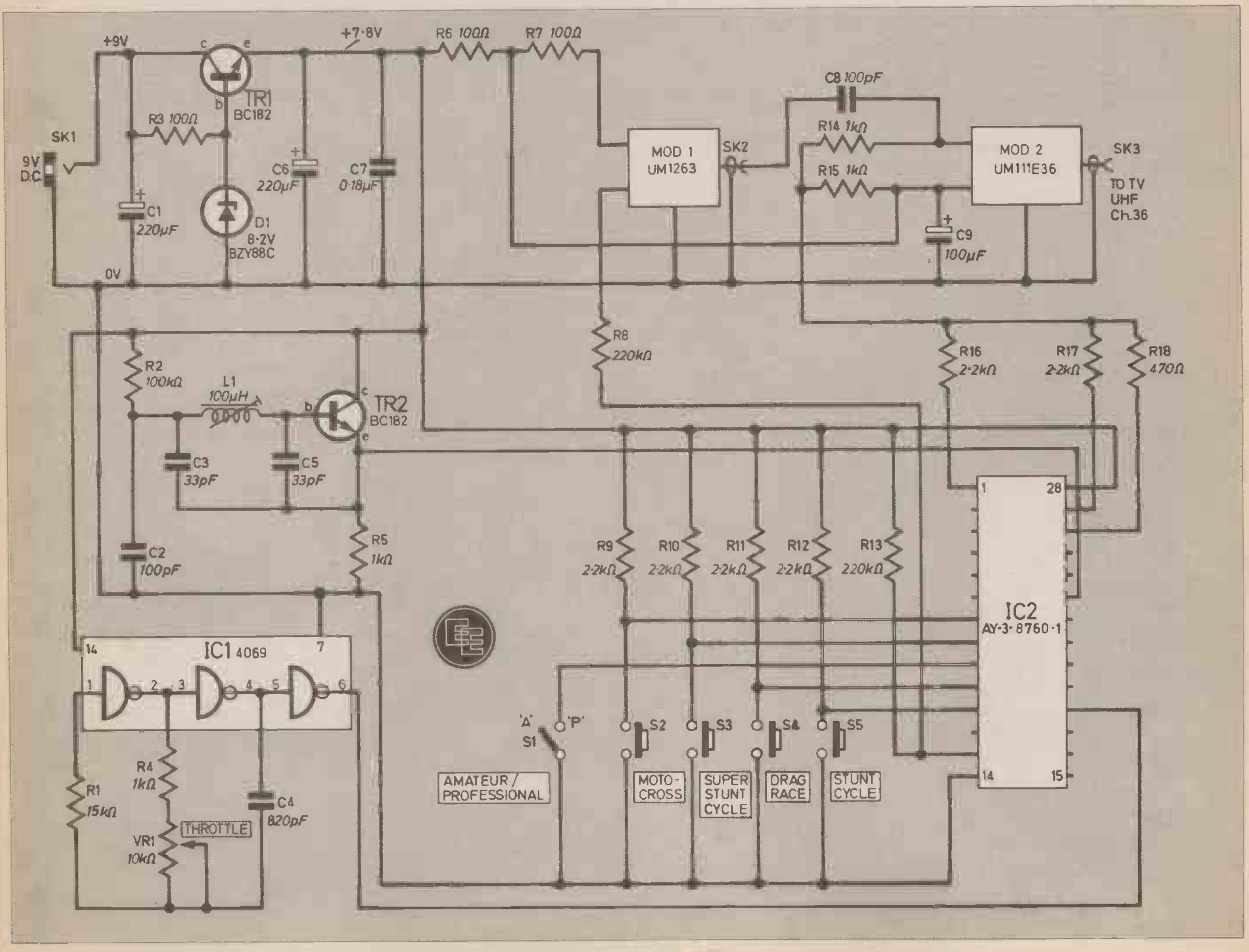
The negative (0V) line is taken to IC1 (pin 7), to IC2 (pin 14) and to one side of each of the five switches. MOD 1 and MOD 2 are both automatically connected to the 0V line via their metal screening boxes.

The total loading on the power supply is 75mA approximately.

CONTROL OSCILLATOR

Two stages of the hex inverter IC1 are used in association with

Fig. 2. Circuit diagram of the Stunt Cycle game.



R1, R4, VR1 and C4 to form a square wave oscillator. This is tunable over the range 50-250kHz by VR1, the Throttle Control. The third inverter is a buffer stage and the oscillator output is fed to IC2, pin 18. (The remaining three inverter stages of the 4069 chip are not used).

CLOCK OSCILLATOR

Transistor TR2 together with associated resistors and capacitors and L1 form an oscillator operating at 3·58MHz. The output is applied to pin 23 of IC2. Fine tuning is possible by adjusting the core of L1.

This clock oscillator provides the timing pulses which control and synchronise all the processes initiated within the games chip IC2.

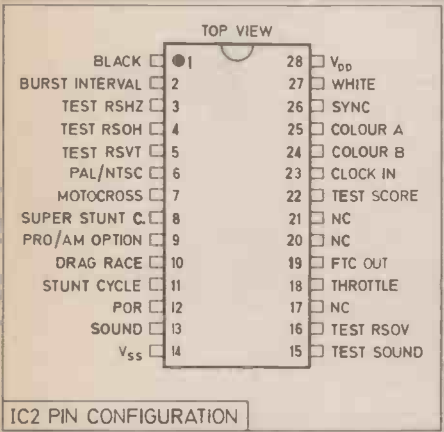


Fig. 3. Pin identification for the Stunt Cycle microcircuit chip AY-3-8760. Connections to be made in accordance with Circuit Diagram (Fig. 2) and Fig. 4 and Fig. 5. Unused pins must be ignored and NOT be used as anchoring points.

SOUND EFFECTS

Sound effects for the motorcycle engine, bus hit, crash screech, and a "good jump" indicator are generated within IC2. This audio output appears at pin 13 and is taken to the audio modulator MOD 1, via R8.

AUDIO MODULATOR

MOD 1 is an f.m. audio adapter unit. The audio input is used to modulate a 6MHz carrier generated within MOD 1. This r.f. output is applied to the input of the u.h.f. modulator MOD 2, via C8.

SYNC AND VIDEO SIGNALS

IC2 provides the horizontal sync and vertical flyback signals for the TV receiver. These signals appear as a combined output at pin 26, whence they are d.c. coupled to MOD 2 via R18.

IC2 also provides the video signal of ramps, tracks and the composite blanking. This output appears at pin 1, and is d.c. coupled to MOD 2 via R16.

The video output signal for the motorcycle, buses, score and obstacles appears at pin 27. This is d.c. coupled to MOD 2 via R17.

GAME SELECTION

Selection of the four individual games is made by pushbutton switches S2-S5. When one of these is pressed, pin 7, 8, 10 and 11 of IC2 is momentarily connected to negative supply line. This causes the appropriate circuits for this game to be actuated within IC2.

MODE SELECTION

When pin 9 of IC2 is connected to negative line by S1 the "Professional" mode of play is actuated within the chip. When S1 is open the "Amateur" mode is actuated.

PAL/NTSC

For European PAL standards (312 vertical lines) pin 6 of IC2 is left unconnected. If this pin is connected to negative supply line the chip is adjusted for the American NTSC standard (262 vertical lines).

UHF VISION MODULATOR

The u.h.f. vision modulator unit MOD 2 receives the sync and video signals from the games chip IC2; also the r.f. frequency-modulated carrier from the audio modulator MOD 1, via C8. The u.h.f. carrier generated within MOD 2 is modulated by these inputs. The carrier is pretuned to the European Channel 36 (591·5MHz) and is made available at phono socket SK2 for feeding to the aerial input of a television receiver.

Photograph of the finished unit showing layout of front panel controls.

1. Mount resistors. Ensure that R9 and R11 do not encroach on area to be occupied by IC2 socket.
2. Mount transistors.
3. Mount capacitors. Ensure correct polarity for electrolytics C1, C6 and C9.
   C8 should be left until modulator MOD 1 is mounted. The top of MOD 1 must be removed to make the connection point on SK2 accessible. Fit ½in of sleeving to one lead of C8; insert this lead into socket of MOD 1, bend end of lead and solder to rear end of SK2 spigot. Replace top and mount MOD 1 onto p.c.b., feeding the three input leads through the appropriate holes. Bend slightly these leads and the two anchoring tags before soldering to the p.c.b. Manipulate C8 carefully to pass its free lead through correct hole in board.
4. Mount sockets for IC1 and IC2. IMPORTANT: Unused pins on IC2 socket must NOT be used as connection points.
5. Mount L1, bending can fixing tags to make secure before soldering.
6. Mount MOD 2.

INTERCONNECTING LEADS

Prepare 8 leads, about 5 inches in length and solder to the holes along the edge of the p.c.b. It is suggested that different coloured leads be used to simplify identification. (If ribbon cable is used, the colours will correspond to those given in Fig. 5.)

Wire a pair of leads (5 or 6 inches in length to points − and +, (adjacent to C1). Connect miniature jack socket SK1 to other end.

Fit the games chip into its socket. Ensure correct orientation of i.c. (see key diagram, Fig. 3).

Carefully align the pins directly over the sockets then apply firm and even pressure to seat the i.c. fully in the socket.

The hex inverter chip IC1 should be handled and fitted in the same manner.

DRILLING OF CASE

Place completed p.c.b. inside case, locating corner holes precisely over screw bushes in bottom of case. Mark side of case for exact alignment with centre of SK2 on MOD 2. Drill case accordingly, also for jack socket. Hole dimensions are given in Fig. 8.

Fit p.c.b. into case and secure with two screws at opposite corners of the board. Fit the jack socket to the case.

FRONT PANEL

Drill front panel as shown in Fig. 7. Apply small dab of glue to the base of each pushbutton switch then fit firmly in position. Fit a 3/16in length of Systoflex over the pin on each switch that passes through the larger panel hole.

Fit the potentiometer and the toggle switch S1. Wire up all these components according to Fig. 6.

Place the front panel in position, carefully dressing the interconnecting leads inside the case. Do not screw the panel down until the following operations have been carried out.

Plug the mains power supply unit into the jack socket SK1. Make up a coaxial lead (television aerial cable) about 6 feet in length with a coaxial plug at one end and a phono plug at the other.

Plug the coaxial lead into socket SK3. Plug the other end of this lead into the television set aerial socket.

Set the television set to a spare channel and tune to channel 36. Diagonal lines will appear on the screen when the correct setting is approached. Carefully adjust the core of L1 until the picture "locks" on the screen. (See photographs.)

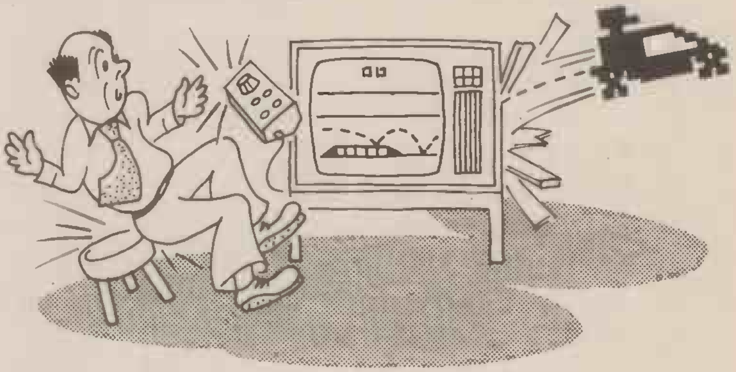
When tuning is completed satisfactorily, replace the panel and screw down.

PLAYING

Set the Throttle Control fully anticlockwise. Select the Amateur (easy) or the Professional (hard) mode of play. Touch the required game button. The motorcycle (and the game) is activated by advancing the Throttle Control. Details of the four games have been given earlier in this article, together with off-screen photographs illustrating typical displays.

The essence of the game lies in sensitive and anticipatory manipulation of the Throttle Control with simultaneous close observation of the motorcycle's career across the screen. With practice a high order of skill can be developed. The ultimate is reached when 36 buses have been jumped. With this achievement the screen becomes filled with buses.

Although essentially a test of an individual's skill, the Stunt Cycle can, of course, be played in a competitive way with other participants, each playing in turn and recording their individual performances. ⌑



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

DESOLDERING

I read the letter from J. R. Hunt in the November 1977 issue of E.E. about clearing solder from holes in circuit boards (for replacement of components) and thought readers might be interested in my method.

After the component has been removed simply remelt the solder around the hole to be cleared and as you remove the soldering iron insert a sharpened matchstick. The matchstick does not attract solder, and is easily withdrawn after the solder has hardened leaving a nice clear hole.

J. A. Noble, Huddersfield.

USING I.C.S.

It is generally agreed that an integrated circuit should be the last item to be fixed to a strip board module, but its absence from the board does not make component fitting and soldering too easy. I use a nylon-pointed pen to mark the d.i.l. holes. Just twist the pen-point into each appropriate hole. Also use the pen-point in the same way to indicate the position of any cut made in the copper strip.

When the module is complete, the entire circuit can be "read" from the front of the board, or checked against a wiring diagram.

When using 0·1 matrix stripboard, which is dark brown in colour, slightly countersink the top surface of the hole where a cut has been made in the copper strip. With the cuts clearly indicated, again it is a simple matter to "read" the circuit without reference to the back of the board.

C. R. Emmans,
Allestree,
Derby

Next Month

100W POWER SLAVE
THE BIG SOUND

PA — DISCO — POP

A rugged amplifier capable of delivering 100 watts r.m.s. into 4 or 8 ohms. Ideal for use in bands and disco. No need to worry about shorting the output leads, this amplifier has built-in electronic short-circuit protection.

VISUAL CONTINUITY TESTER

Most simple continuity testers do not distinguish between circuits of differing resistance values.

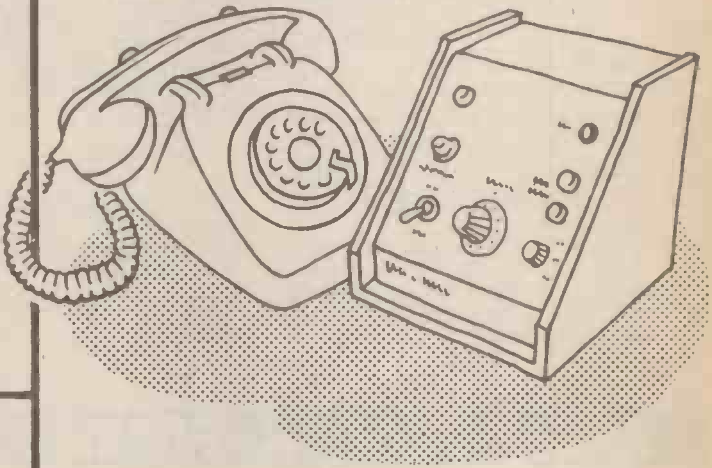
This instrument narrows down the resistance of the circuit under test to one of three ranges, 1-100 ohms, 100-56,000 ohms, and 56 kilohms-12 megohms.

Visual indication is provided.

REMEMBER

EVERYDAY ELECTRONICS HAS SOMETHING FOR EVERYONE. There will be a great demand for our June issue so ensure YOUR copy well in advance. See your newsagent NOW!

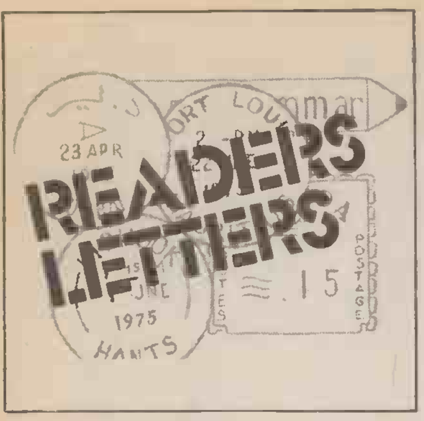
TELE-BELL



This sound-triggered device will let you know when your telephone is ringing if you are out of range of the in-built telephone bell, when working for example in the garden shed, garage or other remote location. Will find many other uses in and around the home.

Everyday ELECTRONICS

JUNE
ISSUE ON SALE FRIDAY, MAY 19



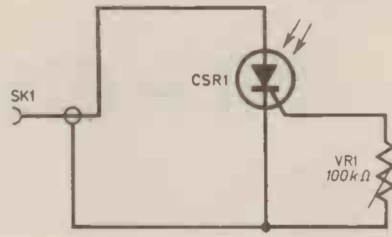
Slave Flash

With reference to your article "Photoflash Slave Unit" in the December 1977 issue. I thought you might be interested in the circuit in Fig.1, which I have built and found very satisfactory, for the same purpose.

I have omitted the rectifier bridge as both the flash guns I own have the same polarity.

The light activated thyristor (CSR1) had a peak inverse voltage (PIV) of greater than 270V, and is readily obtainable from the Tandy chain of stores (Cat No. 276-9024) and cost approximately 80p.

D. Beard,
Cambridge.



Earth Check

With reference to December's EVERYDAY ELECTRONICS, page 267, *For Your Entertainment* and the point about checking your Mains Earth.

Assuming that the earth is alright but the cold water supply pipe is plastic underground this will give a positive reading indicating (incorrectly) that the earth is faulty. Surely, a more reliable method would be to run direct to earth and then connect in one's meter or continuity tester between earth and earth pin.

Hopefully, this would prevent unnecessary worry and expense of involving the Electric Board to check whether the cold water supply is a reliable earth.

S. F. Anderson,
Southampton.

Mr. Hope replies . . .

If Mr. Anderson is sure that the cold water supply pipe is plastic underground that could well make the test less reliable—although I would have thought that there would always be an earth path via the metal pipe sections and water in the pipe.

Dynamo Back-up

With reference to the *Dynamo Back-up* article in the September 1977 issue of EVERYDAY ELECTRONICS, the following observations may help constructors. Many bicycle dynamos, especially those which work against the tyre, have one side of the supply and one side of the lamp connected to the frame. In this case the circuit will not function correctly as one half of the bridge rectifier will be shorted to the frame. It is essential therefore that either the supply or the lamp be isolated from the frame.

Diode D5 is not absolutely necessary as it faces in the same direction as D1 and D2.

J. E. S. Bradley,
Muswell Hill,
London.

It is certainly true that many dynamos are connected in this way, however before anyone rushes to put pen to paper saying that their circuit does not work it might be a good idea to check the system used on their own bike.

The operation of D5 has caused many people some concern. It is in circuit to prevent damage to the bridge rectifier, and the supply from the dynamo in the event of a short across the battery.

Rapid Diode Check

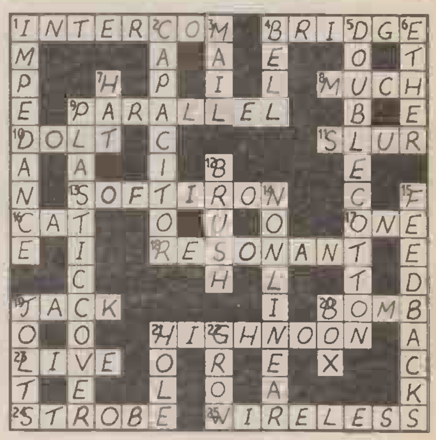
I have decided to make my first project in the hobby of electronics the *Rapid Diode Check*, in the January issue.

The project is now assembled apart from the CD4069BE CMOS i.c. So far I can only obtain a type CD4069. Could you please advise me if the i.c. I have is suitable or else where I could obtain the correct type.

S. Cowles,
Cambridge.

The i.c. you have is perfectly satisfactory for the purpose you require. The last two letters indicate the voltage range over which the i.c. will operate, and does not refer to the internal circuit as such. The most common i.c.s have the suffix AE. On many occasions the letters are dropped altogether.

Crossword No. 3—Solution



JACK PLUG & FAMILY...

BY DOUG BAKER

By E. M. Lyndsell

9 VOLT d.c. POWER PACK

THE majority of constructional projects appearing in EVERYDAY ELECTRONICS are battery powered, and a large proportion of these require a 9 volt supply. In some cases the life of the battery in a unit approaches the battery shelf life, but there are occasions when a device may require a fairly high sustained current output and be in regular use for long periods, requiring frequent replacement of the batteries.

With the high and ever rising costs of batteries, it makes sense to provide some permanent, portable source of low voltage power supply, typically 9 volts.

It is thought that the *E.E. Teleplay Stunt Cycle* project featured this month falls in the above category. The voltage and current requirements are 9 volts and 75 milliamps respectively. Although a single PP9 or six HP2 batteries would fill the bill, these are not cheap and could be viewed as greatly and forever increasing the cost of the game. Using a mains derived power source would, once the initial outlay has been recovered, keep further outgoings to a minimum.

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS

£3.30

excluding case

The unit to be described here was designed specifically for the *E.E. Teleplay Stunt Cycle* but could be used with any equipment requiring a 9 volt supply at currents up to 75 milliamps. Many constructors will probably put this device to use in the workshop when testing battery operated prototypes.

If prototype testing is the main purpose of this unit, it may be wise to incorporate an inline fuse (100 milliamp) in one of the output leads.

START HERE FOR CONSTRUCTION

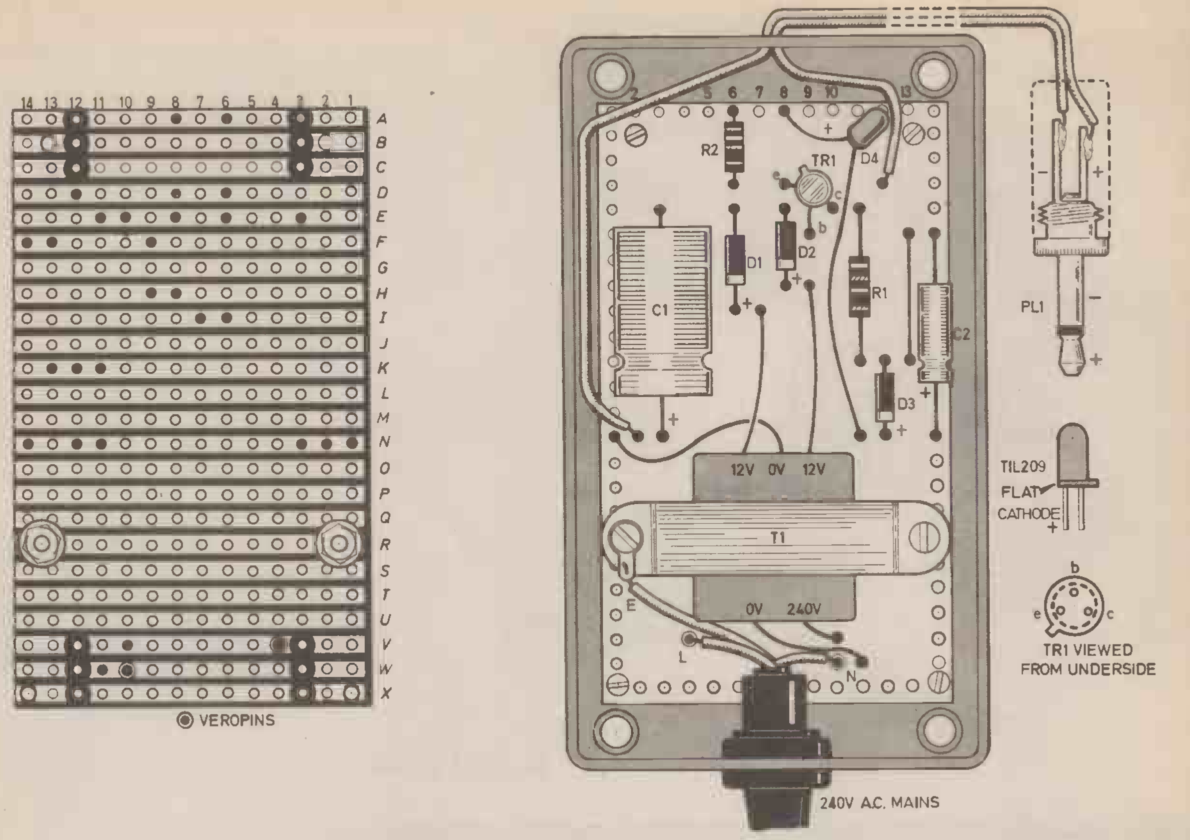
The prototype circuit was built on a piece of 0·15 inch matrix stripboard size 24 strips by 14 holes and housed in a Verobox type 65-2518H with internal dimensions 115 x 60 x 30mm. Any plastic box of similar dimensions will be suitable.

The layout of the components on the stripboard is shown in Fig. 1.

Begin construction by cutting the board to size and making the breaks on the underside, using either the special tool for this job or a small twist drill.

The breaks were made to eliminate possible shorting across the tracks by the brass inserts in the board fixing locations in the Verobox. Drill the board and transformer fixing holes and bolt the transformer to the board using 4BA fixings. Do not forget to fit the earthing solder tag under one of the bolt heads.

Insert the Veropins and solder in the wire link. Next position and solder the resistors followed by the capacitors and semiconductors. The beginner should use a heatshunt on the legs of the latter when soldering. Connect the flying leads from the board to the l.e.d. of sufficient length that the lid can



9 VOLT d.c. POWER PACK

Fig. 1. The layout of the components on the topside of the stripboard and the breaks to be made on the underside. The board is shown fitted in the plastic Verobox with complete wiring details. The output leads are terminated in a jack plug. Pay special attention to polarities at this connector, wired correctly for the Stunt Cycle application.

Photograph of the completed prototype with lid removed.

COMPONENTS

Resistors
R1 390Ω
R2 820Ω
Both ¼W carbon ± 5%

Capacitors
C1 2000μF 16V elect.
C2 10μF 10V elect.

See **Shop Talk** page 433

Semiconductors
TR1 BC461 silicon *pnp*
D1, 2 1N4001 or similar silicon diode (2 off)
D3 BZY88C10 10 volt 400mW Zener
D4 TIL209 light emitting diode

Miscellaneous
T1 Type 1200 (Electrovalue) mains/12-0-12V 100mA secondary
PL1 3·5mm jack plug
Stripboard: 0·15 inch matrix size 24 strips × 14 holes; mains cable; Verobox type 65-218H or similar plastic box; twin-flex; 4BA fixings; Veropins (2); solder tag; sleeved rubber grommet; cable gripper.

sit beside the base when the l.e.d. is fixed in position. Solder a length of twin-flex to form the output lead. Do not attach the jack socket at this stage.

Next drill the case to accept the mains cable, output leads, and l.e.d. mounting hole. Insert the sleeved mains cable grommet and feed through from the inside the mains cable fitted at its internal end with a cable gripper. Bolt the board in place and then wire the mains cable to the board as shown in Fig. 1.

Feed the output leads through the case and wire up to the jack plug as shown. If being used for other applications, the jack plug should be replaced by another suitable connector, paying attention to the polarity of the leads.

Fit the l.e.d. in place and secure with a dab of polystyrene glue.

Thoroughly check out the wiring and when satisfied that all is well, the lid may be fitted and the unit is ready for testing.

The transformer specified is capable of delivering 100 milliamps; 15 milliamps is consumed by the Zener (D3) feed current and 10 milliamps for the l.e.d., leaving 75 milliamps capacity at the outlet. The transistor chosen for this circuit can comfortably handle the maximum output current indefinitely without the use of a heatsink.

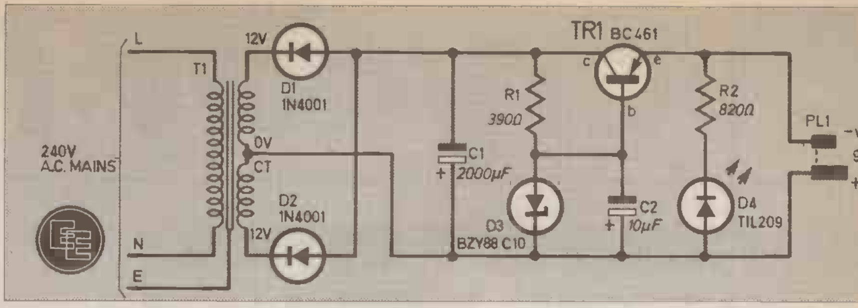


Fig. 2. The complete circuit diagram of the 9V d.c. Power Pack.

CIRCUIT DESCRIPTION

The complete circuit diagram of the 9 Volt d.c. Power Pack is shown in Fig. 2. Mains voltage is applied to the primary winding of transformer T1 which steps down the input voltage to produce a 24 volt a.c. centre-tapped supply across the secondary winding. This is rectified by diodes D1 and D2 arranged to produce full-wave rectification which results in a pulsed d.c. wavetrain of approximately 16 volts peak which feeds smoothing capacitor C1.

The output from C1 is very low ripple d.c. which is applied to the Zener diode D3 and associated series resistor R1.

In this particular circuit the Zener voltage is 10 volts, and is directly coupled to the base of TR1. Thus the base is clamped at −10 volts with respect to the transformer centre-tap point. The voltage at the emitter of TR1 is greater than that at the base by approximately 0·6 volts (base/emitter voltage drop) producing an output voltage level of −9·4 volts (neglecting component tolerances).

Capacitor C2 has been included in the circuit to eliminate any voltage spikes that could result from the rectification stage. The l.e.d. and its series current-limiting resistor gives an indication that the unit is switched on.

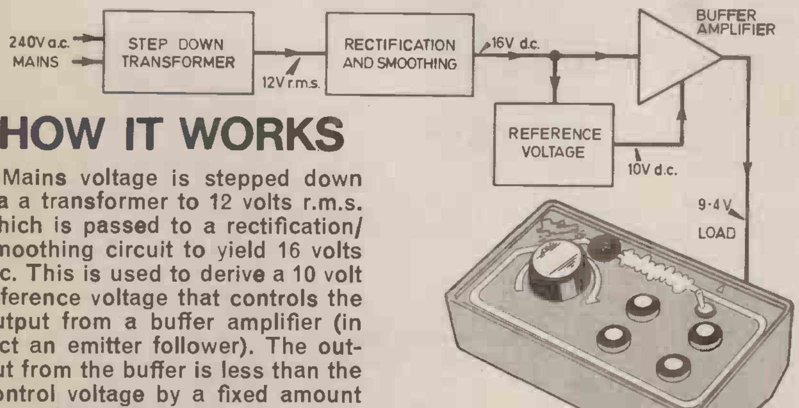
When being used as the power source for the *E.E. Teleplay Stunt Cycle* game, on no account should either of the output supply lines be earthed.

Either supply line may be earthed if necessary when used with other non-mains operated equipment.

TESTING

The mains plug should be fitted with a fuse rated at 1 amp or less. Connect a voltmeter set to at least 10 volts d.c. f.s.d. across the output and switch on at the mains. The reading should be a little under 10 volts and the l.e.d. should light.

Now connect a 120 ohm 1 watt resistor across the output and the output should reduce to about 9·4 volts (±5 per cent due to tolerance of Zener). The above results indicate that the unit is functioning satisfactorily and the unit is ready for use.



HOW IT WORKS

Mains voltage is stepped down via a transformer to 12 volts r.m.s. which is passed to a rectification/smoothing circuit to yield 16 volts d.c. This is used to derive a 10 volt reference voltage that controls the output from a buffer amplifier (in fact an emitter follower). The output from the buffer is less than the control voltage by a fixed amount (0·6 volt) due to the drop across a silicon-semiconductor junction in the buffer amplifier.

6 VOLT AND 12 VOLT UNITS

The voltage output can be easily altered for other applications by changing the value of the Zener diode and its series resistor. For example, with the specified transformer, a 6 volt 75 milliamp power pack can be realised by using a 6·8 volt Zener and changing R1 to 680 ohms. Resistor R2 will need to be altered to 470 ohms. For a 12 volt unit, use a 13 volt Zener, R1 equal to 270 ohms and R2 equal to 1 kilohm. ⌑

Everyday News

BRITISH POST OFFICE LEADS THE WORLD

The world's first public Viewdata service, invented by the British Post Office, will be available to the general public in early 1979, a year ahead of schedule. Market trials for this service are planned to commence in June of this year in seven London areas (Bexleyheath, Hammersmith, Hounslow, Lewisham, Redbridge, Sutton and Waltham Forest), Birmingham (all regions with telephone numbers beginning with 021), and Norwich (including Cromer and Great Yarmouth); 1,500 users are expected to participate.

For the public service, ten more computer centres will be installed that will service the whole of London, Birmingham, Cardiff, Edinburgh, Leeds, Manchester and Norwich. By 1985, the Post Office will have invested more than £100 million in this project.

Viewdata is a communication system linking the telephone and the television set and enables people to call up information stored in a computer and display this on the t.v. screen, in both word and diagrammatic form.

Information on almost any subject can be made available, such as sports results, stock and share prices, news, car prices, welfare services, air/rail/shipping timetables, food price, t.v. radio programmes, to mention just a few topics.

To be able to use Viewdata, customers or "users" will need to buy or rent a colour t.v. set that has been modified to receive Viewdata and would in general be of the remote control variety. Calling up pages of information would be made with a remote keyboard. The domestic telephone is plugged into the t.v. set and the nearest Viewdata computer

centre dialled. Key in the page number (of the information) required (with reference to the index) and instantly it appears on the t.v. screen.

More than 100,000 pages of information will be available during the market trial and at the start of the public service this will have increased to 250,000 pages.

Cost to the user will be the cost of the telephone call to the computer centre plus a charge for each page viewed, the charge varying according to the information called up. The total charge for a session will appear on the t.v. screen at the end of a call, and will be billed each quarter.

Voices on the line

Over 4,000 simultaneous telephone conversations will be possible on the new submarine cable linking the UK and Spain. The project will cost £18 million and laying will start in spring 1980 for service by the summer. Actually 4,140 circuits will be available by using a carrier frequency of 45MHz.

The repeaters will use a new transistor, Type 40, developed by the Post Office. In all, 155 repeaters will be used in the link. The cable will be made by Standard Telephones & Cables and laid by the Post Office cableship Alert.

Twenty-a-Day

Decca Radar has received its 80,000th order for marine radar since the firm started. Acknowledged world leader in marine radars, Decca production is now averaging over 20 radars every working day and this at a time when the world's shipping and fishing industries are depressed.

The patent on the Ideographic Encoder, a machine which enables swift input of Chinese characters to be made for computer processing or line transmission, has been acquired by Cable & Wireless.

The idea was originated by a group of workers on the Chinese Language Project at Cambridge University's Faculty of Oriental Studies.

STEREO BEACON

The stereo transmission pilot tone which enables receivers to decode and convert to two separate sound signals, produces a loud click in some receivers whenever it is switched on or off.

The BBC have now decided to radiate the pilot tone continuously on Radios 1, 2 and 3.

Although this decision means that stereo beacons in receivers will be continuously lit, they point out that as more than 90 per cent of programmes on Radio 2 and Radio 3 v.h.f. are transmitted in stereo, it would be illuminated most of the time anyway.

HOME COMPUTER CLUB

Following on from last month's news of *Computer Power For The Masses*, Commodore are now establishing a users' club for their PET computer.

The aim of the club will be to provide a forum for disseminating and exchanging news, views and information, including programs. The club will be producing its own Newsletter which will be sent periodically to all members.

Membership of The UK PET Users Club is £10 and further details may be obtained from Commodore Systems Division, 446 Bath Road, Slough, Berks SL1 6BB.

Specialists in microprocessor and memory products, Rapid Recall has signed a franchise agreement with the ITT Component Group, under which they will market the ITT PROM programmer and simulator.

A semiconductor manufacturing plant in Harlow, Essex, has been established by International Devices Inc of Los Angeles. The British subsidiary, IDI Semiconductors Ltd., is concentrating initially on germanium power devices and expects to have good export business to Common Market customers.

A Better View

Limitations of page indexing together with drawbacks in the present numeric keyboards used for the Viewdata trials were highlighted in the findings of a special research group at Loughborough University of Technology.

Commissioned by the Post Office, to the tune of £10,420, Loughborough University's Human Sciences and Advanced Technology studied the tree structure of information contained in the computer.

The PO brief asked the HUSAT group to examine the layout of the contents, and to come up with a better system for selection of pages for further reference after the index of contents has been scanned by the user.

ANALYSIS

CREATIVITY AND PROFIT

The shares of EMI took a nasty tumble on the Stock Exchange when EMI chairman Sir John Read recently announced that the world-beating EMI-Scanner was now losing money in the world market.

The scanner, originally developed as a new medical diagnostic tool for examination of the brain, has since been further developed for examination of the whole human frame. The technique is now generally known as CAT (Computerised Axial Tomography) and by the use of data-processing, signal processing and special display units, gives a far superior picture than was possible with the old X-ray machines.

The inventor, Godfrey Hounsfield, thought up the principle while on a country ramble. That was in 1967. Four years later a prototype machine was on clinical trial at Atkinson Morley's Hospital and attracted world-wide attention. Hounsfield was heaped with scientific honours, gold medals, cash prizes. His invention was greeted as the greatest medical diagnostic breakthrough since the original discovery of X-rays.

The machine won a Queen's Award to Industry for Technological Innovation. And EMI started raking in the profits because, as it was the only machine in existance, it had 100 percent of the world market and the Americans, in particular, were falling over each other in their eagerness to buy it. It was good for EMI, and good for Britain because Britain needed dollars to ease an economic crisis.

So what has gone wrong? Nothing, really, except that the EMI-Scanner has inevitably drifted from a monopolistic situation as the only machine available, to one in which hospitals all over the world now have a choice of machines. In fact of a world market estimated to be worth $600 million in 1980, EMI expects to have only 20 percent, hopefully a little more.

In the USA, Ohio-Nuclear, General Electric and others were quick to react with competitive machines. Even Israel with none of the financial muscle of the US giants or EMI is now in the scanner market with a machine called SCANEX, designed and manufactured by Elscint, by world standards a pygmy firm of only 900 employees but strong in brain-power.

EMI had a three-year lead on the world. Now the rest have caught up. The easy ride is over and it's going to be hard graft in the future. Not that this detracts in any way from EMI's achievement whose Scanner sales were £80 million last year.

Whether sales are profitable or not depends far less now on creative brilliance (though one expects further technical advances) and far more on management and workers in getting machines out of the factory at the right price, meeting delivery dates, and providing super after-sales service. The moral of this story is that ideas are quickly copied, good ideas even faster, whether they are patented or not.

Brian G. Peck

Trade test transmissions, "best buy" orientated t.v. and radio programmes and the siting of relay stations were among the subjects discussed at a recent meeting between the BBC and the Radio, Electrical and Television Retailers' Association.

Methods for specifying and measuring the characteristics of audio equipment for Microphones and Loudspeakers has just been published under BS 5428 by the British Standards Institution.

Lasers Join The Army

The British Army is to be equipped with the Ferranti Laser Target Marker and Ranger (LTMR). The equipment is man-portable and enables ground troops to illuminate a target by laser-beam, the laser reflections from which can then be "homed" on by air or ground-launched laser-guided weapons. LTMR equipment will be available to the Army by the end of the year.

Hewlett-Packard believes in further education and training for upgrading technical and management skills. About one third of all staff participate which means that some 10,000 H-P people are on courses at any one time.

Extraterrestrial Life

The American Association for the Advancement of Science has requested over $2 million to build a million-channel radio receiver on which it is hoped to intercept radio signals from other galactic civilisations, should they exist.

The President of AMSAT, Perry Klein, beside the latest Oscar satellite
(Photo courtesy Radio Communication)

The latest in a long line of *Oscars* (Orbital Satellite Carrying Amateur Radio) has been successfully launched.

Like all highly sophisticated equipment there were slight problems and moments of concern during the first few minutes, but since the time of writing all is well.

At the present time telemetry (code giving the state of the satellite) is still being collected, and as such is only just becoming available for general use.

It is the general opinion that because of the sun synchronous type orbit, *AO8* will appear at roughly the same time and place each day, thus making it far more easier to keep track of, than its predecessor *Oscar 7*.

For up-to-date information and latest orbital calculations, a "net" is usually operating on most nights of the week on a frequency of 144·28MHz in the two metre amateur band.

For further information contact: AMSAT-UK Secretary, Mr. R. Broadbent G3AAJ, 96 Herongate Road, Wanstead Park, London E12.

OSCAR 8 ORBITAL INFORMATION

Period of orbit	103·193 minutes
Inclination	98·989 degrees
Longitudinal increment	25·98 degrees West/orbit
Reference orbit 28	Equatorial crossing at 1721 41 GMT, 29·8° West
Modes	
J-Beacon	Beacon 435·095MHz
A 2M to 70cm	Uplink 145·90 to 146·00MHz Downlink 435·1 to 435·2MHz
B 2M to 10M	Uplink 145·85 to 145·95MHz Downlink 29·4 to 29·5MHz

The Extra-ordinary Experiments of Professor Ernest Eversure

by Anthony John Bassett

Bob and the Prof. made their way over to the laboratory workbench at which Tom and Maurice had at last succeeded in dismantling an electro-mechanical joke moneybox called *The Thing*.

PLASTIC HAND AND METAL FOOT

"Just as I thought", remarked Maurice, "a small electric motor which runs at a high speed powered by the 3 volt battery, drives the green plastic hand out very slowly by means of a train of gears, and a metal foot attached to one of the gears projects from the bottom of the box, causing it to rock and sway eerily whenever it is in action".

The Prof. examined *The Thing* and drew the circuit diagram of Fig. 1.

"Here's how it works", he explained. "Normally the motor does not turn because the electrical circuit through the battery is not completed unless either S1 or S2 are closed. Switch S1 represents the contacts which are joined together when a coin is inserted in the slot. The coin itself conducts an electric current which enables the motor to turn.

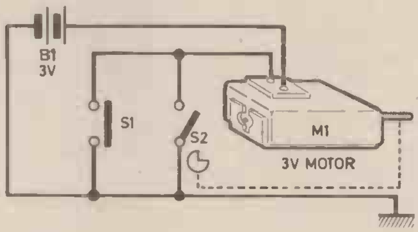


Fig. 1. The original circuit of *The Thing*.

By means of the gear train, the motor drives a metal cam round very slowly, and soon after the motor starts, the cam closes S2 by contacting a strip of springy metal, so that even if, due to the swaying movement of the box, the coin should move a little making S1 lose contact, the motor will continue to operate. Now the movement of the cam drives the green plastic hand out slowly then suddenly releases it. The hand, when it is released, removes the coin and returns to the interior of the box, effectively opening switch S1. At the same time, as the cam releases, it re-opens S2 and, with both switches open, the motor stops, and the mechanism is now reset to await another coin."

"Prof., we guessed it contained a small electric motor," chipped in Maurice, "and we were thinking of connecting various electrical and electronic gadgets in parallel with it so that they would operate whenever the motor was activated. But there is one big problem. Most of the gadgets we were thinking of using do not operate from 3 volts, but from some other d.c. voltage usually considerably higher.

"If we connected them directly to the wires of the motor, the voltage supplied when the motor operates would be insufficient to activate the additional unit. We thought of using a relay, but found that we could not easily obtain relays which would operate from a 3 volt supply. So we wondered whether you could come up with an electronic circuit which will enable *The Thing* to control other devices.

One thing we are thinking of in particular would be an electro-mechanical counter connected to a cam-operated switch, and connected so that it will only count the rotations of the cam-switch when *The Thing* is in action."

TURN THE HANDLE

"This is for a *Turn The Handle* competition, the idea being to have the counter register the number of times which each contestant can turn the handle whilst *The Thing* takes his coin, and at the end of the competition the contestant who has scored the highest number of turns during one complete cycle to be declared the winner."

The Prof. considered the problem briefly.

"I think it would help matters if the circuit were to be re-wired so that one of the terminals of the motor is connected to the chassis" and he drew the circuit shown in Fig. 2.

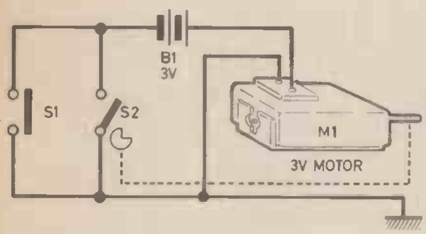


Fig. 2. The circuit of *The Thing* suitably modified by the Prof.

The Prof. picked up a soldering iron and, as all the wiring was now exposed to view, soon had the alteration completed.

"The alteration is not essential, but if it were not done it might become possible to trigger the circuit by touching the chassis to a nearby piece of metal and so a contestant might cheat, or accidentally be given more time! But we are going to fit a two-wire output socket to control the counter, and if one of the terminals of this goes to the chassis the possibility of interference is much reduced.

INTERFACE

"Now we are going to utilise a property which transistors have and which is not always made obvious, which is their ability to act as interface elements between circuits operating at different voltages".

The Prof. began to draw out yet another circuit diagram, see Fig. 3, which could be regarded as having three main sections:

1. The three volt circuitry of *The Thing*.
2. The 12 volt circuitry of the electromechanical counter.
3. The transistor interface which allows the 3 volt circuit to control the 12 volt circuit.

"When *The Thing* operates, a current flows through R1 and provides a bias which enables TR1 to turn on. When TR1 is biased on, current can flow through the counter coil and S3, enabling the counter to register a count each time S3 operates. Diode D1 prevents damage to the circuit from inductive surges when either S3 or TR1 turn off the current flow in the counter coil.

When *The Thing* is not in operation, there will be no bias current to TR1 and so TR1 will not conduct any collector current. Under these circumstances the contestant can turn the handle which operates S3, and there will be no count. So the contestant can only clock up a score by turning the handle during the period between putting the coin in the slot, and having it snatched by the green plastic hand!

"Capacitor C1 helps to smooth out variations in the bias current through R1 due to commutator effects as the motor turns."

SETTING UP THE DEMONSTRATION

Suddenly Maurice began to behave in a very peculiar way. He sat down on the floor of the laboratory and began to go through strange contortions, struggling and grimacing as his hands fought their way through the packed contents of his huge duffle-bag, which he had never been known to clear out. It contained a very odd assortment of strange objects, and at last, from its murky depths, Maurice drew out an electromechanical counter, attached to a strange framework on which were also mounted a handle, and a switch which opened and closed as the handle was turned.

"I brought these along too, Prof., just in case we might be able to rig it up now," he explained.

"That's a good idea, Maurice. Bob can help you to put it together whilst I go and look out a suitable 12 volt power supply unit".

Maurice drilled a small hole in the side of the plastic case of *The Thing* and installed a miniature 3·5mm jack socket in such a position that it would not interfere with the mechanism.

"Connect the 47ohm resistor R1 between the motor and the centre pole of the jack socket, inside the

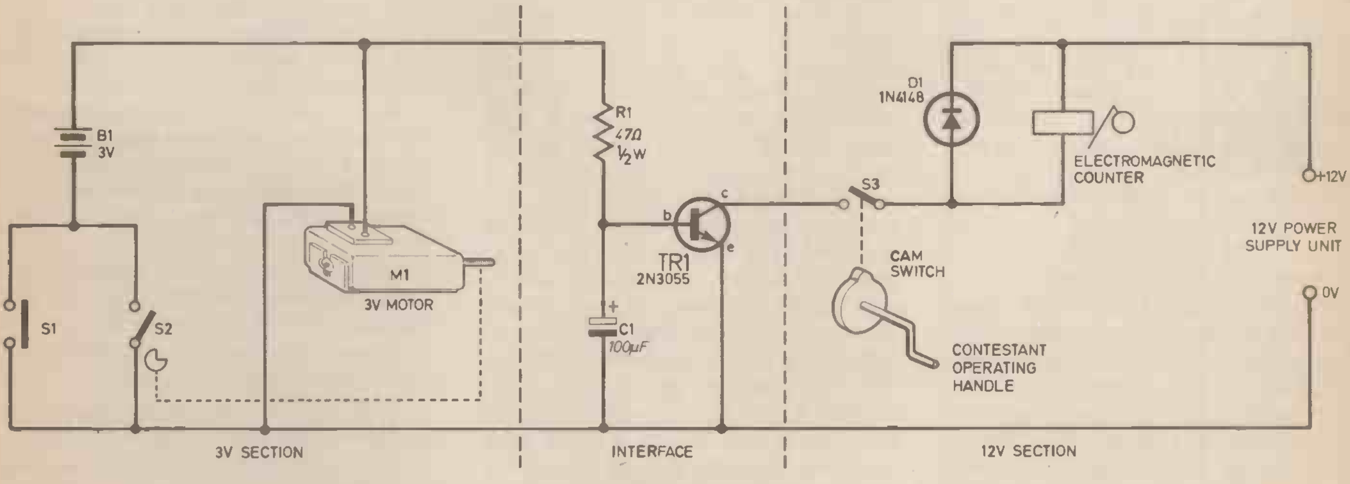


Fig. 3. Basic circuit of *The Thing* incorporating the various modifications The Prof. has been discussing. The resistance of the counter is not critical.

box," Bob told him, "then if the jack plug or the external wire between the socket and TR1 shorts out, it will not draw a huge current from the batteries."

Whilst Maurice installed the 47ohm resistor inside the box, and wired the outer pole of the jack socket to the chassis, Bob mounted a 2N3055 transistor on a small heat sink and soldered a small 100 microfarad electrolytic capacitor between its emitter and its base. After bolting this assembly to the frame of Maurice's cam-switch and counter, he furnished it with a short length of twin flexible wire terminated by a 3·5mm jackplug, so that when this was plugged into the socket on the plastic box, it would give the circuit of Fig. 3.

As Bob was putting the finishing touches to his handiwork, connecting up D1, for which he used a type 1N4001 diode, and wiring up the 2N3055 to the cam-switch, the Prof. arrived back on the scene with the 12 volt power supply. However, there was something strange about this power supply, and when the Prof. connected it to the rest of the circuit Bob noticed that he also connected an extra wire to the cam switch where it was wired to the counter coil.

Before Bob could ask him about this extra wire, the Prof. called Tom over to be the "guinea pig" by acting as the contestant for the first trial. He switched on the power supply and, as Tom began to turn the handle at a furiously high speed, placed a coin in the slot of the mechanical money box. Immediately the counter began to register every turn of the handle, but something else also happened which surprised Tom so much that he hesitated and nearly stopped.

WEIRD SOUNDS

What startled Tom so much, and was also a surprise for Bob and Maurice, was a very loud series of weird sound effects which altered with every turn of the handle.

When at last the coin was snatched and the counter stopped, to reveal that Tom had clocked up quite a respectable score despite the distraction the weird sounds died away.

"That was amazing!" he gasped, "I did not know it was supposed to make sounds as well".

"Neither did I", broke in Maurice.

"Whatever have you done, Prof. It sounded really great!"

"I know what it is!" remarked Bob.

"I have just built the *Weird Sound Effects Generator* from a circuit I found in the March 1978 issue of EVERYDAY ELECTRONICS, and I bet the Prof. has hidden it inside this power supply unit."

Sure enough, when Bob unscrewed the back of the large power supply, he found inside it not only his own *Weird Sound Effects Generator* but also a small amplifier and loudspeaker, and a few other components.

The Prof. had rigged it up so that each turn of the handle gave not only an addition to the figure on the counter, but a burst of weird sound effects from the loudspeaker.

EVEN MORE WEIRD

"The generator is very versatile, and as mentioned by the author of the article, it can be modified in many ways to produce a wide range of sound variations. What I have done is to replace the 9 volt battery which is normally used to power the generator with an electrolytic capacitor which is charged up with each turn of the handle. As the capacitor discharges, the sounds produced are varied even more than usual."

The Prof. began to draw out the circuit of this new arrangement and it is shown in Fig. 4.

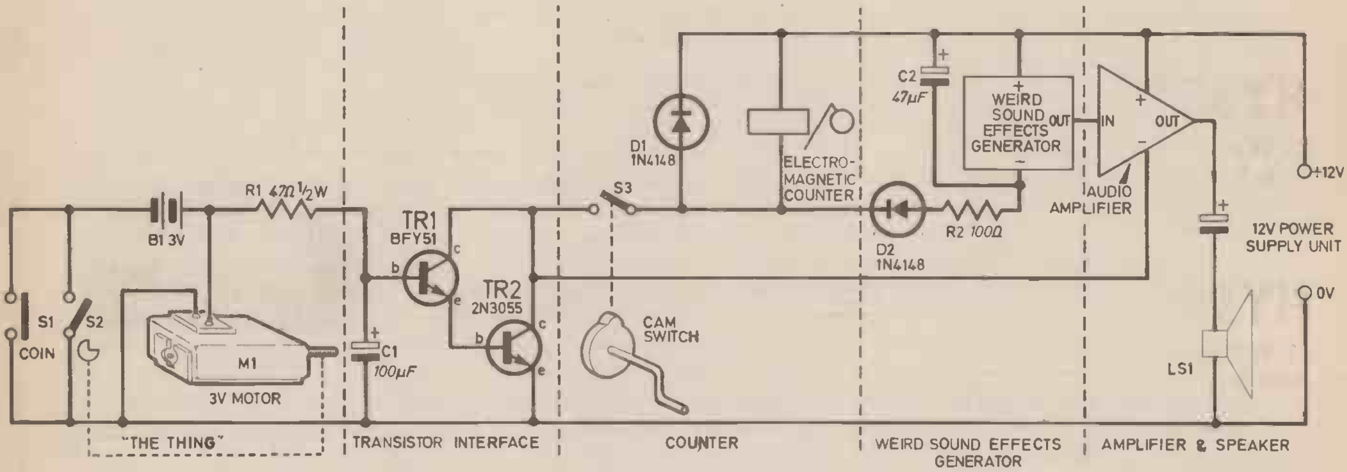


Fig. 4. Final circuit of *The Thing*. In this design all the extras have been included, namely the *Weird Sound Effects Generator*, and an amplifier.

"When S3 closes and TR1 is conducting, C2, is charged up through D2 and R2. After S3 has opened again, C2 holds sufficient charge to operate the *Weird Sound Effects Generator* for a short while. If you wanted to increase this period, you could use a larger value for C2, for instance a 470 microfarad capacitor would give effects for 10 times longer after S3 opened.

The transistor interface also switches the 12 volt amplifier off when the unit is not in action, and when it is being operated from a battery, this will save battery current.

"Bob, can we borrow your *Weird Sound Effects Generator* to use at the Charity Fair?" asked Tom.

"Yes", Bob replied, "so long as you bring it back afterwards.

Tom and Maurice happily gathered up the various gadgets which they were going to use at the Charity Fair, and bade farewell to Bob and the Prof.

To be continued

GEORGE HYLTON brings it down to earth

Loudspeaker Impedance

A READER from Swansea who has recently taken up electronics, asks some interesting questions about measuring the impedance of a loudspeaker and matching it to an amplifier.

If an ohmmeter is connected to a loudspeaker, what does it measure? Is the reading affected by the inductance of the speaker's "voice coil"? Can the impedance be calculated? And can it be changed, from say 3 ohms to 8 ohms?

The trouble with loudspeaker impedance is that it is a variable quantity. I don't just mean that you can buy speakers of different impedances; the *same* speaker's impedance varies depending on the conditions under which it is measured.

An ohmmeter measurement, being made with d.c., tells you only the resistance of the wire in the voice coil. But, as our reader realises, the fact that the voice coil is a coil means that it must have inductance, too. Therefore, its impedance must rise with *frequency*, because that's a characteristic of inductive reactance. So the impedance must be frequency-dependent.

Air Resistance

It is. But it's dependent on something else, too. Remember how a speaker works. Its voice coil is attached to the diaphragm or cone. When the coil moves, the cone moves, pushing the air in front of it. The air, of course, resists pushing. The cone and the voice coil "feel" this resistance.

The impedance of the coil is influenced by this. The extent of this influence depends very largely on the kind of cabinet in which the speaker is mounted. Large vented cabinets *tuned* to the bass resonant frequency of the speaker can have a big effect. If the impedance is measured at different frequencies there is a peak, a sharp increase, somewhere near the bass resonance—sometimes two peaks, and one on either side, depending on cabinet design.

Proof that the cabinet really causes these variations is obtained by making two runs of measurements. One is made with the speaker working normally, and the other with its cone clamped firmly so that it cannot move.

The result is something like that shown in Fig. 1. I say something like because speaker impedance curves usually have a lot of minor wiggles in them as well.

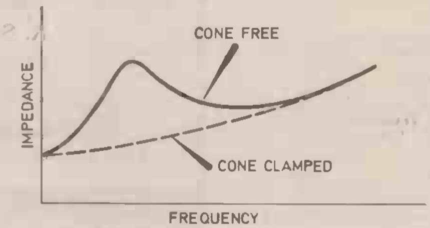


Fig. 1. Illustrating how the impedance can vary with different positions of the speaker cone.

Matching such a variable impedance to an amplifier isn't easy. Nor is it desirable. The resonant peak can "colour" the bass response severely. So hi fi amplifier designers generally ensure that the output impedance of their amplifier is *much less* than the impedance of the speakers which they are designed to drive.

This has the effect of improving the damping, that is, of making the sound output less dependent on the speaker's impedance at any particular frequency. The efficiency of the amplifier is also improved when its output impedance is less than the load (i.e. speaker) impedance.

Impedance

Where does this lead us when it comes to measuring speaker impedance? To the conclusion that the simplest thing to do is just measure the d.c. resistance of the speaker and leave it at that. If a speaker's voice coil is 3 ohms d.c. then it's a 3 ohm impedance speaker. The fact that it may be 9 ohms at 52Hz (because of bass resonance) or 8 ohms at 10kHz (because of the coil's inductance) is normally disregarded. This approximation is justifiable not only because it simplifies matters but often because it is nearly correct.

Modern loudspeakers are extremely inefficient, on the whole. This is the price you have to pay for forcing a small cabinet speaker to reproduce low notes. Instead of 10 watts being enough to drive the speaker, 50 watts is needed. Well over 99 per cent of this power is wasted in heating the resistance of the speech coil or warming up the interior of the cabinet. Far less than 1 per cent comes out as sound energy.

In these circumstances the speaker may hardly know whether it's in a cabinet or not. To the amplifier it's just a coil of thin wire, with resistance and a little inductance.

Can a 3 ohm speaker be modified to turn it into an 8 ohm one? Easily. Add a 5 ohm series resistor. The only snag is that the resistor absorbs $\frac{5}{8}$ of the power and the speaker only $\frac{3}{8}$.

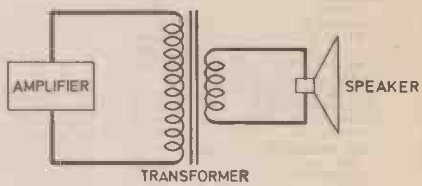


Fig. 2. If a speaker of incorrect impedance is to be used, then a matching transformer is required.

A much better idea is to connect speakers in series. Three 3 ohm speakers in series effectively produces a 9 ohm speaker, which is quite close to the target of 8 ohms and slightly on the high side, which is safe. Too *low* a resistance can overload the amplifier. The classical solution is to use a matching transformer, see Fig. 2.

Matching

A turns ratio of $\sqrt{(8/3)} = 1{\cdot}62$ to 1 will make a 3 ohm speaker look like 8 ohm to the amplifier. Suitable transformers are hard to obtain. There is much more to it than getting the correct turns ratio.

Also, the d.c. resistance of the primary winding of a suitable transformer is very low (0·1 ohms). This may seriously increase the amount of current which surges through the amplifier output at switch-on.

An 8 ohm speaker is at least 8 ohms at any frequency, high or low. A 3 ohm speaker matched with a transformer may, at very low frequencies, look like only 0·1 ohms. So the switch-on surge, which is really a very low frequency pulse could, in theory, be 80 times as much as with a real 8 ohm speaker, with dire effects on the output transistors.

Some amplifiers have built-in protection against surges. Others don't.

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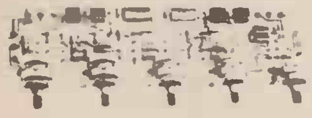

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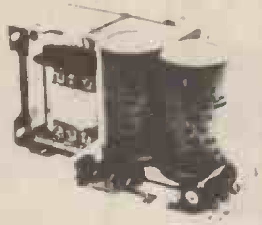

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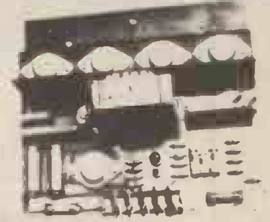

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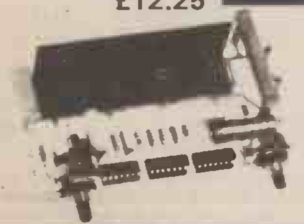

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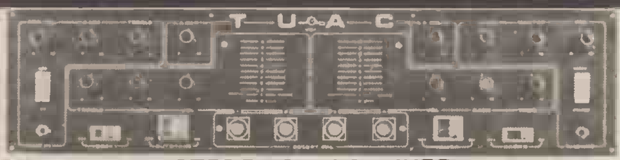

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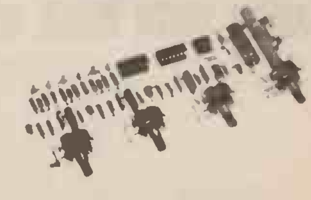

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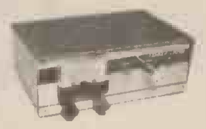

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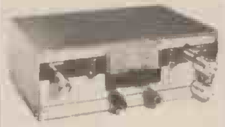

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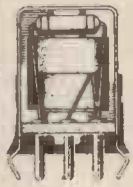

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7486N	0·36

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