PRACTICAL

ELECTRONICS

AUGUST 1970

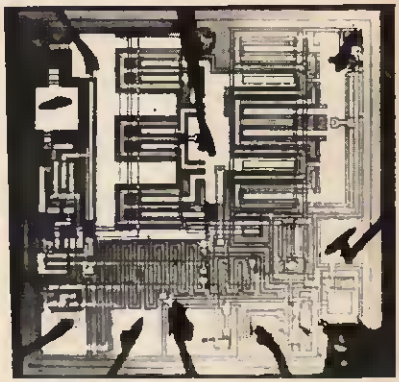
PRICE 3/6

IT COULDN'T BE EASIER!

Project Building for BEGINNERS

ALSO INSIDE:
ANEMOMETER : DECIMAL CURRENCY CONVERTER

MONOLITHIC INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMP



the world's most advanced high fidelity amplifier

The Sinclair IC-10 is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself, a chip of silicon only a twentieth of an inch square by a hundredth of an inch thick, has an output 5 watts R.M.S. (10 watts peak). It contains 13 transistors (including two power types), 2 diodes, 1 Zener diode and 18 resistors, formed simultaneously in the silicon by a series of diffusions. The chip is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is not only more rugged and reliable than any previous amplifier, it also has considerable performance advantages. The most important are complete freedom from thermal runaway due to the close thermal coupling between the output transistors and the bias diodes and very low level of distortion.

The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout) etc. The photographic masks required as part of the process of producing monolithic I.Cs are expensive but once made, the circuits can be produced with complete uniformity and at very low cost. This enables us to cover every IC-10 with the Sinclair guarantee of reliability.

■ SPECIFICATIONS

Output	10 Watts peak, 5 Watts R.M.S. continuous.
Frequency response	5 Hz to 100 KHz±1dB.
Total harmonic distortion	Less than 1% at full output.
Load impedance	3 to 15 ohms.
Power gain	110dB (100,000,000,000 times) total.
Supply voltage	8 to 18 volts.
Size	1 × 0.4 × 0.2 inches.
Sensitivity	5mV.
Input impedance	Adjustable externally up to 2.5 M ohms.

■ CIRCUIT DESCRIPTION

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from crossover distortion at all supply voltages, making battery operation eminently satisfactory.

■ APPLICATIONS

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

SINCLAIR

IC.10 *with IC-10 manual* **59/6**

POST FREE

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SINCLAIR RADIONICS LIMITED
22 NEWMARKET ROAD · CAMBRIDGE
Tel. 0223 52731

Project 60

laboratory standard modular high fidelity

Sinclair Project 60 comprises a range of modules which connect together simply to form a complete stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare in overall performance. Now with the addition of three new modules to the range, the constructor has choice of assemblies with either 20 or 40 watts output per channel, with or without filter facilities.

The modules are: **1.** The Z.30 and Z.50 high gain power amplifiers, each of which is an immensely flexible unit in its own right. **2.** The Stereo 60 preamplifier and control unit. **3.** The Active Filter Unit with both high and low audio frequency cut – offs. **4.** The PZ.5 and PZ.6 power supplies. A complete system could comprise, for example, two Z.30's one Stereo-60, and a PZ.5. The PZ.6 is stabilised and should be used where the highest possible continuous sine wave rating is required. An A.F.U. may be added as required. In a normal domestic application, there will be no significant difference between PZ.5 or PZ.6 unless loudspeakers of very low efficiency are being used, in which case the PZ.6 will be required. For assemblies using two Z.50's there is the new PZ.8 supply unit to ensure maximum performance from these amplifiers.

All you need to assemble your Project 60 system is a screwdriver and soldering iron. No technical skill or knowledge whatsoever is required and, in the unlikely event of you hitting a problem, our customer service and advice department will put the matter right promptly and willingly. Project 60 modules have been carefully designed to fit into virtually all modern plinth or cabinets and only holes need be drilled in the wood of the plinths to mount the control unit and A.F.U. Any slight slip here will be covered by the aluminium front panels of the Stereo 60. The Project 60 manual gives all the buildings and operating instructions you can possibly want, clearly and concisely. Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future as the latest additions to the range show. A stereo F.M. tuner is next to come. These and all other modules we introduce will be compatible with those already available and may be added to your system at any time. And because Sinclair are the largest producers of constructor modules in Europe. Project 60 prices are remarkably low.

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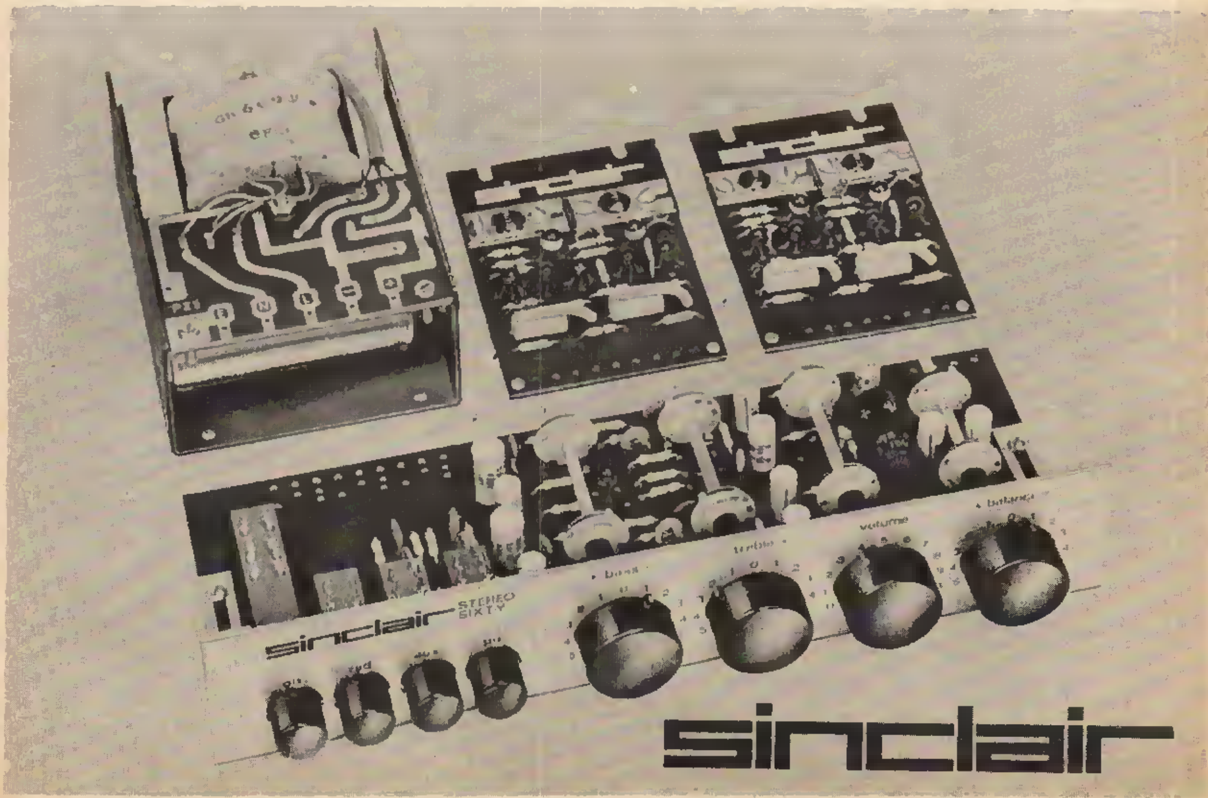

SINCLAIR

Q.16

new elegance in an outstanding loudspeaker

All the superb features which went to make the Sinclair Q.14 have been incorporated in the new Q.16 which gives an exciting new opportunity for you to match your Sinclair equipment with modern decor. Employing the same well proven acoustic system in which materials, processing and styling are used in such a radical and successful departure from conventional design, this speaker presents an entirely new appearance with its attractive teak surround and all-over special cellular foam front chosen as much for its appearance as for its ability to pass all audio frequencies without loss. The Q.16 is compact and slim. Its new styling makes it eminently suitable for shelf mounting, but it is no less versatile than its famous predecessor. Listen to a pair of Q.16s in stereo and marvel at the standards of quality and clarity they give. At the price, this Sinclair speaker represents outstanding value as you will discover the moment you see and hear it.

The Q.16 will handle loading up to 14 watts R.M.S. and presents an 8 ohm impedance to the amplifier output. Frequency response extends from 60 to 16,000 Hz. with exceptional smoothness. A specially designed driver system is used in a sealed and contoured pressure chamber to ensure good transient response at all frequencies. Size: $9\frac{3}{4}''$ square $\times$ $4\frac{3}{4}''$ deep from front to back.

£8.19.6
POST FREE

SINCLAIR MICROMATIC

The world's most successful miniature radio

Specifications
Size:
$1\frac{13}{16}'' \times 1\frac{5}{16}'' \times \frac{1}{2}''$ (46 × 33 × 13mm).
Weight incl. batteries:
1 oz. (28·35gm) approx.
Tuning:
Medium wave band with bandspread at higher frequency end.
Earpiece.
Magnetic type.
Case:
Black plastic with anodized aluminium front panel, spun aluminium dial.

Complete kit incl. earpiece, case, solder and instructions in fitted pack. **49/6** *Inc. P/Tax*

Ready buit, tested and guaranteed, with earpiece. **59/6** *Inc. P/Tax*

Mallory Mercury Cell RM675 (2 required) each 2/9d.

Considerably smaller than an ordinary box of matches, this is a multi-stage A.M. receiver meticulously designed to provide remarkable standards of selectivity, power and quality. Powerful A.G.C. is incorporated to counteract fading from distant stations; bandspread at higher frequencies makes reception of Radio 1 easy at all times. Vernier type tuning plus the directional properties of the self-contained special ferrite rod aerial makes station separation much easier than with many larger sets. The plug-in magnetic earpiece which matches exactly with the output provides wonderful standards of reproduction. Everything including the batteries is contained within the attractively designed case. Whether you build your Micromatic or buy it ready built and tested, you will find it as easy to take with you as your wristwatch, and dependable under the severest listening conditions.

USE THIS COUPON FOR MICROMATIC AND Q.16 ORDERS

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P.E.8/70

SINCLAIR GENERAL GUARANTEE

Should you not be completely satisfied with your purchase when you receive it from us, return the goods without delay and your money will be refunded in full, including cost of return postage, at once and without question. Full service facilities are available to all Sinclair customers.

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SINCLAIR RADIONICS LIMITED
22 NEWMARKET ROAD, CAMBRIDGE Tel. 0223 52731

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR

Sine 18–200,000Hz: Square 18–50,000Hz. Output max +10dB (10kΩ). Operation internal batteries. Attractive two-tone case 7¾in × 5in × 2in. Price £17.10.0. Carr. 3/6.

CLASS D WAVEMETERS

A crystal controlled heterodyne frequency meter covering 1·7–8 Mc/s. Operation on 6V d.c. Ideal for amateur use. Available in good used condition. £5.19.6. Carr. 7/6, or brand new with accessories. £7.19.6. Carr. 7/6.

CLASS D WAVEMETERS No. 2

Crystal controlled. 1·2–19 Mc/s. Mains or 12V d.c. operation. Complete with calibration charts. Excellent condition. £12.10.0. Carr. 30/-.

R209 MK II COMMUNICATION RECEIVER

11 valve high grade communication receiver suitable for tropical use. 1·20 Mc/s on 4 bands. AM/CW/FM operation. Incorporates precision vernier driver, BFO. Aerial trimmer, internal speaker and 12 V d.c. internal power supply. Supplied in excellent condition, fully tested and checked.

£15 Carr. 20/-.

TYPE 13A DOUBLE BEAM OSCILLOSCOPES

An excellent general purpose D/B oscilloscope. T.B. 2 c/s–750 kc/s. Bandwidth 5·5 Mc/s. Sensitivity 33 mV/CM. Operating voltage 0/110/200/250 V. a.c. Supplied in excellent working condition. £22.10.0. Carriage 30/-.

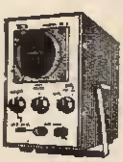
MARCONI CT44/TF956 AF ABSORPTION WATTMETER

1 μ/watt to 6 watts.

£20. Carr. 20/-.

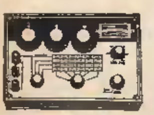
SOLARTRON CD. 71152 DOUBLE BEAM OSCILLOSCOPES. D.C. to 9 Mc/s. Perfect order. £65. Carr. 50/-.

TO-2 PORTABLE OSCILLOSCOPE



A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS–1 MHZ. Input imp. 2 meg Ω 25 P.F. Illuminated scale. 2in. tube. 115 × 180 × 330mm. Weight 8lb. 220/240 V a.c. Supplied brand new with handbook. £22.10.0. Carr. 10/-.

TRANSISTORISED L.C.R. A.C. MEASURING BRIDGE

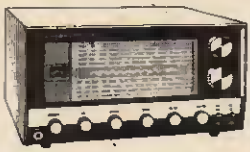


A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω–11·1 megΩ 6 Ranges ±1%. L.1 μH – 111 HENRYS 6 Ranges –2%. C. 10pF ±1110mFd. 6 Ranges ±2%. TURNS RATIO 1:1/1000–1:11100. 6 Ranges ±1%. Bridge voltage at 1,000 cps. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7¼×5×2in. £20. P. & P. 5/-.

UNR-30 4-BAND COMMUNICATION RECEIVER

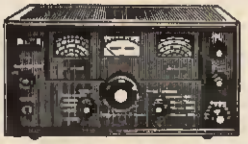
Covering 550 Kc/s–30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/240V. a.c. Supplied brand new, guaranteed with instructions. Carr. 7/6 **13 gns.**

TRIO JR-310 NEW AMATEUR BAND 10-80 METRE RECEIVER. In stock. £77.10.0.



LAFAYETTE SOLID STATE HA600 RECEIVER

5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE 150 kc/s–400 kc/s and 550 kc/s–30 Mc/s F E T front end ● 2 mechanical filters ● Huge dial ● Product detector ● Variable BFO ● Noise limiter ● S meter ● 24in Bandspread ● 230V a.c./12V d.c. neg. earth operation ● RF gain control. Size 15in × 9½in × 8¼in. Weight 18lb. EXCEPTIONAL VALUE. £45. Carr. 10/-. S.A.E. for full details.



TRIO COMMUNICATION RECEIVER MODEL 9R-59DE

4 band receiver covering 550Kc/s to 30Mc/s. continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. bandspread dial ● IF 455Kc/s ● Audio output 1·5W. ● Variable RF and AF gain controls. 115/250V A.C. Mains. Beautifully designed. Size: 7 × 15 × 10in. With instruction manual and service data. £42 Carriage paid.

TRIO COMMUNICATION TYPE HEADPHONES Normally £5.19.6. OUR PRICE £3.15.0 if purchased with above receiver.

TRIO JR-500SE 10-80 Metre AMATEUR RECEIVER £65	TRIO TS 510 AMATEUR TRANSCEIVER with speaker and mains P.S.U. £180

VARIABLE TRANSFORMERS

Input 230V a.c. 50/60Hz. Output variable 0–260V.

BENCH MOUNTING

1 amp, £5.10.0; 2½ amp, £6.15.0; 5 amp £9.15.0; 8 amp, £14.10.0; 10 amp, £18.10.0; 20 amp, £37.0.0.

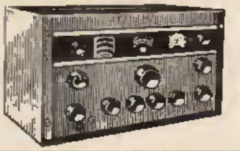
PANEL MOUNTING

1 amp, £5.10.0; 2½ amp, £6.12.6.

B.C. 221 FREQUENCY METERS

latest release 125kHz to 20MHz. Excellent condition. Fully tested and checked and complete with calibrator charts. £27.10.0. each, Carr. 10/-.

LAFAYETTE HA.800 6-BAND AMATEUR RECEIVER. £57.10.0. Carr. Paid.



RCA COMMUNICATION RECEIVER AR88D

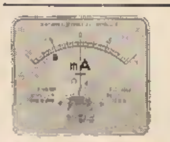
Latest release by ministry BRAND NEW in original cases. 110–250V a.c. operation. Frequency in 6 Bands. 535Kc/s–32Mc/s continuous. Output impedance 2·5–600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price £85. Carr. £2.

LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER

A completely new transistorised receiver covering 152–174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75Ω aerial input. Headphone jack. Operation 230V. A.C./12V. D.C. Neg. earth. £37.10.0. Carr. 10/-.

TELETON MODEL CR 10T AM/FM STEREO TUNER AMPLIFIER

A new model from Teleton. 31 solid state devices. 4 + 4 watt output. Inputs for ceramic/crystal cartridge. Frequency range AM 540-1600 KHz FM 88-108 MHz. Automatic FM stereo reception. Stereo indicator. Controls: Tuning, function selector, Tone and R & L volume controls. AFC switch. Stereo headphone socket. Size: 13½" × 3½" × 9¾" approx. Price £34. Carr. 7/6.



CLEAR PLASTIC PANEL METERS

First grade quality Moving Coil panel meters. Type MR 38P. 1 21/32in square fronts.

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	1mA 27/6	100mA 27/6	300V. D.C.....27/6
	1-0-1mA 27/6	150mA 27/6	500V. D.C.....27/6
	2mA 27/6	200mA 27/6	750V. D.C.....27/6
	5mA 27/6	300mA 27/6	15V. A.C......27/6
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50μA 40/-	750mA 27/6	3V. D.C.......27/6	150V. A.C.....27/6
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100μA 37/6	2 amp 27/6	15V. D.C......27/6	500V. A.C.....27/6
100-0-100μA......35/-	5 amp 27/6	20V. D.C......27/6	S meter 1mA. 32/-
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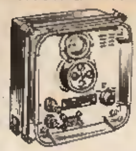
Full range of other sizes in stock. Send s.a.e. for leaflet.

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range ex-stock. Single hole fixing, ¼in. dia. shafts. Bulk quantities available.

25 WATT. 10/25/50/100/250/500/1,000/1,500/2,500 or 5,000 ohms, 14/6. P. & P. 1/6.
50 WATT. 10/25/50/100/250/500/1,000/2,500 or 5,000 ohms, 21/-. P. & P. 1/6.
100 WATT. 1/5/10/25/50/100/250/500/1,000 or 2,500 ohms, 27/6. P. & P. 1/6.

CRYSTAL CALIBRATORS No. 10



Small portable crystal controlled wavemeter. Size 7" × 7½" × 4". Frequency range 500 Kc/s. 10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. 89/6. Carr. 7/6.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: ·01 / ·003 / ·1 / ·3 / 1 / 3 / 10 / 30 / 100 / 300V. R.M.S. 4c/s.-1·2Mc/s. Decibels −40 to +50dB. Supplied brand new complete with leads and instructions. Operation 230V a.c. £17.10.0. Carr. 5/-.

LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

Frequency 0·20 Kc/s on 2 ranges. Output 500Ω or 5kΩ. Operation 200/250V. A.C. Supplied in perfect order. £12.10.0. Carr. 10/-.

TE-65 VALVE VOLTMETER

High quality instrument with 28 ranges. D.c. volts 1·5–1,500V. A.c. volts 1·5–1,500V. Resistance up to 1,000 megohms. 220/240V a.c. operation. Complete with probe and instructions. £17.10.0. P. & P. 6/-. Additional Probes available: R.F. 42/6. H.V. 50/-.

COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

D.c. coupled. Band width 1kc/s. Perfect order. £25. Carr. 30/-.

AM/FM SIGNAL GENERATORS

Oscillator Test No. 2. A high quality precision instrument made for the ministry by Airmec. Frequency coverage 20–80Mc/s. AM C.W./FM. Incorporates precision dial, level meter, precision attenuator 1μV-100mV. Operation from 12V d.c. or 0/110/200/250V a.c. Size 12 × 8½ × 9in. Supplied in brand new condition complete with all connectors fully tested. £45. Carr. 20/-.

RUSSIAN C1-16 DOUBLE BEAM OSCILLOSCOPES

5MHz Pass Band. Separate Y1, Y2 amplifiers. Calibrated triggered sweep from 0·2μsec to 100msec/cm. Supplied complete with all accessories and instructions. £87. Carr. paid.

EDDYSTONE VHF RECEIVERS MODEL 770R. 19–165 Mc/s. Excellent condition. £150

TE-10A Transistorised Signal Generator. 5 ranges 400 kHz-30 mHz. An inexpensive instrument for the handyman. Operates on 9v battery. Wide, easy to read scale. 800 kHz modulation. 5¼ × 5¾ × 3⅛. Complete with instructions and leads. £7.19.6. P.&P. 4/-.

HOSIDEN DH-02S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable headband. 8 ohm impedance. 20–12,000 cps. Complete with lead and stereo jack plug. ONLY 47/6. P.&P. 2/6.

AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded.

150 W. £2.2.6. P. & P. 3/6
300 W. £3.5.0. P. & P. 4/6
500 W. £4.10.0. P. & P. 6/6
1,000 W. £6.10.0. P. & P. 7/6
1,500 W. £7.19.6. P. & P. 8/6
7,500 W. £15.10.0. P. & P. 20/-

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Complete Stereo System £41

WITH VISCOUNT F.E.T. FIELD EFFECT TRANSISTORS AMPLIFIER

This superb stereo system is a real price breakthrough. It comprises the VISCOUNT F.E.T. Mk. I amplifier on which full details are given below, the famous Garrard SP25 Mk. II (including teak veneer base and transparent cover) with diamond cartridge or 2025 TC and the very successful DUO type 2 speakers.

Measuring 17½in × 10¾in × 6¾in, the Duo type 2 speakers are beautifully finished in teak veneer with matching vynair grills. They incorporate a 10¼in × 6¼in drive unit and high frequency speaker, both of which are of 3 ohms. impedance. The Duo speaker system is also available separately at

£6.6.0 each plus 15/- P. & P.

Complete stereo system **£41** plus £2.10.0 P. & P.

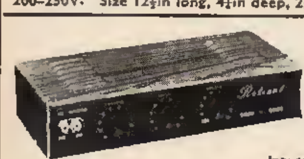
The Classic

Teak finished case

£9.10

Plus P. & P. 7/6

SPECIFICATION: Sensitivities for 10 watt output at 1KHz into 3 ohms. Tape Head: 3mV (at 3¾ i.p.s.) Mag. P.U.: 2 mV. Cer.P.U.: 80mV. Tuner: 100mV. Aux. 100mV. Tape/Rec. Output. Equalisation for each input is correct to within +2dB (R.I.A.A.) from 20Hz to 20KHz. *Tone Control Range: Bass:* 13dB at 60Hz. *Treble:* ±14dB at 15KHz. *Total Distortion:* (for 10 watt output) <1·5%. Signal Noise: <−60dB. A.C. Mains 200–250V. Size 12½in long, 4¼in deep, 2¾in high. **Built and tested.**



THE RELIANT Mk. II

SOLID STATE GENERAL PURPOSE AMPLIFIER

£7.5.0 Plus P. & P. 7/6

In teak finished case

SPECIFICATION: *Output:* 10 watts into a 3 ohms speaker. *Inputs:* (1) for mike (10mV). Input (2) for gram. radio (250mV) individual bass and treble control. *Transistors:* 4 silicon and three germanium. *Mains input:* 220/250 volts. *Size:* 10¼ × 4¾ × 2½in. Mk. I £6.10.0 plus 7/6 P. & P. Less teak finished case.

ELEGANT SEVEN Mk. III (350mW Output)

7-transistor fully tunable M.W.-L.W. Superhet portable. Set of parts. Complete with all components, including ready etched and drilled printed circuit board—back printed for foolproof construction. **MAINS POWER PACK KIT: 9/6 extra.**

£5.5.0 Plus P. & P. 7/6. Circuit 2/6. Free with parts.

THE DORSET (600mW Output)

7-transistor fully tunable M.W.-L.W. Superhet portable with baby alarm facility. Set of parts. The latest modulated and pre-alignment techniques makes this simple to build. Sizes: 12 × 8 × 3in.
MAINS POWER PACK KIT: 9/6 extra.

£5.5.0 Plus P. & P. 7/6. Circuit 2/6. Free with parts.

The Viscount F.E.T. Mk. I £14.5.0 Plus 7/6 P. & P.

High fidelity transistor stereo amplifier employing field effect transistors. With this feature and accompanying guaranteed specifications below, the Viscount F.E.T. vastly surpasses amplifiers costing far more.

SPECIFICATION

Output per channel—10W rms.
Frequency bandwidth 20Hz to 20kHz ±1dB @ 1W.
Total distortion @ 1kHz @ 9W 0·5%.
Input sensitivities—CER. P.U. 100mV into 3 MΩ; Tuner 100mV into 100KΩ; Tape 100mV into 100kΩ.
Overload Factor—Better than 26dB.
Signal to noise ratio—70dB on all inputs (with vol. max).

Controls—6 position selector switch (3 pos. stereo and 3 pos. mono), separate vol. controls for left and right channels. Bass ±14dB @ 60Hz; Treble (with D.P.S. on/off) ±12dB @ 10kHz.
Tape recording output sockets on each channel.
Size 12½in × 6in × 2¾in in teak-finished case. Built and tested.

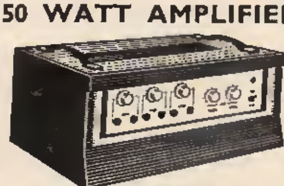
Mk. II (MAG. P.U.) £15.15.0

Specification same as Mk. I, but with the following inputs: Mag. P.U. CER. P.U. Tuner.

Post & packing 10/- extra.

Spec. on Mag. P.U. 3mV @ 1kHz input impedance 47kΩ. Fully equalised to within ±1dB RIAA. Signal to noise ratio—65dB (vol. max.).

50 WATT AMPLIFIER A.C. Mains 200-250V



Price £28.10.0

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VOL. 6 No. 8
August 1970

PRACTICAL ELECTRONICS

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FINE ART

INDUSTRIAL Art has become a recognised subject for comment and serious study. But surprisingly, electronic engineering is not given the amount of attention it would seem to deserve. At first, it may seem a trifle absurd to consider electronic hardware in terms of art. Yet there is a beauty of form and colour in many a humble mass produced component, and intricate patterns pleasing and attractive to the eye are composed by electronic assemblages making up severely functional equipment. No matter how practical and down-to-earth we may be, there is no reason why we should be blind to this aesthetical quality.

But this incidental, or accidental, art of the component manufacturer and the wireman is concealed from lay eyes by sombre metallic shrouds or wooden caskets which have for long been deemed the right and proper housing for much electronic equipment. For the general user, the outward sign of electronics is limited to the appendages mounted on a control panel. Notwithstanding the good styling of these adjuncts, and the obvious thought which is bestowed upon their arrangement, such items are not representative of the true "electronic art" which exists within.

Look again at those delicate nerve-like systems traced by multi-coloured leads of a cableform; at the variety of maze patterns provided by printed circuit boards; and at the mosaics built up from resistors and capacitors variegated not only in hue and shape but in their disposition, and those tiny semiconductor devices whose jewel-like resemblance is often most striking.

Here one would have thought is wealth indeed for artist and sculptor alike to contemplate and adopt for their particular purposes—with tremendous effect. In contrast, how pitiful are certain works of art that some of our artistic contemporaries have presented to the public gaze as representative of, or inspired by, electronic technology!

The moral would seem to be this. If electronics is to have an influence in the world of art commensurate with its great impact in strictly practical matters, it must reveal more to the public eye. Maybe some drastic rethinking by industrial designers and engineers is overdue. Why not make certain domestic equipments living works of art by using transparent cases; or even encapsulating complete assemblies in blocks of transparent resin. And why not think in terms of less conventional shapes for the complete equipment. Flexible printed circuits and wiring boards could free designers from the limitations of the commonplace rectangular box; would not spherical forms be more appropriate for the space age?

F.E.B.

THIS MONTH

Our September issue will be published on Friday, August 14

Editorial and advertisement offices: Fleetway House, Farringdon St., London, E.C.4. Phone 01-236 8080

ANEMOMETER

By J.S.HAGGIS

FOR anyone interested in meteorology, sailing, or just wind speed, the cost of an anemometer is rather high. When the author's son became interested in meteorology, an anemometer was required, so one was constructed using readily available components.

Many commercial remote anemometers work on the a.c. generator principle, that is the faster the generator armature is rotated by the wind force on the anemometer cups, the greater the voltage produced. This has the disadvantage of not giving a linear output, with the consequent difficulty of meter scale production. It also requires about a 5 m.p.h. wind to overcome the resistance of the magnetic poles of the generator before the cups will start to rotate.

With the anemometer described, wind speeds of less than 5 m.p.h. can also be measured, and the scale is linear. The design is suitable for use on sailing yachts, and details are given on how to run the unit from the boat's power supply.

If three anemometer cups are arranged to rotate freely in the wind, and a disc with a number of holes around the periphery is fixed to a shaft being driven by the cups, the holes can be counted as they revolve with the aid of a light source and a phototransistor. This count can then be made to register on a meter.

CIRCUIT DESCRIPTION

When the holes in the rotating disc pass over the phototransistor, light is allowed to fall on the phototransistor (TR1) from the light source, producing a pulse at the collector of TR1 as indicated in Fig. 1, the circuit diagram of the anemometer. The pulse is squared off by transistors TR2 and TR3 which form a Schmitt trigger. The pulse is then differentiated by C2 and R8 to trigger transistors TR4 and TR5 which constitute a monostable. It is arranged by the selection of C2, that the monostable is in its unstable state for 3 milliseconds. This timing is such that at a wind speed of 100 m.p.h. (higher than one hopes to experience) the monostable has time to return to its stable state before the next pulse.

The time of 3 milliseconds is selected to correspond to the disc and hole size described in this article, and any increase or decrease in disc or hole size will have to be compensated for. Meter M1 integrates the 3 millisecond pulses which vary in frequency, but are all of the same duration.

At wind speeds of less than 5 m.p.h. the pulses are detectable on the meter as fluctuation of the needle. The fluctuation can be reduced by fitting a 100µF capacitor (C3) across meter M1; this does not completely eliminate the pulsing, so at very low speeds one can check that the system is not missing pulses by observing a regular flick on the meter.

CIRCUIT POWER SUPPLY

It is essential for consistent reliability to have a good stabilised power supply. The mains power supply in Fig. 2, is stabilised with the aid of the Zener diode D7. It incorporates a series resistor which provides overload protection. When the anemometer is to be used from a 12 volt or 24 volt battery the supply for lamp and circuitry can be as shown in Figs. 3 and 4; all resistors used in these two circuits are wirewound types.

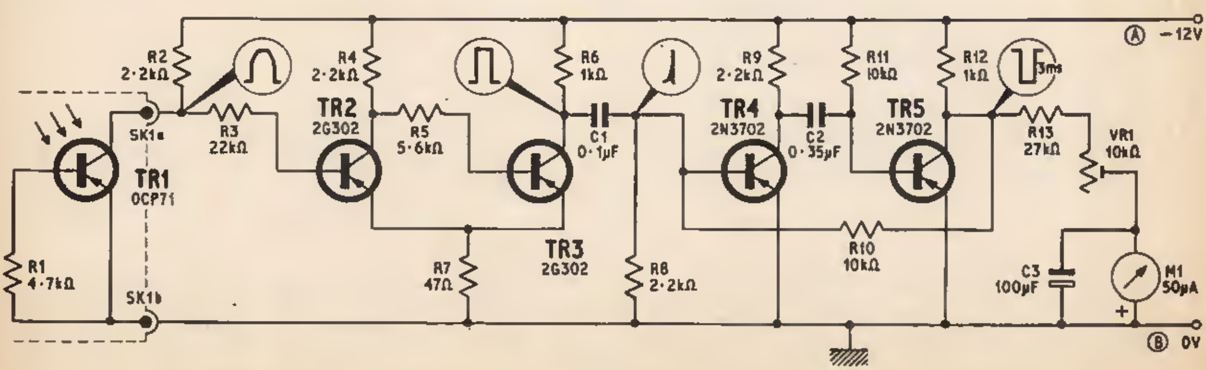
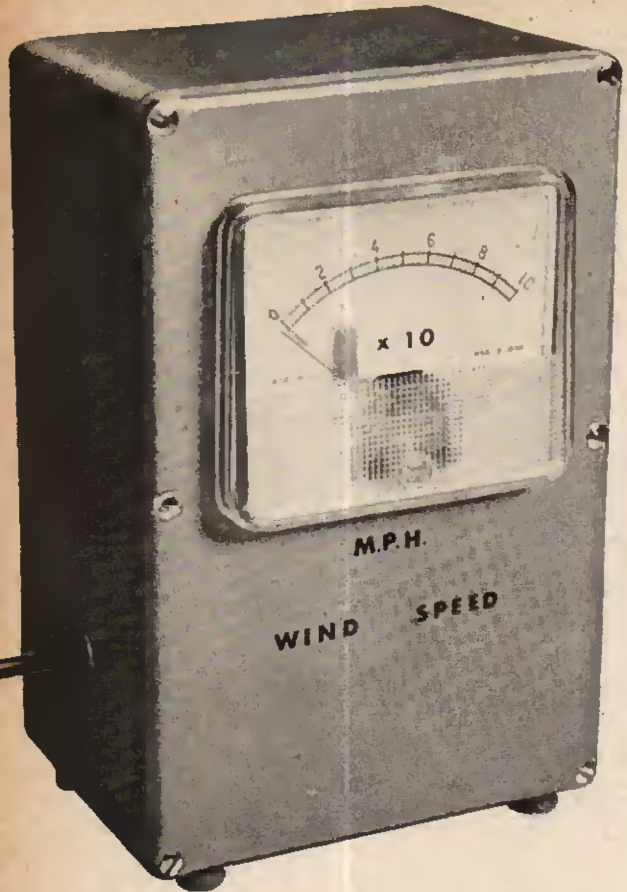


Fig. 1. Circuit diagram of the basic anemometer



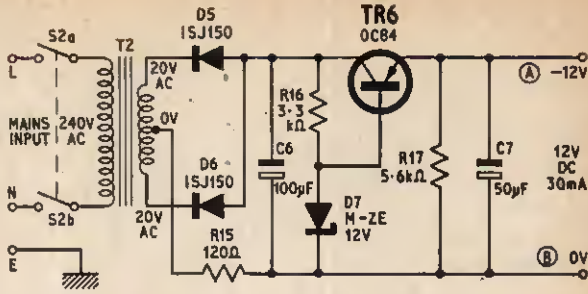


Fig. 2. *Mains power supply circuit for the anemometer circuit*

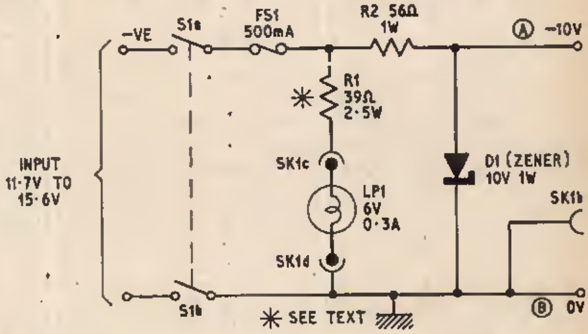


Fig. 3. *Power supply to operate the anemometer circuit and lamp from a 12V battery*

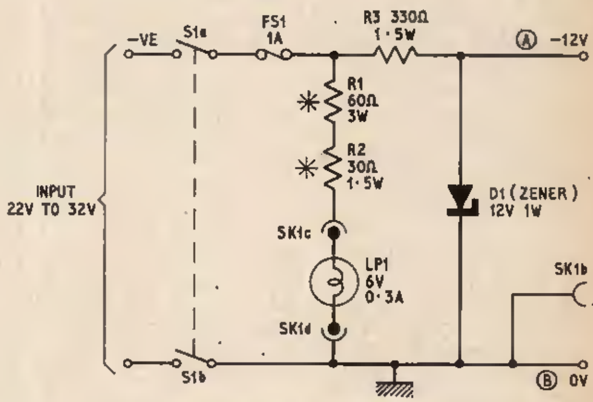


Fig. 4. *Power supply to operate the anemometer circuit and lamp from a 24V battery*

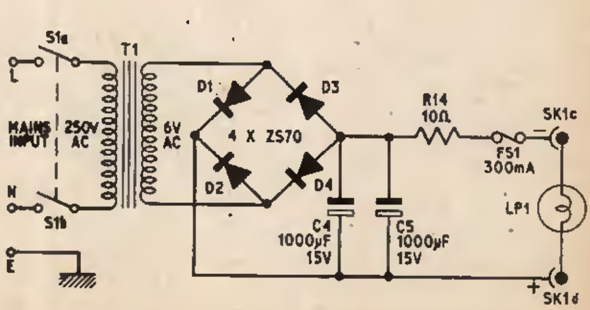


Fig. 5. *Mains power supply circuit for the lamp*

As can be seen from Fig. 3 the supply circuit for a 12 volt battery only provides 10 volts d.c. to the anemometer circuit. This is so that stabilisation of the 12 volt input can be effected by R2 and D1, the lower voltage will not affect circuit operation providing that the instrument is calibrated at the lower voltage, and not used at a higher voltage afterwards.

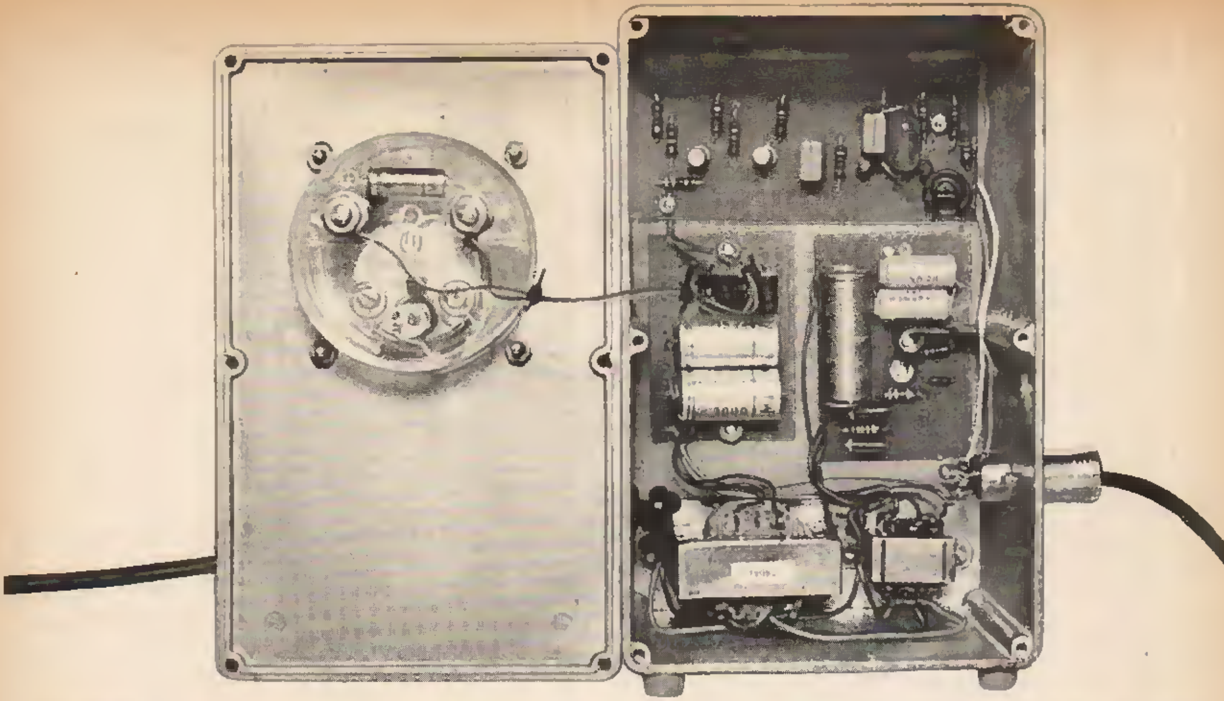
LAMP POWER SUPPLY

A 6·5 volt 0·3 amp bulb is used to illuminate TR1; the voltage on the bulb should be kept as low as possible to increase bulb life. A mains operated circuit for the bulb supply is given in Fig. 5. A good d.c. supply must be used or the anemometer will be unreliable in operation.

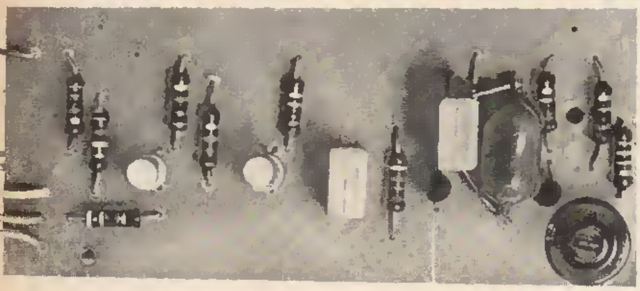
The value of R1 Fig. 3, or R1 and R2 Fig. 4, or R14 Fig. 5, depends on the length of wire used to carry the supply to the anemometer; in most cases this will be many yards, therefore an appreciable volt drop can be expected. Bearing in mind the need to keep the bulb voltage as low as possible, the appropriate resistor may have to be slightly adjusted in value, as explained later.

CIRCUIT CONSTRUCTION

The circuit is assembled on a printed circuit board, details of which are given in Fig. 6. Layout is not critical, but that detailed has proved successful. If the



ANEMOMETER CIRCUIT WIRING



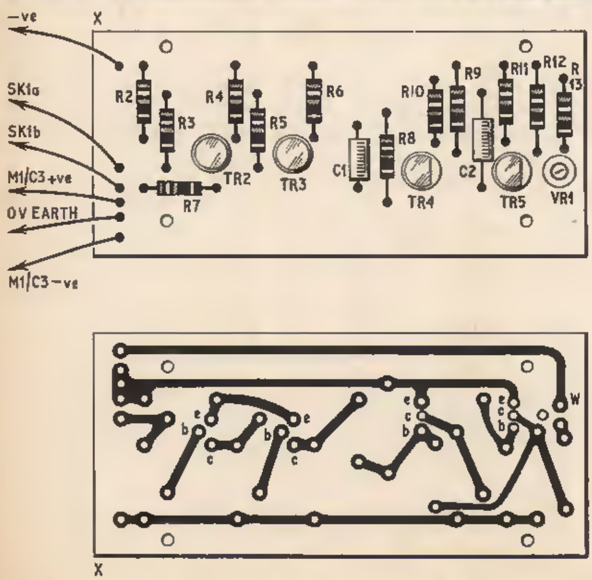


Fig. 6. Layout of the anemometer circuit on a printed circuit board

COMPONENTS . . .

Resistors

R1 4·7kΩ
R2 2·2kΩ
R3 22kΩ
R4 2·2kΩ
R5 5·6kΩ
R6 1kΩ
R7 47Ω
R8 2·2kΩ
R9 2·2kΩ
R10 10kΩ
R11 10kΩ
R12 1kΩ
R13 27kΩ
All $\frac{1}{4}$W, 10% carbon

Capacitors

C1 0·1μF polyester
C2 0·35μF polyester (0·1μF and 0·25μF in parallel)
C3 100μF elect. 12V

Transistors

TR1 OCP71 (phototransistor)
TR2 2G302
TR3 2G302
TR4 2N3702
TR5 2N3702

Miscellaneous

VR1 10kΩ skeleton preset potentiometer
M1 50μA moving coil meter
SK1 Miniature sealed four pin plug and socket
Copper clad s.r.b.p. board $4\frac{1}{2}$in $\times$ 2in

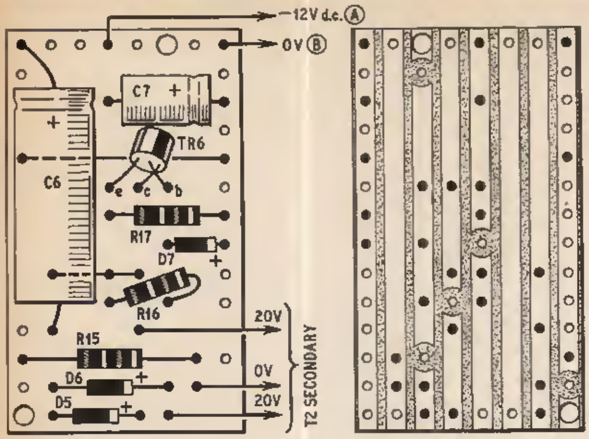


Fig. 7. Layout of the mains power supply for the anemometer circuit using Veroboard

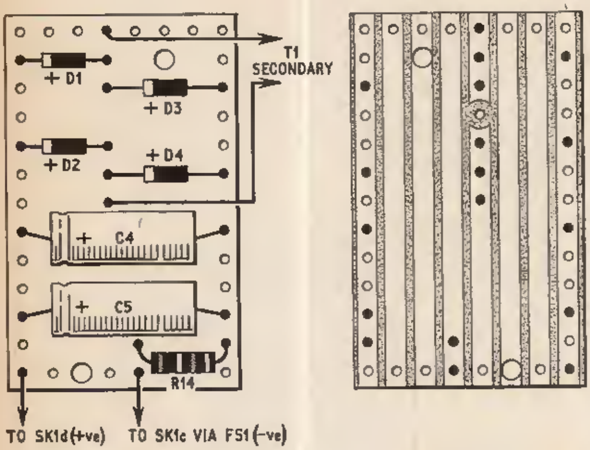


Fig. 8. Layout of the mains power supply for the lamp using Veroboard

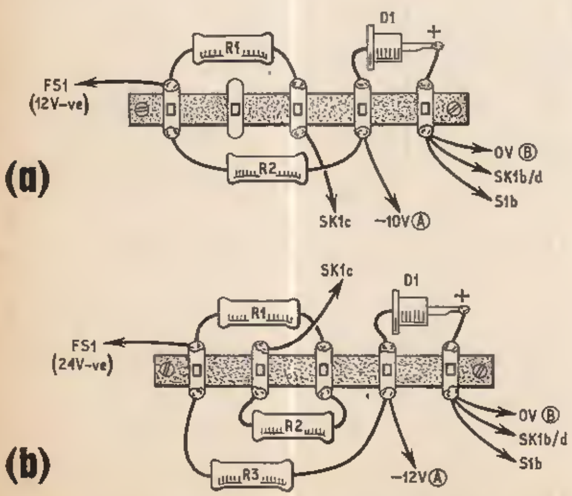


Fig. 9. Layout of the battery supplies using a five-way tagstrip (a) for a 12V battery, (b) for a 24V battery

COMPONENTS . . .

MAINS CIRCUIT SUPPLY

Resistors
R15 120Ω
R16 3·3kΩ
R17 5·6kΩ
All $\frac{1}{4}$W, 10% carbon

Capacitors
C6 100μF elect. 50V
C7 50μF elect. 25V

Semiconductors
TR6 OC84
D5, 6 ZS70 *or* SX641 *or* DD003 *or* ISJ150 (2 off)
D7 12V 250mW 5% Zener type M-ZE12 (Radiospares) or Z12

Miscellaneous
T2 Miniature mains transformer 220/240V primary 20V–0V–20V secondary (Radiospares)
S2 D.P.S.T. toggle switch
Veroboard 2in × 1$\frac{1}{4}$in, 0·15in matrix

COMPONENTS . . .

MAINS LAMP SUPPLY

Resistor
R14 10Ω (see text)

Capacitors
C4 1,000μF elect. 15V
C5 1,000μF elect. 15V

Diodes
D1–4 ZS70 *or* DD003 (4 off)

Transformer
T1 Miniature mains transformer 220/240V primary 6V, 300mA secondary

Miscellaneous
FS1 300mA fuse and holder
S1 D.P.S.T. toggle switch
LP1 6·3V, 0·3A m.e.s. bulb
Clip on m.e.s. bulb holder (Radiospares)
Veroboard 2in × 1$\frac{1}{4}$in, 0·15in matrix

constructor is not able to etch the component board, then Cir-kit copper strip can easily be made to follow the layout given.

Layout and wiring diagrams for the circuit and bulb supplies are given in Figs. 7, 8 and 9. The two layouts shown in Fig. 9 use tag strips because some of the components may warm up when the unit is in use. It is not normally necessary to provide a heat sink for the Zener diode as this diode will only pass current near to its maximum capability when no current is taken by the anemometer circuitry, and when battery voltage is at its highest.

The circuit boards, M1, and S1 can be mounted in a die cast box, the size of which will depend on the type of power supply used. If the unit is for use on a sailing boat, or will be out in the elements, both the inside and outside of the case should be painted; the lid, supply lead and SK1 should be sealed.

Meter M1 can be any 50μA type available with as large a scale as possible and is best mounted on a rubber

HEAD DETAILS

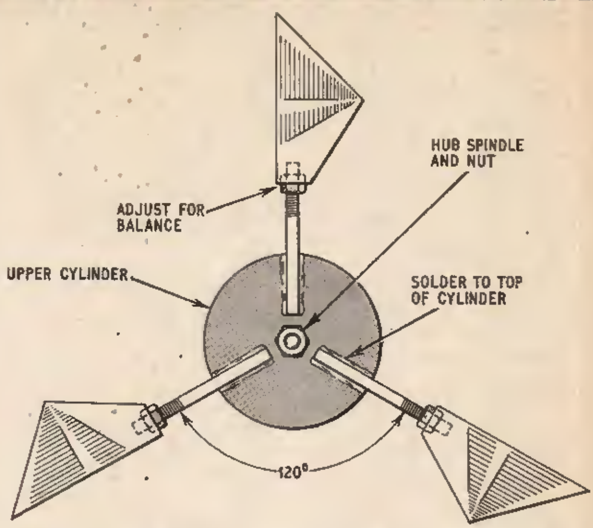


Fig. 12. Arrangement of the cups and arms on the rotating cylinder

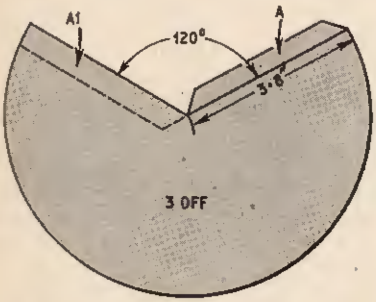


Fig. 10. Development of one cup

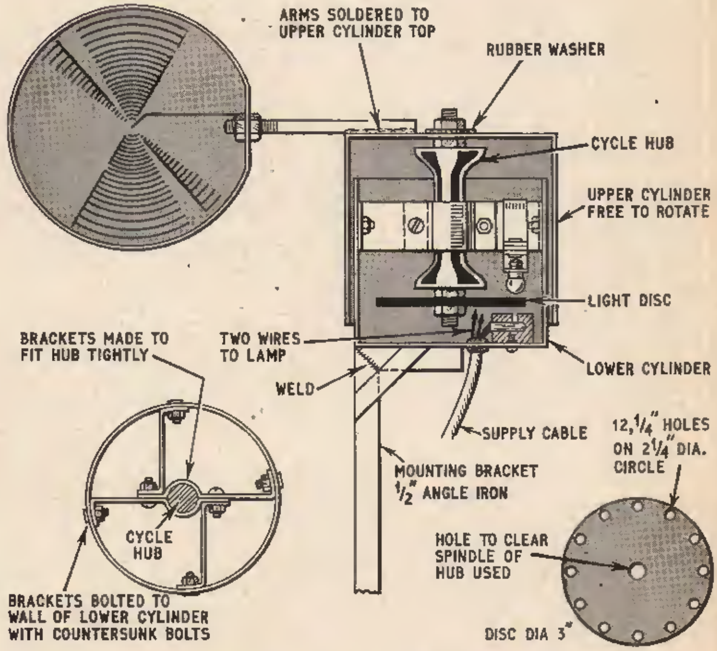


Fig. 11. Construction of the anemometer head, a four core lead out wire is needed

MATERIALS . . .

Brass plate 3½in × 3½in × $\frac{1}{16}$in (disc)
Copper sheet 20in × 20in, 20 s.w.g. (cups, cylinders and hub brackets)
Round brass rod 12in × ¼in diameter (cup arms)
Whitworth nuts ¼in 6 off (cup fixings)
Bicycle front wheel hub complete with nuts (see text)
Nylon or rubber washer to fit hub
Countersunk bolts 4B.A., ½in, 4 off (hub bracket fixings)
Round head bolts 4B.A., ½in, 3 off (hub bracket and TR1 block fixings)
Nuts 4B.A., 6 off
Angle iron 12in × ½in × ½in (mounting bracket if required)
Tuffnol 1½in × ⅜in × ⅜in (TR1 and R1 mounting)
Diecast case (see text)
Veropins 3 off (TR1 and R1 mounting)

washer. The circuit boards can be mounted on foam rubber to provide shock protection where necessary.

MECHANICAL CONSIDERATIONS

With reference to the *Handbook of Meterological Instruments*, it was found that the best arrangement is an anemometer using 3 cups of 5 inches diameter, the centre of the cups rotating 6½ inches from the axis. As will be appreciated, the aerodynamics of the cups bear some relation to the efficiency of the rotation. The cups described here are not the ultimate in design, but they can easily be constructed and are quite adequate for the job, giving reasonable accuracy to the anemometer.

Ideally, all metal work is best made from copper or brass, as there is then no trouble from corrosion, bearing in mind that the instrument will suffer the worst of the elements.

CUP CONSTRUCTION

A development of one cup is shown in Fig. 10; three of these are required to make the three cups. The copper is bent smoothly round so that tab "A" lies on "A1" where it is soldered in position.

On the edge of each cup, by the joint of tabs "A" and "A1", the shape is slightly flattened to take the arms, as shown in Fig. 11. The arms are made from ¼ inch brass rod 4 inches long, threaded at one end. The threaded end passes through a hole in the side of the cup wall near the periphery. One nut either side of the cup wall is used so that the position of the cups on the arms can be adjusted in order that the three can be balanced. It is best not to bolt the cups to the arms at this stage, but to wait until the arms have been soldered to the top of the anemometer body.

BODY CONSTRUCTION

As can be seen in Fig. 11 the body of the instrument consists of two copper cylinders, one fitting over the other. The lower cylinder is fixed, while the upper cylinder is free to be rotated by the pressure of the wind on the cups. The upper cylinder has a diameter of 4·4 inches and is 4 inches deep, while the lower cylinder has a diameter of 4 inches and is 3·6 inches deep. The construction of these two open ended cylinders is quite simple therefore no further details will be given here.

Some form of bearing is required to support the upper cylinder: the prototype unit used the hub from a bicycle front wheel. It is quite important that this hub be in good condition, for if low and reliable wind speeds are to be recorded, there must be very little mechanical friction.

The hub must be secured to the walls of the lower cylinder; this is achieved by making 4 brackets from 20 s.w.g. copper strip as illustrated in Fig. 11. The brackets must be made to fit tightly around the hub—the diameter of the clip will depend on the make of hub used. The brackets should be about 1 inch deep.

The four brackets are bolted around the centre of the hub and placed inside the lower cylinder to ensure that the hub fits precisely in the centre.

The light disc is constructed from $\frac{1}{16}$ inch brass plate as shown in Fig. 11, and is 3 inches in diameter. A hole is drilled in the centre to take the spindle of the hub. Twelve $\frac{1}{4}$ inch diameter holes are drilled around the disc, the centre of the holes being $\frac{3}{8}$ of an inch from the periphery; the holes are set 30 degrees apart. It is advisable to paint the disc with matt black paint when complete, this will stop any chance of light reflections affecting the phototransistor. The inside of both cylinders should also be painted matt black.

ASSEMBLY

The disc is bolted to one end of the hub spindle and the whole assembly, that is the hub complete with brackets and disc, is placed in the lower cylinder leaving a clearance of 0·8 inch between the disc and the bottom of the cylinder. The Tuffnol phototransistor mounting block is situated beneath the disc. No precise measurements are given for the fitting of the hub, because it depends a great deal on the type of hub used. With the hub held in the centre, and with 0·8 inch clearance between the disc and cylinder base, the 4 holes that secure the brackets to the cylinder walls can be drilled through the wall and bracket at the same time. It is necessary to countersink the cylinder holes as much as possible, this being done the brackets can be bolted to the cylinder. The heads of the countersunk bolts are then filed down to conform to the radius of the cylinder wall, to prevent them touching the inner wall of the upper cylinder. The spindle and disc should now spin freely in the lower cylinder.

The upper cylinder is completed by drilling a hole in the centre of the top to take the hub spindle. The arms are soldered in place on the top of the cylinder, they are placed at an angle of 120 degrees to each other, as shown in Fig. 12. The arms are not taken to the centre of the top, as a space is left in the centre to take the nut of the spindle.

When this has been done the cups can be fitted onto the threaded ends of the arms as shown in Figs. 11 and 12. The assembly can now be tried out in position over the lower cylinder by placing the top end of the hub spindle through the hole in the top of the upper cylinder. A nylon or rubber washer is placed over the spindle and the nut is screwed on and tightened; the nylon or rubber washer seals the spindle hole.

The upper cylinder, complete with cups, should be free to rotate over the lower cylinder without touching. Check that there is good clearance between the two all the way round and correct if necessary.

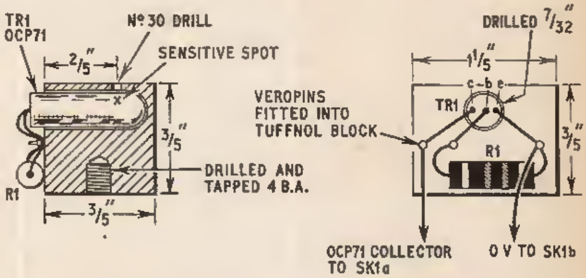


Fig. 13. Mounting block for TR1 and R1

PHOTOTRANSISTOR MOUNTING

Phototransistor TR1 is mounted on a block of Tuffnol as shown in Fig. 13. A $\frac{7}{32}$ inch hole is drilled into the side of the block, as close to the top as possible, this hole is to hold the phototransistor. A second hole is drilled at right angles to the first hole with a No. 30 drill. The two holes connect with each other as shown in Fig. 13. The second hole is to allow light from LP1 to reach the sensitive spot of phototransistor TR1.

In the block, at the rear of TR1, three small holes are drilled to take three Veropins. These pins act as connecting points for TR1 and R1. Resistor R1 is mounted close to TR1 to reduce the number of wires from the anemometer head to the remote circuitry.

A 4B.A. hole is drilled and tapped in the base of the block to secure it to the base of the lower cylinder.

Inspection of the internals of the OCP71 will reveal two junctions, one either side of a flat plate, it is the smaller of these junctions that is sensitive to light, and it is this junction that must be positioned under the small hole in the mounting block. Once TR1 is in position with the sensitive spot placed correctly, a dab of adhesive is applied to prevent the phototransistor from moving.

The bulb to supply the light is mounted in a clip on bulb holder. The clip is pushed over one of the hub brackets, as shown in Fig. 11. It should be positioned close to the disc and directly over the holes.

SETTING-UP

Before any setting up can be completed, the phototransistor block must be secured in position. To do this remove the upper cylinder from the spindle, and remove the hub and bracket from the lower cylinder. Remove the disc from the spindle, and replace the hub, less the disc, and secure. Now position the phototransistor block with its light hole immediately under the bulb and mark its position on the base of the cylinder. Remove the hub and secure the phototransistor block, complete with the phototransistor and R1, to the marked position.

The hole that secures the block to the base of the cylinder can be slightly larger than the 4B.A. bolt as this will allow the block to be finally adjusted. Now re-assemble the lower cylinder.

With the anemometer on the bench, rotate the disc until a hole is directly under the bulb so that light can fall on TR1. Connect the power supply to the anemometer circuit, ensuring the correct polarity, and connect up the bulb supply, using the same length of cable as will be required when the anemometer is installed.

Aim to apply the minimum voltage to the bulb to reliably operate the circuit. In the prototype, the component values shown in Fig. 5 were used. The circuit arrangements shown in Figs. 3, 4 and 5 apply approximately 4 volts to the bulb at the end of 40 yards of 14/0·0076 cable. The d.c. voltage supplied by the circuit of Fig. 5 has a ripple of 270 millivolts.

COLLECTOR VOLTAGE

With light falling on TR1, collector voltage must be less than minus 0·5 volts. If the collector voltage is above 0·5 volts when measured with a d.c. meter, adjust the bulb position, or the position of TR1, until the voltage is correct. In some cases it may be necessary to reposition TR1 in the mounting block. If this fails, then the bulb voltage should be increased by changing the value of R1 in Figs. 3 and 4 or R14 in Fig. 5. Once the voltage has been set rotate the disc to cut off the light, and check that the collector voltage of TR1 has increased to almost the supply voltage. When a battery supply is to be used the above procedure should be carried out at the lowest normal battery voltage.

The upper cylinder complete with cups can now be fitted and revolved. If an oscilloscope is available observe the output from TR1 collector to ensure that the circuit is not missing any pulses. If no oscilloscope is available, connect meter M1 into the circuit with C3 disconnected. Revolve the cups slowly and check that the meter registers regular pulses.

CALIBRATION

At a height of 33 feet above ground level, wind speeds will seldom exceed 70 m.p.h. in this country,

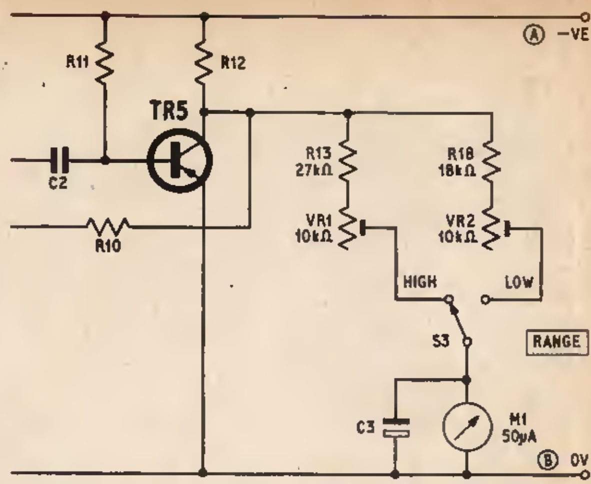


Fig. 14. Diagram of the additional range circuitry

therefore it is suggested that the maximum reading of the meter be 70 m.p.h. If it is required to operate in very exposed areas it may be necessary to have a full scale reading of 100 m.p.h., but the lower the maximum can be kept the better it will be for reading low wind speeds, unless a very large meter is used.

It is possible to add a lower scale to the anemometer by including a range switch and additional resistor and trimmer as shown in Fig. 14. If this is done both ranges will have to be calibrated as described below.

Having decided what maximum scale is required it is necessary to draw the scale on a plain meter backing card, numbering every 10 m.p.h. and marking every single m.p.h. The scale is linear.

The best way to calibrate the instrument is against the reading of an existing anemometer, but an alternative is to calibrate against a car speedometer. To do this a calm day is needed so that the only airflow is that of the cups through still air, and not against a wind adding to the required speed. Hold the anemometer as far away from the car body as possible to get away from any slipstream. With the car travelling at a steady 10 m.p.h. adjust VR1 until the meter of the anemometer reads 10 m.p.h. Then travel at greater speeds to check through the range.

POSITION OF ANEMOMETER

The wind speed near the surface of the Earth varies rapidly with height and is also greatly affected by the presence of obstacles such as trees or houses. The *Handbook of Meteorological Instruments* defines the conditions under which measurements should be made for climatological records, as over open level terrain at a height of 33 feet above ground level. "Open level terrain" is defined as an area where the distance between the anemometer and any obstruction is at least 10 times the height of the obstruction above ground level at the anemometer.

It is unlikely that all constructors will be able to fulfill these requirements, but the position should be chosen with these requirements in mind and a suitable compromise can usually be reached.

The constructor may wish to build the mechanical parts of the instrument in a different manner than that described, or with slightly different dimensions. A pair of small roller bearings can be utilised if this is found to be more convenient than the "hub" system described. ★

Practical Electronics!!

By JUDITH TERRY

I AM constantly being re-assured of the advantages of this table-top hobby. One's husband can be at home, in fact in the very same room as his wife and still pursue his hobby—no gallivanting, leaving a distraught and worried wife at home wondering where on earth he is. True—and this as far as I can see is the only advantage of this hobby, though there *are* others, I am told.

Think of all the marvellous "mod-cons" one can have! The Jones' will really have their work cut out keeping up with us. Automatic garage doors and gates which save us the tedium of getting out of the car to open them; a lawn mower which goes scampering off round the lawn on its own, while my husband sits in a deck chair occasionally glancing up from his paper to see that it is not making a bee-line for him; the automatic camera which clicks each time a little bird sits on the bird table; the automatic chicken feeder which sprays food out to the free-range chickens at regular intervals; and the washing machine which miraculously switches itself on at four in the morning, and by the time we get up, all the weekly wash is done! So what am I complaining about? You may well ask.

As yet, these and many other ideas are only on the drawing board, so to speak, and some, not even as far advanced as that, but are only ideas lurking darkly in my husband's imagination. To begin with, we have not even our own house, let alone garage, gates and lawn and certainly no chickens! However, the projects go ahead as if we had all these things and each time we move, we leave behind a landlady bewildered by what she saw of those embryonic inventions!

Consider the words "table-top hobby". Indeed this is no misnomer! Oh no! There are always little "bits" (and some not so little!) on our dining room table and were it not for the fact that my husband likes food even more than electronics, we should never clear even the smallest space for our meals.

As it is, we sit amidst a jumble of soldering irons smoking ominously, circuit diagrams and hundreds of little striped things, with fine wiry legs which I am told are very expensive. Not that that makes them any the more acceptable!

I noted with a sigh this morning, that when we leave a bewildered landlady behind this time—we will leave an irate one because there are now a dozen little drill holes in that polished table.

When we move, and it seems we are destined to be an itinerant family, all the "bits" go with us. They are carefully and lovingly packed in tin boxes and huge wooden crates.

Amongst the things we carry round with us are several old washing machine motors, which "may come in handy" (I ask you!) and a pair of the most incongruous binoculars I have ever seen! These latter are almost 2ft long and weigh about 9lb and have to be *strapped* onto one's head. If you have ever tried strapping a 2ft long, 9lb weight onto your head (as if you would!) you will know that it results in your having to gaze permanently at your feet!

The strange thing with these binoculars is that one cannot actually *see* one's feet—or anything else for that matter. I am told the reason for this is that they have infra-red lenses. My husband hopes now to use them for his "anti-crash-on-motorways-in-fog" device but initially they were bought for seeing reindeer in the dark in Lapland! Curiouser and curiouser!

When we were in Germany, my husband discovered a "wonderful" electronics shop in Dusseldorf where one could buy all manner of switches, knobs, resistors, capacitors and the like. He and some other enthusiasts all left for Dusseldorf one Saturday morning at 7 a.m.—to be there when the shop opened.

My biggest agony is to be dragged round the electronics shops up and down the Tottenham Court Road (apologies to any advertisers!) Oh I know I *could* go shopping on my own in Oxford Street, but I know too that my husband would *never* meet me at the given time or place later. In fact, I very much doubt whether I would ever see him again. ★

EMMA

ANALYTICAL ELECTRON MICROSCOPE

A GREAT deal that has been written and said about electron microscopes may tend to be glamourised by their ability to show clear pictures of minute particles beyond the scope of conventional optical instruments.

Although the same can be said about the latest instrument, developed jointly by scientists from A.E.I. and Tube Investments Research Laboratories near Cambridge, it is now possible for the operator to correlate the results precisely with information on elemental composition. This information can be obtained from a much smaller area than has been achieved before, even with separate instruments.

In the new instrument, called "EMMA-4", thin film samples can be electron-optically magnified up to 160,000 times, with a resolution of about 10Å. For the first time, they can be simultaneously probed with an electron beam focused down to about 1,000Å in diameter (about four millionths of an inch) which is over ten times smaller than is possible in the normal electron microscope.

This permits both x-ray spectrometric analysis to identify the elements present, and the production of an electron diffraction pattern characteristics of the crystal structure and orientation, from the same very small selected area.

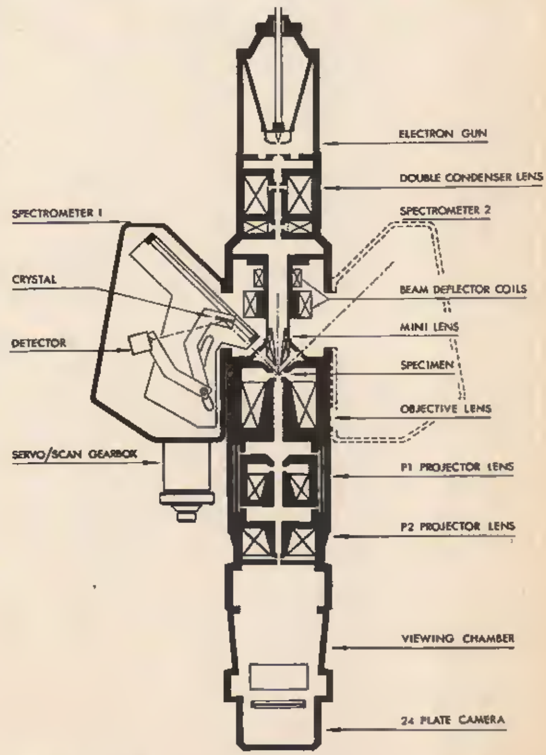
An important characteristic of any instrument designed to perform these functions is ease of operation; the operator must be able to select the facility he requires in a matter of seconds. Only then can the operation of the machine be truly problem-oriented.

It frequently arises, for example, that the classification of a field of particles into several different types requires repeated correlation between position and chemical analysis, with occasional checks on the type of crystal structure. Or again, in a tissue section, details of cell structure may be recognised only by their thin-section morphology, and the chemical analysis of any one feature must be correlated with its position within the cell.

For this reason, particular attention has been paid to the control layout; all controls are grouped on one console and the instrument can be switched very quickly from one mode of operation to another, and all necessary adjustments made from the operating position.

HISTORY AND DEVELOPMENT

The ideas which have culminated in the production of EMMA-4 arose out of earlier work, whereby the first scanning microanalyser was produced. In this instrument, a finely focused electron beam was scanned over a



Simplified section of EMMA-4. The transmission electron image is viewed on a screen at the bottom of the column. X-rays from the specimen are analysed by the crystal spectrometers. Note how the small size of the mini-lens leaves a clear exit path for X-rays from the specimen

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UNISELECTOR SWITCHES

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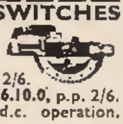

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230	6–12	2 c/o		12/6
280	6–12	2 c/o	I.B.	14/6
700	12–24	2 c/o	I.B.	12/6
700	16–24	4 c/o	I.B.	15/6
700	16–24	4M 2B	I.B.	12/6
1250	36–45	6M		12/6
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5800	80–85	4 c/o		12/6
9000	40–70	2 c/o	I.B.	10/–

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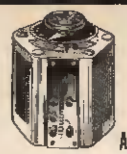

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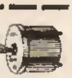

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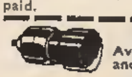

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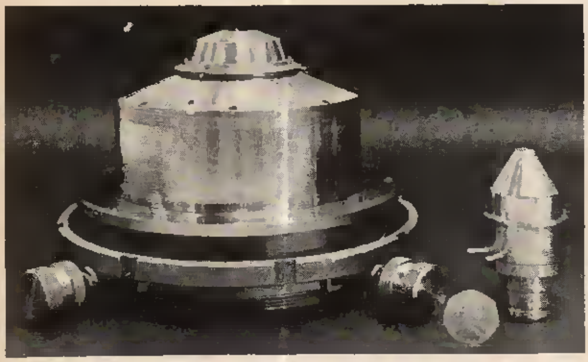
solid specimen; the x-ray emission characteristic of one element present was used to produce an enlarged cathode ray tube image representing the distribution of the selected element over a chosen area. At the same time, the electrons back-scattered from the specimen could be used to present a picture comparable to that produced by an optical microscope.

This instrument proved extremely useful in the identification of local concentrations of residual elements in steel, and of non-metallic inclusions of great significance in the seamless tubemaking process.

A limitation of all instruments dealing with solid specimens is that, due to scattering of electrons within the specimen, the smallest area which can be probed at any instant is about 1μm across. At the same time, neither the electron image, nor the optical microscope with which such instruments are fitted, enables a very high magnification to be used.

EMMA-1

These limitations were overcome by the development of a new instrument in which a thin sample could be used; for example, a metal film, a carbon film carrying particles extracted from a bulk sample, or a thin section of biological tissue. The electrons could then be focused into a probe only 1,000Å in diameter, which passes straight through the specimen without appreciable sideways scattering, exciting x-rays from a region an order of magnitude smaller in diameter than is possible with a solid specimen.



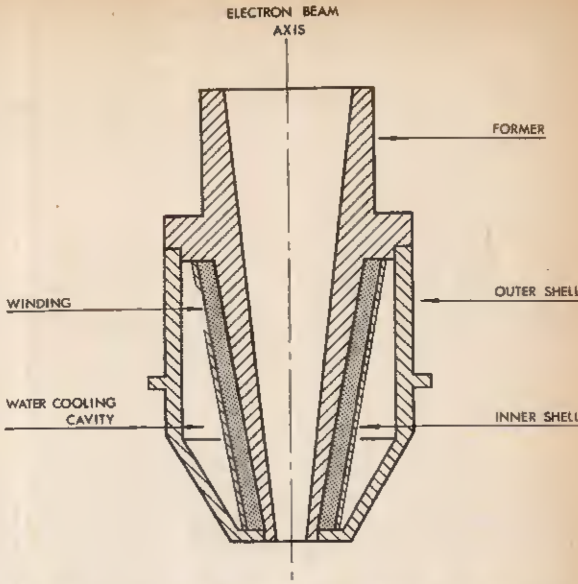
A conventional magnetic lens compared with the mini-lens. Elimination of the bulky and heavy iron core leads to a dramatic reduction in size and a great improvement in performance

Alternatively, the defocused beam could be used to illuminate a wider area of specimen. The transmitted electrons are then used to produce a magnified image on a fluorescent screen, as in a straightforward electron microscope.

This was found to be the first practical combination of electron microscope and microanalyser, and was called "EMMA-1", but was built for development of the technique itself without particular regard for convenience in use. The maximum beam energy was limited to 50keV for ease of construction.

SECOND SPECTROMETER

One early improvement was the addition of a second spectrometer, which permitted the simultaneous analysis of two elements. This was more than a time-saving addition; the ratio of the amounts present could be measured independently of any slight instability of the specimen, since small drifts affect equally the x-ray intensity from each element.



Simplified section of liquid-cooled mini-lens developed for EMMA-4. The precision winding is supported on a copper former, and there is no magnetic core of any kind. This design not only improves focusing performance but gives better access to the specimen

It soon became evident, however, that the beam energy should be increased to a level similar to that of conventional electron microscopes—say 100keV, to give adequate penetration of a wide range of sample types. The main difficulty here was that this would require heavier lenses. In particular, the probe-forming lens would be a heavy and bulky item, tending to obscure the x-ray path into the spectrometer.

MINI-LENS

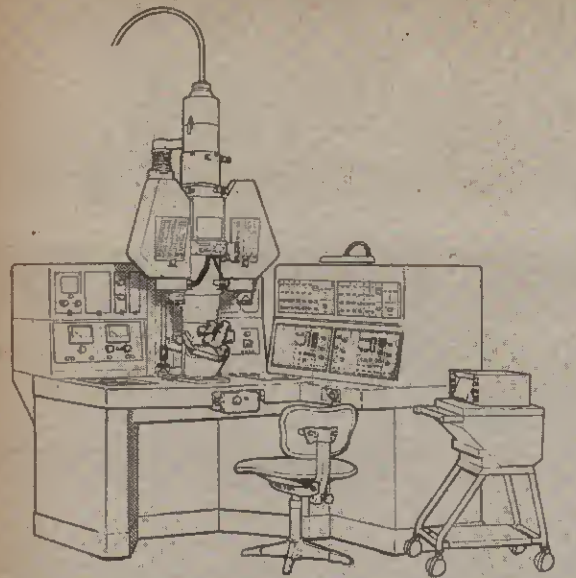
It was at about this time that the Technical University of Delft showed that, if the lens windings could be formed accurately enough, no iron shield or pole-piece would be necessary. Elimination of these heavy and bulky components itself made even smaller windings possible, the result being a spectacular reduction in overall size of the lens—the now well-known "mini-lens", in fact.

It then became apparent that the new A.E.I. EM802 microscope would provide an ideal instrument in which to mount such a lens, having adequate space in the region above the specimen for this purpose, and room on the column to attach two spectrometers.

The joint development work was started, the prime aim being to add the microanalysis system to this microscope with a minimum of modification.

A special design of mini-lens was evolved by T.I. together with a new form of high-sensitivity spectrometer, while A.E.I. concentrated on the specimen stage and other aspects of the microscope. The work was completed in under two years with the emergence of the prototype "EMMA-3".

The production version, "EMMA-4", differs from EMMA-3 only in having the instrument and control equipment fully integrated into a single operating console.



Controls are conveniently grouped on the operating console in the production EMMA-4

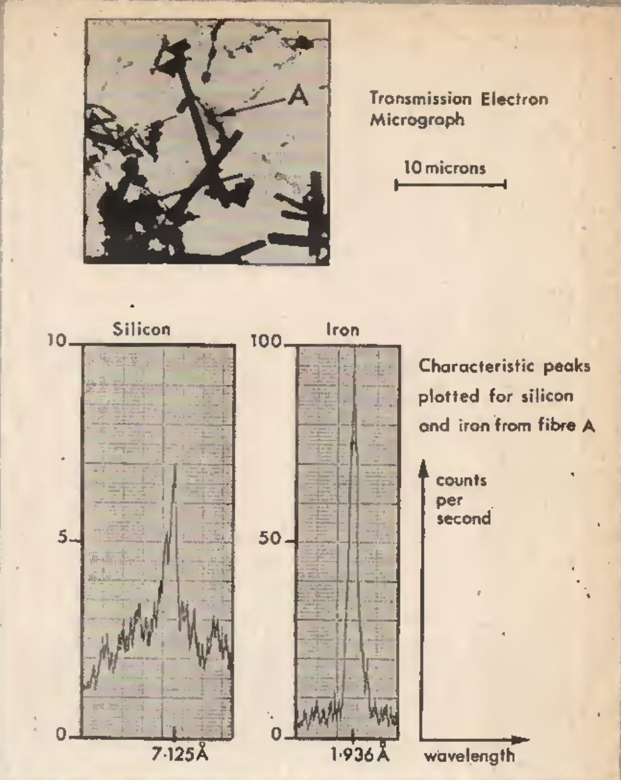


Fig. 1. Electron micrographs diffraction pattern and spectrometer plots identifying fine particles of aluminium nitride in a tube steel

EMMA-4

The microscope column of "EMMA-4" is mounted in the centre of the console, the spectrometers attached on either side. Control of the spectrometers is simplified in that each one carries a tuning scale, which is set out something like that on a radio receiver. Four wavebands are selected by different crystals and each is calibrated directly in x-ray wavelength with each station marked by element name. Tuning may be carried out either by a fine manual control for accurate wavelength determinations or by a servo system, enabling any one of six preset elements to be selected by push-button. A complete spectrum may also be plotted on a chart recorder with the aid of a slow-scan motor. The instrument can analyse for all elements from atomic number 11 (sodium) to atomic number 92 (uranium).

Six specimens up to 3mm in diameter, some of which can be calibration standards for microanalysis, may be accommodated on the specimen stage. These are directly interchangeable without breaking the vacuum but when reloading is necessary, the stage may be withdrawn from the column through an airlock.

APPLICATIONS

EMMA-4 offers unique facilities for the intensive and correlated examination of the morphology, chemical composition and crystallographic structure of extremely small specimen areas. It is expected to be useful in many fields of research where thin film examination is feasible and relevant. Obvious areas are metallurgy, where the prototype instruments have already provided valuable new information on the composition of precipitates and inclusions in steels; biology, in which it has great potential in the examination of bone and tissue sections; and generally for the analysis of particles deposited on thin substrates.

DETECTING SURFACE CRACKS ON STEEL TUBING

During the final stages in the manufacture of steel tubing, the base material is subjected to very severe mechanical working at elevated temperatures. This can result in the surface of the tubes breaking up and the incidence of such defects can be related to the aluminium content of the material.

It is, therefore, important to find where the aluminium is located and since the distribution turns out to be on a very fine scale, the electron microscope is one of the few research tools which can be usefully employed. With the facilities afforded by EMMA-4 it is possible to identify one site for aluminium as a precipitate of aluminium nitride. The aluminium content of the particles is demonstrated by x-ray microanalysis and the specific compound confirmed by electron diffraction.

Fig. 1 illustrates the results of a study of an extraction made from a tube showing surface defects. The precipitates are supported on a carbon film in the conventional manner for electron microscopy. Particle A is identified as aluminium nitride and particle B, and its surrounding neighbours, as pearlite (Fe_3C)—a normal precipitate in the material. The smaller of these particles (A) measures only 1,500Å across and is therefore well below the detection limit of the normal electron probe microanalyser (about 1 micron).

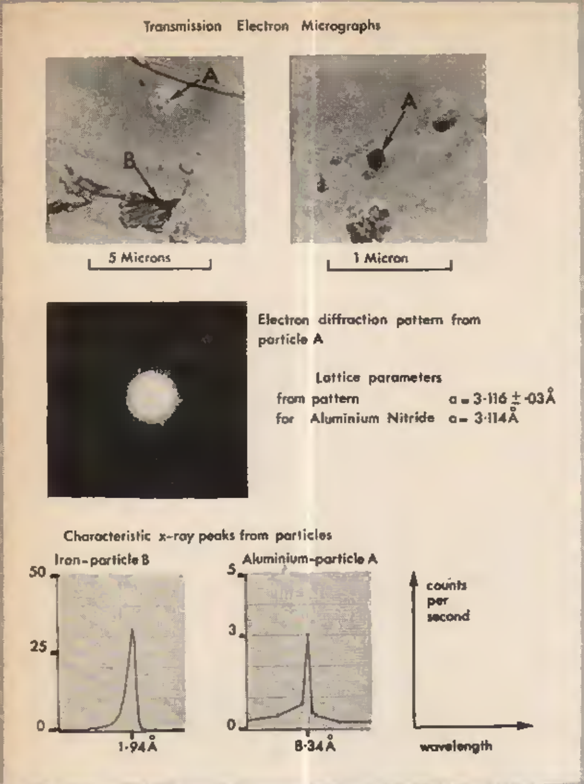


Fig. 2. Electron Micrographs and spectrometer plots showing presence of AMOSITE asbestos fibres in human lung tissue

ASBESTOSIS IN HUMAN LUNG

An example of the application of the EMMA-4 technique in medical research concerns the study of asbestos fibres extracted from human lungs.

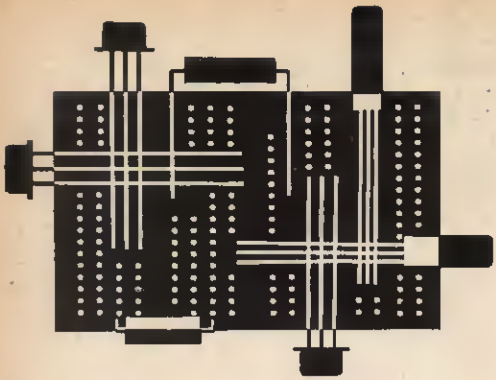
Recent work in several laboratories has demonstrated the danger of inhaling such fibres, and has shown that the ill-effects may not manifest themselves until many years after the inhalation. The problem therefore arises of establishing to which group of the asbestos materials particular extracted fibres belong, in order to be able to relate this to the lung damage and also to trace the source.

Fig. 2 illustrates the type of results obtained with the new instrument. The transmission image shows the fibres on this sample, a lung tissue section, to be as thin as about 1,000Å, often with "trains" of growth along them (top centre of the image). Surface and internal detail are also made visible.

The direct spectrometer output in the form of peaks plotted for silicon and iron (K) radiations from the fibre A is also shown in this illustration. Simply by measuring fibre composition in the form of element ratios from such peaks it is possible to identify these particular fibres as AMOSITE asbestos. Further confirmation can be obtained by electron diffraction, if required.

The essence of the problem posed by this particular specimen, i.e. the correlation of chemical, morphological and crystallographical information on a submicron scale is, of course, very general and it is for this reason that the scope for application of the new instrument is likely to be very widespread. ★

PROJECT



THE new series of practical subjects for beginners to build commences in this issue. Subsequent articles in the series will be easily identified under the "Beginners" heading in the Contents and by the symbol which will appear at the beginning of each article.

THE projects are shown built up on a "breadboard" system for four main reasons.

1. Whilst the initial cost of the systems may be high, this could be more than offset by the fact that components can be easily removed, re-positioned or used again in a more permanent construction.

2. The circuit can be assembled very quickly or expanded by adding extra functions later.

3. The actual layout of the components can follow a similar layout to that in the circuit diagram.

4. Soldering is only needed for connecting wires to large components, such as switches and potentiometers; inter-component wiring is already provided.

USING T-DEC

The "breadboard" system used is called T-Dec. It is a manufactured plastics base plate with a matrix of numbered holes. Certain combinations of interconnection are provided by spring strips underneath the holes. These are shown in Fig. 1a corresponding to the raised lines moulded on to the surface of the board itself.

T-Dec is divided into two sections which are electrically isolated, enabling two or more separate circuits to be built on to the same board. If required any part of one circuit can be connected to any part of the other circuit by using single strand copper link wires.

Some components have very thin connecting wires; these should be helped into the holes by holding the wire with a pair of long-nose pliers.

Transistor and diode wires can be inserted directly into the holes if spacing permits. It may be necessary to open up the spacing of these wires; in which case, careful bending with pliers at least $\frac{1}{8}$in from the encapsulation can do this without damaging the transistor or diode seal. Alternatively, special adaptor plugs supplied by the T-Dec manufacturers can be used to mount these components.

The component wires should be at least $\frac{3}{8}$in and preferably $\frac{5}{8}$in long to ensure satisfactory connection. Longer wires will of course, make the components more versatile in their use. It is never good practice to trim these wires short if they are to be used again.

Whole systems of breadboarding can be built by fitting two or more boards together by the dovetail tongues and grooves around the sides. Small panels for switches, potentiometers, lamps and so on are provided and are easily fitted into the slots on the edge of the boards.

HOLE IDENTIFICATION

Coming now to the numbering of holes for identification you will notice that the T-Dec has two blocks side by side with letter references A to H on both.

Fig. 1a. The T-Dec breadboard. Notice the connections between holes are shown as raised lines

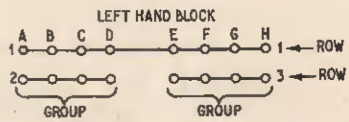


Fig. 1b. How the T-Dec holes are identified. Only the first two rows are shown here

Fig. 2a. Underside view of Veroboard showing the copper strips

BUILDING—for BEGINNERS

The numbers run in sequence for each row or group of holes in a row (see Fig. 1b). It is important not to be confused with these since, in each alternate row per block, there are two groups of four holes which are numbered separately.

In the other rows connection is already indicated between the two groups; these cannot be separated. If insufficient holes are available for a particular junction of components, a link wire can be carried to another vacant group elsewhere on the board.

ALTERNATIVE CONSTRUCTION

Some readers may prefer to use alternative construction systems, perhaps in a more permanent form. These will probably require the use of a soldering iron and, although component recovery is possible, it is not as easy as with T-Dec.

Suggestions for some construction systems are given here, using mainly some form of s.r.b.p. sheet machined or treated by proprietary manufacturers.

In order to simplify translation from T-Dec to these other forms, the same basic layout is assumed and connection code numbers correspond. If the board is too large, it can be trimmed before commencement to the size required, but the basic layout remains the same.

COPPER STRIP WIRING BOARD

Veroboard is the first of the alternative examples here because translation is very straightforward. Fig. 2a shows this board with the copper strips on the underside. To keep the same layout appearance the holes are numbered in sequence so that the top surface is that without the copper.

If the copper strips are cut to conform with the T-Dec

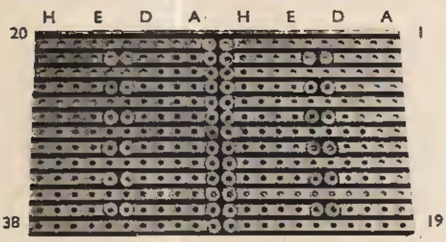


Fig. 2b. Veroboard with the strips cut to show the T-Dec wiring pattern

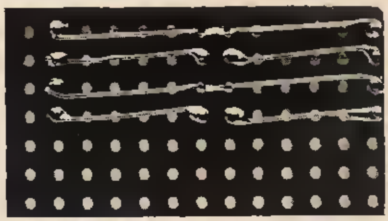


Fig. 4a. Plain perforated s.r.b.p. sheet with copper wire connections and soldering pins

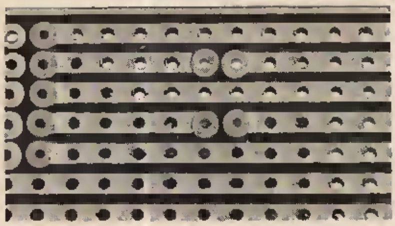


Fig. 3a. Veroboard strips prepared for the first project

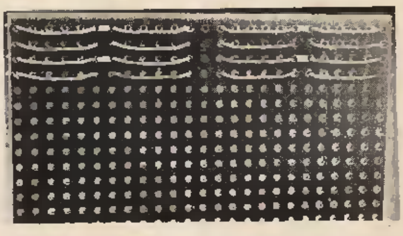


Fig. 4b. Plain s.r.b.p. with the connecting wire hooked through the end holes in the rows

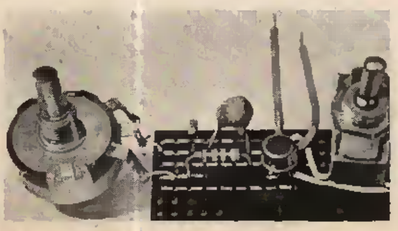


Fig. 3b. The finished metronome project

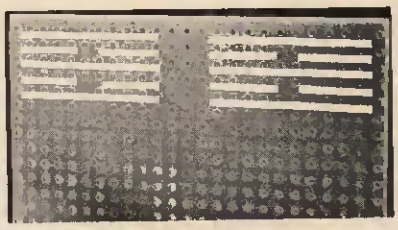


Fig. 5. Cir-kit adhesive copper strips fixed between rows of holes on plain perforated board

layout the appearance would be as shown in Fig. 2b.

The strips can be cut with a special spot-face cutter, a ⅛in drill, or a sharp knife.

Before cutting any strips, study the project circuit layout in the practical article to see how many breaks are really necessary. If only one half of the T-Dec is used none of the centre breaks will be necessary. However, if at a later stage you decide to assemble another circuit on the same board, the copper around the centre columns of holes, between column H on the left and A on the right, will need to be cut. Before doing so, check to see if any links are needed between left and right, in which case leave the appropriate strips uncut.

Next look at the project layout to see if any connections are needed between column D and column E. Having established those required cut all the other copper strips between D and E to form the groups of four holes (Fig. 3a).

Now the columns and rows of holes can be numbered exactly as for T-Dec. You can do this by laying the board on a sheet of paper and marking through each required hole in the board with a pencil. Remember that the T-Dec numbering follows that for Veroboard that has the copper side face down.

Carry out the assembly and soldering making sure that no solder bridges two or more adjacent strips. Good clean soldering is the keynote to success; dry joints will not do. Fig. 3b shows the finished project.

PERFORATED S.R.B.P. AND WIRE

The next system is simple and follows the same lines as with Veroboard, except that plain perforated board has no copper face. All connections are carried out using soldering pins and tinned copper wire; see Fig. 4a. However, do not fit wires that are unlikely to be used; this is a waste of materials and effort.

The pins can be dispensed with if the copper wire is hooked through the end holes of each row and secured with solder. An example of a typical layout is shown in Fig. 4b.

STICK ON WIRING

The third system is a development of the previous one except that the wires are replaced by self-adhesive copper strips called "Cir-kit". The method is otherwise exactly the same (Fig. 5). The narrow strip will just fit between adjacent rows of holes on plain perforated board.

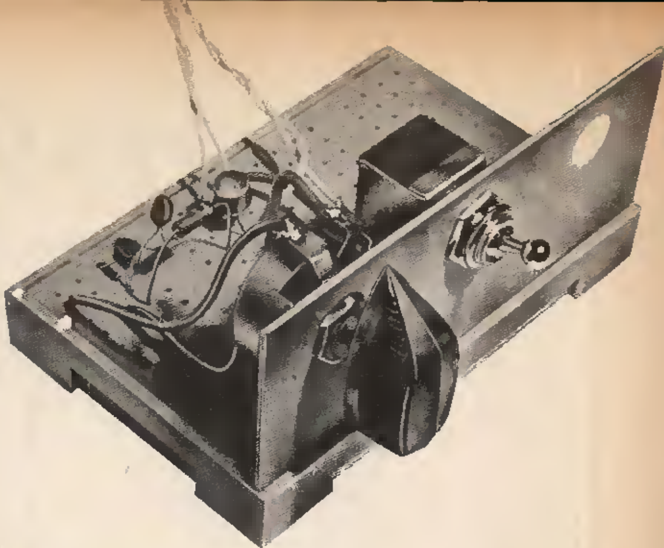
PRINTED CIRCUIT

There is no reason why printed circuit board should not be used. This will require more patience by following the instructions given with the printed circuit kit. Not all kits carry instructions, so if you are unfamiliar with printed circuit techniques try and obtain a kit that has.

It will probably be necessary to sketch out a layout of the copper pattern corresponding to the project actually being built. It is recommended that an experienced friend helps you with this as mistakes can be expensive.

This short introductory article is not intended to provide comprehensive details of using these alternative methods. Full details and instructions can be obtained from manufacturers of these and other proprietary items which are advertised in this magazine.

The project which follows can be built very easily using one of the methods described here. Future projects in the same series are to be dealt with in a similar manner.



To study a musical instrument, one of the most important requirements is strict attention to playing speed. To assist in the correct interpretation of the music's tempo the composer conveniently heads his composition with a rough guide to the rate at which it should be played like *Andante* or *Allegro*, this usually being followed by the number of crotchets, quavers, etc. that should be played per minute.

Whilst the accomplished musician has little difficulty in interpreting these tempo marks, the beginner does need some sort of aid to assist in establishing a sense of time.

More than a hundred years ago Maelzel provided such an aid in his invention of the mechanical metronome which produced loud ticks with the movement of a weighted pendulum. With the simple electronic metronome to be described, we can reproduce these ticks just as effectively without the labour of winding up springs.

RELAXATION OSCILLATOR

To simulate the sound of its mechanical counterpart the circuit of Fig. 1 was designed to produce asymmetric pulses of short width and rapid rise and fall times. The pulse generated across the loudspeaker LS1 is shown in this diagram, and it ensures a very rapid cone movement.

The frequency range extends from 40 to 220 beats per minute, which is adequate.

As this little device is very precise in its counting, it can also be used as an audible "darkroom" timer when set to 60 beats/minute.

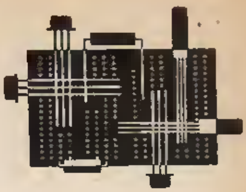
The circuit itself is a simple relaxation oscillator where two complementary *npn* and *pnp* transistors are made to switch on and off at a rate determined by the resistance chain VR1, R1 and capacitor C1. With S1 closed, C1 charges until it reaches about 650mV when TR1 is switched on and immediately discharges the capacitor.

The current pulse produced by TR1 in turn switches on TR2 with the result that almost the whole of the supply voltage is made to appear across the loudspeaker.

The actual discharge time of the capacitor depends on the base-emitter impedance of TR1, the loudspeaker impedance and the output impedance of TR2 which collectively account for the exponential hump on the output pulse waveform.

With the completion of the pulse the capacitor again charges to the conduction potential of TR1, when the pulse cycle starts again.

METRONOME



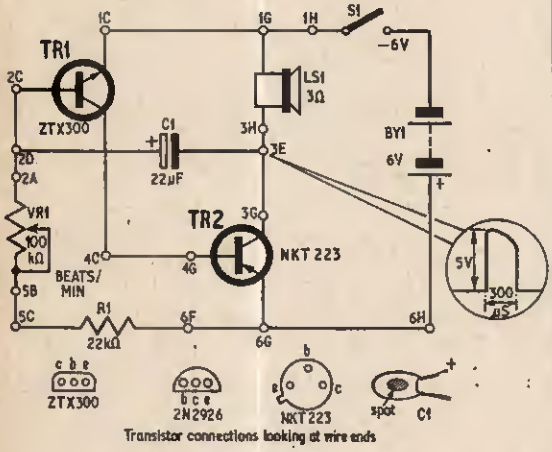


Fig. 1. Circuit diagram of the metronome showing the T-Dec hole connections, transistor wire identification and output waveform

COMPONENTS . . .

Resistors
R1 22kΩ 10% ½ watt carbon

Potentiometers
VR1 100kΩ linear carbon

Capacitor
C1 22μF tantalum elect. 16V

Transistors
TR1 ZTX300 (Ferranti) or 2N2926 orange spot
TR2 NKT223 (Newmarket) or GET102 (Mullard)

Switch
S1 on/off toggle switch

Loudspeaker
LS1 3Ω 5in permanent magnet moving coil unit

Battery
BY1 6V type 996

Miscellaneous
T-Dec.
Single strand connecting wire
Battery connectors or clips

LOW LEAKAGE

In the application of this unit timing precision is important. The simple factor most likely to give trouble in this aspect is leakage current. The choice of a silicon transistor for TR1 and a tantalum electrolytic capacitor for C1 virtually eliminates the problem.

In the choice of speaker it will be found that sound output is a function of cone diameter. In practice, a 5in speaker proved very satisfactory.

CONSTRUCTION

Construction of the unit merely involves plugging the components into the T-Dec as shown in the photograph. For the holes employed refer to Fig. 1, which shows the hole numbers for each junction.

If it is intended to make a permanent unit of this, the wiring configuration will readily translate to any of the board constructional methods outlined in the introductory article.

If such construction is undertaken the potentiometer setting must be calibrated in terms of the number of beats produced per minute. Using a wrist watch with seconds sweep or preferably, a stop watch, the potentiometer should be advanced at 20 beat intervals. These positions can be recorded on a piece of white card. A pointer knob attached to the potentiometer shaft will simplify this operation.

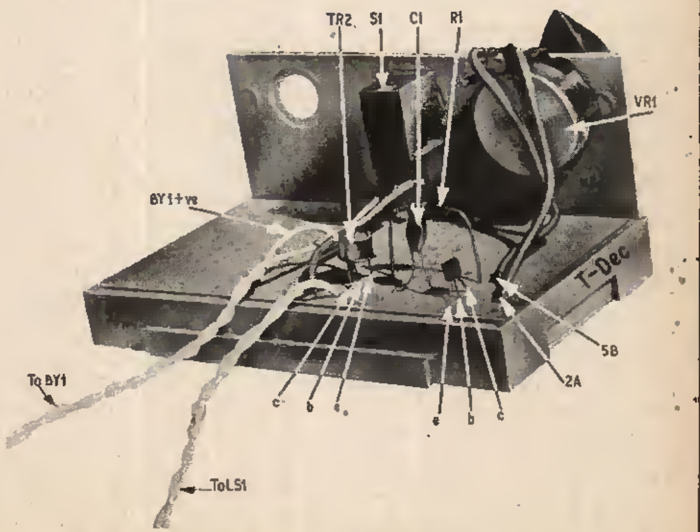


Fig. 2. The layout of components on T-Dec. Make sure the battery is correctly connected

SPACEWATCH

By Frank W. Hyde

APOLLO 13 RESULTS

The results of the special investigation into the results of the *Apollo 13* troubles have been released by the chairman of the committee, Edgar M. Cortright. The explosion was caused by the failure of two thermal switches in the system which controlled the heater inside the oxygen tank. The failure allowed the wires inside the tank to heat up to a high temperature, the insulations burned off and the spark resulting from the short circuit caused the explosion.

The cause of the failure of the switches is thought to be the detanking sequence which is part of the countdown procedure. This procedure does in fact place a much more severe strain on the system than the actual spaceflight. The reason for this is that during the checking sequence the heaters are on for a much longer period and at a higher current level than when in flight.

The necessary modifications are being carried out and at the time of writing the next launch is not likely to take place before December 3 this year.

MARINER 7 PHOTOGRAPHS PHOBOS

Mars has two satellites, Phobos and Diemos, and one of these satellites has been successfully photographed by *Mariner 7*. Both are very small and near to the planet surface, Phobos being some 3,700 miles from the surface and Diemos about 12,500 miles.

The Mariner spacecraft was about 82,000 miles from Phobos when the picture was taken. The satellite was near one of the dark areas on Mars known as Syrtis Major, and appeared as a dark spot on the lighter background of the Aeria region.

Analysis of the photograph was carried out by Dr Bradford A. Smith of New Mexico State University, and he deduced that the satellite was oval shaped with a diameter of 13·75 miles in the plane of its orbit and 11·25 miles diameter across its poles. A significant result of the analysis is that the "albedo" (the ability to reflect light) has proved to be very low, the lowest in fact of any satellite or asteroid in the solar system.

The darkness of the satellite appears to be due to its small size and dust from the surface could easily escape due to the low gravity. In fact it is so low, that should one of the suggestions that it could be used as a space station be implemented, the personnel would have to be careful not to jump with too much enthusiasm or they might go into orbit. The escape velocity is 12 metres a second.

Since the satellite is elongated it is unlikely that it came into being by accretion and it is possible that it is a captured asteroid.

GERMAN SATELLITE

The contract for the construction and systems management of *Aeros*, the second German satellite, has been awarded to the Dornier-System GmbH. *Aeros* is the successor to the recently launched *Azur* and is devoted to the study of the physical processes in the upper layers of the atmosphere. There will be five experiments, four German and one American and it is expected that it will be put into orbit in the summer of 1972, from the Vandenberg test range in California using an American *Scout* rocket.

The instruments to be carried for the German experiments are a mass spectrometer for the study of the atmosphere's chemical composition. This is done by measuring the number density of ions and neutral particles. An impedance probe will determine electron density in the ionosphere. A retarding potential analyser will measure the energy distribution of electrons and ions. An ultraviolet spectrometer will measure the flux and spectral distribution of the far ultraviolet radiation of the Sun.

The American experiment will measure the nitrogen present in the various layers of the upp-- atmosphere and the overall density of the neutral particles.

As the results of the last experiment are required for a NASA satellite due to be launched in 1973, it will be essential that the construction programme and launch date be on time. The planned orbit is a specially selected one and the satellite will be placed in a polar orbit with a perigee of 235km and an initial apogee of 1,000km. The friction of the atmosphere at these altitudes will cause the satellite to fall towards the Earth.

After 105 days the apogee will have been reduced to 580km; at this point it will be raised again by 200km using a hydrazine chemical rocket. The reason for doing this is to collect data from comparable altitudes at different times of the year.

After a period of six months at this new altitude the satellite will then enter the denser parts of the atmosphere and finally burn up. Measurements during the final phase of its life are expected to be of considerable interest.

After each measuring orbit there will be one or two idle orbits to allow the batteries time to be recharged and the stored data transmitted back to Earth. The satellite is an airtight cylinder with one flat and one conical end.

NIMBUS D SATELLITE

Nimbus D was launched from the Western test range in California by a Thorad Agena D. The butterfly shaped satellite weighs 620kg, and is in a circular near polar orbit 1,110km above the Earth and orbits in 107·3 minutes.

The British experiment was developed by GEC-Elliot for Oxford and Reading Universities and uses a very sensitive selective chopper radiometer which can detect radiation at low levels over six discrete bands. The measurements will give the first complete continuous picture of the 15 micron radiation. The temperature field in the region 25–50km above the surface and the conditions below 25km will be of considerable importance to forecasting in the future.

GEC-Elliot are now working on *Nimbus E* due to be launched in late 1972. In this satellite the number of channels will be increased to 16. The Meterological Office will check the data against Radio Sonde measurements and provide daily charts for the Northern Hemisphere with information relating to several levels.

An engineer uses a microscope to examine and find the cause of discolouration to the Surveyor 3 television camera landed on the moon in April 1967, and returned to Earth by the Apollo 12 astronauts last November.

The scientists expect the study to provide a guide in selecting materials and components for future space exploration.

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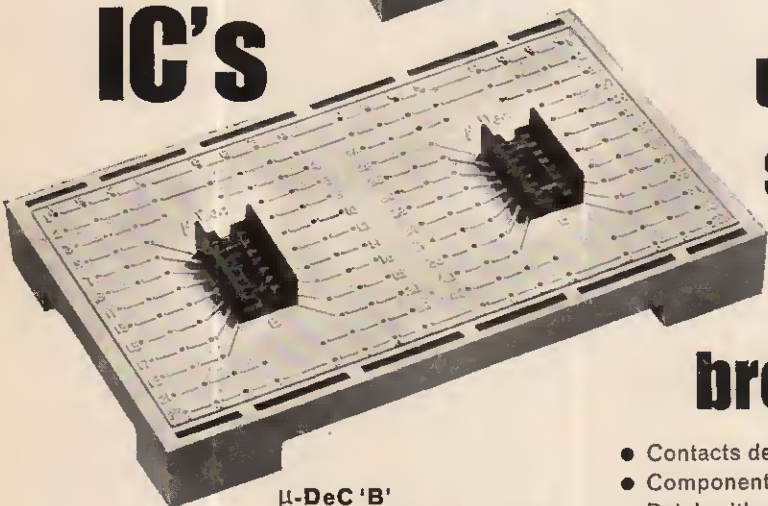

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EBF89	8/-	KT88	32/6	PY83	10/-	50C5	12/6
EB91	5/3	N37	15/6	PY88	8/3	6F23	15/6
ECC81	8/-	N339	25/6	PY500	20/-	6F24/5	12/6
ECC82/3	8/6	PC86/8	10/3	PZ30	16/-	6F26	8/3
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ECH35	13/6	PCC88	14/-	UCC85	9/3	10P14	19/-
ECH42	13/3	PCC89	12/3	UCH42	13/9	20P4	20/-
ECH81	10/3	PCC189	12/3	UCH81	10/9	30C1	10/3
ECH83	8/-	PCF80	10/3	UCL82	10/3	30C15	13/9
ECH84	9/6	PCF82	10/6	UCL83	12/3	30C17	15/9
ECLL800	20/-	PCF84	9/6	UF41/2	11/-	30C18	13/6
ECL80	8/-	PCF86	12/3	UF80/5	7/6	30F5	16/6
ECL82	9/9	PCF200/1	16/3	UF89	8/3	30FL1	12/9
ECL83	11/6	PCF801	12/3	UL41	11/6	30FL12	17/6
ECL86	9/9	PCF802	12/3	UL84	11/-	30FL14	13/6
EF39	10/6	PCF805	13/-	UM80/4	9/-	30L1	9/3
EF80	8/-	PCF806	12/3	UY41	8/-	30L15	15/3
EF83	10/-	PCF808	13/6	UY85	6/9	30L17	14/6
EF85	8/3	PCH200	11/6	U25	15/-	30P12	15/6
EF86	13/3	PCL82	10/3	U26	15/-	30PL1	12/9
EF89	8/-	PCL83	12/3	U191	14/6	30P4MR	20/-
EF91	8/6	PCL84	10/3	U193	8/3	30P19	12/9
EF92	10/-	PCL85	10/6	U301	17/-	30PL13	18/6
EF93	9/6	PCL86	10/3	W729	11/-	30PL14	18/6
EF94	15/6	PD500	30/6	Z759	24/6	30PL15	18/6
EF95	12/6	PFL200	14/9	5Y3	8/6		
EF183	11/3	PL36	12/9	5Z4	9/6		

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AF179	9/-	BF178	7/-	OC200	6/6		
AF180	12/4	BF180	8/-	OC202	9/6		
AF181	9/4	BF181	8/-	OC203	6/6		
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	CRM172	6.12.0	4.12.6
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AW43-80Z	CME1702	6.12.0	4.12.6
	CME1703	6.12.0	4.12.6
	CME1706	6.12.0	4.12.6
	C17AA	6.12.0	4.12.6
	C17AF	6.12.0	4.12.6
AW43-88	CME1705	6.12.0	4.12.6
AW47-90			
AW47-91	A47-14W	7.13.4	5. 7.6
A47-14W	CME1901	7.13.4	5. 7.6
	CME1902	7.13.4	5. 7.6
	CME1903	7.13.4	5. 7.6
	C19AH	7.13.4	5. 7.6
A47-13W	CME1906	10. 5.6	8.10.0
A47-11W	CME1905	8.17.3	7. 0.0
A47-26W	CME1905	8.17.3	7.15.0
A47-26W/R	CME1913R	9. 6.8	
A50-120W/R	CME2013	10.17.0	
AW53-80		8.18.8	6. 5.0
AW53-88	CME2101	8.18.8	6. 5.0
AW59-90			
AW59-91	CME2303	9.11.8	7. 4.0
A59-15W	CME2301		
	CME2302		
	CME2303	9.11.8	7. 4.0
A59-11W	CME2305		
A59-13W	CME2306	13.13.0	10.19.6
A59-16W	CME2306	13.13.0	10.19.6
A59-23W	CME2305	12.12.0	10.10.0
A59-23W/R		12.12.0	10.10.0
PORTABLE SET TUBES			
TSD217			6.15.0
TSD282			6.15.0
A28-14W		9. 3.4	Not supplied
CME1601			7.15.0
CME1602			8. 0.0

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OSCILLOSCOPE CALIBRATOR

By R.CARTWRIGHT

A square wave generator for calibrating oscilloscope Y amplifiers, and the frequency compensation of probes and attenuators.
Is also useful as a general purpose unit for checking audio amplifiers, tone control circuits, Schmitt triggers, monostables, etc.

SPECIFICATION

OUTPUT	Square wave, 10V peak-to-peak max.	OUTPUT LEVEL	0·1V, 0·2V, 0·5V, 1V, 2V, 5V, 10V
FREQUENCIES	1kHz, 10kHz, and 25kHz		
CALIBRATION	With ordinary d.c. voltmeter	RISE TIME	Better than 1μs

One problem often associated with home constructed projects is that of calibration. This article describes a small unit for calibrating the "Y" amplifier of an oscilloscope.

The best calibration waveform for this purpose is the square wave, its flat top and bottom make it easy to see and align with graticule markings. It can also be used for adjusting the frequency compensating capacitance of an attenuator or probe. Having decided on the waveform, we need a method of calibrating the calibrator.

USING A VOLTMETER

A conventional multimeter could be used on the a.c. voltage ranges (but see end of article). Rather old a.c. meters are not recommended because their meter rectifiers tend to change their characteristics with age. In any case, multimeters are usually considered to be more accurate and are more easily checked on the d.c. ranges. It would, therefore, be more convenient to use the d.c. ranges because the meter is an average reading instrument.

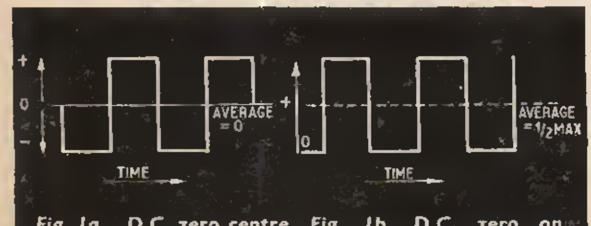


Fig. 1a. D.C. zero centre on square wave *Fig. 1b. D.C. zero on bottom of square wave*

If we try to measure a square wave voltage on a d.c. meter, the reading will be zero (Fig. 1a) because the positive parts of the waveform cancel the negative sections. If we offset the d.c. level to the bottom of the square wave, the meter will read half the maximum (Fig. 1b).

EMITTER TIMING CIRCUIT

The circuit (Fig. 2) is quite straightforward, consisting of a multivibrator followed by an output stage. The multivibrator, TR1 and TR2, has the timing components in the emitters and uses only one capacitor. This is an advantage if different frequencies are required since only one capacitor is required for each frequency.

It is also possible to adjust the frequency by varying the value of the collector resistor of TR1. This makes it possible to set the multivibrator to an exact frequency if required.

The basic frequency of the instrument is 1kHz; this is a "standard" frequency for voltage calibration and is used on commercial oscilloscopes.

The output transistor TR3 has its current set to 10mA

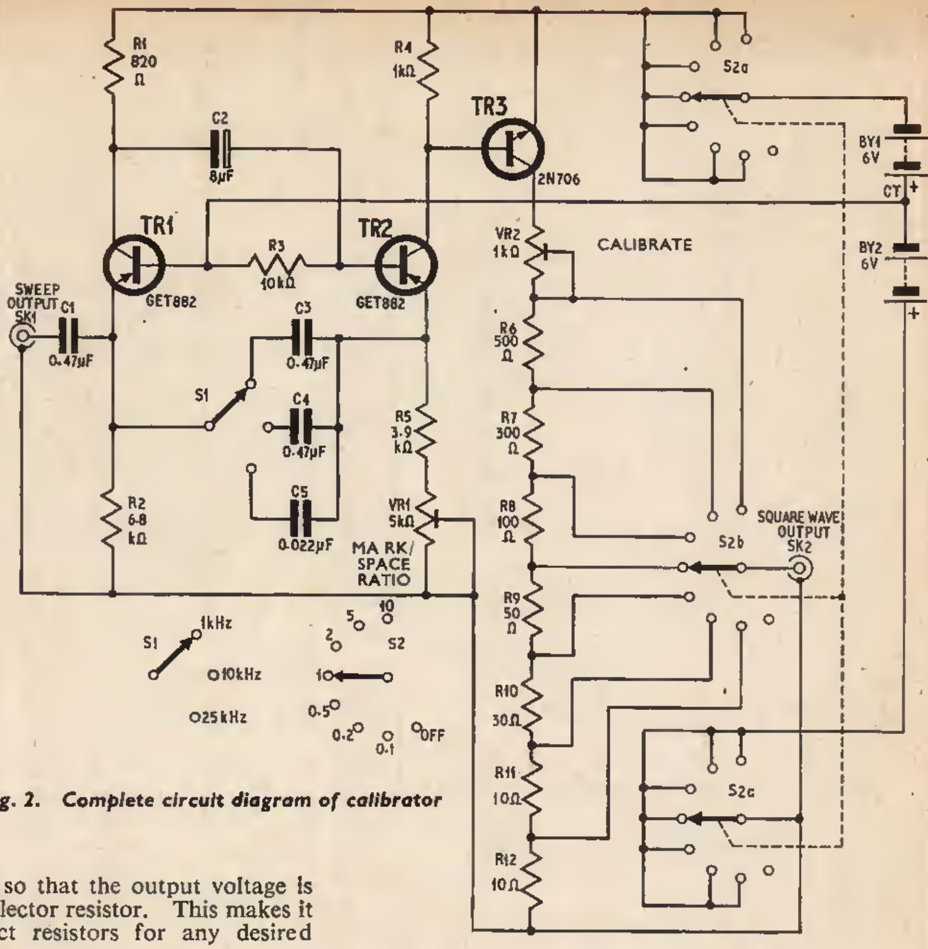


Fig. 2. Complete circuit diagram of calibrator

by VR2 (see setting up) so that the output voltage is directly related to the collector resistor. This makes it a simple matter to select resistors for any desired sequence of output voltages.

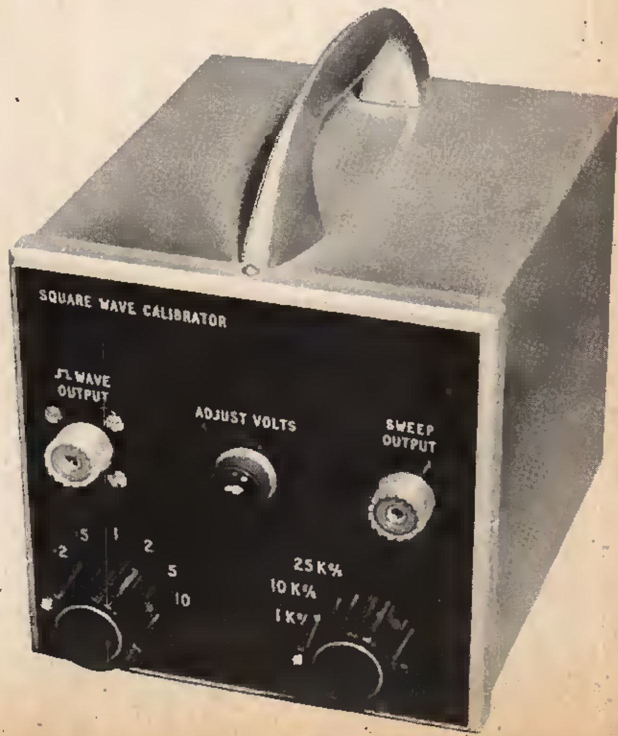
The output is taken from this resistor, the earth being the positive side of the supply. This method of connection gives the d.c. level to the signal. This resistor is divided into sections which subdivide the output voltage in a 1, 2, 5 sequence from 100mV to 10 volts peak-to-peak.

Only the 10 volts position of output voltage selector needs to be adjusted; all other positions depend on the accuracy of the resistors used.

CONSTRUCTION

Layout is not critical, except that the voltage selector switch and VR2 should be close to TR3. See Fig. 3. The resistors used in the voltage selector switch should be selected to 2 per cent or better from 5 per cent stock; all other resistors can be 5 per cent.

Any transistors having similar specifications to those quoted should work satisfactorily. Take care to connect them correctly; the first two are *pnp* and the output transistor is an *npn* type.



SETTING UP

After checking the wiring for errors, switch on and view the output on the oscilloscope. Set the mark space ratio to exactly 1:1 by adjusting VR1. Then, set the output switch to the 10 volts position, connect a d.c. voltmeter to the output socket and adjust the set output control until the reading is 5 volts. The unit is now ready for use. Connect it to the "Y" amplifier input on the oscilloscope.

COMPONENTS . . .

Resistors
R1 820Ω 5%
R2 6·8kΩ 5%
R3 10kΩ 5%
R4 1kΩ 5%
R5 3·9kΩ 5%
R6 500Ω (1kΩ + 1kΩ in parallel)
R7 300Ω (150Ω + 150Ω in series)
R8 100Ω
R9 50Ω (100Ω + 100Ω in parallel)
R10 30Ω (15Ω + 15Ω in series)
R11 10Ω
All ¼ watt, 5% carbon except R6 to R11 at 2%

Potentiometers
VR1 5kΩ skeleton preset or slider preset
VR2 1kΩ linear preset control

Capacitors
C1 0·47μF polyester 5%
C2 8μF elect. 15V
C3 0·47μF polyester 5%
C4 0·047μF polyester 5%
C5 0·02μF polyester 5%
(See Table 1)

Transistors
TR1, TR2 GET882 *or* 2N1305 (2 off)
TR3 2N706

Switches
S1 Single pole, 3-way rotary switch
S2 3-pole, 7-way (8 positions minimum) can be made up from wafer switch parts, two or three wafers, up to 12-way, 8 used

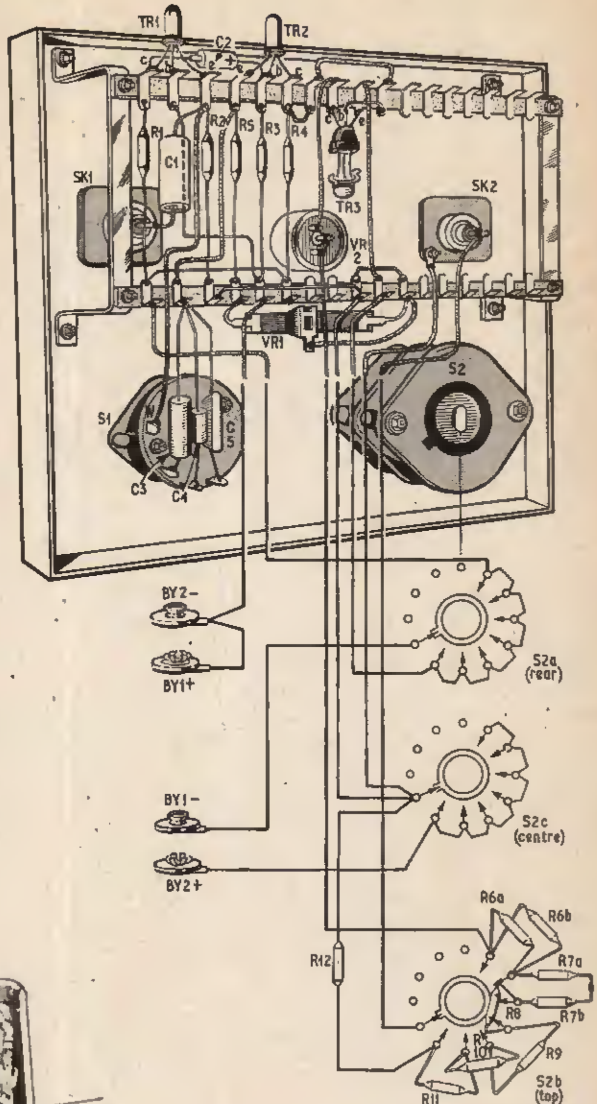
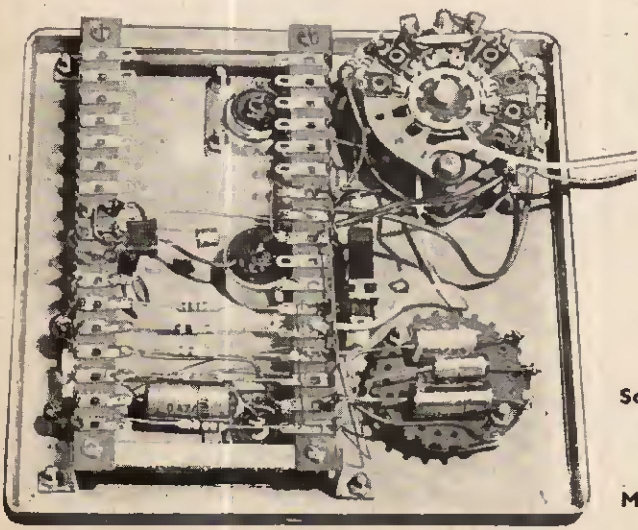


Fig. 3. Wiring and component layout



Sockets (with plugs)
SK1, SK2 Coaxial panel mounted sockets and plugs or "u.h.f." style p.t.f.e. connectors as on model

Miscellaneous
Aluminium case to hold components and batteries approx. 6in × 5in × 5in
Miniature tag strips, knobs and wire

Fig. 4. Square wave of 10V peak-to-peak represented on graticule

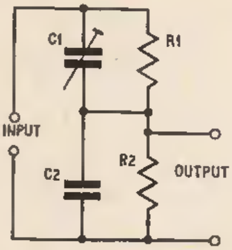


Fig. 5. Oscilloscope attenuator with frequency compensation

USING THE CALIBRATOR

To calibrate an oscilloscope, set the calibrator output voltage switch to the 10 volts position, set the "Y" input switch on the 'scope to 10 volts per centimetre and adjust the preset "Y" gain control until the top and bottom of the square wave are in line with graticule lines 1 centimetre apart (Fig. 4).

Repeat this for the other ranges, checking that the square wave is not distorted on any of them. If it is, adjustment of the attenuator trimmer should correct this to a good waveform with a square corner and flat top. Incorrect compensation will show up as overshoot of the leading edge (over compensated) or as a rounded corner (under compensated).

It does not matter if the 'scope is a.c. or d.c. coupled. If the 'scope is a.c. coupled it will be immune to the d.c. level in the signal. If the 'scope is d.c. coupled a slight readjustment of the "Y" shift control is all that is required.

The signal has a d.c. level so that the unit can be calibrated using an ordinary d.c. voltmeter (preferably an Avo "8"). Once the mark space ratio is set to 1:1 the d.c. level is always half the peak to peak value. This feature makes it unnecessary to use Zener diodes to stabilise the supplies, since it only takes a moment to check the calibration.

FREQUENCY COMPENSATION

As well as voltage calibration the unit is also useful for frequency compensation of attenuators and probes.

The risetime is better than 1μs and the top is flat so that observation of the unit's waveform on the 'scope under test will show if adjustment of the 'scope is required.

The circuit of a typical 'scope attenuator section is shown in Fig. 5. When in correct adjustment the time constant of C1, R1 will be equal to that of C2, R2.

Because a square wave contains high frequency components in the verticals and low frequency components in the flat sections, a square wave at the input will be undistorted at the output only if $C_1 R_1$ equals $C_2 R_2$.

In practice the unit is connected to the 'scope input, the waveform is observed and any departure from the correct waveform is compensated for by adjustment of the trimmer C1 in Fig. 5.

OTHER USES

Apart from these two jobs the unit is useful as a square wave generator for general purposes. Checking audio amplifiers, tone controls, Schmitt triggers, monostables and other switching or CR circuits.

The ramp output SK1 is for checking trigger circuits. If the oscilloscope is fitted with a "Trigger Level" control it should be possible to select any point on the ramp and trigger at that point.

To make the unit more useful as a general purpose square wave generator, two other frequencies are available. These are (on the author's unit) 10kHz and 25kHz. When the original was built, these two frequencies were chosen, together with a slightly different output stage which gave a much faster rise time, for work on oscilloscope delay lines.

They are rather high for audio work though, and some constructors may prefer lower frequencies such as 500Hz and 5kHz for this work. All that needs to be done is to change the timing capacitor, C2, as indicated in Table 1.

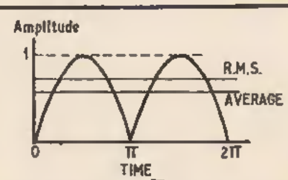
Table 1. EMITTER COUPLING CAPACITANCE

Capacitance	Frequency
1·0μF	500Hz
0·5μF	1kHz
0·1μF	5kHz
0·05μF	10kHz
0·025μF	20kHz
0·02μF	25kHz

METER MEASUREMENTS

There is sometimes confusion about measurements with moving coil meters and especially about the terms "average" and "r.m.s." when applied to readings taken with such meters. The output waveform from the meter rectifier on sine waves is shown in Fig. 6. If the

continued on page 654



To find the average value of the sine between zero and π, find the area and divide by the base.

$$\text{Area} = \int_0^{\pi} \sin x \, dx = \Big[-\cos x\Big]_0^{\pi} = [1] - [-1] = 2 \text{ sq. units.}$$

$$\text{Average} = \frac{2}{\pi} = 0{\cdot}637$$

$$\text{Form factor} = \frac{0{\cdot}707}{0{\cdot}637} = 1{\cdot}11$$

Fig. 6. Meter rectifier output wave form for sine wave input. To find the average value of the sine between zero and π find the area and divide by the base

BOOK REVIEWS

PHOTOELECTRONIC DEVICES

By J. B. Dance, M.Sc., B.Sc.
Published by Iliffe Books Ltd.
172 pages, 8½in × 5½in. Price 42s.

MUCH of the usefulness of modern electronics is due to the exploitation of the photoelectronic effect. It follows that full appreciation of electronic circuits is not possible without a good knowledge of photoelectronic devices. This book is timely and offers a sound introduction to the subject to readers who have a previous knowledge of basic physics to about G.C.E. "advanced" level.

After an introduction to the basic physics of infrared, visible light and ultra-violet radiation, there follow chapters on semiconductor fundamentals, with emphasis on electron energy levels, and photoemissive materials. The remainder of the book deals with a variety of different devices: evacuated tubes, such as photoemissive diodes, photomultiplier tubes, and image intensifiers and converters; semiconductor photodevices, including junctionless photoconductive cells such as the familiar cadmium sulphide and cadmium selenide devices; junction photodevices such as phototransistors, and more sophisticated integrated circuit light detectors, based on new principles.

The final chapter is devoted to electroluminescent devices and provides a valuable curtain raiser to what is undoubtedly going to be a most exciting development area in the future.

To the student and amateur enthusiast alike, the value of this book is enhanced by the inclusion of practical circuits illustrating some everyday applications for the devices described. Component values are included, and device types are specified.

F.E.B.

110 SEMICONDUCTOR PROJECTS FOR THE HOME CONSTRUCTOR

By R. M. Marston
Published by Iliffe Books Ltd.
125 pages, 8½in × 5½in. Price 18s (soft back).

BASIC differences between silicon and germanium transistors and their circuit configurations provide an essential introduction to the common usage of silicon devices. From here on this book describes many well established circuits or "building bricks" which can be found elsewhere.

With a title such as this book carries, one would expect to find more practical details in addition to theory, such as is found in the book "Using Semiconductors" (reviewed in our May issue). This book has no practical guidance at all, and it is left to the "home constructor" to sort out the information himself. He can do much the same by obtaining technical application reports.

The circuits dealt with include one- and two-stage linear amplifiers (small signal only), switching circuits, regulators, f.e.t. amplifiers, unijunction oscillators, s.c.r. switching at low voltages, and a variety of circuits using the simple "dual gate" integrated circuit.

M.A.C.

CIRCUIT CONSULTANT'S CASEBOOK

By T. K. Hemingway
Published by Business Books Ltd.
210 pages, 9in × 5¾in. Price 75s.

FOR circuit designers and trouble shooters alike, this excellent volume goes a long way towards attacking design defects that are all too often overlooked.

Although a circuit can be designed to function fairly easily by using reference works, there are factors which can make the reliability of long term safe operation an unknown quantity. The principle concern of the author here is to safeguard transistors in spurious, irregular, or transient overload conditions.

As Head of Electronic Technology at the Guided Weapons Division of B.A.C., it is easy to understand that diagnosis and cure are by-products of a reliability conscious designer. Yet he has attempted here to help other designers to adopt such an approach to first principles design philosophy.

The text is written in an absorbing manner and should be of value to designers with a fairly broad background in circuit design.

While openly admitting that the examples given are not intended to be the last word in all applications, the author does set the designer on his toes for some of the more common pitfalls.

This book is divided into two parts: Part 1 discusses basic design problems, common errors and their correction; Part 2 deals with the ways of meeting specification requirements not readily achieved by standard textbook circuits. The maths is kept to a minimum and only involves the simple algebra normally expected in basic principles.

It is a curious thing that some of the best books on electronics tend to be pricy, but 75 shillings spent on this could save several pounds on damaged components.

M.A.C.

LUMINESCENT SCREENS, PHOTOMETRY AND COLORIMETRY

By J. Kalmer M.Sc.
Published by Iliffe Books Ltd.
200 pages, 8½in × 6½in. Price 60s

AS THE title of this book suggests, colorimetry and photometry form the subject matter, it is not concerned with luminescence generally, and anyone expecting an explanation of the luminescence mechanism will be disappointed.

The author is concerned only with cathodoluminescence (this is the principle used in cathode ray tubes where phosphors are excited by an electron beam) and then only with the testing of emitted light rather than production of the radiation. Other forms of luminescence, photoluminescence, electroluminescence, etc. are defined on page 1 and then disregarded.

As a book on television screen testing, however, it is difficult to rival. The author, a Czechoslovakian, has had many years experience in objective methods for assessing TV picture quality in both monochrome and colour and practically all aspects are covered. Chapter four, "Colour Measurements" is particularly good.

This book is likely to be of interest to the television enthusiast, particularly with regard to colour, but it is not for casual, general interest reading. The testing methods described are not for the amateur, they are rigorous and require a well equipped laboratory. Mathematical treatment is used throughout.

In all, a very specialised book, but certainly an authoritative work in its field.

K.J.M.

A NEW SERIES FOR THE BEGINNER

THIS

If the input or output device connected to an electronic circuit converts one form of energy into another it is called a "transducer".

The block diagram in Fig. 5.1 shows a typical transducer application, the Geiger counter. A Geiger Müller tube converts energy resulting from radioactive decay processes into pulses of electrical energy, which are then amplified for conversion into "clicks" of sound energy by a loudspeaker.

In the following descriptions transducers are grouped under six main headings; light, heat, sound, magnetism, motion, and atomic radiation, denoting the type of energy conversion involved.

LIGHT SENSORS

Photoemissive Cell

The photoemissive cell in Fig. 5.2a consists of two electrodes in a vacuum or gas. The cathode is coated with a material (such as caesium-antimony alloy) which emits electrons when exposed to light. The anode is positively charged by the battery.

When light falls on the cathode, electrons are liberated and flow to the anode; a voltage appears across resistor R. The output voltage is nearly proportional to light intensity.

Photodiode

A reverse biased semiconductor diode conducts a negligible leakage current, but if light is allowed to reach the *pn* junction it will cause a reverse current to flow. This phenomenon is called *photoconductivity*.

In the circuit in Fig. 5.2b, the diode is reverse biased by the battery, the output voltage being roughly proportional to light intensity.

Photovoltaic Diode

The solar cell used in space satellites is an example of a photovoltaic diode, which acts like a battery when exposed to light (Fig. 5.2c). A small silicon photovoltaic diode will generate a current of several milliamps at a potential of about 0·5V in direct sunlight.

Photovoltaic cells used in photographic light meters employ selenium as the photosensitive material.

Light Dependent Resistor

A photoresistor or light dependent resistor (Fig. 5.2d) has a resistive element, usually made of cadmium sulphide, contained in a transparent case. When light shines on the element its resistance decreases. In the circuit in Fig. 5.2d, the output voltage increases with illumination.

The photoresistor is not polarised like a diode, and behaves like an ordinary resistor under conditions of constant illumination, so can be fed from an a.c. as well as d.c. source.

Phototransistor

The phototransistor has a built-in amplification characteristic. Light on the base-emitter junction causes an internal base current to flow, even when the base lead is left disconnected, and this gives rise to a much larger collector current. In the circuit in Fig. 5.2e, the output varies inversely with light intensity.

Response

There is a limit to the speed with which a photosensor will respond to rapid changes of light intensity. For example, the output signal from cadmium sulphide photoresistors and selenium cells tends to fall off if the light input is made to pulsate rapidly at frequencies in excess of a few hundred hertz.

Ordinary silicon phototransistors and photodiodes can respond quite well to light pulsating at 20kHz, while special photoconductive diodes will reach 300MHz. The upper frequency limit of photoemissive cells is theoretically high, but is usually limited in practice, by the high impedance of the device, to around 25kHz.

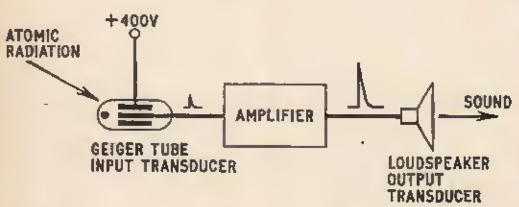


Fig. 5.1. Block diagram of a simple Geiger counter with the circuit symbol for a Geiger-Müller tube

WAY TO ELECTRONICS 5

LIGHT SENSORS

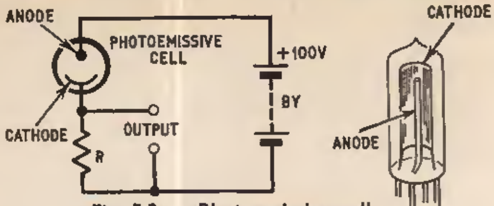


Fig. 5.2a. Photoemissive cell

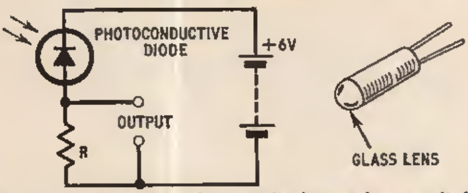


Fig. 5.2b. A semiconductor diode used as a light-sensor

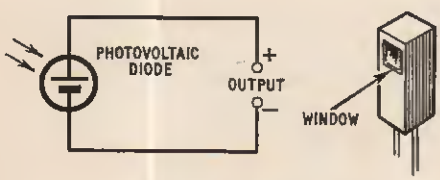


Fig. 5.2c. Photovoltaic diode or solar cell

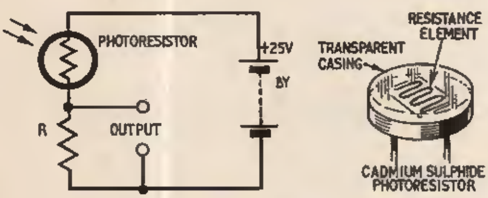


Fig. 5.2d. Light dependent resistor

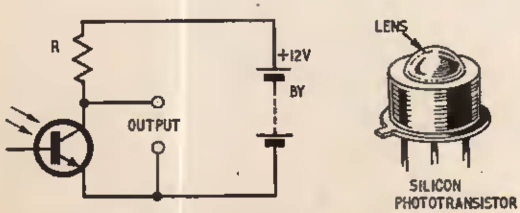


Fig. 5.2e. Phototransistor has light sensitive base emitter junction

LIGHT EMITTERS

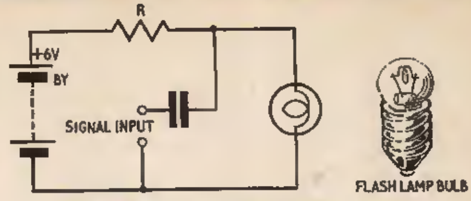


Fig. 5.3a. Tungsten filament lamp

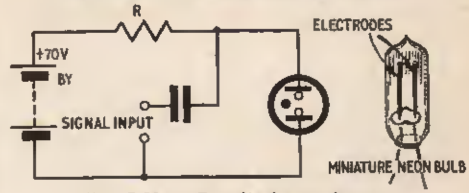


Fig. 5.3b. Gas discharge lamp

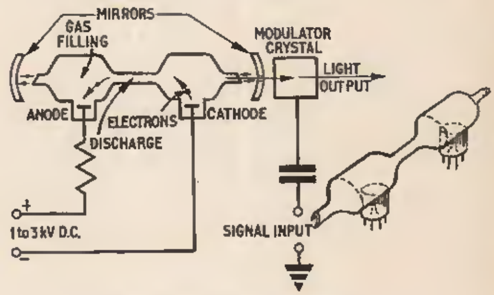


Fig. 5.3c. Laser tube

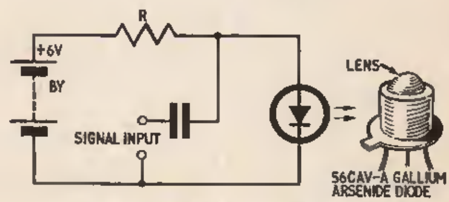


Fig. 5.3d. Gallium arsenide diode

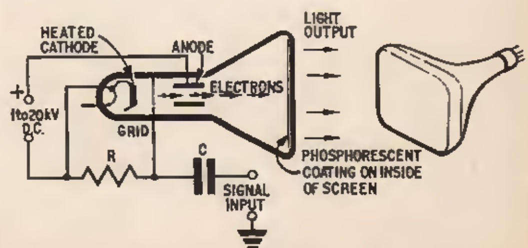


Fig. 5.3e. Cathode ray tube

LIGHT EMITTERS

Filament Lamp

Tungsten filament lamps can be used as output transducers to convert an electrical signal into a modulated light signal, (Fig. 5.3a) examples being colour organs, psychedelic displays, and systems for transmitting information by modulating light instead of radio waves to one of the photosensors mentioned above.

Unfortunately, the tungsten filament transducer is hampered by thermal inertia and cannot respond efficiently to a.c. input signals of more than a few hundred hertz.

Gas Discharge Tube

Gas discharge tubes (Fig. 5.3b) can give pulsating light outputs up to several kilohertz when fed from a high voltage input signal. Applications are similar to those of the tungsten lamp, but also include the stroboscope and photographer's electronic flash gun.

The light amplifier or laser shown in Fig. 5.3c is basically a gas discharge tube, arranged so that most of its light output is reflected back into the tube by mirrors, thus causing a build-up of energy. The output taken from a small orifice in one of the mirrors can be a narrow, high intensity parallel beam of coherent light or infra-red.

One method of modulating the light output is to pass the beam through a crystal which exhibits variable light transmission with applied voltage. Lasers also make effective heat emitters due to the high energy content of the beam.

Semiconductor Diode

Semiconductor diodes made of gallium arsenide will emit infra-red energy (just beyond the red end of the visible spectrum) when forward biased (see electroluminescent diode Fig. 5.3d). Light output is proportional to forward current and can be modulated up to 100MHz.

Cathode Ray Tube

In a television cathode ray tube, a narrow, controlled beam of electrons bombards a phosphorus coating and causes it to emit visible light, Fig. 5.3e.

Although the cathode ray tube is electrically capable of responding to high frequency signals, and can give a fine definition picture of slow moving images, the rate at which the phosphorescent output can change state from white to black is restricted by the afterglow properties of the coating.

Special phosphors used with film scanners can have an afterglow persistence of less than 0·2μs, equivalent to a modulated light output of 5MHz, but ordinary television tubes are much slower than this, say 50μs or more.

HEAT SENSORS

A heat sensor can either work by conduction, in direct physical contact with a heat emitting substance or device, or by radiation when infra-red energy is absorbed. The energy and wavelength of infra-red radiation is dependent on temperature. Several types of light sensor will also respond to infra-red emissions from substances which are not quite red hot, say at 300 degrees C, but are unsuitable for lower temperatures.

There are certain semiconductor devices—mainly confined to the laboratory—that will detect the heat of the human body, but they usually have to be refrigerated in a cryostat at near absolute zero temperature. For temperatures below 300°C there remain the devices which operate by conduction.

HEAT SENSORS

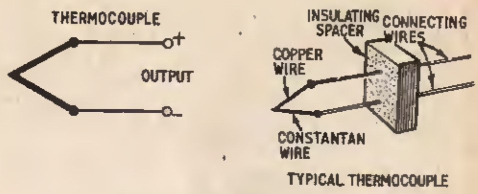


Fig. 5.4a. Thermocouple

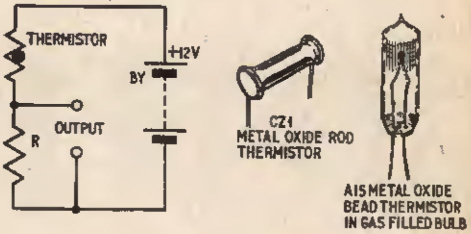


Fig. 5.4b. Thermistor

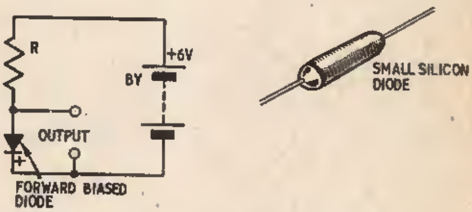


Fig. 5.4c. Heat sensitive diode

Thermocouple

The first example of a heat sensor is the thermocouple in Fig. 5.4a. Two wires of dissimilar metals, say copper and constantan, are joined together to form a bimetal junction. A voltage will be produced across this junction when it is heated or cooled relative to the connecting wires. Output is zero at ambient temperature and of opposite polarities for hot and cold.

Thermistor

A thermistor (Fig. 5.4b) has an exaggerated negative temperature coefficient, that is to say its resistance

HEAT EMITTERS

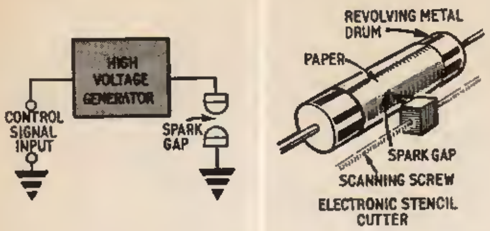


Fig. 5.5a. Electronic stencil cutter

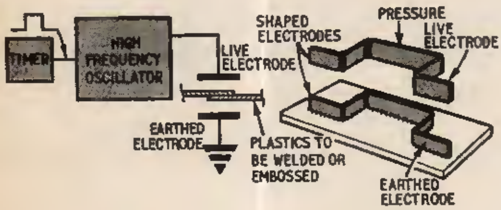


Fig. 5.5b. Dielectric heater

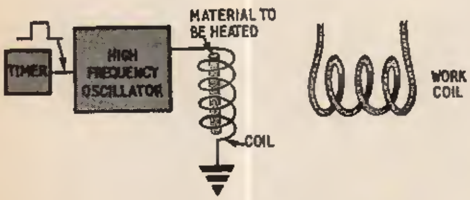


Fig. 5.5c. Inductive heater

decreases markedly with a rise in temperature. In the circuit in Fig. 5.4b, a thermistor is arranged in series with a resistor, so that output voltage will increase with temperature.

The response of a thermistor to temperature is not linear, but varies exponentially with inverse absolute temperature (°K). Positive temperature coefficient thermistors are shown in circuit diagrams with a small circle in place of the black dot.

Heat Sensitive Diode

An ordinary silicon signal diode of the type commonly encountered in electronic circuits will act as a heat sensor when forward biased. The output voltage taken from across the diode in the circuit of Fig. 5.4c is inversely proportional to temperature.

HEAT EMITTERS

Heat emission occurs in electronic circuits as a by-product when resistive components are conducting a current, but this is not the deliberate use of heat as output energy from a transducer.

Spark Maker

The humble electric spark is a heat emitter which is often taken for granted. For instance, the output from an electronic car ignition system is applied at precise intervals by means of a spark.

Then there is the electronic stencil cutter which employs a spark to burn holes of variable diameter in ink duplicator stencils, see Fig. 5.5a. A similar idea is sometimes used to reproduce weather maps from satellite transmissions, on heat sensitive paper.

Dielectric Heater

A dielectric heater—resembling a capacitor—can weld or emboss sheets of thermoplastic material, in the manufacture of motor car seats, purses, wallets, and so on (see Fig. 5.5b).

The plastics to be heated are inserted between two cold electrodes of almost any desired shape and surface finish, which are then pressed together by a spring. One electrode is earthed and the other is fed from the output of a powerful high frequency oscillator (30–50MHz at 1–10kW).

Molecular disturbance within the plastics generates internal heat without appreciable heating of the electrodes, thus softening the plastics. A microwave household oven works on a very similar principle to cook food right through in a short time.

Inductive Heater

Inductive heaters (Fig. 5.5c) are suitable for heat treatment of conductive materials, or materials enclosed in a conductive container. Processes such as melting, hardening, tempering, annealing, soldering, brazing, and sintering can be performed with great precision in this manner.

In Fig. 5.5c an oscillator supplies a.c. to a coil of copper tubing, into which the work to be heated is placed. At low frequencies the work will be heated uniformly, but if the oscillator is tuned to several megahertz, heating will take place only at the surface of the workpiece.

Gas Discharge

Lasers have been successfully employed as heat emitters for micro-spot welding of metals and for fixing detached retinas in eye operations, refer back to Fig. 5.3c.

Part six next month will continue the section on transducers and the series will be concluded with descriptions of miscellaneous electronic devices.

POINTS ARISING

MUSICAL STAVE *(May 1970)*

In the paragraph relating to power output the r.m.s. output voltage should have been given as $\frac{9}{2\sqrt{2}}$ since a sinusoidal swing would be between $\pm 4\frac{1}{2}$ volts. As the actual output from the circuit is rectangular, the power available will vary with the signal mark-space ratio reaching a peak of 580 milliwatts when the ratio is unity.

ELECTRONORAMA

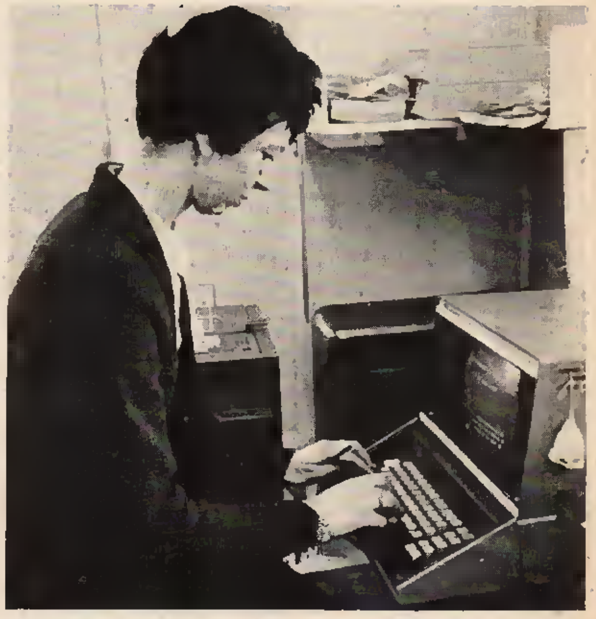
B.B.C. Automatic Data Exchange

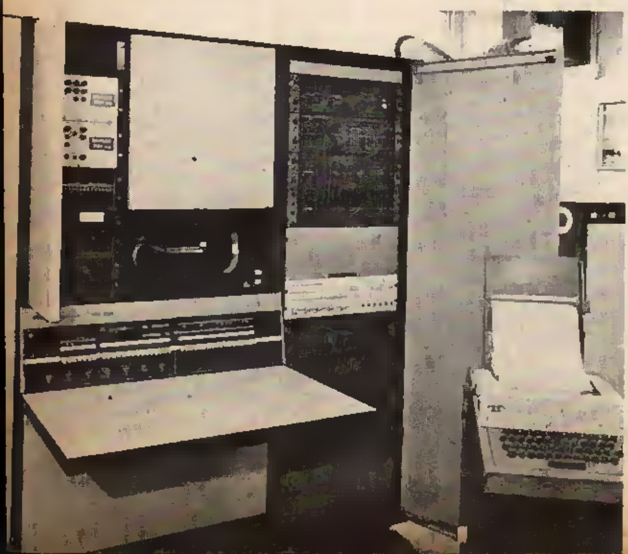
ON April 6 the B.B.C. brought into service a new automatic message switching system using an STC 6350 automatic data exchange (ADX).

The B.B.C.'s Teleprinter network for the transmission of news and other messages serves 60 outstations in London and the Regions. It handles more than 700,000 messages each year and has had an annual growth rate of some 3 per cent. The hub of the system is at the London Communications Centre in Broadcasting House.

Before the introduction of the new system a point had been reached where further expansion was not possible and the congestion that inevitably occurred at peak periods, due to manual connection to addressee outstations, could not be relieved. This congestion created delays in message transmission. Moreover, a substantial amount of urgent news traffic for non-metropolitan stations had to be diverted to the public telephone service to ensure immediate delivery.

In addition to routing and retransmitting messages automatically through the communications centre with a transit time of only milliseconds, some of the major facilities provided by the new 6350 ADX system, the computer section of which is shown below left, are:

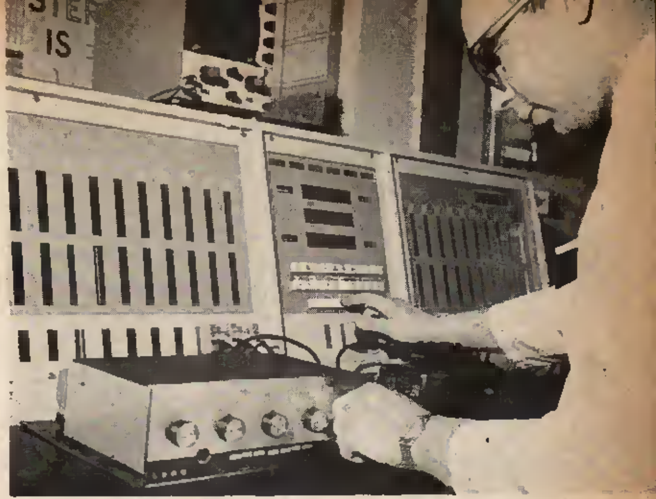




On-line message preparation for messages telephoned into the centre or delivered by messenger, there are six 8-unit code 100 word per minute teleprinters, shown above, which feed the messages to the ADX system that immediately puts the messages into the standard format and transmits them to various outstations according to the addressing information given.

Connection to the automatic Telex network; under licence from the Post Office connections to the network have been included to cater for both incoming and outgoing messages.

System reporting and control facilities that report abnormal conditions for supervisory action. These facilities include a visual display unit, shown in operation above, for the inspection and correction of messages rejected by the ADX because of incorrect or incomplete routing information.



Electronic Test Equipment

Two recently announced electronic circuit test equipments are shown above and left, they are: the Fixit (left), an inspection test system for checking mass-produced electronic circuit board assemblies, and the test console (above) used by H. J. Leak for checking tuners and amplifiers.

Fixit, a plugboard or tape programmed test system, has been introduced by Systomation, Inc., New York. The system has the ability to check the exact values of electronic components, such as resistors, diodes, transistors, etc., even though they are wired together in complex parallel electronic circuits. The system is already in use in the United States.

The comprehensive final testing of high fidelity tuners and amplifiers takes up to forty-five minutes by hand. Now H. J. Leak, part of The Rank Organisation, are using a £10,000 Ethermatic test console that carries out an exhaustive test procedure on each unit in about one-tenth of that time. A print-out of all readings made on a tuner or amplifier is available at the end of each test cycle. The unit is shown in use testing a stereo hi-fi amplifier.

Climatological Station

The photograph below shows a "Hy-Met" recorder test set being used to check the functioning of a Climatological Recording Station. Both the equipments in the photograph are manufactured by the Environmental Sensors Division of Plessey.

The Climatological Station makes and records over 55,000 measurements. It is self-contained and can monitor such parameters as rainfall; humidity; wind speed and direction; air, soil and water temperatures; barometric pressure; solar radiation; water level, flow and pH.

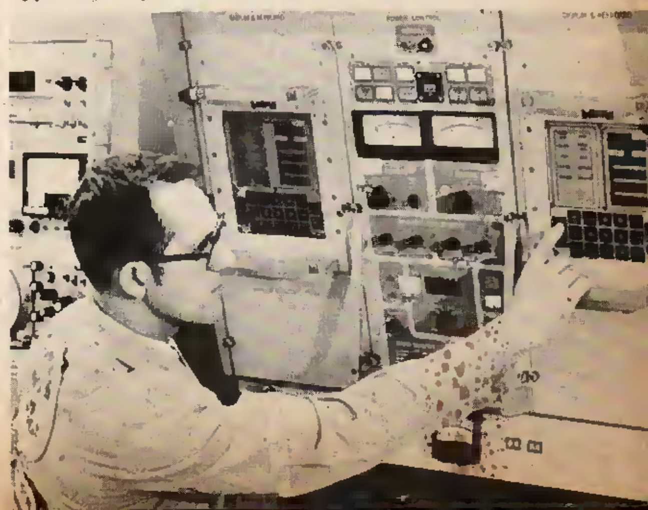
The equipment can be installed on land, drilling rigs, or on board ships and the information is recorded on standard ½ inch magnetic tape. This tape is translated using standard Plessey equipment to provide computer compatible paper tape.

Designed for use with Plessey hydrological and meteorological monitoring and recording systems, the "Hy-Met" recorder test-set provides facilities for readily checking the function of the station.

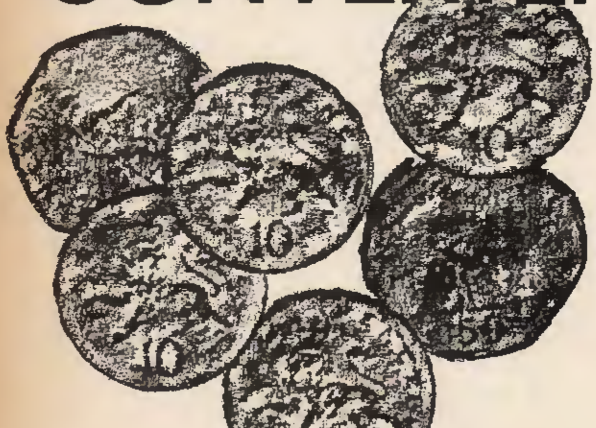
Mini-Computer

The latest commercial mini-computer from Raytheon Computers is only 16 inches high and weighs 75 pounds, yet has a memory expansion of up to 32,000. The computer is particularly suitable for applications relating to instrument and process control, data communications and data acquisition as well as basic scientific research.

A small Raytheon digital computer that was produced specifically for space flight is shown being programmed via a display keyboard, during testing, below. The "brain" of the Apollo flights, these computers are only approximately one cubic foot in volume.



DECIMAL CURRENCY CONVERTER



By G. A. Cozens

THE change to decimal currency in the U.K. on February 15, 1971 draws nearer as the series of new coins is introduced. But the fact remains that we have undertaken a very difficult operation by maintaining the pound as the major unit of currency, and created the task of relating 24 old pennies to 10 new pence.

Electronic methods of conversion to cope with all the 199 values under £1 fall into two categories: analogue or digital computer techniques.

The analogue method using a simple Wheatstone bridge type of balance was tried, but it was difficult to obtain a sufficient degree of accuracy, it being necessary to be within 0·5 per cent. It is difficult to achieve this, even with quite sophisticated circuits and impossible with simple electronics using dials or meters, so this method was abandoned.

DIGITAL CONVERSION

When one tries the digital method it is then that the problems which our planners have imposed become apparent. The instrument finally devised uses switches to select the shilling and pence values, while lamps show the new pence equivalents. Some way of combining the switches and reducing the number of lamps had to be found to reduce the cost of the instrument. It is emphasised at this stage that this instrument carries out conversion only and is not suitable for use as an adding machine. The circuit diagram of the Decimal Currency Converter is shown in Fig. 1.

DIODE LOGIC

This conversion unit uses diode logic. Following the front panel layout in Fig. 2, the selector switches are divided into three rows, one for the even values of shillings (two to eighteen), one row for the odd values of shillings (one to nineteen) and one row for the old pence values—1d, 2d and 3d, 4d, 5d, 6d, 7d, 8d, 9d and 10d, and 11d, thus giving a total of 28 switches. Notice that 2d and 3d are combined on one switch, so are 9d and 10d.

The lamps are arranged in two vertical columns, the left-hand column of nine lamps representing 10p at the bottom of the column, 20p, 30p and so on up to 90p at the top. There is a single lamp to the right of these columns which correspond to ½p.

In this way any of the 199 values of shillings and old pence can be selected using two switches. The equivalent value in new pence will appear in the columns of lamps, one lamp in each column lighting up.

The lamps can be 6 volt 0·1A m.e.s. bulbs or 6V 0·75W l.e.s. bulbs. The relay coil must also be rated for 6 volts operation. Of course, other lamp and relay voltages can be used, but care must be taken not to use current ratings which are too heavy for the diodes to handle.

These diodes are small silicon types such as OA200 or OA202. Some suitable types of diodes are available at very low cost and it may be possible to economise considerably by selecting from these. They are germanium types and are obtainable for as little as 2·5p (6d) each when purchased in bulk quantities.

SWITCH WIRING

Starting with the 1d value, this switch S28 is wired directly in series with the ½p lamp LP19, and S29. See Fig. 3. The 2d and 3d values are combined in the next switch, which is in series with the 1p lamp.

The 4d switch is also in series with this lamp, but there is a diode D1 between the switches and the lamp, which will conduct when either switch is closed.

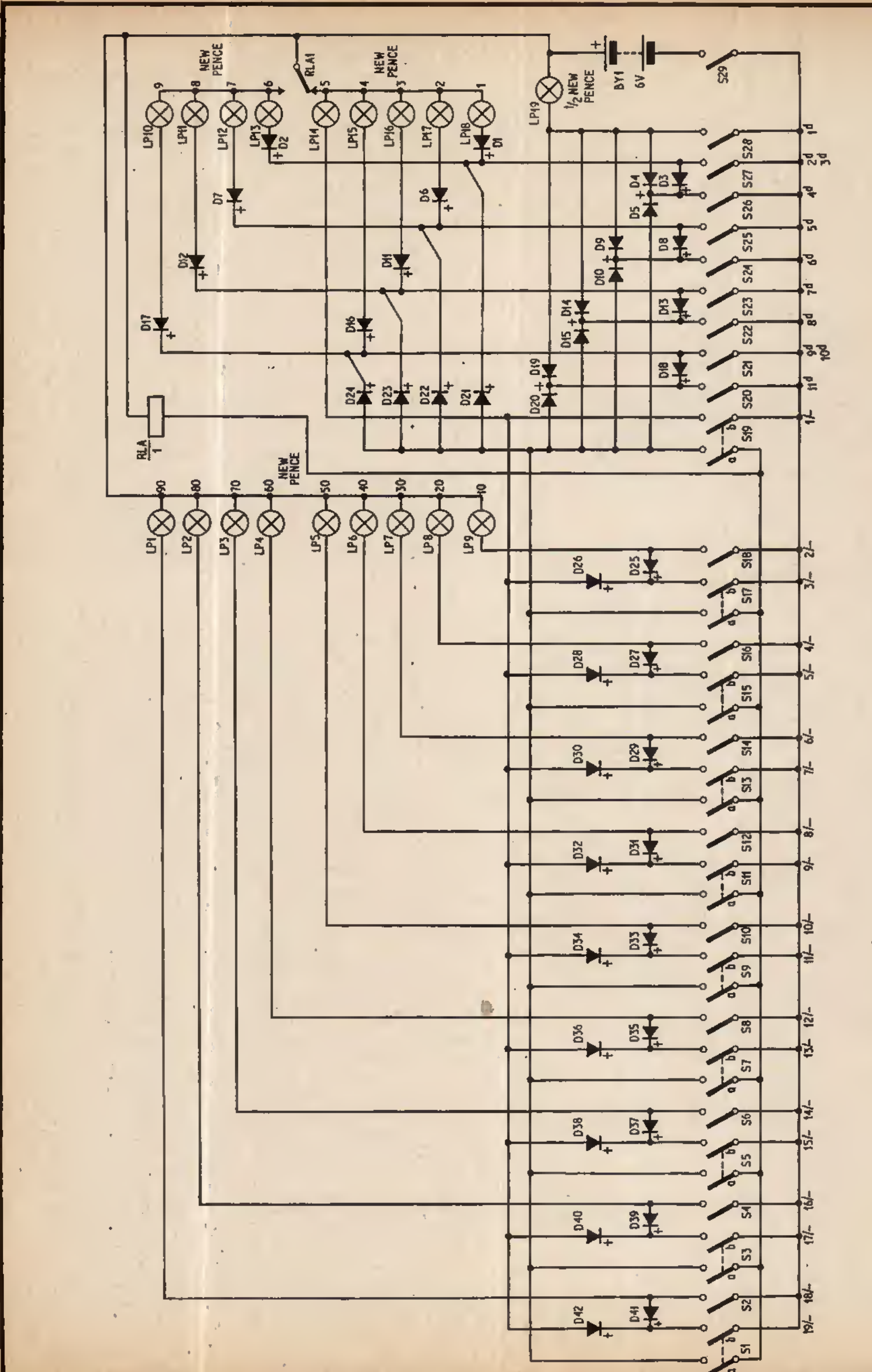
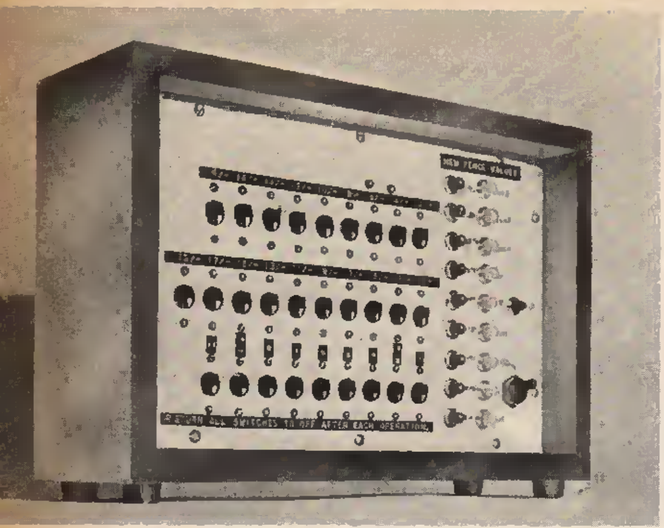


Fig. 1. Complete circuit diagram of the decimal currency converter



Front view of the converter giving layout positioning of components. All switches must be returned to the off position after each calculation

COMPONENTS . . .

Diodes
D1–D42 Any type that will carry 100mA or more (42 off)

Lamps
LP1–LP19 6 volt 0·1A or less; with panel lampholders (19 off)

Relay
RLA Any 6V type with at least one set of changeover contacts

Switches
S1 to S28 Double-pole changeover slide or toggle switches (28 off)
S29 Single-pole, on/off, toggle switch (S2, S4, S6, S8, S10, S12, S14, S16, S18, S20 to S28 can be single pole)

Battery
BY1 6V type 996 *or* 2 × 3V type 800

Miscellaneous
Single row tag strips, ¼in pitch, 7in long (2 off)
Wood for case, p.v.c. covered wire, lettering

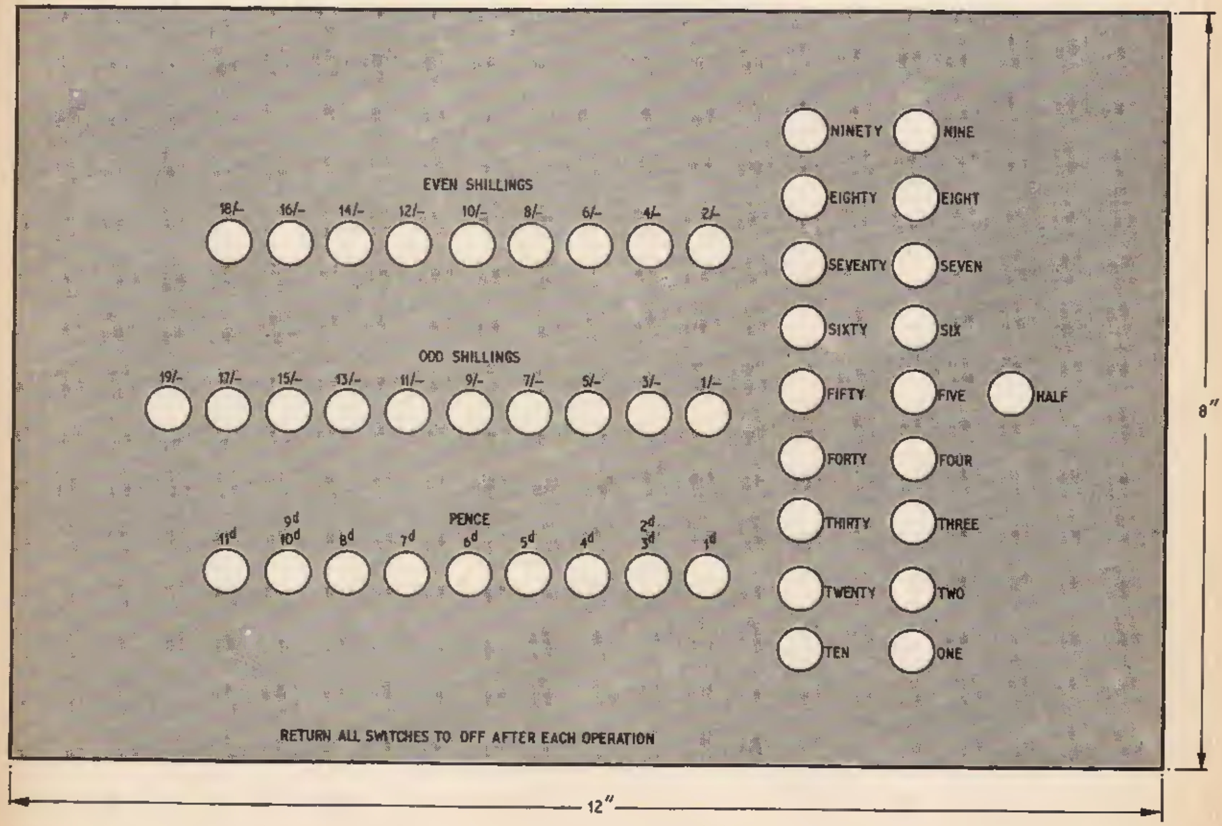


Fig. 2. Front panel layout of lamps and switches

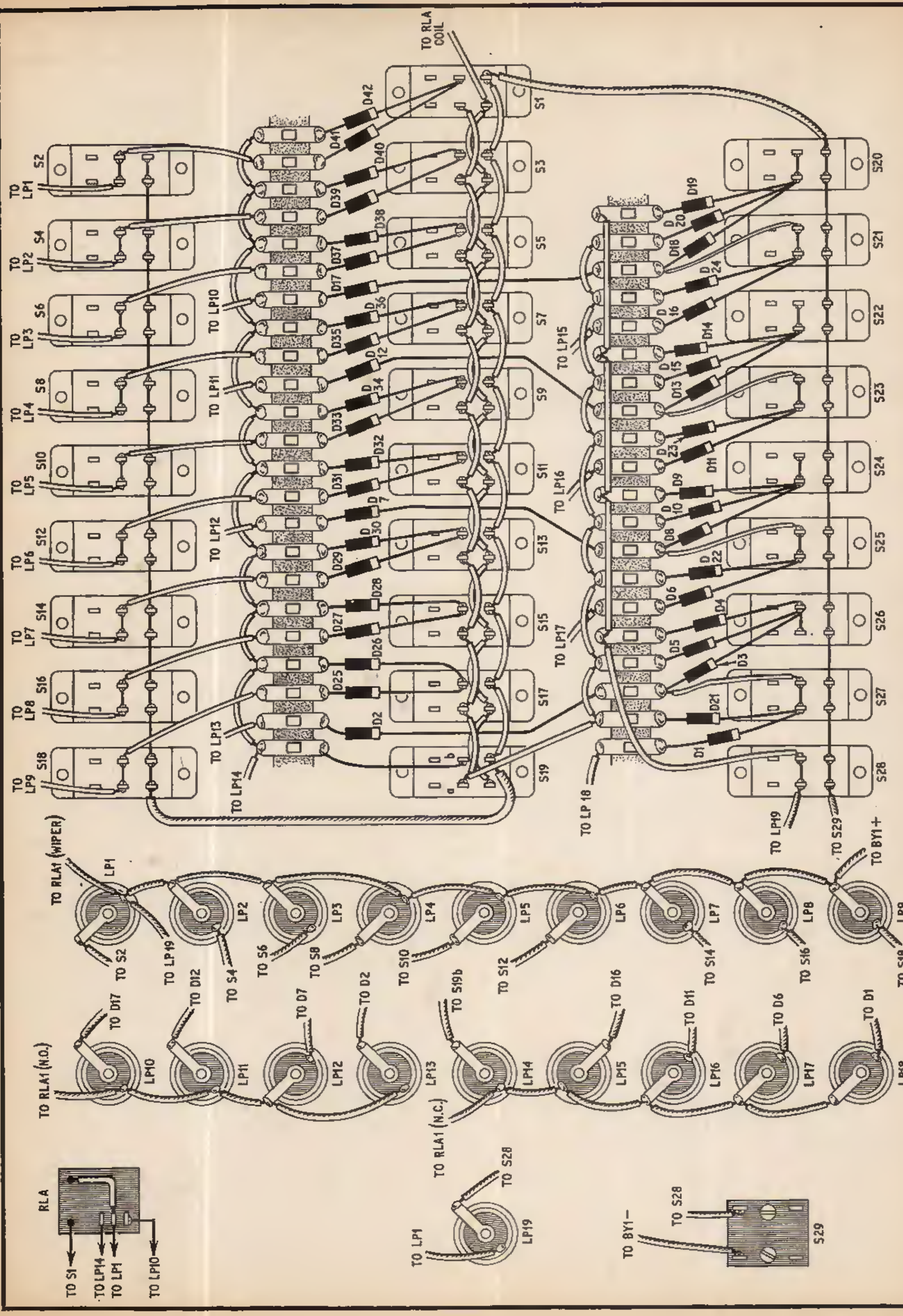
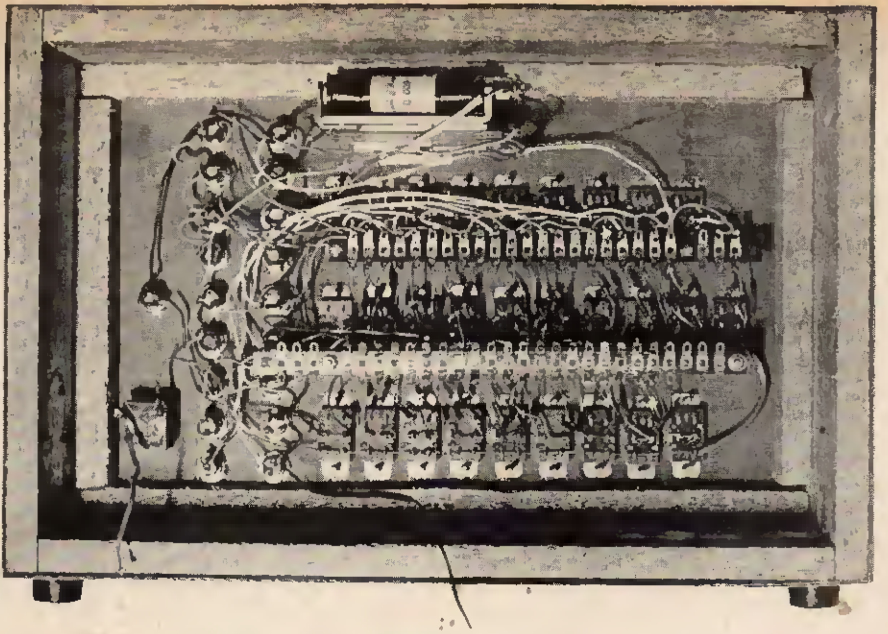


Fig. 3. Layout and wiring of the components on the panel



Rear view of the converter showing components and wiring. The relay can be mounted in any convenient position on an aluminium bracket screwed to the case

Diode D3 separates the 4d switch from the 2d/3d switch and D4 connects the 4d switch to the ½p lamp.

This pattern is repeated for all the values up to 1s, so that the 5d switch turns on the 2p lamp, and the 6d switch the 2½p lamp, the 7d switch the 3p lamp, and the 8d switch the 3½p lamp. The values 9d and 10d and combined in one switch which operates the 4p lamp and the 11d switch operates the 4½p lamp. The 1s switch operates the 5p lamp.

The 2s switch at the start of the row of even shillings switches is in series with the 10p lamp at the bottom of the left hand column of lamps. The even shillings switches are each in series with a corresponding lamp up to the 18s switch, which operates the 90p lamp at the top of the column.

The line of switches corresponding to the odd numbers of shillings calls for comment since these switches are double-pole, single-throw types. One side is in series with the coil of a relay and a diode. When any one of the odd value paths is completed through another diode, and the "pence" switch and back to the battery, the relay operates.

RELAY CONTACTS

The relay contacts are single-pole changeover, changing the battery return lead for the 1p, 2p, 3p, 4p and 5p lamps, so that the 6p, 7p, 8p, and 9p lamps are operated. In this way 5p are added to the value each time an odd number of shillings is selected.

For example, suppose we select the value 2s 11d. The 2s switch operates the 10p lamp, and the 11d switch operates the 4p lamp via diodes D18 and D16, and the ½p lamp via diode D19.

Now try the value 15s 6d. The 15s switch operates the 70p lamp via D37. When the 6d switch is made the circuit through the relay coil is completed via the second contact on the 15s switch and diode D10. The relay contacts change over and the 7p lamp is lit by the circuit through D8 and D7. The ½p lamp is lit through D9.

Thus the 70p lamp, and 7p lamp and the ½p lamp give a complete reading of 77½p.

The fact that the 15s switch and the 6d switch must both operate to bring on the 7p lamp make this an example of the classic AND gate.

COMPONENTS

The bulb holders used in this model are instrument panel indicators. If a protruding lamp is used, it is sometimes difficult to see when the lamp is on in conditions of bright sunlight; the front panel can be set back so that the sides of the case shield the lamps.

The whole instrument can incorporate a small power pack for mains operation; a 6 volt mains transformer and rectifier only is necessary. These should be capable of handling the total current consumption from the relay and the maximum number of lamps in operation at any time. The model shown here used two 3 volt batteries in series; a high capacity 6 volt battery would be equally suitable, for example type 996.

The relay can be almost any type that will operate at 6 volts and has a set of changeover contacts. Examples are Post Office type 600 or Omron type MH2. It is recommended that the coil resistance is as high as is practical to conserve battery power.

TAG STRIPS

This instrument does not lend itself to any of the modern wiring methods; that shown in the diagram uses long tag strips between the switches.

It is important to make sure that the diodes are connected correctly. The end with the coloured spot or band corresponds to the cathode and is shown on the circuit diagram with a + sign. Relay contacts RLA1 are shown in the non-operative position.

The layout of the instrument with component positions is shown in Fig. 3. It is not essential to follow this rigidly. The drilling details of the front panel will depend on the sizes of the lamps and switches; it should not be beyond the ingenuity of the constructor to arrange these as he chooses. ★

MAKING THE MOST OF LOGIC IC's

PART TWO—By R. W. COLES

PRACTICAL RTL DICE

ARMED with the basic facts of RTL from Part 1, we can now consider a simple "novelty" application, an electronic dice unit, which will take the place of the usual cube of dots used in so many games of chance.

Anyone interested in RTL will find plenty to get his teeth into, as the design employs the main elements of this family as well as interface circuits and a multivibrator.

This article will describe the design of a small electronic unit which will replace the conventional playing dice.

It must be appreciated that this is intended purely as an exercise in the use of RTL; it is possible to design a more simply way of simulating dice.

The system is designed around RTL logic integrated circuits, and serves as a useful introduction to the use of these versatile devices, which are now available quite cheaply from several different advertisers in this magazine.

OPERATION OF THE SYSTEM

The operation of the system is quite simple: a free running astable multivibrator is used as the input to a binary counter, which is programmed to divide by six. The six separate states of the counter are decoded by a system of gates, and are used to illuminate six miniature lamps, only one of which will be on at a given time.

Each of the bulbs is assigned a decimal value between one and six, and the bulb which is illuminated at the end of the count represents the "up" side of the dice.

The element of chance is introduced by allowing the "thrower" to control the input to the counter by means of a push button. The multivibrator, or "clock", speed is arranged to be fast enough to prevent the eye from following the count, which will be "frozen" when the button is released.

The unit employs a total of five integrated circuits: two ML914 dual two-input negative logic NAND gates and three ML923 JK bistable flip-flops. These i.c.s are also shown as μL914 and μL923 in suppliers' lists. In addition, eight *npn* silicon bulb-driver stages, ten resistors, and two capacitors are employed.

The "clock" is made by a.c. coupling a dual gate to form a multivibrator which oscillates at approximately 1kHz, and gives a square-wave output to drive the counter. The circuit of the ML914, with the two resistors and two capacitors which set the frequency and pulse width of the output, is shown in Fig. 2.1. To enable the clock to be switched on and off, a push button switch is connected in its positive supply line.

BINARY COUNTER

The divide by six counter is formed from three JK bistables, with feedback to prevent it cycling in unwanted states (because a three-stage counter would normally have eight separate states), each stage dividing by two. The "text-book" way to make a divide by six counter is to force a divide by eight counter to reset to zero when a count of seven is decoded by an AND gate. However, by using JK flip-flops, the same result can be achieved in a simpler way, with the added advantage that bulb decoding gating can also be made simpler than would be the case with a conventional binary divider.

The simplest way to set about designing a counter which is not required to divide to a binary multiple (two, four, eight, 16, etc.), is to divide the required divisor by two until the lowest odd integer is obtained. A counter, with feedback, is then designed to divide by this number, followed by (or preceded by) a number of divide by two stages, to make the final divisor up to the required number.

Our divide by six counter can be constructed by using a divide by three counter followed by one divide by two stage. A further divide by two stage would turn it into a divide by 12 counter, and so on. The advantage of using this method is that it is much simpler to arrange the feedback for resetting a divide by three counter than for a complete divide by six counter.

There is a disadvantage which could be important in some other applications, the counter outputs are not in the natural binary code, as can be seen from the truth tables of the two types of counter discussed (see Fig. 2.2).

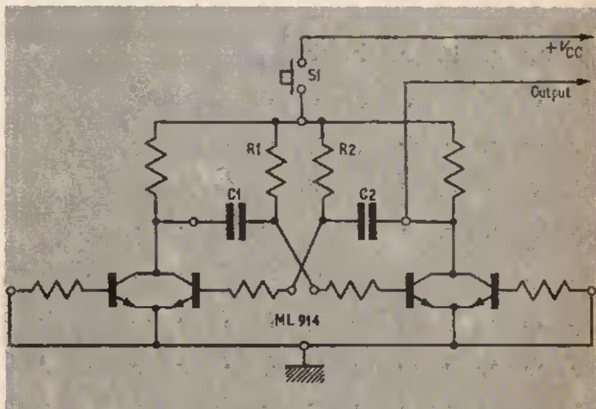


Fig. 2.1. Clock pulse generator made up from two 2-input NAND gates with C1, C2, R1 and R2 added to make up an astable multivibrator. R1 = R2 = 1kΩ. C1 = C2 = 0·68μF

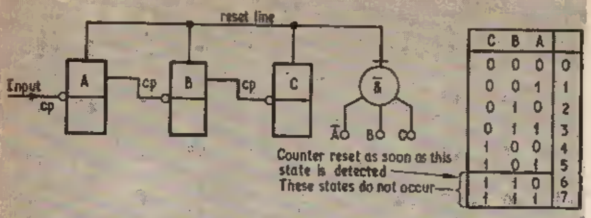


Fig. 2.2a. Conventional ÷6 counter

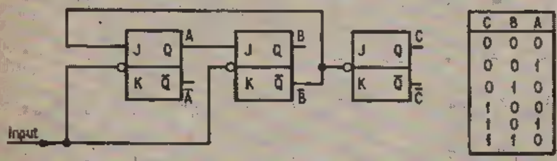


Fig. 2.2b. This ÷6 counter is used in the dice system

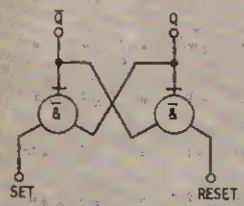


Fig. 2.3a. Simple latch bistable

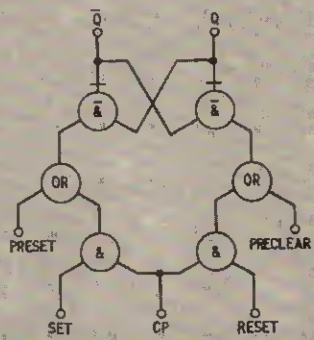


Fig. 2.3b. Shift register bistable

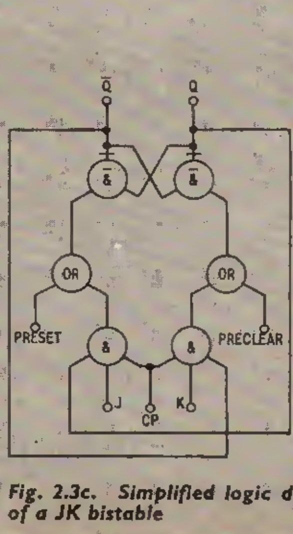


Fig. 2.3c. Simplified logic diagram of a JK bistable

VERSATILE JK

Perhaps it might be as well to consider the way in which the JK has developed to become the "do-anything" device, suitable for use in memory circuits, shift registers, and various forms of counters, used in logic circuitry today.

The simplest form of bistable is the set/reset or latch, which is formed simply from two NAND or NOR gates, as in Fig. 2.3a. The inputs to this circuit must be complementary, and there is no provision for a clock input, so its use is limited and confined to simple memory applications.

The first step in improving the set/reset type is to add AND gates to the inputs, enabling information to be gated in synchronism with a clock pulse, which is common to both gates. The asynchronous inputs of the simple latch can be retained if required by adding an OR gate between the bistable and the AND gates. A circuit of this type is shown in Fig. 2.3b.

This is a useful circuit which may be used in shift registers, but the inputs must still be complementary to ensure proper operation. To enable the circuit to be self-complementing, feedback can be provided from the collector outputs of the bistable to the inputs of the AND gates, ensuring that if two "ones" are present at the inputs of the AND gates, the bistable will change state. This circuit is the basis of the JK flip-flop, and is shown in Fig. 2.3c.

It must be appreciated that this is a simplified representation, and there are some problems which have not been considered in this treatment.

DICE COUNTER

The complete logic system of the electronic dice is shown in Fig. 2.4. A divide by three synchronous counter is made up from the JK flip-flops A and B. The third JK flip-flop C is a divide by two stage. The complete counter conforms to the truth table given in Fig. 2.2.

The decoding of the six separate states of the counter is likely to appear very complicated to those unfamiliar with the "dodges" which are often used in this type of circuitry. A knowledge of Boolean algebra is necessary to design such circuits, but a simple explanation will be given here. By using this in conjunction with the truth table a constructor should be able to sort out exactly what is going on.

The transistors used to drive the bulbs are also used as a form of AND gate. This is possible as a transistor requires both that its base be taken positive, and that its emitter be grounded, before it will turn on, assuming *npn* transistors are used.

Therefore, if we let bistable C control the grounding of the emitters of the bulb drivers, we can see from the truth table that output C is down for three counts. Output $\bar{C}$ is down for the other three counts, enabling the emitters of bulb drivers 1, 2 and 3 to be connected together and ground them through another transistor, whose base is controlled by the $\bar{C}$ output. Drivers 4, 5, and 6 can be similarly controlled by the C output.

Having dealt with the C bistable, A and B can be decoded having gone through two complete counts of three in any count of six. The bases of drivers 1 and 4, 2 and 5, 3 and 6 can be connected together in pairs and driven from the decoded states, which represent the three separate states of bistables A and B.

The decision as to whether 1 or 4, 2 or 5, 3 or 6 is illuminated is carried out by bistable C, switching on only one emitter of each pair.

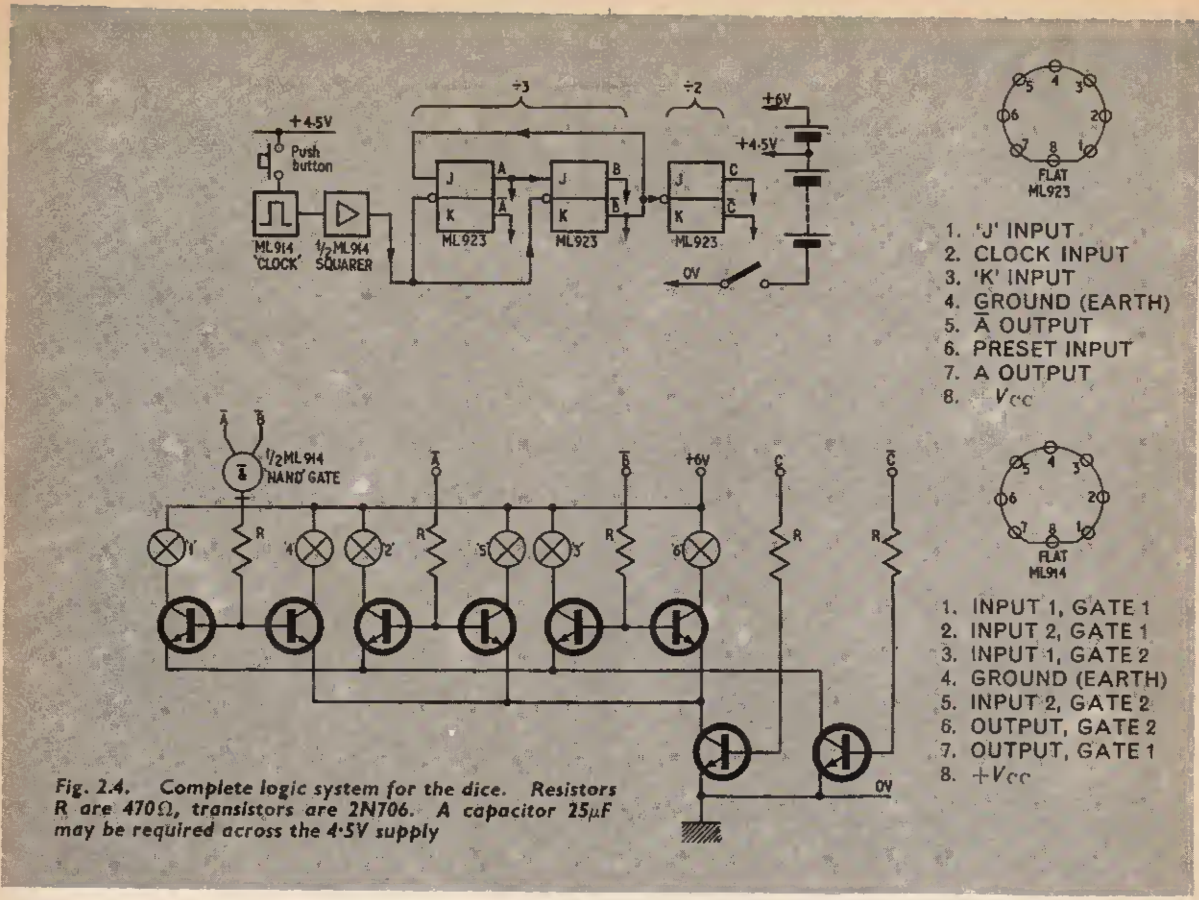


Fig. 2.4. Complete logic system for the dice. Resistors R are 470Ω, transistors are 2N706. A capacitor 25μF may be required across the 4·5V supply

The decoding of each of the three states of A and B is rendered simple by the type of counter employed. The first state has to be described in terms of A and B, but states 2 and 3 are described merely by deciding whether the A output or the B output is "up". A gate is only necessary to decode counts 1 and 4; counts 2 or 5 can be driven by the NOT output of bistable A, as this is positive only during these two states. Similarly, counts 3 and 6 can be driven by the $\bar{B}$ output.

The gate used to decode the first stage of the counter uses half of an ML914, used as a 2-input negative logic NAND gate, its inputs being A and $\bar{B}$, which are both negative at a count of one only.

As a bit of light relief, let us see what has happened to the spare half of the ML914, left over from the decoding circuit. It is in fact being used as an amplifier, with both its inputs connected together, to square up the edges of the clock waveform.

This is necessary, as the JK flip-flop needs a very fast negative edge on the clock input, for it to operate correctly; our clock multivibrator cannot be relied upon to produce such edges.

PRACTICAL DETAILS

This completes the circuit description, except for a few practical details. The supply voltage used poses a bit of a problem, the RTL i.c.s. specified are designed for a supply voltage of 3·6 volts. Since this is not easily obtained from dry batteries, a compromise is used of 4·5 volts, and an extra cell is used to boost this to 6 volts for the bulb circuitry.

The bulbs used must be low consumption types, requiring in the region of 50mA at 6V. Although they will be slightly under-run, due to the saturation voltages of the two driver transistors appearing in series with each of them, this is not a bad thing from the point of view of reliable readout.

The actual layout of the circuit can be safely left to the constructor, as there are no special problems involved, but perhaps a few hints would be useful. There are several kinds of perforated baseboard suitable for the support of this kind of circuit on the market. Veroboard is one which can be used for this particular application.

Using this type of board in the 0·1in matrix size the integrated circuits can be directly inserted, but due to the component density, a good deal of the connections will have to be made using "jumper" wires to realise a compact unit.

The i.c. leads can be left at least ½in long, if desired, but to be sure of re-use of the i.c.s, Lektrokit board can be used. In this case a ring of terminal pins can be used for the i.c.s, which can be mounted upside down on the board, wiring being carried out underneath.

A miniature soldering iron is a virtual necessity when working on this sort of layout, unless the constructor possesses a very steady pair of hands.

The completed unit can be accommodated in a small plastics box, the only controls being the on/off switch, the push button, and a row of six miniature lamp holders.

Next month's article in this series will look into Diode Transistor Logic or DTL.

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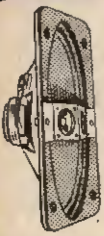

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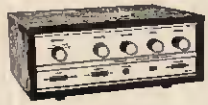

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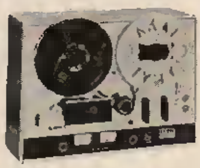

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TRANSISTOR D.C. MULTIMETER

By W. CLELAND

IN this, the final part of the "Transistor D.C. Multimeter", we give mounting details of the components and boards inside the diecast case, final wiring details and setting up instructions.

CASE DETAILS

The multimeter is housed in a diecast case of outside dimensions $8\frac{3}{4}$in × $5\frac{3}{4}$in × $2\frac{5}{32}$in. The box is used upside down, since the screws of the lid prevent the lid from being used as the top panel. The lid, therefore, becomes the underside of the instrument, to which four rubber feet are screwed, and the bottom of the box makes a satisfactory top panel. Top panel dimensions are $\frac{1}{16}$in less than the overall dimensions, because, with a diecast box, the sides taper slightly inwards. When drilled, as in Fig. 9, the case is painted to protect it; paint has to be removed from openings and from the edges and interior of the case when dry.

The neon signal lamp is mounted just under the edge of M1 and is raised $\frac{1}{8}$in, by fitting a piece of black Bakelite under it as shown in Fig. 10. This is positioned on the top panel between the milliammeter and the Perspex switch escutcheon. On final assembly, the signal lamp is fastened from the inside, by pushing on a spire nut, over the plastic lampholder.

SWITCH ESCUTCHEON

The Perspex switch escutcheon is shaped to fit between the signal lamp and terminals, and is dimensioned as shown in Fig. 11. Two $\frac{3}{4}$in diameter holes enable it to fit around the nuts securing the range switches, and it is held in place by two 8B.A. countersunk screws. These are situated under the knobs of the range switches.

To set the switch knobs accurately, a small depression has to be drilled in the shaft for the grub screw. The smooth end of the grub screw can be scored with a file, so that the grub screw will leave a mark on the shaft at the required position. An indentation is made on this spot with a small drill.

NOTE: It is recommended that a suitable meter be obtained before drilling the box. Modifications to layout and drilling may be necessary to accommodate other meters such as the MR-65P

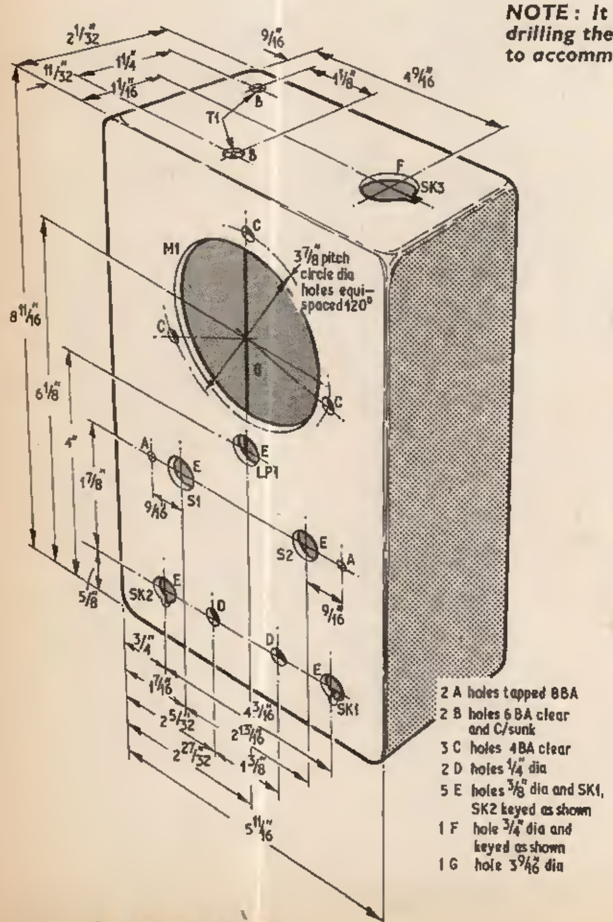


Fig. 9. Case drilling details

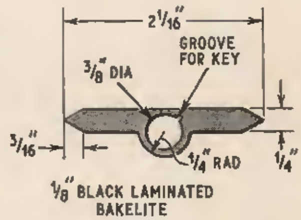


Fig. 10. Signal lamp surround

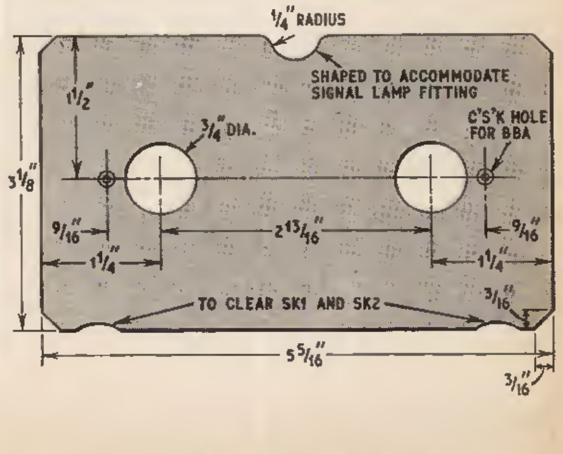
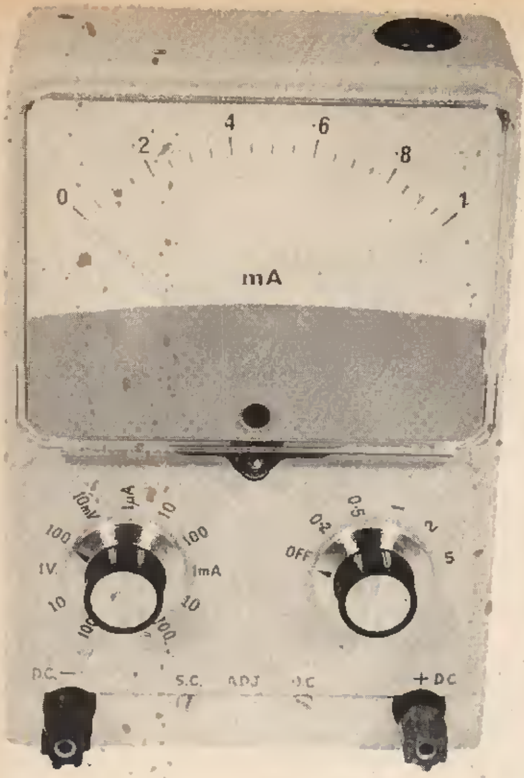
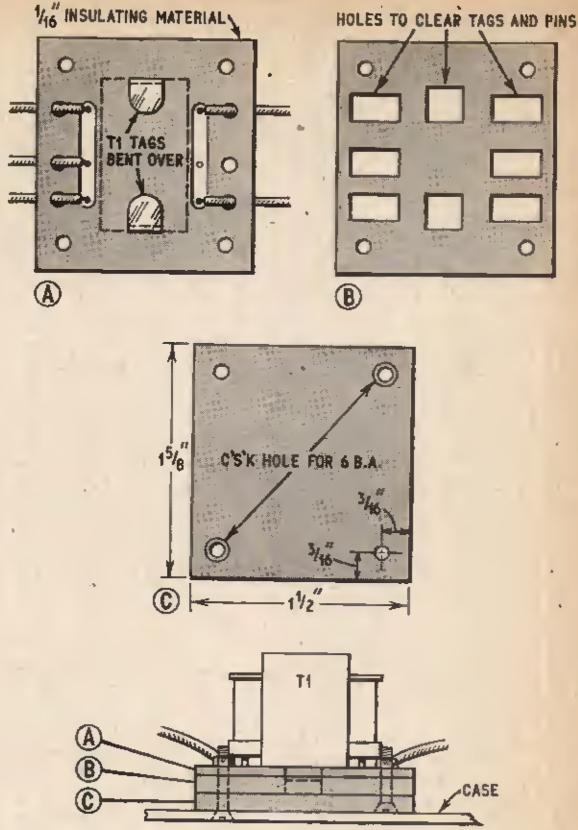


Fig. 11. Perspex switch escutcheon





Adequate clearance has to be ensured between the knobs and the Perspex escutcheon. The escutcheon can be marked, as shown in the photograph, to give switch positions and potentiometer designations.

MAINS WIRING

The metal case of the testmeter has to be earthed to the mains earth via SK3. *The circuit of the testmeter is in no way connected to the metal case or to mains earth.*

The insulated mounting for the miniature mains transformer T1 (Fig. 12) insulates it from the metal case, and provides a junction box for the transformer connections. The p.v.c. insulation of the connecting leads is carried into the insulated mounting, which consists of three rectangular pieces of insulating material sandwiched together. Parts B and C are of $\frac{1}{8}$in laminated Bakelite, and can be bonded with adhesive. These are bolted at two corners to part A, which is of $\frac{1}{16}$in material. A pair of 6 B.A. countersunk bolts at the other corners, secure the mounting to the inside of the case.

The insulated leads from the signal lamp are hardly long enough to reach the mains switch S26, and to avoid running these wires very close to the range resistors, it is necessary to increase the length of the existing leads.

Details are given in Fig. 13 of a special insulated cover for the mains switch, which ensures safety if tests have to be made on the low voltage wiring with the unit turned on. All the mains wiring is double insulated, by wrapping each pair of p.v.c. covered wires with cloth insulation tape, avoiding an excessive thickness.

Fig. 12. Insulated mounting for T1, holes are arranged to clear transformer tags. Sections B and C are $\frac{1}{8}$in thickness Bakelite

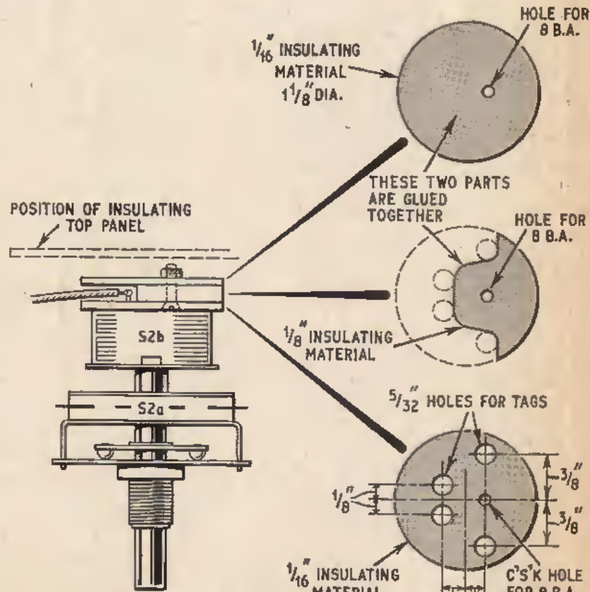


Fig. 13. Insulated cover for S2b. The lower section with the screw in position should be fitted before the wiring is connected to the switch

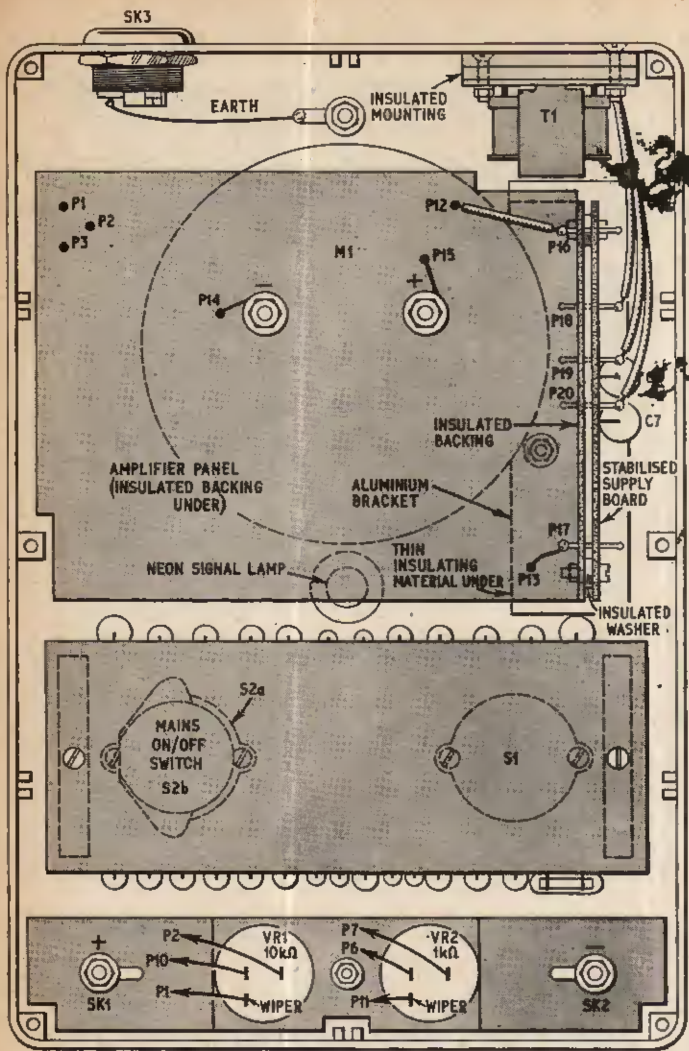


Fig. 14. Interior of the multimeter showing component positioning and potentiometer wiring

COMPONENTS . . .

Potentiometers
VR1 10kΩ miniature carbon
VR2 1kΩ miniature carbon

Sockets
SK1 Red insulated screw terminal
SK2 Black insulated screw terminal
SK3 Miniature three pin mains connector

Transformer
T1 Miniature mains, primary 0–220/240V, secondary 12–0–12V, 40mA, type P9005 (Electroniques)

Meter
M1 Moving coil milliammeter, B.P.L. type S40–V1 (1mA f.s.d.) *or* SEW type MR-65P

Miscellaneous
LP1 Neon signal lamp type SGF9/A (Electroniques)
Knobs pointer (2 off)
Diecast case $8\frac{3}{4}$in × $5\frac{3}{4}$in × $2\frac{5}{32}$in
Bakelite; $\frac{1}{8}$in thickness, $5\frac{7}{16}$in × $3\frac{1}{8}$in,
$\frac{1}{16}$in thickness 4in × $1\frac{1}{2}$in,
$\frac{1}{8}$in thickness black $2\frac{1}{16}$in × $\frac{1}{2}$in
Perspex $3\frac{1}{8}$in × $5\frac{5}{16}$in × $\frac{1}{8}$in thickness
6B.A. and 8B.A. fixings

CONNECTING UP

The Veropins on the amplifier board are connected up with reference to the pin numbers on the circuit diagram (Fig. 2), the switch connection diagram (Fig. 8), and Fig. 14, the plan of the interior of the multimeter. The two Veropins adjacent to the meter terminals are connected to the terminals by short leads, and the Veropins nearest to the stabilised voltage supply, are connected to the two on the vertical panel as shown in Fig. 14. The row of Veropins on the left of the amplifier board are connected by flexible p.v.c. covered wires to the range switching assembly, and to the two potentiometers that are mounted as shown in Fig. 15 by means of strips of $\frac{1}{8}$in insulating material.

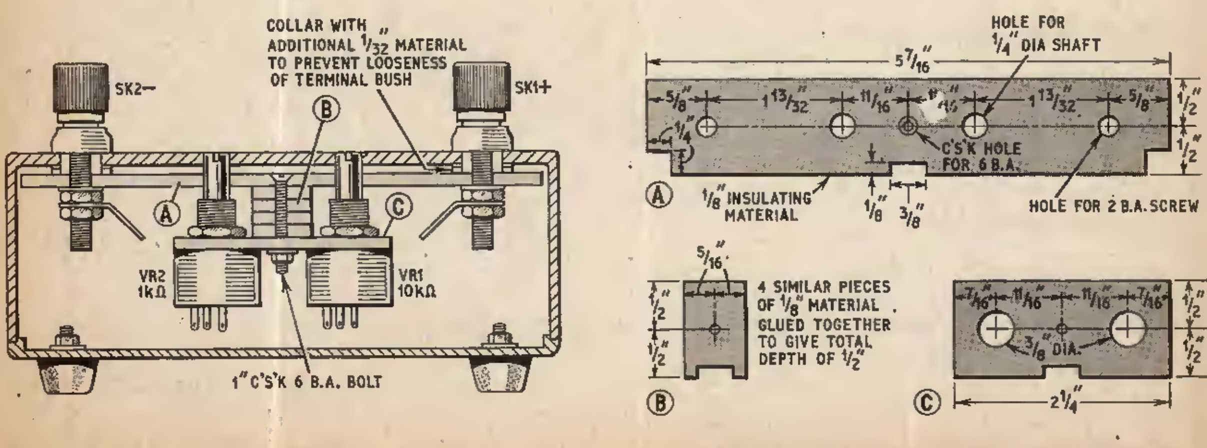


Fig. 15. Potentiometer mounting details, the ends of the spindles should be flush with the top of the case when fitted

The three secondary connections from the mains transformer are joined to the terminal pins on the voltage stabiliser panel.

Positioning of all components is shown in Fig. 14 and once the various sections have been mounted and wired up as described previously the meter can be connected to the mains supply ready for setting up and testing.

OFFSET ADJUSTMENT

A high gain differential d.c. amplifier needs pre-set adjustments to take up the mismatch in transistors and other components; adjustment is at the input stage where the sensitivity is greatest.

In the absence of an applied input, the terminals of the testmeter should be at the same potential. A small difference of potential at the input is called offset voltage, and arises from mismatch in the base-emitter potentials of the two input transistors. It can be balanced out by adjusting VR2, thus bringing the two input terminals to the same potential.

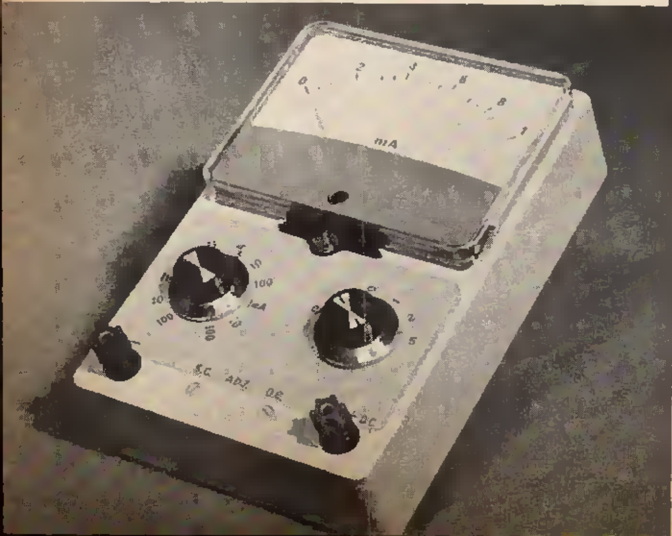
There is also an offset in the bias current of the two input transistors. The bias currents—less than a microampere—flow through the two 1MΩ feedback resistors and produce a small potential drop between output and input. The bias current adjustment is carried out indirectly by VR1 in the collector circuit of the input stage. When both offsets have been balanced out, there will be no potential difference, either at the input or at the output.

METER ZEROING

The two adjustments are not independent of each other. Each potentiometer has to be adjusted in turn to bring the pointer of the meter exactly to zero. A short insulated wire is connected between the input terminals each time that VR2 is adjusted, and temporarily disconnected when adjusting VR1. The potentiometer VR1 is thus the open circuit adjustment, and VR2 the short circuit adjustment, and the two are marked "O.C." and "S.C." respectively on the Perspex escutcheon.

Successive adjustments become smaller and should be continued on the most sensitive 2mV range until the pointer is at zero under both input conditions. The short circuit adjustment (VR2) is rather critical on the 2mV range, and it is probably advisable to solder a 470 ohm carbon film resistor permanently across it to make adjustment easier, providing that the narrower range of adjustment contains the required setting.

Once the above adjustments have been made and the meter has been tested on all ranges it is ready for use. ★



OSCILLOSCOPE CALIBRATOR

continued from page 630

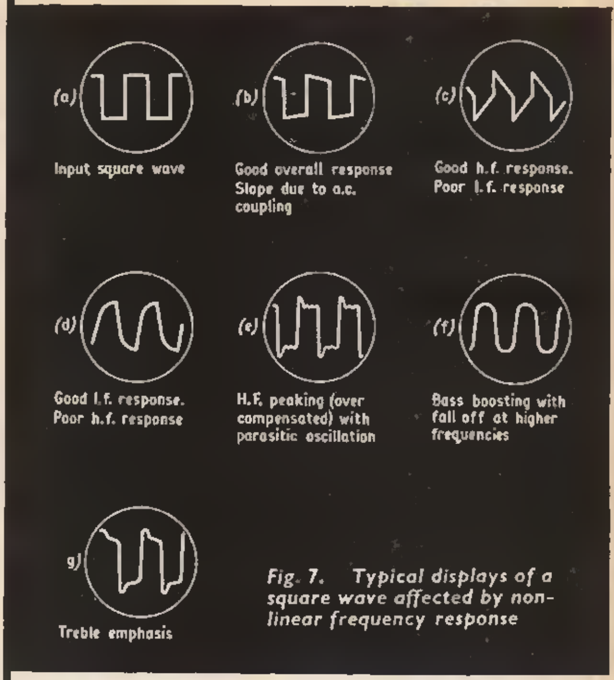


Fig. 7. Typical displays of a square wave affected by non-linear frequency response

maximum amplitude is 1 unit the average is 0·637 and this is what the meter will read.

However, we are usually more interested in the r.m.s. value which is, for sine waves, 0·707. If we divide the r.m.s. value by the average, we find the form factor, in this case 1·11. This is the amount by which the meter is scaled or calibrated. So the meter is known as average reading, r.m.s. calibrated. The form factor is obviously different for other waveforms, this calibration is therefore true only for sine waves.

AMPLIFIER TESTING

Square wave testing of amplifiers has the advantage of time saving. Plotting a frequency response curve is a tedious business. It involves changing the frequency of the signal generator point by point along the frequency base, and noting the amplifier's output reading. From this the output voltage versus frequency graph is drawn.

It is obvious that examining the effects of tone controls of an audio amplifier can be a long and dreary process. But, by applying a square wave to the amplifier input, and monitoring the output on an oscilloscope, the effects of tone controls and filters can be seen by the alteration to the wave shape. See Fig. 7.

Treble boost will show up as overshoot of the leading edge and treble cut as a rounding off. Bass boost will tilt the flat top left to right and bass cut right to left.

Checking a pre-amplifier with a square wave for the first time you may be dismayed to find that the output appears to be distorted. Even at the mid-point of the controls, the leading edge will probably display a slight kink and the top a slight curve. This is due to the type of tone control circuit which is common to many pre-amplifiers. However, the basic square shape, and the variation as the tone controls are adjusted is quite clear. ★

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PRECISION MOTORS by PULLIN
28V, 3,000 r.p.m., 0·0016 h.p.; 28V, 5,000 r.p.m., 0·0014 h.p.; each £4.10.0. P. & P. 5/-.

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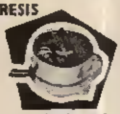
Incorporating two coils. Each coil when energised will produce opposite rotation of output shaft. 120V 60Hz. 1/10 r.p.m. 30/- each. P. & P. 3/-.

LOW TORQUE HYSTERESIS MOTOR MA23



Ideal for instrument chart drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting torque enables relative high inertia loads to be driven up to 6oz/in. Available in the following speeds and ranges: 240V 50Hz. 4 r.p.m., 2 r.p.m., 1½ r.p.m., 1 r.p.m., ¾ r.p.m., ½ r.p.m., ⅓ r.p.m., ¼ r.p.m., 1/10 r.p.m., 1/12 r.p.m., 1/20 r.p.m., 1/45 r.p.m., 1/60 r.p.m., 1/360 r.p.m. 25/- each. P. & P. 3/-.

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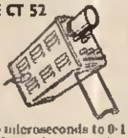

A very handy miniature portable instrument for general purpose applications. 2¾in diam. tube. Wave form investigation from 10Hz–20MHz. Pulse monitoring duration 50 microseconds to 0·1 microsecond. Time base free running 10Hz–40kHz. Also single sweep facility from 50 microseconds to 3 microseconds. "Y" Amplifier. Delay Line Calibration Voltage. Power supply 110–250V 40/60Hz. 50W. Supplied with metal carrying case. L. 13in. H. 8in. W. 5¾in. Weight 14½lb. Price £23. P. & P. 10/-.

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r.p.m.	Amp.	Approx. H.P.
875	0·83	1/16
875	1·8	1/8
875	1·19	1/12
1,275	0·82	1/16
1,300	0·25	1/50
1,300	1·27	1/25
1,300	0·44	1/30
1,300	0·27	1/50
1,300	0·25	1/50
1,300	0·91	1/20
1,600	1·47	1/7
2,500	0·72	1/20
2,600	0·45	1/30

Price 35/-. P. & P. 7/6.

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Model 7X	£15.10.0	P. & P. 7/6
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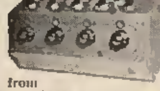

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Cold cathode gas filled in line 0–9 digital display tubes. Long life expectancy. Minimum striking voltage 180V. Side reading Type XN 13 and XN 3, amber. Price 18/6 each. P. & P. 2/6.
Fig. size 20 mm.
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These hard to get, professional recording studio units are ideal for audio signal mixing, fading programmes in and out, etc. Two bank 1,000 + 1,000 ohm wire-wound parallel connection to give 500 ohm 1W. Independent tracks fitted scale makings, with red and blue control knobs. Panel mounting. Ex-equipment. Price £3.19.6. P. & P. 7/6.

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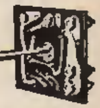
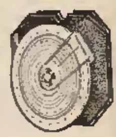


High grade full wave bridge circuit gives linear control of light brightness. Ideal for controlling room lighting and a.c./d.c. commutator motors fitted to portable electric hand drills. Fits standard 2in conduit box. 240V, 50Hz, 600W. Price 59/6. P. & P. 2/6.

POCKET CALCULATOR



Save time and solve all your multiplication, division, percentage, cube and squareroot problems. Easy to use pocket calculator with no errors. Invaluable daily aid, should last a lifetime, offered complete in black wallet with full instructions. 3½in diam. 12/6 each. P. & P. 1/6.

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CARRIAGE EXTRA

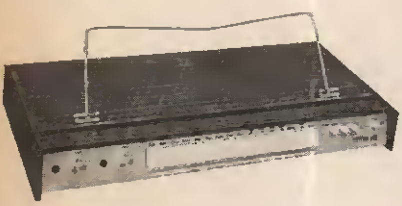
MARKET PLACE

Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned.

RHYTHM UNIT

To interest our musically minded readers this month is a versatile automatic rhythm unit to add complete accompaniment to an organ or other solo instruments.

Known as the Rhythm Ace it gives a choice of 10 different percussion tones: bass drum; small drum; conga (high and low); brush; claves;



Rhythm Ace from Severn Musical Industries

cow bell; cymbal, maraccas, and bongo. There are 16 different rhythm patterns ranging from waltzes to samba and cha-cha.

The required performance is selected by push-buttons and there are four separate cancel buttons for cutting out the cymbal, cow bell, bass drum and claves. The unit is operated by manual start or footswitch operation and a tempo or speed control, mounted on the front panel, is also incorporated.

The rythm unit is designed to play through any high impedance amplifier, retails at £147 and is available from any branch of **Selmer Musical Instruments Ltd.**, or for nearest stockist write to **Severn Musical Instruments Ltd.**, Woodchester, Stroud, Gloucester.

Another sound effect in vogue at the present time is that of reverberation. Readers who are experimenting in this field may be interested in the range of Gibbs Spring Line units from **Hammond Organ (U.K.) Ltd.** These units range from a delay time of 0·027sec large spring, 0·022sec small spring to 0·038sec large spring, 0·025sec small spring. The delay times vary from 2sec to 1·5sec

Prices and further particulars can be obtained from Hammond Organ (U.K.) Ltd., Deansbrook Road, Edgware, Middlesex.

SPEED SENTRY

The fear of prosecution for speeding and the inevitable licence endorsement which accompanies this offence is always a threat to the person who is dependent on his licence for his livelihood. The Speedset Audible Speed Indicator from **Automents Ltd.** is a worthwhile fitment for the car as it removes the necessity for constantly looking down at the speedometer to check the speed, and enables the driver to give full attention to the road.

The Speedset gives an audible alarm instantly a preselected road speed is exceeded. The selection of the required road speed is accomplished by depressing push buttons, the range available is 30, 40, 50, 60 and 70 m.p.h. or for continental use 50, 65, 80, 100 and 120 k.p.h.

The speed alarm consists of two main units, the control unit which is fitted beneath the dashboard, and a self-adhesive transducer which fixes to the back of the vehicle's speedometer and plugs into the control unit. The transducer detects the rotor speed within the speedometer and transmits this to the control unit where the actual road speed is computed and triggers the alarm if the selected speed is exceeded.

An adjustable volume control is fitted and preset potentiometers are accessible from the front panel of the control unit enabling a certain amount of speed setting variations, i.e. 30 m.p.h. can be set between 28 and 38 m.p.h.

Designed to fit any 12V positive or negative earth vehicle the current consumption is claimed to be less than a car parking light. The prize of the Speedset is £19 15s and further particulars can be obtained from Automents Ltd., New Street, Oadby, Leicester.

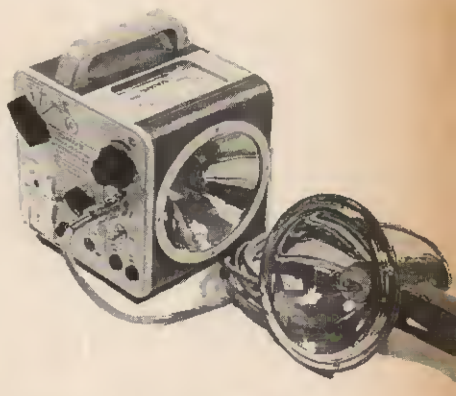
STROBOSCOPE

The latest version of the **Dawe** transistor stroboflash, type 1209C, is ideal for educational and industrial laboratories (not psychedelic).

The new model has internal modifications and additional facilities and is intended for the measurement of the repetition rate of cyclical events, or for observing such events in slow motion.

The instrument has a basic operating range from 300 to 18,000 flashes per minute in three switchable ranges. Speeds up to 180,000 rev/min can be measured by using harmonics by virtue of the very short flash duration of 5–10 microseconds, depending on flash rate. The Xenon tube used gives high-intensity white light and provides a mean illumination at 1 metre distance which increases from 50 lux on the 18,000 flashes/min range to 100 lux on the 1,800 flashes/min range. Mean flash tube power is 6W maximum.

The flash rate is controlled by a variable transistorised oscillator, which also drives the anologue frequency meter calibrated directly in flashes/min. Alternatively, an external mechanical contactor or photoelectric pick-up can be used; in both cases the flash rate is indicated on the meter.

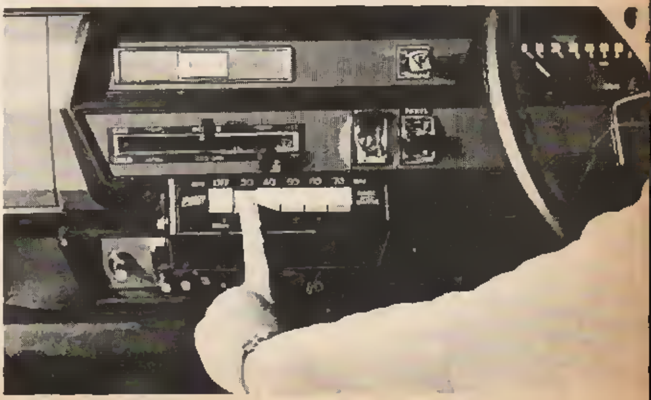


Dawe Stroboflash type 1209C

An extension lamp can be plugged in and there is now a selector switch which enables the output to be switched between the built-in and extension lamps.

Further specifications and application details can be obtained from Dawe Instruments Ltd., Concord Road, Western Avenue, London, W.3.

Speedset audible speed indicator marketed by Automents Ltd.



LOGIC TESTER

A new logic tester, designed to ease the problem of checking a digital system is being manufactured by **Southern Techniques (Electronics) Ltd.**, Waldeck House, Waldeck Road, Maidenhead, Berks.

The tester emits an audible tone, the pitch of which is high when its probes are connected to a logical "1" level, and low when its probes are connected to a logical "0" level. An open circuit condition between the probes is indicated by the absence of tones. An earphone jack is provided which disconnects the internal loudspeaker when the earphone plug is inserted.

A particularly useful feature is a built-in transient detector. With the tester switched to transient detection and the probes connected to a circuit under test, then the arrival of a logical "1" pulse causes the tester to emit a continuous tone until reset.

Logic Tester from Southern Techniques (Electronics) Ltd.

Models of this tester are available for operation from internal batteries or mains supply, and suitable for high or low voltage logic systems, prices range from £15 to £20.

DIGITAL CLOCK INDICATOR

Readers experimenting with their own designs for constructing digital clocks may be interested in the recent product introduced to the U.K. market by **ITT Component Group Europe.** It is a synchronous motor-driven digital time indicator incorporating an alarm setting mechanism. The alarm operates a changeover microswitch which permits any desired warning device to be triggered at the selected time.

The standard model operates from 240V a.c. 50Hz. Time indication is for a 12-hour clock, divided into minute intervals and the alarm graduation is for 24 hours at 10 minute intervals. The indicating numerals are white on black.

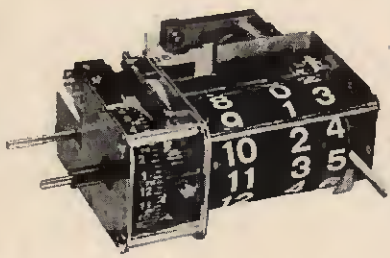
Full particulars are available from ITT Components Group Europe, Trading Services, Edinburgh Way, Harlow, Essex.

INTEGRATED CIRCUITS

A 250mW low power audio i.c. amplifier, type MFC 4000, is the first of a new range of low cost integrated circuits designed specifically for the consumer market by **Motorola Semiconductors.**

The special feature of this i.c. is that the pin spacing is wider, uses smaller chips, fewer circuit elements and is designed so that it will easily mount on the standard perforated boards. Built in a four-lead package, it is the equivalent to six transistors, three diodes and five resistors.

The transformerless output is suitable for loads up to 16 ohms and a typical harmonic distortion figure at 50mW is 0·7 per cent. The input sensitivity is 15mV r.m.s. for 50mW



ITT Synchronous motordriven digital time indicator

output. Powered by a 9V d.c. supply the quiescent current is 3·5mA.

The type MFC 4000 is designed mainly for small radios but can be used for any low power amplifier output stages.

Also in the same range is the type MFC 4010 which is a high gain wide-band amplifier that could be used either as a general purpose a.f. amplifier or as an i.f. amplifier at 465kHz.

This i.c. contains three transistors and five resistors. Typical output noise is 1mV r.m.s. and with a 18V supply the current drain is 3mA.

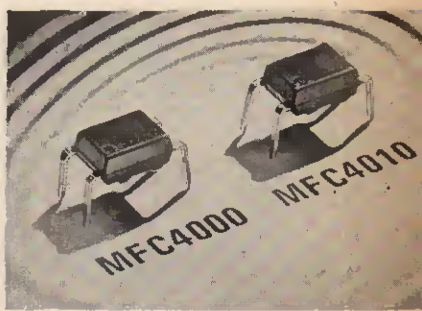
Another integrated circuit for use either as a television intercarrier sound limiter-amplifier, detector and a.f. pre-amplifier, or for a similar function in high quality f.m. stereo radio receivers and tuner units is the TAA661 from **SGS (United Kingdom) Ltd.**

At an input level of 1mV the a.m. rejection is better than 40dB. It is claimed to give good performance from a supply voltage ranging from 4·5 to 15V, with a typical quiescent current of 15mA at 12V. The limiting threshold voltage is about 100μV and remains independent of the supply voltage.

Designed to replace the conventional complementary-symmetry audio output stage, driver and pre-amplifier stages in 9V or 12V battery-operated radio receivers, record players and tape recorders, the TAA661 is capable of delivering 1W r.m.s. from a 9V supply without a heat sink.

The integrated amplifier can be directly driven from a diode detector circuit or crystal pick-up with negligible distortion. Few external components are required and bias conditions are stabilised; no pre-set resistor or setting-up procedure is necessary. Feedback is available if required by the use of one external resistor.

A 3 watt 24V version is available and is designated TAA621.



Integrated circuits from Motorola Semiconductors

LITERATURE

The new edition of the excellent **Henry's Radio** components catalogue has a new companion in the form of a special audio catalogue. Like their other catalogue the same high standard is maintained throughout and separate sections deal with amplifiers, tuners, tape recorders, record decks and accessories.

The catalogues are to be revised every three months in future.

Henry's are now expanding their business to further premises and the electronic components and equipment section is moving to 354 Edgware Road, London, W.2. The high fidelity section, with four demonstration rooms, to 356 Edgware Road, and the store at 309 Edgware Road is to become the electronic organ department coupled with public address and discotheque equipment.

The existing premises at 303 Edgware Road will handle all mail order and identical sales for the time being.

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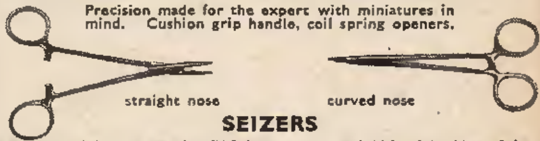

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Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99 (see note below)	100 up
C	1/20W	5%	82Ω–220kΩ	E12	18d	16d	15d
C	⅛W	5%	4·7Ω–330kΩ	E24	2·5d	2d	1·75d
C	¼W	10%	4·7Ω–10MΩ	E12	2·5d	2d	1·75d
C	½W	5%	4·7Ω–10MΩ	E24	3d	2·5d	2·25d
C	1W	10%	4·7Ω–10MΩ	E12	6d	5d	4·5d
MO	½W	2%	10Ω–1MΩ	E24	9d	8d	7d
WW	1W	10% ± 1/20Ω	0·22Ω–3·9Ω	E12	15d all quantities		
WW	3W	5%	12Ω–10kΩ	E12	15d all quantities		
WW	7W	5%	12Ω–10kΩ	E12	18d all quantities		

CODES: C = carbon film high stability low noise. MO = metal oxide Electrosil TR5 ultra low noise. WW = wire wound Plessey.
VALUES: E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades. E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

Prices are in pence each for same ohmic value and power rating, NOT mixed values. (Ignore fractions of 1d *on total resistor order.)*

INTEGRATED CIRCUIT AMPLIFIERS

SINCLAIR IC.10 complete with instruction book giving amplifier circuit details and range of applications. **59/6** nett.

PLESSEY SL403A. Only **48/6** each. 3W into 7·5Ω for 18V supply. Application data with two or more.

WAVECHANGE SWITCHES LONG SPINDLES

1P 12W; 2P 6W; 3P 4W; 4P 3W .. .. 4/9 each

SLIDER SWITCHES D.P.D.T. .. .. .. **3/-** each

NEON INDICATOR LAMPS all 200/250V

Square bezel, red only **3/9**
Round chrome bezel red, amber, clear .. .. **4/9** each
Toggle switches, 250V a.c. 1·5A. Chrome dolly and chrome milled nut S.P.S.T. **3/9**; S.P.D.T. **4/6**; D.P.D.T. **5/9**; S.P.D.T. centre off **5/-**.

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250V 20%: 0·01, 0·022, 0·033, 0·047, **8d** ea.; 0·068, 0·1, **9d** ea.; 0·15, **11d**; 0·22, 1/-. 10%: 0·33, 1/5: 0·47, 1/8; 0·68, 2/3; 1μF, 2/9; 1·5μF, 4/2; 2·2μF, 4/9.

MULLARD SUB-MIN ELECTROLYTIC

C426 range axial lead **1/3** each
Values (μF/V): 0·64/64, 1/40, 1·6/25, 2·5/16, 2·5/64, 4/10, 4/40, 5/64, 6·4/6·4, 6·4/25, 8/4, 8/40, 10/2·5, 10/16, 10/64, 12·5/25, 16/40, 20/16, 20/16, 20/64, 25/6·4, 25/25, 32/4, 32/10, 32/40, 32/64, 40/16, 40/2·5, 50/6·4, 50/25, 50/40, 64/4, 64/10, 80/2·5, 80/16, 80/25, 100/6·4, 125/4, 125/10, 125/16, 160/2·5, 200/6·4, 200/10, 250/4, 320/2·5, 320/6·4, 400/4, 500/2·5.

LARGE CAPACITORS

High ripple current types: 1000/25 **5/6**; 1000/50 **8/2**; 1000/100 **16/3**; 2000/25 **7/4**; 2000/50 **11/4**; 2000/100 **28/9**; 2500/64 **15/5**; 2500/70 **19/6**; 5000/25 **12/6**; 5000/50 **21/11**; 5000/100 **58/3**; 10000/15 **17/-**; 10000/25 **24/6**; 10000/50 **44/-**; 10000/70 **61/-**.

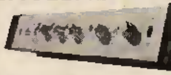
MEDIUM RANGE ELECTROLYTICS

Axial leads: 50/50 **2/-**; 100/25 **2/-**; 100/50 **2/6**; 250/25 **2/6**; 330/25 **2/6**; 250/50 **3/9**; 500/25 **3/9**; 500/50 **4/6**; 1000/25 **4/-**; 1000/50 **6/-**; 2000/25 **6/-**.

SMALL ELECTROLYTICS

Axial leads: 4·7/10, 4·7/25, 5/50, 1/- ea. 10/10, 10/25, 10/50, 33/10, 50/10, 1/- ea. 25/25, 25/50, 47/25, 100/10, 220/10, 1/3 ea.

PEAK SOUND PRODUCTS ENGLEFIELD AMPLIFIER



Build it 12 + 12 or 25 + 25

Stereo amplifier in modular kit form (including cabinet) 12 watts per channel **£38.9.0**; 25 watts **£59.15.0**. Cabinet kit only **£6**. These prices nett. As recently reviewed in Hi Fi Sound.

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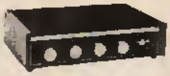

Developed from the very successful SA.8-8 amplifier giving first class stereo amplification featuring separate volume controls for each channel, bass and treble controls. 10 watts per channel into 5 to 8Ω. Kit **£19.7.6** nett.; built **£24.16.8** nett. Suitable 8Ω wide range speakers available **£13.15.0** each nett.

MAINLINE AMPLIFIER KITS

RCA/SGS designed main amplifier kits. Input sensitivity 500–700mV for full output into 8Ω.

Power	Kit price including components	Suitable unreg. power supply kit
12W	140/- nett	92/-
25W	165/- nett	N/A
40W	185/- nett	115/1
70W	210/- nett	138/10

30 WATT BAILEY AMPLIFIER KIT

Special summer reduction (to Sept. 30th, 1970, only). Sensitivity 1·2V for full output into 8Ω. Transistors for one channel **£7.5.6** list, **£6** only nett. Transistors for two channels **£14.11.0** list **£11** only nett. Capacitors and resistors (metal oxide) **20/-** per channel nett. Complete unregulated power supply kit **87/6** nett.

ZENER DIODES

5% full range E24 values: 400mW: 2·7V to 30V **4/6** ea. 1W: 6·8V to 82V **9/-** ea. 1·5W: 4·7V to 75V **12/-** ea. Clip to increase 1·5W rating to 3 watts (type 266F) **9d.**

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Double wiper ensures minimum noise level.

Single gang linear	220Ω to 2·2MΩ	2/6
Single gang log	4·7KΩ to 2·2MΩ	2/6
Dual gang linear	4·7KΩ to 2·2MΩ	8/6
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Any type with ½A D.P. mains switch, extra **2/6.**
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10% on orders for components for £5 or more. 15% on orders for components for £15 or more (No discount on nett items).

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PRICE 15/- EACH

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U6	30 Silicon Planar Transistors NPN sim. BSY95A, 2N706	10/-
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Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked

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100	5/-	6/6	10/6	12/6	50	23/-
200	7/-	7/6	11/6	15/-	100	28/-
400	8/6	9/6	13/6	18/6	200	32/-
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500	3/-	6/-	8/6	30/-
600	3/3	6/9	9/-	37/-
800	3/6	7/6	11/-	40/-
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1200	6/6	11/6	15/-	

TRIACS

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VBOM = Blocking voltage in either direction.

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