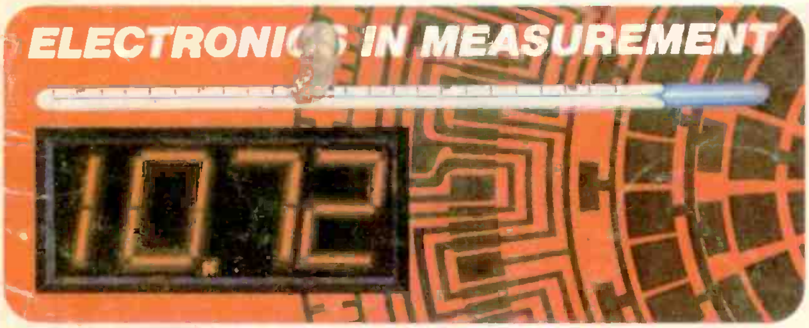
An exciting hobby.... for everyone

everyday electronics

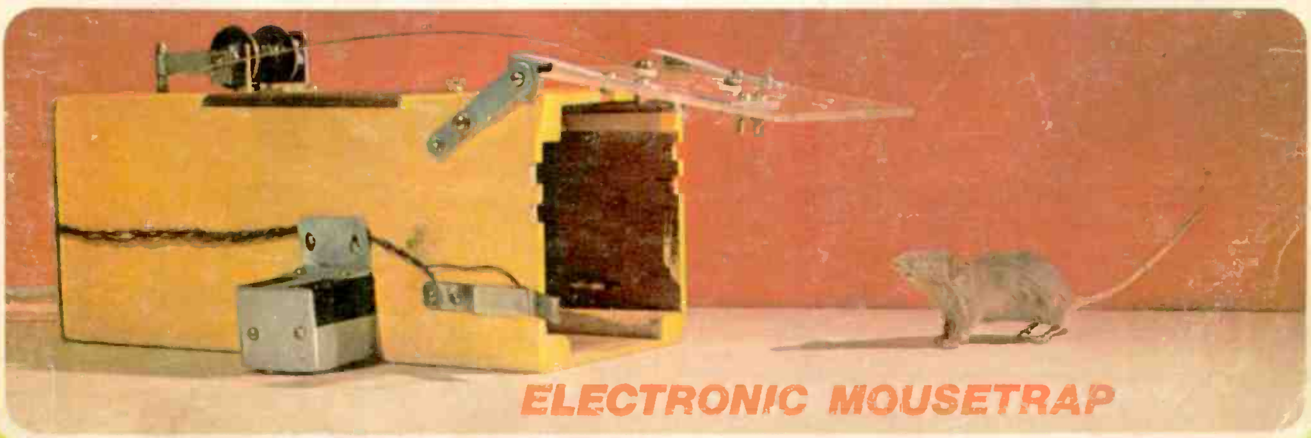
OCT. 72
15 p

REACTOMATIC



ELECTRONICS IN MEASUREMENT

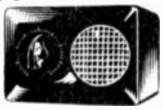
CASSETTE TAPE POWER SUPPLIES



ELECTRONIC MOUSETRAP

INGENIOUS ELECTRONIC SLEEP INDUCER

ONLY **£3·25**



CAN'T SLEEP AT NIGHTS? DO YOU WAKE UP IN THE NIGHT AND CAN'T GET OFF TO SLEEP AGAIN? WOULD YOU LIKE TO BE GENTLY SOOTHED OFF TO SATISFYING SLEEP EVERY NIGHT? Then build this ingenious electronic sleep inducer. *It even stops by itself so you don't have to worry about it being on all night!* The loudspeaker produces soothing audio-frequency sounds, continuously repeated—but as time goes on the sound gradually becomes less and less—until they eventually cease altogether, *the effect it has on people is amazingly very similar to hypnosis.* A control is provided for adjusting the length of times, etc., all transistor, can be built by anyone over 12 years of age in about two hours. No knowledge of electronics or radio needed. Extremely simple, easy-to-follow, step-by-step, fully illustrated instructions included. *No soldering necessary.* Works off standard batteries, extremely economical. Size only 3" x 4¼" x 1¼"—take it anywhere. Kit includes case, nuts, wire, screws, etc. **SEND £3·25** + 25p p. & p. (parts available separately).

BUILD 5 RADIO AND ELECTRONIC PROJECTS

only **£2·45**

Amazing Radio Construction set! Become a radio expert for £2·45. A complete Home Radio Course. No experience needed. Parts including simple instructions for each design. Illustrated step-by-step plans, all transistors, loudspeaker, personal phone, knobs, screws, etc. all you need. Presentation box **45p extra as illus.** (if required) (parts available separately) no soldering necessary. Send **£2·45** + 20p p. & p.

Eavesdrop on the exciting world of Aircraft Communications
V.H.F. AIRCRAFT BAND CONVERTOR

ONLY **£2·85**

Listen in to **AIRLINES, PRIVATE PLANES, JETPLANES.** *Eavesdrop on exciting cross talk between pilots, ground approach control, airport tower. Hear for yourself the disciplined voices hiding tenseness on talk downs.* Be with them when they have to take nerve ripping decisions in emergencies—Tune into the international distress frequency. Covers the aircraft frequency band including **HEATHROW, GATWICK, LUTON, RINGWAY, PRESTWICK, ETC. ETC. CLEAR AS A BELL.** This fantastic fully transistorised instrument *can be built by anyone over nine in under two hours.* No soldering necessary. Fully illustrated simple instructions take you step-by-step. Uses standard PP3 battery. All you do is extend rod aerial, place close to any ordinary medium wave radio (even tiny portables). **NO CONNECTIONS WHATEVER NEEDED.** SEND ONLY **£2·85** + 20p p. & p. for kit including case, nuts, screws, wire, etc. etc. (parts available separately).

FIND BURIED TREASURE?
Transistorised Treasure Locator

ONLY **£2·85**

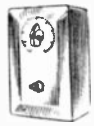
This fully portable transistorised metal locator detects and tracks down buried metal objects—it signals exact location with loud audible sound (no phones used)—uses any transistor radio which fits inside—no connections needed. **FINDS GOLD, SILVER, COINS, JEWELLERY, ARCHAEOLOGICAL PIECES ETC. ETC.** *Extremely sensitive, will signal presence of certain objects buried several feet below ground* No knowledge of radio or electronics required. *Can be built with ease in one short evening by anybody from nine years of age upwards,* with the clear, easy to follow, step-by-step, fully illustrated instructions—Uses standard PP3 battery. No soldering necessary. Kit includes nuts, screws, wire, etc. **ONLY £2·85** + 25p p. & p. (Sectional handle as illustrated 95p extra). Parts available separately. Made up looks worth £15.

SHORTWAVE TRANSISTOR RADIO

only **£2·75**

Anyone from 9 years up can follow the step-by-step, easy as ABC fully illustrated instructions. No soldering necessary. 76 stations logged on rod aerial in 30 mins.—Russia, Africa, USA, Switzerland, etc. Experience thrills of world wide news, sport, music, etc. Eavesdrop on unusual broadcasts. Uses PP3 battery. Size only 3" x 4¼" x 1¼" Only **£2·75** + 20p p. & p. Kit includes cabinet, screws, instructions, etc. (Parts available separately).

SOOTHE YOUR NERVES, RELAX WITH THIS AMAZING RELAXATRON



Only **£2·75**

CUTS OUT NOISE POLLUTION—SOOTHES YOUR NERVES! Don't underestimate the uses of this fantastic new design—the RELAXATRON is basically a pink noise generator. Besides being able to mask out extraneous unwanted sounds, it has other very interesting properties. For instance, many people find a rainstorm mysteriously relaxing, a large part of this feeling of well-being can be directly traced to the sound of falling raindrops!—a well known type of pink noise IF YOU WORK IN NOISY OR DISTRACTING SURROUNDINGS, IF YOU HAVE TROUBLE CONCENTRATING, IF YOU FEEL TENSED, UNABLE TO RELAX—then build this fantastic Relaxatron. Once used you will never want to be without it—TAKE IT ANYWHERE. Uses standard PP3 batteries (current used so small that battery life is almost shelf-life). **CAN BE EASILY BUILT BY ANYONE OVER 12 YEARS OF AGE** using our unique, step-by-step, fully illustrated plans. No soldering necessary. All parts including case, a pair of crystal phones. Components, nuts, screws, wire, etc. no soldering **£2·75** + 25p p. & p. *Parts available separately.*

ELECTRONIC ORGAN

ONLY **£3·25**

Don't confuse with ordinary electronic organs that simply blow air over mouth-organ type reeds etc. Fully transistorised. **SELF CONTAINED LOUDSPEAKER.** *Fifteen separate keys span two full octaves—play the "Yellow Rose of Texas", play "Silent Night", play "Auld Lang Syne" etc. etc.* You have the thrill and excitement of building it together with the pleasure of playing a real, live, portable electronic organ. **NO PREVIOUS KNOWLEDGE OF ELECTRONICS NEEDED.** No soldering necessary, Simple as ABC to make. *Anyone over nine years can build it easily in one short evening following the fully illustrated, step-by-step, simple instructions.* **ONLY £3·25** + 25p p. & p. for kit, including case, nuts, screws, simple instructions, etc. Uses standard battery (parts available separately). Have all the pleasure of making it yourself, finish with an exciting gift for someone.

Find buried treasure with this READY BUILT & TESTED TREASURE LOCATOR MODULE

ONLY **£4·95**

FULLY TRANSISTORISED PRINTED CIRCUIT METAL DETECTOR MODULE. *Ready built and tested*—just plug in a PP3 battery and 'phones and it's working. Put it in a case, screw a handle on and **YOU HAVE A PORTABLE TREASURE LOCATOR EASILY WORTH ABOUT £20!** Extremely sensitive—penetrates through earth, sand, rock, water, etc.—EASILY LOCATES COINS, GOLD, SILVER, JEWELLERY, HISTORICAL RELICS, BURIED PIPES, ETC. Signals exact location by "beep" pitch increasing as you near buried metallic objects. *So sensitive it will detect certain objects buried* **SEVERAL FEET BELOW GROUND!** GIVES CLEAR SIGNAL ON ONE COIN **£4·95** + 30p carr. etc. (High quality Danish Stethoscope headphones **£2·75** extra if required.) **EXAMINE AT HOME FOR 7 DAYS. YOUR MONEY REFUNDED IN FULL IF NOT 100% DELIGHTED.**

CONCORD ELECTRONICS LTD. (EE10U) 8, Westbourne Grove London W.2. Callers Welcome

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Vary the strength of your lighting with a DIMMASWITCH

The DIMMASWITCH is an attractive and efficient dimmer unit which fits in place of the normal light switch and is connected up in exactly the same way. The white mounting plate of the DIMMASWITCH matches modern electric fittings. Two models are available, with the bright chrome knob controlling up to 300 w or 600 w of all lights except fluorescents at mains voltages from 200-250 v, 50Hz. The DIMMASWITCH has built-in radio interference suppression:

600 Watt £3·20. Kit Form £2·70
300 Watt £2·70. Kit Form £2·20

All plus 10p post and packing.
Please send C.W.O. to:

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As supplied to H.M. Government Departments.

INSTRUMENTAL AUDIO EFFECTS

SUPER "FUZZ" UNIT KIT. CONNECTS BETWEEN GUITAR & AMPLIFIER. OPERATES FROM 9v BATTERY (not supplied). ALL COMPONENTS AND PRINTED CIRCUIT BOARD WITH FULL INSTRUCTIONS. KIT PRICE: £2·60 post paid.

CREATE "PHASE" EFFECT ON YOUR RECORDS, TAPES ETC., UNIQUE CIRCUITRY ENABLES YOU TO CREATE PHASE EFFECT AT THE TURN OF A KNOB. OPERATES FROM 9v BATTERY (not supplied) COMPLETE KIT OF COMPONENTS WITH PRINTED CIRCUIT BOARD & FULL INSTRUCTIONS. KIT PRICE: £2·60 post paid.

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EX COMPUTER PRINTED CIRCUIT PANELS 2in × 4in packed with semi-conductors and top quality resistors, capacitors, diodes, etc. Our price 10 boards **50p**, P. & P. 7p. With a guaranteed minimum of 35 transistors. Data on transistors included.

SPECIAL BARGAIN PACK. 25 boards for £1. P. & P. 18p. With a guaranteed minimum of 85 transistors. Data on transistors included.

PANELS with 2 power transistors similar to OC28 on each board—components 2 boards (4 × OC28) **50p**, P. & P. 6p.

9 OA5, 3 OA10, 3 Pot Cores, 26 Resistors, 14 Capacitors, 3 GET 872, 3 GET 872B, 1 GET 875. All long leaded on panels 13in × 4in. 4 for £1, P. & P. 25p.

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8 lead I.C. 1 off **50p.** 50 off **35p.** 100 off **20p.**

250 MIXED RESISTORS 62p
¼ and ½ watt.

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½, ¼ and 1 watt 5% and better.

QUARTZ HALOGEN BULBS
With long leads. 12V 55W for car spot lights, projectors, etc. **50p** each, P. & P. 5p.

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with dial but without bell. **95p** each, P. & P. 30p, £1·75 for 2, P. & P. 50p.

BARGAIN RELAY OFFER
Single pole change over silver contacts 25V to 50V. 2·5k Ω coil. 8 for **50p**, P. & P. 5p.

KEYTRONICS mail order only

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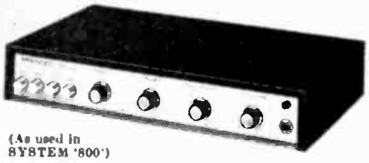
PREMIER 800 STEREO AMPLIFIER



(As used in SYSTEM '800')

A truly high quality stereo amplifier—compare the specification, compare the price. Output: 5 watts per channel. Frequency response: 30-20,000 Hz = 2 db. Distortion: 1% Output Impedance 8 ohms nom. Inputs equalised to R.I.A.A. Magnetic 4mV. Ceramic 100mV. Tuner 100mV. Tape 100mV. Tape out 150mV. Din sockets for inputs and outputs. Controls: Bass, Treble, Volume, Balance, Selector, Mono/Stereo switch. Stereo headphone socket. Attractive slim line design black leatherette cabinet with aluminium front panel. Size 12¼" x 6¼" x 2¼".

ONLY **£15·00** Carr. 50p.

Mk. II Version available with Teak Finish Cabinet. £16·25. Carr. 50p.

PREMIER HI-FI STEREO SYSTEMS

SYSTEM "800"

Consists of the Premier 800 Mk II all transistor stereo amplifier (described left) Garrard auto/manual record player unit fitted stereo/mono cartridge with diamond stylus and mounted in teak finish plinth with cover and two cloth front loudspeaker systems. Absolutely complete and supplied ready to plug in and play. The 800 Mk II amplifier has an output of 5 watts per channel with inputs for ceramic and magnetic pick-up, tape and tuner also tape output socket and headphone socket. Controls: Bass, Treble, Volume, Balance, Selector. Mono/Stereo switch. Headphone socket. Power on/off. Teak finish cabinet with aluminium front panel. Size: 12¼in x 6¼in x 2¼in.

£35·00

Carr. £1·75

SYSTEM "TWO"

as above but with slotted front teak finish loudspeakers, Garrard SP25 Mk. III and magnetic cartridge.

£45·00

Carr. £1·75

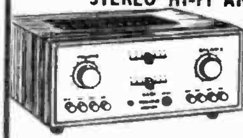
SYSTEM "THREE"

This consists of KLINGER KC903 stereo amplifier giving 6 watts rms per channel with Bass, Treble, Volume and Balance Controls. Inputs for Magnetic and Ceramic pick-up, tuner, tape in and out. Stereo headphone socket. Garrard SP25 Mk. III in teak finish plinth with cover and fitted Sonotone 9TAHCD diamond stereo cartridge. A pair of HMF Speakers size 16½" x 10½" x 9" fitted EMI units complete the matching system.

£57·75 Carr. £1·75

FREE LEADS AND PLUGS SUPPLIED WITH ALL SYSTEMS

PREMIER PARAGON STEREO HI-FI AMPLIFIER



Gives the best possible reproduction of records, radio and tape at a reasonable price.

Fitted with all the controls and facilities you're ever likely to want, the Paragon gives you a degree of sophistication that is usually only found with amplifiers costing twice its price. It has bass and treble slide controls, volume and balance knobs, and eight push-buttons. There's also a standard stereo jack socket on the front panel, plus a ceramic/magnetic cartridge switch and a mains outlet socket on the back panel.

Specifications 10 + 10 watts into 8 ohms. Power/frequency response: 0dB 10 watts into 8 ohms -3dB 20Hz - 25KHz. Distortion typically less than 0·25%. Inputs for Magnetic phono (4mV) Crystal phono (66mV) Radio/Tape (100mV). High and low filters. Teak finish cabinet. Size: 12¼" x 5¼" x 10¼".

£32·50 P. & P. 50p.

WELLER "EXPERT" SOLDER GUN. Saves time and simplifies soldering in the home and service dept. Two position trigger gives instant dual heat. 100/140 watt. 240 volt A.C. **£3·95** P. & P. 50p

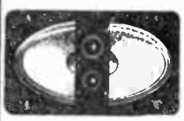
"Marksman" Soldering Iron. Lightweight 3/16" pencil bit. Ideal for regular bench use and around the home. 25 watts. 240 volt A.C. £1·50 P. & P. 16p

VERITAS V-313 TAPE HEAD DEFLUXER

A must for all tape users! Tape heads become permanently magnetized with constant use; this leads to background noise that prevents perfect recordings. Simply applied to recording head the V313 leaves head free of magnetism. Cleans any tape head in seconds.

£1·72 P. & P. 15p.

E.M.I. 13×8in. HI-FI SPEAKERS



Fitted two 2½in tweeters and crossover network. Impedance 8 or 15 ohm. Handling capacity 10W. Brand new.

£3·47 P. & P. 50p

PREMIER HI-FI OFFERS

Rogers Ravensbrook II Stereo Amplifier teak	£38·50
Rogers Ravensbourne Stereo Amplifier teak	£49·00
Metrosound ST20E Stereo Amplifier teak	£25·50
Goldring GL72 less cartridge	£22·00
Garrard SP25 III with Goldring G800 cartridge	£15·00

GARRARD SP25 MK III SINGLE RECORD PLAYER FITTED GOLDRING 800 MAGNETIC STEREO CARTRIDGE. COMPLETE IN TEAK PLINTH WITH COVER.

Total list price over £34.

PREMIER PRICE **£17·95** P. & P. 50p.

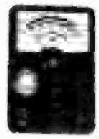
Garrard AP76 with G800, ready wired to 5 pin Din in plinth with cover	£29·50
Garrard AP76 less cartridge	£18·80
Garrard 401 Transcription Unit List £40·15)	£27·40
Garrard 2025 T/C with Stereo Ceramic Cartridge	£8·50
Garrard 2025 T/C with Stereo Ceramic Cartridge ready wired in teak plinth with cover	£12·45

Carriage and Insurance 60p extra any item.

CARTRIDGE BARGAINS!
Goldring G800H £5.00; G800 £5.50; G800E £9·50; P. & P. 10p

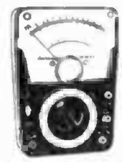
METER BARGAIN

MODEL GT-800 MULTIMETER



A precision made pocket sized test meter, ideally suited for testing electronic circuits or electronic appliances. Supplied complete with test lead and batteries. RANGES—DC Voltages: 10, 50, 250, 1,000V (1,000 opV). AC Voltage: 10, 50, 250, 1,000V (1,000opV). DC Current: 1mA, 100mA. Resistance: 0-150K ohms. Decibel: —10 to +22db (at AC 10V range) £2·47. P. & P. 25p.

MODEL CT680



Ranges - D.C. voltages: 0 - 3 - 15 - 60 - 300 - 600 - 1,200V (30,000 O.P.V.)
A.C. voltages: 0 - 6 - 30 - 120 - 600 - 1,200V (15,000 O.P.V.)
D.C. Current: 0 - 0·03 - 3 - 30 - 300mA.
Resistance: 0 - 16 M ohms.
Decibels: - 20 to + 63dB.
£7·00. P. & P. 25p.

HI-FI STEREO HEADPHONES

Designed to the highest possible standard. Fitted 2½in. speaker units with soft padded ear muffs. Adjustable headband. 8 ohms impedance. Complete with 6ft lead and stereo jack plug.

£2·47 P. & P. 25p.

VERITAS V-149 MIXER

Battery operated 4-channel audio mixer providing four separate inputs. Size 6 x 3 x 2in. suitable for crystal microphone low impedance microphone, with transformer, radio, tape, etc. Max. input 1·5v. Max. output 2·5v. Gain 6 dB. Standard jack plug socket inputs, phonoplugs output. Attractive teak wood grain finish case.

MONO MODEL **£3** STEREO MODEL **£3.47** P. & P. 15p

"VERITONE" RECORDING TAPE

SPECIALLY MANUFACTURED IN U.S.A. FROM EXTRA STRONG PRE-STRETCHED MATERIAL. THE QUALITY IS UNEQUALLED. TENSILISED to ensure the most permanent base. Highly resistant to breakage, moisture, heat, cold or humidity. High polished splice free finish. Smooth output throughout the entire audio range. Double wrapped–attractively boxed.

TT3	3"	450'	POLYESTER	37p	DT6	5¾"	1800'	POLYESTER	£1·12
DT3	3¼"	600'	POLYESTER	57p	TT6	5¾"	2400'	POLYESTER	£1·87
SP5	5"	600'	P.V.C.	42p	SP7	7"	1200'	P.V.C.	62p
LP5	5"	900'	ACETATE	50p	LP7	7"	1800'	ACETATE	75p
DT5	5"	1200'	POLYESTER	75p	DT7	7"	2400'	POLYESTER	£1·25
LP6	5¾"	1200'	ACETATE	75p	TT7	7"	3600'	POLYESTER	£2·50

TAPE SPOOLS 3" 5p, 5", 5¾", 7" 9p.
Post and Packing 3" 5p, 5", 5¾", 8p, 7" 10p (3 reels and over Post Free).

GENUINE EMI—TAPE COMPACT CASSETTES LOW NOISE BRAND NEW IN LIBRARY CASES

C60 (List 71p) 53p
C90 (List 98p) 66p
C120 (List £1·48) 90p
P. & P. 10p

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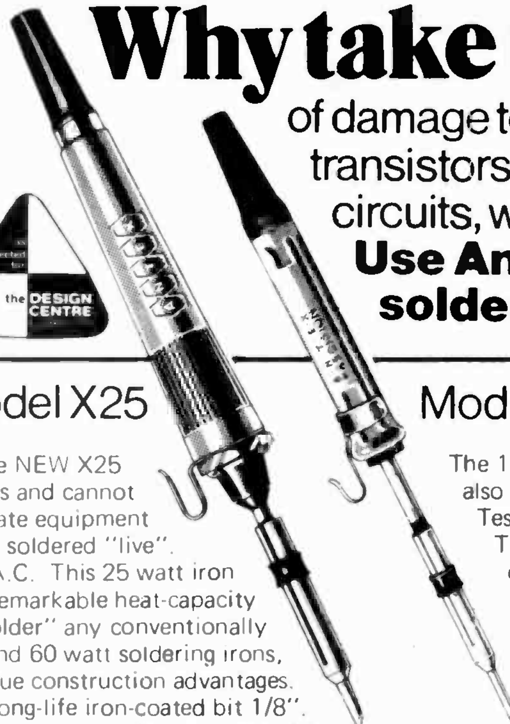
PREMIER RADIO

23, TOTTENHAM COURT ROAD, LONDON, W.1 Tel: 01-636 3451

Why take the risk?

of damage to expensive transistors and integrated circuits, when soldering?

Use Antex low-leakage soldering irons



the DESIGN CENTRE

Model X25

220-240 Volts or 100-120 Volts

The leakage current of the NEW X25 is only a few microamps and cannot harm the most delicate equipment even when soldered "live". Tested at 1500v. A.C. This 25 watt iron with it's truly remarkable heat-capacity will easily "out-solder" any conventionally made 40 and 60 watt soldering irons, due to its unique construction advantages. Fitted long-life iron-coated bit 1/8".

2 other bits available 3/32" and 3/16".

Totally enclosed element in ceramic and steel shaft Bits do not "freeze" and can easily be removed

PRICE: £1.75 (rec. retail)

Suitable for production work and as a general purpose iron

Model CCN

220 volts or 240 volts

The 15 watt miniature model CCN. also has negligible leakage. Test voltage 4000v. A.C. Totally enclosed element in ceramic shaft. Fitted long-life iron-coated bit 3/32"

4 other bits available 1/8", 3/16" 1/4" and 1/16"

PRICE: £1.80 (rec. retail)

OR Fitted with triple-coated, (iron, nickel and Chromium) bit 1/8"

PRICE: £1.95 (rec. retail)

A SELECTION OF OTHER SOLDERING EQUIPMENT.

MODEL CN

Miniature 15 watt soldering iron fitted 3/32" iron-coated bit. Many other bits available from 1/16" to 3/16". Voltages 240, 220, 110, 50 or 24

PRICE: £1.70 (rec. retail)

MODEL CN2

Miniature 15 watt soldering iron fitted with nickel plated bit 3/32". Voltages 240 or 220.

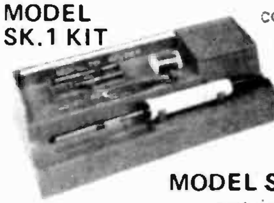
PRICE. £1.70 (rec. retail)

MODEL G

18 Watt miniature iron, fitted with long life iron-coated bit 3/32". Voltages 240, 220 or 110.

PRICE. £1.83 (rec. retail)

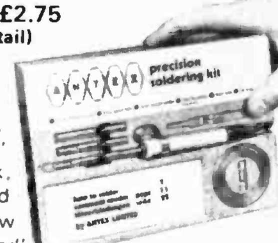
MODEL SK.1 KIT



contains 15 Watt miniature iron fitted with 3/16" bit, 2 spare bits 5/32" and 3/32", heat sink, solder, stand and "How to Solder" booklet.

PRICE £2.75 (Rec. retail)

MODEL SK.2 KIT



contains 15 Watt miniature iron fitted with 3/16" bit, 2 spare bits 5/32" and 3/32" heat sink, solder and booklet "How to Solder"

PRICE £2.40 (Rec. retail)

MODEL MES.KIT Battery-operated 12v. 25 watt iron fitted with 15' lead and 2 heavy clips for connection to car battery. Packed in strong plastic wallet with booklet "How to Solder." **PRICE £1.95 (Rec. retail)**

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an associate Company of LST ELECTRONIC COMPONENTS LTD.

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Now's your chance to get to know us better. Our brand new Catalogue is now awaiting you, hot from the presses.

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Products featured in the Arrow Electronics Mail Order Catalogue include the following

Extended ranges of Bridge Rectifiers, and Capacitors including Variable Capacitors.
Low cost Integrated Circuit Mounting Pins.
Instrument Knobs.
Light Emitting Diodes.
Magneto Resistors.
Optically Coupled Isolators.
Extended Range of Potentiometers.
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Temperature controlled Soldering Irons.
Extended Range of Thyristors.
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Hardware and Accessories including tools.
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An extended range of Opto Electronic Devices.
A very wide range of new Semiconductors.
Test Meters.

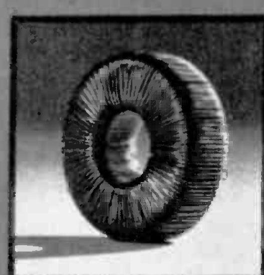
and many other items of great interest to the home constructor.

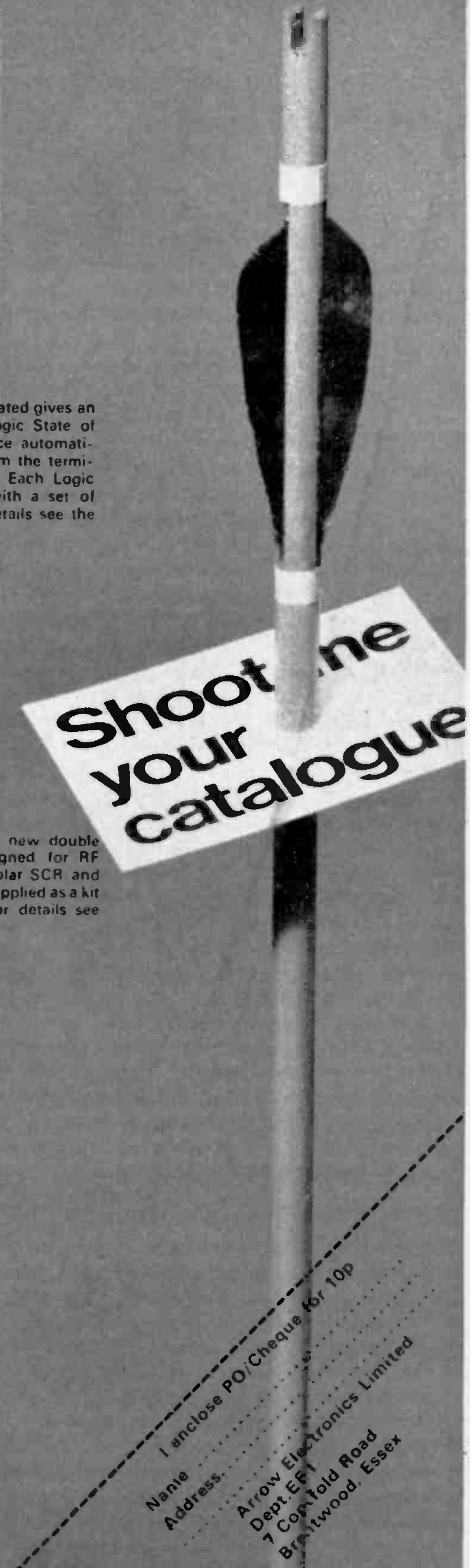
NEW PRODUCT

The unique test instrument illustrated gives an instantly visible display of the Logic State of DIL Integrated circuits. The device automatically selects its power supply from the terminals of the IC's being inspected. Each Logic Checker is supplied complete with a set of clip-on Logic plates. For fuller details see the new Arrow catalogue.

NEW PRODUCT

Arrow are the first to offer the new double wound ring core chokes designed for RF interference suppression in Bi-Polar SCR and TRIAC circuits. The chokes are supplied as a kit including a Delta Capacitor. For details see the new catalogue.





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everyday electronics

PROJECTS...
THEORY......

THE GOAL

As a hobby, electronics offers the ordinary person opportunity for involvement at different levels. The mathematically-inclined applying themselves to the resolution of intricate points of circuit design from first principles, the experimenters seeking the same end but depending largely upon cut and try methods, and the constructors pure and simple relying entirely upon published designs—all of these derive enjoyment and satisfaction from their labours.

The initial approach to the subject may differ, but the final goal for all is the completion of some item of electronic equipment which will be a rewarding achievement in itself. as well as being a device of practical worth.

CONSTRUCTORS

Everyday Electronics is chiefly concerned with the "constructors" (who should take no offence from the "pure and simple" definition given above!) and especially with those having little or no previous knowledge of electronics.

It is abundantly clear that there are thousands who have been fascinated by what they have read or heard concerning this all powerful, all embracing technology, and who have eagerly seized the opportunity provided by Everyday Electronics to use their hands and develop some skill in this branch of light engineering, so admirably suited to table top operators.

NOT DESIGNS, ALONE

We referred to three classes of enthusiasts in our opening paragraph. This division is of course a broad generalisation, but is substantially true. Our concern for the constructors does not end with the publication of designs with every detail clearly laid out. We appreciate the need for simple yet authoriative explanations of circuit theory. A sound knowledge of at least elementary theory is desirable, even for those whose chief interest is in the practical assembly work.

The *Teach-In* series which concludes with this month's article has been widely acclaimed in our post bag. This series has undoubtedly opened the door of electronics to thousands of novices. The awareness of what is happening in a circuit gives extra interest to the subject, and often will provide the urge to learn more. And that's not a bad thing.

PERSONAL CHOICE

We do always remember however that a hobby is first and foremost an activity indulged in for pleasure and recreation. How much time one is able or prepared to devote to it and how seriously one takes it, are all matters for each individual to decide for himself.

It is this freedom of choice, and the absence of rules and constraints governing one's activity which sets a hobby apart from a routine job of work.

Fred Bennett.

Our November issue will be published on Friday, October 15

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..EASY TO CONSTRUCT
..SIMPLY EXPLAINED

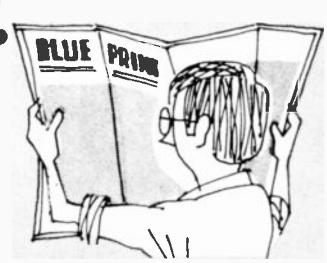
VOL. 1 NO. 12 OCTOBER 1972

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

Due to pressure on space Guide To Circuit Symbols Part 5 is held over to next month

EXTRA NEXT MONTH!
See page 661 for details



Cassette Tape POWER SUPPLIES

Approximate cost of components
£2·00 (mains)
£1·10 (car)

Two units to power a cassette machine from the mains or from a car battery by Mike Hughes

THE thousands of users of cassette tape recorders will know how useful it is to have a battery operated unit but will also be aware of the cost and comparatively short life of the internal battery supply. The recorder manufacturers have gone a long way to relieving the situation with clever design to keep current consumption to a minimum; nevertheless ten hours of intermittent operation seems to be a typical endurance.

This article describes two forms of auxiliary supply which are both simple to make and give excellent results; the first is a straightforward mains powered "battery eliminator" and the second provides a stabilised supply from a 12V car electrical system (operating from positive and negative earthed systems).

OUTPUT

Both units are designed to give a nominal output of 7·5V at currents up to about 200mA. This is the typical supply requirement of the Philips range of small cassette recorders. It is quite likely that the units could power other makes of equipment but the reader should read the manufacturers literature carefully to double check the voltage and current required.

The unit that interfaces with the car electrical system has the ability of providing a range of output voltages (from 7V to 9V at 200mA) hence is comparatively versatile and will probably drive most forms of transistorised radio, tape recorder or record player.

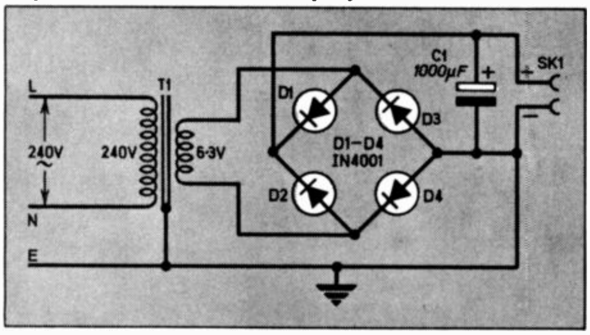


Fig. 1. Complete circuit diagram of the mains powered Cassette Tape Power Supply.

MAINS UNIT

The circuit for the mains unit is shown in Fig. 1 and is a simple unstabilised "sagging" supply. We call it sagging because the output voltage is to some extent dependent on the amount of current being drawn. Up to 200mA no noticeable effect on reproduction quality should be experienced.

Transformer T1 is a small 6·3V heater transformer the output of which is full-wave rectified by the diode bridge D1, 2, 3 and 4. Theoretically the output voltage of the bridge (when smoothed by capacitor C1) will equal the peak voltage ($6\cdot3\times1\cdot4=8\cdot8$V); this is in excess of that required. However we are using silicon rectifiers for the bridge and these will introduce a forward voltage drop bringing the output voltage down to between 7·5 and 8·0V. By the time a load is applied the output will fall to a nominal value of about 7·5V.

With the cassette recorder operating on its own internal speaker no hum is noticed even though the smoothing capacitor C1 is only 1,000μF. If, however, the audio output is to be amplified through a higher quality amplifier it would be worth considering increasing the value of C1 to about 5,000μF.

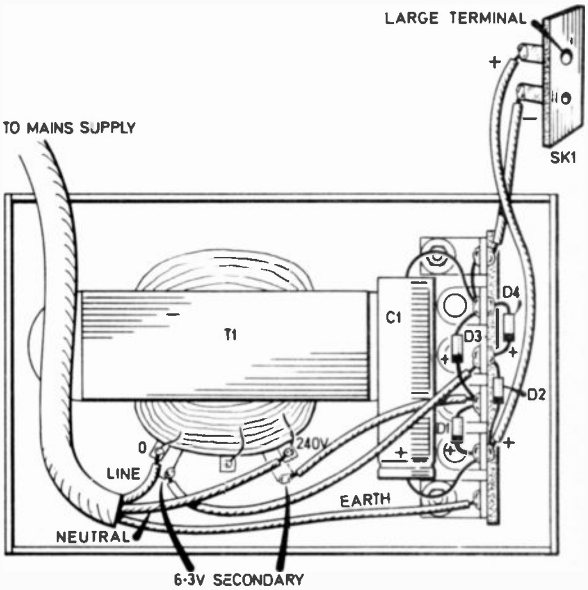


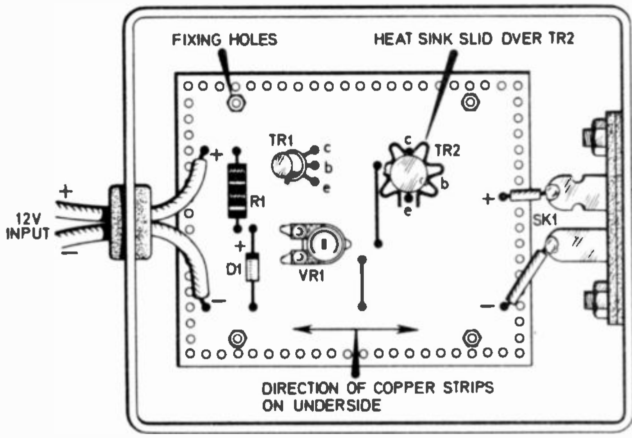
Fig. 2. Construction of the mains unit. Both the case and the negative supply rail are earthed via the earth wire in the mains lead.

CONSTRUCTION

Construction is shown in Fig. 2. The prototype case is a commercial design but could easily be fabricated out of 20 s.w.g. aluminium. Make absolutely sure that the terminations of the transformer do not touch the inside of the lid and ensure that an earth lead is provided. The negative side of the output should also be connected back to the chassis—and hence earth—for safety reasons. No on/off switch or indicator light was fitted on the prototype but these could be installed on the mains side of the transformer (a mains neon indicator may be used for the lamp) if required.

The output voltage is made available at a polarised output socket (i.e., one which will accept a plug one way round only) the type used in the prototype is a simple extension loudspeaker socket—the large contact being taken as positive.

Cassette tape POWER SUPPLIES



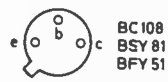


Fig. 4. The components mounted in position on the Veroboard inside the prototype case (Fig. 5.) Note the direction of the copper strips of the Veroboard—there are no cut-outs on these strips.

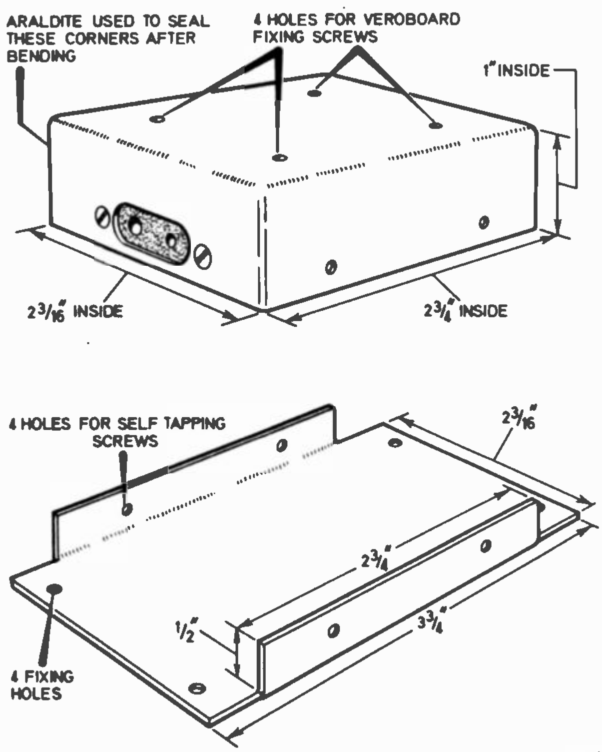


Fig. 5 (above). Dimensions and details of the prototype case used for housing the car unit. A suitable material is 20 s.w.g. aluminium.

Photograph of the assembled car unit with base removed.

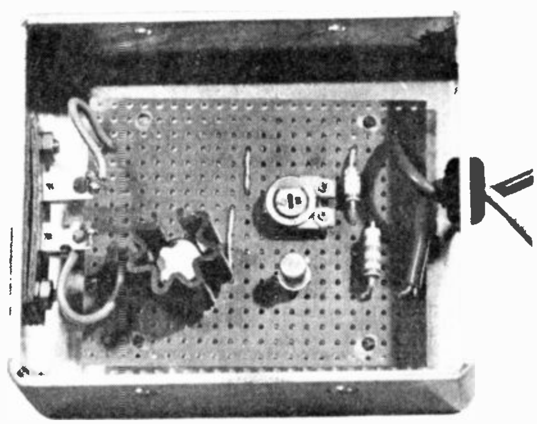
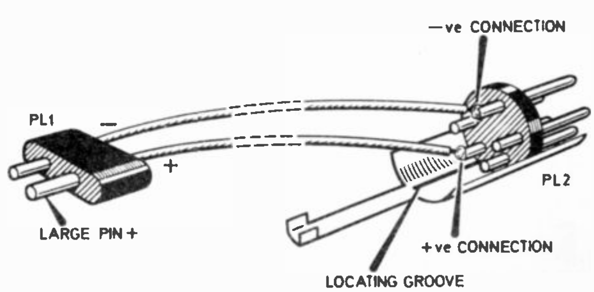


Fig. 6 (below). Details of the supply connection to a 5-pin DIN plug.



Components.... SEE SHOP TALK

Mains Supply

Diodes

D1 1N4001
D2 1N4001 } or any 1A, 50 p.i.v. silicon rectifier diodes
D3 1N4001
D4 1N4001

Transformer

T1 240V primary, 6·3V 1A secondary (small heater transformer)

Capacitor

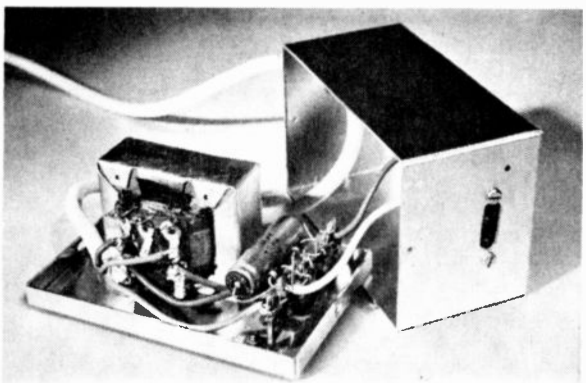
C1 1,000μF elect. 12V (see text)

Miscellaneous

SK1 polarised panel mounting socket (loudspeaker type) Aluminium case (approx. 4in x 2½in x 2in—depending on transformer size), tag strip with 4 insulated and 2 grounded tags, ⅜in grommet, mains lead and three pin plug fused at 2A, connecting wire, 4BA fixings.

Components Common To Both Projects

Polarised loudspeaker plug (to suit SK1), 5 pin, 240 degree, DIN plug (for connection to recorder), two core connecting wire (length as required).



The construction of the mains unit.

CAR UNIT

The problem with running anything from a car's electrical system is that the voltage level (nominally 12V) varies quite considerably depending on the state of charge of the accumulator and the rate of charge from the generator or alternator.

Sometimes it might rise to as high as 15V. Thus we have to introduce some form of stabilisation as well as drop the level to that required by our equipment. We will use the circuit shown in Fig. 3. On the face of it, it may look extravagant using two transistors as well as a Zener diode but all the components are relatively cheap and using a second transistor enables us to use a preset variable potentiometer (VR1) to set any output voltage we require between zero and 9V.

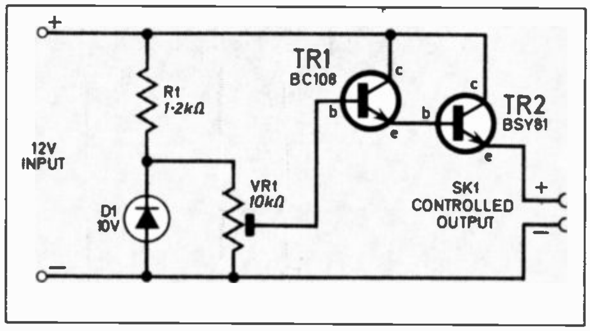


Fig. 3. Complete circuit diagram of car Cassette Tape Power Supply.

OPERATION

The Zener diode that supplies the reference voltage should have a value of approximately 10V. Certainly its value should not be greater than 10·5V and if less than 10V it will not be possible to get output voltages as high as 9V. Preset potentiometer VR1 provides a well defined reference voltage that can be set between zero and the full Zener level. This provides a small drive current into the base of TR1 the emitter current of which provides a much greater drive into the base of TR2 which is operating as a series stabiliser.

The combination of TR1 and TR2 in this configuration is sometimes called a Darlington pair. We need the intermediary action of TR1 because the current available from the Zener diode circuit—in particular when VR1 is set at a low voltage level—is small and the current gain of TR2 in isolation would not be sufficient if we wished to draw up to the 200mA specified.

No smoothing is required in this circuit because we are already operating from d.c. but if the stabiliser is to be used for powering a radio it might be worth incorporating a small capacitor (say 10μF) to prevent any breakthrough of car ignition interference. This should be connected across the power output leads of the unit. When the unit was used with a Philips cassette recorder no interference could be detected at all and the stabiliser even coped with the dramatic voltage drop of the car's electrical system while the starter was being operated

CONSTRUCTION

All the components are mounted on Veroboard (Fig. 4); VR1 should be a flat mounting type so that it can be adjusted after the board has been installed in the box. Make sure that the Zener diode is connected the correct way round—the banded end should be connected to R1. A finned type of heatsink should be slipped on to the can of TR2 (the can size is TO-5). Keep the leads of the components above the board as short as possible to prevent any mechanical vibration but at the same time do not overheat the components when soldering.

The box used in the prototype is formed from 20 s.w.g. aluminium the base being in the form of a flange (Fig. 5) which is used for fitting the unit to the bulkhead on the car. The Veroboard is bolted inside the lid on insulated spacers. Power input leads are taken out through a grommeted hole for permanent wiring to the car and the output connections terminated at a polarised socket identical to that described earlier—make sure that you keep to the same polarity convention!

Note that no electrical connections are made to the metal of the box; this enables the unit to work from either positive or negative earth cars. Before connecting up make sure you know your car's polarity otherwise you may permanently damage the transistors.

SETTING UP

Before connecting up to the tape recorder set VR1 to give the output voltage required by measuring the output with a voltmeter. If you cannot get the full 9V output it means that the Zener diode has a lower breakdown than that specified; check this by measuring the potential difference across the Zener. The output voltage will always be approximately 1V less than the reference voltage set by VR1 because of the forward voltage drops of the base/emitter circuits of TR1 and TR2.

Because of the maximum dissipation of TR2 the output voltages are limited to the range 7 to 9V at up to 200mA. However, if lower voltages are required, these can be obtained by setting VR1 accordingly but the current output will not be so high. For example 100mA at 2V would be permissable and approximately 150mA at 5V.

For Philips recorders it is not necessary to incorporate any switching in the recorder itself. Inserting the DIN plug automatically cuts out the internal batteries. This may or may not be the case with other equipment.

It is worth repeating the manufacturer's instructions that if you do not intend to use the batteries within the recorder for some period of time they should be removed to prevent any possible leakage and corrosion.

SUPPLY CONNECTION

To connect the supply to the recorder an accessory lead is made up using a polarised plug (to mate with the socket just described) and a 5-pin (240 degree) DIN plug that is accepted by the accessory input of the recorder. Make absolutely certain that you connect up to the correct pins as shown in Fig. 6.

This wiring is correct for the Philips equipment and should apply to other manufacturers but you are advised to make absolutely sure by referring to the manufacturer's own leaflet or service sheet. Once this lead has been made up it can be used with either the mains or the car unit.

Components....

SEE SHOP TALK

Car Battery Supply

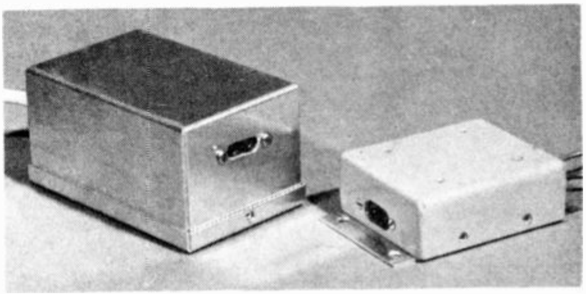
Resistor
R1 1·2kΩ ¼W ±10% carbon

Variable Resistor
VR1 10kΩ skeleton preset (flat mounting type)

Semiconductors
TR1 BC108
TR2 BSY81, or BFY51,
D1 10V 400mW Zener diode

Miscellaneous
SK1 polarised panel mounting socket (loudspeaker type) Veroboard 2in x 1½in x 0·1in matrix, TO5 type heat sink (finned push on type), $\frac{3}{16}$in grommet, material for case (see text), connecting wire, 6BA fixings

Components Common To Both Projects
Polarised loudspeaker plug (to suit SK1), 5 pin 240 degree DIN plug (for connection to recorder), two core connecting wire (length as required).



AUDIO FAIR

EVERYDAY ELECTRONICS and PRACTICAL ELECTRONICS will be exhibiting at this year's International Audio Festival and Fair, Olympia London, October 23-28.

See us on Stand 19, Ground Floor.

Sound Synthesis For The Amateur is the title of a lecture/demonstration to be given by D. Shaw, contributor to PRACTICAL ELECTRONICS, on Tuesday, Oct 24 and Saturday, Oct 28 at 2 p.m.

ONCE again this month we have a couple of new products well worthy of mention so we will deal immediately with buying problems and then take a look at the products.

Just a couple of points concerning the *Weather Station* (August issue); first G. W. Smith have now informed us that they do not supply the case for the monitor unit and unfortunately we have been unable to find a supplier. However Garland Bros. Ltd., who advertise in our pages can supply a slope fronted case in plain aluminium. The second point is that the GL23 thermistor is available from Henry's Radio, who also take space in our issues.

SHOP TALK

By Mike Kenward

Mouse Trap

A very unusual project—the *Mouse Trap*—but surprisingly enough one that has been in demand amongst our staff ever since the prototype was given to us by Fred Judd. Even those people who did not think they had mice (like me) have found that the *Mouse Trap* will catch any that are around; perhaps they are attracted by the light inside!

As far as we can see there should be no buying problems for this project. The Perspex should be available locally at a good hardware shop or from a small firm that uses it e.g. sign makers. Incidentally the door retaining wire can be made from one of the EE binder retaining wires (what a good sales gimmick!)

Easi-Binders to hold 12 issues of EVERYDAY ELECTRONICS are available from Binding Dept., IPC Magazines Ltd., Carlton House, 68 Great Queen Street, London W.C.2. These binders are well worth having even if you are not building the *Mouse Trap*, they are finished in orange de luxe Balacron (similar to p.v.c. in appearance) and cost 88p including postage and packing.

Reactomatic

Few buying problems should be encountered when getting parts for the *Reactomatic*. Two things to note are that the control knob should not have any markings on it and that the lamps used are easily visible in daylight when illuminated. Those shown on the prototype proved rather difficult to see and larger types with enclosed bulbs and bigger lenses may well be better. None of the other components should be difficult to get, any type of push-to-make push button can be used.

Cassette Tape Power Supplies

The two *Cassette Tape Power Supplies* described are likely to be among the most popular designs we have yet published—judging by the correspondence we receive requesting such devices. They have been kept very simple in design and all the parts are easy to obtain.

The case shown for the mains unit is a "Norman case" which was purchased from Radio Component Specialists who advertise in our pages. The car unit could be put in a similar case although this is larger (4in x $2\frac{1}{2}$in x 2in) than that shown in the article.

If you have any difficulty getting the polarised plugs and sockets, most car accessory shops can supply them.

New Products

A new "Cassette Re-Record Kit" has recently been introduced by Bib who already make a vast range of audio accessories. The kit is designed to enable pre-recorded cassettes to be used to record on when the original material becomes outdated.

The kit contains 20 plastic inserts to press into the holes at the back of the cassette, 27 labels to stick over the existing title labels, and a tab removing tool to remove the plastic inserts on existing recorded cassettes, or the inserts in the kit, so that the

cassette can be preserved without the risk of accidental erasure after it has been recorded or re-recorded (if you can follow that).

The kit is available from most hi-fi and audio shops. The recommended retail price is 44p and full instructions for using the kit are printed on the back of the header card.

Another new product from West Hyde Developments—whose cases were mentioned last month—is what they term as a "throw away" multimeter. Primarily intended to be issued to engineers, the meter may well appeal to constructors as a cheap portable meter. The ranges are 15, 150, 1000V a.c., 15, 150, 1000V d.c., 1, 150mA d.c. current, and a resistance range capable of reading values from 100Ω to about 30kΩ, sensitivity is 1,000Ω/V and the meter costs £2.

The beauty of the meter is its compact size—about $3\frac{1}{2} \times 2\frac{1}{4} \times 1$ inch, it is made in Japan and is sold with test leads and a brief, quaintly translated, instruction sheet. The photograph below gives a good idea of the size of the meter.

The meter is available from West Hyde Developments Ltd., Ryfield Crescent, Northwood Hills, Northwood, Middlesex, HA6 1NN.

ELECTRONICS IN MEASUREMENT

MEASUREMENT is the key to new developments in all branches of science and industry. Neither a new type of jet engine nor an improved strain of barley can be derived without experiments being undertaken. In the course of these experiments measurements are made, the results are evaluated and the future line of investigation is decided. Only rarely can the researcher see his goal clearly when commencing work; he reaches his destination not by dead reckoning but by seeking out and interpreting landmarks along the way.

When the measurements are few in number and uncritical in nature, they present no problems; an inexperienced man with his pencil and notebook can do the job. However, it is often necessary to obtain hundreds or even thousands of data in order to arrive at a simple yes/no decision.

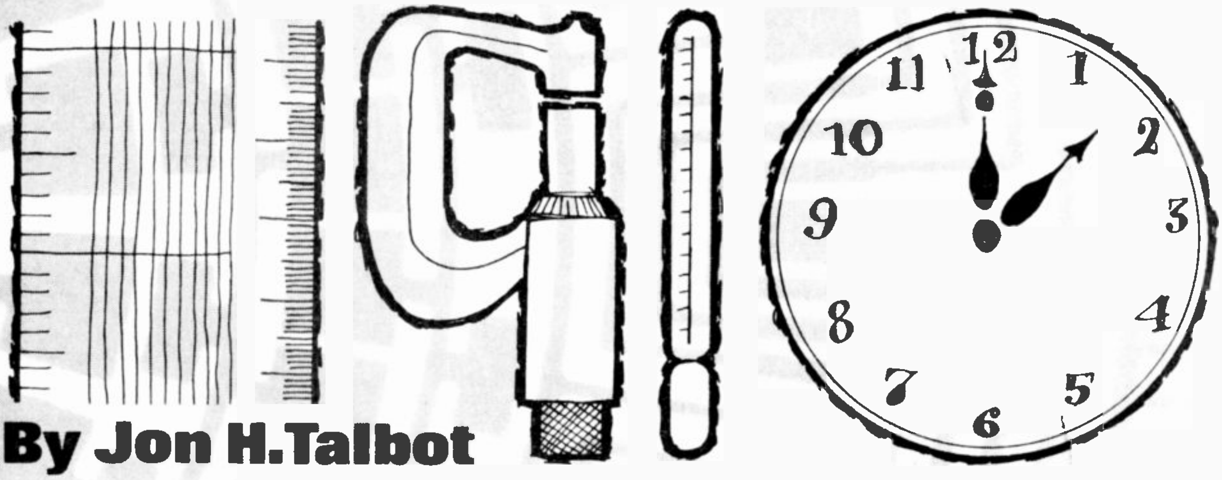
When measurements are required to a high degree of accuracy, and to be repeated at regular intervals and are materially affected by outside influences such as temperature variation, humidity of contamination, then the whole undertaking may become too protracted, too uncertain and too expensive.

Moreover, the man who is content to carry out such a tedious and repetitive task will probably lack the experience and perception to do the job accurately, while the technically competent researcher may obtain no more satisfactory results because he will be overtaken by boredom! It is hardly surprising that much effort has been put into perfecting means of automating tasks of this type.

INDUSTRIAL USE

Electronic methods of measurement began to be used in industry in the mid 1930's but made little real impact until after World War II, when the electronic industry was truly founded. Since that date more and more characteristics of more and more materials and processes have become measurable in electrical terms.

Many of these electrical signals have been obtained by simple adaptation of mechanical or hydraulic instruments whose origins may be very old. For example, a common method of



By Jon H.Talbot

measuring the pressure of a liquid in a pipe is to take a tapping via a small bore tube terminated in a seamless metal bellows. As the pressure rises the bellows becomes distended and moves the pointer of an indicator.

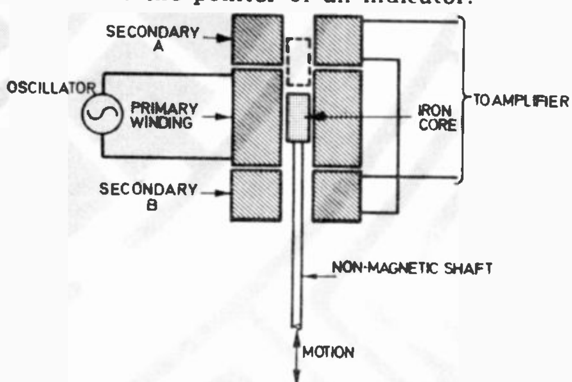


Fig. 1. Schematic diagram of a Differential Transformer (displacement measurement). The cone movement direction is determined by the amplifier by comparing the phase of the received signal with that from the oscillator.

To make this simple pressure gauge generate an electrical signal we can make use of a differential transformer. An iron core is attached to the rod which formerly drove the pointer and this core is located centrally inside a cylindrical coil. The coil is energised by an a.c. signal and is in close proximity to two other coils which are located at either end. As the core rises and falls with increasing and decreasing pressure it causes a larger voltage to be induced in one secondary coil and a smaller voltage in the other (Fig. 1). The magnitudes of these induced signals are a measure of the displacement of the bellows.

ANALOGUE TRANSDUCER

The pressure gauge described above is an analogue transducer: a device producing a signal which varies steadily with the parameter being measured (in this case, pressure) and, in theory at least, it has infinite resolution i.e. an infinitely small change in pressure results in an infinitely small change in electrical output. In practice, of course, the mechanical characteristics of the moving parts will result in the output changing in tiny jerks so the resolution, while fine, is not infinite.

NEW ELEMENTS

Some of the early measuring instruments did not lend themselves readily to such adaptations and entirely new primary elements had to be devised. These new instruments were often designed and developed throughout by electronic firms and as a result were more readily incorporated into complete electronic systems.

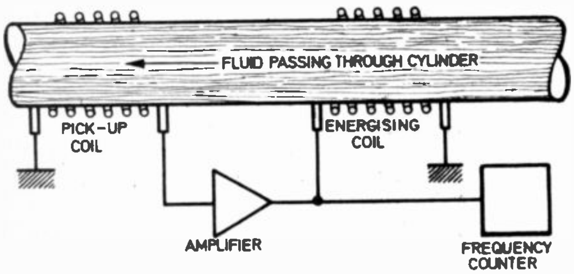


Fig. 2. A cross-sectional diagram of a vibrating cylinder density transducer.

The physical linkages between the medium being measured and the electrical circuit were simpler and more direct, eliminating some of the sources of inaccuracy. An example is the vibrating cylinder density transducer (Fig. 2). An amplifier drives a coil which sets up vibrations in a tube through which a gas or liquid is flowing. When the density of the fluid increases it raises the mechanical loading on the tube and reduces the resonant frequency of what is really a mechanical tuned circuit (rather like a tuning fork). The vibration is detected by a pick-up coil and the frequency of the energising signal is changed in sympathy. This means that the natural frequency of oscillation of the electromechanical circuit is a measure of the fluid density.

This density transducer is, for obvious reasons, described as a frequency-domain device.

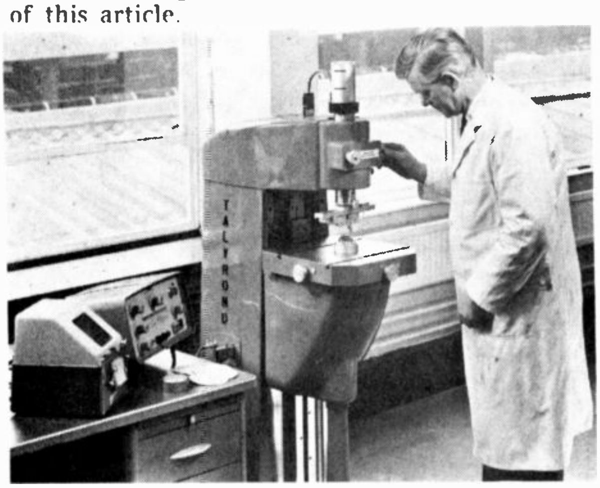
Assembling and testing transducers for gas density measurement. *(Solar Electronic Group Ltd)*

DIGITAL TRANSDUCER

There is a third type of transducer which is more limited in application but possesses the advantage that it needs no calibration as such, while the desired resolution is defined when the instrument is made. This is the digital transducer, of which by far the commonest example is the encoding disc.

In appearance it is similar to a series of stroboscope rings such as those used to check the speed of a gramophone turntable. The centre ring has a small number of segments while the other rings have progressively more segments as their circumference increases.

If the disc is fixed onto a shaft, then the angular position of the shaft at any instant, whether it is moving or stationary, can be detected by examining the position of the segments by photo-electric or mechanical means. An example of such a disc is shown on the front cover and the pattern is also used in the heading of this article.



Checking the finish of a lens with the Talyrond 73 roundness measuring system. This system which can detect surface irregularities of the order of one millionth of an inch, uses a special purpose computer to correct for inaccuracies in work positioning etc. Defects of the work piece are recorded on a rotating chart. ***(Rank Precision Industries Ltd.)***

The disc is often made in the form of a printed circuit board so that its position can be ascertained by picking up an electrical ouput from stationary brushes.

There is a great need for better transducers. This has been highlighted by the increasing importance of detecting pollutants in air and water, yet it is still only possible to isolate certain poisonous substances by carrying out a chemical analysis manually.

DATA LOGGING

The process of automatically collecting and recording information from a number of transducers is called data logging. In its simplest form, a data logger comprises a scanner, an analogue-to-digital converter and an output device (Fig. 3).

The scanner is a series of relays which are operated sequentially such that the ouput from a number of analogue transducers is connected to the converter in turn. The converter samples each signal and feeds the result of its measurement in digital form (binary or binary-coded decimal) to the output driver.

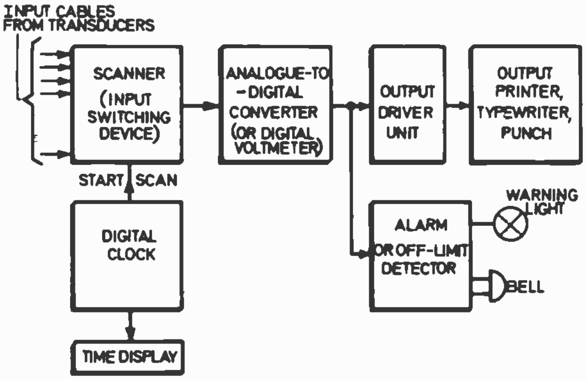


Fig. 3. Block diagram of a typical data logging system.

The output machine may be a strip printer, which prints the results on a tear-off strip for the convenience of the plant operator; it may be an electric typewriter which produces a record in tabular form suitable for binding into a logbook, or it may be a punch, which produces perforated paper tape for subsequent computer analysis.

A more elaborate logger will include a digital clock, which enables the readings to be repeated at accurately determined time intervals, and an alarm detector that flashes a light and rings a bell if a reading is taken that is outside prescribed limits.

APPLICATIONS

The applications of data logging are not restricted to research alone. Frequently the information which has been obtained by a data logger is used to set the controls in a process plant. An obvious development is to use signals from the logger to operate relays, valves and motors controlling the plant, thus avoiding the need for intervention by the plant operator.

In the case of a small electric furnace, where close temperature control may not be needed, this can be achieved easily. If the logger detects that the temperature is too low then the alarm detector energises a relay that switches on the heating elements. When the logger returns to that measuring point (or channel) and finds that the temperature is now too high, then the relay is relaxed and power is removed from the furnace.

If the temperature is to be maintained within close limits a much more refined control system will be needed. A complicated industrial operation may involve a hundred or more variables, not only temperatures but pressures, flows, densities and levels as well.

Many variables are closely interrelated with others and are subject to disturbances of a random nature, so the only means of running the plant is to entrust the whole operation to a digital computer.

However, the largest and fastest computer, controlled by comprehensive programmes, is ultimately dependant upon the information it is given. The plant may produce nothing but waste output if the transducers are badly sited or the scanning system is poorly conceived.

VOLUME MEASUREMENT

There are many fields of measurement which are more complex than they at first appear.

When a petrol tanker discharges at a filling station the driver sometimes checks the level of liquid by means of a dipstick—a convenient and simple tool. At the oil refinery the level of liquid in the huge storage tanks is often checked in a similar manner: a float moves a cable or tape, made of low-expansion alloy, and this drives a remote indicator. The depth of liquid can be measured accurately, but petrol and oil are sold by the gallon—by volume. The relationship between the two types of measurement is not simple.

Oil storage tanks are made of steel and concrete, but they are not as rigid as they appear. When an empty tank is filled, the effect is not unlike that of filling a plastic bucket; the bottom becomes concave and the sides become slightly barrel-shaped, so that each additional

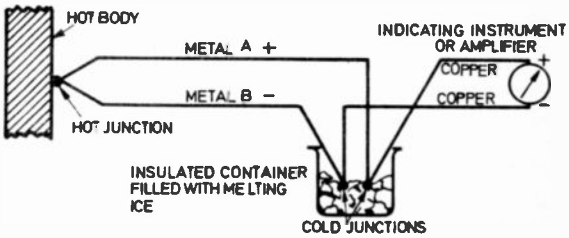


Fig. 4. A schematic diagram of a thermocouple—used for temperature measurement. The thermocouple utilises the principle that if two dissimilar metal wires are joined at their ends, and each function subjected to a different temperature then a current flows, its magnitude being proportional to temperature difference of junctions.

foot of depth represents a different quantity of oil.

The volume of oil is also affected greatly by temperature and barometric pressure; the value of the contents of the largest size of tank is over £1000 more on a hot, sunny day than on a cold, overcast day (there are some anxious moments when the Inland Revenue inspector calls to determine the duty payable!)

Fig. 5 (top). Appearance of a typical strain gauge element. (Bottom) Shows the insertion of the element into a Wheatstone bridge. Utilises change of resistance with element geometry.

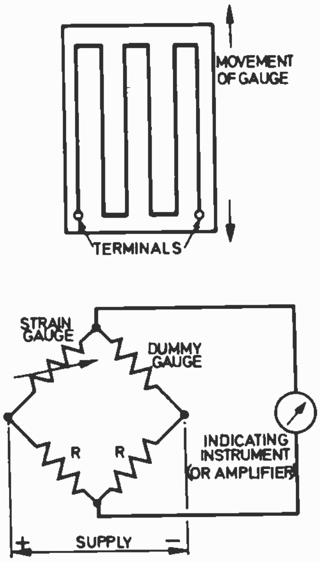


Table 1: Transducers used for measurement in industry

Parameter	Transducers and associated equipment
Temperature	Resistance thermometer Thermocouple Thermistor (temperature-sensitive resistor)
Light	Photo-electric cell Photo-multiplier tube
Acidity	pH electrode (measures hydrogen ion concentration)
Properties of Gases	Infra-red source and Detector Colorimetric Analyser (measurement of transmission of light of various frequencies)
Hardness	Diamond pyramid tester and differential transformer
Magnetic field	Hall-effect element
Mechanical strain	Resistance strain gauge Load Cell
Proximity	Capacitance proximity detector Ultrasonic source and detector
Displacement	Differential transformer

The only way of obtaining a direct reading of the contents, which is corrected to normal temperature and pressure, is to use what is in effect a special-purpose computer that is connected to temperature and pressure sensors and to a depth transducer. This machine combines their outputs by correcting the depth reading according to ambient conditions and to a preset programme which corrects for mechanical distortion of the tank.

Instruments of this type have been made experimentally and will undoubtedly come into common use, but at present they are too expensive to compete with existing equipment.

Many of the potential benefits of electronics in measurement have not been realised in the past because electronics men have concerned themselves more with "pure" rather than applied electronics, while established industries have been slow to adopt new techniques. The alchemists and luddites have their counterparts in modern times!

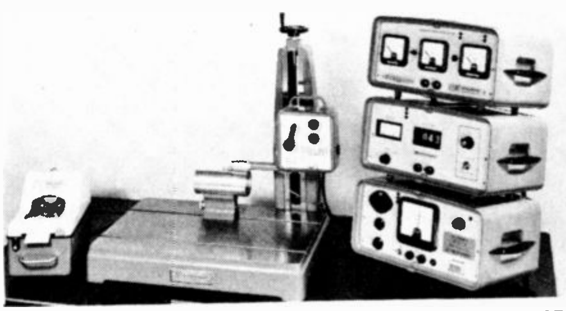
MACHINE TOOLS

One of the slowest industries to adopt electronic methods was that of machine tools, yet precision machining of metals lends itself well to digital measurement techniques. A problem here was that the tools had to be designed around the transducers; it was not enough to add electronic appendages to existing machines.

Nowadays all types of machine-shop work, from the finishing of rough castings to the repetitive milling of complex mechanical structures from the solid, is carried out under the control of signals from magnetic or punched paper tape.

The machine work-table is fed upwards, sideways and forwards, tools are changed and feed rates are monitored and adjusted under electronic control. Here the measurement devices are "closing the loop"—they confirm that a certain operation is being carried out exactly as required by the directions on the tape, and correct for factors such as tool wear that cannot be assessed in advance.

The Talysurf 4 system which counts the irregularities in a machined surface and enables the texture of the finish to be evaluated quantitively. *(Rank Precision Industries Ltd.)*



DYNAMICS

There is increasing interest in measurement that is dynamic rather than static, for time delays are important in many processes. For example, the spring rate of a valve spring for the engine of a motor car can be determined by loading it with a weight and measuring the amount of compression with a rule. This, however, offers very little data on what happens when it is compressed 4000 times a minute in a working engine.

It is more instructive to compress the spring, release it in 1/4000th. of a minute, and then measure how long it takes to come to rest.

It is the transfer function, the relationship between stimulation and response that matters, and this has led to the spawning of a whole new generation of dynamic analysis instruments. These can either simulate an operation electrically on the bench or be coupled temporarily into a working system to cause known perturbations which can be analysed automatically.

Using a Transfer Function Analyser to determine the relationship between respiration and work done by humans. *(Solartron Electronic Group Ltd)*

A new dimension has been added to the science of measurement and provides a fresh view of concepts that had been developed as far as our previous static assessment would allow. ▣

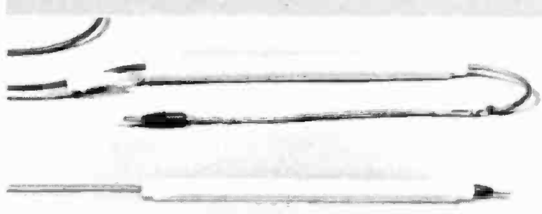
A readers' Bright Idea; any idea that is published will be awarded payment according to its merit. The ideas have not been proved by us.

I have found a way of making test probes for equipment that are cheap, insulated and rugged.

The parts needed are the red and black bodies of two "Scripto" or "Venus Gem Writer" type of felt tip pens that have been used up, a piece of stiff wire such as that used to make coat hangers and two lengths of red and black connecting wire.

To make the probe, remove the ink felt and fibre tip by pulling off the white end and the tip cap. Cut a length of stiff wire—about 6 inches long and file one end to fit into the plastic tip. Cut a small hole in the white cap, pass a connecting wire through the cap, solder it to the stiff wire, and reassemble the pen. The photograph shows the construction and the finished probe.

E. R. Wall,
Chalton, S.E.7.



Please Note: this column is intended for constructional ideas and ideas relating to electronic construction. It is not our intention to publish circuits of any description.

All items submitted should be original and not previously published.

A reaction testing game that can also be converted to a quiz answering indicator.

By D. Smith

RE ACT OMATIC

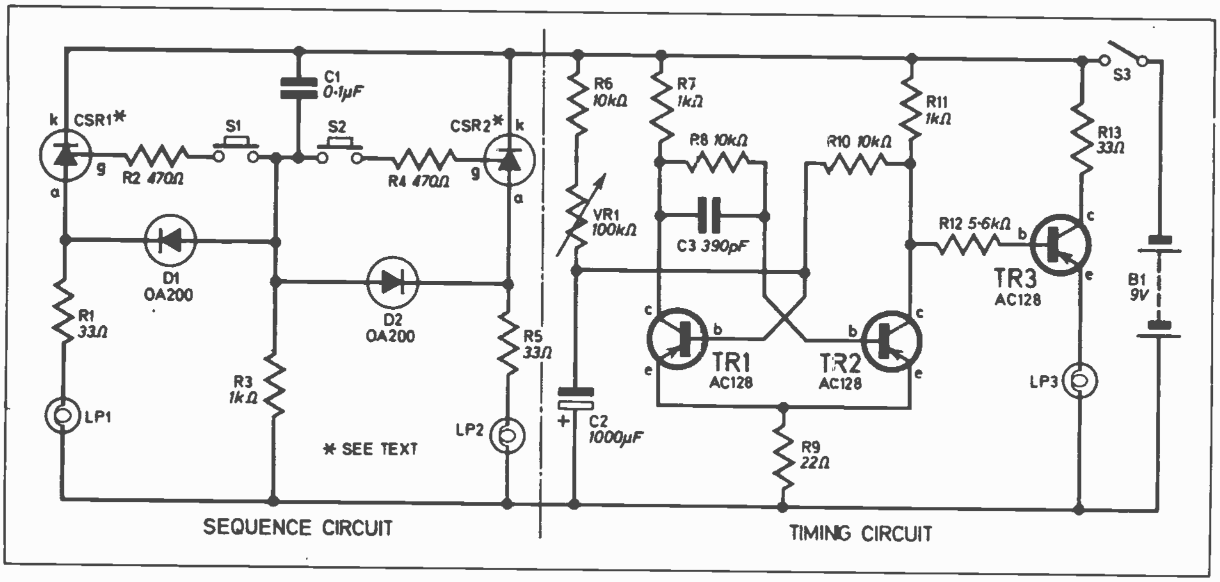


Fig. 1. Complete circuit diagram of the Reactomatic.

THE REACTOMATIC is a game of fun and skill for young and old alike. Being portable, it is ideal to take to parties or clubs. The basic sequence indicator can also be used, with a number of push-buttons, for quiz game answering.

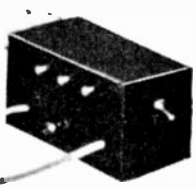
At home it will keep two people amused for hours, testing their skill against each other and, being a silent game (using only bulbs), will not distract the other members of the family.

Since the unit uses batteries there is no risk of shock, it is light in weight, portable and is cheap to build.

CIRCUIT DESCRIPTION

The circuit (Fig. 1) can be broken down into two main parts; the timer circuit, consisting of TR1, TR2, TR3, and their associated components, and the sequence circuit.

If we take the timer circuit first, it will be seen that TR1 and TR2 form a bistable and TR3 is an electronic switch. When the unit is switched on by S3, the bistable flips into "mode one". (TR1 off, TR2 on). A negative charge is then allowed to build up on the base of TR1, via R6, VR1 and C2.



When a certain amount of voltage has built up across C1, it will switch on TR1 which will then, via R8 and C3, switch off TR2. Therefore the voltage at the collector will go negative.

This negative voltage is passed to the base of TR3 via R12. Hence TR3 is switched on and allows voltage to flow through it to light LP3. The time for this to happen is determined by the value of C2, R6 and VR4.

The values shown in the circuit will give a delay of between approximately 5 seconds and 30 seconds. The latter time is ideal to build up tension in the players as they wait for the light to come on.

It should be noted that the knob fitted to VR4 should not be marked in anyway to show the time that has been set. A plain knob should be used, the loser of the previous game, re-setting it to a different time delay.

A 33 ohm resistor has been inserted in series with each of the three bulbs shown in Fig. 1. This is because the supply voltage is 9V and the bulbs are 6V, the resistors reduce the voltage to approximately 6V.

SEQUENCE CIRCUIT

The second part of the circuit containing the controlled silicon rectifiers (thyristors) works as follows. The idea is, that as soon as LP3 lights up each player pushes his button (S1 or S2) and the first one to do so turns his light on (LP1 or LP2 respectively).

Once one light is on the other cannot operate, therefore it is obvious which player pressed first.

When S3 is operated, C1 is charged up via R3. Now when LP3 lights, S1—for example—is pressed first and the positive charge stored in C1 is fed via R2 to CSR1. As only a small pulse of current is needed to switch CSR1 on, LP1 will light and remain lit as the current flowing through CSR1 is more than its holding current.

Once CSR1 turns on, C1 is discharged through D1 and CSR1, hence there is no voltage left in C1 to turn on CSR2.

If S2 is operated first, the reverse will happen, C1 will switch CSR2, via R4, and C1 will be discharged through D2 and CSR2, thus leaving no positive charge to operate CSR1.

All this happens very quickly, but the first person to press his push button will light the respective light. There is no need to keep the

REACTOMATIC

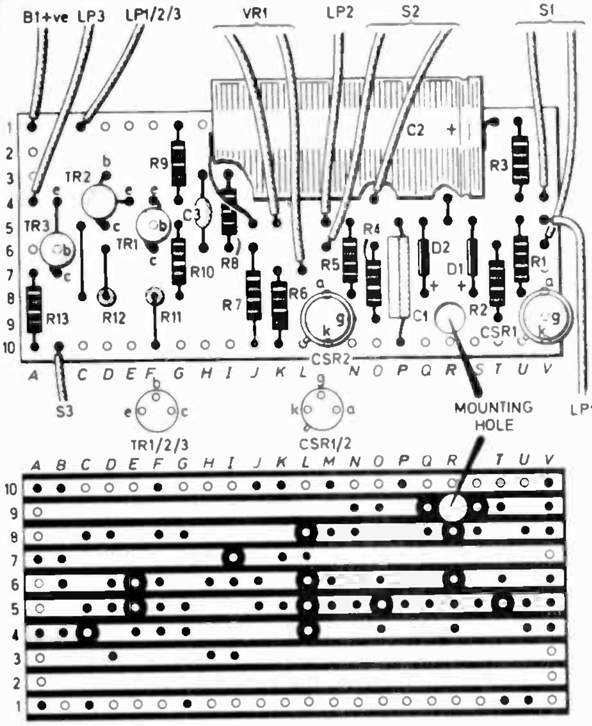
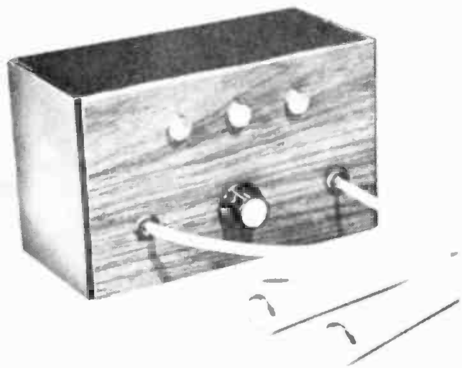


Fig. 2 (above). The layout of the components on the top side of the Veroboard and the regions of copper strip to be removed from the underside.



Photograph of the completed, unit read y for use.

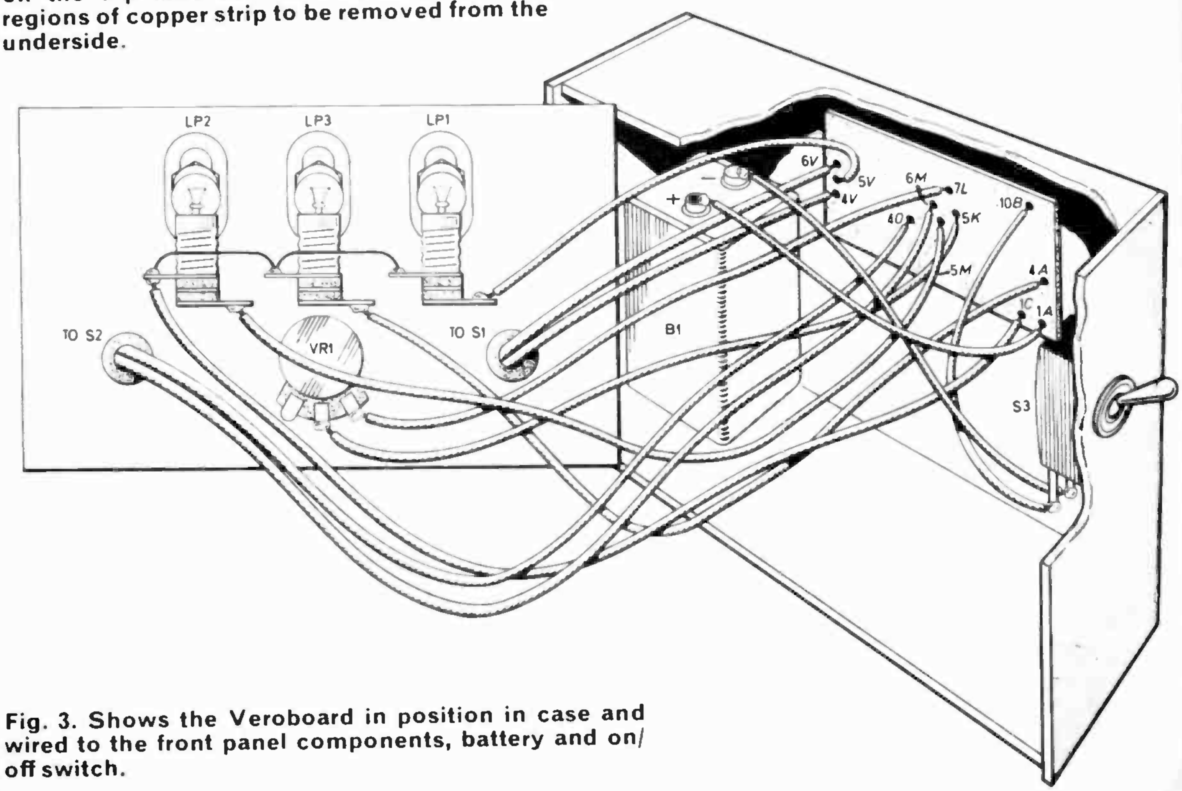
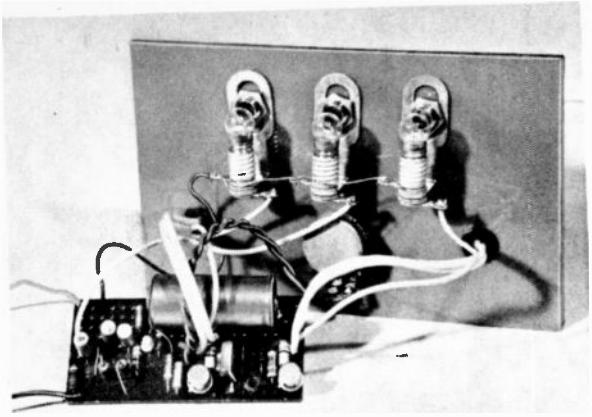


Fig. 3. Shows the Veroboard in position in case and wired to the front panel components, battery and on/off switch.



button pressed as the loser cannot possibly light his light, due to C1 being kept discharged all the time a light is on. Resistors R2 and R4 limit the current which switch CSR1 and CSR2 on.

Once the winner has been shown—by his light —S3 is turned off and then on again to restart the game. This allows C2 to discharge and CSR1 or CSR2 to turn off.

EXTRA PUSH BUTTONS

The sequence circuit can be increased in stages so that it may be used to indicate which of a number of players was first to press the button. To add on each additional lamp, simply repeat the push button, CSR, gate current limiting resistance (R2), lamp, lamp current limiting resistance (R1) and the bypass diode (D1). Components C1 and R3 need not be repeated.

The timing circuit does not need to be included if not required but an on/off switch must be used to reset the circuit. It will not be necessary to increase the battery capacity since only one light in the sequence circuit can be on.

CONSTRUCTION

The prototype unit was housed in a small plastic case, but any suitable box will do; layout is not critical. The three lamps, two push button leads and timer control are all attached to the front panel. On the side of the case is the on/off switch, and the circuit board, on which most of the components are situated, is mounted together with the battery inside the case. The circuit board is fixed to the panel by a single screw and an insulated spacer.

In the prototype the push buttons were mounted in two pieces of plastic tubing such as that used for holding mains wire. Plastic Padding or a similar filler is used to block up the ends of the tube to prevent the wires being pulled out.

If alternative types of push button are used they can be mounted on small blocks of wood. The push button leads should be quite flexible as they have to take a lot of bending; electric razor lead was found to be ideal for this purpose.

The Veroboard should be cut and the components mounted as shown in Fig. 2. Care should be taken not to let heat from the soldering iron travel up the wires of the transistors, thyristors or diodes. A suitable heat shunt should be used when soldering in these components. Once the circuit board has been wired up it can be mounted in the case together with the remaining components and the complete unit wired up as shown in Fig. 3.

PLAYING

To play the game each player holds a push button and one player switches the unit on. When LP3 operates, the first player to press his push button wins (indicated by the corresponding light). The looser is then allowed to vary VR1 to reset the time. If a player pushes before LP3 lights the other player is declared the winner. The battery will last a long time provided the game is switched off as soon as possible. ■

Components....

SEE SHOP TALK

Resistors

R1	33Ω
R2	470Ω
R3	1kΩ
R4	470Ω
R5	33Ω
R6	10kΩ
R7	1kΩ
R8	10kΩ
R9	22Ω
R10	10kΩ
R11	1kΩ
R12	5·6kΩ
R13	33Ω

All ¼W ±10% carbon

Capacitors

C1	0·1μF
C2	1,000μF elect. 12V
C3	390pF

Semiconductors

CSR1	Any 50 p.i.v. 1A thyristor (controlled silicon rectifier)
CSR2	Any 50 p.i.v. 1A thyristor
D1	OA200
D2	OA200
TR1	AC128 germanium *pnp*
TR2	AC128 germanium *pnp*
TR3	AC128 germanium *pnp*

Miscellaneous

LP1, 2, 3	6V 0·2A bulbs and panel mounting lamp holders
S1, S2	S.p.s.t. push to make push buttons
S3	S.p.s.t. toggle switch
VR1	100kΩ lin. carbon potentiometer
B1	9V PP9 battery

Case (approx 7in × 4in × 3in, any material) plain unmarked knob for VR1, connecting wire, material for mounting S1 and S2 (see text), Veroboard 3¾in × 1⅞in × 0·15in matrix, battery connectors, 6BA fixing and spacer.

ELECTRONIC CIRCUITS—
.....IN THEORY and PRACTICE

TEACH-IN

...FOR BEGINNERS

By Mike Hughes M.A.

12 AMPLIFICATION

LAST month some experimenters might have been a little disappointed with the output of the little microphone amplifier we made. This is very understandable, but one must bear in mind that only two transistors were used, one for voltage amplification and the other to provide a low output impedance. This month we shall put matters right and develop a low power amplifier that will produce about 0·5W output —perfectly adequate for a baby alarm etc. But first we must carry out some improvements to our voltage amplifier.

Last month's circuit suffered from the problem that we had to set the bias manually to match the gain of the transistor—a good example for demonstration purposes—but not very practicable.

There are two very commonly used circuits that we can use for biasing that are not so sensitive to variations in h_{FE}; the first is simple, and if used carefully is very adequate, but the second we shall describe is more generally favoured and uses a few more components.

FEEDBACK BIASING

The first option is shown in Fig. 1(a) and is called a **feedback bias** circuit. As before we must decide the output quiescent voltage which we shall fix at mid-rail potential (+4·5V) and at the same time decide the quiescent collector current, say 0·5mA.

This immediately fixes the value of *R1* as 4·5/0·5 kilohm (9,000 ohm); say 10 kilohm.

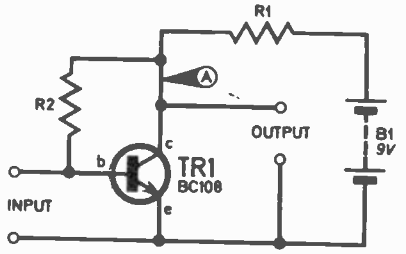


Fig. 1(a). Feedback biasing circuit. For experimental purposes make R1 and R2 equal to 10 kilohm and 1·5 megohm respectively. Check that the output voltage is approximately "mid-rail".

We shall use the potential at point "A" as the source of our base current—you'll see why in a moment—and we'll assume the gain of the transistor to be 200.

The base current for biasing should ideally be

$$\frac{I_c}{h_{FE}} = \frac{0\cdot5}{200} = 0\cdot0025\text{mA}$$

Assuming that the potential at point "A" is 4·5V we can therefore calculate the required value for *R2*. It will be

$$\frac{4\cdot5 - 0\cdot6}{0\cdot0025}\text{ kilohm} = 1\cdot56\text{ megohm}$$

The nearest preferred value is 1·5 megohm. Make this circuit up on Demo Deck and verify that the quiescent voltage at "A" is approximately 4·5V. Try substituting different BC108's and you should find no appreciable change.

This circuit is self compensating as far as bias is concerned. Imagine you had a transistor with a low gain; initially the base current available from point "A" (assuming it was 4·5V) would not be sufficient to turn the transistor on hard enough to make point "A" fall to 4·5V so therefore "A" could not have been 4·5V—it would have been higher in potential.

If it had been at a higher potential then the base current would have increased thus bringing about a reduction in the voltage at "A."

In effect the circuit around the transistor settles itself out so that the potential at "A" is just enough to supply sufficient base current to keep the potential at "A" stable.

If you think we are talking in circles you are quite correct because what we have described is a **negative feedback loop.** If we have carried out our calculations correctly a very small increase in potential at "A" is all that is needed to provide that extra base current to compensate for a low gain transistor. This small increase will not present any major problems and will hardly be noticeable under normal circumstances. The same argument applies to a transistor with higher gain only the output potential will settle to a slightly lower than mid-rail voltage.

MODIFICATION

Modify your circuit slightly as shown in Fig. 1(b) and add the emitter follower output stage that we originated last month. Notice that instead of R2 we are using two resistors in series (470 kilohm and 1 megohm) and have introduced a variable resistor and capacitor.

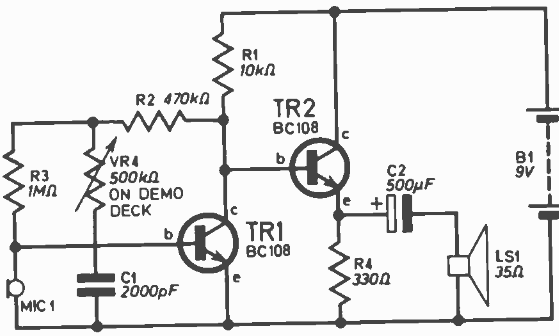


Fig. 1(b). A two-stage microphone amplifier, using a feedback biased stage followed by an emitter follower.

Initially set VR4 to maximum resistance, connect up the microphone, and you should find that the circuit works, but the output is not as great as last month's.

The reason for this is that the signal from the microphone is now appearing amplified at the collector of TR1, but because of the inverting property of the transistor, a certain proportion is being fed back through R2 and R3, 180 degrees out of phase (i.e. in a way that will negate our input signal). Fortunately we can "catch" this fed back signal with C1.

Because the audio voltage is alternating it sees a low impedance in C1 and will be shorted out to the common rail—that is if VR4 is reduced to zero ohms. Try reducing the value of VR4 and you should find an appreciable increase in output from the loudspeaker.

POTENTIAL DIVIDE BIASING

The basic circuit of the second type of biasing system we shall cover is shown in Fig. 2(a). This can best be described as a **potential divide** type of circuit because the bias is dependent on the potential divide effect of resistors R2 and R3.

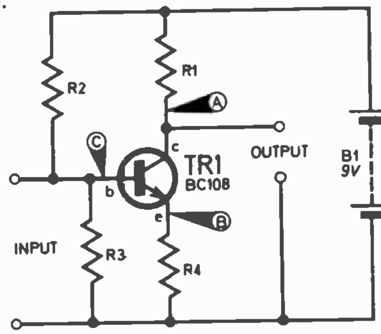


Fig. 2(a). Potential divide bias circuit. See text for the experimental resistor values.

Lets assume a mid-rail quiescent output at a collector current of 0·5mA; this makes R1 10 kilohm. Notice we have introduced a resistor (R4) into the emitter circuit. If current is flowing between collector and emitter (as it must) then the quiescent current of 0·5mA plus any base current, will flow through R4 giving rise to a voltage drop across it. In this article we can ignore the contribution of the base current as it is bound to be small compared with I_c.

The potential at point "B" must not be too high otherwise we will be unable to obtain wide voltage swings at the collector and it is usual to set this emitter voltage at 1V. This means that R4 will be approximately

$$\frac{1}{I_c} = 2{,}000 \text{ ohms}$$

Let's say 2·2 kilohm as the nearest.

For base current to flow the base must be made 0·6V more positive than the emitter (for a silicon *npn* device); this means that the potential at point C will be +1·6V.

STABILITY

The base current we require (still assuming an h_{FE} of 200) will again be 0·0025mA and this will have to be provided through R2. The values of R2 and R3 are arranged so that they form a potential divide that maintains the base potential at the 1·6V we require. For stability reasons it is usual to have a standing current through

150,000

R2 and R3 that is 4 or 5 times the base current. Let's say we will make 4 times the base current flow through R3 and at the same time maintain 1·6V drop across the resistor; the value for R3 will be

$$\frac{1\cdot 6}{4 \times 0\cdot 0025}\ \text{kilohm} = 160\ \text{kilohm}$$

The current for R3 has to pass through R2, but R2 also has to provide the base current; therefore the total current flowing through R2 will be five times I_b. The drop across the resistor will be $(9-1\cdot 6)V = 7\cdot 4V$, so the value for R2 is

$$\frac{7\cdot 4}{5 \times 0\cdot 0025}\ \text{kilohm} = 590\ \text{kilohm}$$

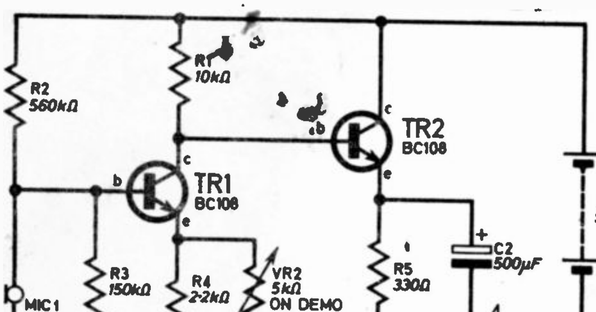
The nearest readily available values for R2 and R3 will be 560 kilohm and 150 kilohm respectively. Make up the circuit and measure the potentials at points "A" "B" and "C." Again the substitution of different BC108s should not cause the output voltage to vary significantly.

TRANSISTOR GAIN VARIATION

If a transistor of low gain was used, I_c would not be the anticipated 0·5mA initially, therefore the potential at point "B" will fall below the assumed 1V. This provides a more attractive set of circumstances for base current to be drawn through R2 so the current through R2 will increase, the potential at "C" will decrease and the current through R3 will decrease. The extra current flowing through R2 passes into the base of the transistor thus increasing the base current and this helps bring the quiescent collector current almost back to normal.

Again we have negative feedback effectively between the base and emitter circuits which self stabilises the biasing. For a transistor having higher gain the opposite will happen.

Fig. 2(b). The circuit diagram of a two-stage microphone amplifier using potential divide biasing.



DRIVING THE LOUDSPEAKER

To complete the experiment make-up the complete circuit of Fig. 2(b) and see that we can drive the loudspeaker. Notice the introduction of VR2 and C1. Initially set VR2 to maximum resistance; the output will be very poor indeed.

The reason is that TR1 is acting in part as an emitter follower. Any "overpotential" we apply at the base in the way of signal will appear at the emitter; thus we will not be producing much in the way of potential difference between base and emitter and hence not cause as much increase in base current as we might have expected. Ideally we want any current from the microphone to add to the base current in its entirity; this we can arrange by again using the fact that our signal will be alternating.

Connecting a large value capacitor between the emitter of TR1 and ground will present a low impedance path for the signal current to flow through without affecting the d.c. bias conditions. You can introduce C1 gradually by reducing the value of VR2 and will notice a dramatic improvement in output signal. We call C1 an **emitter decoupling—or by-pass—capacitor**; the maximum value of it is unimportant—but it must always be "greater than" a certain value.

Try replacing it with a 0·1µF capacitor; the circuit will work but with less output and any bass response which might have been there originally will be lost because the low value capacitor will only effectively decouple at high frequencies.

A problem with this circuit in our application is that the introduction of two resistors of comparatively low values (R2 and R3) in the bias circuit effectively reduces the input impedance of our voltage amplifier, hence, a lot of microphone signal will be shunted out to the power rails. Do not, therefore, expect quite as high an output as for the previous feedback biasing circuit.

We make no apologies for the comparatively low output powers of all these experimental amplifiers so far. It is easier to understand things if you concentrate on only one point at a time; therefore we deliberately made the power output stage as simple as possible so that we could concentrate on the important aspect of voltage amplification.

We hope that, from the two examples this month and the one last month, you appreciate there are several ways of producing the same effect; this happens all the way through electronics and is not limited solely to amplification. Follow other articles in EVERYDAY ELECTRONICS and you will soon see that different designers have different personal opinions and ideas as to what is the best circuit for the job and they may all be equally correct.

Some designs can be cheap but adequate, others expensive and full of special features that aid the quality of the design without altering the fundamental workings.

COMPLIMENTARY CLASS B BASICS

As promised we'll now show you how to get more power from the microphone amplifier and at the same time improve its quality. Firstly let's look at the fundamental circuit of what is called a class B complimentary symmetry output stage. This is shown in Fig. 3(a).

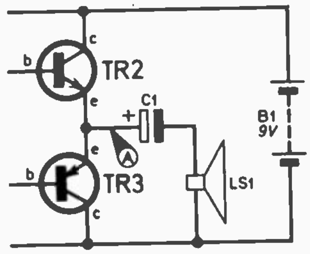


Fig. 3(a). The basics of a class B complimentary symmetry output stage; both an *npn* and a *pnp* transistor are used.

We are introducing a *pnp* transistor for the first time, TR3, but there is no need to worry too much about this except to remember it works just like an *npn* device with opposite polarity of supply voltage.

As shown in the circuit its collector goes to the common or negative rail and to make it turn on we must make its base go negative with respect to the emitter.

Both TR2 and TR3 are working as grounded collector or emitter followers. Assume nothing is connected to the bases of these transistors; no base current will flow in either and hence no current can flow from the collector of TR2 out of its emitter, into the emitter of TR3 and down to ground through its collector (this is the flow path for conventional current). These transistors are to all intents and purposes "open circuit" and we can consider the point "A" as being isolated from either the positive or negative rails.

If we also assume that C1 was charged so that its positive plate was at, say, +4·5V, the capacitor will maintain its charge because there is nowhere it can leak away to.

If we were able to make the base of TR2 more positive than +5·1V (0·6V more positive than its emitter) current will flow through the collector/emitter circuit of TR2 and charge up the capacitor until the potential at "A" rises to a new level that is 0·6V below the base voltage. This charge current must also pass through the coil of the loudspeaker.

Now consider what happens if we leave TR2's base open circuit and make the base of TR3 less than 3·9V (0·6V negative with respect to its emitter). Transistor TR3 will now act as an emitter follower and the capacitor will discharge through the emitter and collector of TR3 until the voltage at "A" is just 0·6V more positive than the base. You might challenge the assumption that point "A" could have been at +4·5V in the first place—this is a fair comment but we assume that no transistors are perfect (there is always a small amount of leakage) and the leakage current through TR2 and TR3 will be about the same and hence we get a sort of potential divide effect at minute currents giving us a "starting" potential at point "A."

DISTORTION

Move on to Fig. 3(b) where we have connected the bases of TR2 and TR3 together and then back to the collector of a feedback biased stage—the quiescent output potential of which is +4·5V. This voltage is not 0·6V more positive with respect to TR2's emitter nor more negative with respect to TR3's emitter, therefore neither transistor will conduct (apart from leakage) and the positive plate of C1 will stay at about +4·5V—unfortunately you cannot measure this without an extremely high resistance voltmeter.

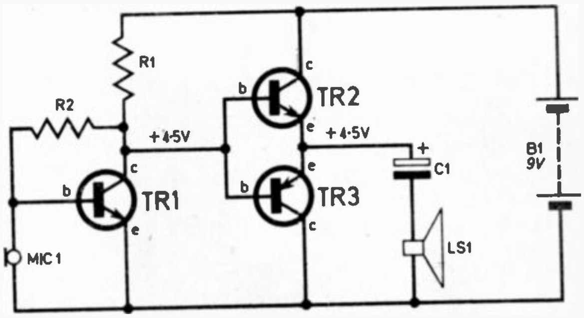
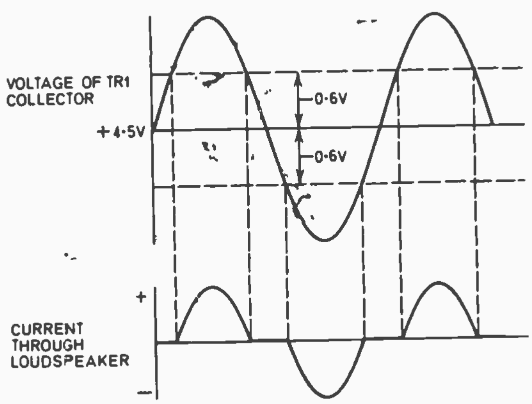


Fig. 3(b). A class B complimentary symmetry output stage preceded by a feedback biased stage.

If we whistled a perfect sine wave note into the microphone we know that the collector of TR1 would follow suit alternating by about 1V above and below +4·5V. As soon as we exceed +5·1V TR2 will start to conduct and charge current will flow through the loudspeaker; when we fall below 5·1V, TR2 will shut off and when we fall below +3·0V, TR3 will start to conduct

Fig. 4. These waveforms refer to Fig. 3(b) and show "crossover distortion."



and discharge current flows through the loudspeaker in the opposite direction.

The only problem, so far, is that we are losing part of our signal. The current through the loudspeaker follows the voltage swings at TR1's collector only when we exceed certain limits; in between these limits it stops and we get a distorted current sine wave as shown in Fig. 4. This distortion is most undesirable and is called **crossover distortion** and is a classic problem with class B stages. Nevertheless it can be avoided as we shall see.

First of all take note of the important point that in the absence of any microphone signal no current at all is flowing through the output transistors—the transistors are dissipating no power.

This is a tremendous advantage over the simple emitter follower stage described last month which had a quiescent current almost as high as the amount of signal current fed to the loudspeaker which is wasteful on power and means that we have a static dissipation in the transistor which is serving no useful purpose (acoustically speaking) and limits the amount of power we can use as signal. This is a problem associated with the type of output stage known as class A.

CROSSOVER ELIMINATION

To overcome crossover distortion we have to arrange that the quiescent voltages at the bases of TR2 and TR3 are just on the threshold of taking the transistors into conduction. This is done by introducing an extra stage in our power amplifier called a **driver.** This is shown as TR1 in Fig. 5(a).

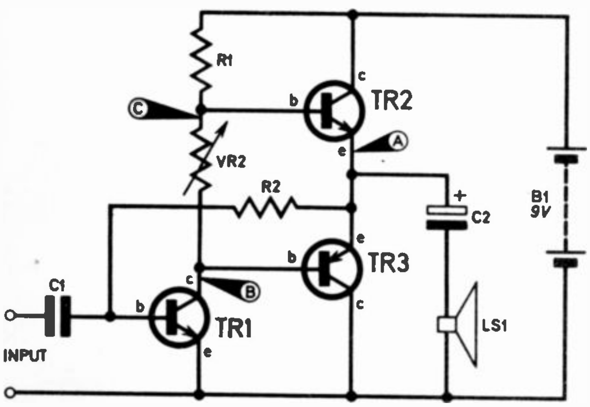


Fig. 5(a). By introducing a "driver" stage, TR1, crossover distortion can be eliminated.

Resistor R2 works like the feedback resistor in our voltage amplifier and by careful calculation we can ensure that the potential at "B" is just enough to start TR3 conducting; VR2 and R1 form the collector load of TR1, but VR2 also ensures that there is always twice 0·6V (1·2V) difference in potential between points "B" and "C." Both TR2 and TR3 will be conducting slightly and point "A" will settle (aided by negative feedback from R2) to about +4·5V. Any negative going signal at the input capacitor will make TR2 go more into conduction, and vice versa for TR3.

This time we will have no crossover distortion provided VR2 is of a high enough value to maintain the quiescent voltage differential between points "B" and "C."

In Fig. 5(b) you will notice that in the practical circuit we are using a silicon diode (D1) in forward biased mode to help maintain the 1·2V difference—it also helps combat variations in temperature that affect the emitter/base forward voltage drops of the output transistors.

MATCHING

A final couple of points before describing Fig. 5(b); in a good quality piece of equipment the h_{FE} of the **complimentary output pair** of transistors (TR2 and TR3) should be accurately matched so that the current through the loudspeaker is symmetrical on the "charge" and "discharge" parts of the cycle. With the low price transistors we have specified this is not possible, but we can tolerate a reasonable amount of distortions at low powers.

Because the voltage across either of the output transistors—when they are conducting—never exceeds 4·5V, and in the quiescent condition no current is flowing, we now have the full current and power rating of each transistor at our disposal. We could, theoretically, charge over 4·5V with a peak current of 100mA which gives a peak power of 0·45W and discharge through TR3 at the same rate giving an overall power output of nearly 1 watt. This, of course, is an absolute maximum and actually exceeds the individual r.m.s. power ratings of the transistors; however this can be tolerated provided the power overload is only temporary.

When dealing with commercial power amplifiers you will find the power ratings quoted as r.m.s and peak—sometimes peak power is described as "music rating" and r.m.s power as "continuous rating."

MICROPHONE AMPLIFIER

Fig. 5(b) is our grand finale for the Teach-In series and represents a reasonable 0·5W r.m.s microphone amplifier that embodies many of the points we have covered in the latter part of the series.

Transistor TR1 is a potential divide biased voltage amplifier, TR2 the output driver and TR3 with TR4 gives us a class B complimentary output stage. The driver serves two purposes; it enables us to bias the output transistors but also, as a by-product, gives us a further stage of voltage amplification. This ensures that we can drive the output pair to "saturation" from

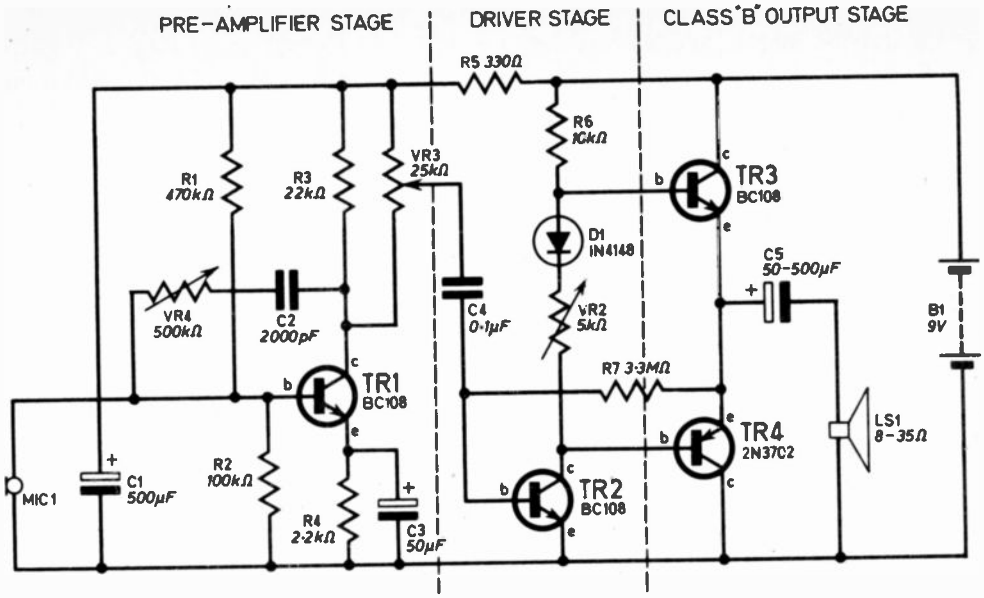
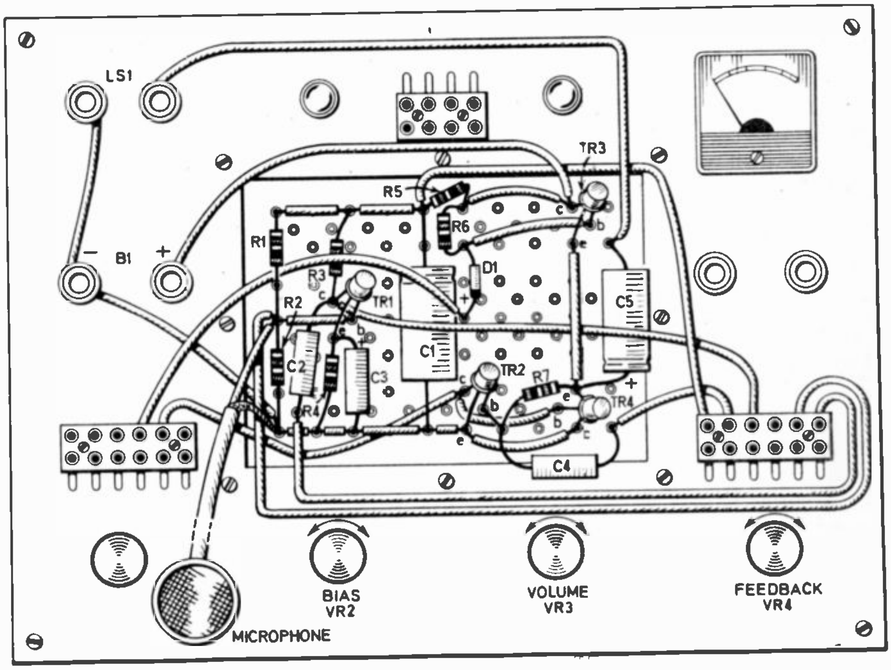


Fig. 5(b) (above). The circuit diagram of a 0·5 watt microphone amplifier using a potential divide biased first stage followed by a driver and class B complimentary symmetry output stage with several refinements.

Fig. 5(c) (right). The circuit of Fig. 5(b) shown wired up on the Demo Deck.



the microphone input should we so wish. In fact there is plenty of unrequired gain in hand. We can make use of this to add in a couple of refinements.

VOLUME CONTROL AND SELECTIVE FEEDBACK

The simplest is a volume control—shown as VR3 (of the Demo Deck) in parallel with a 22 kilohm collector load for TR1—that enables us to "tap off" lower proportions of variations in TR1's collector potential. As this would affect the bias of TR2 we have to decouple the d.c. link between the wiper of VR3 and TR2's base; this is done with capacitor C4 (we have introduced a.c. coupling).

There is still some gain in hand so we can introduce some frequency selective negative feedback between the collector and base of TR1 (with the aid of C2 and VR4). When VR4 is set to a high resistance value, very little feedback occurs and our signal strength will be high; by reducing the value of this potentiometer some feedback will take place but only at high frequencies (C2 still acts as a very high resistance to low frequencies). The more you decrease the value of VR4, the more you will suppress high frequencies and hence counter the rather poor frequency response we had previously—speech will become more "bassy" and appear to have more "body." It may be necessary to increase the volume control to get the best effect.

DECOUPLING

The resistor/capacitor combination, R5 and C1, form what is called a **decoupler;** this prevents any variations in power line voltage caused by high currents being drawn through the output transistors affecting the first amplifier stage. Without these components the whole system could be subject to **positive feedback,** become unstable and oscillate—take them out and see!

SETTING UP THE AMPLIFIER

When setting up the amplifier, start with VR2 at minimum value and slowly increase it while speaking quietly into the microphone. You should initially hear the effect of cross over distortion (it is better heard than described) but stop increasing its value as soon as the distortion disappears. In normal circuits VR2 would be a preset component and VR4 would be of a fixed value determined by the designer.

The little loudspeaker in Demo Deck does not really do justice to this circuit and is of rather too high an impedance to get maximum power. If you have a larger 8 ohm loudspeaker try this in its place—you'll probably be very surprised with the difference. There is no reason why you should not replace the microphone with a crystal pick-up and make a record player amplifier.

LAST WORDS

We've come a long way since the "plumbing" in Part 2 and we hope you have been able to follow us. The subject is only a hobby but it can be great fun if you know some of the inside stories rather than "construct-in-the-dark."

You will find many more articles in months to come which will help fill some of the gaps and also venture on new territory. Ultimately the only way to become proficient at electronics is to make things, have successes and have failures but if you have a failure do not give up in disgust, try and find out what went wrong. Why not round off with the "End of Term Test" on page 670).

Ruminations
By Sensor

Having A Nose For It

I once knew a man (I'll call him John) who had an uncanny knack for fault diagnosis. He was not highly trained in electronics but had grown up with the science and accumulated a vast store, a practical experience which enabled him to find faults very quickly with a minimum of testing. When I first met John, he was working on Radar equipment but he had previously worked on domestic radio servicing; he transferred apparently without any difficulty to television fault diagnosis.

Although his theoretical knowledge was limited, his talent for quick diagnosis was admired and respected by all—even the most senior engineers. It must be remembered that he was dealing with new equipment straight from the production lines—receivers that had never worked before; wiring faults and components of the wrong type and value made the business more complicated than normal servicing work.

Every engineer acquires this "instinct" for fault diagnosis, to a greater or lesser degree. It is an amalgam of keen observation, knowledge of components and their behaviour, the "stock" faults of various models—and a good memory. These factors do not compensate for lack of a sound knowledge of basic theory, which properly applied, will enable one to diagnose any fault, though probably not as quickly as John would have found it. A good beginners series can help those who already have some "instinct" to develop their theory whilst those without either theoretical knowledge or "instinct" can quickly learn sufficient theory to enable them to begin to acquire an "instinct."

One-Upmanship

I once gained some kudos myself by using my required "instinct." I was watching a computer engineer who was looking for a fault. He had isolated the trouble to one particular circuit board and had removed this board from the computer. While he collected together his tools, testmeter circuit diagram and wiring diagram of the particular board in preparation for detailed investigation, I picked up the board and idly glanced over it.

One resistor looked just a shade brighter in colour than the rest, I looked more closely and saw that the thin wax coating, that used to be applied to resistors in those days, was just beginning to soften. "Is that resistor the correct value?" I asked. We looked on the circuit diagram and found that the resistor ought to have been 470 kilohm; it was in fact 47 kilohm and was correctly colour coded. The computer engineer was most impressed!

Somewhere along the line the colour coding had been misinterpreted (orange and yellow can be quite close together in shade) and although there was not much current flowing in the circuit concerned, a change in resistor value of 10 times was sufficient to produce very slight overheating in the resistor and give me a clue to the trouble.

THE Electronic Mouse Trap described herein does not kill or injure a captured mouse. It catches the mouse alive so that it may be released in the local park or a field. This satisfies the R.S.P.C.A. and wildlife preservationists and all others opposed to "blood sports". Only the cats will be unhappy at the risk of being made redundant.

The trap has been well proven in use and has caught six mice during a few weeks of operation. Certain modifications have been made to the prototype due to the annoying habit of the mice to chew the connecting wires inside the trap.

PRINCIPLE OF OPERATION

The principle of operation is quite simple, although the trap may look a little complicated mechanically. The "electronics" consist of a photo-conductive cell which operates a simple d.c. amplifier (Fig. 1), this in turn energising a solenoid (L1).

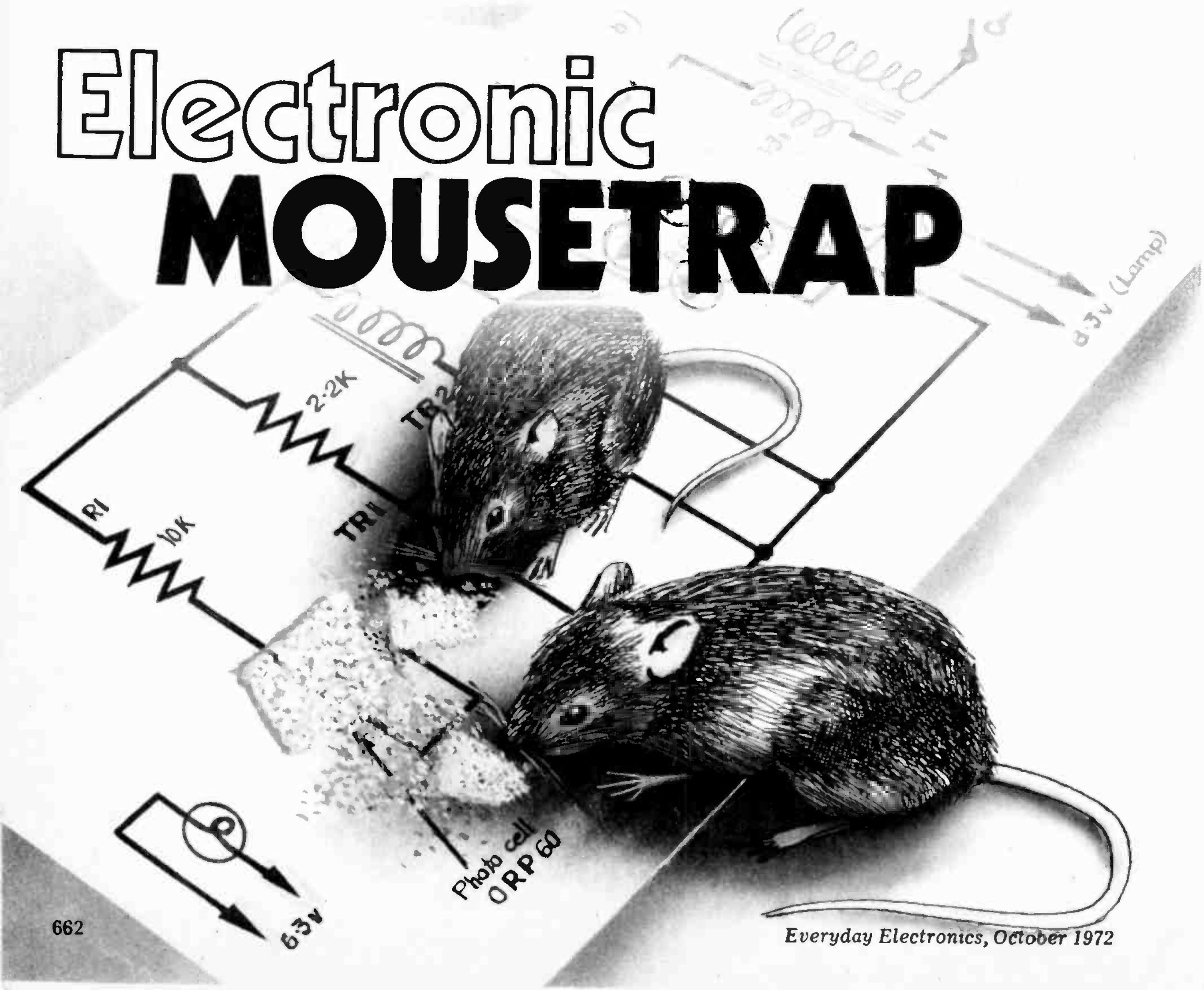
When the solenoid is energised it releases the door retaining spring. The door then promptly closes and at the same time switches off the supply via S1. The sequence is set off by the mouse which, on entering the trap to gain access to the "bait", carefully placed inside at the far end, has to pass through a beam of light shining on the photocell PCC1 from LP1. When the light beam is interrupted the photocell resistance increases and actuates the d.c. amplifier and solenoid.

There are only two ways, well three really, in which a mouse can evade being captured. One, if the mains supply fails or is switched off, two, it could jump over the beam of light or three, just not enter the trap anyway.

A proven design for a humane mouse trap.

By F. C. Judd

Electronic MOUSETRAP



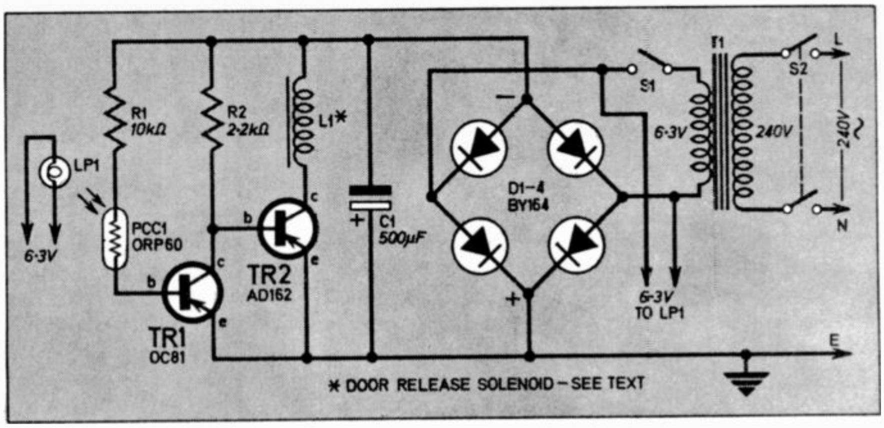


Fig. 1. Complete circuit diagram of the Electronic Mouse Trap.

CONSTRUCTION

The box can be made from hardboard or thin plywood with sides and top etc., held together with half-inch by half-inch battens pinned or glued. Details for the box are given in Fig. 2. Note that a hole is drilled each side of the box about ¾in up from the bottom. These holes allow the light from the external 6·3V lamp (LP1) to shine through and across the box to the photocell opposite.

The trap door can be made from Perspex which enables one to see if a mouse has been caught. It could otherwise be made from hardboard but drill some holes in the door otherwise a caught mouse could die of suffocation!

It has been found that in an effort to escape the mice chew the wooden batten around the door so it is best to make these of the half-inch batten specified. The mice do not seem to want to chew the plywood sides.

The d.c. amplifier and power supply components are mounted on the aluminium panel that forms the rear end of the box and are separated from the captured mouse by an inner dividing wall. Without this wall a mouse could get to the mains supply and possibly electrocute itself.

The amplifier circuit is shown in Fig 1 and consists simply of a d.c. coupled pair of transistors but note that TR2 passes a large current when the light beam is interrupted It is for this reason and because no heatsink is provided for TR2, that a contact (S1), operated by the door, opens and cuts off the secondary voltage of the transformer T1 when the door is closed. This also switches off the light, thus saving current when the trap has done its job.

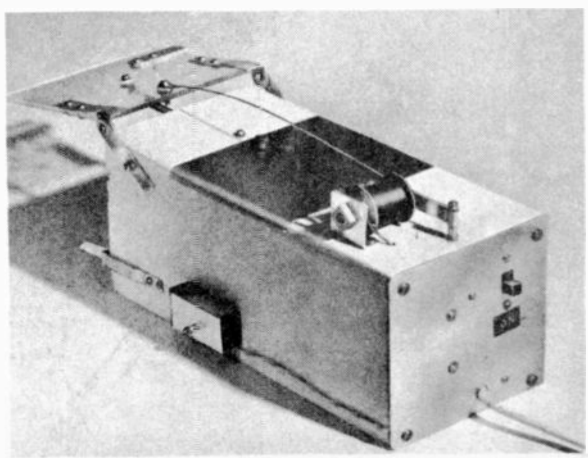
SOLENOID

The solenoid is fairly easy to make and really amounts to a coil of wire with a steel bolt as the electromagnet. Details are given in Fig. 3.

The coil cheeks could be any insulating material, even stiff cardboard and the coil itself consists of enough 32 swg enamelled wire to build up a winding of about ¾in diameter between the cheeks that are fixed one inch apart on a ¼in steel bolt. The d.c. resistance of the winding will be in the region of 20 to 30 ohms.

To make the solenoid cut out two discs 1 inch diameter for the end cheeks and drill two holes in one as shown in Fig. 3. Slide these cheeks onto the bolt—the undrilled one first—and screw on a nut so that the two discs are one inch apart.

Using 32 s.w.g. enamelled copper wire, pass one end out through the inner hole, cover the outer end with sleeving and with the uncovered wire wind on the turns evenly along the length



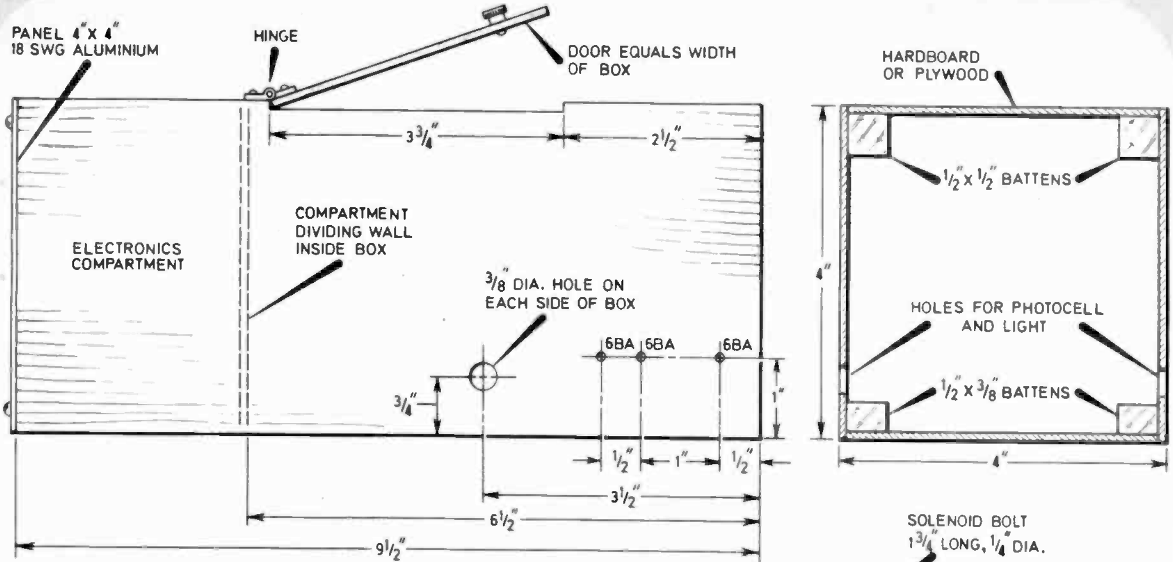
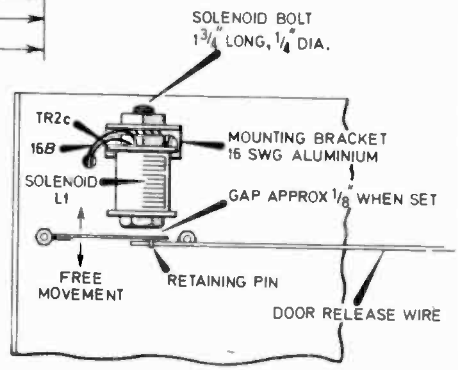
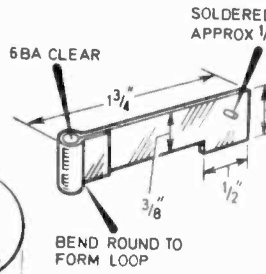


Fig. 2 (above). Details and dimensions of the wooden box as used for the prototype mousetrap showing the electronics compartment at the rear of the unit.



(a)

Electronic MOUSETRAP



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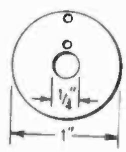


(b)

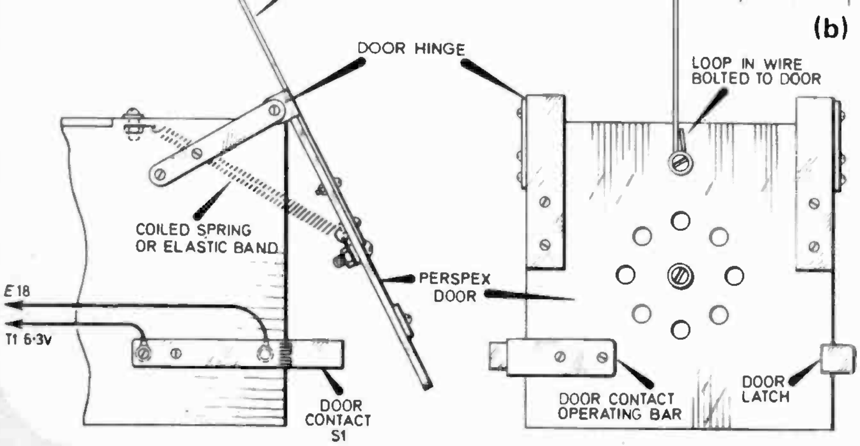


Fig. 3 (above) (a) A plan view of the solenoid arrangement on top of the unit. (b) Shows the dimensions of the card-board cheeks of the solenoid. (c) Details of the operating arm.

Fig. 4 (left) Shows details of the Perspex door, door fittings and S1.

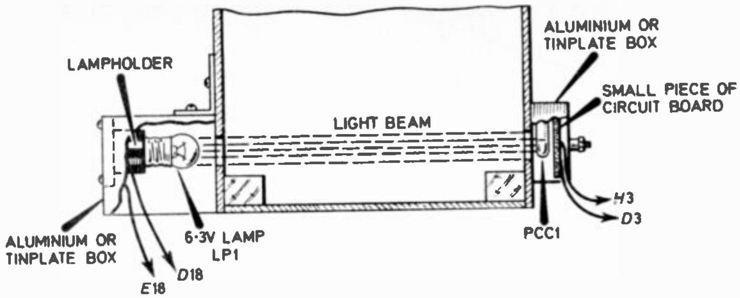


Fig. 5. The mounting and wiring of the lamp and photocell.

of the solenoid, layer upon layer until the winding is approximately $\frac{3}{4}$in in diameter. Pass the other end of the wire through the outer hole, sleeve the wire and secure the winding with insulation tape.

The operating arm, which releases the door retaining wire must be made from tinplate or thin mild steel. A piece cut from an empty tin box will do. A vertical loop is formed at one end as shown in Fig. 3, just large enough to slide over a 6BA screw which will form a bearing for the arm. The position of the arm relative to the solenoid is shown in Fig. 3.

TRAP DOOR

The door is hinged as shown in Fig. 4 and held closed by a light tension coil spring or an elastic band. The tension must not be too great but sufficient to bring the door down smartly from a near horizontal position so that it latches.

Attached to the middle of the door is a piece of springy steel wire long enough to reach back so that the end can be hooked under the pin on the solenoid arm (see Fig. 3). When the solenoid is energized the arm moves in and the door retaining wire is released.

When the door comes down it must break the contact which forms S1, this disconnects one side of the transformer secondary winding from the rectifier and the lamp. Details for the contact are given in Fig. 4 and the position of its operating bar is also shown.

The door fittings can be made from light gauge aluminium but the door contact must be springy i.e., made from tinplate or thin brass. When the door is open the contact must make with the 6BA bolt on the side of the box as in Fig. 4.

Two wires, one from the contact and one from the bolt are taken along the outside of the box to the transformer and circuit board at the rear. The wires should not pass inside the trap as they will soon be chewed away by the captive mice. The door is also fitted with a simple latch to prevent the mouse from pushing it open and escaping.

LAMP AND PHOTOCELL

The photocell is a type ORP60 which has its sensitive element near the top end so this end must be in the light beam as in Fig. 5. The lamp housing consists simply of a small three sided box just large enough to take an MES lampholder (Fig. 5). This is bolted onto the side of the box so that the lamp is in line with the hole and adjusted so that maximum light will shine across onto the photocell.

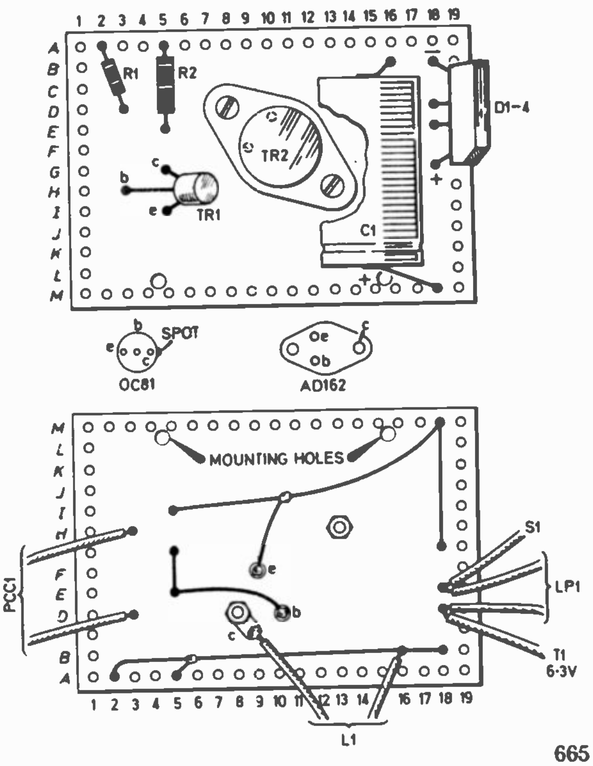
The photocell can be mounted on a small piece of plain circuit board so that the light sensitive end "looks into the box" through the hole. This small assembly is attached to the outside of the box.

It is important that the holes in the box are not too large as the mice may tend to chew the surrounding wood.

AMPLIFIER

The two transistors and remaining com-

Fig. 6. Layout and wiring of the components mounted on the circuit board.



ponents, including the bridge rectifier, are mounted and wired on a piece of plain circuit board as shown in Fig. 6. Mount all the components on the circuit board after it has been cut to size and the mounting holes drilled. Solder the connections, using a heat shunt on the transistor leads and connect up the flying leads.

Leads are taken to the door switch (S1), lamp, photocell and to the solenoid as shown in Fig. 6. Note that the transformer T1 is a 6·3V 1 amp heater type. This transformer is mounted directly on the rear panel together with the circuit board and the mains switch as shown in Fig. 7. It is important that the aluminium panel is earthed via the mains lead.

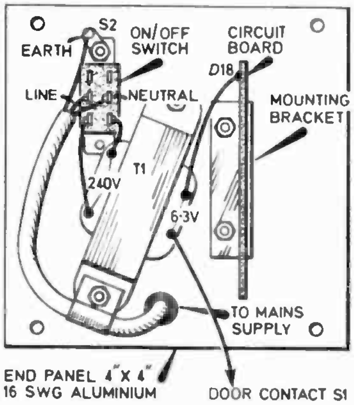


Fig. 7. Wiring of the components on the panel.

Components....

Resistors

R1 10kΩ, R2 2·2kΩ — $\frac{1}{4}$W ± 10% carbon

Capacitor

C1 500μF elect. 12V

SEE **SHOP TALK**

Semiconductors

PCC1 ORP60 photo conductive cell
D1-4 BY164 bridge rectifier or similar IA 50 p.i.v. bridge
TRI OC81 germanium *pnp*
TR2 AD162 germanium *pnp*

Miscellaneous

LP1 6V 0·2A bulb and holder
L1 32 s.w.g. enamelled copper wire wound on $\frac{1}{4}$in × $1\frac{3}{4}$in steel bolt (see text).
S1 Door contact switch (see text)
S2 D.p.s.t. mains switch, slide or toggle
T1 6·3V 1A secondary mains transformer

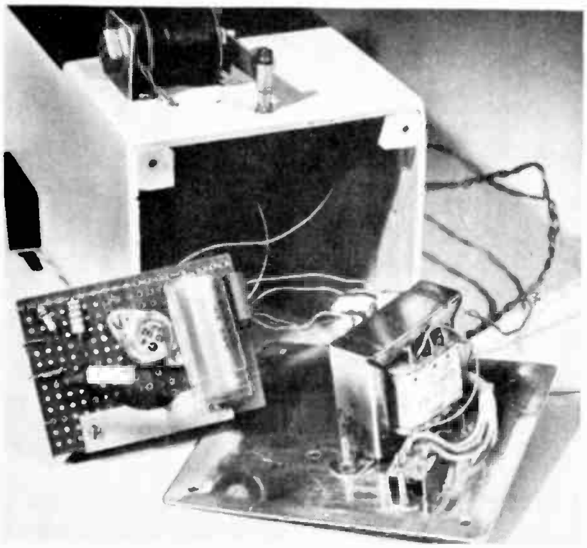
Materials for case, door hinges, door latch, LP1 and PCC1 mounting boxes, solenoid arm, door retaining spring and end mounting panel (see text). Plain perforated Veroboard 3in × $2\frac{1}{8}$in × 0·15in matrix, $\frac{1}{2}$in × $\frac{1}{2}$in × 2in aluminium angle for mounting bracket, mains lead and three pin plug, connecting wire, 6BA and 4BA fixings.

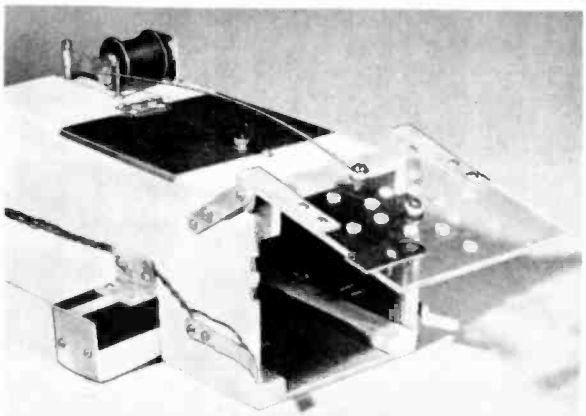
OPERATION

The trap door is set by releasing the catch, lifting it to a horizontal position and retaining it by hooking the long stiff wire under the pin on the solenoid arm. Check that it will release by pushing the arm in towards the face of the solenoid. Only slight pressure should be required.

Now switch on the amplifier, re-set the door, and check that the lamp lights when the door is in the retained position. Providing the photocell is fully illuminated the arm will not move, indicating that TR2 is cut off. Try rolling a cotton reel into the box to interrupt the light beam. This should cause the solenoid arm to move, release the retaining wire and allow the door to instantly close. At the same time the door contact S1 will open and cut off the supply voltage to the amplifier and lamp.

With the door closed the lamp must go out. Should the door contact fail to break the circuit do not leave the amplifier operating as TR2 will be passing a large current and may destroy itself. Make sure that the light always goes out when the trap door closes. ▣





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2G374	0·15
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2N404	0·22
2N696	0·15
2N697	0·15
2N698	0·25
2N706	0·10
2N708	0·12
2N709	0·36
2N718	0·21
2N914	0·15
2N916	0·17
2N918	0·30
2N929	0·14
2N930	0·14
2N1090	0·30
2N1091	0·32
2N1131	0·20
2N1132	0·20
2N1184	1·27
2N1302	0·16
2N1303	0·16
2N1304	0·20
2N1305	0·20
2N1306	0·22
2N1307	0·22
2N1308	0·25
2N1309	0·25
2N1507	0·30
2N1613	0·20
2N1631	0·38
2N1637	0·36
2N1638	0·32
2N1711	0·17
2N1893	0·34
2N2147	0·70
2N2148	0·60
2N2193	0·58
2N2193A	0·61
2N2194A	0·30
2N2219	0·20
2N2220	0·20
2N2221	0·20
2N2222	0·20
2N2222A	0·32
2N2368	0·11
2N2369	0·12
2N2369A	0·17
2N2046	0·45
2N2711	0·12
2N2712	0·12
2N2713	0·17
2N2714	0·17
2N2904	0·18
2N2904A	0·29
2N2905	0·26
2N2905A	0·28
2N2906	0·18
2N2906A	0·23
2N2907	0·18
2N2923	0·12
2N2924	0·12
2N2925	0·12
2N2926	
Green	0·10
Yellow	0·10
Orange	0·10
2N3053	0·15
2N3054	0·47
2N3055	0·60
2N3390	0·20
2N3391	0·20
2N3391A	0·22
2N3392	0·13
2N3393	0·12
2N3394	0·12
2N3402	0·17
2N3403	0·19
2N3404	0·24
2N3405	0·27
2N3414	0·10
2N3415	0·10
2N3416	0·15
2N3417	0·21
2N3570	1·25
2N3572	0·97
2N3702	0·11
2N3703	0·10
2N3704	0·11
2N3705	0·10
2N3706	0·90
2N3707	0·11
2N3708	0·70
2N3709	0·90
2N3710	0·90
2N3711	0·90
2N3715	1·22
2N3716	1·30
2N3791	2·06
2N3819	0·26
2N3823	0·62

2N3854	0·16
2N3854A	0·16
2N3855	0·16
2N3855A	0·16
2N3856	0·16
2N3856A	0·16
2N3858	0·16
2N3858A	0·16
2N3859	0·16
2N3859A	0·16
2N3860	0·16
2N3866	0·70
2N3877	0·25
2N3877A	0·26
2N3900	0·20
2N3900A	0·21
2N3901	0·32
2N3903	0·22
2N3904	0·22
2N3905	0·21
2N3906	0·22
2N4058	0·12
2N4059	0·90
2N4060	0·11
2N4061	0·11
2N4062	0·11
2N4303	0·32
2N5172	0·09
2N5174	0·22
2N5175	0·26
2N5176	0·32
2N5245	0·48
2N5459	0·33
3N128	0·83
3N140	0·76
3N141	0·69
3N142	0·54
3N143	0·64
3N152	0·79
40050	0·50
40251	0·53
40309	0·26
40310	0·37
40360	0·35
40361	0·37
40362	0·40
40406	0·40
40407	0·31
40408	0·41
40410	0·53
40467A	0·57
40468A	0·35
AC107	0·35
AC126	0·20
AC127	0·20
AC128	0·20
AC154	0·20
AC176	0·16
ACY17	0·25
ACY18	0·15
ACY19	0·20
ACY20	0·20
ACY21	0·18
ACY22	0·12
ACY28	0·18
ACY40	0·17
ACY41	0·17
AD140	0·55
AD149V	1·23
AD150	0·55
AD161	0·33
AD162	0·36
AD161 / AD162 PR	0·60
AF106	0·24
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·20
AF118	0·50
AF124	0·24
AF125	0·20
AF126	0·20
AF127	0·20
AF139	0·33
AF178	0·55
AF179	0·65
AF180	0·50
AF211	0·55
AF239	0·36
AF279	0·47
AF280	0·47
ASY26	0·25
ASY27	0·30
ASY28	0·25
ASY29	0·30
ASY50	0·20
ASY55	0·35
ASZ21	0·55
AU103	1·25
BC107	0·12

BC108	0·11
BC109	0·12
BC113	0·13
BC115	0·15
BC116	0·15
BC116A	0·18
BC118	0·11
BC121	0·20
BC125	0·15
BC126	0·20
BC140	0·30
BC147	0·10
BC148	0·09
BC149	0·11
BC157	0·09
BC158	0·10
BC159	0·10
BC160	0·11
BC167B	0·11
BC168B	0·10
BC168C	0·10
BC169B	0·11
BC169C	0·11
BC170	0·11
BC171	0·13
BC172	0·11
BC182	0·10
BC183	0·09
BC184	0·11
BC212L	0·12
BCY30	0·25
BCY31	0·40
BCY32	0·60
BCY33	0·30
BCY34	0·25
BCY38	0·40
BCY39	0·80
BCY40	0·50
BCY42	0·15
BCY43	0·15
BCY58	0·18
BCY59	0·19
BCY70	0·17
BCY71	0·22
BCY72	0·13
BCZ10	0·25
BCZ11	0·50
BD116	0·75
BD121	0·75
BD123	0·82
BD124	0·60
BD131	0·75
BD132	0·75
BDY10	1·25
BDY11	1·50
BDY17	1·50
BDY18	1·75
BDY19	1·97
BDY20	1·00
BDY38	0·65
BDY60	0·90
BDY61	0·65
BDY62	0·75
BF115	0·25
BF117	0·42
BF163	0·20
BF166	0·25
BF167	0·18
BF173	0·19
BF177	0·25
BF178	0·31
BF179	0·38
BF180	0·35
BF181	0·34
BF184	0·17
BF185	0·17
BF194	0·14
BF195	0·15
BF196	0·15
BF197	0·15
BF198	0·18
BF200	0·40
BF224J	0·14
BF255J	0·19
BF237	0·22
BF238	0·22
BF244	0·16
BFX13	0·22
BFX29	0·25
BFX30	0·25
BFX44	0·33
BFX68	0·30
BFX84	0·24
BFX85	0·29
BFX86	0·24
BFX87	0·27
BFX88	0·25
BFX89	0·45
BFY10	0·35
BFY11	0·45
BFY17	0·90
BFY18	0·35
BFY19	0·35
BFY20	0·50
BFY29	0·40
BFY41	0·43
BFY43	0·65

BFY50	0·16
BFY51	0·16
BFY52	0·16
BFY53	0·15
BFY56	0·34
BFY75	0·40
BFY76	0·22
BFY77	0·24
BFY90	0·55
BFY39	0·38
BSX19	0·13
BSX20	0·14
BSX21	0·20
BSX26	0·34
BSX27	0·34
BSX28	0·25
BSX60	0·54
BSX61	0·42
BSX76	0·15
BSX77	0·20
BSX78	0·25
BSW70	0·28
BSY24	0·20
BSY25	0·20
BSY26	0·20
BSY27	0·15
BSY28	0·15
BSY38	0·15
BSY39	0·15
BSY51	0·25
BSY52	0·25
BSY53	0·25
BSY54	0·30
BSY56	0·79
BSY78	0·40
BSY79	0·40
BSY790	0·45
BSY95A	0·09
C111	0·53
C424	0·15
C425	0·36
C426	0·25
C428	0·25
GET113	0·25
GET114	0·20
GET119	0·35
GET120	0·40
GET873	0·15
GET880	0·35
GET887	0·20
GET890	0·35
MJ400	0·78
MJ420	0·86
MJ421	0·88
MJ430	0·75
MJ440	0·71
MJ480	0·75
MJ481	0·65
MJ490	0·94
MJ491	1·10
MJE340	0·47
MJE520	0·59
MPF102	0·25
MPF103	0·33
MPF104	0·32
MPF105	0·33
NKT124	0·42
NKT125	0·40
NKT126	0·38
NKT128	0·48
NKT135	0·26
NKT137	0·32
NKT210	0·25
NKT211	0·25
NKT212	0·25
NKT213	0·25
NKT214	0·15
NKT215	0·21
NKT216	0·46
NKT217	0·50
NKT219	0·25
NKT223	0·17
NKT224	0·25
NKT225	0·21
NKT229	0·29
NKT237	0·31
NKT238	0·18
NKT240	0·19
NKT241	0·20
NKT242	0·15
NKT243	0·63
NKT244	0·17
NKT245	0·18
NKT261	0·21
NKT262	0·19
NKT264	0·21
NKT271	0·18
NKT272	0·18
NKT274	0·18
NKT275	0·23
NKT401	0·70
NKT402	0·76
NKT403	0·65
NKT404	0·61
NKT405	0·60
NKT406	0·63
NKT603F	0·30

NKT613F	0·30
NKT674F	0·24
NKT677F	0·22
NKT713	0·30
NKT717	0·44
NKT781	0·20
NKT10419	0·20
NKT10439	0·27
NKT10519	0·23
NKT20329	0·32
NKT20339	0·36
NKT80111	0·67
NKT80112	0·84
NKT80113	1·00
NKT80211	0·75
NKT80212	0·75
NKT80213	0·75
NKT80214	0·75
NKT80215	0·75
NKT80216	0·75
OC20	0·65
OC22	0·50
OC23	0·50
OC24	0·60
OC25	0·50
OC26	0·25
OC28	0·65
OC29	0·60
OC35	0·50
OC36	0·65
OC41	0·30
OC42	0·35
OC44	0·15
OC45	0·12
OC46	0·27
OC70	0·12
OC71	0·12
OC72	0·12
OC74	0·25
OC75	0·22
OC76	0·22
OC77	0·40
OC81	0·20
OC81D	0·20
OC82D	0·25
OC83	0·20
OC84	0·20
OC139	0·25
OC140	0·30
OC170	0·25
OC171	0·30
OC200	0·40
OC201	0·65
OC202	0·65
OC203	0·42
OC204	0·42
OC205	0·25
P346A	0·18
TIP29A	0·49
TIP30A	0·58
TIP31A	0·62
TIP32A	0·74
TIP33A	1·01
TIP34A	1·51
TIP35A	2·90
TIP36A	3·70
TIS34	0·50
TIS43	0·21
TIS44	0·07
TIS45	0·10
TIS46	0·11
TIS47	0·11
TIS48	0·11
TIS49	0·11
TIS50	0·17
TIS51	0·11
TIS52	0·13
TIS53	0·23

Post & Packing 13p per order. Europe 25p. Commonwealth (Air) 65p (MIN.)
Matching charge (audio transistors only) 15p extra per pair.
Prices subject to alteration without prior notice.

TTL. LOGIC I.C. NEW PRICES

	1-11 £p	12-24 £p		1-11 £p	12-24 £p		1-11 £p	12-24 £p
SN7400	0·20	0·18	SN7433	0·80	0·75	SN7472	0·32	0·30
SN7401	0·20	0·18	SN7437	0·64	0·06	SN7473	0·43	0·41
SN7402	0·20	0·18	SN7438	0·64	0·60	SN7474	0·43	0·41
SN7403	0·20	0·18	SN7440	0·23	0·21	SN7475	0·45	0·44
SN7405	0·20	0·18	SN7441AN	0·87	0·83	SN7476	0·45	0·44
SN7406	0·80	0·75	SN7442	0·65	0·61	SN7480	0·70	0·65
SN7407	0·80	0·75	SN7443	2·86	2·70	SN7481	1·40	1·33
SN7408	0·20	0·18	SN7444	2·86	2·70	SN7482	0·87	0·82
SN7409	0·20	0·18	SN7445	2·50	2·40	SN7483	0·87	0·83
SN7410	0·20	0·18	SN7446	1·00	0·95	SN7484	2·00	1·65
SN7411	0·23	0·21	SN7447	1·00	0·95	SN7485	3·62	3·40
SN7412	0·48	0·46	SN7448	1·00	0·95	SN7486	0·33	0·30
SN7413	0·40	0·38	SN7449	1·00	0·95	SN7490	0·87	0·94
SN7420	0·20	0·18	SN7450	0·20	0·18	SN7491AN	1·21	1·10
SN7423	0·51	0·47	SN7451	0·20	0·18	SN7492	0·87	0·84
SN7427	0·48	0·45	SN7453	0·20	0·18	SN7493	0·87	0·84
SN7428	0·80	0·75	SN7454	0·20	0·18	SN7494	0·87	0·84
SN7430	0·23	0·15	SN7460	0·20	0·18	SN7495	0·87	0·84
SN7432	0·48	0·42	SN7470	0·40	0·38	SN7496	0·87	0·84

SUB-MIN ELECTROLYTIC

range axial lead — 6p each
Values: .(μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·2/63; 4/10; 4/40; 6·4/6·4; 6·4/25; 10/16; 10/64; 16/40; 20/16; 20/64; 25/6·4; 25/25; 32/10: 32/40; 32/64; 40/16; 50/6·4; 50/25; 50/40; 64/10; 80/16; 80/25; 100/6·4; 125/10; 125/16; 320/6·4.

SILICON RECTIFIERS

PIV	50	100	200	400	600	800	1000	1200
1A	8p	9p	10p	11p	12p	15p	20p	—
3A	15p	17p	20p	22p	25p	27p	30p	35p
6A	—	—	25p	30p	32½p	35p	—	—
10A	30p	35p	40p	47p	56p	66p	75p	—
15A	36p	45p	48p	55p	65p	75p	87p	—
35A	70p	80p	90p	£1·00	£1·40	£1·70	£2·75	—

1 amp and 3 amp are plastic encapsulation.

DIODES & RECTIFIERS

IN34A	10p	AA119	7p	BAX16	12½p	FST3/4	22½p
IN914	7p	AA129	15p	BAY18	17½p	OA5	17p
IN916	7p	AAZ13	12p	BAY31	7p	OA10	20p
IN4007	20p	AAZ15	12p	BAY38	25p	OA9	10p
IS44	7p	AAZ17	10p	BY100	15p	OA47	8p
IS113	15p	BA100	15p	BY103	22p	OA70	7p
IS120	12p	BA102	25p	BY122	47½p	OA73	10p
IS121	14p	BA110	25p	BY124	15p	OA79	7p
IS130	8p	BA114	15p	BY126	15p	OA81	8p
IS131	10p	BA115	7p	BY127	17p	OA85	10p
IS132	12p	BA141	17p	BY164	57p	OA90	7p
IS920	7p	BA142	17p	BYX10	22p	OA91	7p
IS922	8p	BA144	12p	BYZ10	35p	OA95	7p
IS923	12p	BA145	17p	BYZ11	32p	OA200	7p
IS940	5p	BA154	12p	BYZ12	30p	OA202	10p
		BAX13	5p	BYZ13	25p	TIV307	50p

"SCORPIO" CAP DISCHARGE IGNITION SYSTEM
(As printed in P.E. Nov. '71). Complete kit £10·00
P. & P. 50p.

BRIDGE RECTIFIERS

A.	PIV		A.	PIV	
1	100	37p	4	50	60p
1.4	140	57p	4	100	70p
2	50	32p	4	400	80p
2	200	41p	6	50	62p
2	400	46p	6	200	80p
			6	400	£1·10

THYRISTORS (SCR)

PIV	50	100	200	300	400
1A	25p	27½p	37½p	40p	47½p
4A	40p	45p	55p	—	60p
7A	82p	87p	92p	—	£1·12p

TIC47 0.6 amp. 200 PIV 55p.
Also 12 amp. 100 PIV 75p
2N3525 at 85p

VEROBOARD

	0·15 Matrix	0·1 Matrix
2½ × 3¾in	17p	23p
2½ × 5in	25p	25p
3¾ × 3¾in	25p	25p
3¾ × 5in	30p	29p
5 × 17in (Plain)	83p	—

Vero Pins (Bag of 36) 20p
Vero Cutter 45p
Pin Insertion Tools (·1 and ·15 matrix) at 55p.

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MINITRON 3015F SEVEN SEGMENT INDICATOR £2·00
TIL 209 LIGHT EMITTING DIODE (RED) 35p.
B9900 PHOTORESISTOR 38p

RESISTORS

Carbon Film
⅛ watt 5%, 1p. ¼ watt 5%, 1p. ½ watt 5%, 1½p. — ¼W, 1W & 2W E24 Series.
½ w 2% M/O 4p.
1 watt 10%, 2½p. 2 watt 10%, 6p. — ½W & ¼W E12 Series.

MULLARD C280 M/FOIL CAPACITORS

0·01, 0·022, 0·033, 0·047 .. 3p each
0·068, 0·10 .. .. 4p each
0.15, 0·22, 0·33 .. .. 5p each
0·47 .. .. .. 9p
0·68 .. .. .. 11p
1μF 14p
1·5μF 21p
2·2μF 25p

WIRE-WOUND RESISTORS

2·5 watt 5% (up to 270 ohms only). 7p
5 watts 5% (up to 8·2kΩ only), 8p
10 watt 5% (up to 25kΩ only), 10p

POTENTIOMETERS

Carbon:
Log. and Lin., less switch, 16p.
Log. and Lin., with switch, 25p.
Wire-wound Pots (3W), 38p.
Twin Ganged Stereo Pots, Log. and Lin., 40p.

PRESETS (CARBON)

0·1 Watt 6p
0·2 Watt 6p
0·3 Watt 7½p
VERTICAL OR HORIZONTAL

THERMISTORS

R53 (STC) £1·20 — VA3705 25p
K151 (1k) 12p — VA1077 20p
Mullard Thermistors also in stock. Please enquire.

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RESISTORS

FULL RANGE OF CARBON FILM RESISTORS

1/5 W (range 4·7 ohms to 470K) 1p each
½ W and ¼ W (range 4·7 ohms to 10 Megs) .... 1p each
1 W (range 4·7 ohms to 10 Meg) 2p each
2 W (range 4·7 ohms to 10 Meg) 3p each

These Miniature High Stability carbon Film Resistors have negligible noise factor.
All Resistors ± 5% (except values over 4·7 Meg). These Resistors are even lower in price than most 10% and older carbon composition types.

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Standard values of pre-sets from 100 ohms to 5 Meg.
Standard/miniature ...... 7p each   Sub-miniature .... 5p each

SIEMENS PROFESSIONAL CAPACITORS

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Voltage	Capacitance	Price
100v	0·1 μF	6p
100v	0·15 μF	6p
100v	0·22 μF	6p
100v	0·33 μF	9p
100v	0·47 μF	10p
100v	0·68 μF	15p
250v	0·01 μF	5p
250v	0·015 μF	5p
250v	0·022 μF	5p
250v	0·033 μF	6p
250v	0·047 μF	6p
250v	0·068 μF	6p
250v	0·1 μF	6p

ELECTROLYTIC

Voltage	Capitance	Price
10v	22 μF	7p
10v	470 μF	11p
16v	47 μF	7p
25v	10μF	7p
25v	100 μF	9p
25v	220 μF	11p
25v	470 μF	14p
25v	1000 μF	22p
25v	2200 μF	42p
35v	4·7 μF	7p
35v	220 μF	14p
100v	10 μF	8p
100v	22 μF	9p
100v	47 μF	14p

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FREE with all orders value £5 or over we will give absolutely free one GSPK P.C. Kit for making your own printed circuits (normal retail price £1·95). Hurry! Offer valid for limited period only.

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AC127	24p	22p	BZY88C			OC76	22p	21p
AC128	19p	16p	Series E12			OC170	24p	21p
AC176	15p	13p	(2·7v–30·0v)	10p	9p	1N4001	6p	5p
ACY18	18p	15p	NKT210	24p	19p	1N4002	6p	5p
AD161	27p	25p	NKT211	24p	19p	1N4003	7p	6p
AD162	27p	25p	NKT212	24p	19p	1N4004	8p	7p
AF139	28p	26p	NKT213	24p	19p	1N4005	10p	9p
BC107	9p	8p	NKT214	19p	17p	1N4006	12p	11p
BC108	8p	7p	NKT218	24p	19p	1N4007	18p	16p
BC109	9p	8p	NKT219	24p	19p	1N4148	4p	3p
BC147	8p	7p	NKT223	26p	20p	2N1302	16p	15p
BC148	8p	7p	NKT224	21p	19p	2N1304	21p	20p
BC149	8p	7p	NKT242	14p	12p	2N1613	14p	13p
BCY70	14p	13p	NKT243	51p	44p	2N1711	15p	14p
BCY71	20p	19p	NKT401	70p	56p	2N2904	29p	28p
BCY72	14p	12p	NKT402	75p	59p	2N2905	24p	22p
BDY20	91p	73p	NKT403	64p	50p	2N2906	19p	18p
BFX29	24p	23p	NKT453	41p	33p	2N2907	22p	21p
BFX30	24p	23p	OA47	6p	5p	2N3053	17p	16p
BFY50	19p	18p	OA79	6p	5p	2N3054	49p	47p
BFY51	18p	17p	OA90	5p	4p	2N3055	57p	52p
BFY52	19p	18p	OC70	12p	12p	(BD130)		

NUMEROUS OTHER ITEMS AVAILABLE INCLUDE :

Switches Comprehensive range of N.S.F. Toggle switches and Rotary Wafer switch kits (to enable you to make *your own* switch to *your own* specification).
Copper laminate and all materials available to make your own printed circuit boards.
Lamps and lampholders for every requirement. **Ready Built Circuits and Modules.**
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10	50	4p	2000	25	15p
16	15	3p	2500	12	10p
16	25	3p	2500	25	30p
20	25	3p			
25	15	3p			
25	25	3p			
32	50	4p			
40	6	3p			
50	10	3p			
50	50	7p			
64	10	4p			
64	25	4p			
64	40	5p			
100	6	3p			
100	50	8p			
250	6	4p			
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75	750	2p
100	750	2p
120	750	2p
220	750	2p
1000	50	2½p
4700	30	2p
0.01	30	3p

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AD162		BD116	79p	MP8511	34p	OC35	25p	IN4003	5p
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160V: 0·01μF, 0·015μF, 0·022μF, 0·033μF, 0·047μF, 0·068μF, **3p.** 0·1μF, **3½p.** 0·15μF, **4½p.** 0·22μF, **5p.** 0·33μF, **6p.** 0.47μF, **7½p.** 0·68μF, **11p.** 1·0μF, **13p.**

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THEY MADE THEIR MARK

No 6 Faraday

(Part 1)

By J. E. Gregory

Table 1: FARAD (F)

The farad is the unit of electric capacitance. A capacitor has a capacitance of one farad when a charge of one coulomb raises the potential between its plates to one volt, hence farads $= \frac{\text{coulombs}}{\text{volts}}$

For everyday use the farad is too large a unit, and smaller units called microfarads (symbol $\mu F = 10^{-6}F$), nanofarads (symbol $nF = 10^{-9}F$) and picofarads (sometimes called "puffs"—symbol $pF = 10^{-12}F$) are used.

The unit was first suggested in 1867 by Latimer Clark, the English engineer and electrician, who besides inventing the Clark standard cell took a leading part in the movement for the systemisation of electrical standards. The farad was adopted as the unit of electric capacitance, at the first meeting of the International Electrotechnical conference in 1881.

IN this, the first half of a two-part article, we meet the man once described as "the Columbus of electricity"—Michael Faraday—who discovered how to make electricity by mechanical means, and gave his name to the unit of electric capacitance (see Table 1).

Michael Faraday was born at Newington, Surrey, on September 22, 1791, the third son of a Yorkshire blacksmith who had migrated to London. At the age of fourteen Michael was apprenticed to one Riebeau, a bookbinder, who gave young Michael time to study the many learned books they were binding. Michael was a good worker, with an aptitude for learning and as a reward Mr. Riebeau took him to a series of lectures, on chemistry given by Sir Humphrey Davy of miner's safety lamp fame.

GREATEST DISCOVERY

The young Faraday was spellbound not only by Davy but by the content of the lectures, so much so that he made notes, bound and illustrated them, and sent them to Davy requesting an interview as an assistant, although impressed Davy wrote to Faraday saying that he should stick to his trade of bookbinding, "Science is too precarious for a young man".

Then fate took a hand, Davy's assistant was dismissed and Faraday was offered a job, and Davy made what he later described as "My greatest discovery". The man who in later years was to succeed him as Director of the Royal Institute.

ROYAL INSTITUTE

Faraday started work at the Royal Institute on March 1. 1813, in a humble capacity assisting lecturers and keeping the apparatus polished, soon he became Davy's experimental assistant, and together from October 1813 to April 1815, they toured Europe lecturing.

On June 12, 1821, Faraday married Sarah Barnard and they moved to apartments at the Royal Institute where he had been promoted to superintendent.

Taking up original work in chemistry Faraday made a number of discoveries among them benzol, and two new chlorides of carbon, he was also much in demand as a lecturer.

Gradually his work in chemistry was eclipsed by his electrical discoveries.

Faraday proved that a conductor carrying a current also induced currents in neighbouring conductors. On a wooden core he wound two coils of insulated wire, and sent electricity through one, while the other was connected to a meter which measured the current. He noticed that while the battery current flowed steadily through the coil, the meter did not move, but when the current was started or stopped, the needle jerked back and forth.

Picking up where Ampère left off he concluded that since electricity produced magnetism, so magnetism might produce electricity. He discovered that if a magnet is thrust into a coil of wire an electric current is "generated" in the coil, when the magnet is withdrawn the current direction is reversed proving that movement can produce electricity. This great discovery—that electricity could be produced by magnetism—was dated in Faraday's notebook as August 29, 1831.

He made a small dynamo in which a current was produced by rotating a loop of wire between the two poles of a magnet. At each half turn of the wire loop the direction of the current was reversed so that it flowed back and forth (a.c.). Faraday eventually fitted a commutator to turn the a.c. into d.c. He demonstrated his dynamo and reported his two discoveries of electrodynamic induction and magnetoelectric induction to the Royal Society in November 24, 1831.

This is generally regarded as the birth of the modern dynamo and transformer, and led to the development of the electric motor.

But Faraday had not finished yet as we shall be seeing in Part 2, next month.

TEACH-IN

End of term test

To wind up the *Teach-In* series we have devised the following questionaire which should help emphasise some of the more important points covered. We shall be publishing detailed answers next month so **please** do not send your answers in to us.

(1) To make a silicon *npn* transistor conduct between collector and emitter must we make the base: (a) 300 mV positive, (b) 300mV negative, (c) 600mV positive or (d) 600mV negative with respect to the emitter.

(2) Generally speaking, and assuming all important parameters such as h_{FE}, breakdown voltages, junction capacitance, current and power ratings and manufacturing materials are the same, do you think you could substitute *pnp* for *npn* transistors in a circuit and simply reverse the polarity of the power supply?

(3) Calculate the quiescent power dissipation of TR1 in Fig. 1. Assume TR1 is a silicon transistor and its h_{FE} is exactly 200; the resistors are precise values and the base/emitter voltage drop is exactly 600mV.

(4) (a) How long will it take C1 to charge up to +4V when S1 in Fig. 2 is opened?
(b) If C1 was a "leaky" capacitor, would it take more or less time to charge to the same potential?
(c) Alternatively, if 18V was applied to the circuit, would the charging time be greater or less than in (a) above?

(5) Why is it sometimes necessary to put a diode in series with the base of each transistor in an astable multivibrator?

(6) A square wave has a mark/space ratio of 10 : 1. The off time is 50mS and represents the "mark". How long is the on time and what are the period and frequency of the waveform?

(7) What are the absolute values of positive and negative peaks of a sine wave having an amplitude of 4V r.m.s. about a d.c. level of +2V?

(8) Would you prefer to use a silicon or germanium diode as a half-wave meter rectifier when the meter has a full scale reading of 5V? There is a good reason for not using one type! What is the reason?

(9) Fig. 3 shows three ways in which a transformer could be drawn in a simple circuit. In two cases the output voltage is in phase with the input. In one case it is out of phase. Which is the latter?

(10) If you are going to buy a transformer to make a simple battery eliminator power supply with a d.c. output in the range 8V to 9V, would you select one with an r.m.s. secondary of: (a) 6·3V, (b) 9V, or (c) 12V?

(11) What would you expect the r.m.s. output voltage from Fig. 4 to be for input frequencies of 50Hz, 100Hz and 200Hz having equal amplitudes of 10V r.m.s.?

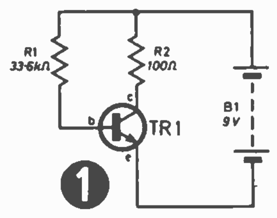
(12) To obtain best power efficiency with least drain on batteries, would you use a class A or class B output stage in a transistor radio?

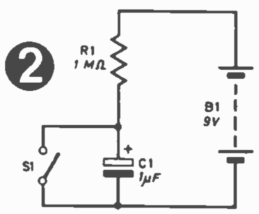
(13) Why do you think that many hi-fi purists prefer a class A output?

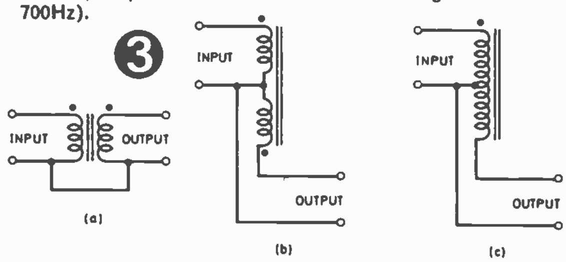
(14) If you connect a crystal microphone to the low input impedance sockets of an amplifier, would you have: (a) uniform frequency response, (b) loss of bass frequencies, or (c) loss of high frequencies?

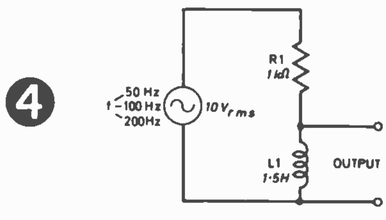
(15) You have a new amplifier that needs a loudspeaker having 7 ohms impedance. You have two loudspeakers having impedances of 3 ohms and 15 ohms respectively and you desperately want to try out the amplifier. Which loudspeaker could you use without fear of damaging the amplifier?

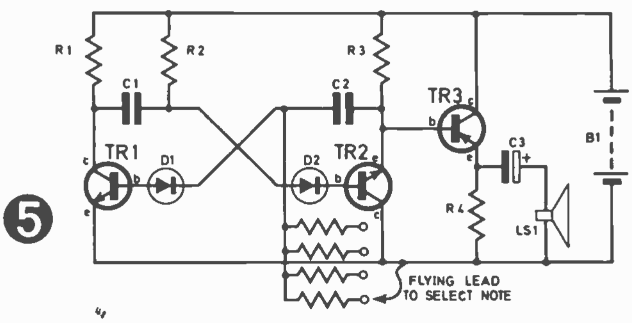
(16) Fig. 5 is the basic circuit of a simple four note electronic organ—no component values are given and there are 5 deliberate mistakes in the fundamental circuitry—assume the battery polarity is correct as shown. See how many of the mistakes you can find and then try and work out the values of all the components to make the circuit work. (Frequencies should be in the range of 300 to 700Hz).



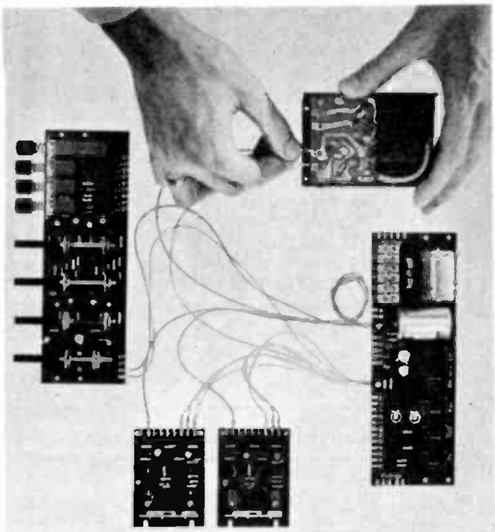








Project 605 the new simple way to assemble Sinclair high fidelity modules



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⅛	2%	10Ω–1M	E24	3·5p	3·0p
½	10%	1Ω–3·9Ω	E12	1·0p	0·8p
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AC126	12p	BC108	10p	BFY50	22p	OC82D	12p	2N3704	13p
AC127	12p	BC109	10p	BFY51	22p	OCP71	40p	2N3705	12p
AC128	12p	BC147	10p	BFY52	22p	ORP12	50p	2N3706	11p
AC131	12p	BC148	13p	BSY56	32p	2N2369	16p	2N3707	12p
AC132	12p	BC149	13p	OC26	45p	2N2646	60p	2N3708	10p
AD140	50p	BC157	13p	OC28	45p	2N2926R	9p	2N3709	11p
AD161	33p	BC158	13p	OC35	45p	2N2926O	9p	2N3710	11p
AD162	36p	BC159	13p	OC42	12p	2N2926Y	9p	2N3711	11p
AF114	20p	BD131	75p	OC44	12p	2N2926G	10p	2N4062	12p
AF115	20p	BD132	75p	OC45	12p	2N3054	58p	ZTX302	15p
AF116	20p	BF179	32p	OC70	12p	2N3055	60p	ZTX500	16p
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IN4007	1000V	1A	12p

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160V: 0·01μF, 0·015μF, 0·022μF, 0·033μF, 0·047μF, 0·068μF, 3p. 0·1μF 3½p. 0·15μF, 4½p. 0·22μF, 5p. 0·33μF, 6p. 0·47μF, 7½p. 0·68μF, 11p. 1·0μF, 13p.

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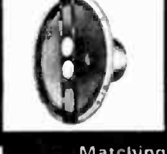

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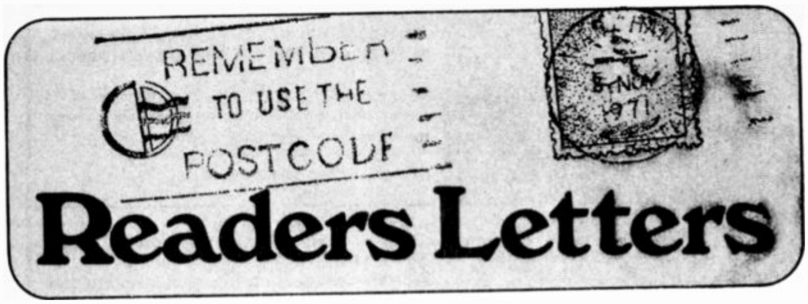

Readers Letters

That Convention

Ref. your reply to Mr. Robinsons comment (July issue) on conventional and electron current, may I point out the following.

(a) Conventional current is no longer in common usage; all secondary schools, at least in Scotland, teach the basics of electricity and magnetism with reference to electron flow.

(b) All the basic laws of electricity and magnetism are not in terms of conventional current, electron current is now used and has been for some time.

To sum up, electron current has now become conventional, and the basic rules of electricity and magnetism not only remain as they always were, but they are now much more realistic. Readers still using conventional current may be brought up to date as far as electro-magnetics is concerned if they simply use electron current and interchange Flemings right and left hand rules.

In closing, may I congratulate you and your colleagues for an excellently produced magazine; I am sure that you have given much pleasure to the professional as well as the beginner in electronics.

Michael F. I. McVoy
Port Glasgow

Our Teach-In *author,* Mike Hughes, *replies:*

Thank you for Mr. McVoy's letter which is very interesting. Here is my reply which you might like to publish as I think his comments are quite controversial.

Mr. McVoy's comments are very interesting but I think that a unilateral decision to drop conventional current teaching could be very dangerous. Certainly in most parts of England the policy of teaching is to stay with conventional current—this is the accepted requirement for the London University Schools' Examination Board when they come to mark GCE papers.

Of course, all established physics and electronics books are written in terms of conventional current and the more recent ones in my possession still maintain this standard. Provided the student is aware of the definition I do not think there is any great harm in maintaining the situation.

I cannot agree with Mr. McVoy's statement regarding Flemings "left" and "right" hand rules. Flemings rules were devised assuming current flow from positive to negative; if you change the convention they can no longer be called "Fleming's" rules, but worse still; I have great difficulty remembering which hand applies to what at the moment; introduce a reversal in sense of flow and I bet—as with a pair of swing doors —I will get the right set of circumstances on the last attempt!

What happens to the "Corkscrew" rule (left hand thread screws?) and those nice twirly N's and S's to tell me which end of a solendoid is the north pole? All transistor and diode symbols have a built in "arrow" which depicts the direction of conventional flow; if we changed the convention sooner or later someone would come along and say the symbols should be changed round. Anyone then referring back to old copies of E.E. would no doubt be reading npn for pnp types!

I have every sympathy with the beginner who may be mesmerised by the apparent nonsense of the convention, but I think it is simpler to stick with it than change it lightly.

Mike Hughes

Clubbed!

I have been interested in electronics for some years but until your magazine came out I had not done anything practical. Now I have built a couple of your projects, due to your magazine making it simple and basic, and my interest has increased.

I would like to join a radio or electronics club to further my interest, but I'm a bit hesitant as being a near beginner I'm not certain if I'd be eligible. If you could suggest a suitable club in my area I would be very grateful.

H. Wagg
Cheshire

We do not know of a club in your area, but there may be a course at a local technical college or an evening course at a school. Otherwise see the following letter.

Thanks to your advice in reply to Mr. Milligan's letter (July issue) I have since joined the British Amateur Electronics Club and found that it fulfils all my requirements. As for a national exhibition this year's has already taken place at Penarth, Glamorgan on July 22 to 29. Amongst the exhibits was a random letter generator, designed by some of our more experienced members, and constructed by any members who were willing to help.

Although our projects sound rather ambitious (the next being a small computer) all attempts are made to help newcomers to the electronics field. Nearly half the quarterly newsletter is devoted to comment and articles to help the beginner, and give that beginner the knowledge he needs to become proficient in pursuance of his hobby, so, if anyone is interested, I am sure Mr. Margetts will send you details. (No, I don't get commission!)

Andrew Cash
Bristol

Weather Coupling

"E.E. Constructionairs" may find this tip useful for the wind generator spindle coupling in the Weather Station (August issue). By cutting away the plastic surround of a 2 amp plastic terminal block, the metal inserts make a suitable spindle coupling for a small model makers motors.

R. A. Lygo
Oxford

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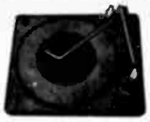

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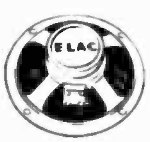

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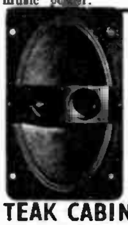

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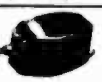

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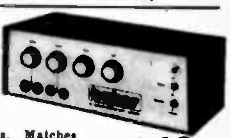

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50-0-50µA	£3·10	100mA	£2·80
100µA	£3·10	500mA	£2·80
100-0-100µA	£3·00	1 amp.	£2·80
200µA	£3·00	5 amp.	£2·80
500µA	£2·90	15 amp.	£2·80
500-0-500µA	£2·80	30 amp.	£2·90
1mA	£2·80	20V. D.C.	£2·80
1-0-1mA	£2·80	50V. D.C.	£2·80
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50µA	£2·10	200mA	£1·60
50-0-50µA	£1·90	300mA	£1·60
100µA	£1·90	500mA	£1·60
100-0-100µA	£1·75	750mA	£1·60
200µA	£1·75	1 amp.	£1·60
500µA	£1·65	2 amp.	£1·60
500-0-500µA	£1·60	5 amp.	£1·60
1mA	£1·60	10 amp.	£1·60
1-0-1mA	£1·60	3V. D.C.	£1·60
2mA	£1·60	10V. D.C.	£1·60
5mA	£1·60	15V. D.C.	£1·60
10mA	£1·60	20V. D.C.	£1·60
20mA	£1·60	100V. D.C.	£1·60
50mA	£1·60	150V. D.C.	£1·60
100mA	£1·60	300V. D.C.	£1·60
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		500V. A.C.	£1·70
		8 Meter 1mA	£1·70
		VU Meter	£2·10

Type MR.52P. 2½in. square fronts.

50µA	£3·10	10V. D.C.	£2·00
50-0-50µA	£2·60	20V. D.C.	£2·00
100µA	£2·60	50V. D.C.	£2·00
100-0-100µA	£2·50	300V. D.C.	£2·00
500µA	£2·30	15V. A.C.	£2·10
1mA	£2·00	300V. A.C.	£2·10
5mA	£2·00	8 Meter 1mA	£2·10
10mA	£2·00	VU Meter	£2·30
50mA	£2·00	1 amp. A.C.*	£2·00
100mA	£2·00	5 amp. A.C.*	£2·00
500mA	£2·00	10 amp. A.C.*	£2·00
1 amp.	£2·00	20 amp. A.C.*	£2·00
5 amp.	£2·00	30 amp. A.C.*	£2·00

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50µA	£2·25	5 amp.	£1·70
50-0-50µA	£2·10	10V. D.C.	£1·70
100µA	£2·10	20V. D.C.	£1·70
100-0-100µA	£1·87	50V. D.C.	£1·70
200µA	£1·87	300V. D.C.	£1·70
500µA	£1·75	15V. A.C.	£1·80
500-0-500µA	£1·70	300V. A.C.	£1·80
1mA	£1·70	8 Meter 1mA	£1·85
5mA	£1·70	VU Meter	£2·25
10mA	£1·70	1 amp. A.C.*	£1·70
50mA	£1·70	5 amp. A.C.*	£1·70
100mA	£1·70	10 amp. A.C.*	£1·70
500mA	£1·70	20 amp. A.C.*	£1·70
1 amp	£1·70	30 amp. A.C.*	£1·70

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100µA	£2·75	50V. D.C.	£2·20
100-0-100µA	£2·65	150V. D.C.	£2·20
200µA	£2·65	300V. D.C.	£2·20
500µA	£2·40	15V. A.C.	£2·30
500-0-500µA	£2·20	50V. A.C.	£2·30
1mA	£2·20	150V. A.C.	£2·30
5mA	£2·20	300V. A.C.	£2·30
10mA	£2·20	500V. A.C.	£2·30
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100µA	£2·35	150V. A.C.*	£1·95
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500µA	£2·20	500mA A.C.*	£1·95
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1-0-1mA	£1·95	5 amp. A.C.*	£1·95
5mA	£1·95	10 amp. A.C.*	£1·95
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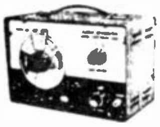

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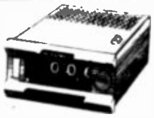

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2G371	15p	2N3568	25p	2S304	75p	BC126	20p	BFX68	67p	NKT241	37p
2G374	20p	2N3569	25p	2S501	22p	BC134	12p	BFX84	25p	NKT242	20p
2G381	22p	2N3570	125p	2S502	35p	BC135	12p	BFX85	30p	NKT243	62p
2N388A	40p	2N3572	97p	2S503	97p	BC136	15p	BFX86	25p	NKT244	17p
2N404	20p	2N3605	27p	3N83	40p	BC137	15p	BFX87	25p	NKT245	20p
2N696	15p	2N3606	27p	3N128	70p	BC138	20p	BFX88	30p	NKT261	20p
2N697	15p	2N3607	22p	3N140	77p	BC140	35p	BFX89	62p	NKT262	30p
2N698	25p	2N3638	18p	3N141	72p	BC141	35p	BFX93A	70p	NKT264	20p
2N699	30p	2N3638A	20p	3N142	55p	BC147	10p	BFY11	42p	NKT271	20p
2N706	10p	2N3641	15p	3N143	67p	BC148	10p	BFY18	25p	NKT262	20p
2N706A	12p	2N3642	18p	3N152	87p	BC149	12p	BFY19	25p	NKT274	20p
2N708	15p	2N3643	20p	40050	55p	BC152	17p	BFY21	42p	NKT275	20p
2N709	62p	2N3644	25p	40250	50p	BC153	20p	BFY24	45p	NKT278	25p
2N718	25p	2N3645	25p	40251	32p	BC154	20p	BFY29	40p	NKT281	27p
2N718A	30p	2N3691	15p	40309	32p	BC157	15p	BFY30	40p	NKT401	87p
2N726	30p	2N3692	18p	40310	45p	BC158	11p	BFY41	50p	NKT402	90p
2N727	30p	2N3693	15p	40311	35p	BC159	12p	BFY43	62p	NKT403	75p
2N914	17p	2N3694	18p	40312	47p	BC160	35p	BFY50	20p	NKT404	55p
2N916	17p	2N3702	10p	40314	37p	BC167	11p	BFY51	20p	NKT405	75p
2N918	30p	2N3703	10p	40315	37p	BC168B	10p	BFY52	20p	NKT406	62p
2N929	22p	2N3704	11p	40316	47p	BC168C	11p	BFY53	15p	NKT451	62p
2N930	20p	2N3705	10p	40317	37p	BC169B	11p	BFY56A	57p	NKT452	62p
2N987	40p	2N3706	9p	40319	55p	BC169C	12p	BFY76	42p	NKT453	47p
2N1090	22p	2N3707	11p	40320	47p	BC170	12p	BFY77	57p	NKT713	20p
2N1091	22p	2N3708	7p	40323	32p	BC171	15p	BFY90	65p	NKT717	42p
2N1131	25p	2N3709	9p	40324	47p	BC172	15p	BSX19	17p	NKT734	27p
2N1132	25p	2N3710	9p	40326	37p	BC175	22p	BSX20	15p	NKT736	35p
2N1302	17p	2N3711	12p	40329	30p	BC177	20p	BSX21	20p	NKT773	25p
2N1303	17p	2N3713	187p	40344	27p	BC178	20p	BSX26	45p	NKT781	30p
2N1304	22p	2N3714	200p	40347	57p	BC179	20p	BSX27	47p	OC16	50p
2N1305	22p	2N3715	123p	40348	62p	BC182	10p	BSX28	32p	OC19	37p
2N1306	25p	2N3716	130p	40360	40p	BC182L	10p	BSX60	82p	OC20	75p
2N1307	25p	2N3773	240p	40361	40p	BC183	9p	BSX61	62p	OC22	50p
2N1308	25p	2N3791	206p	40362	50p	BC183L	9p	BSX76	15p	OC23	60p
2N1309	25p	2N3819	34p	40370	32p	BC184	11p	BSX77	20p	OC24	60p
2N1507	17p	2N3820	55p	40406	57p	BC184L	11p	BSX78	25p	OC25	40p
2N1613	20p	2N3823	50p	40407	40p	BC186	25p	BSY24	15p	OC26	25p
2N1631	35p	2N3854	27p	40408	52p	BC187	27p	BSY25	15p	OC28	60p
2N1632	30p	2N3854A	27p	40409	55p	BC212L	12p	BSY26	17p	OC29	60p
2N1637	30p	2N3855	27p	40410	62p	BC213L	12p	BSY27	15p	OC35	50p
2N1638	27p	2N3855A	30p	40412	50p	BC214L	15p	BSY28	17p	OC36	60p
2N1639	37p	2N3856	30p	40467A	57p	BCY10	27p	BSY29	17p	OC41	22p
2N1701	[illegible]	2N3856A	35p	40468A	35p	BCY30	27p	BSY32	25p	OC42	25p
2N1711	24p	2N3858	25p	40528	72p	BCY31	30p	BSY36	25p	OC44	15p
2N1889	32p	2N3858A	30p	40600	57p	BCY32	50p	BSY37	25p	OC45	12p
2N1893	37p	2N3859	37p	40603	50p	BCY33	25p	BSY38	20p	OC46	15p
2N2147	72p	2N3859A	32p	AC107	30p	BCY34	20p	BSY39	22p	OC70	15p
2N2160	57p	2N3860	30p	AC126	20p	BCY38	40p	BSY43	50p	OC71	12p
2N2193	40p	2N3866	150p	AC127	24p	BCY39	60p	BSY51	32p	OC72	12p
2N2193A	42p	2N3877	40p	AC128	20p	BCY40	50p	BSY52	32p	OC73	30p
2N2194	27p	2N3877A	40p	AC151	18p	BCY41	15p	BSY53	37p	OC74	30p
2N2194A	30p	2N3900	37p	AC152	22p	BCY42	15p	BSY54	40p	OC75	22p
2N2217	25p	2N3900A	40p	AC154	22p	BCY43	15p	BSY56	90p	OC76	22p
2N2218	20p	2N3901	97p	AC176	20p	BCY54	32p	BSY79	45p	OC77	30p
2N2219	20p	2N3903	20p	AC187	25p	BCY58	22p	BSY90	57p	OC78	20p
2N2220	25p	2N3904	25p	AC188	25p	BCY59	22p	BSY95A	12p	OC81	20p
2N2221	25p	2N3905	30p	ACY17	37p	BCY60	97p	C424	15p	OC81D	20p
2N2222	20p	2N3906	25p	ACY18	24p	BCY70	15p	C450	15p	OC82	25p
2N2222A	25p	2N4058	12p	ACY19	24p	BCY71	20p	GET102	30p	OC82D	15p
2N2297	30p	2N4059	10p	ACY20	20p	BCY72	15p	GET113	20p	OC83	25p
2N2368	15p	2N4060	12p	ACY21	20p	BCY78	30p	GET114	20p	OC84	25p
2N2369	15p	2N4061	12p	ACY22	10p	BCY79	30p	GET118	20p	OC139	25p
2N2369A	15p	2N4062	12p	ACY28	17p	BCZ10	27p	GET120	25p	OC140	32p
2N2410	42p	2N4244	47p	ACY39	47p	BCZ11	40p	GET873	12p	OC170	25p
2N2483	27p	2N4248	15p	ACY40	20p	BD112	50p	GET880	30p	OC171	30p
2N2484	32p	2N4249	15p	ACY41	15p	BD116	112p	GET887	20p	OC200	40p
2N2539	22p	2N4250	18p	ACY44	25p	BD121	65p	GET889	22p	OC201	60p
2N2540	22p	2N4254	42p	AD140	47p	BD123	80p	GET890	22p	OC202	75p
2N2613	35p	2N4255	42p	AD149	47p	BD124	60p	GET896	22p	OC203	40p
2N2614	30p	2M4284	17p	AD150	62p	BD131	75p	GET897	22p	OC204	40p
2N2646	40p	2N4285	17p	AD161	35p	BD132	80p	GET898	22p	OC205	75p
2N2711	25p	2N4286	17p	AD162	35p	BDY10	125p	MAT100	25p	OC206	95p
2N2712	25p	2N4287	17p	AF109	45p	BDY20	105p	MAT101	25p	OC207	75p
2N2713	27p	2N4288	15p	AF114	25p	BDY61	125p	MAT120	25p	OCP71	42p
2N2714	30p	2N4289	17p	AF115	25p	BDY62	100p	MAT121	25p	ORP12	50p
2N2904	20p	2N4290	12p	AF116	25p	BF115	25p	MJ400	107p	ORP60	40p
2N2904A	25p	2N4291	15p	AF117	20p	BF117	47p	MJ420	80p	ORP61	42p
2N2905	25p	2N4292	15p	AF118	60p	BF152	28p	MJ421	80p	P346A	22p
2N2905A	20p	2N4294	17p	AF121	30p	BF154	20p	MJ430	102p	ST140	15p
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2N2906A	25p	2N4964	15p	AF125	19p	BF159	35p	MJ480	97p	TI834	62p
2N2907	22p	2N4965	18p	AF126	19p	BF163	35p	MJ481	125p	TI843	40p
2N2923	15p	2N5027	52p	AF127	16p	BF167	18p	MJ490	100p	TI844	10p
2N2924	15p	2N5028	57p	AF139	28p	BF170	33p	MJ491	137p	TI845	27p
2N2925	15p	2N5029	47p	AF178	42p	BF173	19p	MJE340	50p	TI846	11p
2N2926G	10p	2N5030	42p	AF179	45p	BF177	30p	MJE370	80p	TI847	11p
2N2926O	10p	2N5172	12p	AF180	50p	BF178	35p	MJE371	80p	TI848	12p
2N2926Y	10p	2N5174	52p	AF181	40p	BF179	30p	MJE520	60p	TI849	12p
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2N3133	30p	2N5249	67p	ASY26	25p	BF194	15p	MPS3638	32p	XC141	35p
2N3134	16p	2N5265	325p	ASY27	30p	BF195	15p	NKT124	42p	ZTX107	15p
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2N3136	25p	2N5306	40p	ASY29	27p	BF197	15p	NKT126	27p	ZTX109	15p
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2N3391	20p	2N5308	37p	ASY51	32p	BF200	35p	NKT135	27p	ZTX301	15p
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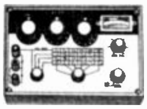

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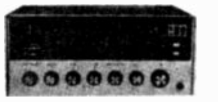

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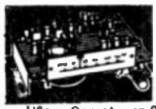

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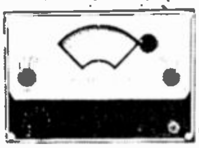

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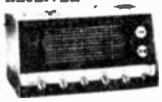

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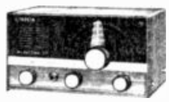

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