PRACTICAL

ELECTRONICS

APRIL 1969

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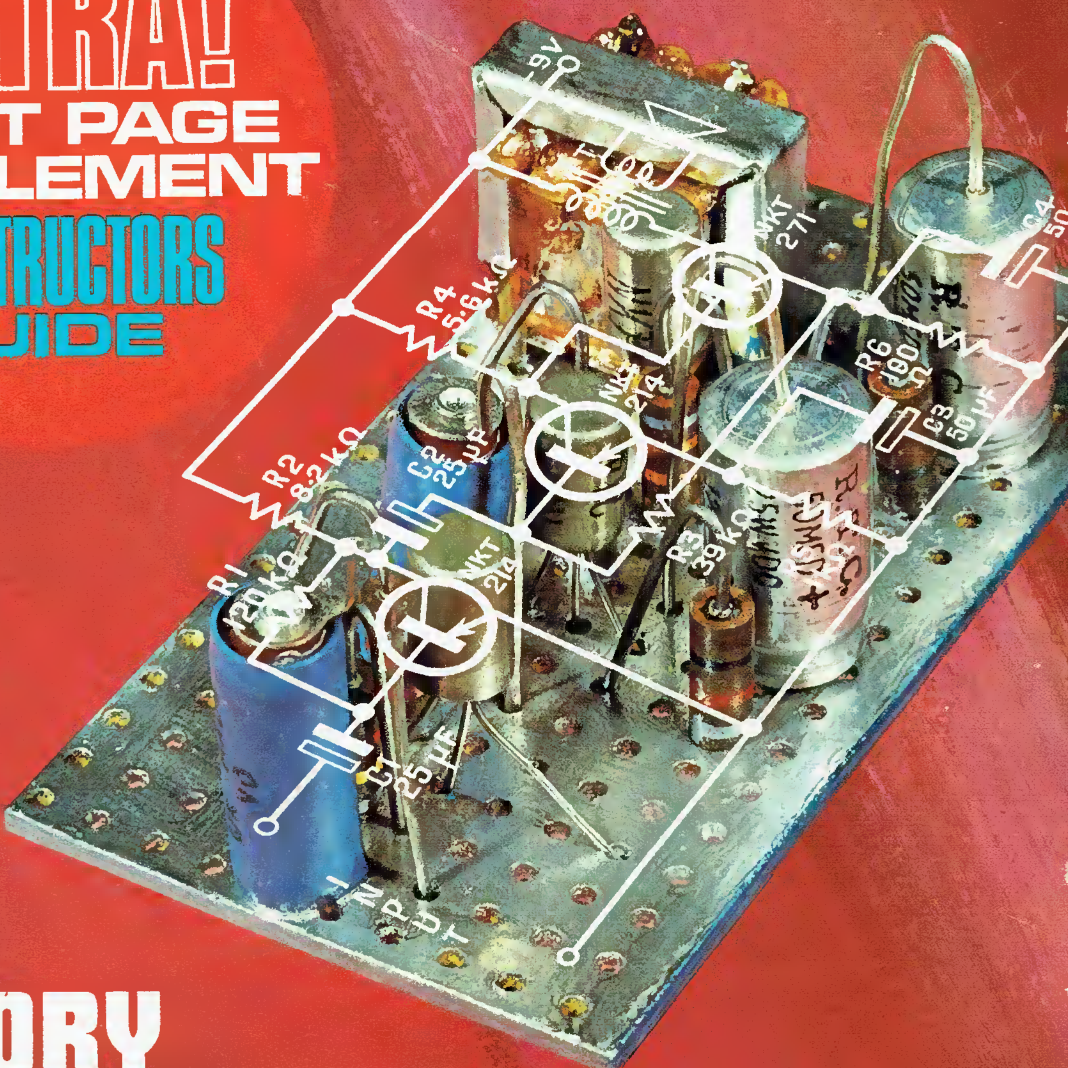
EIGHT PAGE SUPPLEMENT
CONSTRUCTORS GUIDE



THEORY into PRACTICE

ALSO

New Design- MICROPHONE MIXER

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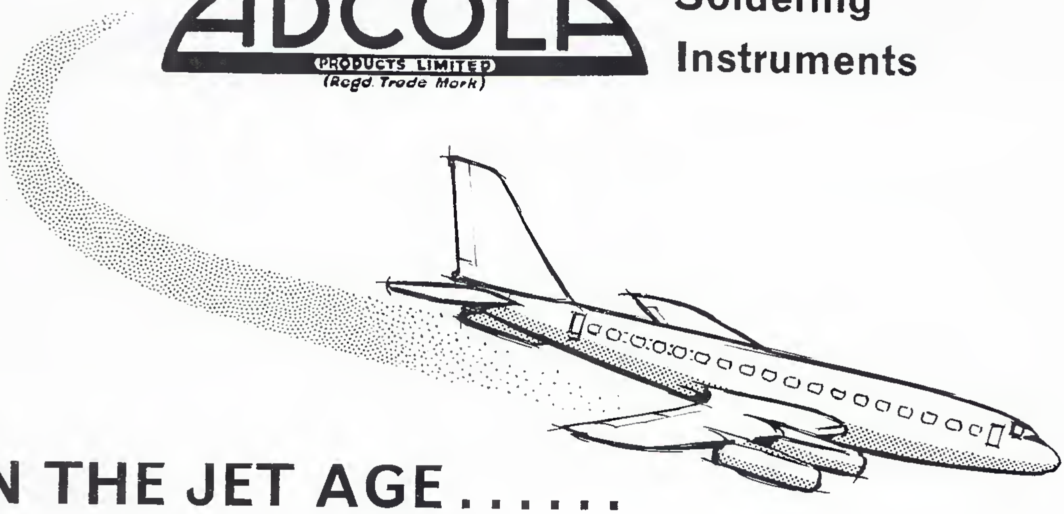
Soldering Instruments



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LASKY'S RADIO ESTABLISHED OVER 36 YEARS

TCC G-1120

HEADPHONE/BOOM MICROPHONE SET

This lightweight headphone and boom microphone assembly is especially suitable for TV camera crews, communications equipment, language labs., recording studios, etc. The fully adjustable headset is extremely comfortable to wear for long periods. Low impedance microphone allows long cables to be used without any signal loss. Used with a Tape Recorder this assembly will provide constant monitoring. High quality specification and superb finish at a price you can afford.
Headset spec.: Dynamic impedance 16 ohms. Frequency res. 20-14-1000Hz. Input 200mW. Cord length 59in with jack plug fitted. Mic. spec:. Impedance dynamic 200 ohms. Frequency res. 200-8000Hz, sensitivity 75dB. Cord length 69in complete with jack plug.

LASKY'S PRICE £6.5.0 Post 2/6

FANTAVOX 500

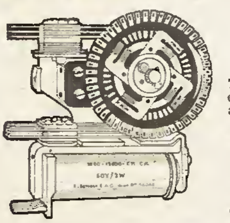
12 WATT STEREO AMPLIFIER

This outstanding amplifier incorporates all the features expected of an expensive unit but at a budget price. The amplifier has separate tone and volume controls for both channels plus stero mono switch and tuner output socket. Finished in an attractive walnut grained metal cabinet with anodised pale gold metal front panel. Brief spec: 12 transistors, 2 silicon diodes. Output, Peak power 12 watts (6 watts per channel). Freq. Response: 40-20,000 Hz, Output impedance 4-16 ohms. Input sensitivity. Phono/Tuner 250mV. Size: 9¼ × 3¼ × 5¼in.

LASKY'S PRICE £12.10.0 Post 5/-

SPECIALIST RELAYS

SCHRACK 4 POLE 12 WAY

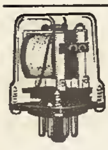


This stepping relay inches one step per pulse of the coil, contacts are provided for continuous stepping and 2 pole changeover at position "6" Uses include programming Christmas tree lights, selection of stations on multiway intercom systems (using standard 2 way intercoms), Servo steering of radio control models. Automatic operation of model railways, etc.

Type RT 319600 60V - 2W coil **OR** Type RT 319120 12V - 2W coil

LASKY'S PRICE 59/6 each Post 2/6

THORN PYGMY PLUG-IN RELAY



A miniature 8 pin plug-in relay with 10A double changeover configuration. Mains operated coil switched for internal powered remote mains switching, using one contact as a latch to hold the relay in until the external circuit is broken. Coil resistance 82K/ohms, 200-240V AC/DC operation.

LASKY'S PRICE 12/6 Post 2/6

AEI MINIATURE RELAY

A miniature shrouded 3 pole "make" relay of the chassis mounting type. DC coil resistance 900 Ω 24V operation. Useful for remote Audio switching circuits, control systems, using low voltage and current, controlling small D.C. motors and pilot lights, etc., and any application switching three circuits from one switch.

LASKY'S PRICE 8/6 Post 1/6

AD-76K MOVING MAGNET CARTRIDGE

New high compliance moving magnet stereo cartridge that really breaks the quality/price barrier. SPECIFICATION: Diamond Stereo LP stylus. Compliance 10×10^{-6}cm/dyne. Frequency response 20-20,000c/s. Channel separation 20dB. Output 5mV. Tracking pressure 2 grammes. Standard ½in mounting. Replacement Diamond stylus available. Fully guaranteed.

LASKY'S PRICE 90/- Post 2/-

NEW TTC Model A-1008 BUDGET FM TUNER

For size, quality and price we feel sure the Model A-1008 FM Tuner is unbeatable. Probably the world's most compact FM tuner with 6 transistor and 3 diode printed circuit, self powered—operating from any 9V D.C. source. Slow motion tuning drive. Housed in beautifully finished walnut cab net with classic silver trim. Clear horizontal tuning scale covering the entire FM band .88-108 Mc/s. Complete with FM aerial. Brief Spec.: aerial imp. 75 ohms. Sensitivity better than 10uV (at 100% modulation for 20dB S/W). Size 7½ × 5 × 3¼in.

LASKY'S PRICE £9.19.6 Post 3/6

ADD MULTIPLEX TO THE MODEL A-1008

You can enjoy stereo sound with the Model A-1008 FM Tuner above by adding the TTC Model A-1005M Multiplex Adaptor. Brief Specification: MPX input sensitivity 100mv. Output 150mV. Self powered by a 9V battery. 4 transistor and 6 diode circuit. Size 5¼ × 2 × ¾in. Also suitable for use with other FM tuners with MPX input.

LASKY'S PRICE 99/6 Post 3/6

NEW INTERNATIONAL TAPE

FAMOUS AMERICAN MADE BRAND TAPE at RECORD LOW PRICES

3in.	Message tape, 150ft.	2 6	5¾in.	Standard play, 850ft. PVC	11 6
3in.	Message tape, 225ft.	3 9	5¾in.	Long play, 1200ft. Mylar	15 0
3in.	Message tape, 300ft.	7 6	5¾in.	Triple play, 2400ft. Mylar	45 0
3¼in.	Triple play, 600ft. Mylar	10 0	7in.	Standard play, 1200ft. Acetate	12 6
4in.	Triple play, 900ft. Mylar	17 6	7in.	Standard play, 1200ft. Mylar	12 6
5in.	Double play, 1200ft. Mylar	15 0	7in.	Long play, 1800ft. Mylar	19 6
5in.	Long play, 900ft. Acetate	10 0	7in.	Double play, 2400ft. Mylar	25 0
5in.	Standard play, 600ft. PVC	8 6	7in.	Long play, 1800ft. Acetate	15 0
5in.	Triple play, 1800ft. Mylar	35 0	7in.	Triple play, 3600ft. Mylar	50 0
5¾in.	Double play, 1800ft Mylar	22 6			
5¾in.	Long play, 1200ft. Acetate	12 6			

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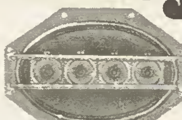

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8" × 5" 19/6,
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3" 9/6, 5" 14/6,
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Post and Packing 1/6

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2	15	1/6	25	10	1/6	100	50	2/6
2	350	2/0	25	25	1/6	125	4	1/6
2·5	16	1/9	25	50	1/6	200	16	2/-
4	15	1/6	32	15	1/6	250	25	2/9
4	40	4/9	32	40	1/6	250	50	3/9
4	350	2/3	32	450	1/6	320	10	1/6
5	15	1/6	40	6·4	1/6	400	16	2/9
6·4	6·4	1/9	40	16	1/6	500	6	2/6
8	18	1/6	50	12	1/6	500	25	3/9
8	40	1/6	50	15	1/6	500	50	4/9
8	450	3/-	50	25	1/6	640	16	3/6
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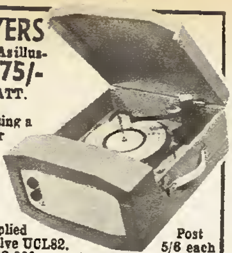
DE LUXE PLAYERS



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		3000 Stero/Mono	£12.19.6

All fitted LP/78 stylii and mono pickup crystal complete. Stereo/mono pickups 20/- extra except UA70 and 3000.

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PICK-UP ARM Complete with ACOS LP-78 GP67 Stylii 29/6; XTAL GP67 17/6; Stereo Ceramic 35/-. Powerpoint 56 15/-

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1½ × ⅜in. 6/6; ACOS 1½ × ⅜in. 8/6. BM3, 1" dia. 9/6
MOVING COIL MIKE with Remote Control Switch 19/6

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I.F. P50/2CC 470 kc/s	5/7	Printed Circuit, PCA1	9/6
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Telescopic Chrome Aerials 6in. extends to 23in. 5/-.
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Long spindles. Midget Size 5 K. ohms to 2 Meg. LOG or LIN. L/S 3/-. D.P. 5/-. STEREO L/S 10/6, D.P. 14/6. 5K. S.P. Edge type, 5/-.

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PINS 36 per packet 3/4. FACE CUTTERS 7/6.
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Q MAX CHASSIS CUTTER

Complete: a die, a punch, an Allen screw and key

½in. 16/-	⅞in. 17/6	1⅛in. 19/6	1½in. 24/-	2$\frac{3}{32}$in.	44/3
⅝in. 16/-	1in. 19/6	1¼in. 20/6	1¾in. 29/-	2½in.	57/3
¾in. 16/9	1$\frac{1}{16}$in. 19/6	1⅜in. 21/6	2in. 39/-	1in. sq.	36/6

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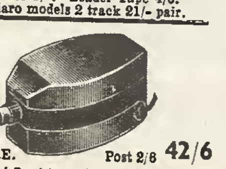
5" reel, 900' with LP strobe markings. also cine light deflector-mirror for synchronisation. 14/- each.
UNIVERSAL TAPE CASSETTES C60. OUR PRICE 14/-.

Tape Spools 2/6. Tape Splicer 5/-. Leader Tape 4/6.
Reuter Tape Heads for Collaro models 2 track 21/- pair.

'THE INSTANT" BULK TAPE ERASER AND RECORDING HEAD DEMAGNETISER



200/250 v. A.C. Leaflet S.A.E. Post 2/6 **42/6**

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Attractive Slim PLAYER CABINET with B.S.R. Stereo Autochanger 4 + 4 AMPLIFIER and TWO matched LOUDSPEAKERS. Carr. 10/6 **£19.19.6**
(Only 4 pairs of wires to join).

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25/25V	1/9	16+16/450V	4/3	60+100/350V	11/6
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250V RECTIFIERS. Selenium ½ wave 100mA 5/-; BY100 10/-.
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5 watt	0.5 to 8.2 ohm 3 w.	2/-
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250-0-250 50 mA. 6.3 v. 2 amps, centre tapped	19/6
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MIDGET 220 v. 45 mA., 6.3 v. 2 a. 2½ × 2½ × 2in.	17/6
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2 p. 2-way, or 2 p. 6-way, or 3 p. 4-way 4/6 each.
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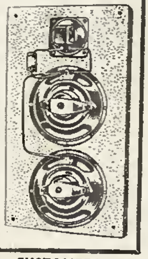
MINI-MODULE LOUDSPEAKER KIT

10 WATT **55/-** CARR. 5/-



Triple speaker system combining on ready cut baffle. ½ in. chipboard 15 in. × 8¾ in. Separate Bass, Middle and Treble loudspeakers and crossover condenser. The heavy duty 5 in. Bass Woofer unit has a low resonance cone. The Mid-Range unit is specially designed to add drive to the middle register and the tweeter recreates the top end of the musical spectrum. Total response 20-15,000 cps. Full instructions for 3 or 8 ohm. Teak veneered bookshelf enclosure £5.10.0 extra.

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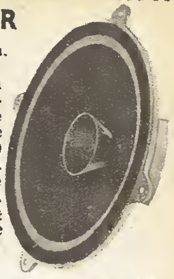

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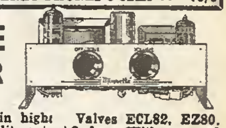

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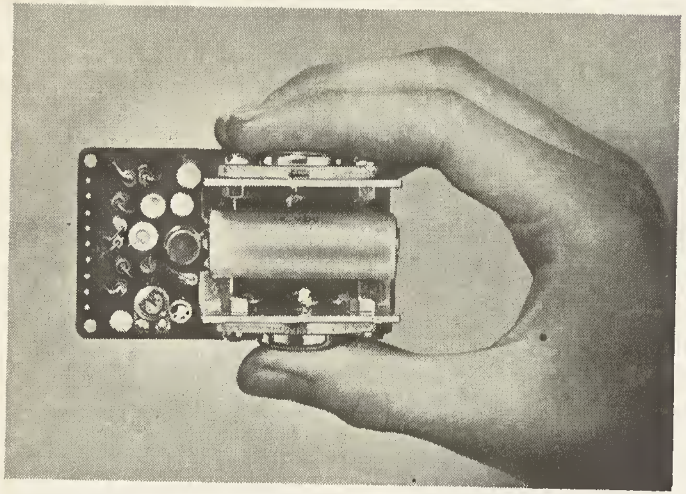
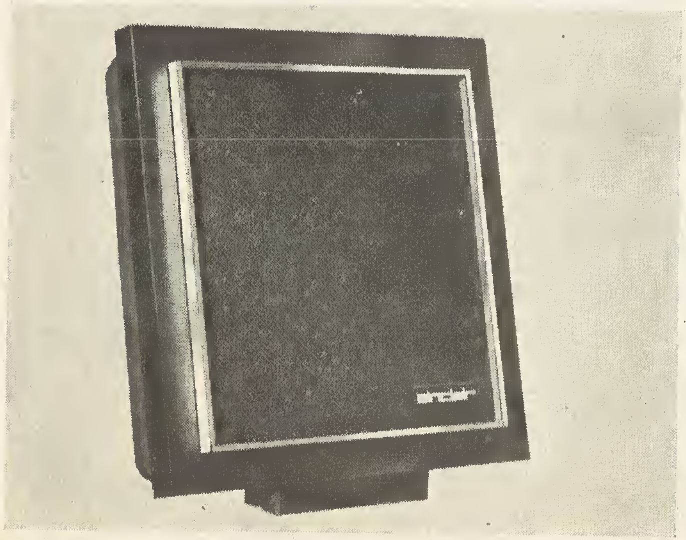


Z.12 - for all you want from any amplifier

The Z.12 is a most versatile integrated amplifier and pre-amp in which power, compactness and true high-fidelity standards are combined within a unit of very modest price. The most widely used unit of its kind in the world, the Z.12 has an output of 12W R.M.S. continuous sine wave (24W peak) or 15W music power (30W speak). It has Class B ultralinear output which can be fed into any loud-speaker from 3 to 15 ohms. (Two 3 ohm speakers can be used in parallel.) Frequency response—15 to 50,000Hz ± 1dB; input sensitivity—2mV into 2 K/ohms. The Z.12 will operate from any power source between 6 and 20V d.c. As such, a car battery or the PZ.4 are eminently suitable, giving much wider than usual scope in the applications to which the Z.12 may be put. As well as hi-fi, these include systems for P.A. electronic guitars, organs, intercom systems, laboratory, education or industry. You will find the Z.12 in use in such instances again and again. The Sinclair Z.12 is supplied ready built, tested and guaranteed, complete with manual of circuits and instructions for matching it to your precise requirements. Two may be used in stereo when, with the Stereo 25 and PZ.4 together with two Q.14s, you will have an ideal high fidelity assembly.

89/6

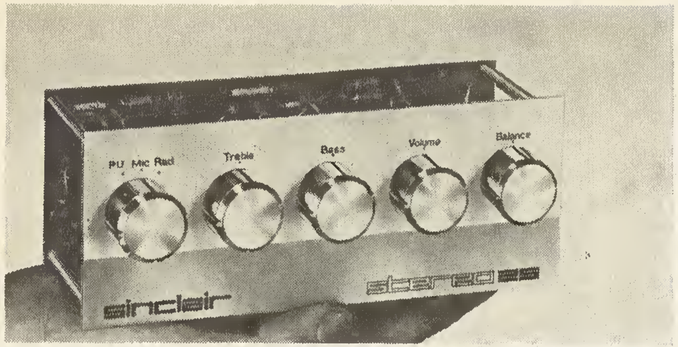


Q.14 - the unique loudspeaker

New materials and original design techniques have been used to produce speaker of fantastic quality at a most attractive price. Experts and reviewers have enthusiastically endorsed its performance. The shape and size of the Q.14 make it far more adaptable to its environment than is the case with conventionally styled speakers so that it is much easier to position this speaker in the room in which it is to be heard. The Sinclair Q.14 has a substantially flat frequency response from 60 to 16,000Hz and outstandingly good transient response. It will comfortably handle up to 14W loading and is positively brilliant in stereo. Measuring 9¾in square by 4¾in deep, this loud-speaker is finished in matt black with solid aluminium bar trim.

Try the Q.14 in your own home without delay. If you are not delighted with it, your money including cost of return postage to Sinclair will be refunded immediately.

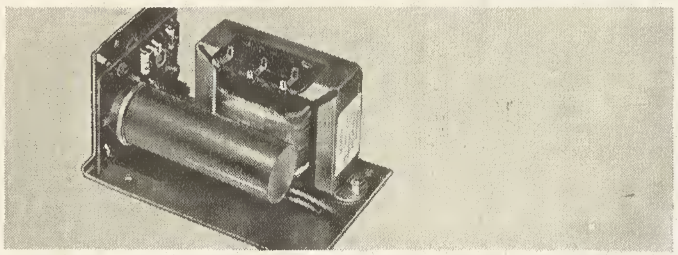
£7.19.6



Stereo 25 de-luxe pre-amp/control unit

This is a very elegantly styled unit, which, although designed basically for use with the Z.12, is readily adaptable for use with any high quality power amplifier system. The switched input selector allows for Pick-up, Radio and Auxiliary and there are controls for bass cut and lift, treble cut and lift, volume and stereo balance. P.U. input is equalised to R.I.A.A. curve from 50 to 20,000Hz ± 1dB and the instructions manual provided gives matching details for pick-ups, shows how to connect up, etc. The front panel of the Stereo 25 is finished in brushed and polished aluminium embellished in black. The control knobs are in solid aluminium to match. Size $6\frac{1}{2} \times 2\frac{1}{2} \times 2\frac{1}{4}$in plus knobs. Supplied built, tested and guaranteed.

£9.19.6



PZ.4 - stabilised power supply unit

Designed specially to meet the power requirements for an assembly of two Z.12s and the Stereo 25, this heavy duty transistorized power supply unit has stabilised output of 18V d.c. at up to 1·5A. It is for a.c. mains operation 200/250V.

Supplied built, tested and guaranteed.

99/6

SINCLAIR MICROMATIC

Whether you buy your Micromatic in kit form or built ready for use, you must not deny yourself the thrill of owning this fantastically small British receiver. Smaller than a matchbox, it has power, range and selectivity that must be experienced to be believed. The high quality magnetic earpiece supplied with the set ensures excellent reproduction indoors and out. The Micromatic tunes over the medium waveband and has A.G.C. to counteract fading from distant stations. Bandpass tuning makes reception of Radio 1 easier; in fact you will find this set performing in some cases where other sets cannot be heard at all. The Micromatic is housed in a neat black case given an elegantly modern appearance by the attractive aluminium front panel and matching tuning control.

Kit in fitted pack with magnetic earpiece, instructions and free solder

49/6

Built, tested and guaranteed, inc. magnetic earpiece

59/6

Mallor Mercury Cell type RM.675 (2 required) 2/9 each

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Frequency Response: 30–16,000Hz.
Impedance: 15-160Hm
OUR SPECIAL PRICE 97/6
PLUS P/P 6/6

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Add 5/6 p/p for each speaker set

● **BARGAIN — Speakers, Hi-Fi — The Baker Selhurst Stalwart.** 12in round, 15 watt rating, 12,000 lines gauss, 15 ohms, response 45-13,000c/s. Bass resonance 40-50c/s, solid aluminium chassis. **Our price £5.9.6. p/p 6/6**

● **BARGAIN — Speakers, Hi-Fi — The Baker Selhurst Guitar Group 25,** 12in round, 25 watt rating, 12,000 gauss, 15 ohms, response 30-10,000c/s, solid aluminium chassis, heavy duty cone. **Our price £5.9.6. p/p 6/6**

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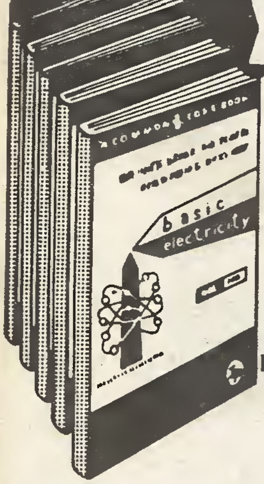

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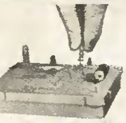

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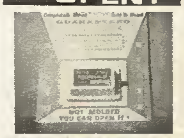

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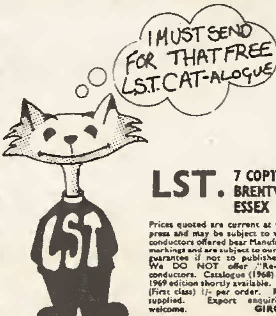

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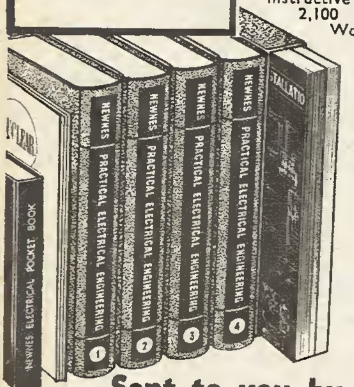

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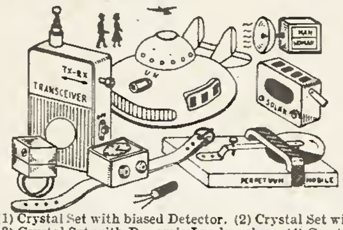

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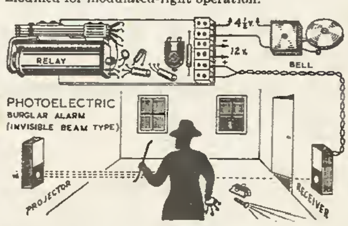

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12 PHOTOELECTRIC PROJECTS. (1) Steady-Light Photo-Switch/Alarm. (2) Modulated-Light Alarm. (3) Long-Range Stray-Light Alarm. (4) Relay-less Alarm. (5) Warbling-Tone Alarm. (6) Closed-Loop Alarm. (7) Project Lamp Stabiliser. (8) Electronic Project Modulator. (9) Mains Power Supply. (10) Car Parking Lamp Switch. (11) Automatic Headlamp Dipper. (12) Super-Sensitive Alarm.

INVISIBLE BEAM OPTICAL KIT
Everything needed (except plywood) for building: 1 Invisible-Beam Projector and 1 Photocell Receiver (as illustrated). Suitable for all Photoelectric Burglar Alarms, Counters, Door Openers, etc.
CONTENTS: 2 lenses, 2 mirrors, 2 45-degree wooden blocks, Infra-red filter, projector lamp holder, building plans, performance data, etc. Price 19/6. Postage and Pack. 1/6 (U.K.). Commonwealth: Surface Mail 2/-; Air Mail 8/-.

JUNIOR PHOTOELECTRIC KIT
Versatile Invisible-beam, Relay-less, Steady-light Photo-Switch, Burglar Alarm, Door Opener, Counter, etc., for the Experimenter.
CONTENTS: Infra-Red Sensitive Phototransistor, 3 Transistors, Chassis, Plastic Case, Resistors, Screws, etc. Full Size Plans, Instructions, Data Sheet "10 Advanced Photoelectric Designs".
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CONTENTS: 2 Lenses, Infra-red Filter, Lampholder, Bracket, Plans, etc. Everything (except plywood) to build 1 miniature invisible beam projector and photocell receiver for use with Junior Photoelectric Kit.
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Automatically turns parking lamp on at dusk, off at dawn. Protects your car. Saves the battery. Miniature construction. Simply insert in parking lamp lead. Price: 27/6. Post and Packing 2/6 (U.K.).

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Add a touch of luxury to your home. Adjust the light at parties, while watching TV, etc. Ideal for Children's bedroom. (100 watts max.) Replaces on-off switch.
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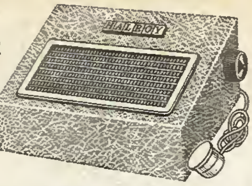
PORTABLE AMPLIFIER UNIT



By well known British Maker.

A luxury unit at a bargain price. Only 35/- P. & P.

Designed as a Telephone Amplifier but can be used in many different ways — a booster amplifier for transistor radios, a baby alarm, intercom, paging system, etc., etc. High gain four transistor amplifier unit housed in attractive leathercloth covered wooden cabinet with upward facing 3" high flux P.M., speaker covered by neat plastic grille. Fitted 3.5 mm jack socket and volume/on/off control. Size 7" × 4½" × 3½" high. Operates on standard PP6 or VT6 battery. Supplied complete with telephone pick-up induction coil fitted suction pad, lead and 3.5 mm jack plug.

Our Special price 35/- P. & P. 4/6

Or as above with 3.5 mm plug and DLR5 unit for use as sensitive microphone for baby alarms, communication systems, etc. Will operate over distances of up to 200ft or more when connected with twin flex or bell wire.

PRICE 40/- P. & P. 4/6

(Batteries and flex not included)

BRAND NEW 3 OHM LOUDSPEAKERS
5in.14/-; 6½in. 18/6; 8in.27/-; 7×4in.18/6; 10×6in. 27/6. E.M.I. 8×5in. with high flux magnet 21/-. E.M.I. 13½×8in. with high flux ceramic magnet 42/- (15 ohm 45/-). E.M.I. 13×8in. with two inbuilt tweeters and crossover network. 3 or 15 ohms 4 gns. P. & P. 5in. 2/-, 6½ & 8in. 2/6, 10 & 12in. 3/6 per speaker.
BRAND NEW. 12in. 15W H/D Speakers, 3 or 15 ohms. By well-known British maker. Now with Hi Flux ceramic ferrobar magnet assembly. £5.10.0. P. & P. 5/-. Guitar Models: 25w. £6; 35w. £8.
E.M.I. 3½in. HEAVY DUTY TWEETERS. Powerful ceramic magnet. Available in 3 or 8 ohms 15/- each; 15 ohms 18/6 each. P. & P. 2/6.
12in. "RA" TWIN CONE LOUDSPEAKER. 10 watts peak handling. 3 or 15 ohm, 35/-. P. & P. 3/6.
35 OHM SPEAKERS
3½in. 12/6; 7×4in. 21/-. P. & P. 2/- per speaker.

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QUALITY PORTABLE TAPE RECORDER CASE. Brand new. Beautifully made. Only 49/6. P. & P. 8/6.
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ACOS HIGH IMPEDANCE CRYSTAL STICK MIKES. OUR PRICE 21/-. P. & P. 1/6.
CARBON MIKE INSERTS. Brand New. 2½in. dia. 5/-. P. & P. 1/6.

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Also some similar to above but coil resistance 5,800 ohms 48 volt operation. 8/- each. P. & P. 1/6.

SPECIAL OFFER! PLESSEY TYPE 29 TWIN TUNING GANG. 400pF + 146pF. Fitted with trimmers and 5:1 integral slow motion. Suitable for nominal 470 kc/s I.F. Size approx. 2×1×1½in. Only 8/6. P. & P. 2/6.

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MAINS TRANSFORMER. Primary 200-240V two separate ½ wave secondaries giving approx. 16V at 1 amp and 20V at 1·2 amp; secs. can be connected in series for 36V at 1·5 amp. Ideal for transistor power supplies. Drop through mounting. Stack size 2¾ × 3¼ × ¾in. 15/-. P. & P. 6/-.
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MATCHED PAIR OF 2½ WATT TRANSISTOR DRIVER AND OUTPUT TRANSFORMERS. Stack size 1¼×1¼×¾in. Output trans. tapped for 3 ohm and 15 ohm output. 10/- pair plus 2/- P. & P.
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Now using Silicon Transistors in first five stages on each channel resulting in even lower noise level with improved sensitivity. A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors giving 8 watts push pull output per channel (16W mono). Integrated pre-amp. with Bass, Treble and Volume controls. Suitable for use with Ceramic or Crystal cartridges. Output stage for any speakers from 3 to 15 ohms. Compact design, all parts supplied including drilled metal work. Cir-Kit board, attractive front panel, knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification: Freq. response ±3dB. 20–20,000c/s. Bass boost approx. to +12dB. Treble cut approx. to −16dB. Negative feedback 18dB over main amp. Power requirements 25V at 0·6 amp.
PRICES: AMPLIFIER KIT £10.10.0; POWER PACK KIT £3.0.0; CABINET £3.0.0. All Post Free.
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Heavy 8½in. metal turntable. Low flutter performance 200/250 V shaded motor (90 V tap). Complete with latest type lightweight pick-up arm and mono cartridge with t/o stylii for LP/78. LIMITED NUMBER ONLY 63/-. P. & P. 6/6.

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B.S.R. UA25 with latest mono compatible cart... £6.19.6
All plus Carriage and Packing 6/6.
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PLINTH UNITS cut out for Garrard Models 1000, 1025, 2000, 3000, AT60, SP25. With rigid perspex cover. OUR PRICE 5 gns. complete. P. & P. 8/6.

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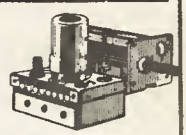
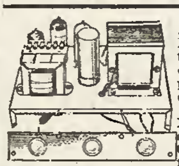
LATEST RONETTE T/O Mono Compatible Cartridge for EP/LP/78 mono or stereo records on mono equipment. 30/-. P. & P. 2/-.
FEW ONLY! ACOS GP69/1. For EP and LP 10/-. P. & P. 2/-

QUALITY RECORD PLAYER AMPLIFIER MK II
A top-quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, EZ80 valves. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 3 d. × 6 h. Ready built and tested. PRICE 75/-. P. & P. 6/-.
ALSO AVAILABLE mounted on board with output transformer and speaker ready to fit into cabinet below. PRICE 97/6. P. & P. 7/6.
DE LUXE QUALITY PORTABLE R/P CABINET MK II
Uncut motor board size 14½ × 12in., clearance 2in. below, 5½in. above. Will take above amplifier and any B.S.R. or GARRARD changer or Single Player (except AT60 and SP25). Size 18×15×8in. PRICE 79/6. P. & P. 9/6.

FM/AM TUNER HEAD



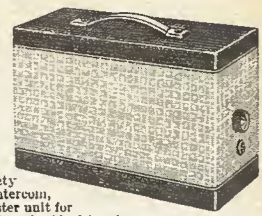
Beautifully designed and precision engineered by Dormer & Wadsworth Ltd. Supplied ready fitted with twin ·0005 tuning condenser for AM connection. Prealigned FM section covers 86–102Mc/s. I.F. output 10·7Mc/s. Complete with ECC85 (6L12) valve and full circuit diagram of tuner head. Another special bulk purchase enables us to offer these at 27/6 each. P. & P. 3/-.
GORLER F.M. TUNER HEAD. 88–100 Mc/s. 10·7 Mc/s. I.F. 15/- plus 2/6 P. & P. (ECC85 valves, 8/6 extra).



3-VALVE AUDIO AMPLIFIER MODEL HA34
Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in w.×4in. d.×4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate Bass, Treble and volume controls. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only £4.5.0. P. & P. 6/-.
HSL "FOUR" AMPLIFIER KIT. Similar in appearance to HA34 above but employs entirely different and advanced circuitry. Complete set of parts, etc. 79/6. P. & P. 6/-.

BRAND NEW TRANSISTOR BARGAINS. GET 15 (Matched Pair) 15/-; V15/10p, 10/-; OC71 5/-; OC76 6/-; AF117 7/6.
Set of Mullard 6 transistors OC44, 2—OC45, AC128D, matched pair AC128 25/-; Mullard LFH3 Audio Transistor Pack AC128D and matched pair AC128 12/6; ORP12 Cadmium Sulphide Cell 10/6. All post free.

SPECIAL OFFER!



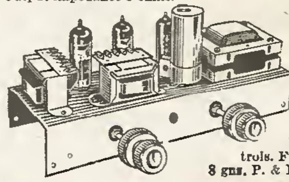
A great opportunity to purchase a first class GENERAL PURPOSE, HIGH GAIN, HIGH SENSITIVITY, PORTABLE AMPLIFIER. Completely self contained and can be used for a variety of purposes, i.e. Intercom, Baby Alarm, Booster unit for transistor radios etc., also ideal for classroom unit etc. Works perfectly with our special offer ACOS Stick Microphone (21/-). Output 1000mW. Uses standard 9 volt battery. Smart two tone carrying case size 12×4×9in. fitted standard input jack socket, volume controls, 7×4in. speaker. Completely built and tested, brand new with full maker's guarantee.

Only 79/6 POST FREE

STEREO AMPLIFIER

Incorporating 2 ECL86's and 1 EZ80, heavy duty, double wound mains transformer. Output 4 watts per channel. Full tone and volume controls. Absolutely complete. Output impedance 3 ohms.

ONLY **£5.9.6** P. & P. 8/-.



Super De-luxe version with ECL86 valves, sep. bass, treble and balance controls. Full feedback. 8 gns. P. & P. 8/-.

HIGH GAIN 4 TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT
Type TA1

● Peak output in excess of 1½ watts.
● All standard British components.
● Built on printed circuit panel size 6×3in.
● Generous size Driver and Output Transformers.
● Output transformer tapped for 3 ohm and 15 ohm speakers. ● Transistors (GET114 or 81 Mullard AC128D and matched pair of AC128 o/p). ● 9 volt operation.
● Everything supplied, wire, battery clips, solder, etc.
● Comprehensive easy to follow instructions and circuit diagram 2/6 (Free with Kit). All parts sold separately.
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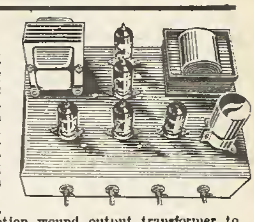
HARVERSON'S SUPER MONO AMPLIFIER

A super quality gram amplifier using a double wound mains transformer, EZ80 rectifier and ECL82 triode pentode valve as audio amplifier and power output stage. Impedance 3 ohms. Output approx. 3·5 watts. Volume and tone controls. Chassis size only 7in. wide×3in. deep×6in. high overall. AC mains 200/240V. Supplied absolutely Brand New completely wired and tested with valves and good quality output transformer. LIMITED NUMBER.

OUR ROCK BOTTOM BARGAIN PRICE 49/6 P. & P. 6/-

10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3–15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet 2/6 (Free with parts). **All parts sold separately.** ONLY £7.9.6. P. & P. 8/6. Also available ready built and tested complete with std. input sockets, £9.5.0. P. & P. 8/6.

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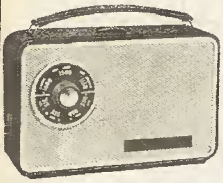
SEVEN WAVEBAND PORTABLE

7 FULLY TUNABLE WAVE BANDS—MW1, MW2, LW, SW1, SW2, SW3 and Trawler Band. Extra Medium waveband provides easier tuning of Radio Luxembourg, etc. Built in ferrite rod aerial for Medium and Long Waves. 5 Section 22in chrome plated telescopic aerial for Short Waves—can be angled and rotated for peak S.W. listening. Socket for Car Aerial. Powerful push-pull output. 7 transistors and two diodes including Micro-Alloy R.F Transistors. Famous make 7 × 4in P.M. speaker. Air spaced ganged tuning condenser. Volume/on/off control, wave change switches and tuning control. Attractive case with carrying handle. Size 9 × 7 × 4in approx. First grade components. Easy to follow instructions and diagrams make the Roamer 7 a pleasure to build.

Total building costs £5.19.6 P. & P. 7/6

Parts price list and easy build plans 3/– (FREE with parts).

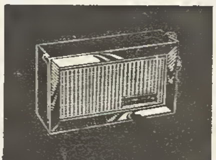
Personal Earpiece with switched socket for private listening, 5/– extra.



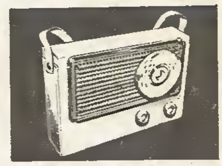
"NEW LOOK" MELODY SIX
MED. AND LONG WAVES. WITH SPEAKER AND EARPIECE

6 transistors and 2 diodes. Push-pull output, tuning condenser, high "Q" ferrite rod aerial, $3\frac{1}{2}$in speaker, and personal earpiece with switched socket for private listening, $6\frac{1}{2} \times 4 \times 2$in. **Total Building Costs 69/6.** P. & P. 4/3.

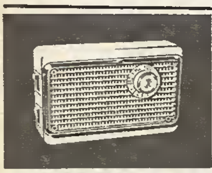
Plans and parts list 2/- (free with parts).



POCKET FIVE
MED. and LONG WAVES AND TRAWLER BAND to approx. 50 metres. *WITH SPEAKER AND EARPIECE.* 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, moving coil speaker, etc. $5\frac{1}{4} \times 1\frac{1}{4} \times 3\frac{1}{2}$in. **Total Building Costs 44/6.** P. & P. 3/6. Plans and Parts list 1/6 (free with parts).



ROAMER SIX
6 WAVEBANDS — MW1, MW2, SW1, SW2, LW AND TRAWLER BAND. 6 transistors and 2 diodes. Ferrite rod and telescopic aerials. 3in speaker. Top grade components. Size $7\frac{1}{2} \times 5\frac{1}{2} \times 1\frac{1}{2}$in. **Total Building Costs 79/6.** P. & P. 4/6. Plans and parts list 2/- (free with parts). Personal Earpiece with switched socket for private listening, 5/- extra.



TRANSONA FIVE
MED. AND LONG AND TRAWLER BAND to approx. 50 metres *WITH SPEAKER AND EARPIECE.* 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, volume control, moving coil speaker. $6\frac{1}{2} \times 4\frac{1}{2} \times 1\frac{1}{4}$in. **Total Building Costs 47/6.** P. & P. 3/9. Plans and Parts list 1/6 (free with parts).

SUPER SEVEN
MED. LONG AND TRAWLER BAND. 7 transistors and 2 diodes. 3in speaker, 2 R.F. stages, push-pull output, etc. $7\frac{1}{4} \times 5\frac{1}{4} \times 1\frac{1}{2}$in. **Total Building Costs 69/6.** P. & P. 4/6. Plans and parts list 2/- (free with parts). Personal Earpiece with switched socket for private listening, 5/- extra.

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Requires single supply between 9 and 24 Volts, drives 22 ohm loads, also compatible with 8 and 16 ohm loads. Dual-in-line package

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With single supply ideal as audio pre-amp. With two supply lines becomes economical operational amplifier. Dual-in-line package

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Very popular $\frac{1}{2}$ Watt, single supply line amplifier. DC to video. Suitable for motor control, Linear mixers, switches, etc.

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3 amplifiers in one TO-5 (multilead) package, overall voltage gain well over 1,000,000 times. Can be used as 3 separate amplifiers

G.E. 2N5306 DARLINGTON PAIR 11/6
2 transistors in one package connected as Darlington Pair. Min. $\beta = 7{,}000$ at $I_C = 2$mA (i.e. base current less than 290 Nanoamps!!). Ideal as low level, low noise input stage for pre-amps. Also $f_T = 60$MHz min.

Lead spreaders free with RCA types. Add 1/– for data sheets if required. Data sheets only 1/6 each, post free

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NPN Fast switches				
TIS44	20V	50mA	β = 20 (min)	1/9
TIS49	15V	200mA	β = 40–120	2/6
NPN Low level, low noise				
2N3707	30V	30mA	β = 100–400	4/–
2N3708	30V	30mA	β = 45–660	2/5
BC182L	50V	200mA	β = 100–480	3/3
BC183L	30V	200mA	β = 100–850	2/5
BC184L	30V	200mA	β = 250 (min)	3/2
NPN Medium power				
2N3704	30V	800mA	β = 100–300	3/9
2N3705	30V	800mA	β = 50–150	3/4
PNP Fast switch				
TIS50	12V	200mA	β = 40–150	3/9
PNP Low level, low noise				
2N4058	30V	30mA	β = 100–400	4/6
2N4059	30V	30mA	β = 45–660	3/5
BC212L	50V	100mA	β = 60–300	3/9
BC213L	30V	100mA	β = 80–400	3/9
BC214L	30V	100mA	β = 140–400	4/–
PNP Medium power				
2N3702	25V	200mA	β = 60–300	3/6
2N3703	30V	200mA	β = 30–150	3/3
N Channel FET				
2N3819	25V	10mA	9m – 2-6·5mA/V	9/–
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HIGH SPEED MAGNETIC COUNTERS (4 × 1 × 1in). 4 digit. 12/24/48V (state which) 6/6 each. P. & P. 1/-.

COPPER LAMINATE BOARD ($8\frac{1}{2} \times 5\frac{1}{2} \times \frac{1}{16}$in). 2/6 each. 5 for 10/-.

RE-SETTABLE HIGH SPEED COUNTER ($3 \times 1 \times \frac{3}{4}$in). 3 digit. 12/24/48V (state which) 32/6 each.

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100 Capacitors 50pF to 0.5μF.
250 Carbon Resistors $\frac{1}{8}$ & $\frac{1}{4}$W (Transistor types).
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100 Ceramic Capacitors 2—1,000pF.
25 Vitreous W/W Resistors (5%).
12 Precision Resistors (0.1% several standard values included)
25 Close Tolerance Caps. (2%).
12 Silicon Diodes 500 p.i.v. 750 m.a.
4 Silicon Rects. 400 p.i.v. 3 amp.
8 Silicon Rects. 100 p.i.v. 3 amp.
50 Silicon Trans. (2N706/708, BSY28/29. BCY41/42 types.) Unmarked, Untested.

ANY ITEM 12/6. ANY 5 ITEMS £2.10.0.

S.C.Rs. (Thyristors) CRS1/20 5/6; CRS1/40 7/6; CRS3/10 7/6; CRS3/30 8/6; CRS3/40 10/-; CRS3/50 12/6 each.

'3000' TYPE RELAYS (ex. new equip.) 10 for 25/- (our choice) P. & P. 5/-.

VENNER LIGHTWEIGHT ACCUMULATORS (1oz $1\frac{3}{4} \times 1\frac{5}{8} \times \frac{1}{2}$in). 1·5 Ahr 12/6 each.

COMPUTER LOGIC BOARDS containing: 14 BCZ11, 2 trimpots, diodes, etc., 20/- each.

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AC127	2/4	OC200	3/6
AC128	2/4	OC201	7/–
ACY17	3/–	2G301	2/6
AF114	4/–	2G303	2/6
AF115	3/6	2N711	10/–
AF116	3/6	2N1302-3	4/–
AF117	3/6	2N1304-5	5/–
AF118	3/6	2N1306-7	6/–
AF119	3/6	2N1308-9	8/–
AF186	10/–	2N3844A	5/–
AF139	10/–	**Power Transistors**	
BFY50	4/–		
BSY25	7/6	OC20	10/–
BSY26	3/–	OC23	10/–
BSY27	3/–	OC25	8/–
BSY28	3/–	OC26	5/–
BSY29	3/–	OC28	7/6
BSY95A	3/–	OC35	5/–
OC41	2/6	OC36	7/6
OC44	1/11	AD149	10/–
OC45	1/9	AUY10	30/–
OC71	2/6	**Diodes**	
OC72	2/6	AAY42	2/–
OC73	3/6	OA95	2/–
OC81	2/6	OA70	1/9
OC81D	2/6	OA79	1/9
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AC176	5/6	BSX19	5/6		15/6	OCP71	12/6
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Z series. All voltages from 3.9–50 volt. 250mW, 2/6 ea. 1.5w 4/- ea. 7w 5/- each.

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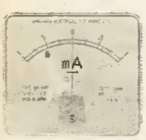

First grade quality Moving Coil panel meters available ex-stock. S.A.E. for illustrated leaflet. Discounts for quantity. Available as follows: Type MR 38P, $1\frac{21}{32}$ in. square fronts.

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		5mA	25/-	2A d.c.	25/-	15V a.c.	25/-
		10mA	25/-	5A d.c.	25/-	50V a.c.	25/-
50μA	37/6	20mA	25/-	3V d.c.	25/-	150V a.c.	25/-
100μA	35/-	50mA	25/-	10V d.c.	25/-	300V a.c.	25/-
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POST EXTRA. Larger sizes available—send for lists.

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Accurate wide range signal generator covering 120Kc/s - 260 Mc/s on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240V a.c. Brand new with instructions. **£15.0.0.** P. & P. 7/6. S.A.E. for details.

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2pF-2,000 mfd 2 ohms-200 megohms. Also checks impedance, turns ratio, insulation, 200/250V a.c.

Brand New £17.10.0. Carr. 7/6.

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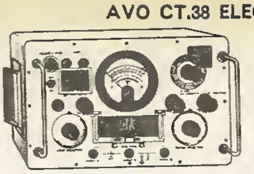

High quality 97 range instrument which measures a.c. and d.c. Voltage, Current, Resistance and Power output. Ranges d.c. volts 250mV–10,000V. (10megΩ–110megΩ input). D.c. current 10μA 25 amps. Ohms: 0–1,000mgΩ. A.c. volt 100mV–250V (with RF measuring head up to 250Mc/s). A.c. current 10μA–25 amps. Power output 50 micro-watts–5 watts. Operation 0/110/200/250V. C. Supplied in perfect condition complete with circuit lead and RF probe **£25.** Carr. 15/-.

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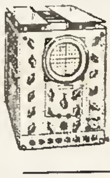

An excellent general purpose D/B oscilloscope. T.B. 2c/s–750, kc/s. Bandwidth 5·5 Mc/s. Sensitivity 33mV/CM. Operating voltage 0/110/200/250V a.c. Supplied in excellent working condition. **£22.10.0.** Or complete with all accessories, probe, leads, lid, etc. **£25.** Carriage 30/-.

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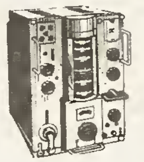

Just released by the Ministry. High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650kc/s – 30Mc/s, I/F 500kc/s. Incorporates 2 R.F. and 3 I.F. stages, band-pass filter, noise limiter, crystal controlled B.F.O., calibrator I/F, output, etc. Built-in speaker, output for phones. Operation 150/230V a.c. Size $19\frac{1}{2} \times 13\frac{1}{2} \times 16$in. Weight 114lb. Offered in good working condition, **£22.10.0.** Carr. 30/-. A few available Brand New **£35.** Carr. 30/-. With circuit diagrams. Also available B.41 L.F. version of above 15kc/s–700kc/s. **£17.10.0** Carr. 30/-.

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A crystal controlled heterodyne frequency meter covering 1·7–8Mc/s. Operation on 6 volts 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.

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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 $12 \times 8\frac{1}{2} \times 9$in. Supplied in brand new condition complete with all connectors fully tested. **£45.** Carr. 20/-.

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Supplied in excellent condition, fully tested and checked. Complete with prods, leads and instructions. Model 7 **£13.10.0.** P. & P. 7/6.

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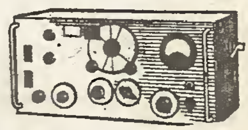

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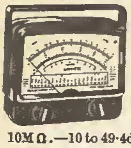

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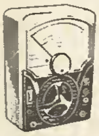

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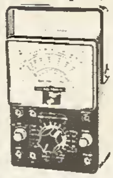

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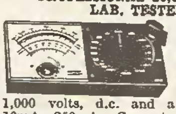

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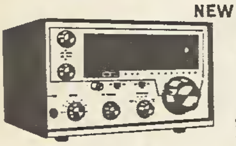

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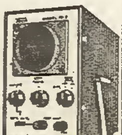

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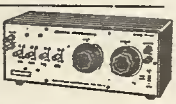

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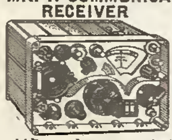

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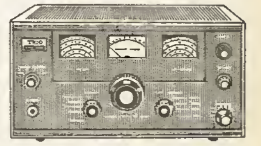

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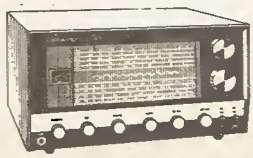

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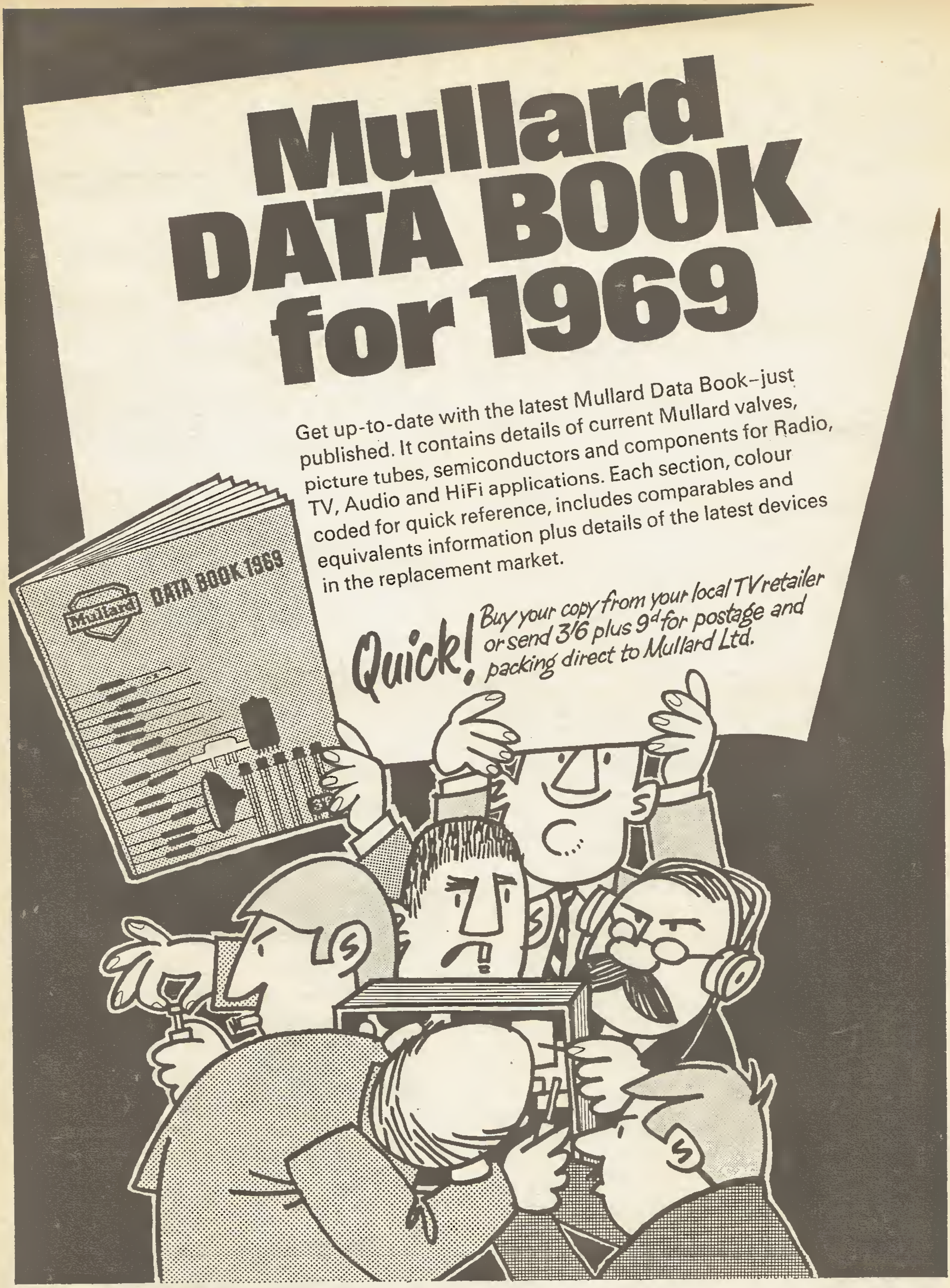

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VOL. 5 No. 4
April 1969

PRACTICAL ELECTRONICS

BROWSERS AND BEGINNERS

NOT all readers of this magazine are doers. Many are armchair constructors—though, let us hasten to add, they are just as welcome as the most zealous manipulators of soldering irons and pliers. That they do at anyrate *read* about electronics is a distinct mark in their favour! But we always try to coax the browsers from their armchairs into productive activity.

The varied range of projects described in these pages provide a strong incentive for action. At one stage or another some of our passive readers become enthused by the possibilities of certain projects and the plunge is taken. But others still hesitate on the brink, as enquiries we receive concerning the possibility of purchasing made-up projects testify.

Knowledge and practical skill are not obtained without effort. As with all specialised interests, electronics demands study of fundamentals and then practice.

Articles aimed at helping the beginner in the first steps of constructional work appear frequently in these pages. This month we are giving extra special attention to the needs of beginners—whether they be new readers or chair-bound regulars. The Constructors Guide included as a supplement in this issue should dispel any remaining qualms in the mind of the most hesitant reader. This guide will familiarise him with the principal features of components and enable him to translate the theoretical circuit diagram into a practical model. The most popular methods of construction are described; the tools and materials required and the techniques employed are concisely but clearly explained.

Having digested this basic information, the first steps in construction can be taken with confidence. Obviously simple projects should be tackled at the start, but with regular practice skills will be acquired and increased familiarity with components gained. A whole range of exciting projects will then come within reach.

But even when a state of high proficiency is reached, there will always be something new to read about: new components and new circuit techniques are constantly being evolved. Things are always happening—that's one reason for the great fascination of electronics. Just *reading* about the subject is only part of the story however; making practical use of these new developments is even more rewarding.

F. E. Bennett—*Editor*

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SUPPLEMENT

CONSTRUCTORS GUIDE

Our May issue will be published on Monday, April 14

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, IPC Magazines Ltd., Tower House, Southampton Street, London, W.C.2. Advertisement Offices: PRACTICAL ELECTRONICS, IPC Magazines Ltd., 15/17 Long Acre, London, W.C.2. Phone: 01-836 4363.
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THEORY INTO

Transistor circuits lend themselves readily to several simple forms of layout and construction, due to the facilities of direct transistor connection without the need for plug-in holders. Some of these methods are briefly outlined in this month's extra supplement *Constructors' Guide* in the centre of this issue.

The following article shows just how easy it is to make a constructional layout when given a circuit diagram only. It is based on a three-transistor class A amplifier, which does not boast a hi fi specification, but can be useful as a monitor in sound recording or as a booster for crystal tuners or pick-ups.

ONE of the problems faced by the amateur constructor, using laminated plastics and copper wiring boards, is the translation of a theoretical circuit to a practical layout.

This can be done quite easily by using a piece of squared paper to represent the hole matrix of the board. The horizontal rows of holes, those which lie along the length of the copper strips, are given a letter *A–Z*, and the vertical rows are given a number *1–26* or more.

These letters and numbers give a set of co-ordinates to work from. The size of the board to be used is determined after a rough layout has been drawn on the squared paper, showing the physical size of the components that are under consideration.

If space is not a major consideration, the components can be layed out flat on the board; for a more compact layout the resistors and capacitors can be stood up on end as shown in the example. If components are laid flat on the board, one has to determine the amount of space to be occupied, governed mainly by component length.

To give an example for guidance, a ½ watt resistor occupies a minimum length of five holes on a matrix pitch of 0·15in.

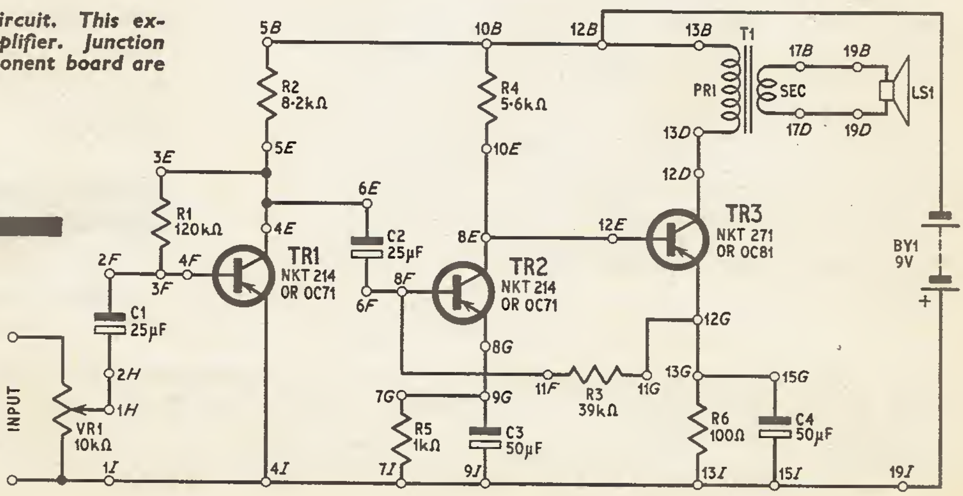
SQUARED PAPER LAYOUT

When preparing the layout of the circuit on the board, take a piece of square paper, and mark it out as near as possible according to the circuit layout in the theoretical diagram. Take as an example for this exercise a simple general purpose linear amplifier (see Fig. 1).

Make a start with the transformer and, after taking a measurement of its size and finding the number of holes required, place this at the top right hand corner of the paper. Position it so that the secondary winding is nearest to the right hand end (Fig. 2). Two rows of holes are left clear of the transformer for the connection wires to the loudspeaker. The holes required are marked on the paper with large dots, for example, *17B* and *17D* (secondary), *13B* and *13D* (primary). Enter these references down in a table with the component reference number by the side of it. The copper strips are cut at *15B* and *15D* so that primary and secondary windings are not shorted.

The components can be drawn on the squared paper in block form and marked with reference numbers. The values can be placed on the position chart if required. The next components to be located will be TR3. The collector is marked out for the hole *12D*, the base at

Fig. 1. Theoretical circuit. This example is a class A amplifier. Junction positions for the component board are shown



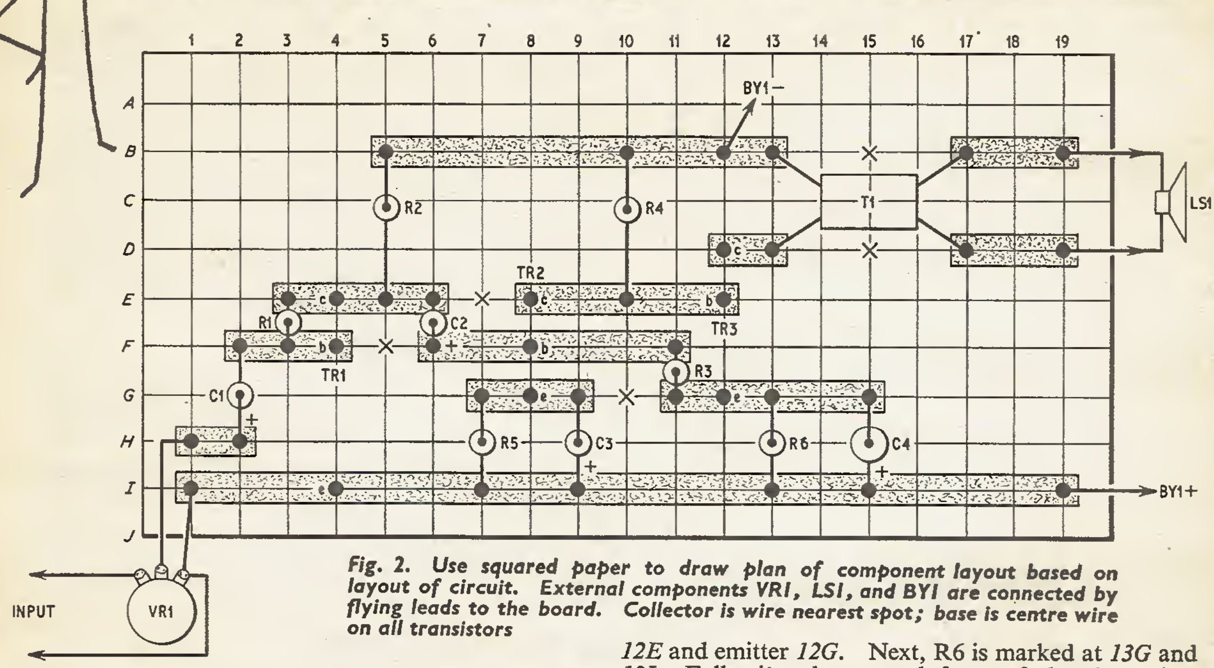


Fig. 2. Use squared paper to draw plan of component layout based on layout of circuit. External components VR1, LS1, and BY1 are connected by flying leads to the board. Collector is wire nearest spot; base is centre wire on all transistors

COMPONENTS . . .

Resistors
- R1 120kΩ (*3E–3F*)
- R2 8·2kΩ (*5B–5E*)
- R3 39kΩ (*11F–11G*)
- R4 5·6kΩ (*10B–10E*)
- R5 1kΩ (*7G–7I*)
- R6 100Ω (*13G–13I*)

Potentiometer
- VR1 10kΩ log (Wiper to *1H*, Common to *1I*)

Capacitors
- C1 25μF elect. 15V (*2F–2H*)
- C2 25μF elect. 15V (*6E–6F*)
- C3 50μF elect. 15V (*9G–9I*)
- C4 50μF elect. 15V (*15G–15I*)

Loudspeaker
- LS1 3 ohms (*19B–19D*)

Transformer
- T1 9·2:1 output transformer (Radiospares type T/T4) (Primary to *13B–13D*; Secondary to *17B–17D*)

Transistors
- TR1 NKT214 *or* OC71 (collector to *4E*, base *4F*, emitter *4I*)
- TR2 NKT214 *or* OC71 (collector to *8E*, base *8F*, emitter *8G*)
- TR3 MKT271 *or* OC81 (collector to *12D*, base *12E*, emitter *12G*)

Battery
- BY1 9 volts (negative to *12B*, positive to *19I*)

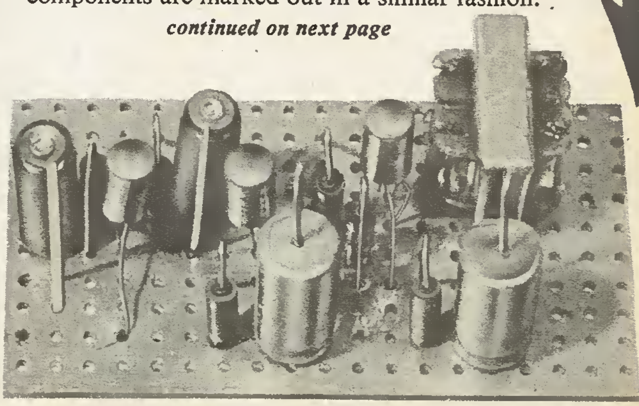
Component Board
Printed wiring board, can be either Veroboard (see Fig. 2) or plain s.r.b.p. with Cir-Kit copper strip

12E and emitter *12G*. Next, R6 is marked at *13G* and *13I*. Following the general form of the theoretical circuit, C4 will be next and is connected to the emitter via hole *15G* and *15I*.

Resistor R3 is also connected to the emitter of TR3 and the base of TR2. Its position is marked on the paper at holes *11G* and *11F*. Mark in the conductor strips that are required by drawing parallel lines on the paper for each strip (see Fig. 2) between the points of entry of the components wires to be joined, e.g. between *15G* and *11G*.

TR2 base is connected to R3 through hole *8F*. The collector is direct coupled to the base of TR3 through *8E*. The emitter of this transistor is connected through *8G* to R5 and C3 negative which are inserted at *7G* and *9G* respectively. The other end of these two components are inserted at *7I* and *9I* for direct connection to the positive supply line. It should be an easy matter to follow the layout of the first stage now. The rest of the components are marked out in a similar fashion.

continued on next page



TRANSFER TO COMPONENT BOARD

When the last component has been drawn the size of the piece of board can be determined, which in this case will be given by the line *J* and row *19*.

Before placing any components on the piece of board all necessary copper strip breaks must be made. These must be indicated on the paper with crosses.

The drilling of holes is best carried out by clamping the board on a piece of wood, copper side up; this avoids tearing the copper foil. Where a copper strip has to be cut, a $\frac{5}{32}$in drill will do this by putting the point of the drill in the holes and twisting it until the copper is removed. Be careful or the copper strip may be lifted.

The components are placed in their respective positions on the plain side of the board and all soldering is done on the copper side. The finished article should look like that in the photograph. With practice quite a compact layout can be achieved, and if the stand up method of fixing is used, a very small layout can be obtained.

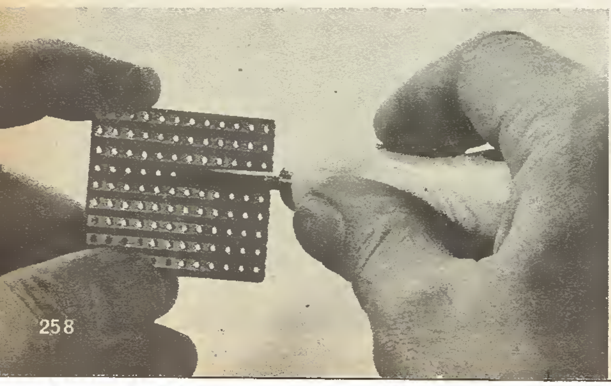
When soldering on this type of wiring board a hot, clean iron must be used, and done quickly, otherwise prolonged heat may raise the copper foil from the base board.

Transformers, tags and pins or flying leads are either connected with insulated wire or soldered direct to the copper strip. If volume controls (potentiometers) are to be mounted direct on the printed wiring board, a hole must be carefully drilled in the board to accept the threaded fixing ($\frac{3}{8}$in). The copper strip must be cleared away from the locking nut with a sharp knife to prevent short circuits. The potentiometer tags are connected to the board by insulated link wires soldered to the appropriate copper strips.

60mW AMPLIFIER

The circuit used in this example is a simple general purpose amplifier suitable for coupling to a crystal set tuner or gramophone crystal pick-up. In this latter application a 100 kilohm resistor should be connected in series with the input to VR1 to avoid mismatch to the amplifier.

TR1 is a small signal amplifier stage providing sufficient drive for the direct coupled power amplifier. The bias current for TR1 is derived through R1 to maintain stable d.c. operating conditions. The bias current for TR3 is taken directly through R4, whilst R3 feeds bias for TR2 from the potential divider formed by T1, TR3 emitter, and R6. With any increase in current through TR2, the base-emitter voltage of TR3 is reduced. This causes less current to flow through TR3. Consequently, the voltage across R6 is reduced, causing a simultaneous reduction in supply to TR2 base. The operating conditions of TR2 and TR3 are heavily dependent on R3 for stable working without over-running TR3. The power output fed to a 3 ohm loudspeaker is about 60mW, which is adequate for personal listening. ★



NEWS BRIEFS

Inflated Dome for Radar Stations

SEVERAL of the long range radar stations provided and operated by the National Air Traffic Control Service of the Board of Trade are sited on exposed positions and are therefore exposed to the most adverse weather conditions. At the Clee Hill Radar Station this problem has been overcome by enveloping the complete aerial system in a 40ft diameter inflated dome made of hypalon coated terylene. A blower system designed and developed by Premier Precision Ltd., inflates the dome with clean dry air, the pressure being controlled at 0·1 p.s.i. greater than the pressure imposed on the outer surface of the dome by the wind. Pressure control instrumentation was supplied by Thorn Automation and the dome was supplied and erected by the Frankenstein Group.

Computers for Hospitals

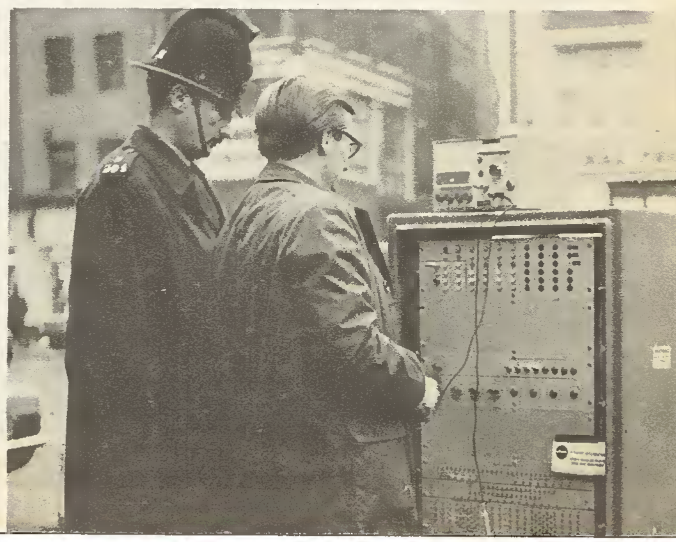
THE Department of Health and Social Security have ordered six small on-line computers, from Elliot Automation System Ltd., for automating bio-chemical analysis in hospitals.

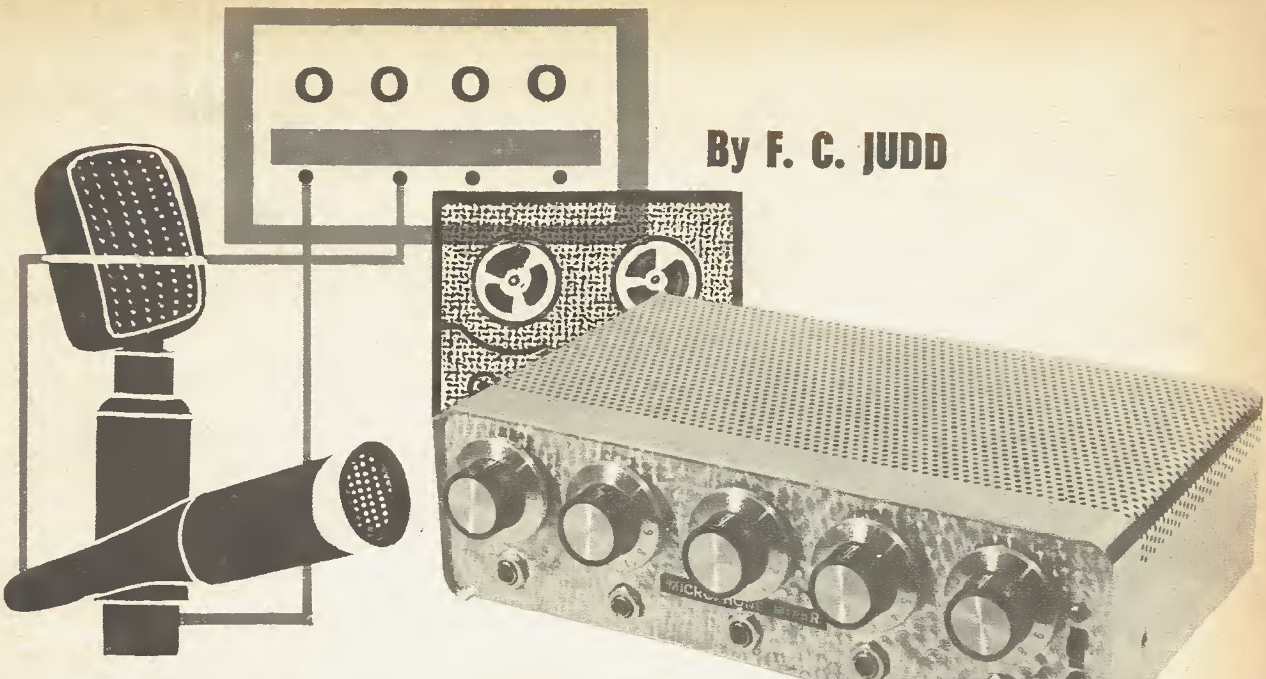
The analysis of bio-chemical samples is carried out by hospital pathology laboratories for diagnostic reasons. By linking mechanical analysers directly to an on-line computer, skilled technicians will be relieved of the repetitive and time consuming clerical work involved in making the manual calculations which are otherwise necessary when producing data sheets.

Solid State Traffic Controller

THE first British designed and manufactured solid state traffic controller to be installed in the UK is now in operation at the Bishopsgate-Middlesex Street intersection in the City of London. The design is based on a set of interchangeable modules from which a controller can be assembled and programmed to cater for any intersection. The most complex intersections can be controlled by one equipment and additional modules enable the controller to cope with any increase or change in traffic demands.

The controller is used in conjunction with an inductive vehicle detector which uses a loop of cable buried under the road surface. Two versions of the detector are available—presence and passage detectors—both of which are used in the City of London installation (see photograph below). The presence detector gives an output to indicate queueing vehicles and the passage detector, which is sensitive even to bicycles, is arranged to ignore parked vehicles.





By F. C. JUDD

MICROPHONE MIXER

If you make high quality tape recordings that require mixing microphones and high level radio tuner inputs, this five channel audio mixer might be just the companion piece for your tape recorder.

Designed around two of the amplifier circuits that appeared in last month's article *Modern Audio Circuits*, this mixer has the added advantage that the constructor need not be limited to the two microphones and three high level signal inputs provided in the prototype as the amplifier circuits can be duplicated so providing more channels if required.

LOW Z MICROPHONES

The mixer can be constructed to cater for low impedance microphones such as ribbon or moving coil types where the microphone transformers are built-in.

Otherwise the microphone inputs have a nominal impedance of 120 kilohms which is suitable for low impedance microphones having their own matching transformers to provide a medium to high output impedance.

HIGH LEVEL INPUTS

The high level inputs are suitable for the output from other pre-amplifiers, radio tuners, and tape recorder high level outputs, that is, signals from audio outputs of between 600 ohms (line) and up to 500 kilohms at between 100 to 500mV. Adjustment can be made so that the input signals to both the microphone and high level inputs can be increased without introducing distortion.

NOT FOR CRYSTAL MICROPHONES

While the microphone pre-amplifiers have sufficient gain for use with crystal microphones, the input impedance of 120 kilohms would considerably reduce the bass response. This follows from the fact that crystal microphones have a high source impedance and also high internal capacitance.

Although the high level inputs have an impedance of 500 kilohms, these are equally unsuitable as a high signal voltage is required which the crystal microphone does not produce.

SPECIFICATION . . .

Sensitivity at mic inputs
3mV–10mV max. for 1 volt r.m.s. output

Sensitivity at line (high level) inputs
200mV–500mV max. for 1 volt r.m.s. output

Distortion for these inputs—Mic: Less than 0·75%
Line: Less than 0·15%

Microphone input impedance (without transformers)—120 kilohms

Line (high level) input impedance—500 kilohms

Output impedance—Nominal 600 ohms

Signal to noise ratio
Mic inputs—60dB below 1 volt at output
Line input—66dB below 1 volt at output

Frequency response—Mic: 40Hz to 15kHz ± 2dB
Line: 30Hz to 20kHz ± 2dB

Total current consumption—12mA

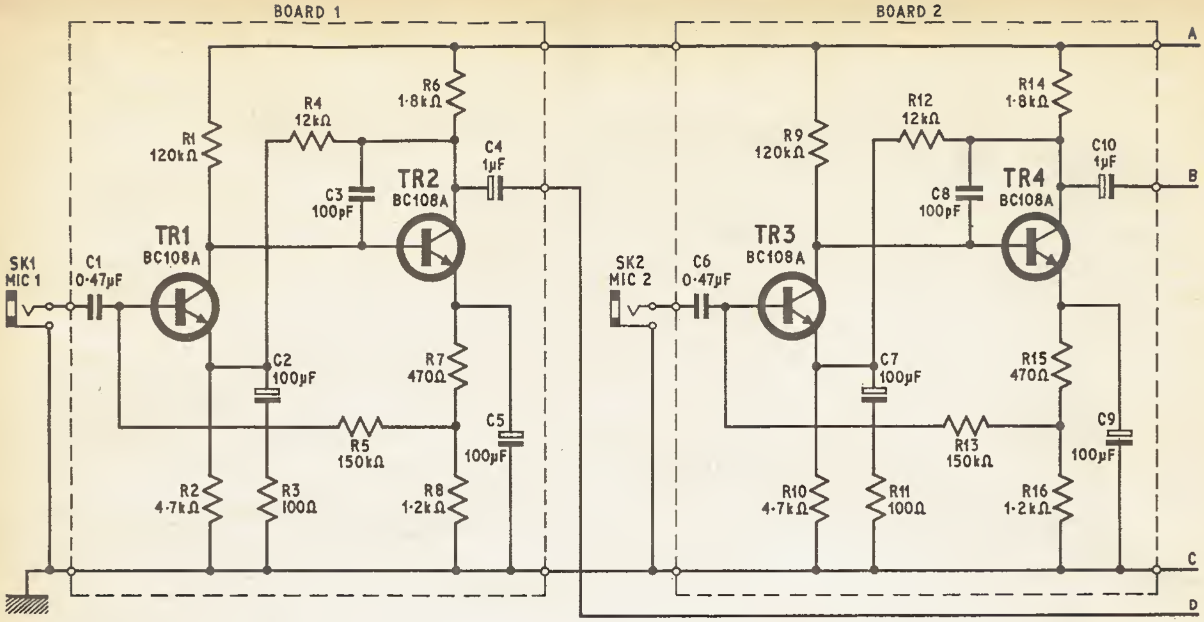


Fig. 1. Circuit diagram of mixer unit. Amplifier sub-assemblies are contained within the dashed lines

CIRCUIT DETAILS

The basic amplifier given in Fig. 1 consists of TR1 and TR2 microphone 1 pre-amplifier; TR3 and TR4 microphone 2 pre-amplifier, and TR5 and TR6 the mixing amplifier.

Common to all of the stages is the use of d.c. feedback loops to achieve stabilisation against temperature variations.

The gain of each microphone pre-amplifier is fixed at approximately 40dB for a distortion level of less than 0·75 per cent. The gain of the mixing amplifier is adjustable between approximately 13 and 30dB but, for the overall performance as per the specification, is adjusted to around 15dB. This more than compensates for the insertion losses of the passive network of mixing amplifier input potentiometers and associated series resistors.

A nominal 600 ohm output allows for a long screened connecting lead to a tape recorder without loss of treble response and will provide more than sufficient signal for tape recorder line or high level inputs at impedances between 600 ohms and 500 kilohms or greater.

FEEDBACK CONTROL

The pre-set control VR6 in the emitter circuit of TR5 controls the amount of feedback between the collector of TR6 and the emitter of TR5 and therefore the overall gain of this stage. With VR6 at maximum resistance the gain will be at a minimum but the circuit will accept much larger input signals. At the same time the gain from the microphone pre-amplifiers will be decreased but they will also accept larger input signals.

It follows that the microphone inputs could therefore be used for electric guitar pick-ups with a medium impedance but fairly high signal output, say 50mV or so.

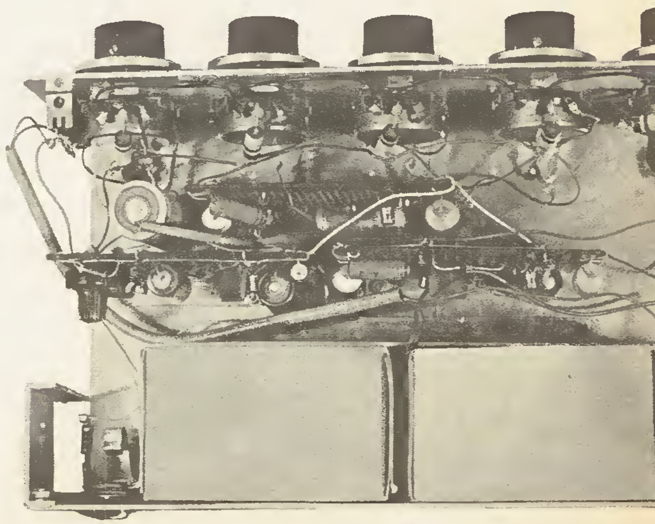
For this application VR6 must be pre-set to its maximum value of 10 kilohms. Otherwise VR6 is adjusted as described later, to provide the performance given in the specification.

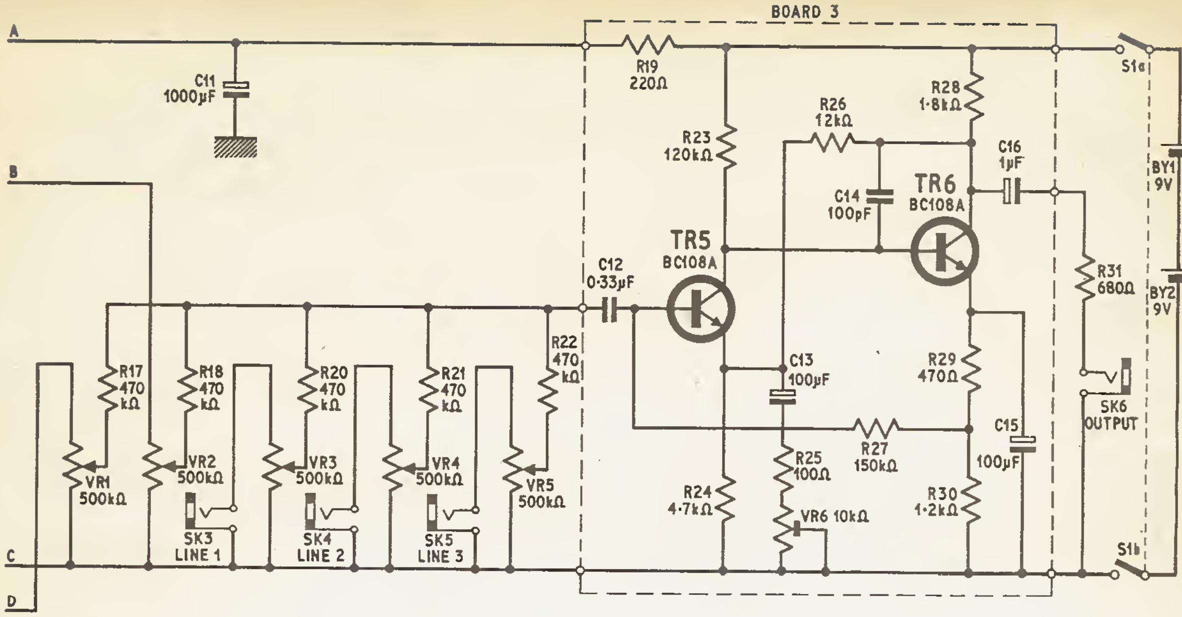
POWER SUPPLIES

The mixer operates from an 18V supply, consisting of two 9V batteries in series, at a total current consumption of 12mA. It would undoubtedly operate quite efficiently from a mains power unit, but this could lead to problems with mains hum pick-up by the microphone transformers if these are built into the mixer.

In view of the fairly low current consumption and the fact that a mixer is rarely run for so long and so frequently as most other kinds of audio equipment, it would hardly be worthwhile providing it with a mains supply.

Battery operation has the advantage of making the mixer completely portable and quite independent of mains supplies.





COMPONENTS . . .

Resistors

R1	120kΩ	R17	470kΩ
R2	4·7kΩ	R18	470kΩ
R3	100Ω	R19	220Ω
R4	12kΩ	R20	470kΩ
R5	150kΩ	R21	470kΩ
R6	1·8kΩ	R22	470kΩ
R7	470Ω	R23	120kΩ
R8	1·2kΩ	R24	4·7kΩ
R9	120kΩ	R25	100Ω
R10	4·7kΩ	R26	12kΩ
R11	100Ω	R27	150kΩ
R12	12kΩ	R28	1·8kΩ
R13	150kΩ	R29	470Ω
R14	1·8kΩ	R30	1·2kΩ
R15	470Ω	R31	680Ω
R16	1·2kΩ		

All $\frac{1}{4}$ watt ±10% carbon

Capacitors

C1 0·47μF tubular paper
C2 100μF elect. 25V
C3 100pF silvered mica
C4 1μF elect. 25V
C5 100μF elect. 25V
C6 0·47μF tubular paper
C7 100μF elect. 25V
C8 100pF silvered mica
C9 100μF elect. 25V
C10 1μF elect. 25V
C11 1,000μF elect. 25V
C12 0·33μF tubular paper
C13 100μF elect. 25V
C14 100pF silvered mica
C15 100μF elect. 25V
C16 1μF elect. 25V

Transistors

TR1–6 BC108A (6 off)—LST Components, 7 Coptfold Road, Brentwood, Essex.

Potentiometers

VR1–5 500k carbon log. (5 off)
VR6 10k carbon lin preset—Electroniques type MPC

Sockets

SK1–6 Standard type jack sockets (6 off)

Switch

S1 Double pole on/off switch

Batteries

BY1, BY2 Ever Ready PP9, 9 volts

Miscellaneous

Aluminium case—Electroniques type, series 222

Calibrated control knobs—Electroniques type NK2

Perforated s.r.b.p. (0·15in matrix) $3\frac{1}{4}$in × $2\frac{1}{2}$in (3 off)

Microphone transformers (if used)—Electroniques/Parmeko type 2549 for 25 ohm microphones, or type 2570 for 100–600 ohm microphones

P.V.C. covered wire. Battery connectors (4 off)

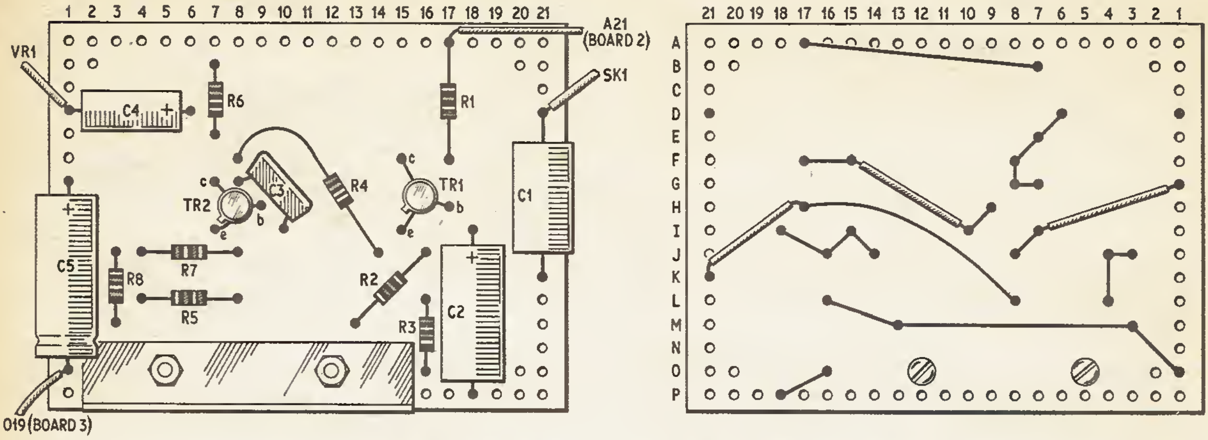


Fig. 2. Component layout and wiring for Board 1, comprising the pre-amplifier for Microphone 1

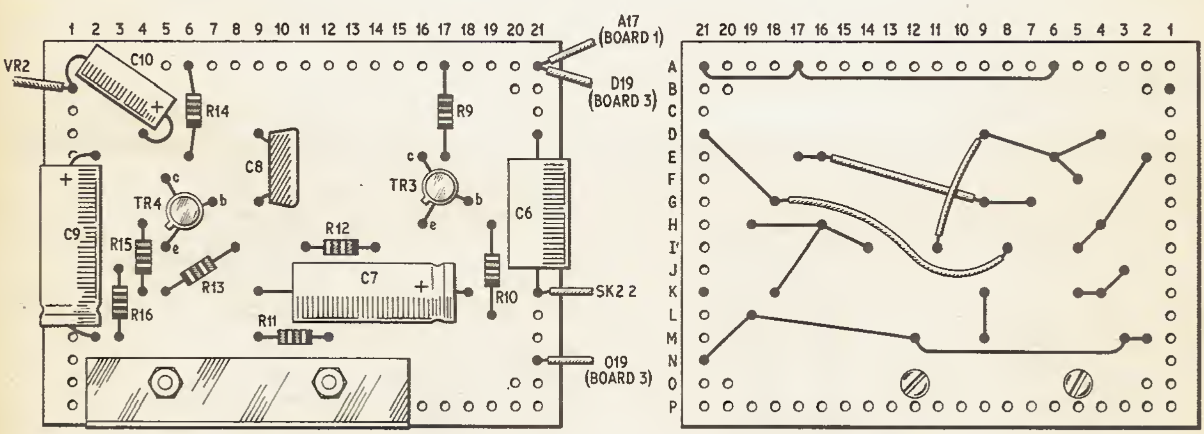


Fig. 3. Component layout and wiring for Board 2, comprising the pre-amplifier for Microphone 2

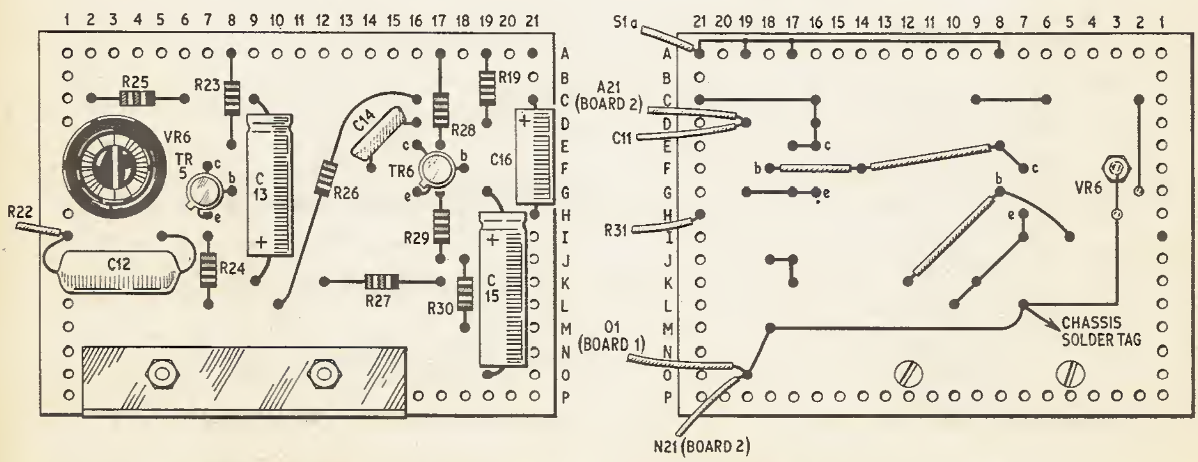


Fig. 4. Component layout and wiring for Board 3, comprising the mixing amplifier

CONSTRUCTION

Each amplifier stage is assembled on a piece of perforated s.r.b.p. board measuring 3¼in × 2½in. The holes in these boards are on a 0·15in matrix.

Assembly details of these amplifiers is given in Figs. 2, 3, and 4.

Space limitation in the aluminium case demand a vertical mounting of the component boards. Details for making the angle brackets for this purpose are given in Fig. 5b. Fig. 5a gives details for making the battery retaining bracket. Before mounting these the front panel of the case should be drilled as shown in Fig. 6. When this is done, the input potentiometers, jack sockets and supply switch S1 can be attached.

Attachment of boards and brackets and other chassis mounted components can now be done as shown in Fig. 7.

Fig. 8 gives the wiring layout to complete the construction of the mixer.

MICROPHONE TRANSFORMERS

Space for two microphone transformers is shown by the dotted outline in Fig. 7. The transformers can be mounted one above the other on a single fixing bracket.

It should be noted that if the frequency response from the microphone inputs is to be maintained as per the specification, the specified transformers should be used. Inferior microphone transformers will result in poor performance.

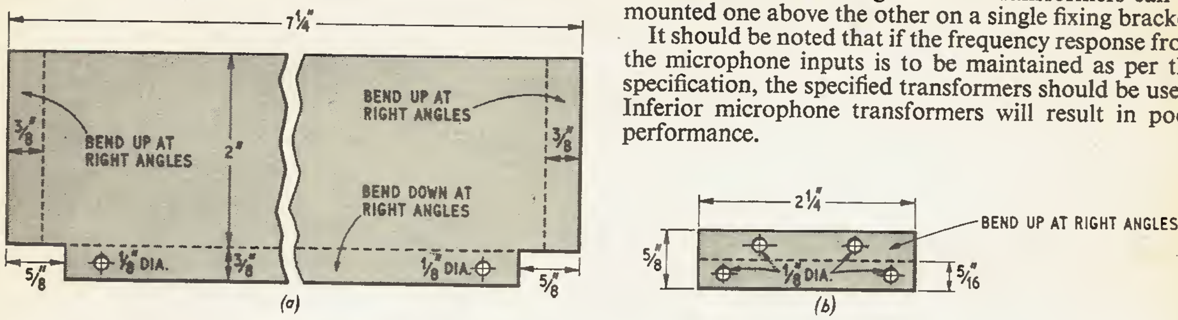


Fig. 5. Retaining bracket for (a) the batteries; (b) the three boards

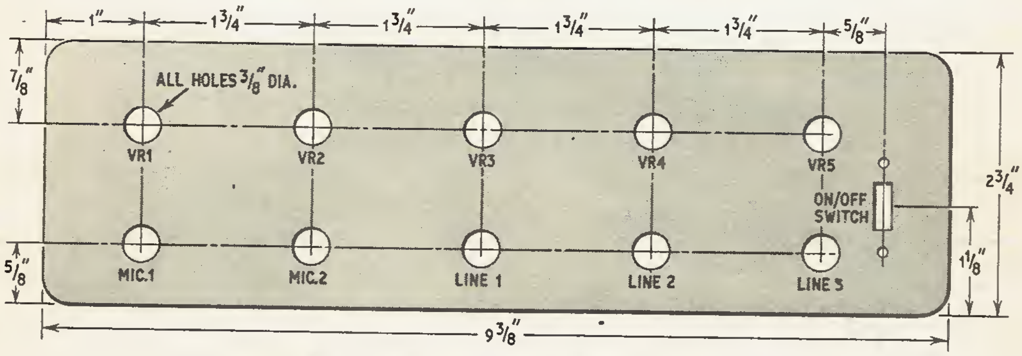


Fig. 6. Front panel drilling details for chassis

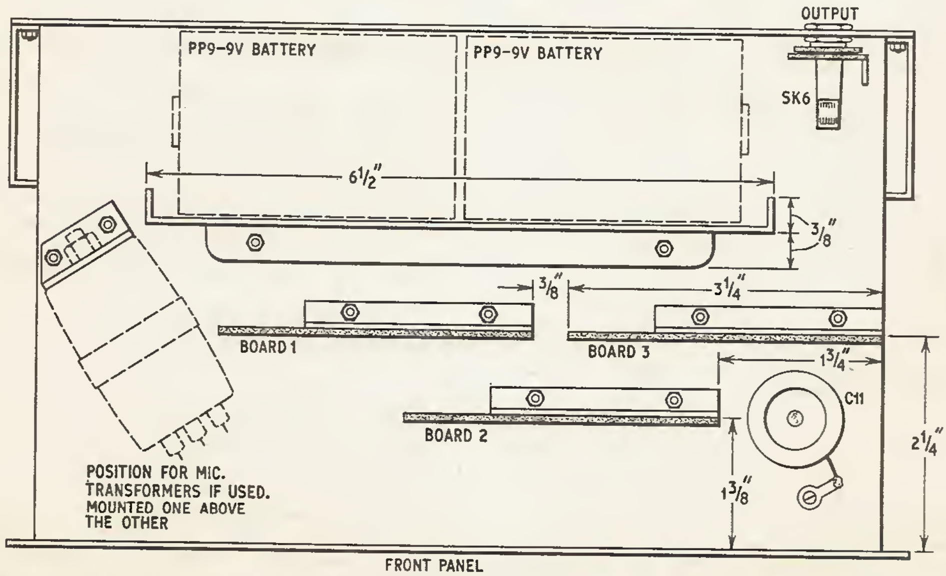


Fig. 7. Layout of components and board sub-assemblies connected to chassis base and rear panel

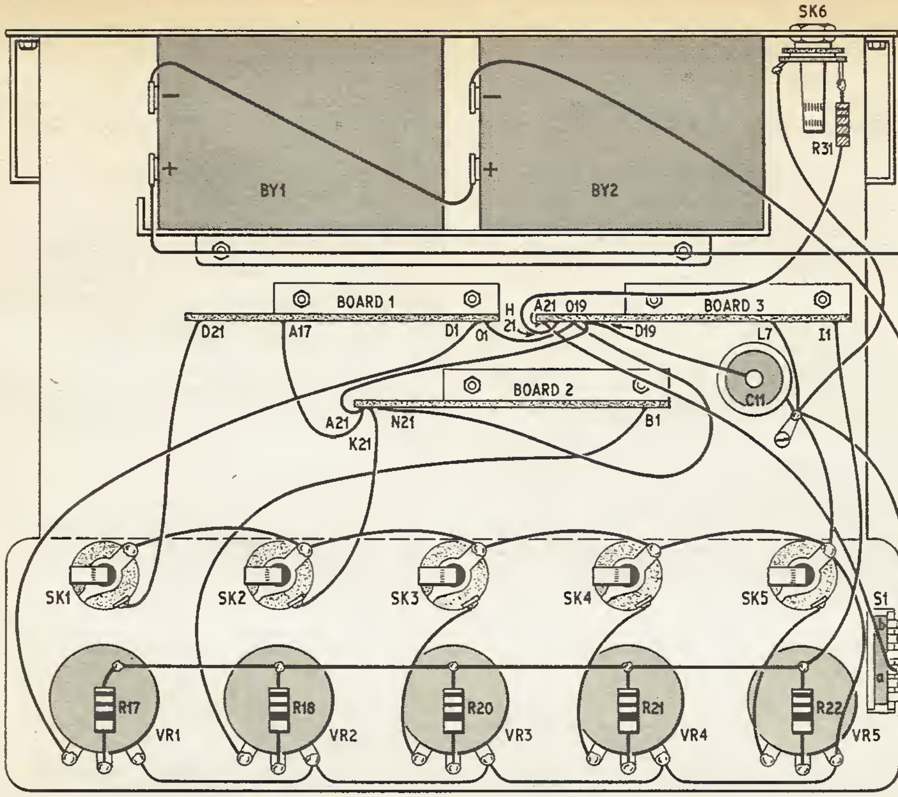
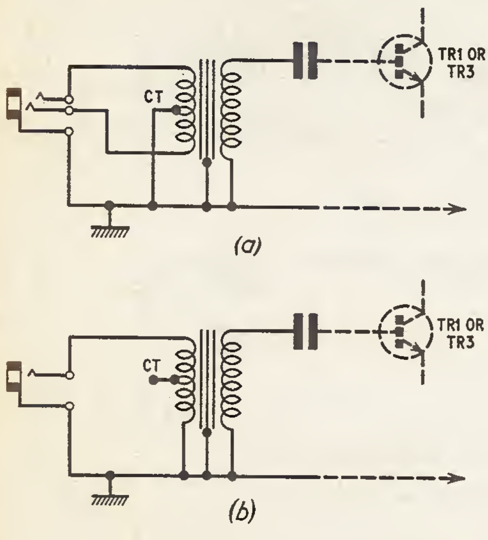


Fig. 8. Wiring of microphone mixer unit



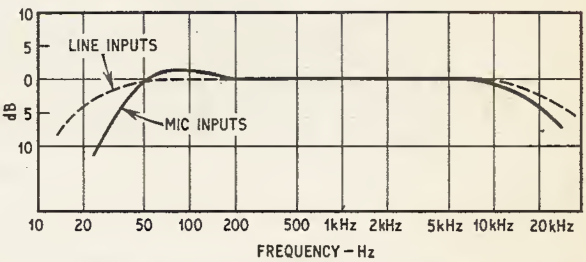


Fig. 10. Frequency response for microphone and line inputs

Fig. 9. Microphone transformer connections for (a) balanced input; (b) unbalanced input

The Electroniques type P.2549 is a 40 : 1 ratio transformer for 25 to 30 ohm microphones. The type P.2570 is suitable for 400 to 600 ohm microphones and has a ratio of 10 : 1.

Connections for balanced or unbalanced inputs with these transformers are shown in Fig. 9. Balanced inputs will require three way, sleeve ring and tip, jack sockets.

PERFORMANCE CHECKS

Frequency response and gain checks, etc. should be carried out with an audio signal generator and valve voltmeter.

With approximately 200mV of sine wave signal fed into either of the line inputs and with the gain control set to maximum, adjust the feedback control VR6 until the signal level at the output is approximately 1 volt r.m.s.

With this setting a 2 to 3mV signal fed into the microphone inputs should similarly produce this output of 1 volt.

The overall frequency response for these input and output signal settings is shown in Fig. 10.

If no test instruments are available VR6 must be pre-set by trial.

To perform as in the specification, around 2 kilohms of VR6 will need to be in circuit.

With all the preset resistance in circuit giving maximum negative feedback, the input signals to the high level sockets can be increased to around 1 volt and that to the microphone inputs around 50mV. ★

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5¾" 900' Except Agfa	29/5	24/–
7" 1200' Except Agfa	36/7	29/6
LONG PLAY		
3" 210' Not Scotch	9/3	7/6
3" 300' Scotch only	9/7	7/9
4" 450'	14/9	12/–
4¼" 600' BASF, Agfa only	22/–	18/–
*5" 900'	29/2	23/6
*5¾" 1200'	36/5	29/6
*7" 1800'	51/7	41/6
8¼" 2400' BASF, Scotch	74/–	58/9
10" 3280' Agfa only	85/9	68/9
10" 3600' BASF only	96/6	77/6
10½" 4200' Agfa, BASF only	113/6	89/3
SCOTCH DYNARANGE (L/P)		
5" 900'	32/8	26/3
5¾" 1200'	41/–	33/–
7" 1800'	58/1	46/6
8¼" 2400' (Metal Reel)	84/3	67/6

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3" 400' Scotch only	16/7	13/3
4" 600'	26/–	21/–
4¼" 900' Agfa, BASF only	31/–	25/–
5" 1200'	43/2	34/9
*5¾" 1800'	56/11	46/–
*7" 2400'	79/–	63/6
10" 4600' Agfa, only	140/9	112/9
TRIPLE PLAY		
3" 450' Not Scotch	22/3	18/–
3" 600' Scotch only	24/10	19/9
4" 900'	40/–	32/3
*4¼" 1200' Agfa, BASF only	50/–	40/3
5" 1800' Not Scotch	67/2	54/–
5¾" 2400 Agfa, BASF -only	91/4	73/6
7" 3600' Agfa, BASF -only	116/6	93/6
QUADRUPLE PLAY		
3" 600' Kodak only	37/–	29/6
3¼" 800' Kodak only	46/3	37/–
4" 1200' Kodak only	64/6	51/6
COMPACT CASSETTES		
C.60	17/6	14/3
C.90	25/–	20/3
C.120	33/6	27/–

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551-12	1200' on 5" reel Double Play	42/–	29/6	86/–	166/–
551-16	1650' on 5¾" reel Double Play	55/–	33/6	97/6	189/–
551-24	2400' on 7" reel Double Play	77/6	49/6	145/6	285/–

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900' on 5" reel Long play P.V.C.	29/1	17/6	50/6	96/6
1200' on 5" reel Long play P.V.C.	36/1	22/6	65/–	125/–
1800' on 7" Long play P.V.C.	51/4	29/6	86/–	165/–
1200' on 5" reel Double Play (Polyester)	43/1	27/9	81/–	157/6
1800' on 5¾" reel Double Play (Polyester)	56/1	36/–	105/–	204/–
2400' on 7" reel Double Play (Polyester)	78/10	49/6	145/6	285/–

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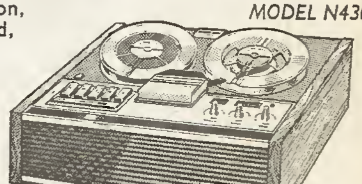

SPECIFICATION

Freq. Range 60–14,000Hz. **Signal to noise** 45dB. **Wow and Flutter** ±0·25%. **Output Power** 2 watts. **Inputs** Mic. 2mV, Radio/Diode 2mV, Gram. 100mV. **Power Supply** Mains voltage 110/250V. **Dimensions** 16½"×11¾"×5¾".

● Mono recording and playback at 3¾ i.p.s. ● Takes 7" spools. ● Provision for mono playback of two parallel tracks. ● Monitoring facilities. ● Position indicator. ● Tone control. ● Socket for direct recording from Mic./Record player. ● Ext. speaker socket. ● Stylishly housed in wooden cabinet. ● Complete with microphone, tape and spool.

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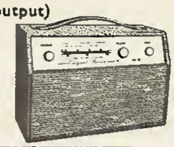

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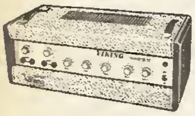

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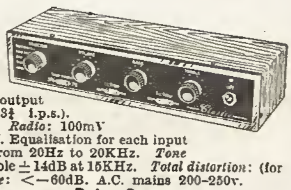

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400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, 6d. 6,800pF, 0·01, 0·015, 0·022µF, 7d. 0·033µF, 8d. 0·047µF, 9d. 0·068, 0·1µF, 11d. 0·15µF, 1/2. 0·22µF, 1/6. 0·33µF, 2/3. 0·47µF, 2/8.
Modular, Subminiature, Epoxy encapsulation, Polyester film, P.C. mounting. 10%, 100V: 0·001, 0·002, 0·005, 0·01, 0·02µF, 6d, 0·05µF, 8d, 0·1µF, 10d, 0·2µF, 1/1, 0·5µF, 2/-.

POLYSTYRENE CAPACITORS: 5%, 160V (unencapsulated): 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82, 100, 120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820pF, 5d. 1,000, 1,500, 2,200pF, 6d. 3,300, 4,700, 5,600pF, 7d. 6,800, 8,200, 10,000pF, 8d. 15,000, 22,000pF, 9d.
1%, 100V (encapsulated): 100, 120, 150, 180, 220, 270, 330, 390, 470, 500, 550, 630, 820pF, 1/3. 1,000, 1,200, 1,500, 1,800, 2,200, 2,700, 3,300, 3,900, 4,700, 5,000, 5,600, 6,800, 8,200, 10,000, 12,000, 15,000pF, 1/6. 18,000, 22,000, 27,000, 33,000, 39,000pF, 2/-. 0·047, 5,000, 0·056µF, 2/3. 0·068, 0·032, 0·1µF, 2/9. 0·12µF, 3/3. 0·15, 0·18µF, 3/9. 0·22µF, 4/9. 0·27, 0·33µF, 5/–. 0·39µF, 6/6. 0·47, 0·5µF, 7/6.

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POTENTIOMETERS (Carbon): Long life, low noise, ¼W at 70°C. ±20% ≦ ½M, ±30% > ½M. Body dia., ⅞in. Spindle, 1in × ¼in. 2/3 each. Linear: 100, 250, 500 ohms, etc., per decade to 10M. Logarithmic: 5k, 10k, 25k, etc., per decade to 5M.

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Submin. 0·1W at 70°C. ±20% ≦ 1M, ±30% > 1M. Horizontal (0·4in × 0·2in P.C.M.) or Vertical (0·2in × 0·1in P.C.M.) mounting, **10d** each.

SEMICONDUCTORS: OA5, OA81, 1/9. OC44, OC45, OC71, OC81, OC81D, OC82D, 2/–. OC70, OC72, 2/3. AC107, OC75, OC170, OC171, 2/6. AF115, AF116, AF117, ACY19, ACY21, 3/3. OC140, 4/3. OC200, 5/–. OC139, 5/3. OC25, 7/–. OC35, 8/–. OC23, OC28, 8/3.

SILICON RECTIFIERS (0·5A): 170 P.I.V., 2/9. 400 P.I.V., 3/–. 800 P.I.V., 3/3. 1,250 P.I.V., 3/9. 1,500 P.I.V., 4/–. (0.75A): 200 P.I.V., 1/6. 400 P.I.V., 2/–. 800 P.I.V., 3/3. (6A): 200 P.I.V., 3/–. 400 P.I.V., 4/–. 600 P.I.V., 5/–. 800 P.I.V., 6/–.

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PHASE SPLITTER — FREQUENCY DOUBLER

THIS circuit is intended for use as the phase splitting stage in high quality push-pull amplifiers and oscilloscopes, or in any application where two equal signals, in anti-phase with each other, are required from a single input signal. The unit is particularly useful in applications where two output signals are required to vary about similar or identical mean d.c. levels. By suitably arranging the output connections of the unit, it may be used to act as an amplifier with a single output, variable in voltage gain between approximately +1 and −1, or it may be used as a frequency doubler for all a.f. and low r.f. signals.

Before delving into the details of this particular circuit, it is necessary to mention briefly some of the more conventional methods of phase-splitting, and the relative merits (or otherwise) of these alternative systems.

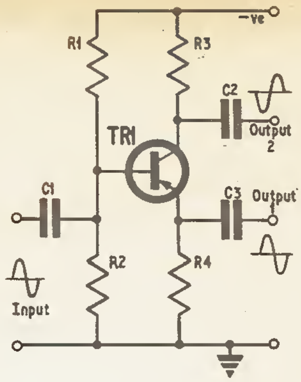


Fig. 1. The balanced inverter phase splitter

BALANCED INVERTER

Fig. 1 shows a single-transistor phase splitter, sometimes known as a balanced inverter. The circuit has equal loads in the emitter and collector lines (R3 and R4), and an output is taken from across each load. Since the currents flowing in the emitter and collector lines are nearly equal, the signals appearing across the two loads will also be nearly equal in amplitude, but opposite in phase. Apart from its simplicity, the circuit has the great advantage that the balance of the two output signals is virtually unaffected by variations in the transistor characteristics, since any change (in frequency response, etc.) will affect both output signals by an equal amount. The major snag of the circuit is that the two outputs are at very different impedance levels, so that severe unbalance may result when the outputs are terminated. Other minor snags are that the two outputs are at totally different mean d.c. levels, that the overall voltage gain between each output and the input is slightly less than unity (as in the case of the emitter follower) and, since the emitter and collector currents are not quite identical, the two outputs are not *perfectly* balanced.

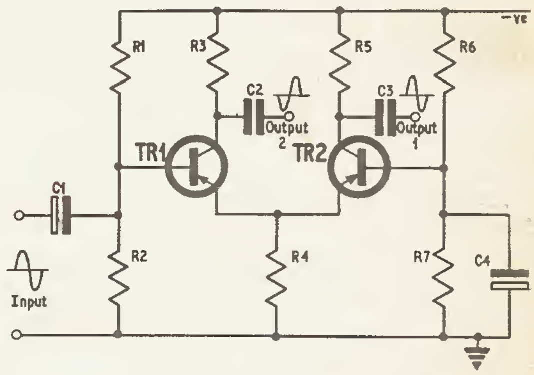
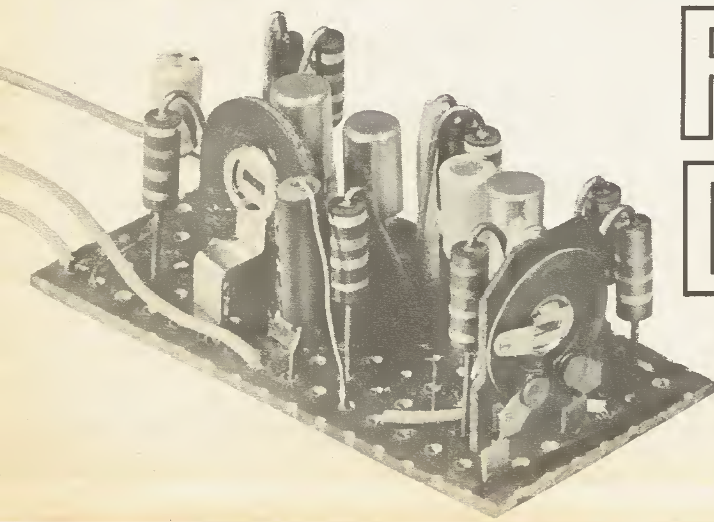


Fig. 2. Long-tailed pair phase splitter



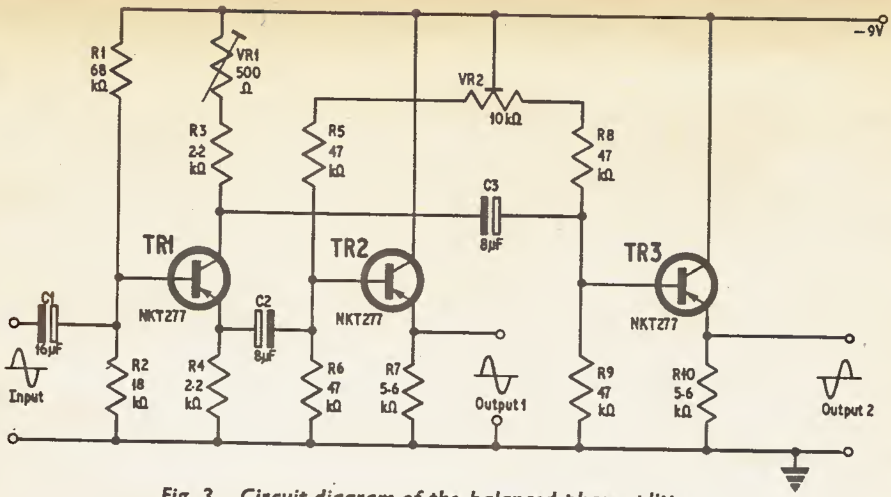


Fig. 3. Circuit diagram of the balanced phase splitter

LONG-TAILED PAIR

Fig. 2 shows an alternative phase-splitter circuit, known as the long-tailed pair or paraphase amplifier, which is widely used. Here, two transistors are used, each of which is wired as a common emitter amplifier, but sharing a common emitter resistor (R4). This common resistor introduces negative feedback to both transistors, with the result that, when an input is fed to TR1 base, both transistors are affected by the signal, and, if TR1 collector becomes more negative TR2 collector will become more positive; the circuit thus acts as a phase-splitter. Theoretically the greater the value of the common emitter resistor (R4), the larger will be the negative feedback and the more nearly balanced will be the two output signals.

This circuit offers two particular advantages: both output signals are at the same impedance, and, if components are suitably selected, both outputs are available at the same mean d.c. level.

The circuit also has the following disadvantages: *perfect* balance of the output signals is obtained (in theory) only when the emitter resistor is infinitely large, in which case the voltage gain of the circuit falls to zero. When practical values of emitter resistance are used, voltage gain is obtained and the two outputs may be nearly balanced, but this balance is upset by any difference in the characteristics of the two transistors (such as gain, frequency response, etc.).

BALANCED PHASE SPLITTER

It can be seen that both the above circuits give rather doubtful results. However the circuit shown in Fig. 3, offers a performance superior to either of these alternative circuits. Here, TR1 is wired as a balanced inverter, but the load in the collector circuit is made variable and slightly greater than that in the emitter circuit. Thus, the two output signals can be made *exactly* equal in magnitude by suitably adjusting VR1, the balance condition then being unaffected by the transistor characteristics. The output from TR1 emitter is fed, via C2, to the base of TR2, which is wired as an emitter follower, and the output from TR1 collector is fed, via C3, to the base of TR3, which is also wired as an emitter follower.

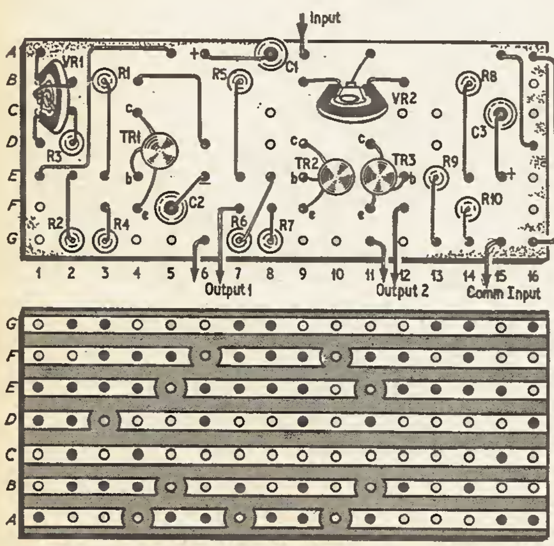


Fig. 4. Layout and wiring of components on the Veroboard

COMPONENTS . . .

Resistors

R1	68kΩ	R6	47kΩ
R2	18kΩ	R7	5·6kΩ
R3	2·2kΩ	R8	47kΩ
R4	2·2kΩ	R9	47kΩ
R5	47kΩ	R10	5·6kΩ

All 10%, $\frac{1}{4}$W carbon

Potentiometers
VR1 500Ω skeleton preset
VR2 10kΩ skeleton preset

Capacitors
C1 16μF elect. 15V
C2 8μF elect. 15V
C3 8μF elect. 15V

Transistors
TR1 NKT277 TR2 NKT277 TR3 NKT277

Miscellaneous
Veroboard
Plastic covered wire
Battery terminals
9V battery

The emitter follower circuit has a high input impedance, a low output impedance, and gives a voltage gain of near unity. In Fig. 3 a pre-set variable resistor, VR2, is made common to the base-bias circuits of each emitter follower, making it possible to set both emitters at exactly the same d.c. level, or to set any required degree of difference in d.c. levels that may be needed.

The two balanced outputs of the unit are at low impedance, output 1 being in phase with the input, and output 2 being in anti-phase.

CONSTRUCTIONAL DETAILS

The unit is very easy to build, and all the details for wiring using Veroboard are shown in Fig. 4. The breaks in the circuit board are made first and then the components and fly-leads are wired in. All components are mounted vertically on the Veroboard panel; layout is in no way critical.

FREQUENCY DOUBLER

The principle by which the unit is made to act as a frequency doubler is best understood with the aid of Fig. 5. Here, it can be seen that a conventional centre-tapped mains transformer and full-wave rectifier are made to act as a frequency doubler, the transformer acting as a phase splitter, while the rectifiers chop off one half of each secondary signal and add the two remaining signals together.

Exactly the same general principle is employed when the phase splitter of Fig. 3 is used as a frequency doubler, this being accomplished by simply shorting the emitters of TR2 and TR3 together after first setting VR2 to give an exact d.c. balance between these two points. In this case, TR1 is used as the phase splitter (in place of the transformer of Fig. 5), TR2 and TR3 act as diodes (in place of the rectifiers), and frequency doubling is obtained. It should be noted, however, that although TR2 and TR3 are used as diodes, they can not be replaced by conventional diodes as correct biasing is essential to circuit operation. Similarly, if the balance of TR2 and TR3 emitters is not correctly set by VR2 before the emitters are shorted together, unbalanced rectification will result.

If the unit is to be built purely as a frequency doubler, the break at "10*F*" on the Veroboard may be omitted and R7 and R10 replaced by a single 2·7 kilohm resistor. The setting of VR2 for balanced rectification is obtained with the aid of an oscilloscope. It should be noted that, if balanced rectification is to be obtained, the input signal to the unit should be symmetrical, and preferably of sine form.

SINGLE VARIABLE OUTPUT

The unit of Fig. 3 may be adapted to give a single output, the amplitude of which can be varied between approximately +1 and −1. This is done by connecting a 10 kilohm variable resistor across the two output connections, and taking the output of the unit from the moving arm of this variable resistor. It should be noted that this modification does not give an output that is fully variable in phase, but an output that is either in phase or anti-phase with the input, but is variable in amplitude.

SETTING UP PROCEDURE

Before the unit is used, it must be correctly set up. An audio generator and an oscilloscope or a.c. valve voltmeter are necessary for this operation. Connect the generator to the input of the unit, and measure

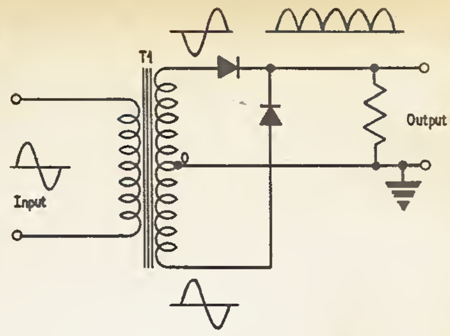


Fig. 5. Principle of the frequency doubler

"output 1" on the oscilloscope or voltmeter, noting the amplitude of the signal. The frequency of the generator is not particularly important, but the input signal should be approximately 1 volt peak to peak in amplitude. Now connect "output 2" to the oscilloscope or voltmeter and adjust VR1 until the amplitude is the same as that of "output 1". Disconnect the generator and the oscilloscope or voltmeter, and connect a d.c. voltmeter between outputs 1 and 2, and adjust VR2 until a null is obtained. The unit is now ready for use.

APPLICATIONS OF THE PHASE SPLITTER

Using the phase-splitter described here in a high quality amplifier, gives perfectly balanced drive and the necessary bias for any following transistors can be obtained by suitably adjusting VR2. Thus, although this circuit uses three transistors and gives unity voltage gain, it virtually eliminates the need for heavy negative feedback (to overcome distortion) in a complete amplifier system, thus enabling higher gain to be used elsewhere.

Similarly, the unit may be used in the amplifier stages of an oscilloscope, to give push-pull X or Y deflection, or, if used in an early part of the amplifier, to enable the trace to be displayed either in phase or in anti-phase with the input signal.

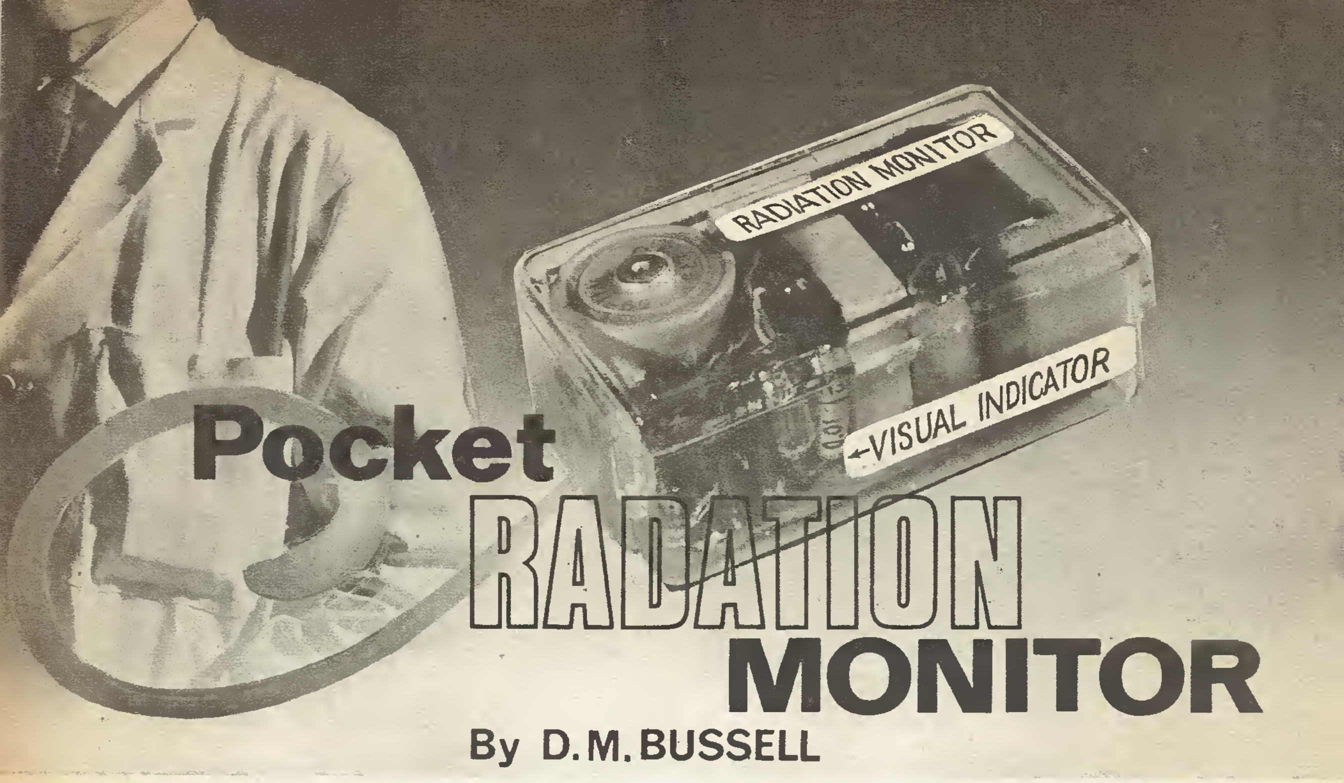
APPLICATIONS OF THE FREQUENCY DOUBLER

As a frequency doubler, the unit may be used, in conjunction with suitable filters, to form the basis of a high quality signal generator. Many generators employ only one oscillator range, additional ranges being added by selecting and filtering harmonics of the fundamental range. This system has the advantage that very pure waveforms can be obtained, and has only one tuning scale requiring calibration, all other scales being multiples of this basic range.

The frequency doubler may also be used to obtain special recording effects, although additional circuitry may be required. "Pinky and Perky" effects can be obtained, for example, by feeding normal voice signals into the input of the unit, and feeding the output to an amplifier or tape recorder via a filter circuit. To cover the full range of voice levels, however, a speech compresser should be used in front of the frequency doubler, and a matched speech expander should be used after the doubler.

Many other uses will, no doubt, occur to the reader.

★



Pocket RADIATION MONITOR

By D.M. BUSSELL

PERSONAL ALARM FOR WORKERS CLOSELY INVOLVED WITH RADIATION SOURCES

NOVEL COMPACT DESIGN USING MINIATURE GEIGER MULLER TUBE

This radioactivity monitor was evolved as a warning device for persons working near units which emit X-rays such as medical X-ray or cobalt units used in hospitals, thickness gauges in industry, or wherever radioactive isotopes are used. It was designed as a personal alarm and not as an accurate measure of beta, gamma or X-ray radiation.

The author has built a small number of these monitors which are giving good service in X-ray and radiotherapy departments of two large General Hospitals. Full cost of this unit will be between £8 10s 0d and £10 maximum, depending on availability of parts. The miniature G.M. tube accounts for £5–£7 of this amount. It may seem an expensive device, however in situations where the need is to be aware of radiation sources it can prove to be a life saver.

The radiation monitor circuit consists basically of four sections: monostable, blocking oscillator, h.t. voltage doubler circuit, and the G.M. tube. See Fig. 2.

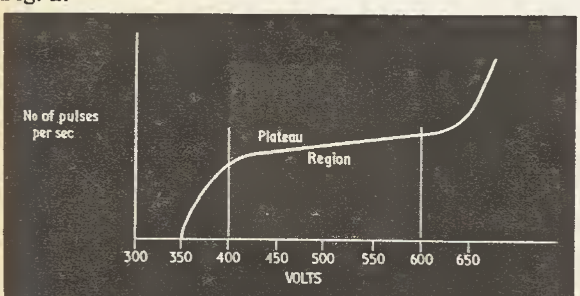


Fig. 1. Response curve for G.M. tube

THE GEIGER MULLER TUBE

An MX151 Geiger Muller tube is employed as the radiation detector; see Fig. 1 as a guide to operating point. The tube becomes sensitive to particles or radiation at around 350 volts, and its normal operating voltage is where the curve tends to flatten; this portion is referred to as the *plateau.* With the tube biased between 400 and 600 volts there is little change in its sensitivity, i.e. number of discharges per volt applied. It is not advisable to apply a higher voltage than indicated in Fig. 1 as the tube may be destroyed by the discharge which follows the application of voltages above the plateau region.

When a particle of radiation enters the G.M. tube with the correct voltage applied, a controlled, short discharge through the gas in the tube is triggered off, resulting in a negative pulse being produced at the tube anode. This pulse is used to switch on the circuitry, thus producing an audible bleep, a visible neon tube flash and—through the action of the blocking oscillator—replacement or restoration of the h.t. voltage level.

THE MONOSTABLE

The monostable circuitry is in the form of an all-off complementary transistor circuit. TR1 being a *pnp* transistor is switched on by the negative pulse from the G.M. tube. TR1 when on will also turn on TR2; the latter is an *npn* transistor and part of its negative going collector voltage is fed back via R3 and C2 to TR1 base, so holding the monostable in the on condition, until the charge has leaked away from C2 via the input circuitry. The negative square wave on TR2 collector is used to supply the base current for the TR3 blocking oscillator circuit, which is then turned on.

BLOCKING OSCILLATOR

In the blocking oscillator converter, formed by TR3–T1, an audible frequency around 1 to 2kHz is generated and fed to the earpiece transducer X1 which is connected across the base winding of T1. The "tweet" duration is governed by C1 and C3 in combination.

HIGH VOLTAGE SUPPLY

The high voltage for the G.M. tube is produced or replenished by the h.t. winding on T1. The voltage across the third winding of T1 is doubled by the rectifying circuit D2–D7 and stored in the reservoir capacitor C6, ready for the next particle to produce a discharge in the G.M. tube.

While the "tweet" is audible from the earpiece X1, the h.t. will tend to rise above 600 volts and the neon circuit serves two functions; as a visible indicator, plus a high voltage limiter, making use of the reverse breakdown of the two EC401 diodes. The current through this circuit is limited by R8.

To measure the h.t. voltage use only an electrostatic meter, as the high impedance supply will be loaded by any other meter system. In its quiet condition and at room temperature of 25°C, the monitor's consumption from a 5 volt mercury battery is measured at less than 15 nanoamps. During the "tweets" which occur at intervals of one to two per minute depending on the natural background radiation, the current rises for a quarter of a second to around 10 milliamps. In areas of high radiation of 50 milliröntgen or more the unit will produce a continuous tweeting sound and glow from the neon.

In low radiation areas, the batteries can last up to three months in the case of a Mallory TR114. Alternatively, three DEAC 225DK rechargeable cadmium cells can be used.

CONSTRUCTION

The monitor will be sensitive to high level static or r.f. fields if mounted in a plastic case as in the suggested design, and this should be remembered if for instance radiation from television 25kV e.h.t. rectifiers is being monitored. The "tweet" due to an r.f. field is recognisable by its regularity.

Construction is not difficult if one has had some previous experience in building small compact units. If the monitor is not required for carrying in the pocket, a larger, easier-to-construct layout can be adopted.

A piece of circuit board measuring 1¼in by 2 3/16in is used as the base for the monitor, the components being mounted as indicated in Fig. 3. Breaks in the copper strips are made, as shown in Fig. 3, before the assembly work commences. The earpiece X1 rests on a small cushion of sponge material laid on top of C5. Battery clips are fashioned from small pieces of brass, see Fig. 3. The complete assembly fits comfortably into a plastics box with hinged lid measuring 1 7/16in by 2⅜in by 1 1/16in deep.

In the original unit fibre glass board was used for its high insulation properties to prevent leakage from the high impedance h.t. circuitry. However, the standard Veroboard has been used successfully with p.t.f.e. stand-off insulators for the h.t. section. In conditions of high humidity or where leakage in the high voltage circuitry is a problem, a larger reservoir C5 up to 0·1μF 630V may be desirable, as the storage in C5 is essential for the continuous operation of the unit.

Encapsulation of the high voltage section is an alternative in high humidity situations.

CRITICAL COMPONENTS

The high voltage diodes D2–D7 have a low reverse leakage. Three Fairchild EC401 125 volt diodes can be used in series, making eight diodes altogether.

High voltage capacitors should be of 630 d.c. volt working but no breakdown has yet been experienced with over-run 400V d.c. working types. Ceramic capacitors may be too leaky for use in this application.

The earpiece should be a near equivalent to the unit type specified. Re-triggering of the monostable and less output volume may be experienced with higher impedance devices. To increase the audible output a small horn or 2in × ½in tube fitted over the earpiece will help to resonate the sound and increase the audible output, but this will depend also on the case size.

The only suitable G.M. tube for this circuit is the Mullard MX151, or the Japanese version (which may be available). When fitting do not solder direct onto the

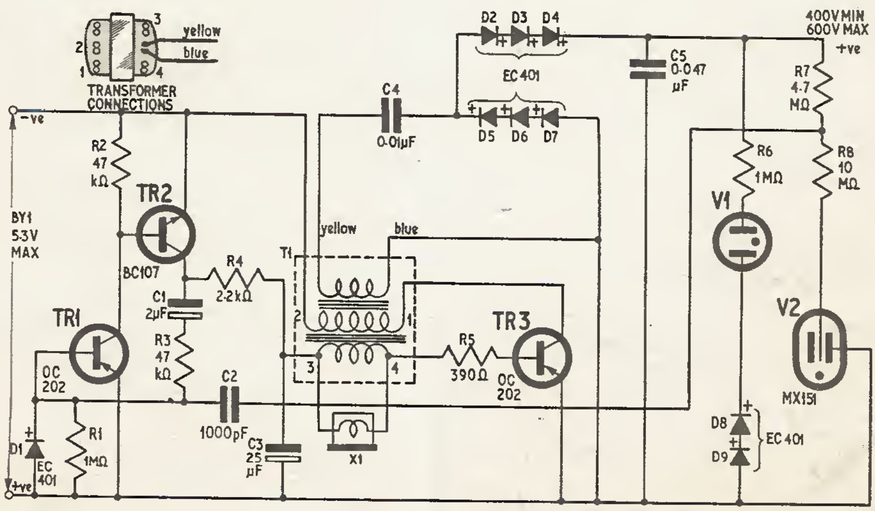


Fig. 2. Circuit diagram of the pocket radiation monitor

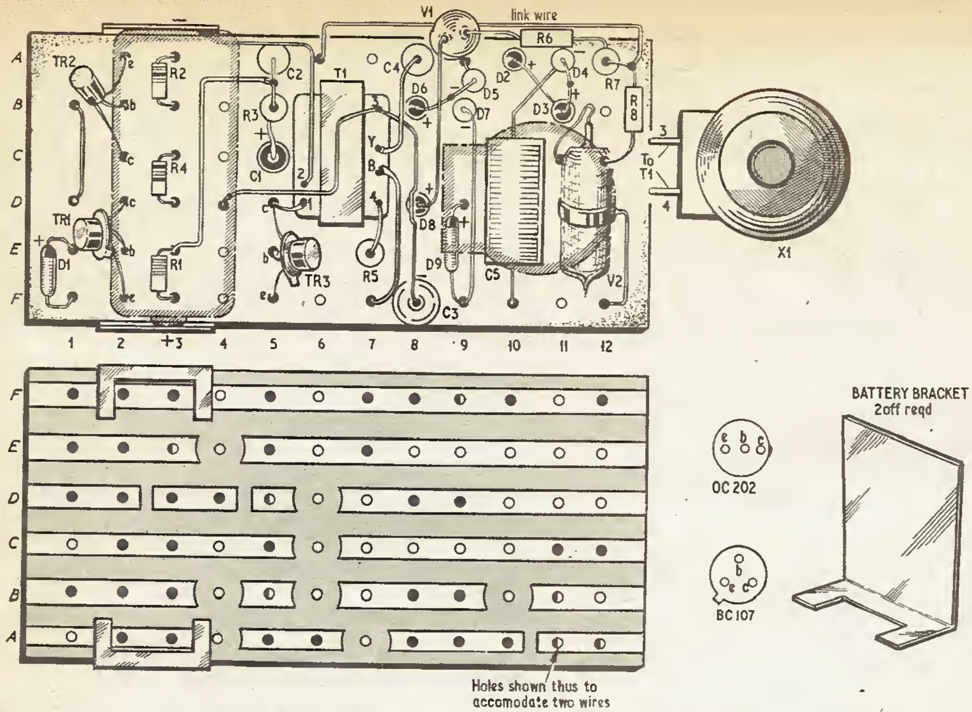


Fig. 3. Layout and wiring of the board. The battery and microphone are positioned as indicated by the dotted lines, see text. The battery clips are made from strips of brass or similar material

COMPONENTS . . .

Resistors

R1	1MΩ	R4	2·2kΩ	R7	4·7MΩ
R2	47kΩ	R5	390Ω	R8	10MΩ
R3	47kΩ	R6	1MΩ		

All ±10%, ¼W carbon

Capacitors

C1 2μF elect. 6V
C2 1,000pF paper 1kV*
C3 25μF elect. 6V
C4 0·01μF paper 400V
C5 0·047μF paper 630V*
* Wima (C.E.S. Ltd., P.O. Box 11, Cambridge)

Diodes

D1 EC401 (Fairchild)
D2, 3, 4 EC401 (3 off)
D5, 6, 7 EC401 (3 off)
D8, 9 EC401 (2 off)

Transistors

TR1 OC202 (*pnp* silicon)
TR2 BC107 (*npn* silicon)
TR3 OC202 (*pnp* silicon)

Miscellaneous

V1 Neon, wire-ended (Radiospares)
V2 G.M. tube MX151 (Mullard)
T1 Transformer: primary 6V; secondary 400V (Parmeko L1321/4)
X1 Earpiece 30–100Ω, miniature magnetic
BY1 5·3V battery. (Mallory TR114); or (Deac 225DK) (3 off)
Veroboard $1\frac{1}{4}$in × $2\frac{3}{16}$in. Plastics box $1\frac{7}{16}$in × $2\frac{3}{8}$in × $1\frac{1}{16}$in
Sponge rubber pad. Material for battery clips

centre anode pin or overheat the tube; use the anode clip supplied and only solder the clip into the circuit with the tube unplugged.

TESTING THE MONITOR

On completion of construction very carefully check the wiring with the circuit diagram. Check also the polarity of C1, C3, and the diodes. The h.t. should be monitored with an electrostatic voltmeter—but if this is not available the flashing of the neon will indicate voltages of over 600 or over.

The monitor may be made operative by connecting and disconnecting the 5 volt supply until "tweets" are heard in the earpiece and the neon flashes. Alternatively, a 10 kilohm resistor may temporary be connected between terminal 2 and 4 of T1. The unit is now ready for a radiation test. The most handy source is a luminous watch dial which will usually give tweets every two or three seconds when the dial is held as near as possible to the tube.

The neon visual indicator should light only for the duration of the audible "tweet". If it stays lit longer and there is no radiation response, the D8 and D9 EC401 diodes may have too low a reverse breakdown voltage and a third series diode should be tried. The neon may not light if D8 and D9 have too high a reverse breakdown; in this case one or both diodes should be substituted. (In the author's experience this condition only arose in about one in ten diodes, and as their current price is near 3s it is not a bad risk.)

No battery decoupling is used and when the battery is nearing the end of its life the tweet becomes much shorter with a clucking sound. This indicates a change is soon required. ★

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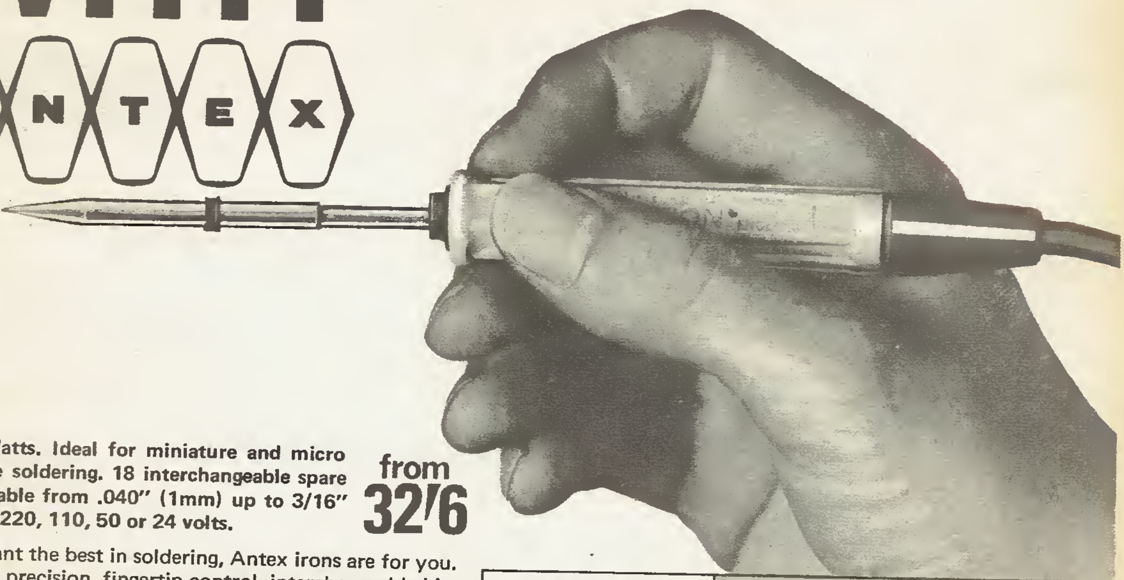

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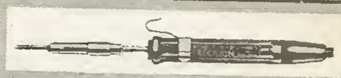

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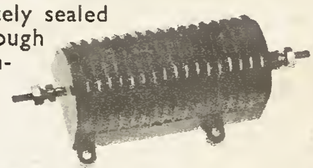

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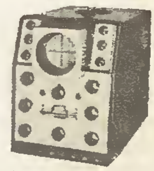

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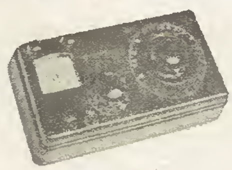

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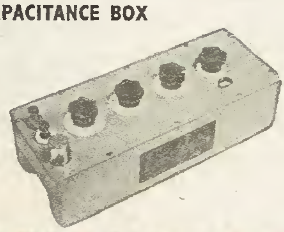

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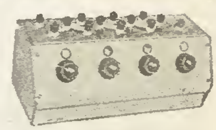

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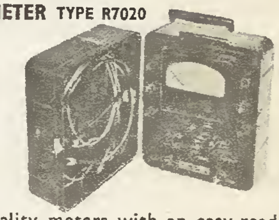

20K ohms. per volt.
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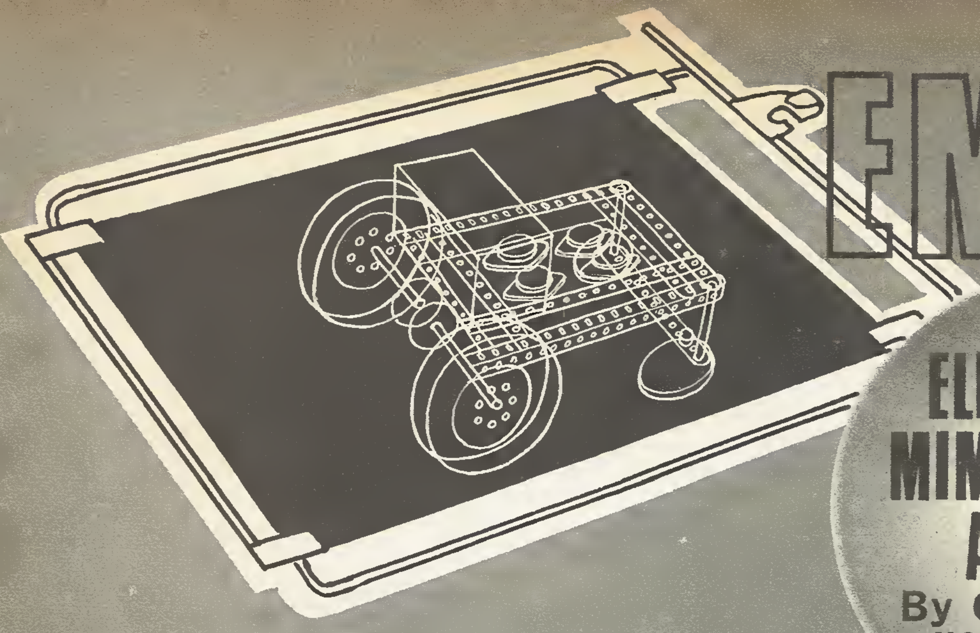


EMMA

ELECTRONIC MIME MOBILE ANIMAL

By G.C.BROWN
M.S.H.A.A. A.M.R.S.H.

PART one of EMMA detailed the theory and wiring of the complete reflex functions board. This month we describe the "muscle" control and load monitoring circuit and board, the power supply wiring and the mechanical details of EMMA's "skeleton". The block diagram for the electronic parts was shown in Fig. 1 (last month), enclosed by a separate broken line, designated "Board No. 2".

"MUSCLE" CONTROL

The "muscle" (motor) control circuits (Fig. 5) consist of two channels providing power switching for the port and starboard motors. Each channel comprises a pair of OC35 power transistors driven by a complementary input arrangement. Due to their inexpensiveness, common types of power transistors have been used as an alternative to more exotic miniature devices connected in full complementary format. Although larger, the cheaper versions have the advantage that with the small current demands made upon them additional heat sinks are not required.

The motor in each channel is connected between the centre-point of its associated power transistors and, via R67, the common point. With either input Mc1 or Mc2 at ground level the input transistors will be effectively non-conducting and the motors will be switched-off. A positive level on Mc1, however, will turn-on TR26 causing TR28 to conduct and hence drive the starboard motor forward. Taking Mc1, negative will turn off TR26 and switch on TR25 thus causing TR27 to conduct and the motor to drive in the opposite direction. The channel controlling the port motor is operated in an identical fashion.

Despite the employment of separate power supplies, some interference resulting from motor "hash" inevitably reaches the reflex functions board. In an attempt to minimise this complaint and make the motor control system a little more sanitary, two $0{\cdot}1\mu F$ capacitors (C17 and C18) are wired in parallel with the motors.

LOAD SENSING CIRCUIT

During forward motion of EMMA, the joint current demands made by the two motors are monitored by transistor TR33 (Fig. 5) which under no load conditions is arranged to be just cut-off. Any mechanical load applied to either or both motors will increase the current drawn through R67 and therefore take the emitter of TR33 more positive causing the transistor to conduct. The collector level of TR33 under these conditions will thus tend to go more and more positive with increasing loads and be an indication of the degree of loading. Potentiometer VR3 sets the level for no-load conditions and controls the sensitivity of the circuit.

Resistor R67 can be fabricated from easily obtainable electric-fire element wire. A few turns of this should be cut off and preferably measured on an ohmmeter for correct value. When the resistance is the correct value, the wire ends should be filed clean to facilitate soldering. R67 must obviously be kept low in value because the motors themselves only have a resistance of about 3 ohms.

CIRCUIT BOARD DETAILS

Illustrations of the "muscle" control board are given in Figs. 6a and b. The board should be drilled as indicated to accommodate the four power transistors. No heat sinks are required because the transistors are not called upon to dissipate any over-large currents.

The reflex functions board, which was detailed last month, is firmly mounted by way of 18 s.w.g. wire soldered between its four corners and the corners of the "muscle" control board. Such an arrangement lends itself well to instant modification and occasional "surgery", additional boards being freely accommodated in minutes.

POWER SUPPLIES

The "animal" requires two power supplies, termed "A" and "B". Two sources of supply are used in preference to one because of the demand for large de-coupling capacitors with a single supply. In fact the additional supply takes up less space than would the capacitors. Supply "A" feeds the whole of the reflex circuitry and consists of a pair of type 1289 batteries.

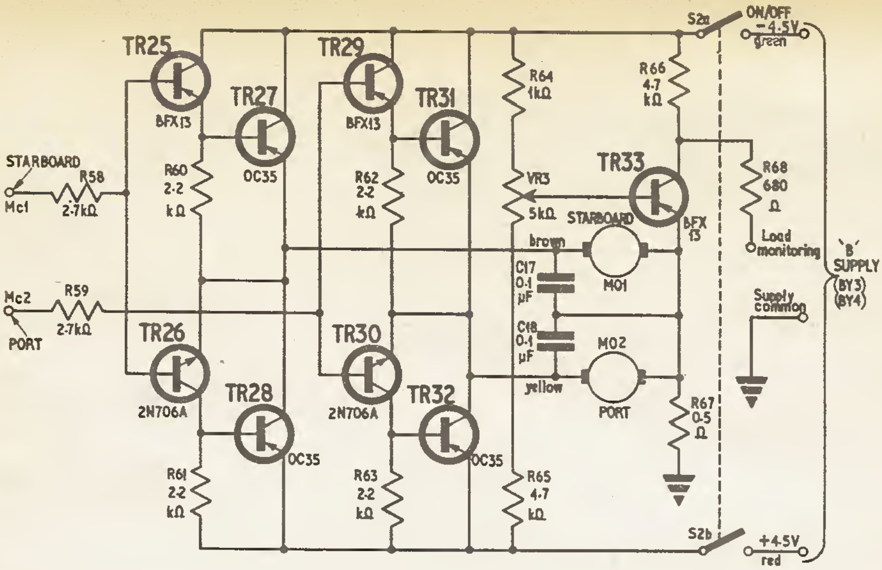


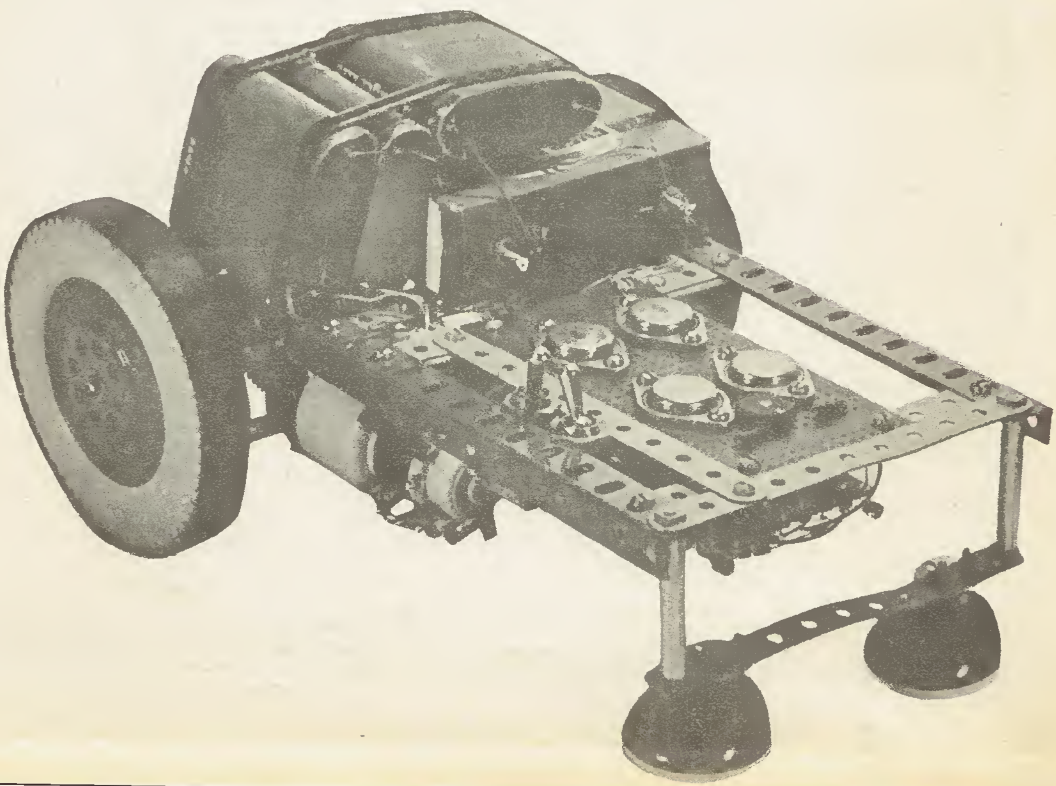
Fig. 5. Electronic mime mobile animal "EMMA". Circuit diagram of the motor control and load sensing circuits

Supply "B" feeds the motor control circuit and comprises a type 126 battery for forward drive (a heavy duty battery is used here because EMMA is more frequently in this mode) and a type 1289 battery for reverse drive. In both cases the supplies are connected so as to form 4·5V—0—4·5V sources (see Fig. 7), the zero point being common to "A" and "B".

CHASSIS DETAILS

In order to make the construction problem minimal, Meccano components were chosen for the model. The chassis which is of extremely simple construction is shown in Figs. 8, 9 and 10 and essentially comprises a rigid skeleton plinth, formed from two main longitudinal angle girders connected together by five cross members. The cross members in addition to lending strength to the chassis also carry the motors, motor control board, and override switches S1 and S2, the switches being mounted between two chassis members and thereby dispensing with the need for drilling.

Downward extensions at the front and rear of the plinth support the castors and axles respectively. At the rear of EMMA this is constituted by four double-angle strips bolted between the plinth and a tie-strip. The frontal (anterior) end comprises a pair of screwed rods running between the plinth and a lower cross member. This member and the plinth are separated by



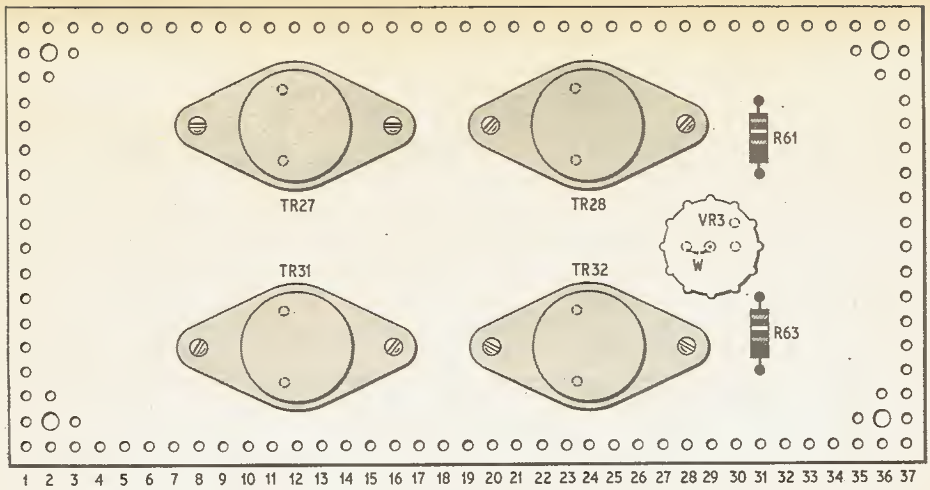


Fig. 6a. Top view of the motor control board. The board should be drilled to accommodate the OC35 mounting screws and the base and emitter pins. Mounting holes for the board are made at each corner to line up with the Meccano mounting strips

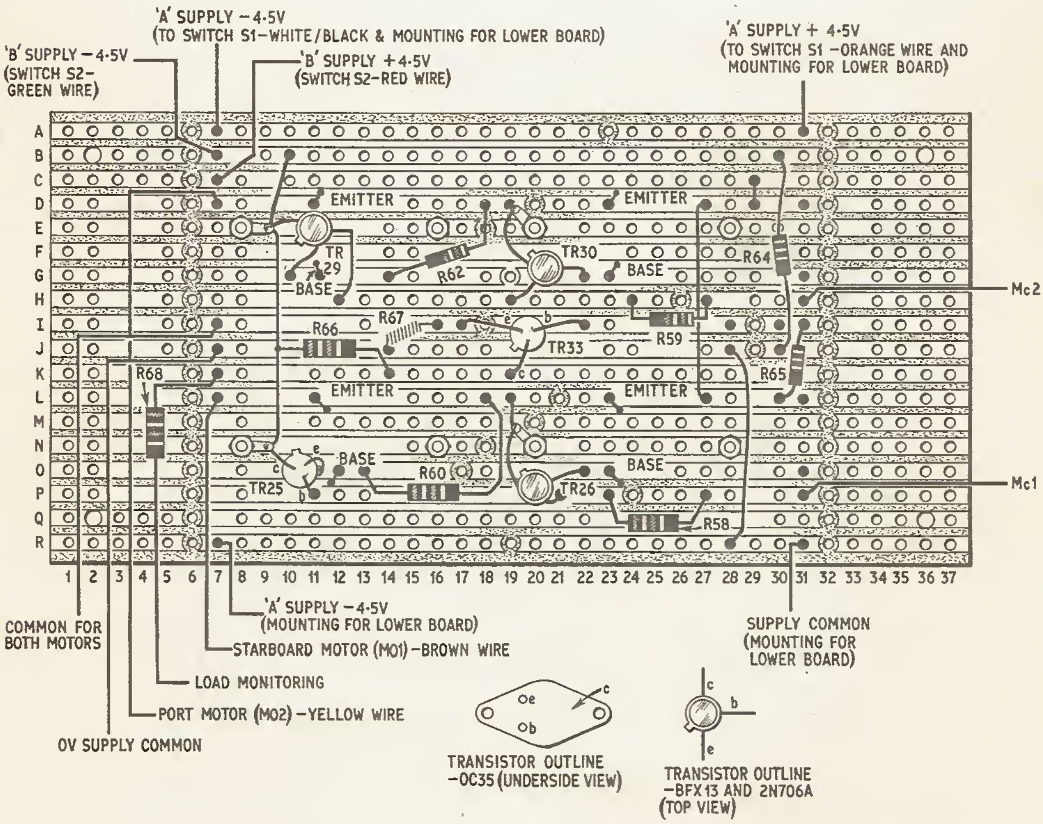


Fig. 6b. Underside view of the Veroboard showing component wiring and breaks in the circuit strips. Care should be taken that the emitter and base leads from the OC35's do not short with adjacent copper strips. All link wires should be of the plastic covered type. Transistors TR25 and TR33, which are mounted upside down, should be kept well clear of the copper strips

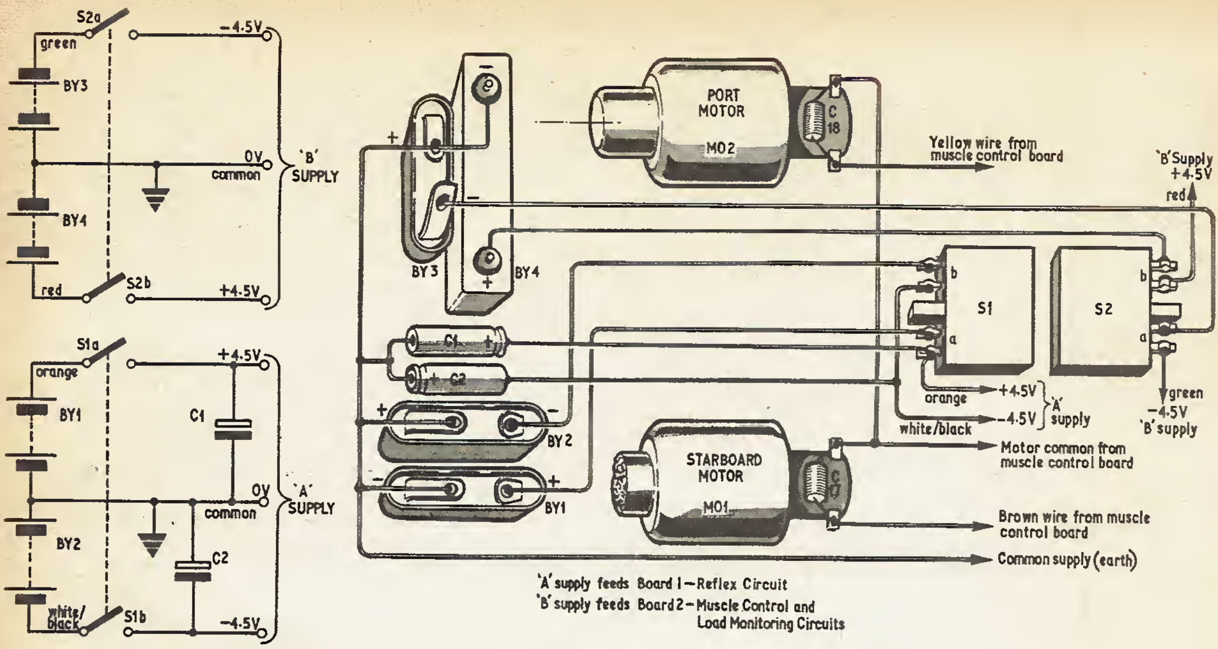


Fig. 7. Circuit and wiring of the two power supplies and motors. Capacitors C1 and C2 were shown in the main circuit diagram (Fig. 2) last month

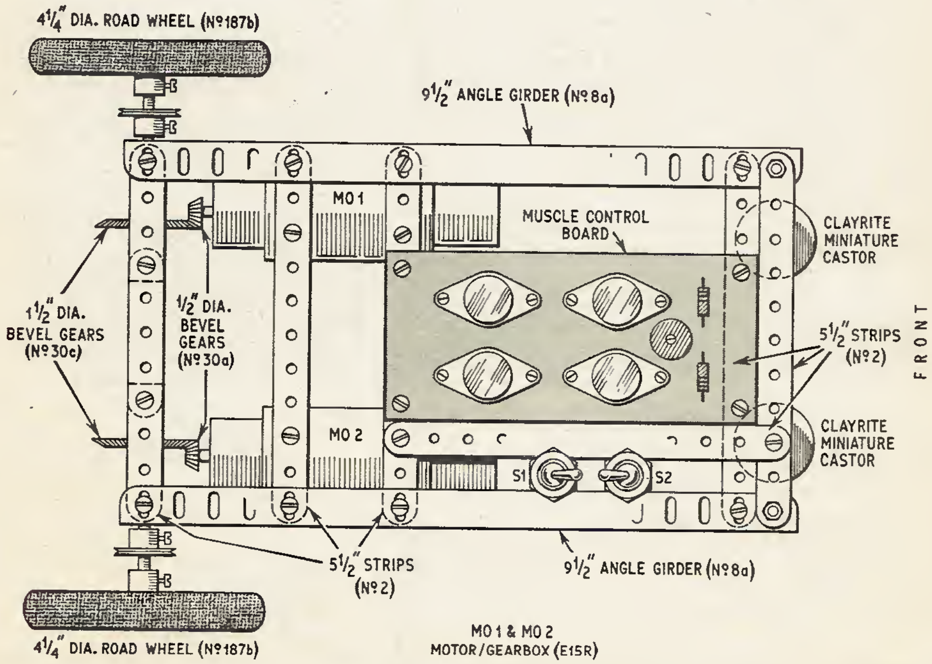
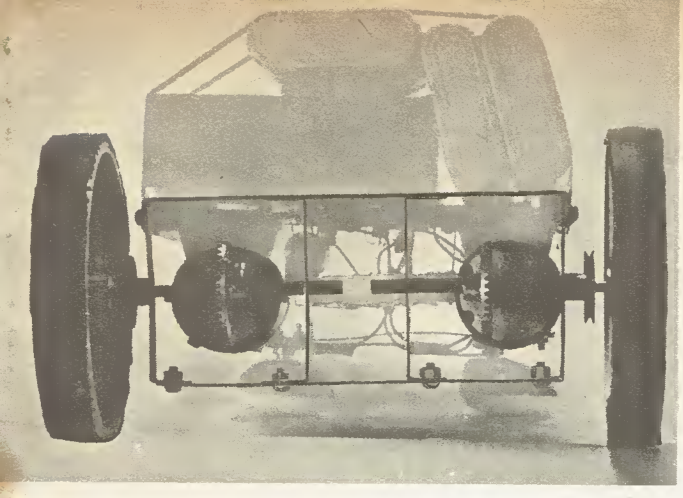


Fig. 8. Top view of EMMA's skeleton showing chassis construction and component mounting positions. Batteries BY1, 2, 3 and 4 occupy the rear end of the skeleton, above the motors (see photos)



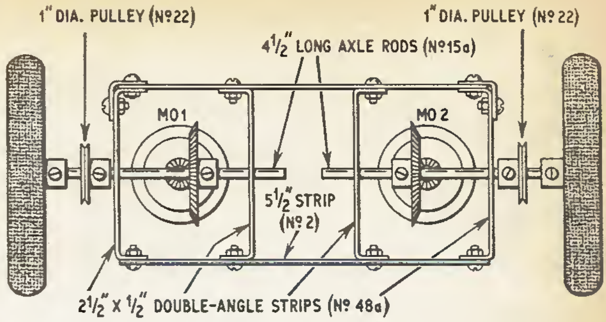


Fig. 9. Rear view of the chassis showing the drive arrangements

tubular pillars which slide over the screwed rods.

Space for the batteries is provided above and just rear of the motor mounting position. For easy access the batteries can be secured in place by way of elastic bands or plastics strips attached to either side of the chassis.

FINAL-DRIVE ARRANGEMENT

EMMA's motive power is derived from a pair of Meccano "Power Drive" motor/gearbox units; these are located port and starboard on the chassis and each is secured in position by four 4B.A. nuts and bolts. The gearboxes, which are of the epicyclic type, have provision for the selection of several gear ratios; in the model the lowest (60 : 1) is used. Output from the gearboxes is taken via bevel gears which provide a further 3 : 1 reduction, thus giving an overall figure of 180 : 1 between the motors and road wheels.

The final-drive axles which run through the centre holes of the double-angle strips each carry a road wheel, a large bevel gear, and a pulley. The pulley, properly adjusted, serves the purpose of reducing end-float and ensures correct meshing of the gears.

INTERCONNECTION WIRING

Wiring between the boards, switches, motors and power supplies is shown in Fig. 7. It must be emphasised that motor leads should be kept as short as possible and maintained clear of the reflex functions board and its wiring. The "A" and "B" power supply leads should not run in the same cableform and must have quite separate routes to avoid coupling motor "hash" into the reflex functions circuits.

SYSTEMS CHECK-OUT

When the circuit boards have been completed they should be carefully examined to ensure that components are correctly connected and no dry joints exist. Check too that there are no accidental solder bridge-overs between adjacent conductors.

Prior to check-out of the complete system, the inputs to the motor control board (Mc1 and Mc2) should be temporarily disconnected. At this time the "animal" is best raised off its wheels so that they are free to turn during the checks which follow.

MOTOR CONTROL AND LOAD SENSING

Connect both supplies and switch S2 on. Temporarily connect inputs Mc1 and Mc2 together and take this common input to zero (ground); under these conditions neither motor should run. Reconnect the common input to the positive supply rail; both motors should now run in the forward direction—if this is not the case, reverse the connections to the offending motor(s). Now disconnect the common input from positive and connect to the negative rail, ensuring both motors now run in reverse.

COMPONENTS . . .

MOTOR CONTROL

Resistors

R58 2·7kΩ
R59 2·7kΩ
R60 2·2kΩ
R61 2·2kΩ
R62 2·2kΩ
R63 2·2kΩ
R64 1kΩ
R65 4·7kΩ
R66 4·7kΩ
R67 0·5Ω (see text)
R68 680Ω

Capacitors

C17, C18 0·1µF polyester 150V

Transistors

TR25 BFX13 *or* BFX12
TR26 2N706A
TR27 OC35
TR28 OC35
TR29 BFX13 *or* BFX12
TR30 2N706A
TR31 OC35
TR32 OC35
TR33 BFX13 *or* BFX12

Miscellaneous

VR1 5kΩ min
MO1 Meccano "Power Drive" motor/gearbox
MO2 Meccano "Power Drive" motor/gearbox
S2 double pole on/off toggle switch
BY1, 2, 3 type 1289, 4·5V batteries
BY4 type 126, 4·5V battery
Veroboard 5⅜in × 2⅞in (0·15in pitch)
22 s.w.g. plastic covered wire

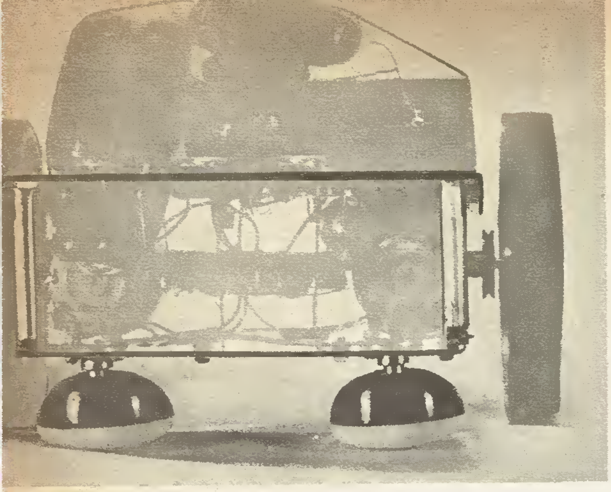
MECHANICAL

Chassis Components

No. 2 strips (8 off)
No. 8a angle girders (2 off)
No. 37a nuts (4 off)
No. 48a double angle strips (4 off)
No. 80 screwed rods (2 off)
} Meccano
2in × ¼in dia. dural pillars (2 off)
4B.A. and 6B.A. fixings

Drive Components

No. 15a axle rods (2 off)
No. 22 pulleys (2 off)
No. 30a bevel gears (2 off)
No. 30c bevel gears (2 off)
No. 187b road wheels (2 off)
} Meccano
Miniature slipper castors (Clayrite, 2 off)



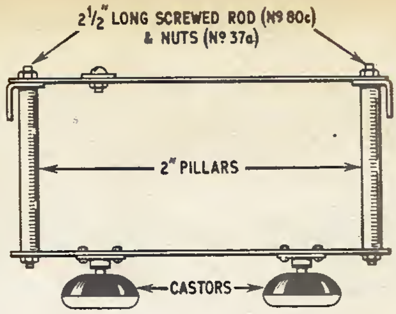


Fig. 10. View from the front of EMMA, with circuit boards removed, showing the castor mountings

Reconnect the common input (Mc1 and Mc2) to the positive rail and connect a voltmeter between the negative supply point and the collector of TR33. Adjust VR3 for zero indication under no-load conditions. Now gently load both motors, by slowing the road wheels, and ensure that the indicated voltage increases with increasing load. Disconnect the common input, separate Mc1 and Mc2 and return them to their normal connections with the reflex functions board. Switch S1 on.

LOAD THRESHOLD AND AVOIDANCE SYSTEM

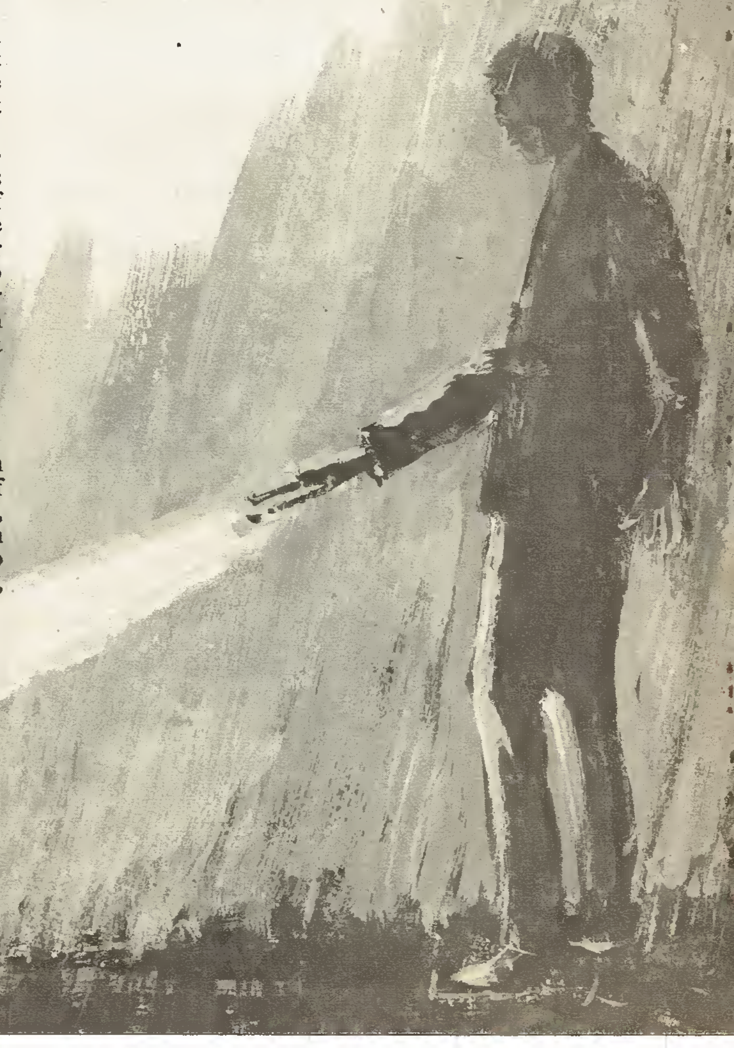
Connect the voltmeter between the negative rail and the collector of TR18. Adjust VR2 so that the Schmitt fires at a point consistent with moderate loading; the circuit will fire after a short delay due to the transient damping.

During the load threshold checks one can simultaneously establish that the avoidance system is functioning correctly—i.e. that with application of loads exceeding the set threshold the motors reverse their direction of rotation and that one or other continues to reverse for a further period prior to resumption of the normal forward mode. Remember that there should be obvious randomness as to which motor runs-on in reverse. If not, adjust VR1 a fraction until some degree of randomness is present.

STEERING SELECTION AND FINAL CHECKS

Place EMMA on the floor and ensure that the random function also manifests itself in the forward mode of operation. EMMA should quite unpredictably stop, start and turn right or left. During encounters with various obstacles, EMMA should back and turn to commence a new, more favourable course. Finally, shine a light onto EMMA's photo-sensors to ensure that she turns away and then resumes her previous mode.

Although crude compared with some of the most simple living animals, EMMA demonstrates in a quite striking way that electronics can be used to model a few of the basic reflexes. In a later article EMMA will "fill-out" her structure with a learning faculty; in the meantime however the constructor will have his hands full with a "pet" running around the house that requires little exercise and lives a lifetime—provided the battery manufacturers stay in business! ★



A unijunction circuit for modern cars fitted with permanent magnet wiper motors

INTERRUPTED SCREENWIPER CONTROL

By C.J. MILLS

In our October issue we published a "Vari Windscreen Wiper" control; this control was designed for use on any car having self parking wipers. We have since discovered that many modern cars are now fitted with permanent magnet wiper motors which have to be shorted to stop them. The circuit diagram of the latest wipers is shown in Fig. 1; in this case the parking switch is a change over type which disconnects the supply and short circuits the permanent magnet motor to stop it in the parking position; the "Vari Wiper" (October issue) cannot be used with these motors.

This article describes a circuit which is designed for the modern permanent magnet type of wiper and provides power to the motor to move it from the parking position; the motor will then continue to run until the wipers return to the parking position. After a controllable time interval another pulse is applied to the motor and the cycle repeats itself.

CIRCUIT DESCRIPTION

The circuit shown in Fig. 2 uses a unijunction, a transistor and a relay instead of the thyristor used in our previous article. The circuit works as follows: when the delay unit is switched on the 80μF capacitor (C1) charges up through diode D1 and control resistance R2 and VR1 until the unijunction trigger voltage is reached. When the unijunction is triggered it's voltage drops, reverse biasing the diode and producing a square wave voltage output at the unijunction base B1. The duration of this square wave is controlled by the discharge time of capacitor C1 through the 5·6 kilohm resistor (R1). The voltage at B1 switches on the transistor and turns the relay on long enough to start the motor and drive it beyond the parking position. The parking switch now completes the motor circuit and breaks the control circuit allowing capacitor C1 to discharge through R1 until the parking position is again reached when the cycle repeats.

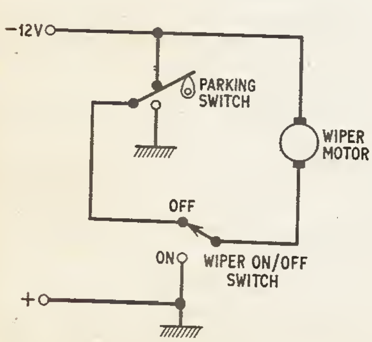


Fig. 1. Circuit diagram of a modern screenwiper using a permanent magnet motor

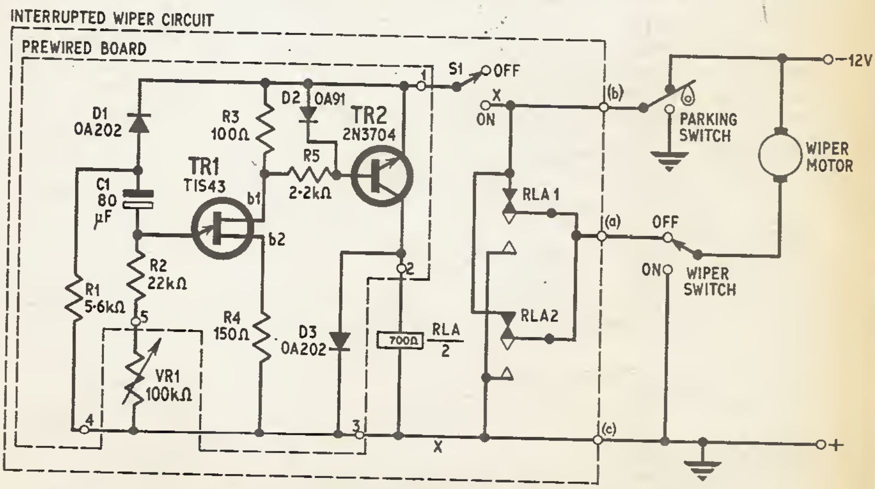


Fig. 2. Circuit diagram of the interrupted screenwiper control. Points a, b and c show connections to the car wiring

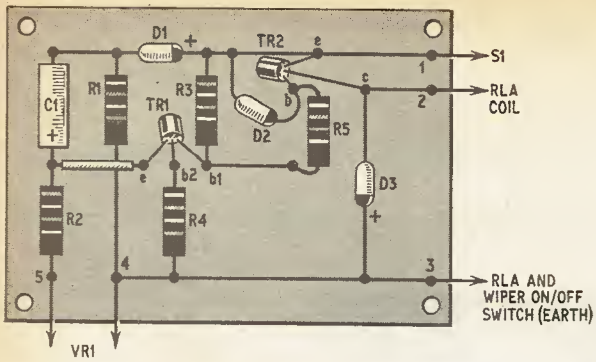


Fig. 3. Wiring diagram of the component-board

COMPONENTS . . .

Resistors
R1 5·6kΩ R3 100Ω R5 2·2kΩ
R2 22kΩ R4 150Ω
All ±10%, ¼W carbon

Potentiometer
VR1 100kΩ carbon linear

Capacitor
C1 80μF elect. 16V

Semiconductors
TR1 TIS43 (unijunction) D1, D3 OA202
TR2 2N3704 D2 OA91

Miscellaneous
RLA 12V 700Ω 2 pole change-over relay (Keyswitch type MH2)
S1 single pole on-off toggle switch
Perforated s.r.b.p. (3in × 2⅛in) and solder pins
Die cast box (see text)
Control knob; 3 core 5A lead; 6B.A. fixings

PRACTICAL POINTS

The delay time is controlled by the 100 kilohm variable resistor (VR1) in series with the fixed 22 kilohm resistor (R2). If a shorter delay is required the value of C1 should be reduced since resistor R2 is a minimum value for this circuit. Alternative types of unijunction may require different combinations of *R* and *C* but if the time constant (*RC*) is kept the same the delay time will not be affected. Any adequately rated *npn* switching transistor can be used with a base resistor to limit the base current—the relay given in the components list requires a current of only 17mA. It is a 12V type with two pole change over contacts connected together in parallel. As the inductive motor circuit is broken by the parking switch a 2 amp rating for the relay contacts is adequate and permits a smaller relay to be used.

Note: connections at points "X" in Fig. 2 must be reversed for use with negative earth systems.

CONSTRUCTIONAL DETAILS

The unit can be conveniently built into a small die cast box, although any suitable container may be used. The front of the box is drilled to take the control potentiometer (VR1) and the on/off switch S1. The remainder of the components, except the relay, are mounted on a piece of perforated s.r.b.p. which is trimmed to fit in the box behind the switch and potentiometer. If a small relay is used, the components can be mounted in a box with internal dimensions 4¼in × 2¼in × ⅞in. The relay is screwed to the box at one end and wired up using flexible plastics covered wire. The rest of the components are mounted on the board as shown in Fig. 3. Layout is not critical but an arrangement which is similar to the circuit diagram makes wiring and checking easier. Taper pins are used to anchor the component leads and the insulated wire connections from the rest of the circuit.

The prewired board is held in position by four 6B.A. screws (Fig. 4) and the three control leads from the relay are brought out through a grommeted hole. A control knob and a numerical scale complete with unit.

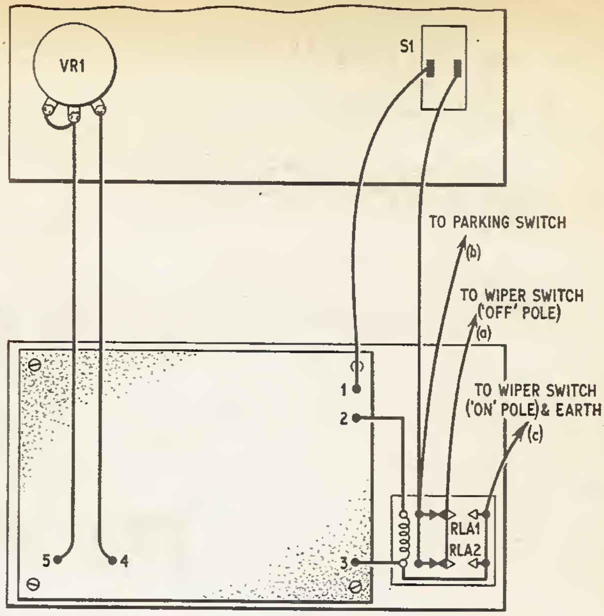


Fig. 4. Layout and wiring of the components mounted in the diecast case; all interconnections should be made using plastic covered wire. S1 and VR1 are positioned to avoid contact with the relay and component board when the front of the case is screwed down

FITTING DETAILS

The die cast box was attached with a suitable bracket to the underside of the parcel shelf. A short 3 core 5 amp lead is required to reach the rear of the wiper on/off switch and the connections are as follows:

(a) Attach a flat female connector to the common relay contact lead and plug it on to the back of the wiper on/off switch in place of the lead which goes to the parking switch.
(b) Attach a flat male connector to the negative and normally closed relay contact lead and plug it into the lead disconnected in (a).
(c) Connect the positive and normally open contact lead to the earth lead on the wiper switch—routing the positive lead via the case and mounting is not recommended.

Double check these connections and then turn on the wiper control at S1. The wiper blades should remain stationary for a short period and then execute one complete sweep and stop for another short period. This process will repeat *ad infinitum*, the length of the pause being varied by VR1. ★

In next month's PRACTICAL ELECTRONICS

PRACTICAL ELECTRONICS ORGAN

Thrill to the sound of a complete family of organ tone colours in your own home. Delight in a frequency range that encompasses keyboard music from 'classics' to 'pop.' Next month PRACTICAL ELECTRONICS gives you the first of a series of articles on how to build a professional class instrument which you will be proud to own for years to come. Designed by an acknowledged authority on organs, it is all solid state using up-to-the-minute silicon planar transistor techniques.

Voiced to produce the sound of an authentic theatre organ, it has two full 61-note manuals, 30 pedals and 19 stops, with the unusual feature of separate expression pedal for both the solo and accompaniment manuals to permit greater flexibility and tonal range. Separate two-unit speaker enclosure. Optional Leslie tremulant to manuals.

Simple unit construction enables you to complete the organ section by section so forestalling any initial large capital outlay. The total cost would be of the order of £200 — the completed job comparable with a commercial organ costing £600 upwards. This is the only home organ in existence with a complete 2ft top octave providing a host of exciting new tonal combinations.

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Goonhilly 2

IN January of this year the G.P.O. opened its new Goonhilly 2 global communications system. The new installation will maintain for the Post Office a leading role as an Earth station owner in the expanding system of global communications via Intelsat III satellites. These satellites have facilities which provide flexible interconnections between a multiplicity of Earth stations, each satellite can carry a total of 1,000 telephony conversations and relay one colour television programme simultaneously. The now outdated Early Bird satellite has facilities to link only two Earth stations, with 240 telephone conversations or one television programme.

The new installation at Goonhilly was built to a Post Office specification, which meets the technical requirements of the International Telecommunications Satellite Consortium (INTELSAT), at a total cost (including roads, buildings, etc.) of approximately £2m.

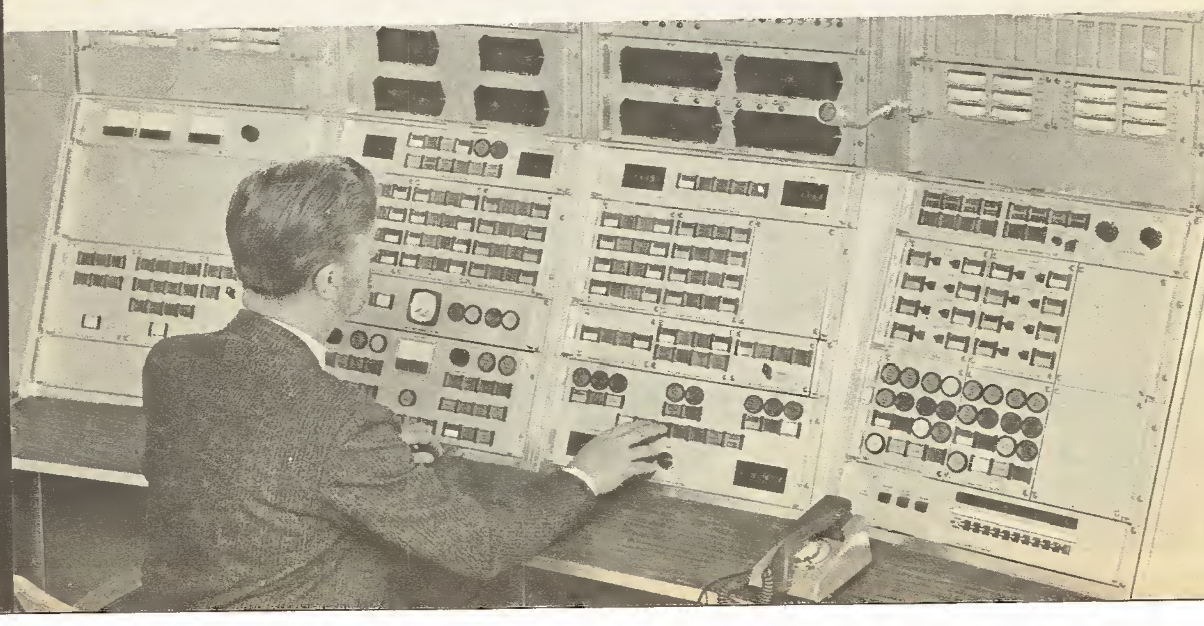
The 90ft diameter aerial was built by Marconi who were the main contractors, threshold extension demodulators and certain other equipment have been supplied and installed by GEC-AEI (Electronics) Ltd.

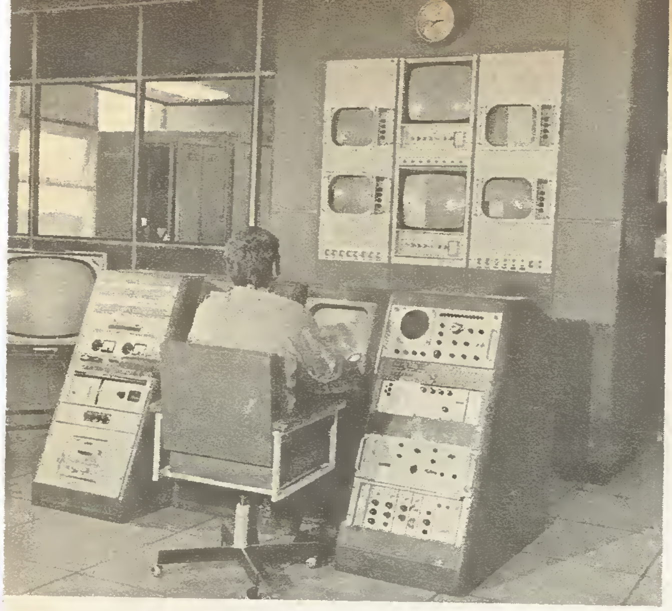
The new aerial follows the pattern established by the first Goonhilly installation of dispensing with a radome. This practice has since been followed by most other Earth station designers. The aerial makes use of a Cassegrain configuration with a spinning horn at the apex of the main reflector. The spinning feed-horn introduces a conical scan of the aerial beam only at the frequency of the satellite beacon signal. Thus it avoids unwanted amplitude modulation of the communication carriers or significant degradation of aerial efficiency for either direction of transmission. By this means auto-tracking can be achieved either by servo control of the main reflector mounting or, within a range of about 40 minutes of arc, by deflection of the sub-reflector. Provision has also been made for control of the aerial manually and for the addition of tape control facilities later, if required.

The very weak signals from the satellite in the 4GHz band are amplified by a three-stage parametric amplifier, cooled to 16°K in a closed-circuit, gaseous-helium refrigeration system, followed by a tunnel-diode amplifier. The four stages have an overall gain of 40dB over the 500MHz frequency band assigned for the down path from the satellite.

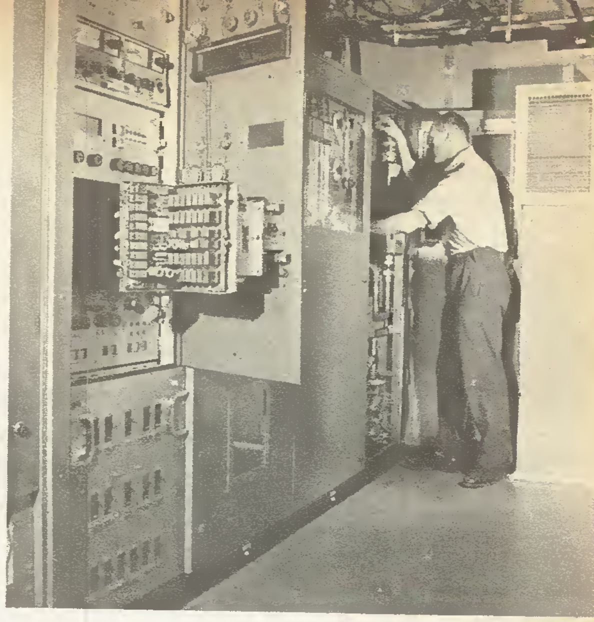
The aerial and telecommunications equipment are controlled and monitored from a suite of consoles in the

The remote control console in the main Goonhilly station building, full control of all components of the Goonhilly 2 space terminal is provided at this position





Comprehensive testing and monitoring facilities for both colour and black and white television signals is provided at this control console



Part of the transmitter cabin with an operator adjusting the coolant supply for the output travelling wave tube of one of the transmitters. The local control panel in the foreground is open to show the controls for setting up the drive unit

central building. Each carrier, which may transmit up to 132 telephony channels, is monitored separately and reserve equipment is switched into use automatically if a disabling fault condition arises. Faults which cause degradation of the service but do not interrupt it can be located and eliminated by manual switching of their component sub-systems without interference with traffic. A separate console enables the television service to be monitored and tested. The extensive use of duplicated equipment and monitoring facilities ensures a reliability of 99·9 per cent for the complete system, which is less than 9 hours per year out of service.

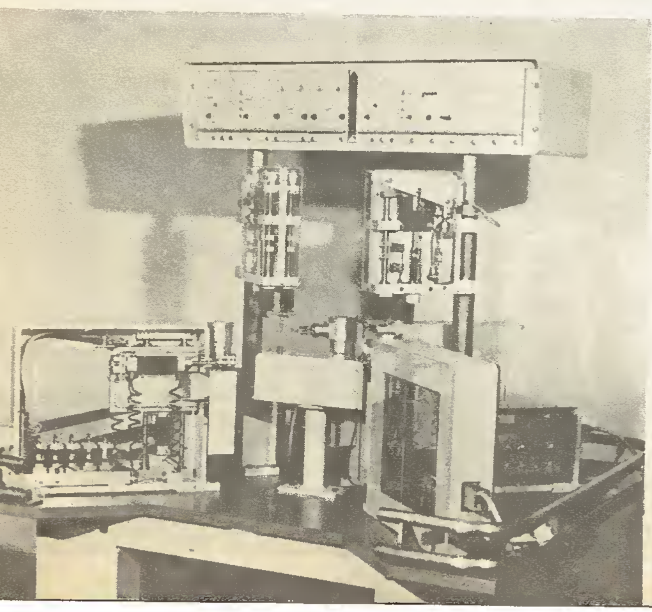
Initially Goonhilly will operate telephony circuits to only the USA and Canada but as more Earth stations become operational the system will expand until by 1971, Goonhilly is expected to be working to 20 countries. Goonhilly 1 aerial is now being refurbished to communicate with countries to the East and will be back in service as soon as an Intelsat III satellite is available over the Indian Ocean.

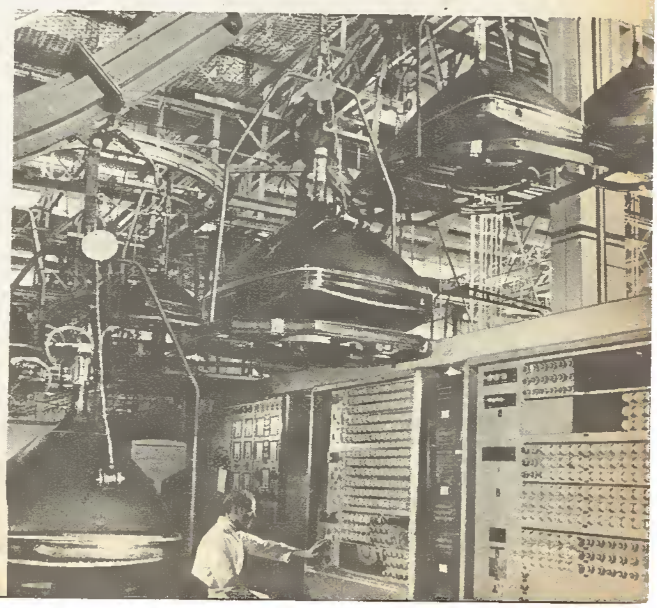
Faster TV Tubes

PRODUCTION of television picture tubes at the Mullard tube plant at Simonstone, Nr. Burnley has been speeded up with the introduction of a new machine shown below. The machine was developed and built by the Department of Production Engineering and Production Management of Nottingham University and is designed to assemble part of the electron gun automatically.

The electron gun is a precision sub-assembly comprising a large number of small components requiring the use of highly-skilled female labour for assembly; this machine automatically assembles three of the components. The component parts are fed by vibrating feeders to "pick-and-place" units which place the components on mandrels at welding stations, an electronically controlled sequence then takes over and the parts are assembled and eight welds are made to produce the (grid 3) assembly.

On completion of the picture tubes an "ageing" process has to be carried out before the tubes are dispatched. This process is carred out at the Mullard plant whilst the tubes are moving around the factory on a conveyor. The still photograph below is from the film "Mullardability" and shows the conveyor carrying the picture tubes.





LOUDSPEAKERS

by P.T. Harrison

THERE is more to achieving high fidelity reproduction from a loudspeaker system than just matching its electrical impedance characteristic to that of the amplifier. Apart from electro-acoustic efficiency, mechanical loading of the moving element is a significant factor in obtaining an acceptable aural response free from distortion and disturbing resonances.

The loudspeaker can be likened to a transmitting aerial but with polar response related to audio frequencies. Horns or baffles act as deflectors to obtain certain directional properties and avoid frequency cancellation effects. Acoustic impedance matching is another factor to be considered.

This article traces the history of development of electro-acoustic receiving transducers, then goes into the main features of the moving coil loudspeaker with particular emphasis on solving some of these problems.

HORN LOADED LOUDSPEAKERS

The earliest type of electro-acoustic receiver was that using an electromagnet with moving metallic diaphragm, still in use in principle today in telephones and headphones. The efficiency is poor due to the difference in mechanical impedance between the diaphragm and the air. See Fig. 1a.

Attempts were made to match these impedances by attaching a conical horn to electro-magnetic receiver (Fig. 1a), the horn acting as an acoustic transformer between the low impedance of the air and the high impedance of the stiff diaphragm of the telephone type of receiver. It was soon discovered that an exponentially shaped horn gave better results, especially in the low frequency range. Sound waves propagated along the axis of an exponential horn are not distorted, as reflections from the wall of the horn are in phase with the propagated waves. Fig. 1c illustrates an example of such a unit.

The efficiency of the horn loaded loudspeaker was limited at the lower frequencies by the size of the horn. Increases in the overall efficiency were achieved by arranging for the resonance of the diaphragm to be in the frequency range over which the unit was used.

The Brown loudspeaker (Fig. 1b) dispensed with the telephone receiver and used instead a spun aluminium diaphragm driven by an electro-magnetically motivated reed. The reed was fixed at one end (Fig. 2), whilst the remaining end was free to move under the influence of a magnetic field produced by a coil. The apex of the diaphragm was secured to the reed, which acted as a "mechanical transformer".

The response of this unit showed a marked improvement upon the response of the units which used a telephone type receiver, but was in many ways inferior to the response of the direct radiator loudspeakers that were to follow.

A further drive mechanism, which when horn loaded gave favourable results, was incorporated in the ribbon loudspeaker. A corrugated aluminium foil ribbon was suspended in the gap between the poles of a powerful magnet.

An electric current was caused to flow through the ribbon, thus giving rise to a magnetic field which interacted with the field produced by the permanent magnet and consequently caused the ribbon to move. The movements of the air surrounding the ribbon were coupled, via an exponential horn, to the outside air. This form of unit is still produced, but is used mainly as a tweeter to reproduce frequencies above 2,000Hz.

The low mass and low impedance, in conjunction with a high value of Young's Modulus for aluminium, make the speaker particularly suitable for the reproduction of high frequencies. (The value of Young's Modulus for a given material, determines the degree of stress that the material will withstand before fracture, i.e. Young's Modulus equals the ratio of longitudinal stress to longitudinal strain.) A powerful magnet is required to produce a high magnetic field strength across the gap in which the ribbon is situated.

ELECTROSTATIC LOUDSPEAKERS

The simplest form of electrostatic loudspeaker comprises two large flat metal plates mounted closely together. A potential difference developed across the plates causes a force to be exerted between the plates. A d.c. polarising voltage is usually required, in addition to the alternating voltage signal provided from the audio amplifier.

In its earlier development stages, it was difficult to obtain a wide frequency response compatible with low distortion; sensitivity was relatively low. However, some commercial concerns have in recent years applied specialised techniques to these shortcomings to provide effective and sometimes competitive results over a wide frequency range.

DIRECT RADIATOR LOUDSPEAKERS

The direct radiator loudspeaker superseded the large exponential horn, the diaphragm being coupled directly to the air. Various systems were used to drive the diaphragm, including a reed as in the Brown loudspeaker. Unless the mechanical arrangements of the reed mechanism is critically controlled, severe amplitude distortion could result.

One method of reducing this distortion is to use a balanced armature system (as in the modern lightweight telephone receiver), in which the reed is pivoted at its centre and attached, via a rod, to a cone. The reed moves under the influence of the magnetic field produced by two coils. An example of this form of loudspeaker is illustrated in Fig. 3.

The most popular form of direct radiator loudspeaker is the moving-coil loudspeaker, early examples of which were produced by Magnavox and Rice Kellogg.

The main functional components of the moving-coil loudspeaker are an electrical conductor in the form of a coil, suspended in a strong magnetic field produced by a powerful magnet (Fig. 4), and attached to a large diaphragm (cone), which is free to move under the influence of the forces exerted upon the coil as a result of the current through it.

Early types of moving-coil loudspeaker employed an electromagnetic field usually powered from the h.t. line, but this was later replaced by a permanent magnet.

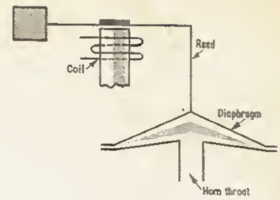


Fig. 2. Simplified illustration of the reed drive mechanism

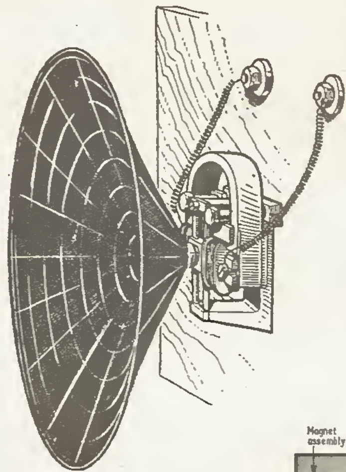


Fig. 3. Celestion Loudspeaker; early direct radiator loudspeaker

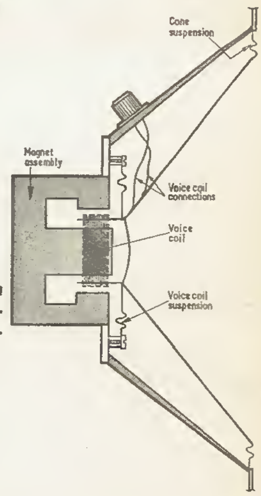
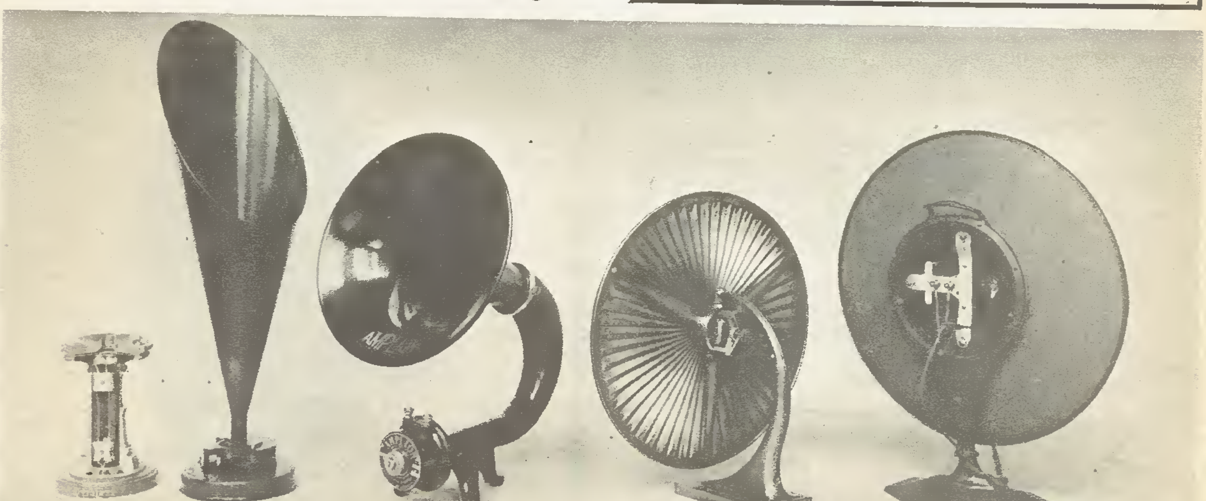


Fig. 4. Cross section through a typical moving coil loudspeaker. Notice the suspension arrangements



(a) Telephone receiver *(b) Brown reed receiver with conical horn* *(c) Amplion exponential horn* *(d) Sterling direct radiator* *(e) Western Electric direct radiator*

Fig. 1. Group of early moving iron loudspeakers (Crown copyright, Science Museum, London)

Unlike the loudspeaker shown in Fig. 4 all the early moving-coil loudspeakers were fitted with a front "spider" suspension system attached to the magnet for centring the coil in the air gap. The efficiency of a loudspeaker fitted with a front spider tends to be reduced at low frequencies, whilst at higher frequencies severe peaks in the response become prominent. The overall aural effect is rather harsh. Present-day types (Fig. 4) employ a corrugated foil or fabric suspension system behind the cone.

The popularity of the moving-coil loudspeaker is due, in the main, to the ease of construction and use, smaller space requirements, and the much improved frequency response; the latter is limited mainly by the dynamic characteristics in relation to the air mass which the cone has to move, and the side effects of wave propagation between front and rear. Fig. 5 illustrates an example of a modern moving-coil loudspeaker.

The main problems in any ideal audio system are concerned with the prevention of unwanted distortion and the maintenance of a reasonably flat frequency response throughout the audio frequency range. The loudspeaker is probably the most difficult part of the reproducing chain in which to achieve anything approaching perfection. Let us now look at the problems involved and see if they can be sorted out.

FREQUENCY RESPONSE

The response of a loudspeaker should not be confused with its efficiency. The efficiency of a loudspeaker is determined by the ratio of the sound power output to the electrical power input. The frequency response of a loudspeaker is a measure of the sound pressure produced at a specific position in the surrounding medium (usually in line with the axis of the cone) due to a known electrical input at a given frequency. The acoustic conditions, under which the test is performed, should also be specified. If the loudspeaker were non-directional there would be no differentiation between the efficiency characteristic and the frequency response characteristic.

A reasonably flat average response over a frequency range can be achieved with a direct radiator, moving-coil loudspeaker. (The term average is used because the speaker should respond to transients, see later.) The main problems are concerned with maintaining the response at both ends of the audio frequency range and reducing peaks in the response which occur at both low and high frequencies.

The mass of the vibrating system of a moving-coil loudspeaker, at low frequencies, may be regarded as equal to the sum of the mass of the voice coil and the mass of the cone; the compliance of the system may be considered as being the resultant of the compliance of the supports of the coil and cone.

The mass of a mechanical system is analogous to the inductance of an electrical system, whereas the compliance of a mechanical system is analogous to the capacitance of an electrical system. Consequently, as in an electrical system, the inherent mass and compliance of a mechanical system produce a fundamental resonance based on these two factors.

RESONANCE

The fundamental bass resonance of a moving-coil loudspeaker is an important factor. For a typical 12in diameter loudspeaker this bass resonance can occur around 30Hz, whereas for an 8in diameter loudspeaker the resonant frequency can be 60Hz or higher.

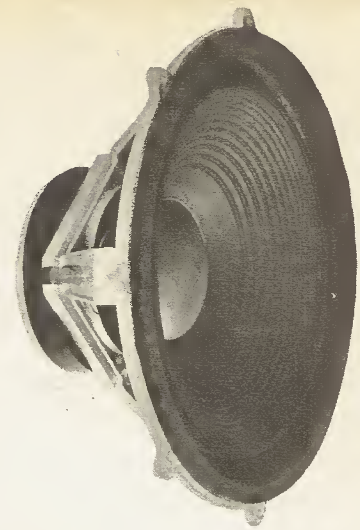


Fig. 5. Modern form of moving-coil loudspeaker manufactured by Wharfedale

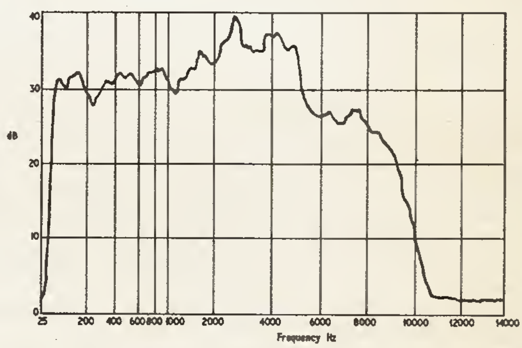


Fig. 6. Frequency response to be expected with a typical 10in moving coil loudspeaker mounted on an infinite baffle

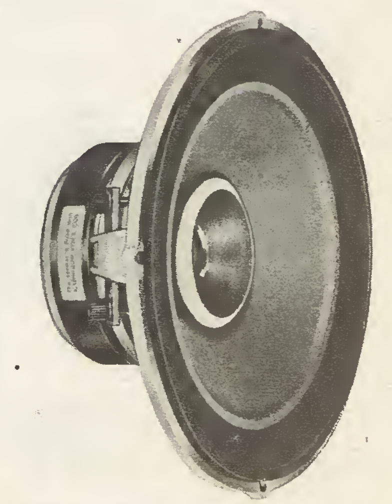


Fig. 7. Dual-cone loudspeaker manufactured by Wharfedale

Fig. 6 shows the frequency response curve for a typical 10in diameter loudspeaker. The fall-off in response of the moving-coil loudspeaker at low frequencies is due, in part, to the inability to match the output of the loudspeaker to the surrounding air. This problem can be partially overcome in a variety of ways. Mounting the loudspeaker in a reflex cabinet (mentioned later in this article), tends to improve the low frequency response, whilst an exponential horn may be used as an "acoustic transformer", as described previously. Of course, the same result can be achieved by using a moving-coil loudspeaker with a larger cone.

The fundamental bass resonance is important in the determination of low frequency response. Below this resonant frequency the response of a loudspeaker falls off rapidly. Furthermore, unwanted harmonics are produced at and around the resonant frequency. It would appear that the aim should be to reduce, as far as possible, the frequency at which bass resonance occurs.

In practice, however, lowering this resonant frequency, by the use of a suspension with a greater deal of freedom can give rise to certain problems. The manufacture of such a loudspeaker tends to be very difficult and also results in a unit whose robustness leaves much to be desired. The centring of the voice coil would be unstable and could be easily affected by small mechanical shocks.

It is worth noting, that although the efficiency of a moving-coil loudspeaker rises at the bass resonant frequency, the actual increases in the response are normally not as great. This is due to the high damping factor of modern amplifiers, which incorporate negative feedback. It is therefore apparent that the effects of variations in the design, which influence the behaviour of a moving-coil loudspeaker, are more readily observed when the loudspeaker is driven by an amplifier without negative feedback.

EFFECTIVE WORKING RADIUS

At low frequencies, the time taken for a displacement of the cone, at its centre, to travel to the rim, is small compared with the period of the signals reproduced, and consequently may be neglected. The cone can thus be considered to behave as a rigid surface, similar to a vibrating piston.

However, at higher frequencies the cone no longer vibrates as a whole; the amplitude of vibration of the cone becomes smaller nearer its rim, hence causing the effective working radius of the cone to be reduced. The overall effect is an increase in the efficiency of the loudspeaker at frequencies in the order of 1,000 to 2,000Hz.

Sharpening of the directional pattern of a moving-coil loudspeaker is lessened by the reduction of effective cone radius which accompanies the increase in frequency.

It can be seen that the reduction of effective radius at higher frequencies is a desirable feature; it may be enhanced by employing a loudspeaker which has circular corrugations formed in its cone.

VOICE COIL

Another point to be considered with regard to the high frequency response of a moving-coil loudspeaker, is the electrical impedance of the voice coil. This impedance increases with frequency, consequently causing a fall-off in the high frequency response. Increases in voice coil impedance, with a constant applied voltage, result in a reduction of the current through the coil, which in turn causes the driving force to be reduced. To maintain the response at higher frequencies requires a reduction in the mass of the voice coil; this can be achieved by using a coil wound with aluminium instead of copper.

Apart from utilisation of various forms of cabinet (mentioned later), a flat frequency response over a wide range can be achieved by using several loudspeakers, each using a filter to reproduce a section of the audio frequency band. The size of loudspeaker cone has a bearing on the frequency range which that loudspeaker can reproduce well; consequently, larger sizes are employed for low frequencies and smaller sizes for high frequencies.

Instead of using more than one loudspeaker it is possible to incorporate two cones in one loudspeaker (Fig. 7), a mechanical arrangement being used to couple the two cones. At low frequencies the entire system vibrates as a whole, both cones radiating together. At high frequencies the small cone vibrates, without damping interference from the large cone. This system is generally termed dual concentric. In some cases the two cones are energised from two separate voice coils, so that each can be suitably tailored for best response within its range.

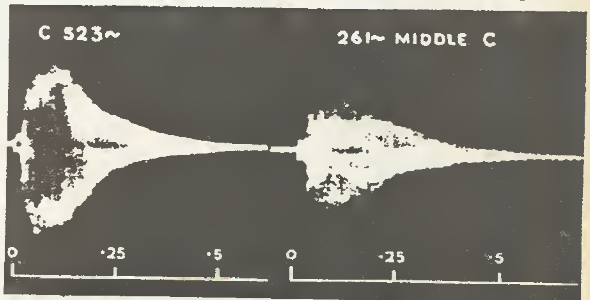


Fig. 8. An oscillogram showing the wave-envelope of a piano tone

TRANSIENT RESPONSE

A point often overlooked when considering the sound quality of a moving-coil loudspeaker, is its transient response. The transient response determines the ability of a loudspeaker to follow very rapid changes in the amplitude of the applied signal. The normal frequency response curve only illustrates the ability of a loudspeaker to respond to a constant sinusoidal signal irrespective of time.

In practice a loudspeaker is rarely used to reproduce pure sine waves of constant amplitude, but has to be able to handle signals, the waveforms of which can be of the form shown in Fig. 8. (Notice in this illustration the wave envelope of a piano tone, with its percussive attack and exponential decay.)

The source impedance of the amplifier used to drive the loudspeaker, and the flux density of the magnet used in the loudspeaker, both determine the transient response of the loudspeaker, in addition to the fundamental bass resonance previously discussed. High flux density in the magnet and reductions in the source impedance, by the use of negative feedback in the amplifier, tend to improve the transient response of a moving-coil loudspeaker.

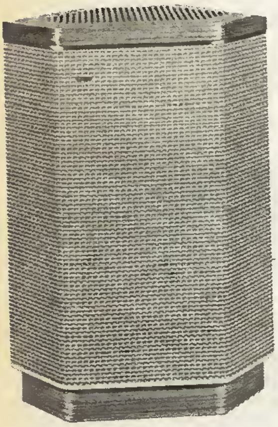
POWER HANDLING

Another important property of a loudspeaker, is its power handling capacity. The output of a moving-coil loudspeaker is limited by the maximum permissible axial displacement of its cone. The greatest displacements occur at low frequencies, while high frequencies are damped to some degree as mentioned above.

The loudspeaker should be designed to handle the lowest frequency (about 16 or 32Hz for organ music) without the risk of cone tearing or voice coil former being damaged. An unpleasant rasping sound at low frequencies is a sign to employ a larger loudspeaker. Similarly distortion and vibration at medium frequencies could also point to the need for a larger loudspeaker, but not always.

DISTORTION

Most of the distortion produced by a moving-coil loudspeaker is due to non-linearity of the cone suspension system. This non-linearity results in the production of harmonics and subharmonics. The harmonic distortion as stated earlier, is predominant around the fundamental bass resonant frequency, whereas the production of subharmonics due to the cone suspension system occurs at very low frequencies and is not usually noticeable. The troubles associated with the production of subharmonics, are apparent in the mid-frequencies where non-linearity of the cone itself occurs.



The "Airedale" hexagonal enclosure for corners designed by Wharfedale. Three loudspeakers are housed inside with a half-section three-way cross-over seperator unit. Dimensions are 38½in × 27½in × 14in

Another source of distortion in the moving-coil loudspeaker is non-uniformity of the magnetic field in which the voice coil moves. This can be overcome by employing a voice coil winding, longer than the air gap in which the coil is positioned, thus ensuring that the whole of the voice coil winding remains in the air gap, even during maximum excursions of the coil.

The sources of distortion so far described also give rise to another form of distortion, known as intermodulation distortion. Intermodulation distortion occurs when the simultaneous reproduction of any two frequencies results in the production of another frequency. This form of distortion is reduced by ensuring that the cone suspension system behaves, as far as possible, in a linear manner, and that non-uniformity of the magnetic field is eliminated, in the manner already described.

BAFFLE

The sound energy radiated from the back of the cone of a moving-coil loudspeaker is 180 degrees out of phase with the sound energy radiated from the front. If, therefore, a loudspeaker is not mounted on a baffle board, or in a cabinet of some form, the sound energy radiated from the back of the cone will interfere with the sound energy from the front of the cone, thus resulting in a reduction of acoustic perception at the listening position. This can be overcome by mounting the loudspeaker on a flat baffle of suitable dimensions with frontal aperture.

The choice of dimensions is governed by the size of loudspeaker and required low frequency response; the lower the frequencies to be reproduced, the larger must be the baffle. However, the baffle need only be made large enough to ensure satisfactory response down to the bass resonant frequency of the loudspeaker. Beyond that frequency, no matter how large the baffle is made, the response of the loudspeaker will fall off rapidly.

The use of a small baffle can also produce a dip in the frequency response at higher frequencies. This is more pronounced when using small loudspeakers. It may be significantly decreased by mounting the loudspeaker off-centre on the baffle.

E.M.I. elliptical woofer and high flux tweeters with crossover unit, suitable for a 1·5 cu ft enclosure

The size of a flat baffle necessary to ensure satisfactory response is not generally practical and one must accept a compromise by using a smaller baffle with a poorer low frequency response.

TOTALLY ENCLOSED CABINET

A more satisfactory arrangement is often achieved by mounting the loudspeaker in a totally enclosed cabinet (infinite baffle cabinet). The sound energy radiated into the surrounding air then emanates from the front of the loudspeaker cone only, as with an infinite baffle.

The main objection to this form of cabinet is the increase in the frequency of bass resonance of the loudspeaker, as a result of the additional stiffness contributed by the mass of air confined within the cabinet. This causes the response at low frequencies to begin falling off at a higher frequency than if the loudspeaker were mounted on an infinite baffle.

This may be partially overcome in one of two ways; by increasing the volume of the cabinet, thus reducing the additional stiffness, or by using a loudspeaker with a lower bass resonant frequency (i.e. a loudspeaker suspension with greater freedom).

The sound energy radiated from the back of the cone still produces undesirable effects, in this instance causing, at certain frequencies, standing waves to be set up within the cabinet. This results in unwanted dips and peaks in the frequency response, but can be significantly reduced by lining the interior surfaces of the cabinet with a layer of sound absorbent material (e.g. fibre glass, cotton wool, etc.). This reduces the magnitude of the standing waves and also decreases the peak in the response at the bass resonant frequency.

OPEN-BACKED CABINET

One of the simplest ways of mounting a loudspeaker, is in an open-backed cabinet. This is a suitable way of applying a "folded" baffle where space is limited. Here once again, sound energy radiated from the back of the loudspeaker cone combines with sound energy radiated from the front of the cone to produce a rapid fall-off in the response below the fundamental resonant frequency of the cabinet.

The cabinet resonance, is in itself troublesome, as it introduces an unwanted peak in the frequency response. However, by arranging for the bass resonant frequency of the loudspeaker to be lower than that for the cabinet, a smooth and extended low frequency response may be achieved. Standing waves are not a problem due to the air pressure flexibility at the rear.

REFLEX CABINET

The use of a reflex cabinet enables the sound energy radiated from the back of the cone of a loudspeaker to be added, in phase, with the sound energy radiated from the front, thereby increasing the output at lower frequencies.

The reflex cabinet comprises essentially, an enclosed cabinet with a vent aperture situated below the loudspeaker aperture. At high frequencies the vent has no significant effect and the cabinet behaves as a totally enclosed cabinet. The interior of the cabinet must therefore be lined with a sound absorbent material to avoid the presence of standing waves.

At low frequencies, sound energy, radiated from the back of the cone, after undergoing a phase shift of 180 degrees, emanates from the vent, thereby reinforcing the sound energy, radiated into the surrounding air, from the front of the cone.

At frequencies below the resonant frequency of the cabinet, however, this phase shift rapidly decreases, and the air in the vent tends to move in phase with that at the back of the cone. The resultant response due to radiation from the vent and from the front of the cone produces the poor low frequency response associated with a small baffle at frequencies below cabinet resonance.

CONSTRUCTION OF LOUDSPEAKER CABINETS

In the preceding paragraphs the walls of the cabinet have been assumed to provide a definite boundary for the sound waves. In practice, careful attention has to be paid to the choice of cabinet wall dimensions to avoid vibrations of the cabinet itself. This is more important for totally enclosed and reflex cabinets, where high pressures may be set up with the cabinet.

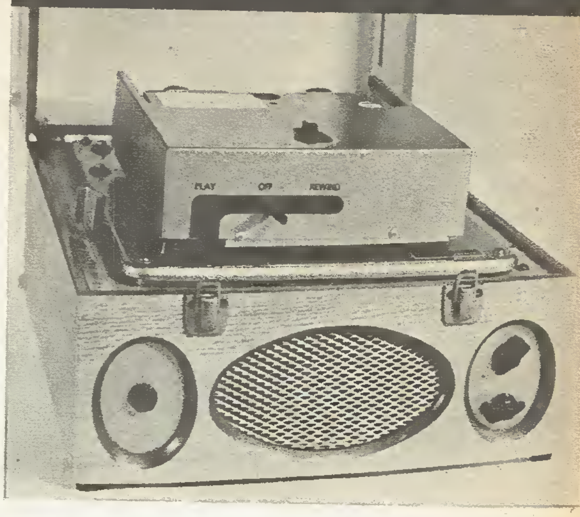
Additional rigidity of the cabinet walls can be achieved by using cavity walls filled with sand. These are constructed by spacing two stout wooden sheets, say ½in to 1in apart, and filling the cavity with dry sand; even better results can be achieved by constructing the cabinet of concrete or bricks.

More precise details of cabinet dimensions are not given here because they should be matched where possible to the loudspeaker to be used. Manufacturers' literature should be consulted or alternatively some text books may offer guidance.

ACKOWLEDGEMENTS

The author wishes to acknowledge Rank Wharfedale Ltd. and Sir Isaac Pitman & Sons Ltd. for assistance in compiling this article. ★

NEWS BRIEFS



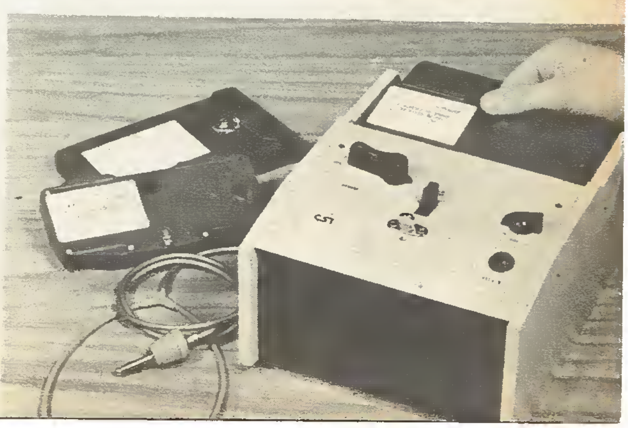
Talking Books Conversion for New Cassette

THE British Talking Book Service for the Blind, administered by the R.N.I.B. is now rapidly expanding due to the development of the Mark IV type tape cassette. This cassette, which is very much smaller than has hitherto been used, contains up to 13 hours of recording time, playing at $\frac{15}{16}$in per second on a ¼in tape. New features of the MkIV have brought about the development of a small portable machine (shown below) that has largely superseded the larger MkI version. Transistors are employed to amplify the tape signal and, in the case of the students' library, to give audible signals at high speed for fast chapter location.

Whilst there are still large quantities of MkI machines which are expected to offer another 10 years of service, they must be made capable of replaying both MkI and MkIV cassettes.

A special adaptor has been developed to enable the MkIV cassette to be played on the MkI machine, after minor modifications to the machine as shown above.

Due to the rapid expansion of the Talking Book Service (some 250 titles and 6,000 new members each year) the problem of voluntary installation and service mechanics is becoming acute in many parts of the United Kingdom. Persons who are willing to give occasional help on a voluntary basis to enable blind people to use the Talking Book machine and assist with repairs would be gratefully acknowledged. Further information and offers should be addressed to The Manager, British Talking Book Service for the Blind, Mount Pleasant, Alperton, Wembley, Middlesex.



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.

BETTER RECEPTION

Now that colour television programmes are in full swing and more people are taking delivery of colour television receivers, **Belling-Lee Ltd.,** decided to develop a pre-amplifier which would improve colour, black and white, and stereo f.m. radio reception. The result of these developments is the Concord pre-amplifier which is claimed to give a signal amplification of approximately four times.

Designed to operate on all television channels and f.m. radio band, the Concord is an ultra broad band pre-amplifier which boosts the incoming signal giving better picture quality, sharpening contrast, reducing "snowstorm" noise effects, and, on colour sets, gives better colour quality.

The pre-amplifier is ideally suited for fringe areas and is easily installed by simply hooking the moulded grey case, measuring 5in × 3½in × 2½in, onto the rear of the television or radio receiver. Plugging the aerial lead into the input socket, inserting a screened link lead between the pre-amplifier output socket and receiver aerial input socket, and connecting the mains lead to the supplies completes the installation.

Power consumption is very small, approximately the same as an electric clock, and the recommended selling price is £7 7s.

Once installed, it is claimed no further adjustments are necessary.

Belling-Lee ultra broad band pre-amplifier

LOGIC KIT

To meet the needs of electronic project work in schools amongst students of all ages, **Geatronix Ltd.,** have developed the Norkit range of electronic kits.

The basic building brick is a NOR logic module which, together with the other components supplied, enables the rapid assembly of a sequential control system for any automatic device.

There are three Norkit ranges at the moment: the junior, price £8 16s; the senior, price £17 12s; and the advanced kit, price £26 8s.

The junior kit contains seven NOR logic circuits, two output units, diodes, lampholders and lamps, push buttons, reed switch and magnet, capacitors and resistors and all necessary interconnecting wires and solder.

The senior kit contains 12 NOR logic units, three bistable circuits, three output units, microswitch, and a larger selection of all components supplied with the junior version.

The advanced kit introduces components associated with automation equipment, and contains power driver units, photo cells, Zener diodes, thyristors, unijunction transistors, etc.

Handbooks supplied with the kits clearly outline the fundamentals of logic and automation and give a good introduction to computer work.

Most items can be purchased separately and further details can be obtained from, Geatronix Ltd., 28, Redstock Road, Southend-on-Sea, Essex.

Another product aimed at education is the Pidam range of teaching modules from **West Hyde Developments Ltd.**

These modules are digital and analogue plug-in devices which can be used to make up demonstration models, and can be used to construct teaching machines which can be loaded with questions and answers in elementary physics.

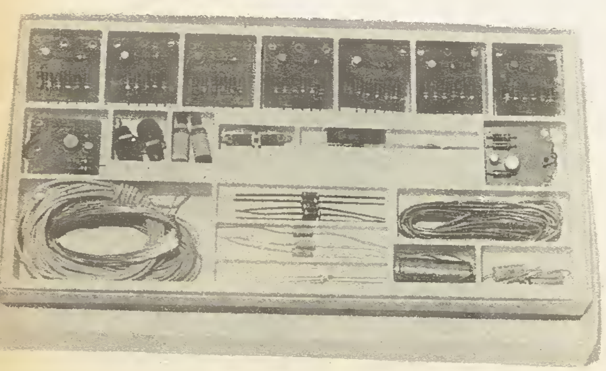
Further details can be obtained from, West Hyde Developments Ltd., 30 High Street, Northwood, Middlesex.

SOLDER

A handy size dispenser for solder has just been introduced by **Multicore Solders Ltd.,** Hemel Hempstead, Hertfordshire. The new, pen size pack contains 21ft of 60/40 Ersin 5-core solder and is ideal for the tool box, and for use when soldering small components, fine wires and printed circuit work.

The dispenser is known as size 15, costs 3s and is claimed to be designed so that the solder cannot fall back inside the container. If the reader only requires enough solder for the odd repair, then possibly the size 2 pack will suffice. This is a larger gauge 5-core solder contained in an envelope with full soldering instructions printed on the back. The size 2 pack costs 6d and contains enough solder for 80 average joints.

Junior logic kit manufactured by Geatronix



Solder dispenser from Multicore Solders

Pidam logic modules produced by West Hyde Developments

CRYSTAL HOLDERS

Constructors may be interested in the range of Augat crystal holders marketed by **Electrosil Ltd.**, Pallion Trading Estate, Sunderland, Co. Durham and available from some retail stockists.

Crystals may be easily inserted or removed without any adjustments to latches or screws, and once inserted it is claimed that the crystal will not shake loose under severe vibrations.

Developed to take crystal sizes HC-6/U, HC-13/U and sub-miniature type HC-25/U, the holders are easily bolted onto any chassis, and the solder terminals are completely insulated.

A 5-pin TO5 outline relay socket is also available from Electrosil Ltd., and can be supplied for printed circuit board or chassis mounting.

FINGER TOOLS

The items in our photograph (bottom right) are not stick-on claws to even up the sexes but finger tools useful for miniature electronic assembly work.

Known as Deli-Cut tools they consist of miniature cutters, tweezers and positioners. The tools are attached to the finger tips by a self-adhesive band and worked by the thumb. A different tool can be carried on each finger, if necessary.

Marketed by **Henri Picard and Frere Ltd.**, 34 Furnival Street, London, E.C.4., the tools are steel hardened and vary in shapes and cutting angles.

IC CARD

A printed board designed specially to accept integrated circuits is now available from **A.P.T. Electronic Industries Ltd.**, Chertsey Road, Byfleet, Surrey.

Designated Cardic 24 (part number LK-3121), 24 dual in-line (14 or 16 leads) integrated circuits can be mounted on one card. Printed power supply copper tracks run to each i.c. and a 24-way input/output edge connector provides plug-in facilities.

The cards are designed specifically to achieve simplicity of i.c. insertion and removal without undue damage to the wiring or device.

These cards are also supplied as part of a kit assembly, Lektrokit No. 10, which includes the components for a complete rack mounting framework with 12 sockets and guides for £23 10s.

PHOTO CELL

A new range of CdS photoconductive cells are now being distributed by **Hird-Brown Ltd.** Complimenting the existing 1in, $\frac{1}{2}$in and $\frac{1}{4}$in diameter devices these additional cells are packaged in TO5 outline encapsulations.

Described as types NSL481 to NS484 and NSL487, they offer twice the power ratings and values cover 2·5 kilohms to 160 kilohms, measured at one foot candle.

Spectral response covers the normal CdS range peaking at 0·55 microns, similar to that of the human eye.

All devices have a power rating of 200 milliwatts at 25 degrees centigrade. Maximum peak voltage is rated at 250V a.c. or d.c.

Any further information can be obtained from Hird-Brown Ltd., Lever Street, Bolton, Lancashire.

LITERATURE

Colleges and evening institutes may be interested in a booklet published by **Mullard Educational Service** describing an aid for teaching counting systems and logic functions.

Entitled *A Digital Integrated Circuit Training Aid* (DICTA), the booklet describes a system using integrated circuits and indicator lamps that can be easily arranged to make 100 different types of counter and shift register.

This is achieved by rearranging simple patching links made with copper-plated split pins. The equipment can also be used to demonstrate the logic functions of various types of gate and combination of gates as found in adders and decoders.

Copies of the booklet can be obtained free, from Mullard Educational Service, Mullard House, Torrington Place, London, W.C.1.

Readers of *Hi Fi News* will know just what to expect in their Audio Annual 1969—the fourth edition to be published by **Link House Publications.** It looks very much like a fat edition of the above journal with layout and presentation in the same style.

All this is by the way—most audiophiles will be looking for the usual run-down of audio equipment test reports and reviews that have appeared over the last year. For those about to embark on a spending spree and want to know more about what has come onto the market during this period, this Annual could be 7s 6d well spent.

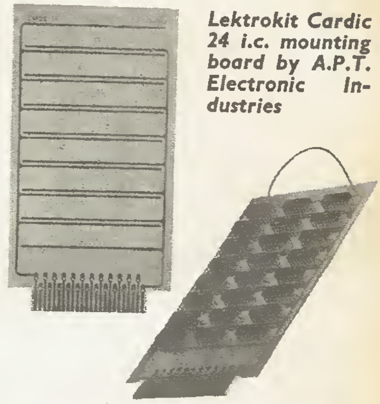
A regular group of consultant contributors have provided some light hearted and serious articles on the general aspects of hi fi, including a survey of progress over the past 50 years.

This annual contains 132 pages including 50 pages of advertisements for current equipment. It is available from most large newsagents.

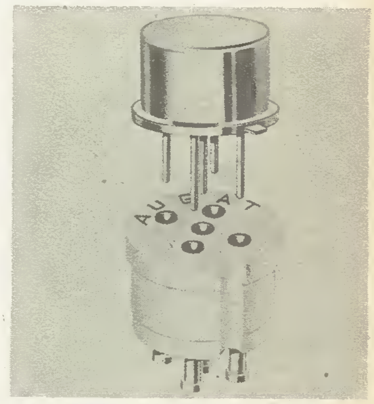
Available from distributors of International Rectifier components are a range of charts giving detailed operating characteristics for thyristors, triacs and unijunctions; low power and Zener diodes; voltage surge protectors, high power diodes and rectifier assemblies.

Further details of nearest IR distributors can be obtained from **International Rectifier Co. Ltd.**, Hurst Green, Oxted, Surrey.

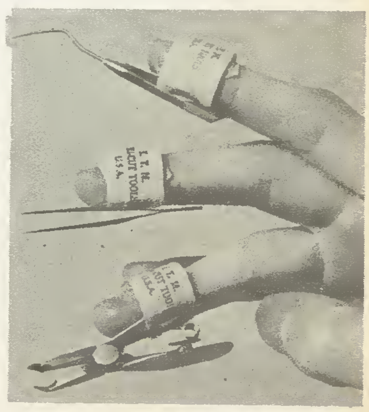
NSL 481 photocell from Hird-Brown



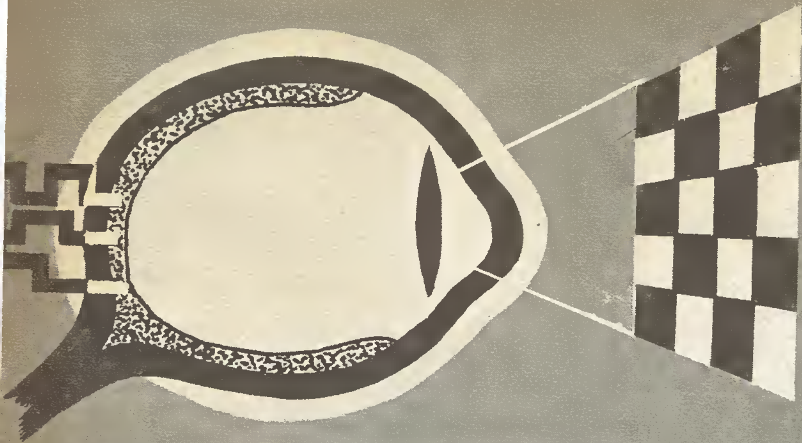
Lektrokit Cardic 24 i.c. mounting board by A.P.T. Electronic Industries



Augat 5-pin TO5 relay socket from Electrosil



Deli-Cut tools marketed by Henri Picard and Frère



6

PROPERTY DETECTORS PATTERN RECOGNITION

BIONICS

BY G.C.BROWN
M.S.H.A.A., A.M.R.S.H.

Actual hardware versions of the edge and bug property detectors mentioned in our last discussion really "eat up" photo-cells in the number required to do the job. Such devices additionally demand well matched and sensitive receptors; so even if we had decided upon using, say, ORP12's the total cost could have been extremely high. Unfortunately too, most cheap photo transistors are inappropriate in that they are light sensitive only from the side of the glass envelope—the requirements being that a group of receptors be mounted together so that they may be exposed to illumination end-on.

We will therefore "keep our expensive ideas to ourselves" and look at some equally interesting property detectors which require fewer receptor elements. (While in the meantime we can only hope that manufacturers will make an attempt to equalise the scandalous price differential between their transistors and photo-sensitive devices).

Unlike some of the previous examples which were based more upon inductions from physiological data, the property detectors we shall consider now will tend to be of the invented kind. The first is shown in Fig. 6.1.

A CRUDE FORM OF SIMULATION

The notion we have here is one which, although fundamentally simple, could prove to be quite advantageous if utilised in certain automata. One aspect of a higher animal's abilities is that which permits it to judge the speed of objects moving in relation to itself. Just how this is performed in the biological brain is a matter for further research and contemplation. However, in the diagram we see the basis for a method of obtaining a form of crude simulation. The basic scheme includes just one monostable plus a NAND gate. Its operation is most easily seen if we install a pair of eyes (photo-cells) in the device, so that it can "observe".

For the sake of example we may assume that the monostable as shown in Fig. 6.1 has a period of 0·7 seconds. Now if a moving light, or even a bright object, passes photo-cell X1 the monostable will be triggered. If during the time the monostable is in this quasi-stable condition the moving object passes X2, the output from the gate will change from 1 to 0 permitting this output to appear up to the time that the monostable reverts to its stable state. On the other hand, if X2 receives the stimulus *after* the monostable has "switched back", or indeed if it never gets stimulated, the output will remain unchanged.

Such a device, though crude, could be used to classify "fast" and "slow" moving objects. How "slow" and how "fast" we of course do not know, except that the speed of movement was either above or below 0·7 seconds. We cannot be certain either that the stimulus at X2 was caused by the same object! Nevertheless, it is possible to improve the scheme a great deal by employing more classifiers.

MORE ADVANCED DETECTOR

In Fig. 6.2 the scheme is a little more ambitious, for not only does it break the classifications into "fast", "medium", and "slow"; but also permits observation of objects from either direction and additionally tells us the direction. (Fig. 6.1 was strictly "one-way only".)

This improved property detector operates in much the same way as the previous example, except that now we have three monostables in each side. Now each monostable in a group has a different period; so if, as before, X1 "saw" the approaching object first, then all the monostables in the associated group would turn on.

The design and construction of electronic "animals" or machines with artificial intelligence

Fig. 6.1. A crude form of property detector for judging speed of moving objects

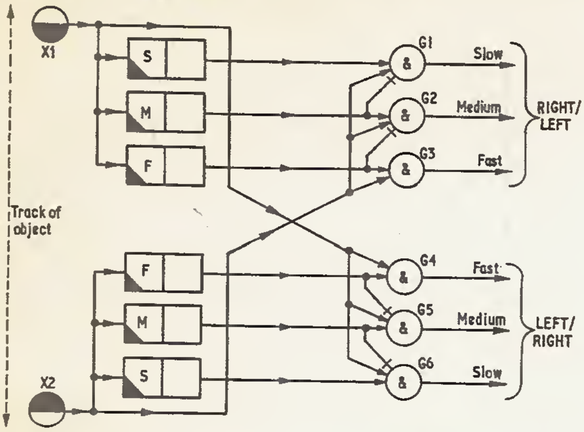


Fig. 6.2. Property detector for judging direction and speed of passing objects

We can arrange to do this by mutually inhibiting each group of monostables with the output from the opposite "slow" element. The machine will now be incapable of looking at anything else until the sampling time is over. Unfortunately, there is no easy way of overcoming this fault of "working backwards" once the sampling period is finished, unless *we* decide when it is going to "take a look".

COMPLETE CIRCUIT

The constructor might well like to try out the device in Fig. 6.1 for himself, and so in Fig. 6.3 we see the circuit. The monostable used here is fairly conventional and is triggered if X1 (an ORP12) is illuminated. This triggering arrangement, like so many we have used before, is unlikely to require its being preceded by a Schmitt, because generally there is a sufficiently abrupt change in illumination at the photo sensor as to make the inclusion of a threshold element unnecessary.

Following the firing of the monostable, TR2 collector will be at almost ground potential and therefore one half of the gate, TR3, will be enabled. Hence if X2 becomes illuminated at any time during this period, TR4 will be released with the result that the gate output will go negative (the "O" state); thus indicating that the

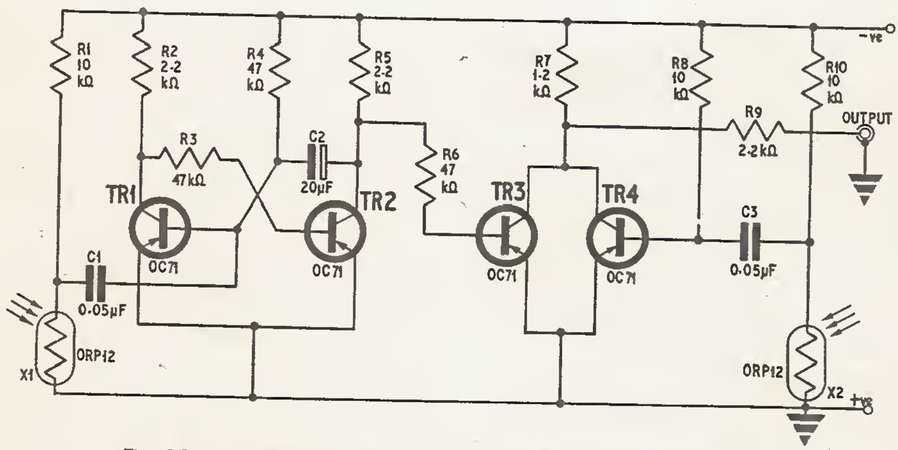


Fig. 6.3. Circuit diagram for property detector outlined in Fig. 6.1

(Notice that the gates at the outputs of the "slow" and "medium" speed monostables have inhibitory connections taken from the next shorter period element.)

If the moving object passes X2 before the "fast" monostable has reverted to its stable condition, then a "1" will appear at the output of G3. Without the inhibition at gates G1 and G2 a "1" would occur at their outputs too. Assuming the object was moving less quickly, the "medium" or perhaps "slow" speed monostable would probably "catch it", with the result that G2 or G1 would show a "1".

As with all our schemes this one is not without its gremlins either, because when the object passes the second receptor all the monostables on the opposite side will fire too! Thus, it is only necessary for a further object to enter the machine's purview from the same direction to elicit a false response from G4, G5 or G6. This problem can, to a large extent, be overcome by "playing a waiting game" with the "slow" or longest period monostables.

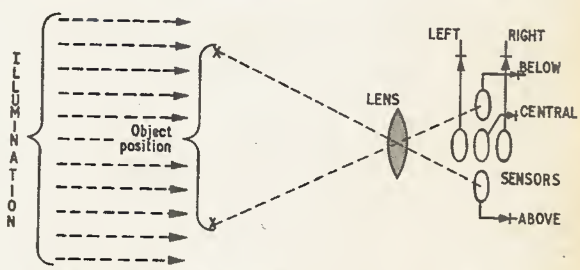


Fig. 6.4. Position detector employing a number of photo receptors. Each sensor delivers an output "1" if the source of illumination is obscured by an object

lighted object passing across the field of view was travelling at a rate faster than the period of the monostable. So far as the machine is concerned, the "apparent" rate of the object will depend on the distance between the sensors.

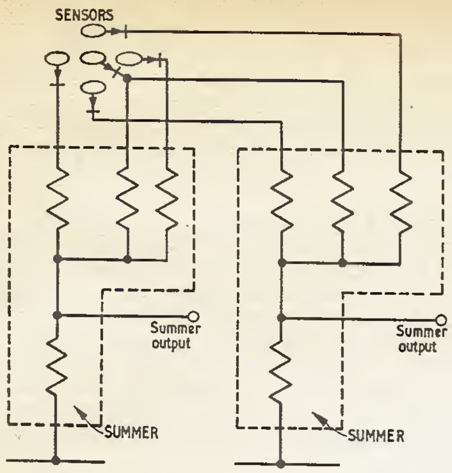


Fig. 6.5. Device for determining length of passing object

POSITION DETECTOR

In addition to establishing the rates of moving objects, there are other factors of which the machine could be made aware without involving a great deal of difficulty. Assuming an object moved into the field of view then it would be distinctly advantageous if its spatial position could be determined. To achieve this the minimum number of photo receptors required is likely to be about five, see Fig. 6.4. However, these five receptor elements are certain to be called upon to perform other functions as well, so the initially somewhat large number would be justified.

The device in Fig. 6.4 has a number of drawbacks, one in particular being the existence of blind spots between receptors. This effect can be reduced by either decreasing the size of the central receptor, so bringing the remaining elements closer together, or alternatively increasing the overall number of receptors. Nevertheless in view of the relative crudeness of the device certain disadvantages must be expected.

DETERMINING LENGTH

Up till now we have assumed that the object within the machine's purview has been "seen" only by one receptor at a time; suppose though that two, or perhaps three, elements become stimulated. This information could (depending upon the distance of the object) be used to obtain a rough idea of the object's length. To overcome the distance problem, and because the blessing of stereoscopic vision is not being considered, we must cheat just a little by standardising the distance at which objects pass the machine.

If all the passing objects now have this standard distance, we could arrange a device like that in Fig. 6.5. This utilises Kirchhoff resistive summing networks driven from the receptors. When an object stimulates just one receptor a certain voltage will appear at the output from the summer; but if more than one receptor is active then the output level will increase accordingly. Depending then on the length of the object, the summer will return either a greater or a smaller output.

Generally, when *we* think of a particular length (it might be one inch), if asked to describe it or perhaps draw a line of about the same length, we have little difficulty. We do not possess "odd inches" or "yards" of some fictitious stuff in our heads, but the ability to convert realistically none-the-less exists.

Just as we perform these transformations, the machine discussed is in principle doing the same sort of thing: it however converts length to voltage. These voltages although already quantised into relatively discrete "bits" by virtue of the all-or-nothing characteristic of each sensor, need to be referred to some standard value if meaningful information is to be obtained. This can be achieved quite simply by taking each summer output to a circuit like that in Fig. 6.6.

STANDARDISATION CIRCUIT

Consider the case where the image of an object measuring an inch just activates two receptors, and we require to set this as our standard. The summer output at this time may also be causing the standardisation circuit to return an output as well, so this level must be backed-off at VR1 until it is reduced to zero. Then for lesser or greater outputs from a summer, there will be corresponding positive or negative levels appearing at the output of the standardisation unit. It will thereby give an approximation to the size of an object in relation to some definite dimension.

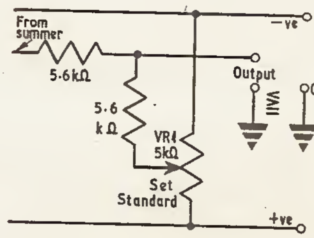


Fig. 6.6 Standardisation circuit for use in conjunction with the device shown in Fig. 6.5

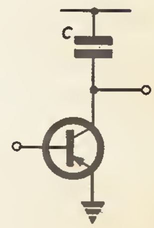


Fig. 6.7. A basic summation circuit

Apart from physical length, property detectors can be designed which determine the duration of an event—or perhaps the length of one event in relation to another. The number of devices which can accomplish this are manifold; the simplest though usually rely upon the necessary summation being performed by linearly charging a capacitor. An arrangement allied to this (though not strictly linear), was seen in the "learning" circuit discussed in the third article of this series.

SUMMATION DEVICE

A basic example of a device which will linearly sum the duration of input events is shown in Fig. 6.7. An "event" of course will constitute the length of time a current flows into the base of the transistor. Now providing this current remains substantially constant, the capacitor will charge linearly towards earth potential. The actual charge that it finally acquires will largely depend upon its capacity and the duration of the charging current. Thus the voltage E appearing across the capacitor will be equal to It/C; where I is the charging current, t the time taken to reach this voltage, and C the value of the capacitor.

It should be remembered that in reading-out the level across the capacitor, only a very high impedance must be applied. Without this precaution the accuracy of any data would be seriously impaired. To meet this need the output is generally fed into an emitter follower, or better still, a Darlington "triplet". Once the information has been read, the capacitor can be discharged and so made available for further use.

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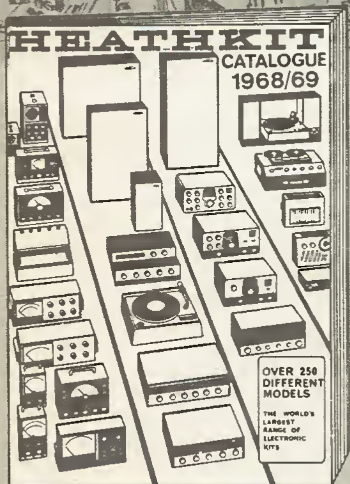

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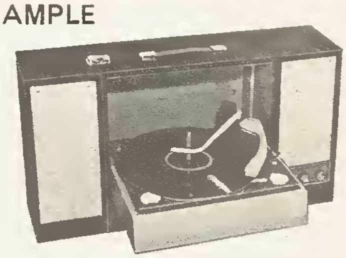

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In order to compare (as suggested earlier) the duration of one event with another, the outputs from two summation devices can be fed via suitable buffer amplifiers to a differential circuit. This will then give an indication of the degree of parity existing between the two inputs.

PATTERN RECOGNITION

The next natural step from property detectors is of course pattern recognition devices, and ultimately machines capable of reading the printed word. Research which has been aimed at discovering ways and means for achieving machine recognition (essentially of alpha-numerics, i.e. letters and figures) has been conducted for something like the last 20 years. The fruits of such labours have however been singularly modest; this to a very large extent being the result of inadequate information concerning the recognition processes employed by animals, particularly humans.

Although various forms of automatic character recognition are an actuality today, they nearly all suffer from disadvantages of one kind or another. Typically their abilities seem limited to recognising typefaces in some standard font and size, so that process by which scansion of the characters is performed may be maintained substantially simple and economic.

An example of a scanning process still currently used in some recognition systems is shown in Fig. 6.8. Here is seen the result of scanning the letter "T". The output pulses from the machine are produced by moving the character past a number of receptors; in this way a series of bits (binary digits) can be generated which, following suitable translation, uniquely categorise the letter.

The process of readout from the receptors is essentially in serial/parallel form, although some schemes utilise a single photo-cell which is made to scan each character several times to provide a wholly serial output. This of course is much like the method employed for interrogating the images projected on to

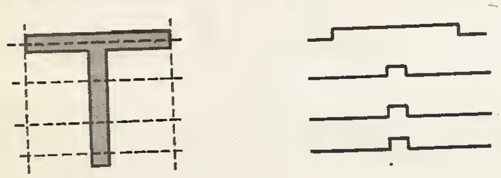

Fig. 6.8. A scanning process used in some character recognition systems

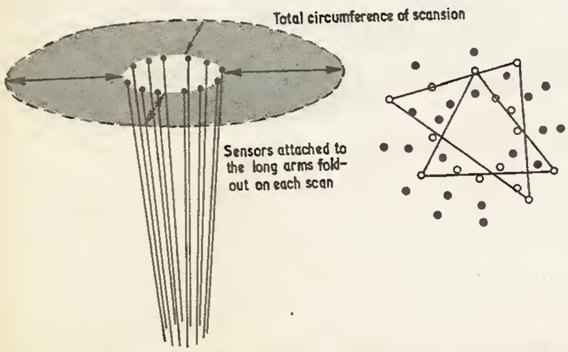

Fig. 6.9. A circular scan system used by one type of machine designed to recognise line drawings (left) pulse pattern when scanning a triangle

the mosaic of a Vidicon camera tube. Indeed, with the remarkable resolution which Vidicons display, it is hardly surprising that they too are now finding extensive use in this application.

MACHINES LIMITATIONS

Despite the severe limitations imposed by current recognition devices, a greater degree of versatility has been achieved by endowing them with memories for several forms of typeface. Nevertheless this form of recognition still falls very short of human capabilities in this field. With consummate ease we can decipher sloppy handwriting, and letters either lost in a background of irrelevant "splodges" or with such a lack of contrast, that one almost doubts if machines could ever approach this standard. To add insult to injury, we also remain perfectly able to read characters in just about any size, configuration, or position. The machine has many problems indeed!

Our considerable feats versus the few merits displayed by some machines do not however constitute a "checkmate". On the contrary, the people involved in this work are unruffled, and treat this more as a challenge than a vain hope.

BASED ON LOGIC

The argument, if argument there is, for the feasibility of really sophisticated pattern classifiers, stems from the fact that every pattern whether a geometrical figure or the written word is equivalent to some logical function in the field of input data. Hence any example of a particular pattern could have a logical value of "1", and any other input would constitute a "0". In simpler terms this means that any visual image either is or is not a square, a circle, an ellipse, a figure "4" or whatever. Thus for *any* pattern there must exist a unique set of rules for determining what it is.

However, for a machine to recognise, it must needs be capable of generalising to a certain extent. This is essential since, for example, no two B's or even "cows" are necessarily alike. Nevertheless, a "B" is always a "B" regardless of the way it may be written, and a "cow" is a "cow" for all that! Each particular pattern therefore has quite definite invariants by virtue of which it can generally be recognised.

Exceptions to this hypothesis are such figures as squares, which if rotated 45 degrees become diamonds, and with moderate distortion can take on the form of rectangles or even parallelograms. Another difficult figure of course is the "x". This can be taken to mean the letter "x" *or* a "times" sign; or, if rotated 45 degrees, it becomes a sign for "sum".

Problems of this kind can often be minimised by inspecting such characters in context with others. Hence if a machine is reading across a row of input patterns and it sees, say, a square, there is very little chance that this could be taken to imply a diamond because to make such a mistake the sensors would require to be moving diagonally to their normally accepted direction of travel.

CIRCULAR SCAN SYSTEM

A machine, built in the U.S.A. some years ago, which recognises simple line drawings is certainly worthy of mention here. This is a system which can account to an extent for size, lateral displacement, and rotation of a pattern, yet remain able to recognise it. The machine's ability to perform in this way is largely dependent on the method of scansion and the placement of its receptors during this process, see Fig. 6.9.

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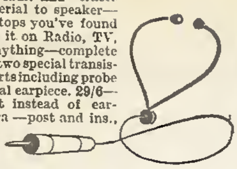

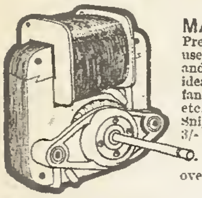

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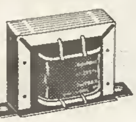

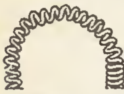

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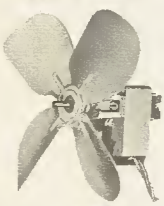

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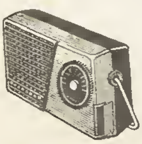

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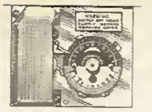

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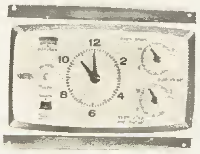

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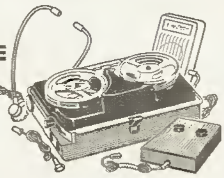

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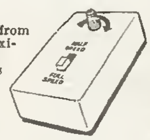

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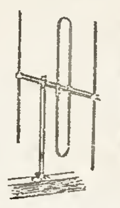

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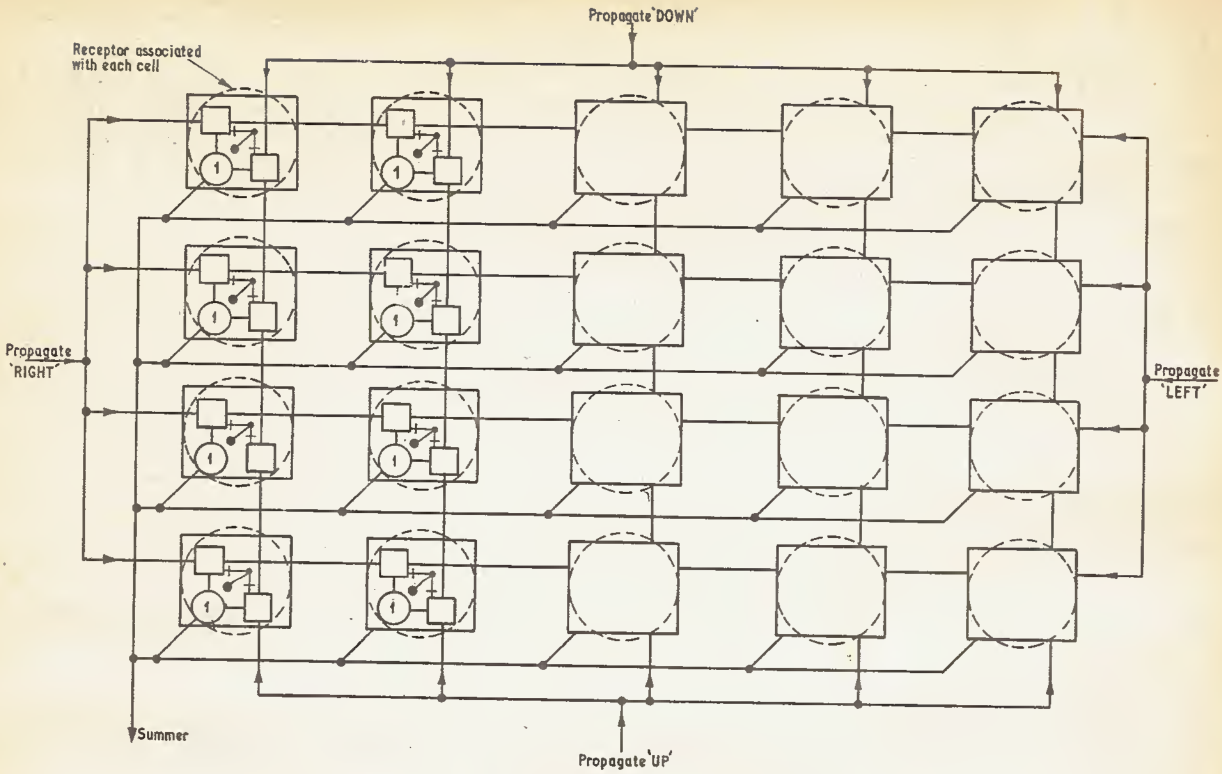

Fig. 6.10a. Basic principles of the fixed matrix system. Note: separate hold, trigger, and reset lines not shown

The receptors which form a circle are mounted at the ends of long scanning arms controlled by a motor-driven "iris-like" device. Thus as the motor runs, the iris progressively opens and the arms fan outwards. In this way the receptors are caused to describe a circular scan, and optically interrogate any illuminated pattern presented before them.

It will be seen that if during the scanning process the output from the receptors is sampled, the result will essentially consist of a series of "off" pulses. Furthermore, in the case of a triangle for example, the pattern of signals will almost invariably consist of a "wave" of three separate groups of pulses. Substantially this will hold true despite variations in orientation—the degree of spacing between the signals will in fact afford a measure of information about the shape of the triangle too. Actual identification of a pattern can of course only come following suitable processing.

FIXED MATRIX SYSTEM

Since the inception of this last type of machine, others possessing even more sophisticated modes of operation have come into being. A particularly exotic device was one which appeared (in experimental form) during 1965. This, instead of utilising a scanning system of moving sensors, relies upon a whole matrix of stationary elements upon which the image of the character to be recognised can be mapped. An understanding of the basic operating principles of the machine is best gained by initially referring to Fig. 6.10a.

In the illustration only an extremely small matrix is considered: in practice, a matrix containing an array of something like 30 × 30 elements would be used. Each sensor in the matrix is connected so as to inhibit the output of a cell containing essentially a pair of bistable elements and an OR gate, every gate output passing along common lines to a summing network.

Assuming initially that no image is mapped upon the cells, then none of them will be inhibited; thus as we apply a pulse to any one of the "propagate" inputs, each one of the bistables in the rows or columns will switch successively until this wave of activity ends at the edge of the matrix when they will all be turned "on". Hence all the associated OR gates will present an output, resulting in the summer returning a maximum level. So far, so good!

Facilities (not shown in Fig. 6.10a) do exist for resetting the bistables, and we will accept now that they have all been reset. We might now consider the case where an image has been mapped upon the sensors. For the sake of simplicity we will assume that the machine is expected to recognise any character in a three letter alphabet; this will comprise the letters U, T and H.

RIGHT AND LEFT PROPAGATION

Now depending on the character being interrogated, there will result a corresponding image on the sensors, causing the associated cells to be inhibited. (At this stage it is important to realise that once the cells have been switched or inhibited they will, unless reset, act as barriers to propagation. A propagation can hence continue along every row/column until it encounters either a "barrier" or one of the edges of the matrix.)

Referring to Fig. 6.10b it will be seen that if we propagate "right" then "left", a different result will

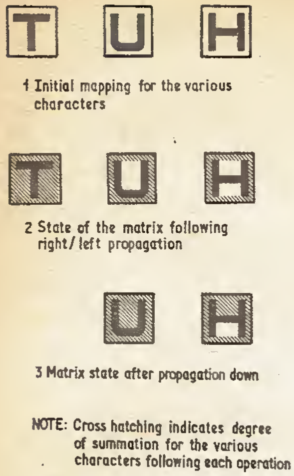

Fig. 6.10b. Images formed on sensors as characters are interrogated

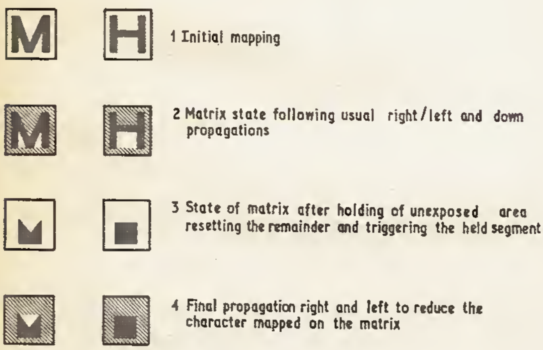

Fig.6.10c. Modified operation to deal with difficult characters

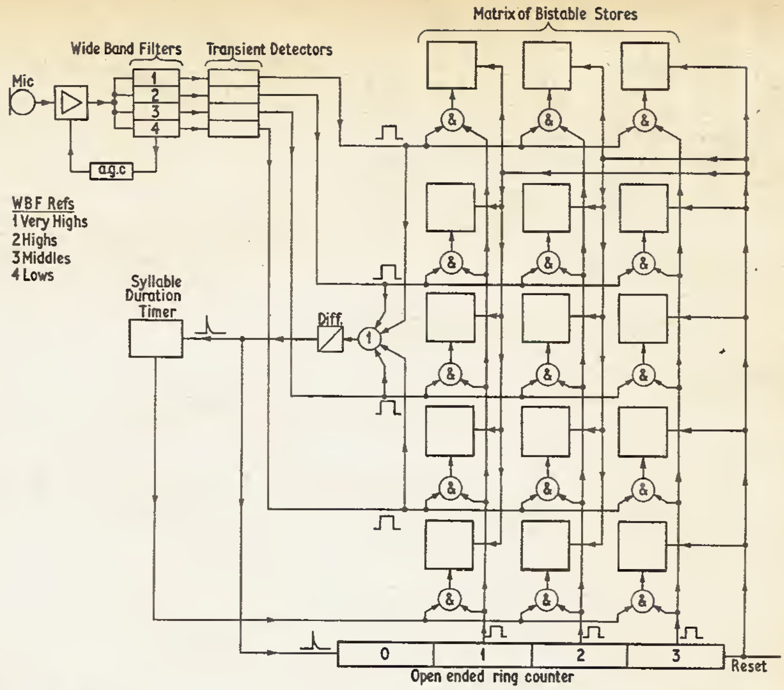

Fig. 6.11. A possible system designed for simple word recognition

If we again propagate "right" and "left", the summer will return a maximum level for the letter H, and (by virtue of a partly unexposed area) a lower level in the case of an M. By similar "artful dodges" this type of machine can be extended to not only the task of recognising the whole of the alphabet (a real one that is!), but also to "reading" characters in different sizes and fonts.

exist for each character. Thus if, following this operation, we inspect the summer output and discover this to be at maximum, then it can be concluded that the letter T is present. Conversely, if the summer does not return such a result, we can assume that the character must be either a U or an H.

If we continue the operation by propagation "down" the matrix, then check the summer level again, we can now be certain about the identity of the character. A maximum output will thus correspond with the letter U, and a lower output with an H. In practice the summer is generally fed into a number of Schmitt triggers set to fire at the different thresholds corresponding to various patterns.

TRICKY CHARACTERS

The capabilities of the machine are now however limited to just U, T and H. Consider the result of "throwing a spanner in the works" by presenting the machine with an M (Fig. 6.10c).

The same routine as described before can be applied, but when we come to the decision "is the character an H or an M?", the operation must obviously be modified. The procedure adopted is then to "hold" the unexposed area of cells whilst removing the image and resetting the remainder; following this (and by applicable gating arrangements) the "held" area is then inhibited.

SPEECH RECOGNITION

Yet other devices have been "dreamt up" for recognition of the spoken word; most of these machines are however even more complex than the last! Nonetheless, one relatively simple example of this form of machine will be given now.

Such a machine might be of the adaptive kind; that is to say it could be *taught* to recognise a certain vocabulary of input words. The actual number of words to be "understood" by the device would be restricted according to the application.

Let us then, for convenience, choose a vocabulary comprising ten words; these might be the numbers zero through to nine. Several avenues for achieving an initial segregation of these input sounds are open to us; we however are only interested in ten basic types, and so the encoding method can be kept relatively uncomplex.

Referring to Fig. 6.11 we see a rather interesting example of a machine that could be built for simple word recognition. The input sounds are first passed to an audio amplifier which, possessing a measure of a.g.c., maintains signal amplitudes within reasonable limits. The amplifier output is then fed via a bank of four wideband filters to separate transient detectors which indicate either the presence or absence of a particular group of frequencies. In this way the various speech

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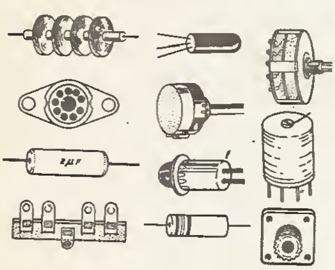

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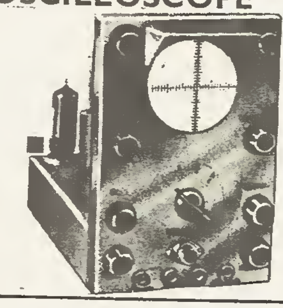

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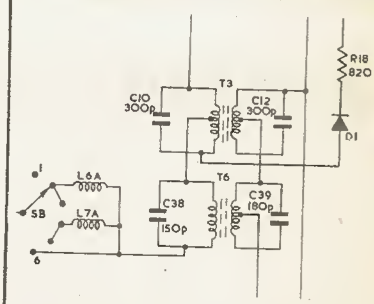

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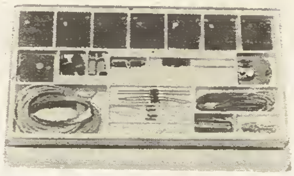

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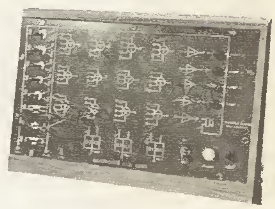

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sounds (i.e. vowels, through to the dentally generated fricatives like "S" and "F") can be broken down into their respective components.

Now the utterance of every syllable in a word can be reckoned to have a duration of some average time. So if we settle on a value for this the signals can be encoded into two further categories, i.e. those within such a duration, and those whose length exceeds this.

Following the breakdown of a word into these discrete bits, it is necessary to store this data in order that the machine can be taught to assign a particular meaning. Storage of the information may be performed in a series-parallel fashion, by sequentially gating the signals into the columns of a bistable matrix.

RING COUNTER

This function is achieved by utilising the leading edge produced by any one of the signals to step-up an "open-ended" ring counter controlling the input gating to the matrix. Hence, the presence of components in the first three syllables of a word will be successively represented as a binary number in any of the first few rows of the matrix. The fifth row in the matrix is reserved for syllable duration information: this is derived from a timer (also triggered by the start of any signal) which generates a pulse only if a syllable exceeds some previous duration. No output pulse will appear from the timer if the next syllable occurs prior to the completion of this period—in fact the timer will be reset for the next duration.

LEARNING ABILITY

Having placed all this data into a memory, facilities must now exist which permit the machine to learn. This can be performed by first feeding the matrix outputs into an even larger matrix and, by so doing, expanding the original pattern to show it up in greater detail. The data stored in this expansion matrix can then be passed to a number of binary "weighted" decision devices corresponding with the various positions in the matrix. Combinations of outputs from the decision devices can then be used to drive a particular lamp relating to the spoken number at the input to the machine.

If the incorrect lamp comes on, the machine must be trained to give the right answer by manually adjusting the "weights" in its decision devices until it becomes successful. Once the machine has been trained for one word, further inputs may then be given—however as this process continues it may require re-training for some of the original words.

IN CONCLUSION

Throughout the present *Bionics* series, we have tried to capture just a mere glimpse of those aspects of electronics which hitherto only a few of us are likely to have come in contact. For various reasons much has been omitted; however it can be expected that further articles on this subject will appear in due course. Some of these, it is anticipated, will take the form of actual constructional projects: for example, one will be concerned with the fabrication of chemical memory devices, while another is likely to deal with a more sophisticated version of the "animal" *EMMA* described elsewhere in this month's issue.

In the meantime, it is the author's hope that he might have widened (just a little) the scope of amateur electronics, and simultaneously portrayed the folly in believing that living animals are essentially uncomplicated things. ★

NEWS BRIEFS

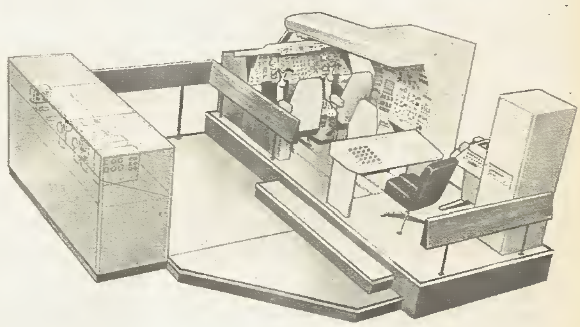
Solar Storm Probe

THE first launch by the European Space Research Organisation of a fully stabilised sounding rocket payload, from the Salto di Quirra range in Sardinia, carried an experiment designed to probe solar storms and assess the amount of X-ray radiation emitted from them. Such research is important because of the health hazard presented to astronauts and passengers in supersonic airliners by hard radiation. An understanding of such storms may also enable short wave blackouts to be predicted. The payload was aligned with the sun's centre to an accuracy of one three-hundredth of a degree by an attitude control unit supplied by Elliott Space and Weapon Automation Ltd.

Concorde Engines Simulator

A CONCORDE engines simulator, for training airline pilots and ground crew, has been ordered from Hawker Siddeley Dynamics by Rolls-Royce. The trainer (see picture) will be installed this Autumn in the Patchway (Bristol) Training School, of the Bristol Engine Division, pioneers in propulsion system trainers. It will simulate the Rolls-Royce Bristol/SNECMA Olympus engines of the Concorde supersonic airliner in all flight phases. Faults can be injected by the instructor at any stage of the training programme.

In addition, the trainer can simulate engine ground running, without noise, and can be used in conjunction with airline checkout and engine test equipment for ground crew training. Engine instrumentation in the trainer's Concorde flight deck mock-up is represented by realistic, inexpensive simulated instruments which receive information direct from a digital computer. The trainer is easy to maintain and programming is simple and flexible; no specialised computer training is required.



British Amateur Electronics Club

THE BRITISH Amateur Electronics Club now boast twenty overseas members, and is increasing all the time.

Two members serving in the British Forces in Germany have arranged an announcement to be made on their local radio programme about the activities of the club, and hope this will encourage other members of the overseas Forces to join.

The club issues a regular Newsletter to all its members containing much technical information and details of constructional projects as well as club activities and future functions. Newsletter No. 11 contains details for a Noughts and Crosses Computer and an Electronic Roulette (inspired by an article in P.E.).

ORBITING OBSERVATORY

One of the astronauts speaking of the *Apollo 8* flight made the point that although the situation in the sky, so far as the Earth and moon were concerned, took on an entirely new aspect when viewed from the spaceship, the stars were completely unchanged except in respect of clarity. This emphasises the fact that the galaxy and all that lies beyond needs instruments for exploration.

The advantages of being free from the Earth's atmosphere makes near space and the moon itself an obvious place for such instruments. Space platforms are already one evolving method. Here a team of observers will be able to operate sophisticated apparatus with direct control. The cost of such space laboratories will be high but inevitable.

SPACEWATCH

By Frank W. Hyde

In the meantime a half-way house is afforded by the Orbiting Astronomical Observatory. Launched at the beginning of December 1968, America's OAO is engaged on the most extensive mapping of the heavens ever undertaken. It is the heaviest unmanned satellite that has been put into orbit by the USA. It weighs some 2 tonnes and carries 11 telescopes. Its expected lifetime is six months but it may last longer. If it should last a year it will be able to chart some 100,000 stars and should it be fortunate that it lasts for two years then the whole sky will be mapped. OAO is in a circular orbit 474 miles above the Earth.

The mapping programme will be carried out by a battery of four telescopes. They were built by the Smithsonian Astrophysical Observatory under the direction of Dr F. L. Whipple. The heart of the system is a special television tube which is sensitive to ultra-violet light. The telescopes will lock onto a star and study the wave emission bands in the ultra-violet spectrum before moving on to the next star.

The other seven telescopes were built by the University of Wisconsin under the direction of Dr A. D. Coode. This unit is for the study of a limited number of stars each day. The programme is to be concentrated on "young stars" and also interstellar dust from which new stars are brought into being. A young star is one which is of the order of 100,000 years old and too faint to be seen by Earth based telescopes.

The telescope packages are fitted at either end of the satellite which is 10ft long. They will share the observing time working a week at a time in turn.

The satellite is fitted with a special stabilising system designed so that even at its orbital speed of 16,000 miles per hour the telescopes can be pointed with an accuracy sufficient to lock on to the stars chosen. As a comparison it is about equal to being able to distinguish between two marbles at a distance of about 150ft.

Power supply is obtained from solar cells in panels which extend about 21ft.

Information is stored on tape and disc and on each orbit the storage systems transmits the information to the ground stations. The Smithsonian unit can be used in "real time", that is, it can directly relay its observations on command. Six ground stations receive the transmission as the satellite orbits the Earth. A computer aboard the satellite can store 256 commands, more than for any previous satellite.

Until now the observations planned in this orbiting observatory have been accomplished only on a few occasions with sounding rockets and balloons. Now there will be a continuous observation, with this and other craft to be launched later, in the gamma-ray, X-ray, and ultra-violet spectrum. It is thought by Dr H. Friedman, an astrophysicist, that X-ray stars may be more numerous than ordinary stars and if this is so new light may be thrown on the origin of the universe.

MARS MISSIONS

It is three years since the first space probe sent back pictures of Mars on its close fly-past. This year there are to be two more such missions.

In 1965 when the spacecraft took 21 pictures from a distance of 6,000 miles they showed that the surface of the planet was marked with craters like the moon. The new spacecraft will be able to approach within about 2,000 miles and there will be a more sophisticated two camera system on board which will take some 66 pictures, some of them with a resolution of the order of 300 yards (as seen by the naked eye).

One spacecraft is to fly by the south polar cap and the other by the equator. At the time of closest approach to the planet the two vehicles will be about 62 million miles from the earth. The two camera system which will have wide angle and narrow angle facilities will take pictures of the whole disc and close-ups of specified areas. The spacecraft will carry other scientific equipment to provide information about the martian atmosphere and surface.

The weight of the craft has increased to 900lbs each as compared with 575lbs on the previous mission. The radio transmitter power is increased from 10 to 20 watts. The power is supplied by banks of solar cells incorporated in the four "sails" and a high gain dish antenna is used for maintaining contact with Earth.

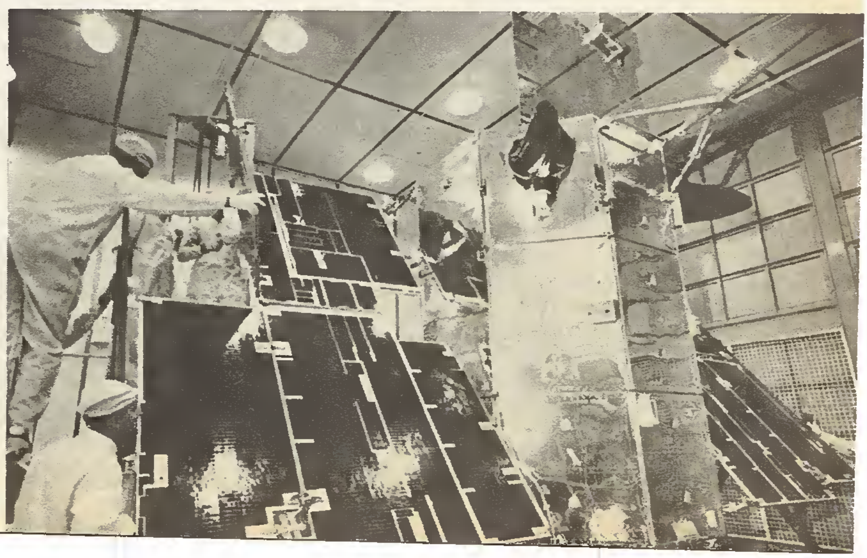
RADIO CAMERA

A new radio camera device is being developed which will enable the reflection of radio waves to be used to produce pictures with the aid of a special emulsion and laser light. The camera has been developed to make use of the fact that when radio waves are directed at a target a small amount of heat is generated.

The back scatter of waves from a reflecting source, such as a ship for example, is directed on to a plate which has a special assembly. A sandwich of heat sensitive cholesterol backed by mylar plastic to pick up the reflected radio waves, and coated with a thin film of crystals suitable for the production of an image when bathed in laser light. The plate is processed as a negative and contains all the information as a refactory pattern. A laser beam played on the pattern produces a hologram with three dimensional image.

There are many applications for such a camera leading to safety measures for ships and aircraft, examining plastics, even to discover if unborn babies are single or twins.

The Orbiting Astronomical Observatory (OAO-2) undergoes final tests



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Readout—
A SELECTION FROM OUR POSTBAG

Arsenide Diodes

Sir—I and some fellow members of my school science society would be interested in carrying out some experiments in "Optical Communication using Laser Diodes" as published in the February issue of PRACTICAL ELECTRONICS.

We would be very grateful if you could indicate a supplier of the gallium arsenide diodes used for this project.

J. Martin,
Lymington,
Hants.

This is one of many similar enquiries we have received on this subject. GAL 1 and GAL 2 devices can be obtained from S.D.S. (Portsmouth) Ltd., Hillsea Industrial Estate, Portsmouth, Hants. at a cost of £4 and £8 respectively. Unfortunately the price of these devices is rather high; however we understand that Proops Bros. of 52 Tottenham Court Road, London, W.C.1 have offered "surplus" gallium arsenide diodes at low price, in the region of 28s each.

We can only hope that in the course of time these devices will become readily available to the amateur at a lower price—Ed.

Post Office Bill

Sir—Restrictions on the radiation of electromagnetic energy of any frequency is fair enough, following the activities of pirates and industrial spies. Legitimate users are already familiar with radio licensing, and presumably the Post Office will be prepared to grant licences to laser operators on a fairly free basis. However, if the term electro-mechanical does not refer to sound then the pirates have an immediate loophole. If they are prepared to go to the trouble of using short range light communication then they can equally well communicate by supersonic carrier over similar distances, by radiating from a multiple transducer array.

Electric, magnetic, and electromagnetic energy has been subject to restrictions for some time, and the Bill merely seeks to tie up a few loose ends, but what are the obscure intentions and implications behind the term electro-chemical and electro-mechanical energy? To what do they apply and for what reasons? It might well be that the new restrictions are more far reaching than they at first appear to be!

D. Bollen,
Beaworthy,
Devon.

Make Light The Way

Sir—Regarding "Post office privilege", as I understood it, all those proud experimenters, building, and then giving the knowledge—via the various radio magazines—to others, of the use of light rays to pass any form of intelligence from one point to another, are controlled by the same regulations as "Hams"; those with licence to use normal radio methods.

It is quite clear, internal use will be just as one would make use of a signal generator, but I doubt if many would understand this limit when experiments to improve the distance have been tried.

Here then, we have the answer to all those, for and against letters, which Editors have for so long had from, would be "Hams", and others.

No morse test, no inference with important services, no exams, just pay and keep to the rules.

Many years ago, experts had a very poor opinion of short waves, amateurs being given the use of them lead the way.

Pioneers, make light the way!

C. S. Burton,
Bulwell,
Nottingham.

Electronics Scouts

Sir—On 2nd, 3rd and 4th May 1969 a camp will be held at Polyapes Camp Site, Oxshott (N.G.R. TQ131597) for all members of the Scout Movement who have an interest in any branch of electronics.

The full programme has yet to be finalised but it is hoped to include demonstrations, talks and discussions on the following: Hi-fi equipment, recording, model control, short wave listening, and amateur radio. In addition it is hoped to have experienced people with test equipment facilities to help the enthusiast with his home constructed projects.

For further details groups or individuals are invited to send a foolscap s.a.e. to:

J. A. Carter,
c/o Baden-Powell House,
Queensgate,
London, S.W.7.

Amorphous Devices

Sir—Further to R. F. Shaw's article on Amorphous Semiconductor Devices in February's edition your readers might like to know some of the history behind the, so called, "Ovionic" devices.

Mr. Shaw refers to the devices as a comparatively recent discovery. By semiconductor standards this is not altogether true. As long ago as 1962 Stanley Ovshinsky—President of Energy Conversion Devices Inc.—was working on specialised materials to form the basis of thermo-electric generators when he suddenly discovered that under certain electrical conditions an alloy of germanium and tellurium showed different apparent conductivity.

The same piece of material would for some apparent reason change from high to low resistance, and on further investigation he found that the material, when changing from a high resistance to a low resistance state, exhibited a characteristic very similar to a gas tube in that when a certain voltage across the material was exceeded it would "break down" and start to conduct. Unlike the gas tube the voltage drop across the material when conducting was very low, i.e. the resistance change was quite extraordinary changing from the order of 10 megohms to approximately 10 ohms. Another unusual phenomena was that which Mr. Shaw describes as the permanent memory out of circuit.

Although it was not known how the device actually worked Ovshinsky took out patents and proceeded to publish details of practical applications of such a device.

Readout—

A SELECTION FROM OUR POSTBAG

In 1963 a British firm obtained exclusive rights to exploit the device and started a research programme to try and evaluate the mechanism of the rather strange conduction characteristics.

At the same time a British Press Conference was called and representatives of most of the technical journals were given a demonstration of the prototype device. The demonstration was met with a widely differing reaction from wonderment to sheer scepticism.

Nevertheless a limited budget research programme was started and attempts were made to obtain government grants to subsidise the work which was progressing satisfactorily. All attempts to obtain such a grant failed—perhaps due to the risk of investing in such an unknown quantity—but the company continued its work and eventually exhibited a number of development devices at the 1964 IEA exhibition at Olympia. Two types of device were shown; the memory device using pure germanium telluride as a material and a threshold device—as described by Mr. Shaw—using germanium telluride with added quantities of arsenic.

In those days the devices were made from pellets of material with point contacts of beryllium copper forming the electrodes (see Fig. 1).

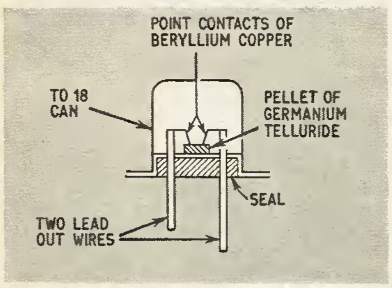

Fig. 1 Structure of the germanium telluride device of 1964

Unfortunately production devices were never made due to several artifects in the development devices.

These problems all stemmed from the basic problem that the mechanism of conduction was not known. It was impossible to predict the all important breakdown (or threshold) voltage of the device and this could vary from batch to batch; typical values being anything between 20 and 100 volts. Worse still this threshold voltage would vary for a single device throughout its life—which was comparatively short.

For some unknown reason the threshold voltage was load sensitive; for instance with a high resistance load the break-down could occur at voltages as high as 200 volts and with a large load drawing approximately 2 amps this would fall to the normal range of value (20 to 100 volts).

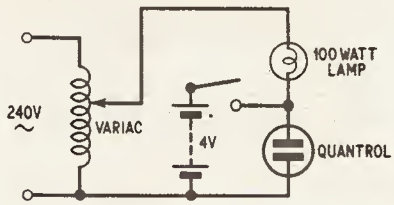

Fig. 2 Prototype test rig for the Quantrol device using a 4V battery for the high current pulse

Fig. 2 shows the type of circuit in which the device operated. The device—at that time called Quantrol—would be connected in series with a load such as a 100 watt electric light bulb. The circuit was supplied from a variable transformer. Starting with the device in the non-conducting state and the applied voltage at zero the voltage would be increased to the threshold level and when this was reached the Quantrol would break down to a low resistance and the lamp would light. To turn the device off it was necessary to apply a comparatively high current pulse obtained from a low impedance. In the prototype test rig this was provided by a 4 volt battery and a push button switch.

Another disadvantage which is apparent from the above circuit was that the device was inherently a two terminal unit; isolated control as can be effected by a transistor, valve, or relay was impossible. It was suspected that the device worked by some type of field effect and attempts were made to introduce a third electrode using the material in a structure very similar to the present-day f.e.t.

All attempts to trigger the device by applied electric fields failed, and this led the researchers to believe that perhaps the device was operating by way of normal dielectric breakdown. The materials used were extremely easily oxidised—some of the alloys used were made by sintering in air which automatically oxidised the surface and others made by casting the molten alloy would not operate until the surface had been oxidised using strong nitric acid.

All the results indicated normal oxide breakdown (similar to that occurring with foil capacitors) and in many cases during the actual breakdown micro sparks could be seen at the junction between the electrode and the material. This effect adequately described the switch on characteristic, and switch off could be explained by the re-formation of an oxide under the surface of the contact by the thermal energy of the high current pulse. If this was the mechanism, the device was working on a physical destruction and reforming principle which would have been highly unreliable in practice. In all fairness, however, this was never conclusively proved and when the allocated research budget ran out further work stopped.

It is interesting to note that at about the same time an American company brought out a device exhibiting identical characteristics which was composed of two electrodes embedded in, but separated by a block of aluminium powder and epoxy resin. This device never reached full production due to the instability of its characteristics.

It seems rather strange that after a lapse of five years the identical device is again being exploited with virtually no change to its characteristics, and still considerable doubt as to its mechanism.

M. J. Hughes,
Westerham,
Kent.

Mr Michael J. Hughes' comments on amorphous semiconductor devices are most interesting and informative, but I would like to point out the fact that although the devices at present have similar characteristics to the older devices, they are vastly improved in their characteristics.

The new devices have very stable threshold voltages and other electrical characteristics providing one takes care to operate the devices within their prescribed parameters The newer devices use both different glass alloys and physical device configurations arrived at by both empirical and theoretical considerations which resulted in their improved characteristics, stability, and reproducibility.

As Mr Hughes correctly pointed out, similar switching has been observed in oxide based devices, but there is now sufficient evidence to rule out this mechanism in the Ovshinsky devices described above.

The five year lapse since the first prototype does not seem unduly long for research and development in this field, since only at the present time has the theory of armorphous materials in general progressed to the state where we can make reasonable postulations as to their conduction mechanisms.—Robert F. Shaw.

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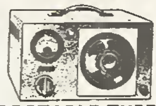
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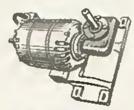

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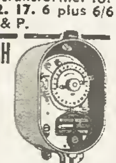

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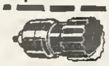

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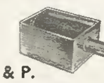

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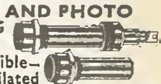

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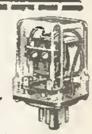

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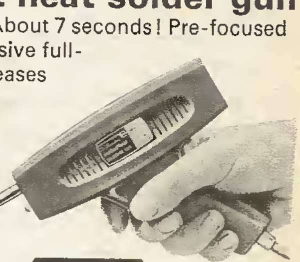

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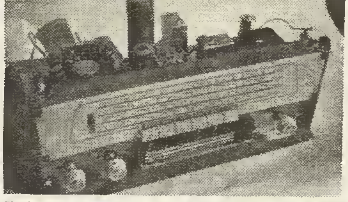

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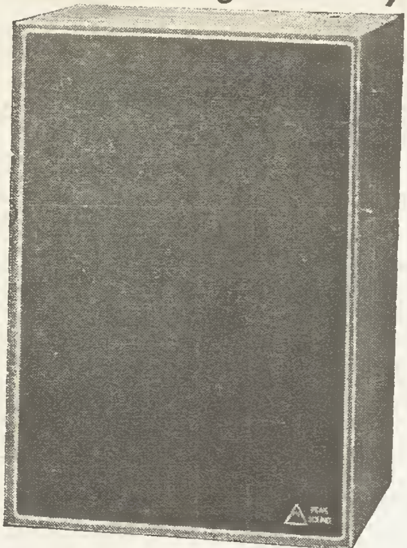

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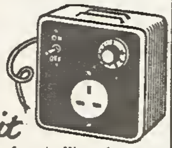

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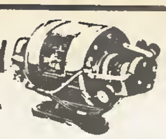

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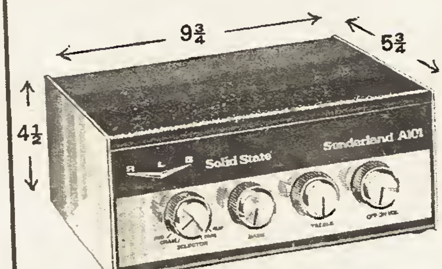

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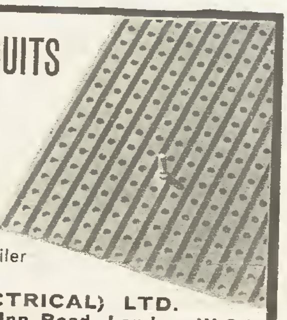

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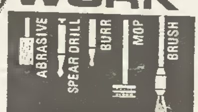

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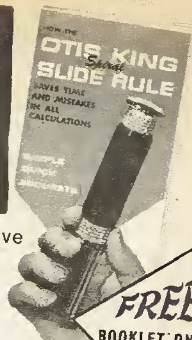

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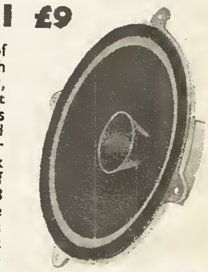

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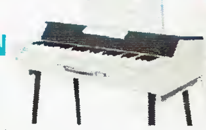

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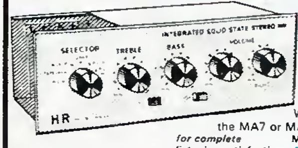

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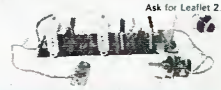

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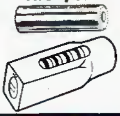

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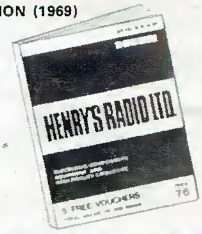

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