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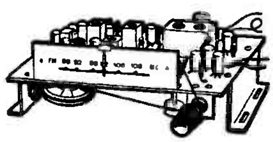

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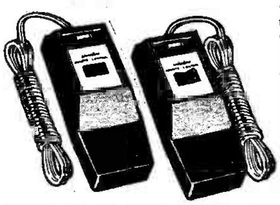

Comprising transistorised signal transmitter unit and receiver relay switching unit this is an extremely compact, simple to use and install remote switching system for use with a wide range of mains operated equipment. The high frequency (inaudible) signal which the transmitter produces is relayed to the remote switching unit via the a.c. mains circuit into which the units are plugged—providing instant on/off—off/on control of appliances. Ideal for use with audio, radio, TV, lights, electric blankets and most other domestic equipment. Spec.: 3 transistor and 1 diode circuit. Frequency 190kc/s (factory pre-set). Power 220/240V a.c., 50/60c/s. Max. power of equipment to be switched 300W. The appliance to be triggered simply plugs in to the switch relay unit. Strong plastic cabinets size 5½ × 2½ × 1½in, each fitted with neon indicator lamp. Complete with flex and operating instructions.

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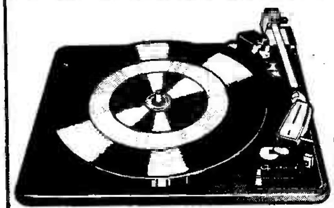

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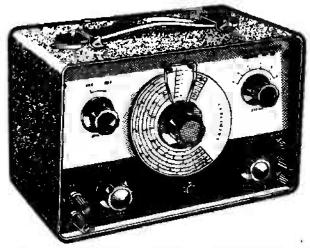

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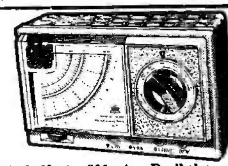

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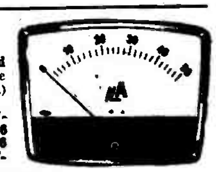

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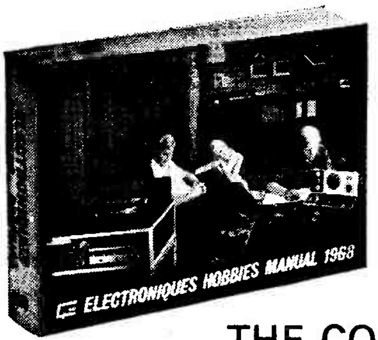

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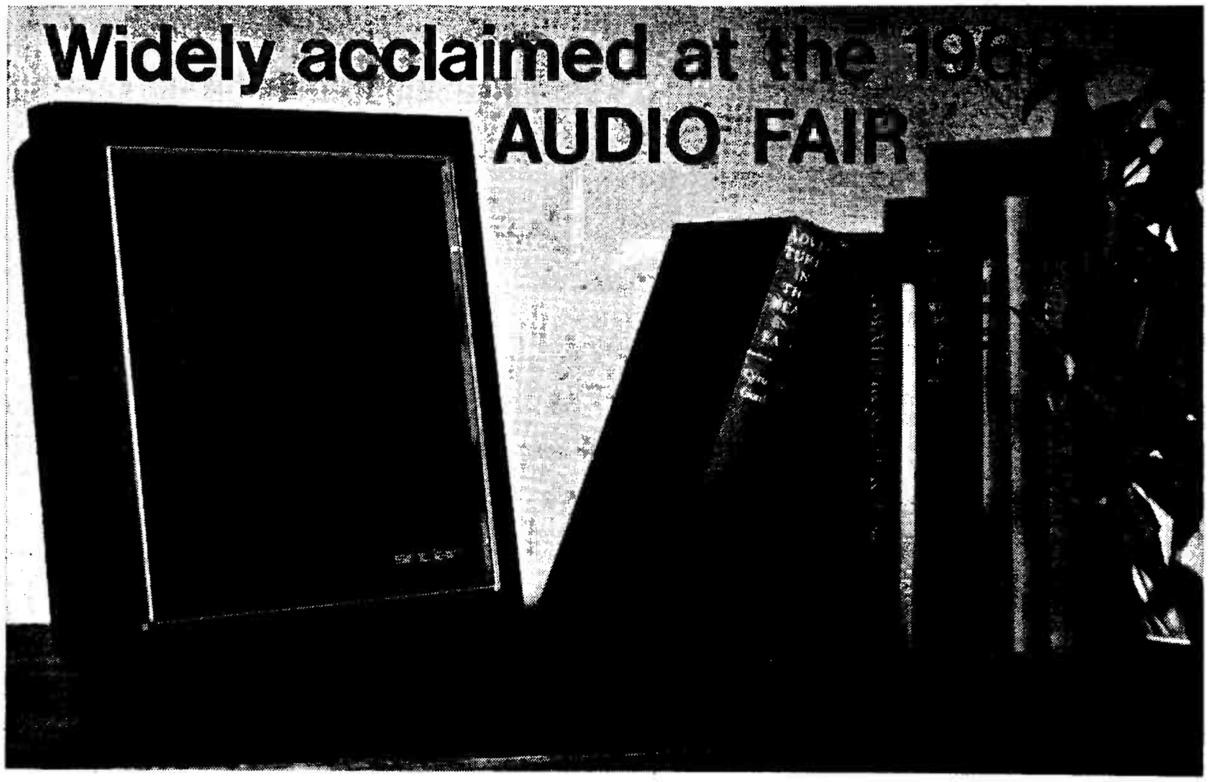
3in.	150ft.	2/3	3in.	225ft.	2/9
4in.	300ft.	4/6	4in.	450ft.	5/6
5in.	600ft.	7/6	5in.	900ft.	10/6
5¾in.	900ft.	10/6	5¾in.	1,200ft.	13/-
7in.	1,200ft.	12/6	7in.	1,800ft.	18/6
Double Play			**Triple Play**		
3in.	300ft.	4/-	4in.	900ft.	13/-
4in.	600ft.	8/-	5in.	1,800ft.	25/-
5in.	1,200ft.	15/-	5¾in.	2,400ft.	34/-
5¾in.	1,800ft.	19/6	7in.	3,600ft.	44/-
7in.	2,400ft.	27/-	**Quadruple Play**		
			3in.	600ft.	8/6

Postages 1/- reel.
Post Free less 5% on three reels.
Quantity and Trade enquiries invited.
NOTE. *Large tape stocks at all branches.*



SINCLAIR Q.14

a brilliant advance in high fidelity loudspeaker design

- ACOUSTICALLY CONTOURED
- 60–16,000Hz
- 15Ω IMPEDANCE
- LOADING UP TO 14 WATTS
- BRILLIANT TRANSIENT RESPONSE
- NEW MATERIALS
- NEW STYLING
- ALL BRITISH

When the Sinclair Q.14 was demonstrated at this year's Audio Fair, it delighted some of the world's keenest and most critical listeners. It more than held its own against far more expensive loudspeakers and proved beyond all question that research and careful design could produce a quality loudspeaker for a remarkably low price. The Q.14 measures 9¾in square on its face and is finished in black matt with natural aluminium bar embellishment. Its unique shape allows it to be tried and used in a far wider choice of positions than conventionally shaped speakers. A pair in stereo give true "in-depth" performance with complete freedom from listening fatigue. If you missed the Audio Fair, why not hear this speaker in your own home. Should you not be pleased with it, your money including cost of return post to this office will be refunded in full.

" The very finest value for money."
SAYS THE EDITOR OF "TAPE RECORDING MAGAZINE."
Page 267, June issue.

" . . . After a great deal of listening I have formed the positive and unshakeable opinion that in the Q.14 we have the very finest value for money it is possible to buy. In the B & K graph * lies the answer to the astonishing quality of these little fellows. My recommendation (to persons not ready to spend £100 or more on speakers) is to invest in Sinclair Q.14s and sit back and enjoy them for the next few years."

** Published Practical Electronics, November 1967.*

ACCLAIMED BY USERS TOO!

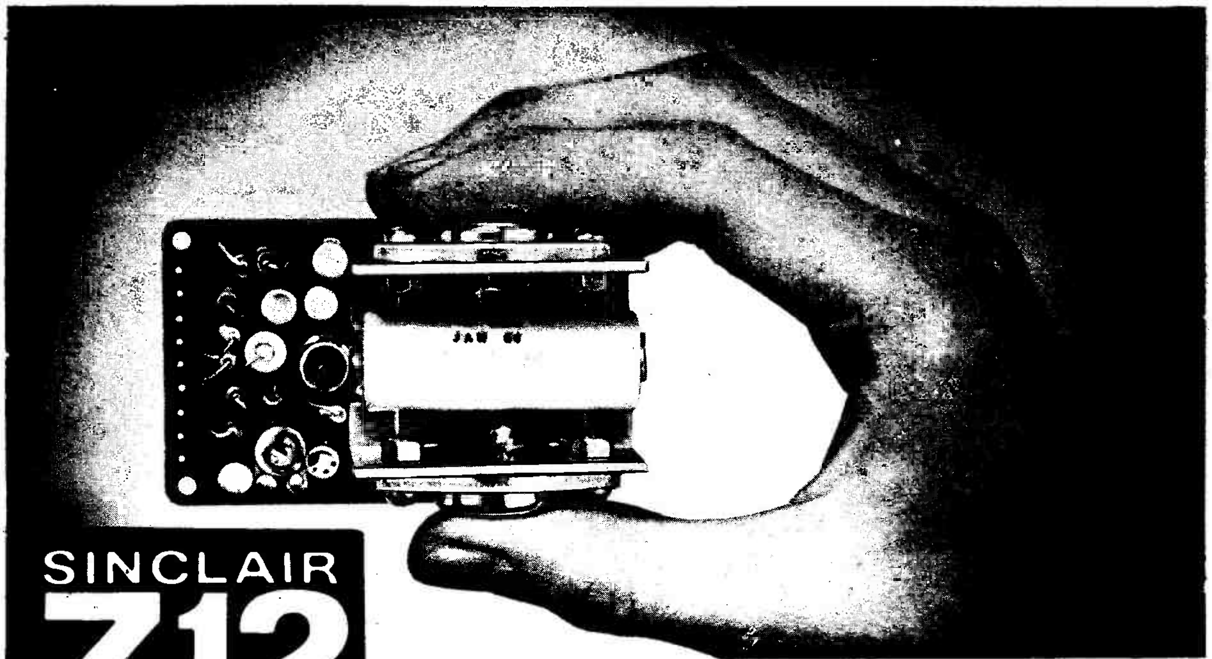
P.G. of Newry, N. Ireland writes:
"I have always been cynical about letters written to manufacturers praising their goods, but I am so delighted with the (two) Q.14 speakers that I feel I must write this for it sounds that you have given me a new collection of records. I congratulate you on a marvellous speaker at very reasonable cost."

SUPERB VALUE AT

£7.19.6

sinclair

SINCLAIR RADIONICS LTD, 22 Newmarket Road, Cambridge
Phone OCA3-52996



SINCLAIR Z.12

COMBINED 12 WATT HI-FI AMP AND PRE-AMP

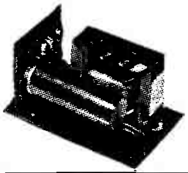
The small amplifier with the enormous output

No constructor's amplifier has ever achieved such success as the Sinclair Z.12. It has fantastic power-to-size ratio, and far greater adaptability. It will operate from batteries or mains supply unit PZ.4, and give superb stereo reproduction for a modest outlay. Thousands are in use throughout the world—in hi-fi, electronic music instruments, P.A., intercom systems, etc. This true 12 watt amplifier is supplied ready built, tested and guaranteed together with the Z.12 manual which details control circuits enabling you to match the Z.12 to your precise requirements. For complete listening satisfaction, use your Z.12 system with Q.14 loudspeakers. It assures superb quality with substantial saving in outlay.

★ **IDEAL FOR BATTERY OPERATION.**

3in × $1\frac{3}{4}$in × $1\frac{1}{4}$in. ● Class B Ultralinear output. ● 15–50,000Hz ± 1dB. ● Suitable for 3, 5, 8 or 15Ω speakers. Two 3-ohm speakers may be used in parallel. ● Input—2mV into 2kΩ. ● Output—12 watts R.M.S. continuous sine wave (24W peak). 15 watts music power (30W peak). ● Ready Built, Tested and Guaranteed.

89/6



SINCLAIR PZ.4 STABILISED POWER SUPPLY UNIT

A heavy duty a.c. mains power supply unit delivering 18V d.c. at 1·5A. Designed specially for use with one or more Z.12s. Ready built and tested.

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SINCLAIR STEREO 25 PRE-AMP/CONTROL UNIT

For use with two Z.12's in stereo. With full control and matching facilities. Attractive aluminium front panel and knobs.

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$1\frac{4}{5}$in x $1\frac{3}{10}$in x $\frac{1}{2}$in

the world's smallest radio

BUY IT IN KIT FORM OR READY BUILT

Complete kit including magnetic earpiece and instructions

49/6

Ready built with magnetic earpiece

59/6

Mallory Mercury Cell RM.675 (2 needed) ea. 2/9

This amazingly tiny receiver is the ultimate in personal listening. The Micromatic is as easy to have with you as your wristwatch. It has enormous power and range, and the magnetic earpiece now supplied assures marvellous quality. Hear how Radio 1 and other stations simply pour in over the whole medium waveband. Build it yourself or buy your Micromatic ready built. This is the set you will never be without once you hear it for yourself.

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PE.7

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HARVERSONS 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 7″ w. × 3″ d. × 6″ h. overall. A.C. mains 200/240v. Supplied absolutely Brand New completely wired and tested with valves and good quality output transformer. LIMITED NUMBER ONLY. Our Rock Bottom Bargain Price 49/6 P. & P. 6/-

E.M.I. 3½in. HEAVY DUTY TWEETERS. Powerful ceramic magnet. 3 or 8 ohm, **15/-**. P. & P. 2/6. 15 ohm. **18/6.** P. & P. 2/6.

TRANSISTOR STEREO 8 + 8

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, £9.10.0 (Built and Tested **£12.10.0**). P. & P. 4/6.

Power Pack Kit, £2.10.0 (Built and Tested **£3**) P. & P. 4/-.

Cabinet, £2.10.0. P. & P. 5/6.

(**Special Offer—£14.10.0,** post free if all above kits ordered at same time or built and tested for **£18** post free).

Circuit diagram, construction details and parts list (free with kit) **1/6** (S.A.E.).

HIGH GAIN 4 TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT Type TA1 (as illus. in June issue)

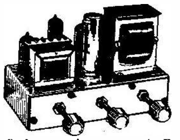
● Peak output in excess of 1½ watts. ● All standard British components. ● Built on printed circuit panel size 6 × 3in. ● Generous size Driver and Output Transformers. ● Output transformer tapped for 3 ohm and 15 ohm speakers. ● Transistors (GET 114 or 81 Mullard OC81D and matched pair of OC81 o/p). ● 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. **SPECIAL PRICE 45/-.** P. & P. 3/-. Also ready built and tested, **52/6.** P. & P. 3/-.

FM/AM TUNER HEAD by Dormer and Wadsworth with valve and tuner head circuit diagram. (See June issue). ONLY **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.)

BRAND NEW MAINS TRANSFORMERS for Bridge Rectifier. Pri. 240v. A.C. Sec. 240v. at 50mA and 6·3v. at 1·5 amp. Stock size 2⅞″ × ¾″ × 1¼″ **10/6.** P. & P. 3/6. (Special quotations for quantities).

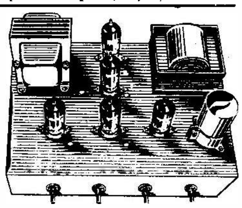
3-VALVE AUDIO AMPLIFIER MODEL HA34



Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7¾in. w. 4in. d. × 4⅞in. 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/-

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.

MATCHED PAIR OF 2½ WATT TRANSISTOR DRIVER AND OUTPUT TRANSFORMERS. Stack size 1¼ × 1¼ × ⅞ in. Output trans. tapped for 3 ohm and 15 ohm output. **10/-** pair plus 2/- P. & P.

HUGE PURCHASE! E.M.I. 4-Speed Player. Heavy 8¾in. metal turntable. Low flutter performance 200/250v. shaded motor (90v. tap). Complete with latest type lightweight pick-up arm and mono cartridge with t/o styli for LP/78. LIMITED NUMBER. ONLY **63/-.** P. & P. 6/6.

4-SPEED RECORD PLAYER BARGAINS

Mains models. All brand new in maker's packing.

E.M.I. MODEL 999 Single player with unit mounted pick-up arm and mono cart. £5.5.0.

B.S.R. UA25 with latest mono combatible Cart. ... £6.19.6

All plus Carriage and Packing 6/6.

LATEST GARRARD MODELS ALL types available 1000, SP25, 3000, AT60, etc. Send S.A.E. for latest Bargain Prices!

LATEST B.S.R. X1H MONO COMPATIBLE CARTRIDGE With turnover sapphire styli for playing EP, LP and Stereo records with mono equip. ONLY 22/6. P. & P. 1/6

SONOTONE 9TAHC Compatible Stereo Cartridge with diamond stylus **50/-.** P. & P. 1/6.

MONO T/A CARTRIDGE. Complete with LP & 78 sapphire styli. Brand New **12/6.** P. & P. 2/-.

QUALITY RECORD PLAYER AMPLIFIER

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. × 3in. d. × 6in. 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

Uncut motor board size 14¼in. × 12in. clearance 2in. below, 5½in. above. Will take above amplifier and any B.S.R. or GARRARD Autochanger or Single Player Unit (except AT60 and SP25). Size 18in. × 15in. × 8in. **PRICE £3.9.6.** P. & P. 9/6.

BRAND NEW 3 OHM LOUDSPEAKERS

5in., **14/-**; 6½in., **18/6**; 8in., **27/-**; 7in. × 4in. **18/6**; 10in. 6in., **27/6.** E.M.I. 8in. 5in. with high flux magnet **21/-.** E.M.I. 13½in. 8in. with high flux ceramic magnet, **42/-** (15 ohm, **45/-**). P. & P. 5in. 2/-, 6½in. & 8in. 2/6, 10in. & 12in. 3/6 per speaker.

BRAND NEW. 12in. 15w. H/D Speakers, 3 or 15 ohm. 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.**

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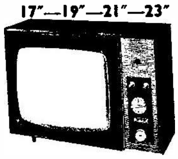

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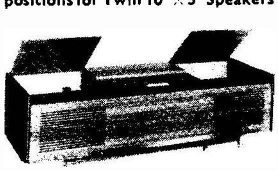
An elegant Stereogram Cabinet in modern Veneered Mahogany and cloth covered Front Panel

BLACK LEATHERETTE SIDE PANELS

Dimensions: 52″ × 17½″ × 12″. Speaker positions for Twin 10″ × 5″ Speakers



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6 Transistors, LW/MW. Telescopic Aerial. Brand New. Famous British Manufacturer (LESS SPEAKERS). P. & P. 4/6.

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8 Transistors LW/MW. Brand New. Famous Manufacturer (LESS SPEAKER 10Ω) Dia. 9½″ × 5″. P. & P. 4/6.

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An attractive discreetly designed space saving cabinet in natural grained polyestered sapele. Press-drop flap for autochanger and record storage compartment. 10″ × 5″ speaker position. Complete with legs. Dim. 29½″H × 14½″D × 29″W. Carr. Ins. 25/-.

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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 (8½ × 5½ × 1/16 in). **2/6** each. 5 for **10/-.**

RE-SETTABLE HIGH SPEED COUNTER (3 × 1 × ¾in). 3 digit. 12/24/48V (state which) **32/6** each.

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50 Silicon Diodes 200 m.a. 100 p.i.v. Sub. Min.

ANY ITEM **10/-.** ANY 5 ITEMS **£2.**

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

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

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P. C. CONNECTORS (13 way in-line), **4/6** pair.

LARGE CAPACITY ELECTROLYTICS: 100 + 400μF, 275V; 1,000μF, 50V; 2,500μF, 70V; 3,200μF, 16V; 5,000μF, 15V, **4/-** each. 4,000μF, 90V; 5,000μF, 25V, **7/6** each. 5,000μF, 50V; 6,300μF, 63V; 10,000μF, 30V; 16,000μF, 15V; 25,000μF, 15V, **10/-** each.

SPEAKER BARGAINS (E.M.I. 13 × 8in.) With two Tweeters and ×/over, 15 ohm, **65/-**; with Dual Cone, 15 ohm, **52/6**; Single Cone, 3 or 15 ohm, **45/-.** P. & P. 3/-.

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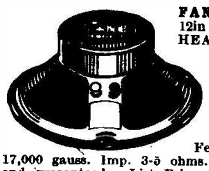
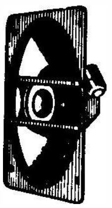


FANE 122/17. 12in in 25 WATT HEAVY DUTY HI-FI LOUD SPEAKERS. With high efficiency Antistropic Ferrite magnet, 17,000 gauss. Imp. 3-5 ohms. Brand new and guaranteed. List Price £12. **LIND-AIR PRICE £8.19.6.** P. & P. 7/6.



E.M.I. COMBINATION LOUD SPEAKERS. 13¼ x 8½in. Elliptical with 3¼in dia. Tweeter. Imp. 8 ohms. Power handling 10 watts. Brand new and guaranteed. List price £8.5.0. **LIND-AIR PRICE 99/6.** P. & P. 7/6. (Also available without tweeter **59/6.** P. & P. 7/6.)

FANE 301 3in TWEETERS Imp. 3-5 ohms. 17,000 gauss. 12 watt. Brand new and guaranteed. List price £3.15.0. **LIND-AIR PRICE 59/6.** P. & P. 3/6.

GOODMANS SPEAKER BARGAINS! 5in 3 ohms, **15/6**; 6in 3 ohm, **29/6**; 8in 3 ohm, **32/6**; 10in 5 ohm, **65/-**; 10in x 6in 3 ohm, **32/6**, Tweeter, **19/6.** P. & P. 3/6 per Speaker.

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Enjoy Stereo Sound as you have never heard it before. **MODEL TTC. G1111** as illustrated. Soft padded earphones. Adjustable headband. Impedance 8 ohms per phone. Frequency range 25-13,000c/s. With 5ft. lead. Price **69/6.** P. & P. 4/6. Other similar types available. **AKAI ASE8S.** 8 ohms. **£7.10.0. CORAL E102** 16 ohms, **£5.19.6. EAGLE SE1.** 16 ohms, **84/-. T.T.C. Stethoscope** 8 ohms, **49/6.** P. & P. 4/6 each.

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Input 0-200, 220, 240V
Output 110V.

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200W	**£3.5.0**	4,000W	**£34.18.0**
300W	**£4.5.0**	0-30V, 1A	**30/-**
400W	**£4.19.6**	0-30V, ½A	**17/9**
500W	**£5.9.6**	0-30V, 2A	**37/6**
600W	**£6.9.6**	0-30V, 3A	**42/-**

Post extra

MAINS TRANSFORMERS

Input 200/250V 50c/s.

24V 3A	**£2.12.6**	24V 8A	**£5.5.0**
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Post extra.

Mains and Output Transformer lists available on request.

EXTENSION TELEPHONES

ONLY 37/6 P. & P. 5/-.

Complete with lead, automatic dial numbered 1–10 and internal bell. Guaranteed perfect working order. Made by famous manufacturer to G.P.O. Specification.

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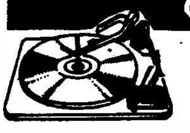

TEAK FINISH PLINTHS with perspex cover 6½ gns. (for LAB80 8½ gns.). P. & P. 12/6
Agents for Thorens, Dual, Goldring, etc.

3000 with Sonotone 9TAHC Stereo Cartridge	**£9.19.6**
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All plus P. & P. 12/6

Mono Cartridge 17/6 extra.
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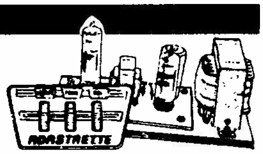
2-3 WATT AMPLIFIER



An ideal basis for building your own portable record player. Just add speaker and turntable, and you will have an above-average model for a mere fraction of the cost. 2–3 watt printed circuit with control panel on flying lead. ON, OFF, TONE CONTROL AND VOLUME, colourful escutcheon. Brimar valves: EZ80, ECL82 and composite installation booklet. Price **85/-** P. & P. 3/6.

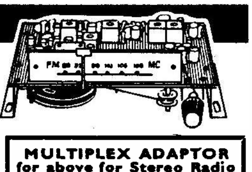
BARGAIN OFFER! FANTAVOX CASSETTE TAPE PLAYER

Specially designed to replay the well known and popular Musicassettes—prerecorded tape cassettes offering a wide choice of all types of music from pop to classical. Up to 40 minutes of quality reproduction through built-in speaker. Simple off/play and volume controls. Fully transistorised operating on six penlight batteries. Modern compact styling with earpiece socket and wrist strap. Size 6¼ × 4¼ × 2in.

LIND-AIR PRICE, **£9.19.6.** Carr., Pkg. and Ins. 5/-.

TRANSISTOR F.M. TUNER

SAVE £2.2.0 !



6 Transistor FM tuner. Frequency range 88–108Mc/s. Size 6 × 4 × 2½in. Ready built for use with most amplifiers, 9V battery operation. Complete with instructions. LIST PRICE 9 gns.

LIND-AIR PRICE **7 gns.** P. & P. 4/-.

MULTIPLEX ADAPTOR for above for Stereo Radio Reception £5.19.6 extra

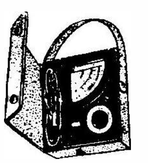
LINEAR AMPLIFIERS

Latest a.c. Mains Models offering highest quality at modest cost.
LT66. All Transistor 12 watts Stereo. Inputs for Tuner, Gram, Mike, Separate Bass, Treble, Balance and Volume Controls **£15.15.0.** Carr. 7/6. Teak case **£3.10.0** extra.
PTA 15 (as illus.). All Transistor, 15 watts Mono. Inputs for Tuner, Gram, Mike, Guitar, Bass, Treble and two volume controls, **£15.15.0.** Carr. 7/6. Teak case **£3.10.0** extra. **LT45**, 2 Valve 5 watts Mono. Inputs for Tuner, Gram, Bass, Treble and volume controls, **£6.19.6.** Carr. 7/6. Metal cover 15/- extra. Full details sent on request.

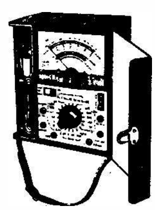
9 in 1 ELECTRONIC KIT

Build nine different projects from one basic kit—simple instructions, no technical knowledge required for you to build a Police Siren, Metronome, Morse Code amplifier, Electronic Massager, W/T Transmitter, Radio Telephone, One-transistor Radio Two-transistor Radio, Electronic Music Kit. Completely safe-operated on 9V PP3 battery. Hours of fun for boys and dads of all ages. Complete with all parts and simple step by step instructions. **ONLY 69/6.** P. & P. 5/-.

MULTIMETERS



MODEL TTC.1001. 20,000 O.P.V. with overload protection; d.c.volts, 5, 25, 125, 500, 2,500V; a.c. volts, 10, 50, 250, 100V; d.c. mA 250mA-50A. With prods and carrying case. ONLY **85/-** P. & P. 3/6.

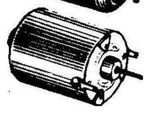


MODEL TTC. 1030. 50,000 O.P.V.; d.c. volts, 0-3, 12, 60, 120, 300, 600, 1,200V; a.c. volts, 6, 30, 120, 600, 1,200V; d.c. mA 0-03-300. With prods and carrying case ONLY **£11.19.6.** P. & P. 5/-.

MOTOR BARGAINS

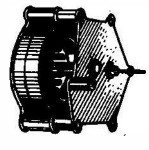
Ideal for model makers, record players, tape decks, etc.

6.3 d.c. Motor. 10,900 r.p.m. at 230mA. 1¼in × 1in dia. Shaft ½in long × 3/64in dia. **9/6.** P. & P. 2/6.



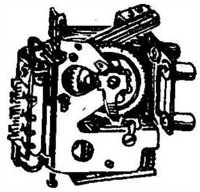
9V d.c. Gram deck replacement motor. 2in × 1¼in dia. Shaft ¼in long × 3/32in. **17/6.** P. & P. 2/-. Two for **30/-** P. & P. 2/-.

SYNCHRONOUS CLOCK MOTORS



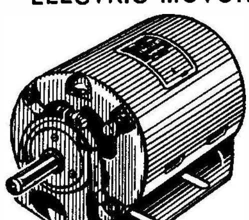
Geared for 40 revolutions per hour. 230v 50 cycle, with mounting flanges. Size approximately 1¼in deep x 2¼in diameter. **ONLY 22/6.** P. & P. 2/6.

SELECTOR DRIVE



Numerous applications Electro-magnet and brass tooth wheel. A switch wafer and contacts are coupled to this and arranged to be on for 10 pulses and off for 15. An Auxiliary contact is normally on but off 1 in every 25. Complete with suppressor, resistors, plus series contact for continuous operation. Ideal window displays, switching lamps, models, etc. 12V or 24V d.c. Brand new and boxed, **12/6.** P. & P. 2/6.

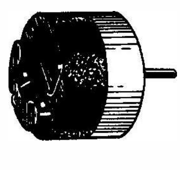
ELECTRIC MOTOR



FEW ONLY LEFT

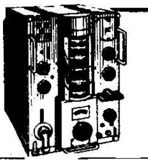
Made by Crompton Parkinson. Single phase ¼ h.p. Motor. 230/250V, 50 cycles. 1·3 amps. 1,425 r.p.m. Continuous rating. Spindle 1¾ x ½in dia. Overall size less spindle approx. 8 x 6in. Perfect condition. A bargain for the work bench. **ONLY 79/6.** Carr. 20/-.

DELAY ACTION TIME SWITCH



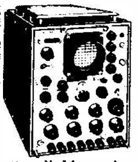
Made by Smiths. A.c. operation 200 / 250V. Double pole. Will give time delays from 0–10 minutes. Size 2¼in dia. x 2¼in long inc. ⅜in x 3/16in dia. spindle. **BARGAIN PRICE 17/6.** P. & P. 2/6.

ADMIRALTY B.40 RECEIVERS



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 19½ × 13½ × 16in. Weight 114lb. Offered in good working condition, £22.10.0. Carr. 30/-. With circuit diagrams. Also available B.41 L.F. version of above 15Kc/s.–700Kc/s. £17.10.0. Carr. 30/-.

SOLARTRON CD711S.2. DOUBLE BEAM OSCILLOSCOPE



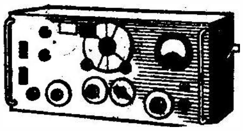
An extremely high quality oscilloscope originally costing £400. Switched beam. Identical Y1, Y2 Amplifiers d.c. to 9Mc/s. Sensitivity 3mV/CM to 100 V/CM. Time base 10μ/sec. to 10M/secs. Calibrator. X amplifier d.c. to 2·5Mc/s. Z Modulation. 110/200/250V a.c. Supplied in good working order. £65, carriage £2, or available as received from Ministry unserviced. £50. Carriage £2. (Handbooks £2 extra.)

AVO CT.38 ELECTRONIC MULTIMETERS

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: 0-1,000megΩ. A.c. volt 100mV-250V. (with R.F. measuring head up to 250Mc/s). A.c. current 10μA-25 amps. Power output 50 microwatts-5 watts. Operation 0/110/200/250V. C. Supplied in perfect condition complete with circuit lead and R.F. probe £25. Carr. 15/-.

MARCONI TEST EQUIPMENT

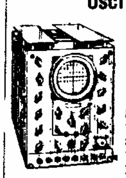
EX-MILITARY RECONDITIONED.
TF 144G STANDARD SIGNAL GENERATORS, 85Kc/s-25Mc/s, £25, carr. 30/-.
TF.885. VIDEO OSCILLATOR. 0-5Mc/s, £45, Carr. 30/-.
T.F.195M. BEAT FREQUENCY OSCILLATOR 0-40kc/s, 200/250V a.c. £20, carr. 30/-.
All above offered in excellent condition fully tested and checked.
TF. 1100 VALVE VOLTMETER, Brand New, £50. TF. 1267 TRANSMISSION TEST SET, Brand New, £75.



AM/FM SIGNAL GENERATORS

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

TYPE 13A DOUBLE BEAM OSCILLOSCOPES

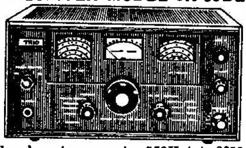


An excellent general purpose D/B oscilloscope. T.B. 2c/s–750 kc/s. Bandwidth 5·5 Mc/s. Sensitivity 33mV/CM. Operating voltage 0/110/200/250V a.c. Supplied in excellent working condition. £22.10.0. Or complete with all accessories, probe, leads, lid, etc. £25. Carriage 30/-.

Variable Voltage TRANSFORMERS

Brand new, guaranteed and carriage paid.
High quality construction. Input 230V 50-60 cycles.
Output full variable from 0-260V. Bulk quantities available.
1 amp.—£5.10.0; 2.5amp.—£6.15.0; 5 amp.—£9.15.0;
8 amp.—£14.10.0; 10 amp.—£18.10.0; 12 amp.—£21; 20 amp.—£37.

TRIO COMMUNICATION RECEIVER MODEL 9R-59DE



4 band receiver covering 550Kc/s to 30Mc/s. continuous and electrical band spread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. band spread dial ● IF 445Kc/s ● Audio output 1·5W. ● Variable RF and AF gain controls. 115/250V. a.c. Mains. Beautifully designed. Size: 7 × 15 × 10in. With instruction manual and service data. £37.10.0. Carriage 12/6.

AUTO TRANSFORMERS

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

500 W.	£3.10.0,	P. & P. 6/6
1,000 W.	£5.10.0,	P. & P. 7/6
1,500 W.	£6.10.0,	P. & P. 8/6
3,000 W.	£7.10.0,	P. & P. 12/6
7,500 W.	£15.10.0,	P. & P. 20/-

SOLARTRON MONITOR OSCILLOSCOPE TYPE 101

An extremely high quality oscilloscope with time base of 10Ω/sec. to 20m/sec. Internal Y amplifier. Separate mains power supply 200/250V. Supplied in excellent condition with cables, probe, etc., as received from Ministry. £8.19.6. Carriage 30/-.

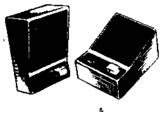
HOSIDEN DH04S 2-WAY STEREO HEADSETS

Each headphone contains a 2½ in woofer and a ½in tweeter. Built in individual level controls. 25–18,000c/s. 8Ω imp. with cable and stereo plug. £5.19.6. P. & P. 2/6.

TRANSISTORISED TWO-WAY TELEPHONE INTERCOM

Operative over amazingly long distances. Separate call and press to talk buttons, 2-wire connection. 1000's of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets. £6.19.6. P. & P. 3/6.

INTERCOM/BABY SITTER



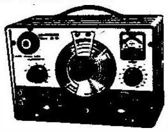
Transistorised Intercoms, ideal for home / office / workshop etc. 2-way buzzer call system. For desk or wall mounting. Supplied complete with connecting wire, batteries, instructions, 2 station 59/6. P. & P. 2/6. 4 station £6.12.6. P. & P. 5/-.

SINCLAIR EQUIPMENT

Z12 12 watt amplifier, 89/6. PZ4 Power Supply Unit 99/6. Stereo 25 Preamp., £9.19.6. Q14 Speakers, £7.19.6. Micromatic Radio Kit, 49/6. Built 59/6. Micro FM Radio Kit £5.19.6. All Post Paid.

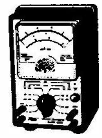
SPECIAL OFFER
2 Z12 Amps., PZ4 Power Supply. Stereo 25 Preamplifier. **£22**
Or with two Q14 Speakers. £37.

LAFAYETTE TE46 RESISTANCE CAPACITY ANALYSER



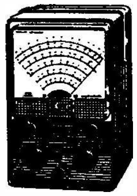
2pF-2,000mF 2 ohms 200 megohms. Also checks impedance, turns ratio, insulation, 200/250V a.c. Brand New £15. Carr. 7/6.

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



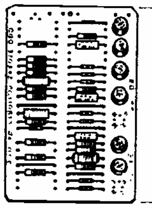
10 meg. input 10 ranges: ·01 / ·003 / ·1 / ·3 / 1 / 3 / 10 / 30 / 100 / 300V. R.M.S. 4c/s.-1.2Mc/s. Decibels—40 to +50dB. Supplied brand new complete with leads and instructions. Operation 230V a.c. £17.10.0. Carr. 5/-.

TE-65 VALVE VOLTMETER



High quality instrument with 28 ranges. D.c. volts 1·5–1,500V A.c. volts 1·5–1,500V Resistance up to 1,000 MΩ. 220/240V a.c. operation. Complete with probe and instructions. £17.10.0. P. & P. 6/-. Additional Probes available: R.F. 35/- H.V. 42/6.

PRINTED CIRCUITS



Five assorted printed circuit boards with transistors, diodes, resistors, condensers, etc. Guaranteed minimum 20 transistors. Ideal for experimenters, 5 boards for 10/-. P. & P. 2/-.

2-WAY RADIOS

Super quality. Brand new and guaranteed.

3 transistor	£6.15.0 pr.
4 transistor	£6.19.6 pr.
5 transistor	£7.19.6 pr.
6 transistor	£8.12.6 pr.
6 transistor De Luxe	£12.10.0 pr.
10 transistor	£22.10.0 pr.
13 transistor 500mW	£31.10.0 pr.

Post extra
These cannot be operated in U.K.

NOMBREX TRANSISTORISED TEST EQUIPMENT

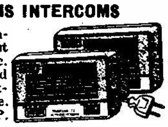
All Post Paid with Battery

Model 22. Power Supply 0–15V d.c.	£14.10.0
Model 30. Audio Generator.	£19.10.0
Model 31. R.F. Signal Generator.	£12.10.0
Model 32. C.R. Bridge.	£10.10.0
Model 33. Inductance Bridge.	£20.0.0
Model 66. Inductance Bridge.	£18.0.0
Model 61. Power Supply.	£6.10.0

COSSOR DOUBLE BEAM OSCILLOSCOPES

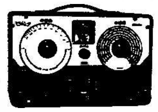
Type 1035. General purpose. A.c. Coupled. Type 1049 L.F. d.c. Coupled. £35 each. Carr. 30/-.

MAINS INTERCOMS



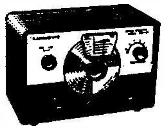
No wires, no installation, just plug into a.c. power point and operate. Extremely sensitive. £8.12.6. P. & P. 3/-.

ARF-100 COMBINED AF-RF SIGNAL GENERATOR



AF. SINE WAVE 20–200,000c/s. Square wave 20–30,000c/s. O/P HIGH IMP. 21V P/P600Ω 3·8 P/P. TF 100kc/s–300 Mc/s. Variable R.F. attenuation int/ext. modulation. Incorporates dual purpose meter to monitor AF output and % mod. on R.F. 220/240V a.c. £27.10.0. Carr. 7/6.

TE-20RF SIGNAL GENERATOR

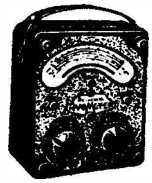


Accurate wide range signal generator covering 120kc/s — 260 Mc/s on 6 bands. Directly calibrated Variable R.F. attenuator. Operation 200/240V a.c. Brand new with instructions. £15.0.0. P. & P. 7/6. S.A.E. for details.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20c/s to 200kc/s on 4 bands. Square: 20c/s to 30kc/s. Output impedance 5,000 ohms, 200/250V a.c. Supplied brand new and guaranteed with instruction manual and leads, £15. Carr. 7/6.

AVOMETERS



Supplied in excellent condition, fully tested and checked. Complete with prods, leads and instructions. Model 47A £9.19.6. Model 7 £13.10.0. Model 8 £18. P. & P. 7/6 each.

AMERICAN TAPE

First grade quality American tapes. Brand new. Discount on quantities.

3in., 225ft. L.P. acetate	3/6
3¼in 600ft. T.P. mylar	10/-
5in. 600ft. std. plastic	8/6
5in. 900ft. L.P. acetate	10/-
5in. 1,200ft. D.P. mylar	15/-
5in. 1,800ft. T.P. mylar	32/6
5¾in. 1,200ft. L.P. acetate	12/6
5¾in. 1,200ft. L. P. mylar	16/-
5¾in. 1,800ft. D.P. mylar	22/6
5¾in. 2,400ft. T.P. mylar	39/6
7in. 1,200ft. std. acetate	12/6
7in. 1,800ft. L.P. acetate	15/-
7in. 1,800ft. L.P. mylar	20/-
7in. 2,400ft. D.P. mylar	25/-
7in. 3,600ft. T.P. mylar	45/-

Postage 2/-, Over £3 post paid.

EVERSHED VIGNOLES SERIES II 500 VOLT MEGGERS. Perfect condition £21. P. & P. 10/-.

CT.53 SIGNAL GENERATORS. 8·9–15·5 and 20–300Mc/s. Output 1μV–100mV. Mains operated. Perfect condition less charts. £12.10.0. Carr. 15/-.

WS.88 TRANS/RECEIVERS. A and B sets available. Complete with valves. 39/6 each. P. & P. 4/6. Accessories available.

No. 10 MICROPHONE AND HEADSET. Moving coil Accessory for 19 set. Unused. 15/-. P. & P. 4/-.

DUBILIER NITROGEL CONDENSERS. Brand new. 8mF 800V, 8/6. P. & P. 2/-; 2mF, 5,000V, 42/6. P. & P. 5/-.

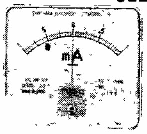
LUCAS 20/0/20 AMMETERS. Brand new boxed. Suitable car/motorcycle. 12/6. P. & P. 2/-.

G. W. SMITH & Co. (Radio) Ltd.
3-34 Lisle St., W.C.2
ALSO SEE OPPOSITE PAGE

SEW PANEL METERS

Send S.A.E. for full lists. Other ranges available. Please include postage. Special quotations for quantities.

CLEAR PLASTIC METERS



5mA	......37/6	300V d.c.	....37/6
10mA	......37/6	15V a.c.	....37/6
50mA	......37/6	300V a.c.	....37/6
100mA	....37/6	S Meter 1mA	.39/6
500mA	....37/6	VU Meter	....59/6
1 amp.	....37/6	1 amp. a.c.*	..37/6
5 amp.	......37/6	5 amp. a.c.*	..37/6
10V d.c.	....37/6	10 amp. a.c.*	.37/6
20V d.c.	....37/6	20 amp. a.c.*	.37/6
50V d.c.	....37/6	30 amp. a.c.*	.37/6

Type MR.38P. 1 21/32in square fronts

50µA	......37/6	750mA	....25/–
50-0-50µA	..35/–	1 amp	......25/–
100µA	......35/–	2 amp	......25/–
100-0-100µA	.32/6	5 amp	......25/–
200µA	......32/6	3V d.c.	....25/–
500µA	......37/6	10V d.c.	....25/–
500-0-500µA	.25/–	20V d.c.	....25/–
1mA	......25/–	50V d.c.	....25/–
1-0-1mA	....25/–	100V d.c.	..25/–
2mA	......25/–	150V d.c.	..25/–
5mA	......25/–	300V d.c.	..25/–
10mA	......25/–	500V d.c.	..25/–
20mA	......25/–	750V d.c.	..25/–
50mA	......25/–	15V a.c.	....25/–
100mA	....25/–	50V a.c.	....25/–
150mA	....25/–	150V a.c.	....25/–
200mA	....25/–	300V a.c.	..25/–
300mA	....25/–	500V a.c.	..25/–
500mA	....25/–	S meter 1mA	29/6
		VU meter	..39/6

Type MR.45P. 2in square fronts

50µA	......42/6	10V d.c.	....27/6
50-0-50µA	39/6	20V d.c.	....27/6
100µA	......39/6	50V d.c.	....27/6
100-0-100µA	.35/–	300V d.c.	..27/6
500µA	......29/6	15V a.c.	....27/6
1mA	......27/6	300V a.c.	..27/6
5mA	......27/6	S meter 1mA	35/–
10mA	......27/6	VU meter	..42/6
50mA	......27/6	1 amp a.c.*	..27/6
10mA	....27/6	5 amp. a.c.*	.27/6
500mA	....27/6	10 amp. a.c.*	27/6
1 amp.	......27/6	20 amp. a.c.*	.27/6
5 amp.	......27/6	30 amp. a.c.*	27/6

Type MR.52P. 2½in square fronts

50µA	......59/6	100-0-100µA	.45/–
50-0-50µA	..49/6	500µA	......42/6
100µA	......49/6	1mA	......37/6

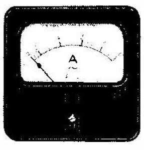
Type MR.85P. 4¼in × 4¾in fronts

50µA	......69/6	15 amp.	......49/6
50-0-50µA	..59/6	30 amp.	......49/6
100µA	......59/6	20V d.c.	....49/6
100-0-100µA	.59/6	50V d.c.	....49/6
200µA	......55/–	150V d.c.	....49/6
500µA	......52/6	300V d.c.	....49/6
500-0-500µA	.49/6	150V a.c.	....49/6
1mA	........49/6	300V a.c.	....49/6
1-0-1mA	....49/6	S Meter 1mA	.55/–
5mA	......49/6	VU meter	....69/6
10mA	......49/6	1 amp. a.c.*	..49/6
50mA	......49/6	5 amp. a.c.*	..49/6
100mA	....49/6	10 amp. a.c.*	.49/6
500mA	....49/6	20 amp. a.c.*	.49/6
1 amp.	....49/6	30 amp. a.c.*	.49/6
5 amp.	....49/6		

Type MR.65P. 3½in × 3¼in fronts

50µA	......65/–	50V d.c.	....39/6
50-0-50µA	..52/6	150V d.c.	....39/6
100µA	......52/6	300V d.c.	....39/6
100-0-100µA	.49/6	15V a.c.	....39/6
500µA	......45/–	50V a.c.	....39/6
1mA	......39/6	150V a.c.	....39/6
5mA	......39/6	300V a.c.	....39/6
10mA	......39/6	500V a.c.	....39/6
50mA	......39/6	S meter 1mA	.45/–
100mA	....39/6	VU meter	....65/–
500mA	....39/6	50mA a.c.*	..39/6
1 amp.	....39/6	100mA a.c.*	..39/6
5 amp.	......39/6	200mA a.c.*	..39/6
10 amp.	....39/6	500mA a.c.*	..39/6
15 amp.	....39/6	1 amp. a.c.*	..39/6
20 amp.	....39/6	5 amp. a.c.*	..39/6
30 amp.	....39/6	10 amp. a.c.*	.39/6
50 amp.	....39/6	20 amp. a.c.*	.39/6
10V d.c.	....39/6	30 amp. a.c.*	.39/6
20V d.c.	....39/6		

BAKELITE PANEL METERS

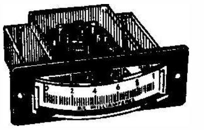


Type MR.65. 3½in square fronts

25µA	......67/6	500mA	......32/6	30V a.c.*	....32/6
50µA	......45/–	1 amp.	......32/6	50V a.c.*	....32/6
50-0-50µA	..42/6	5 amp.	......32/6	150V a.c.*	....32/6
100µA	......42/6	15 amp.	......32/6	300V a.c.*	....32/6
100-0-100µA	.42/6	30 amp.	......32/6	1 amp. a.c.*	..32/6
500µA	......39/6	50 amp.	......32/6	5 amp. a.c.*	..32/6
1mA	......32/6	5V d.c.	......32/6	10 amp. a.c.*	.32/6
1·0·1mA	....32/6	10V d.c.	....32/6	20 amp. a.c.*	.32/6
5mA	......32/6	20V d.c.	....32/6	30 amp. a.c.*	.32/6
10mA	......32/6	50V d.c.	....32/6	50 amp. a.c.*	.32/6
50mA	......32/6	150V d.c.	....32/6	VU meter	....59/6
100mA	....32/6	300V d.c.	....32/6		

*Moving iron, all other moving coil.

NEW RANGE OF "SEW" EDGEWISE METERS



MODEL PE70. Dimensions 3 17/32 × 1 11/32
2¾ deep overall. Available as follows:

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50–0–50 microamp	5/–	1 milliamp	45/–
100 microamp	55/–	300V a.c.	45/–
100-0-100 microamp	52/6	VU meter	62/6
200 microamp	52/6	Post extra	

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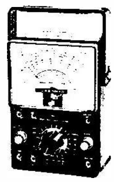

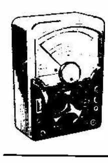

NEW MODEL 500.30,000 O.P.V. with overload protection. Mirror scale. 0 / 0·5 / 2·5 / 10 / 25 / 100 / 250 / 500 / 1,000V. d.c. 0 / 2·5 / 10 / 25 / 100 / 250 / 500 / 1,000V. a.c. 0/50µA / 5 / 50 / 500mA. 12 amp. d.c. 0/60/K6. Meg./60megohm **£8.17.6.** Post paid.

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It has the fullest capacity for checking on A, B and Ico. Equally adaptable for checking diodes, etc. Spec: A: 0·7–0·9967. B: 5–200. Ico: 0-50 microamps 0–5mA. Resistance for diode 200Ω–1MΩ. Supplied complete with instructions, battery and leads. **£5.19.6.** P.&P. 2/6.

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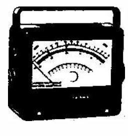
57 Range Super 50,000 O.P.V. Multimeter. D.c. Volts 125V-1000V. A.c. Volts 1.5V-1000V. D.c. Current 25µA-10 Amp. Ohms. 0-15 MegΩ. dB. –20 to +81dB. Overload Protection. **£12.10.0.** Carr. 3/6.

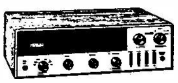


Many other models from as low as **39/6**

LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER

19 transistors, 8 diodes, IHF music power, 30W at 8Ω. Response 30–20,000 ±2dB at 1W. Distortion 1% or less. Inputs 3mV and 250mV. Output 3–16Ω. Separate L. and R. volume controls. Treble and bass control. Stereo phone jack. Brushed aluminium, gold anodised extruded front panel with complimentary metal case. Size 10¼ × 3⅝ × 7¾in. Operation 115/230V. A.V. **£25.** Carr. 7/6.

LAFAYETTE LR-500T



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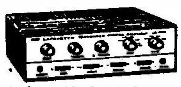
LAFAYETTE LA-85T



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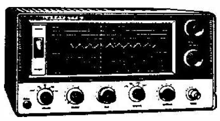

8 valves, 5 bands incorporating 2 MECHANICAL FILTERS for exceptional selectivity and sensitivity. Frequency coverage on 5 bands 150-400Kc/s, 550-1,600Kc/s, 1·6-4·0Mc/s, 4·8-14·5Mc/s, 10·5-30Mc/s. Circuit incorporates R.F. stage, aerial trimmer, noise limiter, B.F.O. product detector, electrical bandspread, S meter, slide rule dial. Output for phones, low to 2KΩ or speaker 4 or 8ohms. Operation 220/240V. a.c. Size 7⅝ × 15 × 10in. Supplied brand new and guaranteed with handbook. **36 GNS.** Carr. 10/-. S.A.E. for leaflet.

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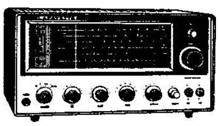
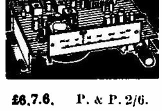


★ TRANSISTORISED FM TUNER ★



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VOL. 4 No. 7
July 1968

PRACTICAL ELECTRONICS

DOWN-TO-EARTH BUSINESS

Long distance radio communication via artificial earth satellite is now accepted as normal. Already, an immense amount of international traffic is handled by space systems and one wonders just how we would have managed if this method had not been conceived and if the required expertise (and money) had not been found to design, produce, and operate the peculiar kind of hardware needed.

The satellite repeater station and the associated rocketry employed to put this fascinating package of electronics into a defined orbit receive, quite rightly, much attention. So far, all satellite launchings for Intelsat, the international organisation responsible for commercial space communications, have been performed by the U.S.A. Disappointing as this may be to some British and European interests, this seems to be the pattern for the future as well. But this is only one aspect of the matter, for the earth terminal station is an equally important component in any space communication system. In the short history of space communications, British industry (and notably the Marconi Company) has established itself as an undoubted leader in the design and construction of earth stations. As the planning, organising, and operating body for the first U.K. earth station at Goonhilly, the Post Office also deserves its full share of credit for the great reputation this station has won for Britain.

The demand for radio links for telephony, telegraph, data, and television channels is increasing every minute. This "communication explosion" is real—and it concerns the private person as well as the business man, the computer as well as the television network. A global space communications system cannot be far off. Indeed the launching of a further generation of satellites Intelsat III later this year will be another large step towards this goal.

Here then is a great opportunity for British industry to capitalise on their unique experience and know-how in earth stations. A world wide market awaits—but first the potential buyers must be educated into the mysteries of programme planning, drawing up specifications, and operating earth stations. It was with this purpose in mind that the U.K. Seminar on Communication-Satellite Earth Station Planning and Operation was held in London last May. Jointly sponsored by The British Government and Industry, this meeting was attended by representatives from more than 50 countries. Despite keen competition from the U.S.A. and Japan, the prospects for our industry are bright. The sponsoring of this seminar confirms this country's determination to "sell hard" in this expanding field of global communications.

F. E. Bennett—*Editor*

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

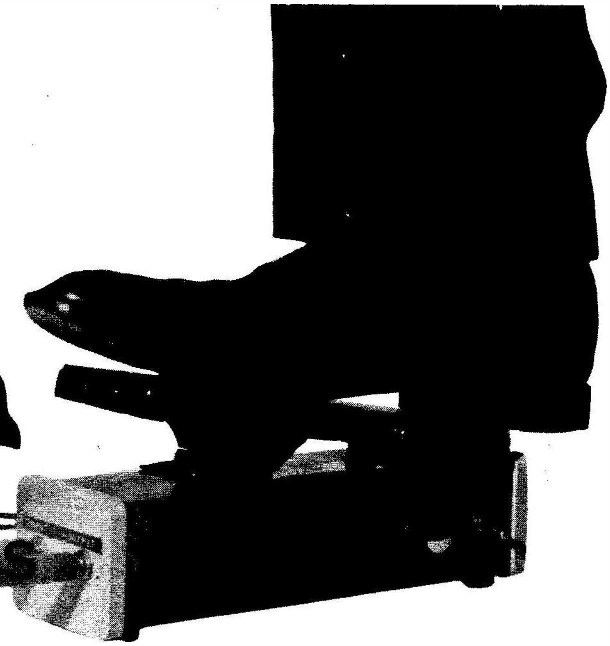
GENERAL FEATURES

NEWS AND COMMENT

Our August issue will be published on Friday, July 12

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., 15/17 Long Acre, London, W.C.2. Phone: 01-836 4363. Telegrams: Newnes London. Subscription Rates including postage for one year, to any part of the world, 36s.

WAA-WAA PEDAL UNIT FOR ELECTRONIC GUITARS



By B.H. BAILY

HARDLY a half-hour programme of "pop" music passes without the sound of the now-popular Waa-Waa effect. This extraordinary sound may lead the listener to believe that a fairly complicated circuit must be used.

Do not be deceived! The model described can be produced for an outlay of about £2 in parts, and takes only an hour or two to build.

PRINCIPLE

The secret of the Waa-Waa lies in the use of a selective amplifier; that is to say, an amplifier which applies boost to a selected band of frequencies within the audio range, while amplifying the remaining frequencies to a lesser degree. The position of the boosted band, relative to the rest of the band, can be shifted up and down in frequency by operation of a foot pedal.

CIRCUIT DESCRIPTION

The circuit (see Fig. 1) uses only one transistor, type 2N2926, of green spot (high gain) classification. This is connected into a circuit, which, despite its unusual appearance at first glance, is basically a phase-shift oscillator, except that feedback is restricted to a value which is just insufficient to maintain self-oscillation.

When a signal is applied to the transistor base, the circuit behaves as a selective amplifier, and affords higher gain to all harmonics lying within a certain defined band than to those outside this band. The selective band lies between limits which are spaced on either side of the natural resonance of the circuit.

This natural frequency may be varied by changing the resistance of VR2, which is connected between the junction of C4/C5. Using the capacitor values shown, the value of this component should be variable between zero and about 50 kilohm. However, it was found necessary to use a 100 kilohm log-law potentiometer in this position, since the simple mechanical linkage allows only partial rotation of the pot. shaft. Hence, with the chosen component, it was found possible to get a maximum value of about 50 kilohm while having to rotate the shaft less than half its normal travel, from the fully-anti clockwise position. Minimum resistance raises the boosted frequency band, whilst increasing resistance lowers the band.

BUFFER CIRCUITS

Since the input and output connections are made to the oscillatory circuit in rather a direct manner, it was found necessary to build in buffer circuits. These, while "matching" the input impedance to the more common 50 kilohm, allow for some variation in input and output matching with a minimum of variation in the performance of the circuit. The buffer resistor network is composed of R1, R2, R3, R4, and R5.

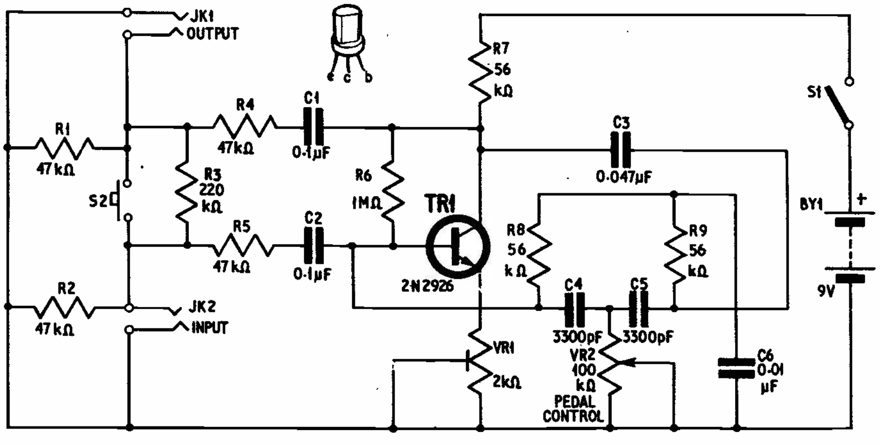


Fig. 1. Circuit diagram of the Waa-Waa pedal. R3 is adjusted on test to give minimum change in overall volume when S2 is operated

COMPONENTS . . .

Resistors
R1, R2, R4, R5 47kΩ (4 off)
R3 220kΩ (see text)
R6 1MΩ
R7, R8, R9 56kΩ (3 off)
All 10% ½W carbon

Potentiometers
VR1 2kΩ linear pre-set
VR2 100kΩ log.

Capacitors
C1, C2 0·1μF plastic (2 off) C4, C5 3,300pF (2 off)
C3 0·047μF plastic C6 0·01μF plastic
All 160V polyester

Transistor
TR1 2N2926 (green spot)

Switches
S1 Single pole on/off toggle
S2 Single pole, press on, release off push-button

Sockets
JK1, JK2 Standard two-terminal jack sockets (2 off)

Battery
BY1 9V (PP3 or equivalent)

Miscellaneous
Eight-way tagboard. p.v.c. covered wire. Wood. Wood screws. Rubber household adhesive, plastic trim beading, ribbed rubber sheeting, 2½in hinge. Plastics box, outside measurements 10in × 2½in × 3in, from D.E.W. Ltd., 254 Ringwood Road, Ferndown, Dorset

The emitter resistor VR1 is a preset potentiometer, which allows the sensitivity of the circuit to be adjusted. This control allows the feedback to be adjusted to the required near-oscillation point for optimum results.

Battery consumption is of the order of 100 microamps, which ensures many months of normal use on the tiny PP3 battery.

CONSTRUCTION

The circuit of the prototype Waa-Waa unit was constructed on a five-way two-row group board. Mullard 400V capacitors were used since space was not at a premium, but lower voltage types could be used instead to conserve space. However, avoid using the very low voltage disc-type (below 50V) capacitors in this circuit, because these often have a high leakage current and are unsuitable in the critical phase-shift circuit.

The components group board is mounted inside a case upon which is fitted the pedal. In the prototype a proprietary plastics box 10in × 2½in × 3in was used —see illustrations. However, a suitably strong case could be made from aluminium or wood, if preferred. Contact adhesive is used to fix the group board to the case.

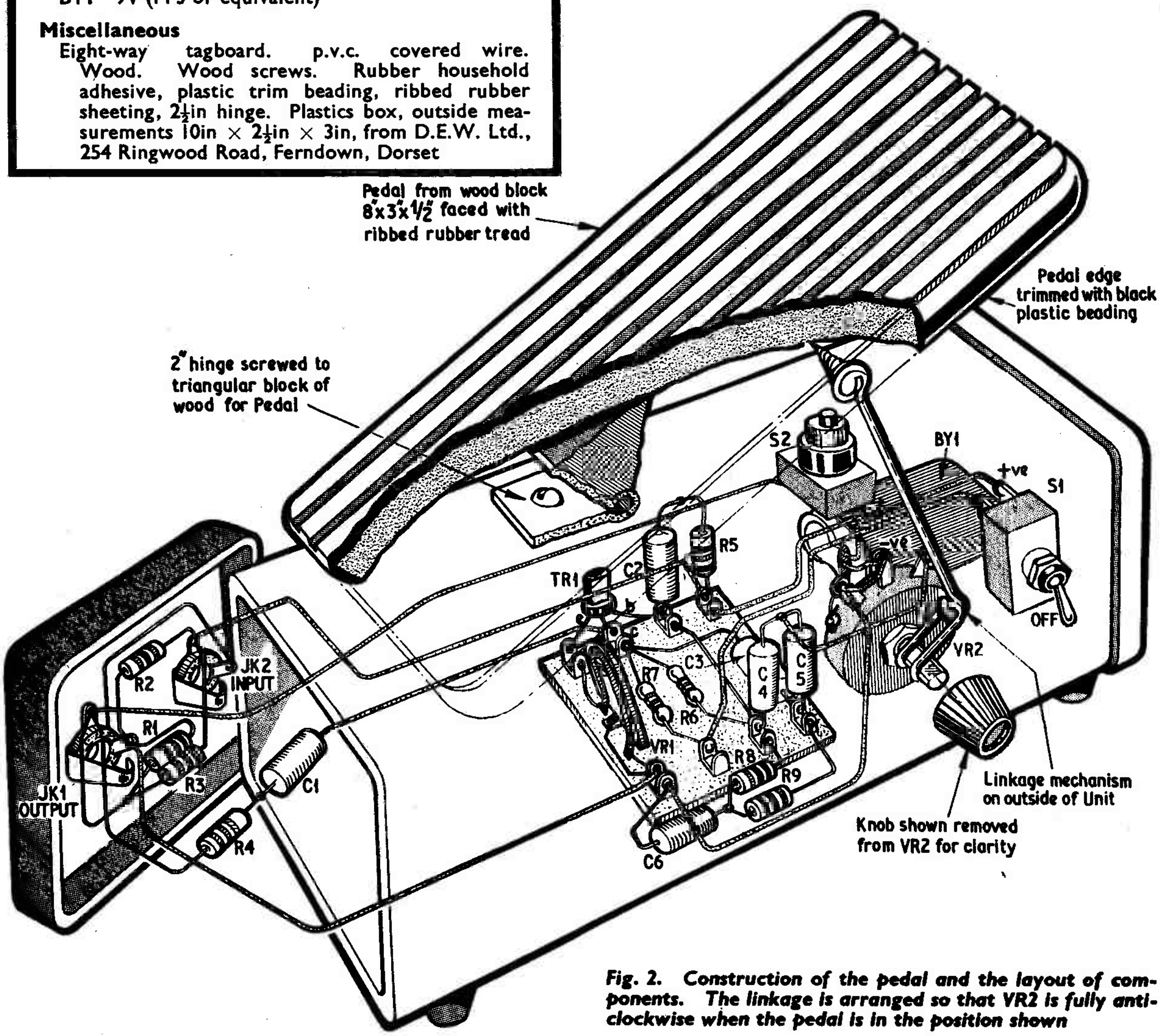


Fig. 2. Construction of the pedal and the layout of components. The linkage is arranged so that VR2 is fully anticlockwise when the pedal is in the position shown

THE PEDAL

The pedal was made from a piece of ½in × 3in × 8in wood, pivoted by a hinge mounted on a short length of 1in triangular cross-section strip. The method of assembly should be first to screw the hinge to the triangular strip, and then screw the other half of the hinge to the box or base. Next, the pedal can be pinned and glued to the strip from above. The pedal is then ready to receive its trim. p.v.c. trim was used, and a small piece of ribbed rubber sheeting was obtained from a garage service department to give the pedal a professional and non-slip top finish. The details of the pedal construction are clearly shown in Fig. 2.

The linkage from the pedal to the shaft of VR2 was fashioned from two short lengths of 10 s.w.g. galvanised fencing wire. One length of wire was formed into a crank by wrapping it around a sawn-off length of potentiometer shaft in a vice. It was then removed and pushed over VR2 shaft, and pinched on tightly with pliers. Fitting a small control knob prevented the wire coming off, while the half-flat section on the shaft prevented rotational slippage.

The other length of wire was bent to form a small loop at each end. One loop was secured under the head of a wood screw driven into the side of the pedal, and the other loop passed over the crank end, which was then doubled back to secure it. Positions for the control VR2, the pedal pivot, and the link screw, as well as the finished linkage length, must be found by experiment since they are fairly critical. Final adjustments can be made after completion by slightly bending the crank and link to ensure that the "up" position of the pedal exactly corresponds to the fully anticlockwise position of VR2.

SETTING-UP

To set the position of VR1, connect the unit to the instrument and amplifier with which it will normally be used. The amplifier must be connected to the output jack, and the guitar or organ to the input jack. Connect unit to battery and switch on. Turn VR1 to minimum resistance, and a howl should be heard from the loudspeaker of the amplifier. Back VR1 off slowly, until the howl just ceases, and rock the pedal slowly up and down over its full range. If the howl recurs at any position, turn VR1 back a fraction more. You should hear a slight *Waa-Waa* sound imposed on the background hiss, but no howl.

Ideally, VR1 should be mounted in a fairly accessible position, since it is just possible that it may require

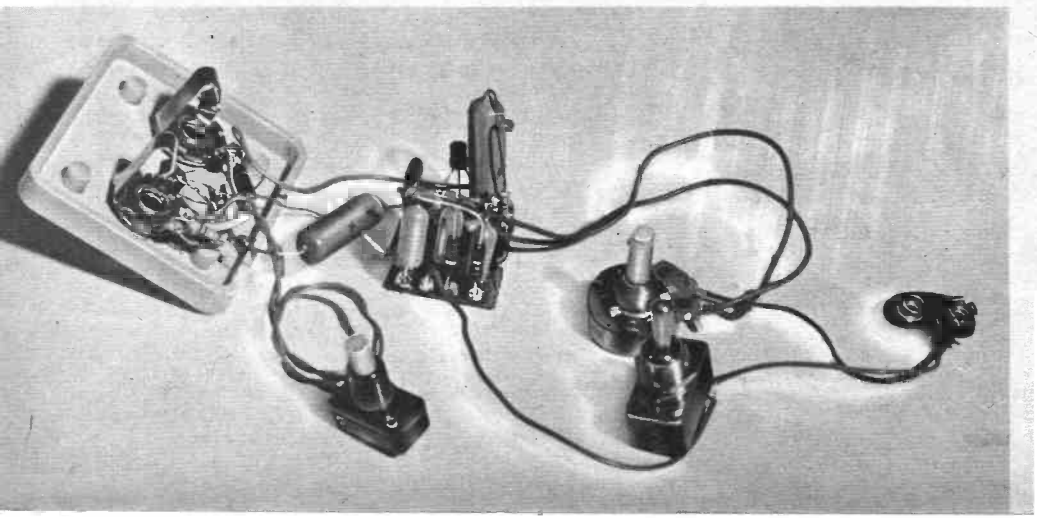
View of the pedal linkage. To avoid stress, the cut-out button (S2) should be positioned carefully so that it operates just before the pedal stops against the top of the case

slight re-adjustment if the unit is used with other equipment. Should the Waa-Waa effect lack "life" on an instrument, it may be necessary to advance VR1 setting closer to the point of oscillation to obtain the right effect.

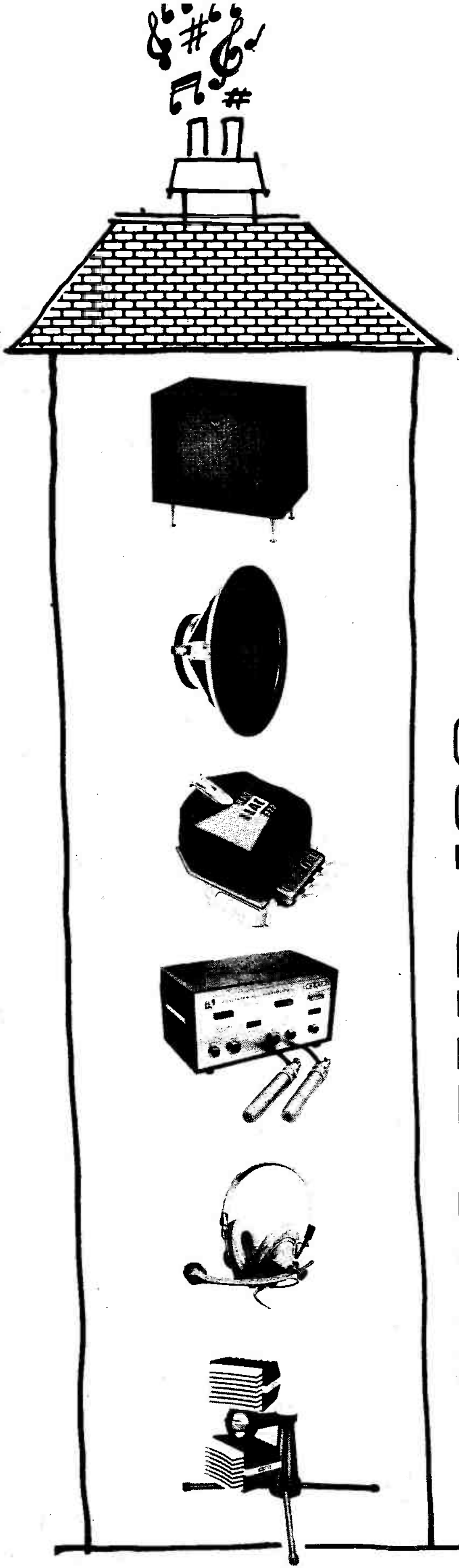
USE OF UNIT

The unit may be used with any electronic musical instrument which gives an output rich in harmonics, e.g. guitar (not bass), organ, harmonica (with microphone), etc.

The push-button S2 under the pedal allows the operator to cut out the effect completely if he desires, without having to reach down and disconnect the unit. The switch short-circuits the input direct to the output when the pedal is pushed fully down. The full range of frequencies is then passed to the output, with virtually no modification. The value of R3, nominally 220 kilohm may require to be selected carefully to ensure minimum change in overall volume when the switch is operated. ★



Completed circuit ready for insertion into the plastic case



AUDIO FAIR '68

. . . ONE VISITOR'S IMPRESSIONS

A RECORD 40,000 people braved corridors, queues and mild suffocation to hear the hi fi industry's latest offerings at the 1968 Audio Festival & Fair.

This year 99 exhibitors, just under half of continental origin, occupied the full six floors of the Hotel Russell. The size of the event, and the greater proportion of specialised professional equipment, provoked further officially-denied whispers of a future move to an exhibition site.

As before, there were several unveiling ceremonies and rather fewer real technological breakthroughs. There was some aural evidence of a year's progress in loudspeakers and low-cost pickup cartridges, and ample visual confirmation of the trend to integrated tuner/amplifiers and "package deal" installations. There was also a heartening increase in the number of British designers taking advantage of f.e.t.s.

BIGGER SPEAKERS

Starting with speakers (as most visitors to the fair seem to do) there was a noticeable soft-pedalling of the mighty midgets that made their first appearance four or five years ago. Although many of these have proved highly acceptable—aided by higher-powered transistor amplifiers to overcome low sensitivity—better known makers were concentrating on units of around 2 to 3 cubic feet. Among the handful of manufacturers who consistently draw long queues, Celestion unveiled the Ditton 25, a progression in size, performance (and price) on the Dittons 10 and 15.

Goodmans were demonstrating the M range of speakers in conjunction with the Maxamp 30 amplifier, Stereomax tuner and MT1000 player unit. Juliet and Janet were two new bookshelf speakers incorporating the Jordan-Watts module—a versatile driver of interest to home constructors.

Lowther used a five-octave electronic organ of their own manufacture to demonstrate this form of home music-making and their extensive range of horn-loaded and cabinet speakers. Tannoy were showing the improved Monitor Gold concentric in a new enclosure, alongside the enormous Autograph.

Wharfedale's Denton and Super Linton speakers make their first appearance at the fair in a typically relaxed and informal demonstration.

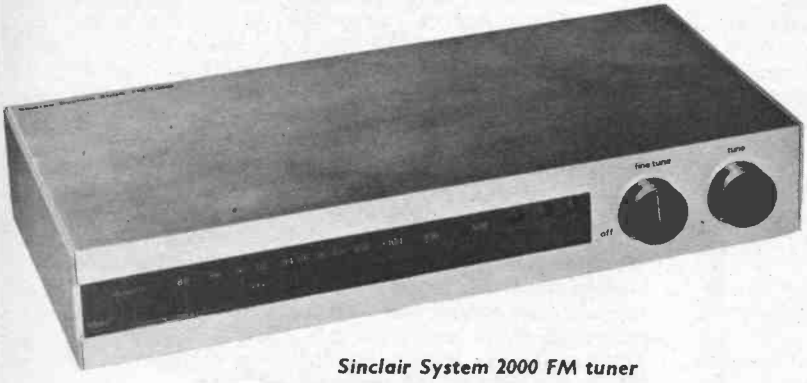
"FLEXION" DIAPHRAGM

The Yamaha demonstration room was packed with people attracted by the extraordinary construction of the "Natural Sound" speaker. This was, to quote the publicity, "Inspired by the rich tonal resonance of the grand piano . . . it replaces the piston action of the cone speaker with a new flexion movement of the diaphragm." When we called in to listen, it was reproducing non-demanding pop music which made judgement difficult. It nevertheless sounded much better than it looked.

To sum up the speaker situation, no unit has yet been produced that sounds totally convincing on all forms of input. At a given price, the better products sound progressively more alike and difficult to choose between—particularly amid the fun of the fair. Only when speakers are perfect will they all sound the same!

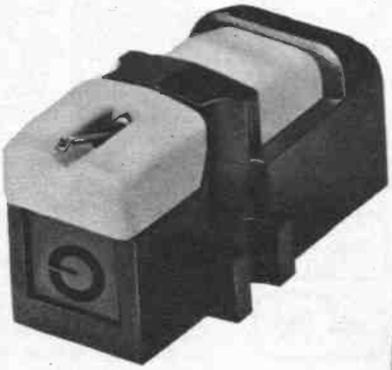
AMPLIFIERS, TUNERS

With one striking exception, amplifier manufacturers continued to retreat from valves, and to pack ever more watts into smaller boxes. Packing in the tuner as well were Armstrong, Fisher, Pioneer, Rogers, Sanyo and Sansui.



Sinclair System 2000 FM tuner

Lustraphone VR/65/NS stereo microphone



(above) Goldring G800 "free field" cartridge

(left) Goodmans Magnum-K loudspeaker

Ferrograph Series Seven recorder

(above) Garrard Model SL95 transcriptor

(right) Richard Allan Class A amplifier

The Sinclair "Neoteric" f.m. tuner was a newcomer to the select minority of commercial units incorporating a pulse-counting detector. Unlike conventional ratio and Foster-Seeley discriminators, this circuit provides near-perfect linearity and does not need occasional re-alignment. The tuner can be converted to stereo with a plug-in module.

Crossover distortion is still a sore point with designers and users of Class B amplifiers, and Richard Allan provided the obvious answer with the introduction of two Class A transistor amplifiers, the twin 10 watt model A21 and the twin 20 A41. (And congratulations to R.A. on their 21st anniversary, celebrated on opening day!)

"Odd man out" was Richardson Electronics, a relatively new firm exhibiting for the first time a range of high grade stereo and mono valve amplifiers with outputs of up to 70 watts. However, their pre-amplifiers were transistorised, with f.e.t. front ends.

CARTRIDGES A AND B

Gramophone cartridge seekers climbed five floors to hear the Miniconic semiconductor cartridge demonstrated by the importers Elstone Electronics. Its design permits a bass response down to 1Hz.

Those on a tighter budget were treated to a courageous A-B comparison by Sonotone (Technical Ceramics Ltd.) of their low-cost 9TAHC ceramic cartridge against a £20 magnetic. There *was* a difference, as the demonstrators readily conceded, but it was up to the listener to decide how much the difference was worth.

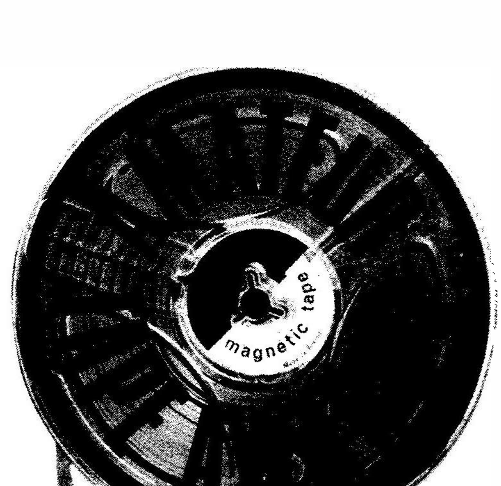
One of the few autochangers possessing a plausible hi fi specification was the new Garrard SL95. It [illegible] a twin-rotor motor to achieve both high [illegible] constant speed, and a "fold[illegible] for uncluttered ma[illegible]

In the tape[illegible]olution turned into revolution s[illegible] overnight. The new Series 7 Ferrographs were a sensation for those to whom the solid Wearite deck and valve amplifier had become part of life. The new continental styled models use silicon transistors and f.e.t. input stages, have variable speed spooling and less than 0·08 per cent wobble at 7½in/sec. Another relatively conservative manufacturer, Brenell, gave a preview of a completely new all-transistor mono recorder which boasted the exceptionally low noise level of –66dB.

MICROPHONE EXHIBITS

Of a dozen firms exhibiting microphones, only three catered for the average, hard-up, quality seeking amateur by demonstrating recordings made with instruments in the under £20 class. Lustraphone had recorded an amateur orchestra to demonstrate the VR/65/NS ribbon, an all-in-one stereo pair for well within this price range. Reslo showed three new dynamic microphones and played piano recordings made with the established VRT/L ribbon. Sennheiser had a 15-minute tape containing a variety of stereo recordings made with four microphones ranging in price from £15 to nearly £100; a particularly valuable demonstration that won several orders on the spot.

Spreading the fair to the sixth floor made for a more civilised event, with less Bach/Beatles cross-modulation than in previous years. But there were the usual endearing scrambles for the best "stereo seat", the hawk eyes on tone control settings and the arguments about "honest" watts. ★



THE presentation of prizes to winners of the 1967 British Amateur Recording Contest was made on Saturday, April 2[illegible] this year, at the London Audio Fair.

The [illegible]n recording categories covered documentary, technical recording, stereo, speech and drama, reportage, school entries, and a set subject.

Tape of the Year winner was Paul Griffin of High Wycombe who was awarded the EMI trophy for this as well as the Kodak Shield for the "Technical Experiment" section. The superb multi-track guitar rendition of "[illegible]", an old popular tune by Richard Rogers, was made by Paul Griffin with quite modest recording equipment in [illegible] garage. The tape was originally selected by F. C. Judd, a member of the BATRC committee and one of the preliminary judges. Paul Griffin's tape was chosen as also were others as winners of their respective sections by a team of eminent judges including music maestro Eric Robinson, Basil Boothroyd, Anne Duchene, and Christopher Bishop (EMI).

The presentation of prizes was made by Mr Rex Hassan, Director of the London Audio Festival. Miss Brenda Marriott of Grundig Limited presented the prizes to winners of the "schools section". In view of the fact that the *Tape of the Year* award was made for a multi-track recording, the proceedings were begun with an electronic organ and guitar multi-track recording by F. C. Judd (whose articles on Electronic Music and multi-track recording techniques have appeared in recent issues of PRACTICAL ELECTRONICS). He commented on the tremendous creative possibilities that multi-tracking offers to tape recording enthusiasts.

MULTI CHANNEL FOR MODEL

The steering actuator framework is of brass sheet $\frac{1}{16}$in thick accurately bent in a vice and fitted with bearing bushes of $\frac{1}{4}$in brass drilled and soldered to the outside of the support cheeks to carry the leadscrew. The leadscrew is a piece of 2B.A. threaded mild steel rod which should be cut clean and slightly under-size, with each end reduced in diameter to 0·09in (2·3mm) as in Fig. 9. A power drill and file can be used for this operation if a lathe is not available.

The leadscrew thrust is borne by the gear wheel at the drive end and by a thrust pad soldered to the bearing bush at the non-drive end.

The leadscrew and block, with its reaction peg, have to be assembled to the sidecheeks prior to bolting them up to the base plate, and the end float can then be taken up during final assembly on the threaded support and peg guide rails, slotted holes being provided in the base plate to accommodate this adjustment.

The mild steel running block has a lateral hole tapped 2B.A. for the leadscrew, and another 4B.A. tapped hole at right angles to take the swivel pin at the top and the reaction peg at the bottom. Remember to tap the 2B.A. hole last.

The reaction peg engages loosely between the two guide rails which also serve to strengthen the assembly.

The time taken to traverse from "lock to lock" is about 4 seconds.

This month's article describes the construction of the mechanical drive system, and then deals with the installation and co-ordination of this gear with the electronics and power supply inside the model boat.

STEERING GEAR

The rudder is of the compensated pattern, and is made exactly to the profile recommended in the Aero-kits plans, from $\frac{1}{16}$in sheet brass, soldered to a $\frac{5}{32}$in diameter brass spindle.

The rudder spindle is rotated by means of the slotted linkage, which engages the pin on the travelling block and leadscrew arrangement. The leadscrew is driven by a 3 : 1 reduction using nylon gear wheels (available from most model shops) and an "ORBIT 505" motor MO2. See Fig. 8 and Fig. 9.

The motor rotation is selected by the appropriate relay contacts, in series with limit switch contacts S3 and S4. These switches are constructed from relay spring sets.

The steel travelling block is cushioned by small coil springs at the end of its travel so that it does not jam during overrun of the switches. The lead screw is $4\frac{3}{8}$in long, this being the maximum length that can be accommodated in the after-well width, and gives an angular movement of the rudder of ± 40 degrees, which is ample for good manœuvrability.

The rudder spindle is supported by a brass tube fastened into the keel and the upper end of the spindle is threaded 4B.A. to engage in a tapped hole in the feedback potentiometer VR2 which is clamped to a bracket screwed to the transom. The potentiometer body can be rotated in the bracket and locked in position to obtain correct "tracking" with the rudder control potentiometer. It is apparent that only 80 degrees of the potentiometer track is actually used.

The "lock-to-lock" range is adjusted to correspond with the transmitter control by selection of the value of R23 when setting up.

THROTTLE GEAR

The throttle control gear is a miniature version of the steering gear, this time using lighter gauge materials, with a 4B.A. leadscrew $3\frac{1}{4}$in long driven by a cheap miniature model motor MO1. Full details of the construction and general assembly appear in Fig. 10 and Fig. 11.

The power required to actuate the throttle lever is of course much less than that required for steering; however, in practice the current consumption of the two motors is about the same (200–400mA) due to the lower efficiency of the smaller motor.

Space is somewhat restricted in the region around the carburettor and so the throttle actuator was dimensioned such that it could just be accommodated on the port side of the engine, the starboard space being used for the fuel tank. The arrangement of the actuator is such that the motion of the linkage from the running block to the throttle lever produces a non-linear rate of throttle rotation.

This is achieved by deliberately setting the leadscrew axis at an angle of 20 degrees to the axis of the boat, so that relatively large block movement is needed to rotate the throttle at low openings, compared with the

RADIO CONTROL

BOATS - PART TWO - By E. J. PEPPER

C.Eng. M.I.E.E.

STEERING MECHANISM

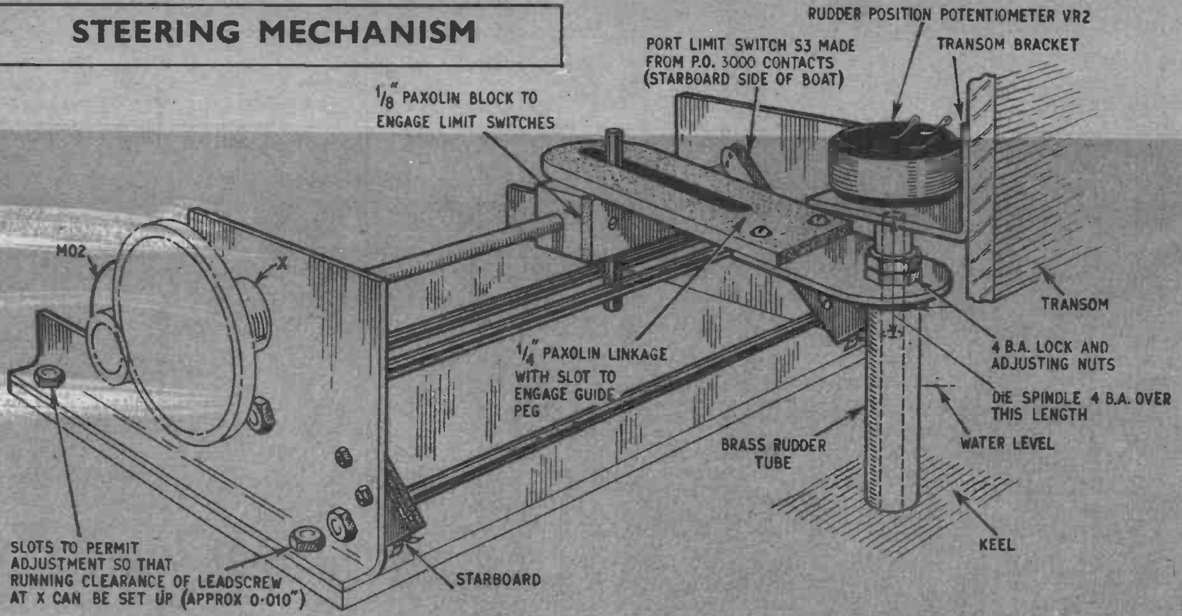


Fig. 8. General view of the steering mechanism showing arrangement of the steering linkage and feedback potentiometer VR2

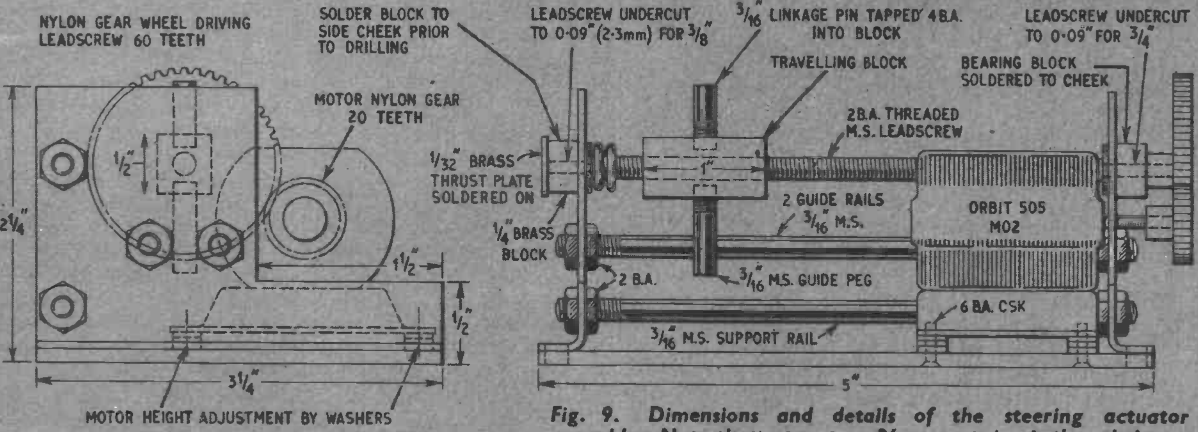
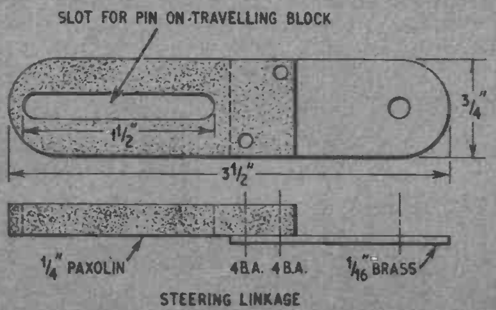
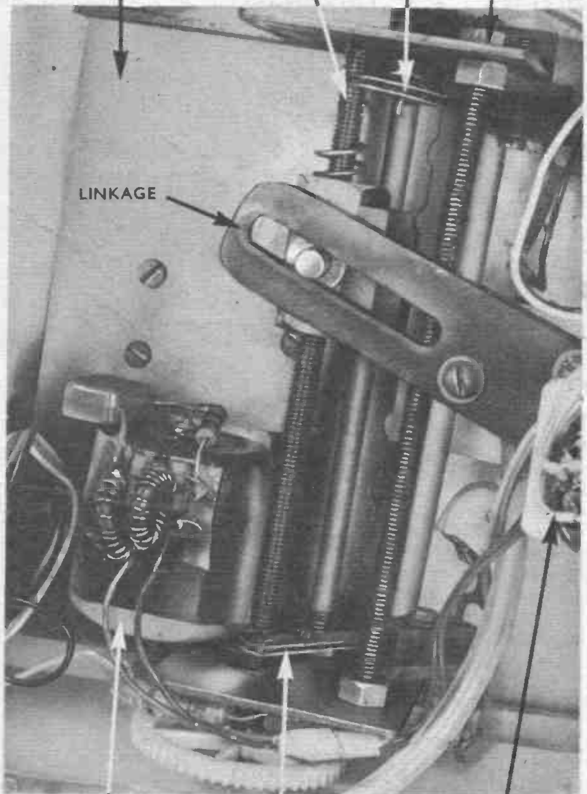


Fig. 9. Dimensions and details of the steering actuator assembly. Note that a two turn 26s.w.g. spring is threaded over each end of the leadscrew to cushion the block and prevent jamming





Close-up view of the steering mechanism

movement near full throttle. This is desirable, as the effect of throttle position on engine power is non-linear, and fine control of the throttle at low settings is essential.

The throttle limit switches are shown in Fig. 10. The throttle open limit switch S6 is virtually identical to the steering limit switches. There is, however, no room for the throttle closed limit switch S7 on the actuator itself, so this is suspended from the side deck supports, which are immediately above the throttle motor drive end. The pair of P.O. 3000 leaves are secured with brass woodscrews passed through the spring set spacers into the deck.

The throttle actuator is best protected from engine oil by means of a polythene sheet, cut to shape and Sellotaped down; otherwise, the oil tends to prevent the contacts making on the limit switches.

In operation, the actuator becomes well bathed in unburnt fuel oil and lubrication is certainly no problem. In fact, on the prototype equipment, as a result of the over-generous oil supply, the open type limit switches were eventually replaced by miniature enclosed micro-switches. One of these (S7) can be seen in the accompanying photographs.

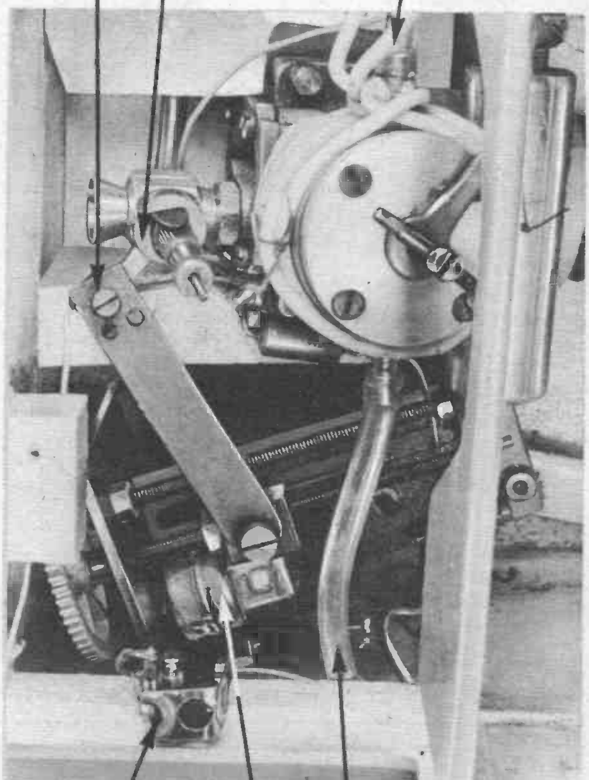
POWER SUPPLIES

The total consumption of the electronics and the relays varies from 70mA (both motions operating together) to 40mA in the quiescent state, and the 15 volt nominal supply is adequately catered for by DEAC cells of 225mAh capacity (BY1). These cells suffice for several hours' operation between charges.

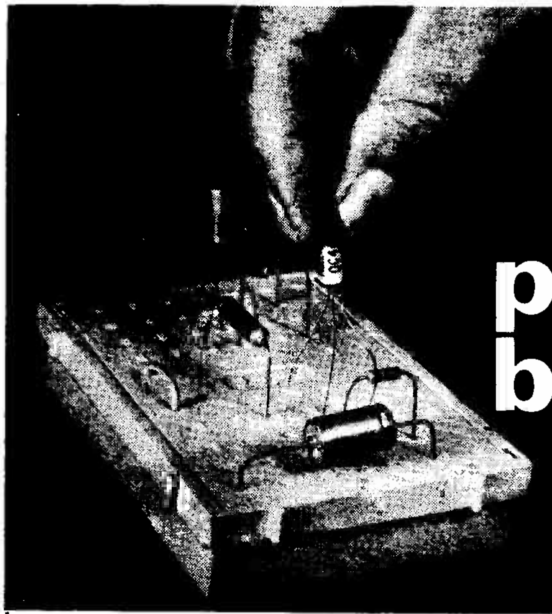
It is not desirable to operate the motors from the "electronics" supply, and 2 volts was found adequate to give positive motor action. This supply is derived from a group of miniature sealed lead–acid cells connected in parallel to give 1·6Ah capacity (BY2). These cells have been found to give a discharge life comparable with that of the electronic supply, as the loading is of a very intermittent nature.

The addition of small capacitors C21, C25 across the motor terminals was found to give adequate protection from interference, and it is wise to bond all metal parts together, and connect to the stern tube, which provides a good "earth".

Battery charging terminals and readily accessible isolator switches for each motor (S2, S5) and one for the electronics (S1) are fitted in the battery/relay compartment. These switches greatly facilitate the setting-up procedure. See Fig. 12 and photograph.

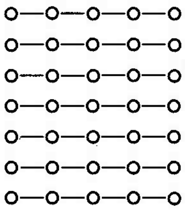


Close-up view of the throttle mechanism



S-DeC the professional breadboard

DeCs are a professional breadboard which are used in their thousands in industrial and Government research laboratories and being used increasingly in educational establishments from degree level electronics courses to the teaching of electricity to primary school children. This breadboard is sold world wide, and over 50% of current production is exported.



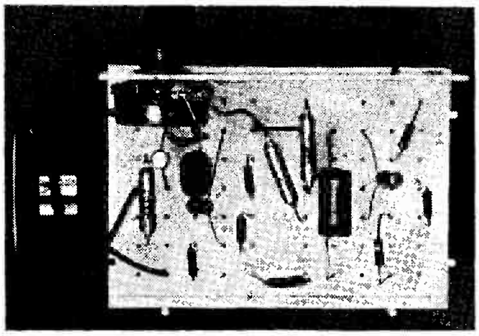
The diagram shows the layout of the contacts on S-DeC. Each S-DeC contains two of these panels, permitting most electronic building blocks to be accommodated. DeCs may be joined using the keying method provided to form a stable area of any size. The connection points are on a ¼in matrix. Components are simply pushed into the contacts and may be withdrawn at will.

Experiment and Project Guides: S.D.C. Products provide a series of experiment and project guides for educational users. These are available to the enthusiast and full details can be supplied, either from 'Electroniques' (Edinburgh Way, Harlow, Essex) or the manufacturers, S.D.C. Products (Electronics) Limited.

Accessory Kits: With every S-DeC kit purchased there are included accessories. A control panel is supplied for mounting such things as potentiometers, and this panel simply slots into the S-DeC base. Other accessories include small compression springs for making solderless connections to controls and clips for mounting such things as ferrite rods on the panel. Also included with each kit is an instruction leaflet and booklet of projects.

Projects on S-DeC: In every kit a booklet of circuits is supplied with full instructions for assembly of the circuits on DeCs. The circuits include a three transistor reflex radio with diode detection, morse practice oscillator, electronic flasher, a monostable multivibrator, a three stage audio amplifier (picture of amplifier mounted on a DeC below), and circuits for a number of oscillators.

Insertion/Withdrawal Force . . . . : . 90 gm. wt.
Capacitance between adjacent rows of contacts 3pF
Resistance between adjacent contacts 10mΩ
Resistance between adjacent rows of contacts . . . . 10^{10}Ω



Single DeCs: One S-DeC with Control Panel, Jig and Accessories for solderless connections to controls, etc., with booklet 'Projects on S-DeC' giving construction details for a variety of circuits. **29/6** retail.

4-DeC Kit: Four S-DeCs with two Control Panels, Jigs and Accessories and the booklet 'Projects on S-DeC' all contained in a strong attractive plastic case. Ideal for the professional user, **£5.17.6** retail.

Available from leading suppliers and 'Electroniques' dealers

In case of difficulty DeCs may be purchased direct from the manufacturers. Include 6d. (in the case of single DeCs) and 2/6d. (in the case of 4-DeCs) to cover postage and packing.

S.D.C. PRODUCTS (Electronics) LTD
Corn Exchange : Chelmsford : Essex

TELEPHONE OCH 5 56215

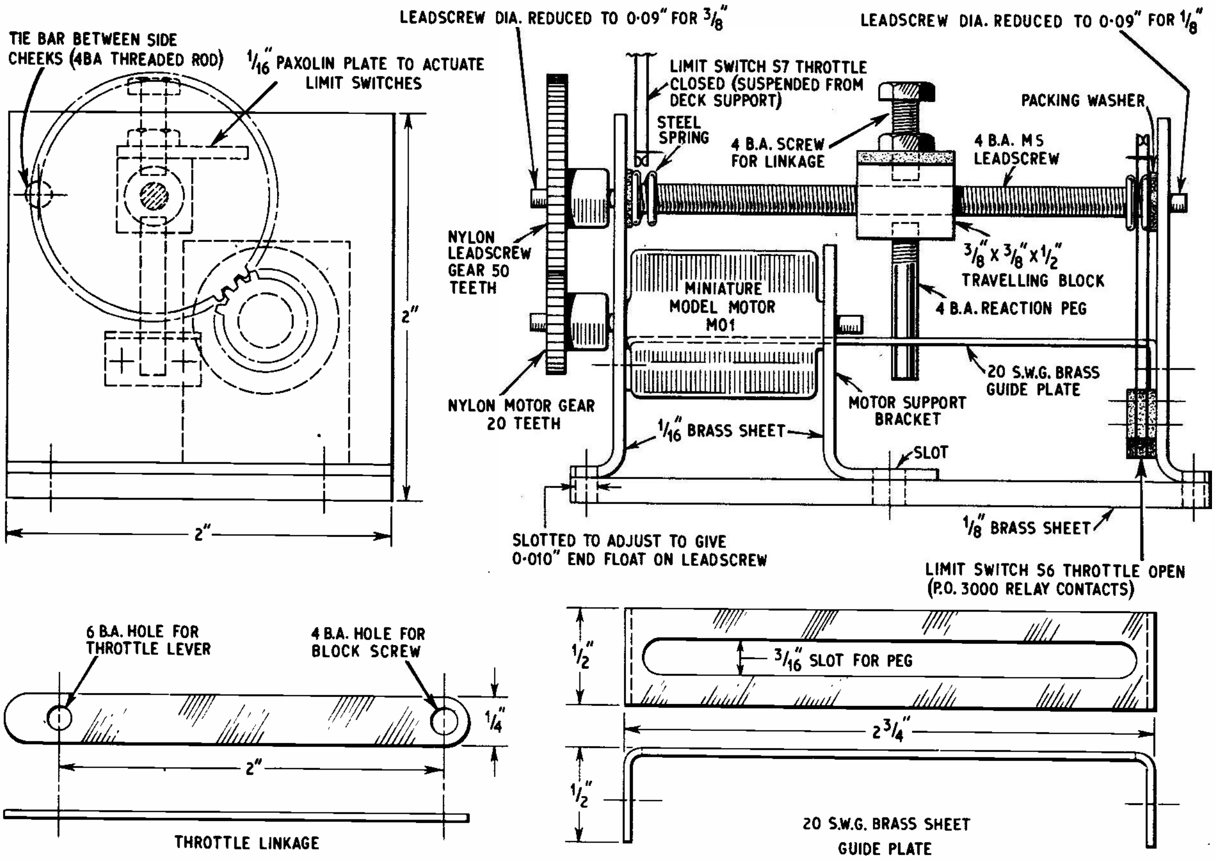
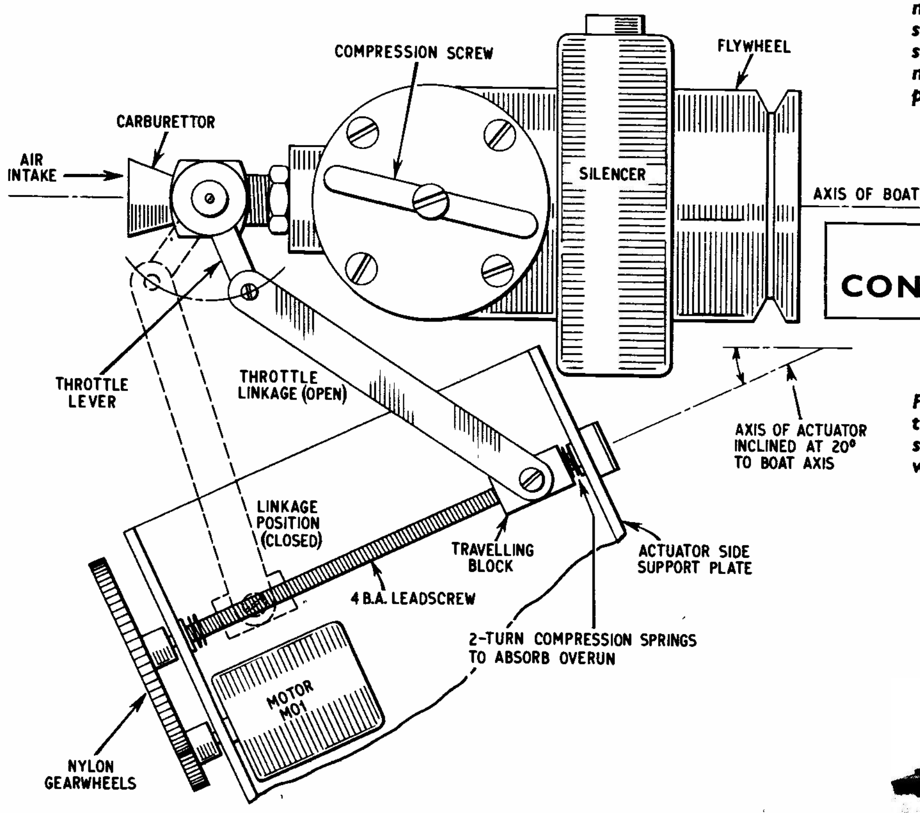
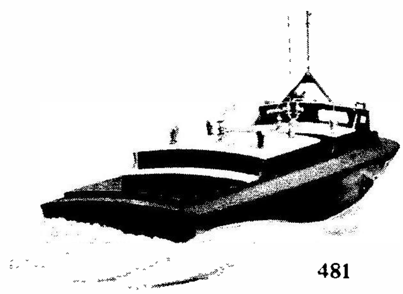


Fig. 10. Throttle control mechanism assembly dimensions and details. The limit switches S6 and S7 can be miniature microswitches, see photograph opposite

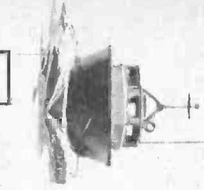


THROTTLE CONTROL MECHANISM

Fig. 11. Arrangement of the throttle actuator linkage showing position of actuator with respect to engine



RADIO CONTROLLED VOSPER R.A.F. CRASH TENDER GENERAL LAYOUT



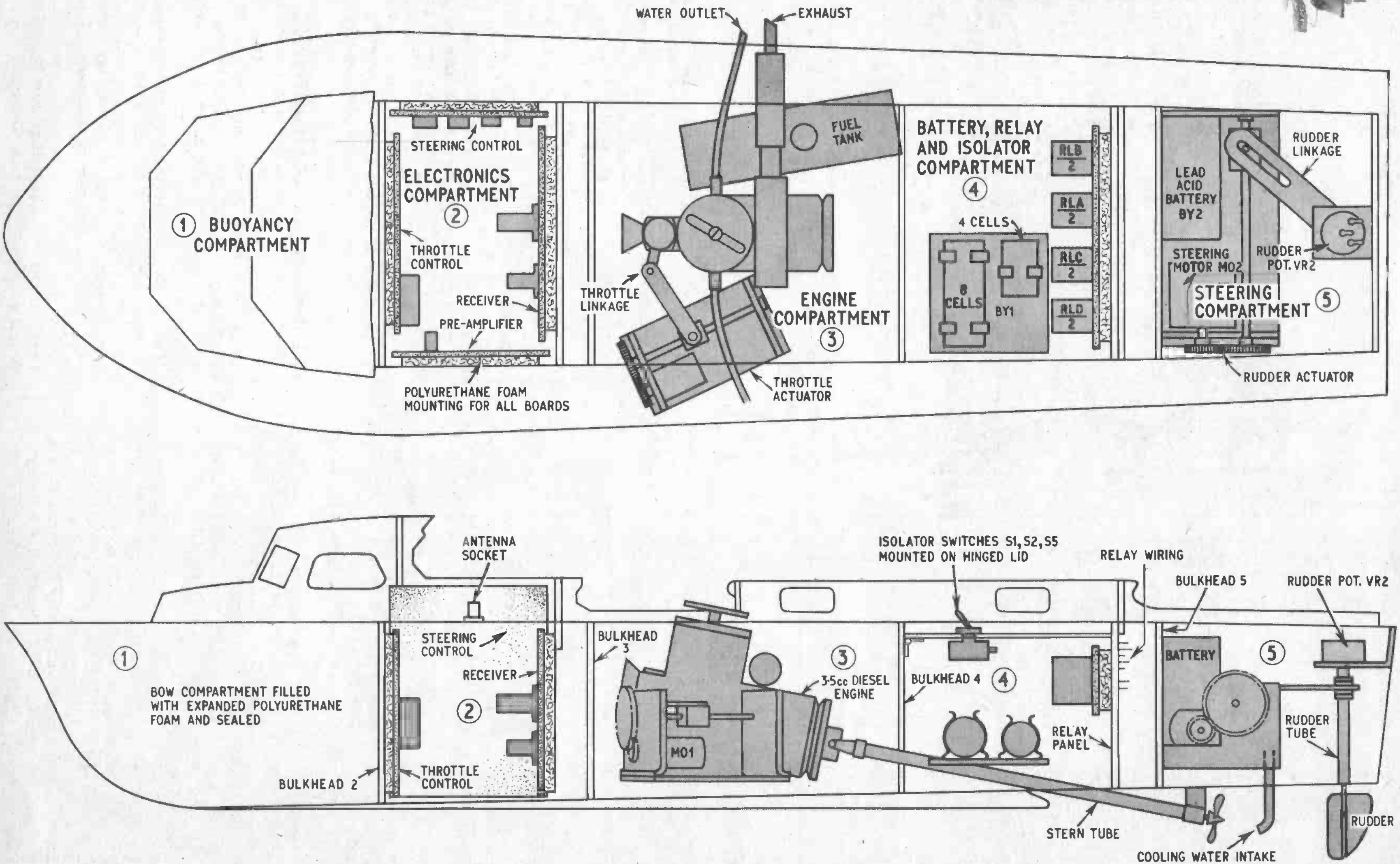
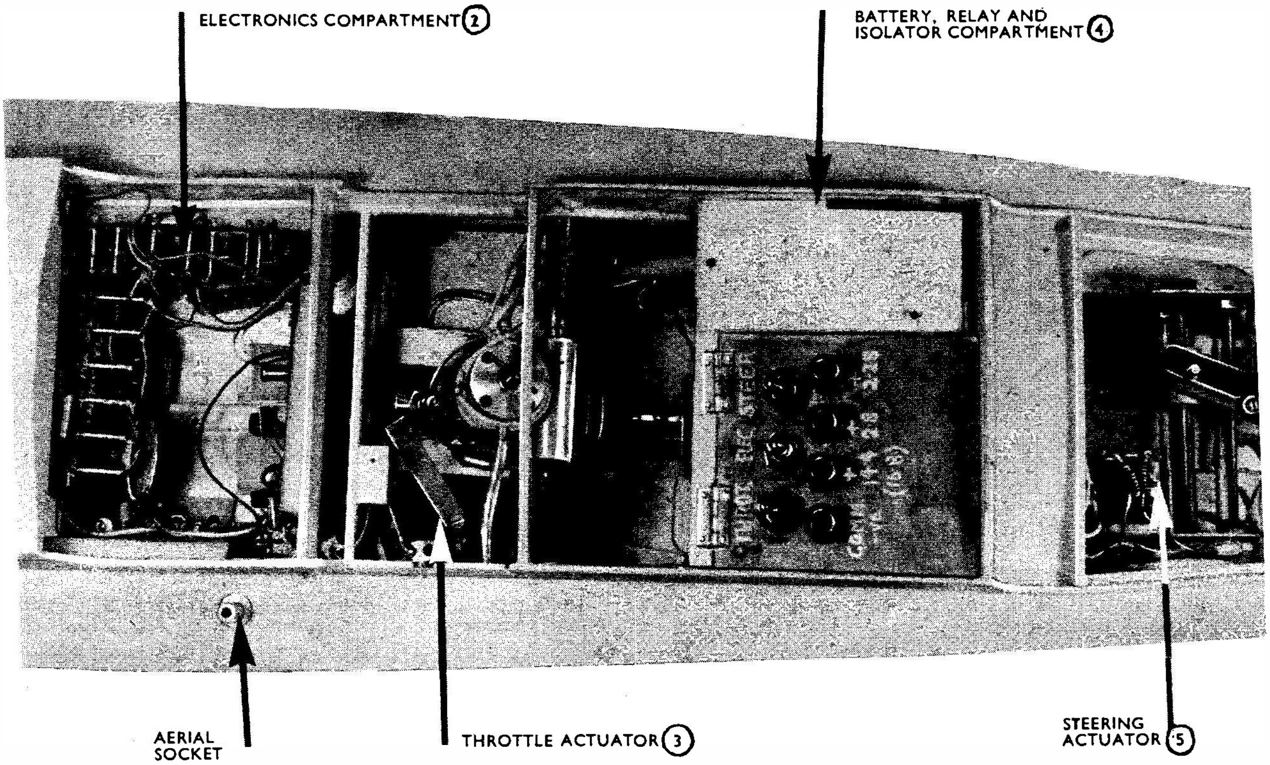


Fig. 12. Plan and side elevation of the boat. The shaded areas show the placement of equipment relative to the boat compartments



General view of the boat interior

INSTALLATION IN BOAT

Plan and side elevation views of the complete craft appear in Fig. 12. The distribution of the equipment amongst the five boat compartments is clearly indicated, and only a few notes are needed to supplement the information given in these diagrams.

The four circuit boards should be mounted on pads of $\frac{1}{8}$in thick polyurethane foam and secured to the sides of the No. 2 compartment by means of brass woodscrews, screwed through the foam into either the bulkheads or the side deck supports as appropriate.

The interconnection wiring should be carried out by referring to the circuit diagram Fig. 2, and to the diagrams of the various boards, Figs. 4 to 7, given last month. Leads are soldered directly to the appropriate pins, with sufficient slack to permit partial withdrawal of the boards for servicing purposes. Those leads going to the other compartments should be laced together to form a neat cableform which is then run down the craft, passing through holes cut near the tops of the various bulkheads, with individual leads branching out as required, *en route*.

The aerial consists of a single section whip 14in long. This fits into the socket mounted on the port side. The socket and plug used were heavy duty, all brass, banana type 0·175in diameter. The plug is soldered to a 14in length of $\frac{1}{16}$in brass wire (e.g. Triang Railways overhead catenary wire (0·05in) available in 14in lengths from any model shop).

ENGINE COMPARTMENT

To facilitate starting, a preheat coil is fitted around the engine cylinder. (This can be seen in the photograph of the throttle actuator.) Connections to this coil are brought out to two pins on the bulkhead, to which a car battery is temporarily connected by means of crocodile clips, to preheat.

BATTERY, RELAY, AND ISOLATOR COMPARTMENT

The twelve 1·25V DEAC nickel cadmium cells, which together comprise the 15V battery BY1, are available in units of eight, already sleeved and connected together. Hence $1\frac{1}{2}$ units are used (it is possible to cut the units into portions as required).

The cells are accommodated on a plywood board measuring $2\frac{1}{2}$in $\times$ 3in which is glued horizontally from chine to keel, the cells themselves lying laterally across the boat secured by Terry clips. See Fig. 12.

The four actuator relays RLA–RLD are mounted on a 4in square s.r.b.p. board. This board is mounted vertically (with a polyurethane foam pad, in a similar manner to the other electronic boards), on the forward side of No. 5 bulkhead, under the hinged switch lid.

Mounted on the hinged lid of this compartment (in line abreast) are the three isolator switches S1, S2, and S5. When wiring these components, sufficient "spare" wire should be allowed to permit the opening of this lid.

STEERING GEAR COMPARTMENT

Four 2V 400mAh cells connected in parallel (BY2), are wrapped in polythene sheet. This pad is held together by elastic bands, and wedged in the space immediately forward of the rudder linkage, in the cut-out on the starboard side cheek of the steering gear, against No. 5 bulkhead. See Fig. 12.

These cells are advertised by Messrs Henry's Radio, and give adequate range between charges. In the prototype a two pin miniature plug and socket is fitted to the "battery", so that it can be detached when not in use to avoid the risk of corrosion of the steering actuator.

Next month : Transmitter construction; setting up and alignment of the complete system.

Transistor Amplifier DESIGN 6

AMPLIFIERS; ACTIVE FILTERS

By A. Foord

THIS is the final article of the present series, and here we shall be considering two main topics: firstly, high input, low output impedance amplifiers and secondly, active filters.

HIGH INPUT—LOW OUTPUT IMPEDANCE AMPLIFIERS

We know that an emitter follower gives a high input impedance and a low output impedance, but the emitter follower is really an example of an amplifier of one stage with 100 per cent negative feedback. This can be shown by redrawing the circuit, remembering that the supply lines present a low impedance to signals and are effectively shorted. See Fig. 6.1.

The circuit now becomes a common emitter amplifier, where all the output voltage is applied in series with the input, to give an overall gain of unity, a high input impedance and a low output impedance as we would expect.

This arrangement has the practical advantage over the conventional arrangement that bias resistors on the transistor base do not shunt the input, but only shunt the transistor input impedance, which is low in any case. It has the disadvantage that both input leads are floating above earth, but since each lead is a comparatively low impedance to earth, this is quite often not a problem. A practical circuit is Fig. 6.2.

We have used an emitter follower in the conventional manner to avoid loading the 27 kilohm resistor. Input impedance can be as high as 1 megohm, suitable for a crystal microphone or ceramic cartridge. The method often used of bootstrapping bias resistors in the conventional circuit, Fig. 6.3, has a severe disadvantage.

INDUCTIVE EFFECT

Using ordinary germanium transistors an input impedance of 1 megohm is easily obtained, provided the d.c. bias resistors are bootstrapped to effectively increase their a.c. value.

Unfortunately, when the circuit is used with a capacitive source (such as a ceramic pick-up!) the feedback via the *C* can cause a peak in the response at the low frequency end, at low frequencies the feed-back capacitor will have an appreciable impedance, and can behave as an inductor in effect.

This "inductor" resonates with a capacitive source and for typical values can produce a peak of up to 20 times at 200Hz. Decreasing the value of *C* from (say) 5μF to 0·1μF helps reduce the peak, but the input impedance drops at l.f. where we most require it to be high with a ceramic pick-up.

It is possible to optimise values, but we still cannot obtain much output from the cartridge below 1kHz, as shown in Fig. 6.4.

We must hasten to add that the moderate bootstrapping used in the preamplifier with switched equalisation is acceptable provided we do not attempt to use a capacitive source!

If we use silicon transistors we can operate at low collector currents and high resistance bias values, to achieve a high input impedance directly, Fig. 6.5. We need to use transistors with a high f_T because with a collector current of tens of microamps for the first transistor its frequency response is drastically reduced.

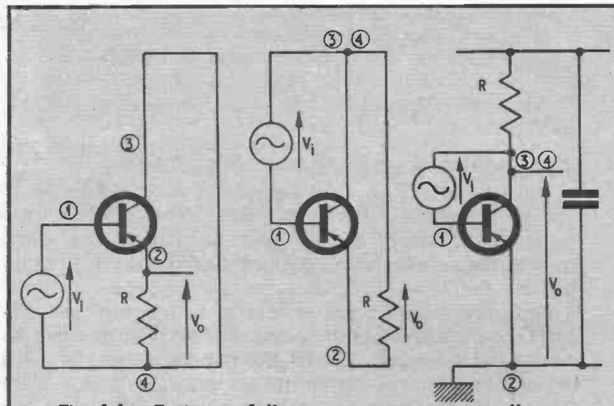


Fig. 6.1. Emitter follower or common collector amplifier under a.c. conditions rearranged to form common emitter amplifier where the output is in series with the input. Numbering is for terminal identification

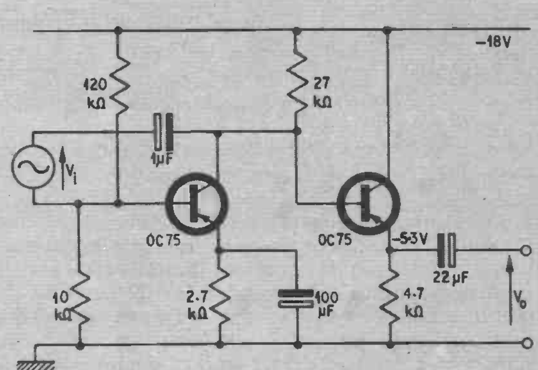


Fig. 6.2. Two stage matching amplifier with high input and low output impedance. Driving source may be crystal or ceramic transducer

This circuit has an input impedance of 1 megohm up to 20kHz or so. Note that we are bootstrapping the *collector* of the first transistor, but this is completely safe because its only 50 per cent bootstrapping, and because it extends down to d.c. so we cannot possibly have any "inductive" effects. Incidentally, we must use a paper dielectric capacitor for the input, since leakage current though an electrolytic can be sufficient to completely alter bias conditions!

We have already seen that the type of feedback we called voltage output, series input, can have the effect shift of 180 degrees around the loop will cause oscillation if the loop gain then exceeds unity (since the feedback then becomes positive rather than negative).

In this case we have the open loop gain of two transistors in series, and 100 per cent feedback, so instability is quite possible. Worst conditions occur if each transistor has a similar phase/frequency characteristic, since TR1 is working in common base (as far as the loop gain is concerned) and TR2 is operating in common emitter; h.f. instability is most likely to occur if:

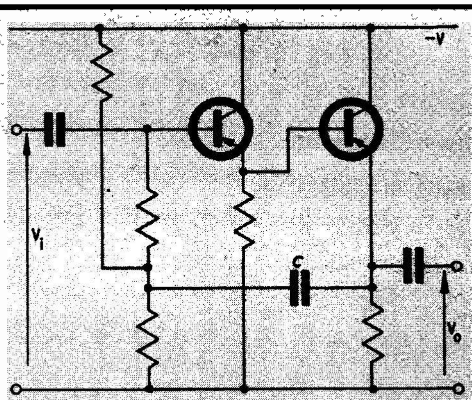


Fig. 6.3. Bootstrap high impedance amplifier. Capacitor C feeds back a signal voltage from top end of emitter follower resistor

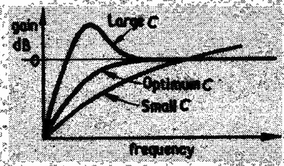


Fig. 6.4. Graph showing gain/frequency variations with changes in the value of the bootstrap amplifier's feedback capacitor

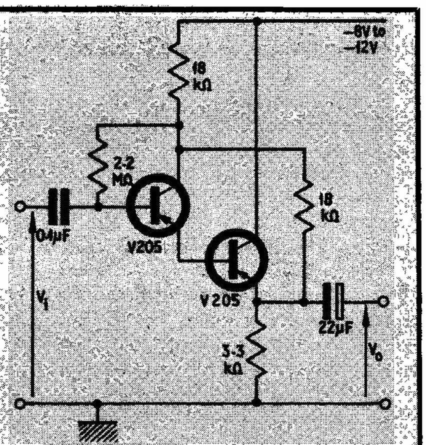


Fig. 6.5. Compound emitter follower with 50 per cent bootstrapping

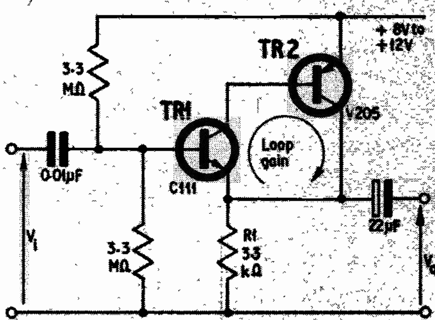


Fig. 6.6. Emitter follower with complementary arrangement of transistors

Fig. 6.7. High frequency peaking on response curve shows up as "ringing" on square wave test signal
Fig. 6.8. Acceptable peak with square wave showing reduction in overshoot amplitude

of increasing input (and decreasing output) impedance, and the reasoning behind the emitter follower suggests that we try an amplifier with 100 per cent negative feedback. The *npn pnp* pair lends itself admirably to this circuit arrangement, Fig. 6.6.

Input impedance is given by:

$$Z_i = \beta_1\beta_2 \cdot R_1$$

and output impedance tends to zero ohms.

We have to remember that TR1 is operating at a low collector current, so its β must be that associated with a low current. Since the feedback is 100 per cent d.c. conditions are very stable, and we have no need to consider leakage current for silicon, so we do not require a bias resistor in TR2 emitter circuit.

INSTABILITY PROBLEM

With 100 per cent feedback we may have a stability problem, as in any feedback system, an extra phase

Worst Conditions.

$$f_{T1} = \frac{f_{T2}}{\beta 2}$$

Transistors of the same f_T are marginally safe, but preferably

$$f_{T1} \gg \frac{f_{T2}}{\beta 2},$$

so that the transistor in common emitter is the limiting factor.

For any two transistor pairs we cannot use the *npn* or *pnp* first depending on our use of a positive or negative supply rail, we MUST use the transistor with the highest f_T in the common base position TR1.

Instability would be evident by a peak in the response or by ringing on a square wave signal, Fig. 6.7.

As previously suggested a peak in the response of up to 2dB and one overshoot would be acceptable, Fig. 6.8.

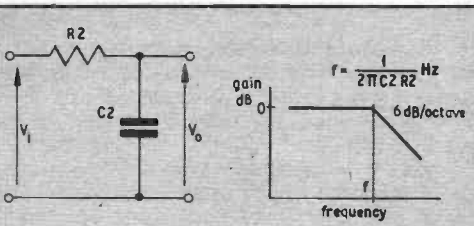


Fig. 6.9. Simple low pass CR filter with response curve showing how turnover frequency is related to filter component value

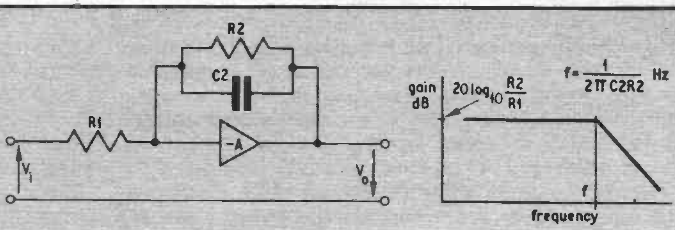


Fig. 6.10. Basic active low pass filter with response curve. Note that mid band gain is a function of the ratio of R2 and R1

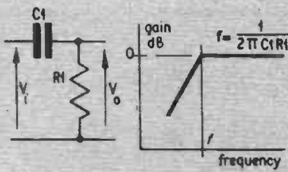


Fig. 6.11. Simple high pass CR filter and response curve. Like the low pass filter the reciprocal of the CR product determines the turnover frequency

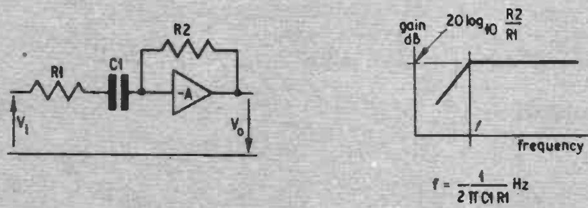


Fig. 6.12. Basic active high pass filter with response curve

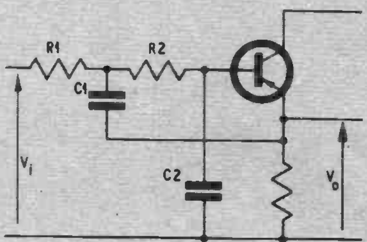


Fig. 6.13. Active low pass filter where R1 and R2 are normally equal and the ratio of C1 to C2, determines turnover point

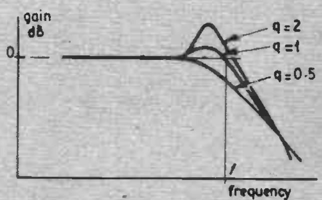


Fig. 6.14. Response curve for active low pass filter showing changes in turnover as q, the ratio of C1 to C2, is varied

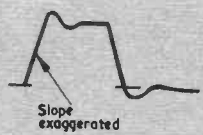


Fig. 6.15. Output from low pass filter when q = 1. Square wave input frequency is 1kHz

ACTIVE FILTERS

Conventional filters use inductors, capacitors, and resistors, but at audio frequencies circuits without inductors may be preferred, both from the hum pick-up point of view and because they would need impracticably large values of inductance.

Passive filters using only resistors and capacitors do not give the sharp cut-off obtainable with L.C.R. filters; but by using R.C. networks in active feedback systems this restriction can be overcome, and all the frequency responses usually associated with L.C.R. networks can be obtained.

We have already considered how the bandwidth of our feedback amplifiers may be shaped to roll off at 6dB/octave, but for special applications we may require an accurately defined high or low pass characteristic with a 12 or even 18dB/octave slope.

It is convenient to talk of 1st, 2nd or 3rd order filters, where the order refers to the number of reactive components. Thus a 1st order filter rolls off at 6dB/octave, a 2nd order at 12dB/octave, and a 3rd order at 18dB/octave.

FIRST ORDER FILTER—LOW PASS

The simplest passive filter consists of an R and C network, Fig. 6.9.

At zero frequency the reactance of C2 is infinite, and there is no current, and no voltage drop across R2, so output equals input voltage. As frequency increases, the reactance of C2 falls, *i* increases, there is an increasing voltage drop across R2, and output voltage falls. Eventually the reactance of C2 becomes small compared with R2, *i* becomes constant (and equal to input voltage divided by R2) and the output falls off inversely with frequency.

THE ACTIVE CASE

Similar reasoning applies in the active case, Fig. 6.10. At low frequencies the reactance of C2 is large, and gain is determined by R2 and R1, as frequency increases the reactance of C2 decreases, providing more negative feedback. When the reactance of C2 is equal to that of R2 (at *f*) the overall gain is 3dB down, and continues to fall at 6dB/octave. The active circuit has the advantage over the passive circuit that the output can be loaded and an overall gain at mid band (R2/R1) can be obtained.

FIRST ORDER FILTER—HIGH PASS

Again for the passive filter, Fig. 6.11, at high frequencies the capacitor impedance is zero, and output equals input. Towards the l.f. end of the band the capacitor impedance increases, and output drops.

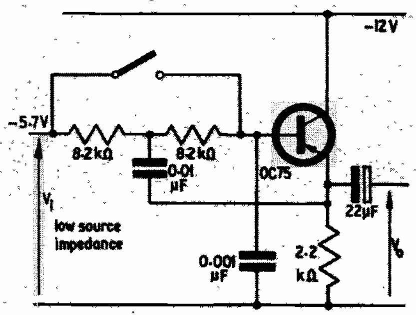


Fig. 6.16. Practical low pass active filter

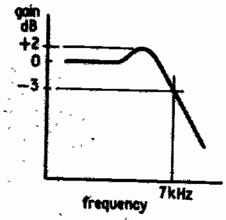


Fig. 6.17. Response curve of active low pass filter where the theoretical turnover point is 6·1kHz

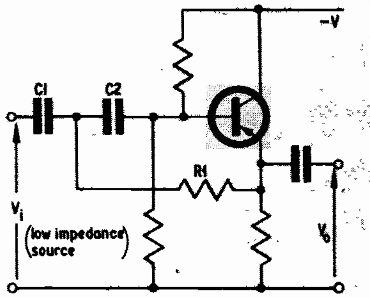


Fig. 6.18. High pass active filter

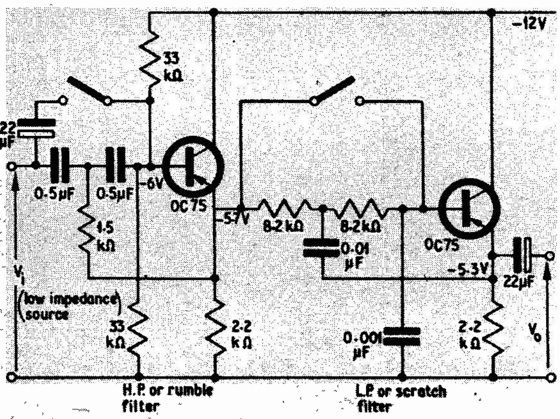


Fig. 6.19. Combination of high pass and low pass filters

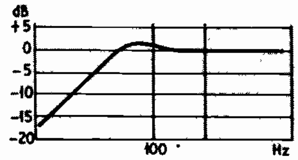


Fig. 6.20. Low frequency response curve of combination filter where theoretical turnover point is 67Hz

For the active filter, Fig. 6.12, the impedance of the capacitor is zero at h.f. giving an overall gain of R2 divided by R1. Towards the l.f. end of the band the reactance of the capacitor increases, increasing the source impedance and giving a reduction in gain.

SECOND ORDER FILTER—LOW PASS

In the low pass active filter, Fig. 6.13, there is an energy interchange between the output and input via C1, and since we have two reactive components a 2nd order filter is possible.

Normally R1 and R2 are made equal and C1 and C2 are chosen to give the required turnover point. By choosing a suitable ratio for C1 to C2 it is possible to obtain one of several responses, Fig. 6.14.

An arrangement with a q of about 1 is often used in audio preamplifiers as a scratch filter, the 2dB peak in the frequency response is accompanied by a pronounced overshoot on a 1kHz square wave, but this is tolerated to obtain a sharp cut off, Fig. 6.15. This is shown in the photographs.

In this response of a filter with 7kHz f to an input square wave of 1kHz, rise time is degraded and there is an overshoot, as we would expect.

If we assume a perfect emitter follower (high input impedance, low output impedance, unity voltage gain) then the turnover frequency f is given by:

$$f = \frac{1}{2\pi\sqrt{(R1R2.C1C2)}} \text{ Hz}$$

and

$$q = \frac{\sqrt{(R1R2.C1C2)}}{C2.(R1 + R2)}$$

For our practical circuit of Fig. 6.16.

The response curve is Fig. 6.17, and is 3dB down at 7kHz and 18dB down at 20kHz. These figures compare well with the theoretical values of 6·1kHz with a q of 1·6, which assume unity voltage gain for the emitter follower.

Since the response is 3dB down at 7kHz the point where the curve recrosses the 0dB line is almost exactly the 6kHz predicted by the formula, but the actual q obtained in the circuit is about 1 because of the finite current gain of the emitter follower.

SECOND ORDER FILTER—HIGH PASS

Complementary to the arrangement used for the low pass filter, a high pass filter can be designed, Fig. 6.18.

R2 can be considered to be the input impedance of the emitter follower, including the bias resistors. Again with this arrangement we can obtain various values of q

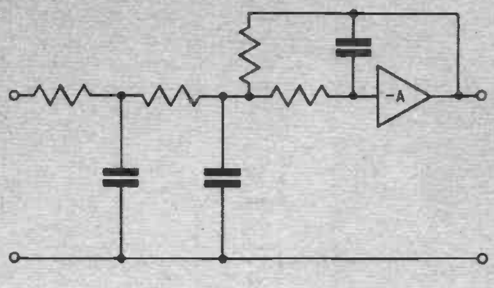


Fig. 6.21. Basic third order filter

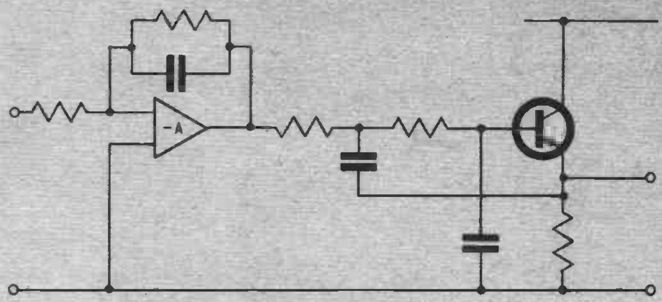


Fig. 6.22. Third order filter achieved by combination of low and high pass filters

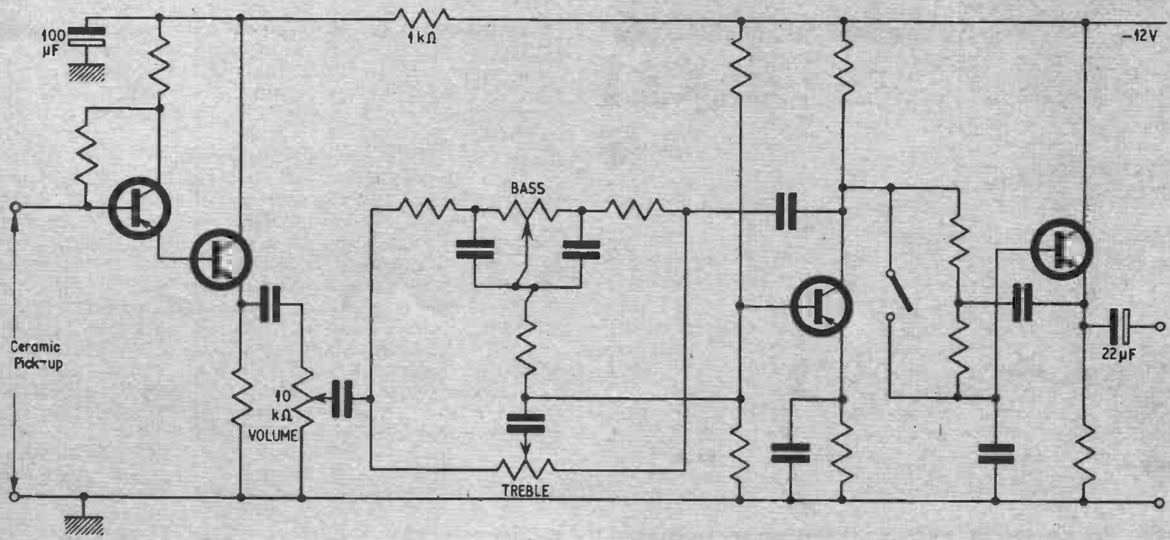


Fig. 6.23. Feedback and filter circuits of typical audio pre amplifier

by making C1 and C2 equal and selecting the required ratio for R1 and R2. For a q of about 1, in theory:

$$f = \frac{1}{2\pi\sqrt{(R1R2.C1C2)}} \text{ Hz}$$

and

$$q = \frac{\sqrt{(R1R2.C1C2)}}{R1.(C1 + C2)}$$

Our practical low pass circuit can be biased from our high pass circuit, and the two are shown together in Fig. 6.19.

The response curve for the high pass filter is shown in Fig. 6.20.

Performance 3dB down 50Hz
18dB down 20Hz

Max output 500mV r.m.s. 1 kilohm load (either filter).

Midband gain X1 (either filter).

These figures compare well with the theoretical turnover point of 67Hz (where the curve crosses the 0dB line) and a q of 1·5 (ideally).

THIRD ORDER FILTERS

Third order filters can be designed around one amplifier, for example the low pass filter of Fig. 6.21, but the mathematics can become rather involved.

If third order filters are required it is probably easier to combine a first and second order, e.g. Fig. 6.22.

CONCLUSION

In this series of articles we have considered many circuits separately, although they could be combined in various ways to produce complete audio amplifiers to suit the individual needs of the constructor. For example, it is possible to combine a high-low impedance converter such as Fig. 6.3 with the tone controls described in Part 5 and the scratch filter of Fig. 6.16. Fig. 6.23 shows this arrangement. ★

INGENUITY UNLIMITED!

A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.
This is YOUR page and any idea published will be awarded payment according to its merit.

CINE AND TAPE SYNC

I WOULD like to make a few points in reply to Mr Watts' letter in Readout (May 1968) concerning Cine and Tape Sync. Using reflected light from the screen the output from his l.d.r. will vary according to the light content of his picture, and on dark scenes or fadeouts will lose his signal altogether, therefore losing his sync.

Secondly, a three segment shutter is used on many projectors and consists of a large segment blanking off the light while changing frame, the other two segments maintain flicker frequency but are made small to allow maximum light passage. This will give an asymmetrical waveform from the l.d.r. as shown in Fig. 1.

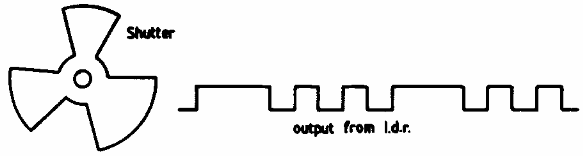


Fig. 1. Optical pickup produces an asymmetrical waveform

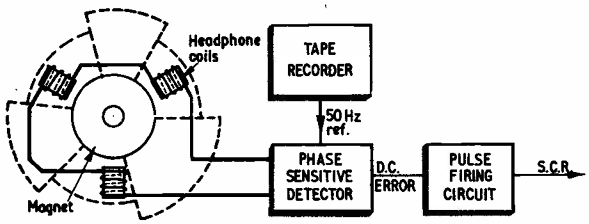


Fig. 2. Using a sine wave reference from the projector

An alternative arrangement besides using a separate shutter and optical arrangement independent of the light path of the film, would be to fit a circular magnet on the shutter spindle with three coils in close proximity. This would give a sine wave output (as apposed to a square wave which would require changing to sine wave with a harmonic filter). See Fig. 2.

For his "black box" this 50Hz error signal after suitable amplification could be fed to a phase sensitive detector together with his reference signal from tape recorder. The d.c. output from this could then control a thyratron or a pulse firing circuit for a silicon controlled rectifier.

If the coils were replaced with a reed switch and the reference frequency lowered accordingly (frame speed), the reed switch could then demodulate the tape recorder reference frequency directly providing a d.c. error suitable for the Pulse Firing Circuit. This would provide a simple method for accurate Cine Tape Sync and because of the low reference frequency used, a two track tape recorder could be used with suitable filtering for the separation of the reference frequency and audio signal.

N. I. Bridger,
Macclesfield, Cheshire.

"FLIP FLOP" SYNC

IN reply to the letter "What's in the box?" by D. Watts of Lincoln (May edition), may I point out that to use a thyristor in this way is impracticable since once the trigger pulse applied to the gate has switched it on, any further pulse will not switch it off again. The only way to switch it off is to remove the mains supply from it.

A simpler and cheaper method is to use a "flip flop" relay in conjunction with perforated cine tape. See Fig. 1.

A four track tape recorder is not required with this type of synchroniser. The only slight modification to the projector is to fit a one pulse per picture contact cam and to put the relay contacts in series with the motor circuit. The relay must be of the high speed type.

By fitting a similar one pulse per frame contact maker and interrupting the battery supply with the relay, this device can be made to synchronise a movie camera with a tape recorder providing the camera is electric and not clockwork.

It must be observed that for this device to operate the projector manual speed control must be set to fast (i.e. faster than 16 f.p.s.) and that the camera must have a slightly higher voltage than normal (i.e. six penlight cells instead of four). This condition is necessary because the synchroniser can only slow the motors down to the exact speed, it cannot speed them up.

As for the fitting of contact makers, this must be left to the discretion of the reader as it is impossible to generalise on the numerous types of projectors or cameras. Basically a nylon half bush cemented to the drive shaft made to lift a phosphor-bronze contact strip off the shaft will do providing the shaft is making one revolution per picture frame.

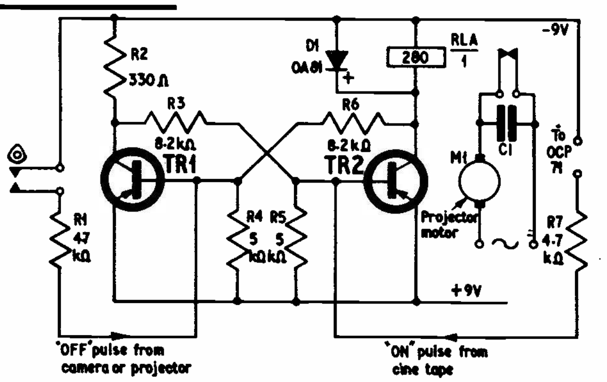


Fig. 1. In the "black box"—a transistor flip flop

As for the tape perforation scanner, this can be done either by a contact spring that drops through the perforations on to a capstan or the tape could be made to interrupt a light beam on to an OCP71 phototransistor or ORP60 light dependent resistor. This latter method however requires another battery to supply a light source on the scanner.

R. S. Hodgson,
Huthwaite, Notts.

DRILL SPEED CONTROLLER

By J. N. Watt

Electric hand drills are deservedly popular with home handymen, and others, but do have the disadvantage that the running speed is too high for many jobs. The drilling of masonry is an example, and even drills with built-in two speed gear-boxes can be made more useful by a reduction of speed.

At first sight the simplest way of reducing the running speed would appear to be to lower the voltage applied by means of a series resistor, or a voltage dropping transformer. Both of these simple schemes result in a serious loss of torque, however, and, in the case of the series resistor, the generation of a large amount of heat, which is, of course, wasted. Both methods are also less flexible in use than the method to be described.

A much better and more sophisticated way of controlling speed is to use a thyristor or silicon controlled rectifier (s.c.r.), as the controlling element. As will be seen later, the circuit used is so arranged that when the drill is loaded and thus tends to slow down, extra power is automatically applied to it to make up for the extra work it is called upon to do.

THYRISTOR PROPERTIES

Readers familiar with the gas filled valve or thyratron will recognise the following description of the properties of a thyristor, for both are very similar in general operation—in fact the name "thyristor" is derived from "*thyr*atron trans*istor*".

Briefly, a thyristor has three very important properties.

(a) It will conduct only in one direction.

(b) Even with a positive voltage applied to its anode it will not start to conduct until the third connection, known as the gate, is made a small amount positive with respect to the cathode. It will then conduct freely.

(c) Once conducting, it will continue to do so even if the positive voltage is removed from the gate, until either the anode is no longer held positive or until the current through the device has fallen below a very low value (known as the holding current).

POWER CONTROLLER DESIGN

We shall employ all of these characteristics in the electronic speed controller.

Consider the mains voltage waveform; suppose we use a thyristor in series to block the negative half-cycles (shown shaded in Fig. 2). With only the remaining positive half-cycles applied to a drill motor, there will be a reduction in the speed at which it runs, compared to normal, but, somewhat surprisingly, this

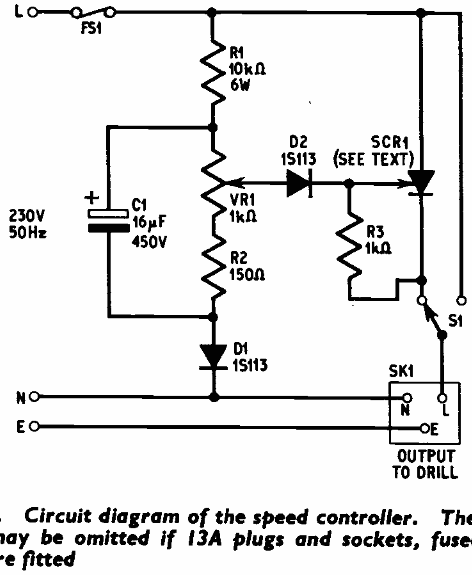


Fig. 1. Circuit diagram of the speed controller. The fuse FS1 may be omitted if 13A plugs and sockets, fused for 3A, are fitted

reduction is not very great. Some means of controlling the positive half-cycles is required, and this is where we can make use of the second property of the thyristor.

If we do not allow the gate to become sufficiently positive to cause the thyristor to conduct (or trigger) until some time after the start of each positive half-cycle, then no power will be supplied to the drill until that time. The third property of the thyristor will ensure that power continues to be supplied until the end of the half-cycle, and the whole process will be repeated when next the anode goes positive. See Fig. 3.

It can be seen that, taken over many cycles of the mains, the average voltage supplied is less than before, and hence the drill runs more slowly. It remains to arrange for the trigger point to be varied to have control over the speed in use.

CIRCUIT OPERATION

The complete circuit diagram for the drill controller is given in Fig. 1.

The voltage applied to the gate of SCR1 is derived from the mains via a potential divider, R1, VR1, R2, with a diode D1 in series to reduce the mean current through the resistors and hence allow components of a reduced wattage rating.

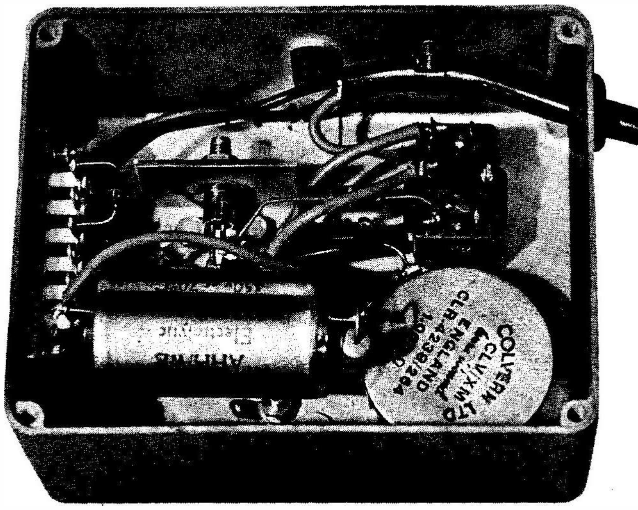


Fig. 6. Interior view of the completed controller

The waveform at D2 anode will vary in amplitude as VR1 slider is moved. This voltage, applied to the gate of the thyristor, will cause the latter to conduct at varying points during positive half-cycles, as shown in Fig. 5. The large value capacitor C1 introduces sufficient phase shift to allow the thyristor trigger point to be varied over the whole of the positive half-cycle, thus giving complete control of drill speed down to a few r.p.m. D2 protects the thyristor gate from negative half-cycles of the mains and R3 provides a d.c. path from gate to cathode.

This does not, however, exploit all the possible virtues of the circuit. It will be recalled that the gate of the thyristor must be taken positive with respect to the cathode. Now, in the circuit (Fig. 1), it is seen that the cathode is connected to the drill itself. Suppose the drill motor is running freely, unloaded, and at about half speed. The back e.m.f. of the motor will appear at the cathode and the gate must exceed that voltage level by a small amount before the thyristor will conduct.

If now a load is applied, the speed will tend to drop, the back e.m.f. will fall and hence the gate voltage will exceed that of the cathode earlier in each half-cycle and hence the average voltage supplied to the drill will rise. This will tend to automatically maintain the speed of the drill as it is used, for example, for drilling masonry. The effect is quite noticeable; the sound emitted by the drill will be heard to change as a load is applied, and this is an indication that the circuit is functioning correctly.

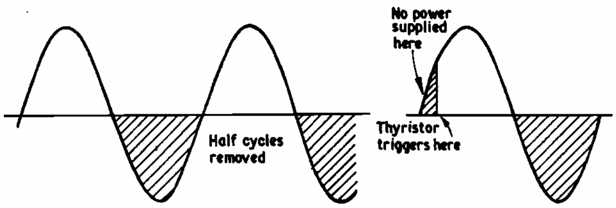
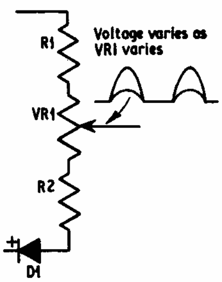


Fig. 2 (above left). With the gate held sufficiently positive relative to the cathode, the thyristor behaves as a half-wave rectifier, blocking negative half-cycles of the supply

Fig. 3 (right). By preventing the gate of the thyristor from receiving a large enough pulse to trigger the device until some time after the start of each positive half-cycle of the mains, no power will be conveyed until that time. Therefore a smaller percentage of the energy in the positive half-cycle will be available to feed the load



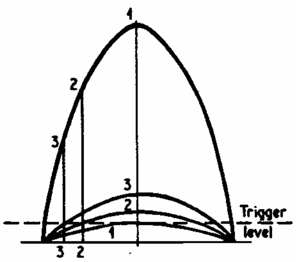


Fig. 4 (above left). The instantaneous level of the positive pulse fed to the gate of the thyristor, and thus the point on the incoming mains half-cycle at which the device conducts, is adjusted by VR1—the speed control. D1 avoids dissipating unwanted negative half-cycles through the potential divider chain

Fig. 5 (right). The curves at the bottom show three (arbitrary) levels of voltage input to the thyristor gate and the corresponding shifts in the point on the supply half-cycle at which the device conducts or "fires"

CONSTRUCTION

The general layout is as shown in Figs. 6, 7 and 8.

A strong case is required to house the unit, and an alloy diecast box is specified, for the controller will doubtless be subject to hard usage in service.

The thyristor should have a voltage rating of at least 400V, for it must withstand the peak mains voltage, and a current rating of 3A. It will require to be mounted on a heat sink of about 3 sq in and for this a piece of angled aluminium sheet is suitable, which *must* be insulated from the case on nylon screws with insulated washers between case and heat sink (see Fig. 7).

COMPONENTS . . .

Resistors
R1 10kΩ 6 watt wirewound
R2 150Ω $\frac{1}{4}$W carbon
R3 1kΩ $\frac{1}{2}$W carbon

Potentiometer
VR1 1kΩ wirewound

Capacitor
C1 16μF 450V elect.

Thyristor
SCR1 400V, 3 amp rating (available from G. W. Smith & Co., 3 Lisle Street, London, W.C.2)

Diodes
D1, D2 1S113 or similar with 400V 50mA rating

Switches
S1 Changeover toggle switch

Fuse
FS1 Miniature 3A fuse and holder (see text)

Socket
SK1 13A fused mains supply socket (see text)

Miscellaneous
Die-cast box (Eddystone *or* S.T.C.), approx. $4\frac{1}{2}$in × $3\frac{1}{4}$in × $2\frac{1}{4}$in. Six way tag strip. Nylon screws, 4 B.A. Aluminium for heat sink.

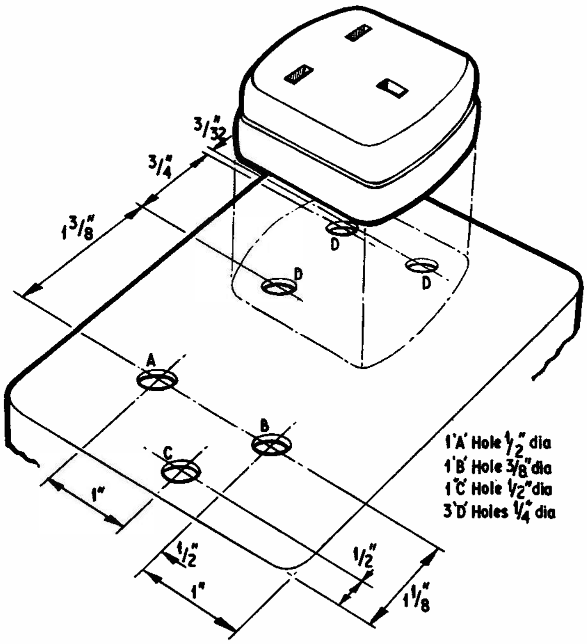


Fig. 8. Position of controls and socket on the die-cast box. Location of feed-through holes (D) will depend on the design and type of socket. Hole C is only needed when a separate fuse is fitted

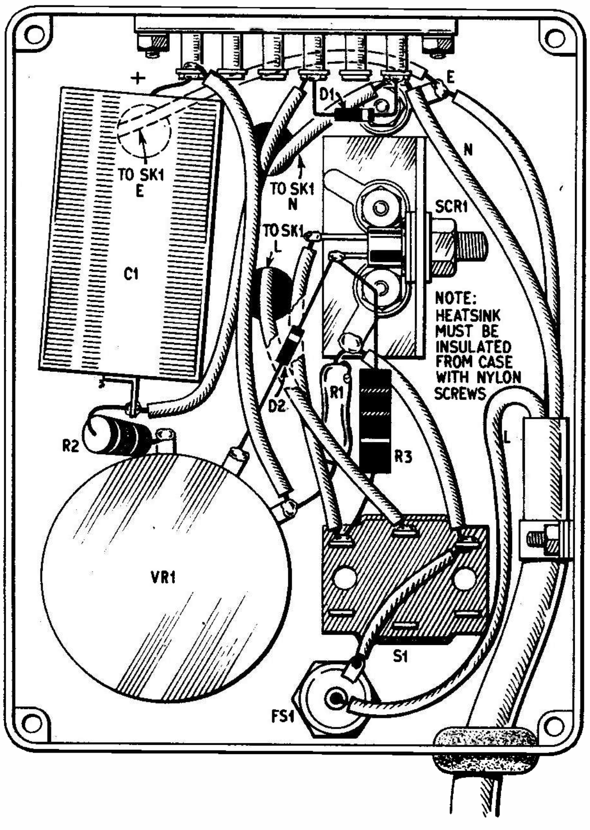
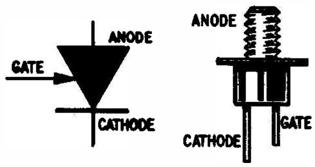


Fig. 7. Layout of components inside the die-cast box. The fuse FS1 is only necessary when unfused (5A or 15A) plugs and sockets are used

Fig. 9. Thyristor symbol and terminal connections



Otherwise, construction is straightforward and should give no difficulty even to a beginner. A small tagstrip is useful for mounting the large phase shift capacitor and one of the diodes, while the resistors can be supported in the wiring. Ensure that there can be a free flow of air around R1.

FUSE PROTECTION

The thyristor should be protected against overload. If 13 amp plugs and sockets are used with the controller, these can be fitted with 1in × $\frac{1}{4}$in 3A cartridge fuses (available from Radiospares stockists). Models using 5A plugs and sockets (or 15A types without fuses) should incorporate a separate miniature 3A fuse and holder, connected in the "live" supply lead to S1. This fuseholder can be mounted inside the box as indicated in Fig. 7.

REACTION TO LOAD CHANGES

As mentioned previously, the speed controller circuit reacts to load changes; the effectiveness of this depends on the residual magnetism of each individual motor, but in any case will be most effective when the trigger point occurs at peak input voltage. It is at that point that a small change in trigger point will cause most change in the resultant output power.

It may be noticed that at very slow speeds the motor will fire intermittently, and in fact will sound rather

continued on page 519

NEWS BRIEFS

▲

New Task for No. 1

AERIAL No. 1 at Goonhilly is to be re-equipped to enable it to carry commercial telephony traffic and television programmes between the U.K. and countries in the East, via a communications satellite over the Indian Ocean.

Work will begin when the aerial is freed from its present task of tracking the Early Bird satellite, probably in the late summer of this year, and will be completed in the first half of 1969. The contractors are GEC-AEI (Electronics) Ltd.

To reduce the amount of apparatus that would otherwise be needed in the limited space on the aerial itself, the connection to receivers in the central control building, a quarter of a mile away, will be through a semi-flexible waveguide operating at 4GHz. Tests are to be made to see whether a similar system can be used for the transmitting direction.

Artificial Earthquake

RUSSIAN scientists are building a huge "artificial earthquake" machine which will be used to put architectural methods and materials to the crucial test. It uses an electronically-controlled "seismic platform" to simulate the reciprocating and rotary oscillations of a ferro-concrete framed building during a 'quake, and a variety of instruments for detecting the resultant static and dynamic stresses.

Officially Accurate

THE British Calibration Service, set up by the Ministry of Technology in 1966 to provide industry with authenticated calibration facilities for a wide range of measuring instruments, has received Royal assent for an official badge (right) to appear on the certificates it issues to approved laboratories. It comprises the mathematical signs for "not greater than" and "not less than", surmounted by a crown.

CROWN COPYRIGHT

Faster Forecasts

COMPUTERS are helping to produce weather maps much more quickly than by previous methods, but to speed up the transmission of facsimile copies by landline or radio to met. offices and airports calls for higher grade circuits with increased bandwith. New equipment which doubles the transmission speed over existing networks, without any increase in bandwidth, has been developed by the Muirhead Group. It makes the most of the available frequency band of the telephone line by transmitting the picture signals on a carrier of 2·4kHz. Only a vestige of the upper sideband is transmitted. At the receiving end, both the upper and lower sidebands are reconstructed and fed to the reproduction machine.

Cleaning up the TV

WHEN the telly goes on the blink—give it a wash! Removing the film of dirt from the components of long-serving equipment can bring a definite improvement in performance, but in busy repair shops it creates a bottleneck. Telehire Ltd. have adopted a modern method that speedily bestows "as new" appearance and performance on reconditioned TV sets. The complete chassis is immersed in the vapour of ICI Arklone solvent (trichlorotrifluoroethane in full) and hosed down with a jet of the solvent. The solvent drips from the chassis, carrying the dirt with it, and is distilled and recirculated to the jet.

More Phone Exchanges

"MASSIVE" five year programme of expansion by the GPO will see the completion of more than 200 new telephone exchanges and the enlargement of a further 600 by the end of this year.

This was announced by the Postmaster General, Mr Roy Mason, at a ceremony in London to launch Telephone Fortnight. His speech was linked by television with 16 towns and cities throughout the country.

Computer Plans Conference

THE Institution of Electrical Engineers is using its own computer to plan a conference on electronics design, to be held at Cambridge University in September. A large number of engineers have completed questionnaires on the choice of topics, and their preferences are being analysed. One observation to emerge from the computer is that while junior designers are more interested in design method and research into design processes than their seniors, they are much less concerned with human factors and the behaviour of design teams.

Transistor U.H.F. Drive

THE Marconi Co. has begun production of an all solid-state u.h.f. drive unit for use in colour television transmitters. The new drive, providing 5W vision and 10W f.m. sound, is less than half the size of conventional valve units. A single crystal oscillator controls the output frequencies.

The Mullard Plant at Simonstone, Nr. Burnley, Lancs, is the largest TV picture tube production unit in the U.K. and is the most modern in Europe. It includes a glass works second in size only to Pilkington's in the U.K.

The Simonstone Works has a current capability for manufacturing about 1½ million monochrome tubes per year. Present plans for colour tube manufacture envisage a production capability rate of over 150,000 tubes per annum towards the end of 1968.

THIS is an account of the production processes involved in the making of a colour picture tube. It is prefaced by a brief outline of the principles behind the shadowmask colour tube.

FEATURES OF THE COLOUR TUBE

All television picture tubes have a screen layer which fluoresces under the impact of a high velocity electron beam generated at the cathode of an electron gun and accelerated by voltages applied within the tube. Monochrome tubes have a single continuous layer of phosphor on the screen which glows white when struck by the electron beam generated by a single gun. Colour tubes have three phosphors which glow red, green or blue when struck by the electron beam. Various "mixes" in illumination of these three basic colours provide the full colour spectrum.

The red, green and blue phosphors are not in a continuous layer but are arranged in discrete dots forming "triads" over the whole screen surface. Three electron guns are used, one to activate each colour and to ensure that each gun can only activate its own phosphor colour, a shadowmask is interposed between the three electron guns and the screen.

The shadowmask is a thin steel sheet, typically 0·006in thick, perforated with tiny holes and manufactured to great precision. In a typical colour tube there are some 440,000 triads each consisting of a red, green and blue dot of phosphor. The final assembly must ensure that an electron beam from the red gun can "see" through the shadowmask only dots of red phosphor, the green gun only green phosphor and the blue gun only blue phosphor.

General view of the ultra-clean Flow Coating Room. Bulk of the space is taken up by the three large automated flow mills. Along the left hand walls are the "lighthouse" stations. Note the air filter bags suspended from the ceiling

PREPARING THE FACEPLATE

Tube production starts with reception of faceplates from the stores. These are first washed in hydrofluoric acid, rinsed off and dried. A layer of potassium silicate is then laid on the screen to act as a barrier between the phosphor and the glass. The layer maintains the brightness of the screen by eliminating any possible reaction between oxides in the glass and the phosphors.

The faceplates are then passed to the ultra-clean flow-coating room which is temperature and humidity controlled. This is the area where the red, green and blue phosphors are laid on the screen in a triad formation.

The order of laying the phosphors is first green, then blue, followed by red. A separate flow mill is used for each phosphor. The temperature of the glass, which must be clinically clean, of course, is critical at the start of the process. The flow mills are entirely automatic in operation including the dispensing of the correct amount of slurry—the phosphor suspended in a mixture of polyvinyl alcohol, distilled water and ammonium dichromate.

An essential quality of the phosphor slurry is that it must act as a photo-resist. That is, if exposed to ultraviolet light the particles should adhere and become insoluble. Unexposed particles should remain unaffected and be easily washed off.

FIXING THE DOTS

After laying the green phosphor the faceplate is passed to a photo-exposing equipment dubbed a "lighthouse". Before exposure to ultraviolet light concentrated through a quartz resonator, the shadowmask is fitted to the faceplate. The shadowmask acts as a template for fixing the green dots, and this is achieved by positioning the light source at exactly the same position that the electron gun for that colour will be in the final assembly. The light source shining through the holes in the shadowmask will harden every spot of green phosphor in direct line with the green electron gun. From this moment on, that particular shadowmask must be clearly identified with that particular faceplate.

After exposure the shadowmask is removed and the faceplate mounted in the second flow mill where the first operation is the washing away of all the unexposed green phosphor, leaving a pattern of green phosphor dots on the screen. The blue phosphor is then applied and, after drying, the faceplate is again passed to the photo-exposing equipment.

Again the same shadowmask is fitted and the blue phosphor is exposed to ultraviolet light, but this time the light source is positioned to simulate the blue electron gun. The process is then repeated with the red phosphor.

The final result is that the screen is now fully covered with triads of red, green, and blue dots positioned accurately in relation to the holes in the shadowmask.

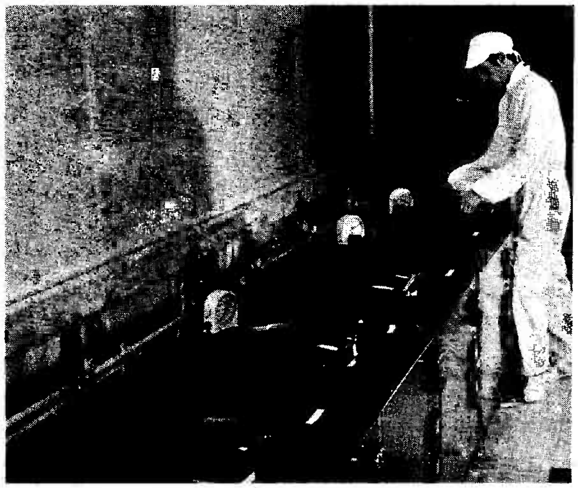
The assembly station for mounting the shadowmask to the faceplate. The operator in the foreground is spot welding steel strips round the edge of the shadowmask. These prevent stray electrons reaching the screen round the edges of the shadowmask

Completed faceplates are now passed through an airlock to an adjoining area and placed on a lacquer mill, lacquered and dried. The faceplates are then cleaned carefully by hand to eliminate all traces of phosphor from the screen walls and the operators here paint on a small oblong patch of graphite to connect electrically with a spring on the shadowmask at a later assembly stage.

Cones are also part processed in this area. The graphite coating is applied to the inside surfaces and the neck and powdered glass in suspension is applied to the ground edges of the cone.

ALUMINISING PROCESS

Faceplates are then subjected to the aluminising process. In this, the faceplate is placed on a machine and all air evacuated. A slug of aluminium is heated



Faceplates in position on the "lighthouse" stations where each layer of colour phosphor is exposed to ultra-violet light

in the vacuum and eventually vaporises to deposit a very fine film of aluminium over the inner surface of the faceplate. An interesting feature of the aluminising plant is that the thickness of the aluminium layer is automatically checked by a capacitive probe while the faceplate is still on the machine. The lacquer is then baked off to complete the process.

FITTING THE SHADOWMASK

The time has now arrived for the final meeting of the faceplate and its shadowmask. This takes place in a clean area where shadowmasks are also optically inspected. After clipping the shadowmask into position a series of thin steel plates is spot welded round the shadowmask periphery. This is to prevent stray electrons escaping round the edges of the shadowmask and activating the phosphors—a process which, if allowed, could cause colour dilution. The same operator also spot welds two springs to the shadowmask which will make electrical contact with the conducting graphite surface on the interior of the cone.

MATING OF CONE AND FACEPLATE

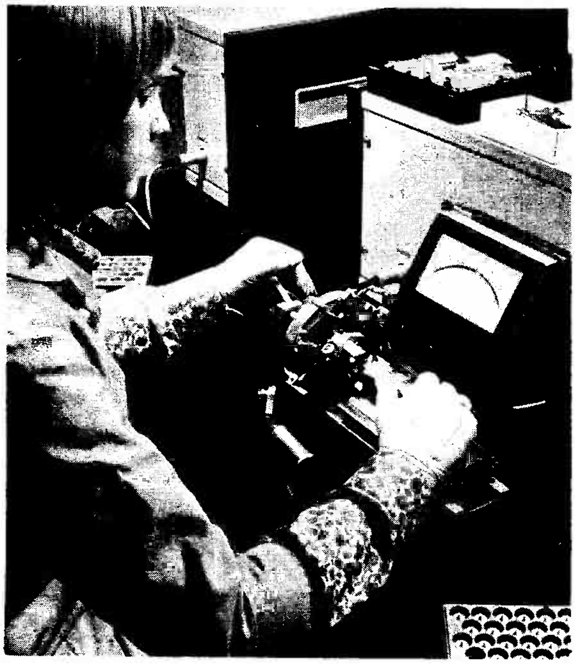
The faceplate assembly is now ready for mating with the cone. The cones have undergone a baking process at 450°C and are received at the entry to the Frit oven.

Assembly of colour gun components to insulating rods (beading)

Electrical and visual final inspection of colour guns

Here the cones are mounted on precision jigs and the faceplates accurately positioned ground-edge to ground-edge with the powdered glass, previously applied to the cones, between the two surfaces. By exposure to a temperature of around 450°C for one hour the powdered glass slowly melts and fuses the two components together. This process at low temperature is necessary in order to prevent damage to the shadowmask.

Insertion of cathode to colour gun using capacity setting equipment



ELECTRON GUN

After a full inspection the next operation is the fitting of the electron gun assembly into the neck of the tube. Electron guns are kept in a hot box in readiness for the process. This reduces the possibility of thermal shock during the sealing-in process. The bulbs are placed on a vibrator which automatically sweeps over a vibration frequency range of 600–1,100Hz which includes the resonant frequency of the bulb. This process shakes out any residual foreign matter. The necks are then cleaned manually with chamois leather and alcohol. The gun assembly is then sealed into the tube on an automatic machine.

TUBE EVACUATION

Nearly 90 self-contained pumping stations are in operation on the all important evacuation process. Each has two fast pumps capable of creating a vacuum of atmospheric pressure 5×10^{-6} Torr. The evacuating process takes about 3 hours. During the process the bulb is heated to 400°C, which assists in out-gassing the glass and metal components, and, during a later stage of the process, the tube heaters are energised for about 40 minutes, an important part of the cathode activating process. By applying high voltages to the tube it functions as an ion gauge, and can therefore be used to check its own vacuum.

The next series of tests and processes are designed to further activate the tube and search out rejects. The normal maximum operating voltage of a "Colour-Screen" tube is 25kV but they are tested at much higher voltages. The electrical quality of the Frit seal is tested at 44kV and must successfully withstand this voltage. A voltage of 65kV is applied to the anode to break down any sharp points in the internal structure which could lead to flashovers, a process known as "spot-knocking".

Evacuation is completed by gettering—a process in which a small pellet of barium is fired internally in the bulb to absorb any gases remaining and to maintain the excellence of the vacuum for the tube's working life.

Extensive testing is undertaken in the later stages of manufacture. Picture shows a battery of high voltage testers

AGEING AND FINAL TEST

The tubes are then mounted on the ageing conveyor. On this, each tube is electrically connected and, during a 1½ hour period on the conveyor, current is drawn from the cathodes, the emission is stabilised and two more periods of spot-knocking are sustained.

Final test is conducted at a bank of five specially designed colour test boards. All "ColourScreen" tubes are tested for blemishes in each colour and in white, for convergence, linearity, cathode quality, overvoltage, etc. The process, once cumbersome and time consuming, has been streamlined by careful design of the test boards and the inclusion of modern aids such as digital read-out for colour purity checks. To completely test a colour tube now takes under 10 minutes giving a throughput of up to 30 tubes an hour from the five test boards. As production increases, so will the number of test boards be increased in proportion.

After visual inspection the tubes are fitted with a reinforcement guard, given a final wash, receive a coating of graphite on the cone exterior.

GUN ASSEMBLY

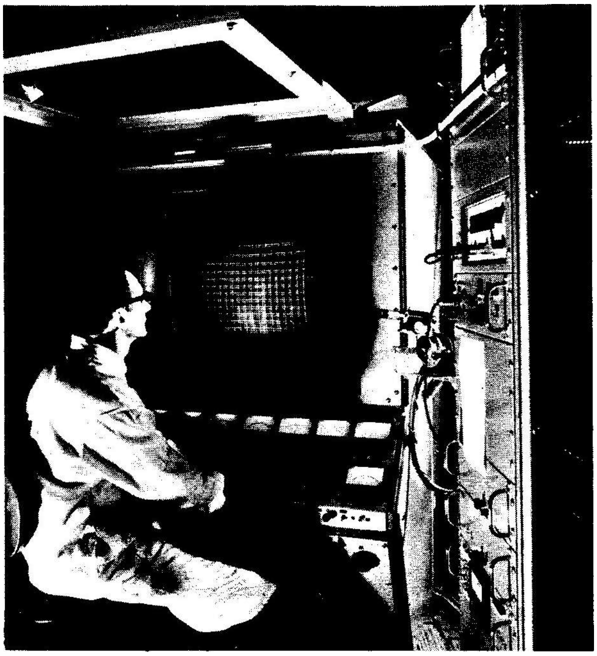
Gun assembly is undertaken in a completely separate part of the factory away from the heat and noise and general bustle. The assembly area is air-conditioned and has clean rooms in which nylon overalls are mandatory. Even in the less critical general assembly area the operatives are obliged to wear nylon gloves. Electron guns are virtually "untouched by hand". The department employs over 200 girls skilled in fine assembly work.

STAINLESS STEEL PARTS

Piece parts for the triple-guns are manufactured at the Mullard Blackburn Works. The quality of the raw materials is closely controlled. Metal parts are stainless steel and these are stored in a dry hydrogen atmosphere at 1,050°C. Parts for immediate use are withdrawn from the hot store and retained in vacuum jars up to the assembly stations. All mica parts are vacuum stoved before use for de-gassing. The chamber is pumped out to 10^{-4} Torr at 500°C and as the chamber cools down the vacuum can rise to as high as 10^{-6} Torr.

Nearly 30 stages of assembly are necessary. The key to accuracy lies in a number of ingenious assembly jigs and the skill of the operator.

Close-up of one of the final test stations. The engineer is checking linearity with a grid pattern on the screen. On the right of the picture is a further electronics cabinet and the digital readout of colour purity can be seen in the upper section of this unit



SPECIAL TEST GEAR

Another feature of gun assembly is the specially designed test gear. For example, in an early stage of assembly the correct positioning of the cathode micas into the structure is critical. The correct positioning on assembly is determined by measuring the capacity between the cathode and g2. The method was developed in the Mullard organisation. Another ingenious machine is the auto-tester designed at Simonstone and used in the final assembly clean rooms. This completely checks over 60 parameters for continuity and short-circuit as well as measuring the heater resistance.

THE SHADOWMASK

The shadowmask is a critical component in all colour TV picture tubes. A typical shadowmask has 440,000 tiny holes at a density of some 1,500 to the square inch. The holes have to be microscopically accurate in position and dimensions. Furthermore, the holes, depending on their position on the shadowmask, vary in size down to 220 microns in diameter and are tapered.

The process involves etching the holes in acid baths after exposing the thin sheet steel of the shadowmask between two photographic negatives. This sounds simpler than it is but there are enormous problems in careful alignment of the negatives, handling and cleanliness. A single spot of dust, for example, can become an unwanted hole.

One aspect of the shadowmask is that in service it must withstand a temperature increase without deformation. Even with a density of 1,500 holes to the square inch, the holes represent only about 25 per cent of the shadowmask area and thus only 25 per cent of the electrons fired at it from each gun pass through to bombard the fluorescent screen. This is one of the reasons why a higher e.h.t. voltage is required on colour tubes. The shadowmask itself has to absorb an electron bombardment which results in a typical heat dissipation of 20W in the shadowmask. For colour purity this must be absorbed without flexing or other distortion of the mask.

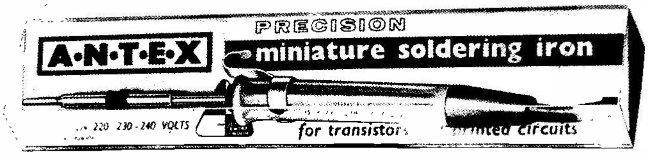
THE GLASS FACTORY

Special quality glass is required for TV picture tubes. The qualities required include mechanical strength to withstand atmospheric pressure and a force of several tons when the TV tube is evacuated. The faceplate must be completely free from blemishes and distortion, must have a good "colour" and not be subject to discoloration when subjected to bombardment by high velocity electrons. Finally, the glass must be capable of withstanding scores of thousands of volts without electrical breakdown.

Clearly, the quality of the glass is fundamentally related to the final quality of the TV picture tube. By retaining complete control of glass manufacture Mullard are able to control quality from the start. Among the routines is a daily chemical analysis of glass quality and immediate feedback of reject trends from inspection points to the processing stations. ★

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.



Model CN iron from Antex Ltd

WORKSHOP AIDS

There are a number of items this month worthy of consideration for addition to the workshop.

The new range of multimeters from **Daystrom Ltd.** (Models IM-16 and IM-25) are ideal for the workshop, and being in kit form also give that personal feeling of satisfaction when built-up at home.

The Heathkit model IM-16 is an all transistor multimeter operating either from the mains or from internal batteries. There are separate switches for each individual function.

There are seven switched ohms ranges x1 to x1megohm; the x1 range has a 10 ohm centre scale. The meter has eight a.c. and d.c. ranges from 0·5V to 1,500V f.s.d. The meter accuracy on the a.c. ranges is ± 5 per cent full scale, and ± 3 per cent on the d.c. ranges. The input impedance on the d.c. range is 11 megohms, and 1 megohm on the a.c. range.

The new bench-top styled IM-16 is available in kit form at £28 8s 0d or pre-assembled and tested at £35 8s 0d. Postage and packing is 6s extra.

The **Nombrex C-R 32 Test Bridge** is a neat and fairly inexpensive piece of test equipment at £10 10s that is ideal for the workshop. The three resistance ranges cover 1 ohm to 100 megohms. Capacitances of 1pF to 100μF can be measured, also in three overlapping ranges. There is provision for indication of leakage and power factor in larger values of capacitors.

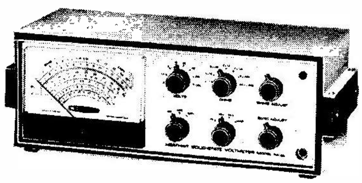
Housed in a steel case and powered by battery, the bridge has a total consumption of approximately 25mA. There is provision for external power supply by mains or battery.

Antex Ltd, announce a new pack for their 15 watt Model CN iron. The miniature iron is fitted with a $\frac{3}{32}$in bit, specially suitable for use on transistor and other miniature circuitry. The list price is 31s and is available from most component stockists.

MINIATURE MOTORS

The elimination of radio and television interference problems are two major advantages of a new range of miniature d.c. motors announced by **Impex Electrical Ltd.,** Market Road, Richmond, Surrey.

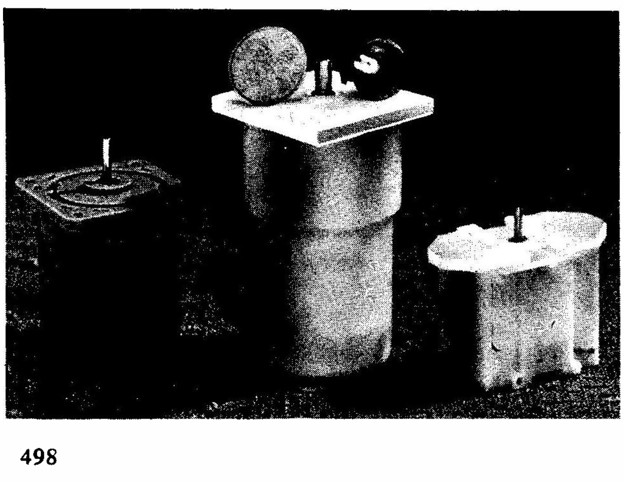
The motors, series 12005 and 12007, incorporate a transient voltage suppressor and are particularly suitable for use in servo mechanisms and radio controlled apparatus.



Heathkit IM-16 voltmeter

The 12005 motors operate from a 4V supply and produce a nominal torque of 20gcm at 3,800 r.p.m. The 12007 motors operate from 6V supply and produce a nominal torque of 30gcm at 4,000 r.p.m. Motors for use at other voltages and speeds are also available.

A modified version of the 12007 series has the advantage of an integral gear box. The gear ratios available extend from 1 : 5·5 to 1 : 729, thus allowing the designer to use a slower speed with a greater torque if required.



Miniature d.c. motors from Impex Electrical, left to right type 12007, 12007 with gearbox, and type 12005

COMPUTER TOYS

Teachers, clubs and education establishments should find the new showrooms of **Electronix Products Ltd.,** 171–175 Southampton Way, London, S.E.5, of particular interest. At the Electronix showrooms are demonstration models of their range of computer toys and teaching aids.

It is claimed that for an investment of less than £5 the binary system can be taught to a group in a week, with little or no assistance from the teacher.

LIGHTING

Suitable for controlling lamps up to 300 watt and rated at 220/250 volts a.c., the Varibrite light dimmer is British made and designed to meet British Standards specification. The control circuit is housed in a moulded body and can be fitted in place of an existing light switch.

Available from **M. & J. Supplies and Sales,** 30-40 Dalling Road, Hammersmith, W.6, the Varibrite costs 49s 6d plus 2s 6d postage and packing and is guaranteed for 12 months.

Although thyristor light dimmers are now becoming increasingly popular, it should be pointed out that they can cause electrical interference on some domestic receivers. We understand that the G.P.O. is making investigations in this respect.

TELEVISION

The first **Ultra** 19in colour television receiver, Model 6701, is an all transistor set using modular construction. Housed in a teak veneered cabinet with matching stand, model 6701 is recommended to be sold to the public at 284 guineas.

The set has push-button switching for channel selection and also includes a personal tint control for correct white balance.

AUDIO

"Fluff-free" dusters for cleaning audio and electronic equipment are now available from component and hi fi shops. Called BIB Hi-Fusters, the cloths are made from soft, highly absorbent viscose rayon material. They measure 16½in × 13in, cost 2s 6d per packet of two dusters, and are manufactured by **Multicore Solders Ltd.**

Dixons photographic shops are now expanding their range of Audio-Hi Fi Departments and will specialise in Philips and Arena ranges of audio equipment.

COLOUR FILMS

The manufacture of Mullard ColourScreen picture tubes for colour television receivers is the subject of a new film which has just been released by **Mullard Ltd.**, and added to the company's film library.

Available on free loan and entitled "It's The Tube That Makes The Colour", the 16mm film runs for 19 minutes and, appropriately, is in colour. The aim of the film is to show in detail the theory and immense amount of skill and care which goes into the production of these tubes.

Another 16mm film entitled "Colour Television" lasting 16 minutes is also available from Mullard's at a hire fee of £1 15s 0d per booking.

This film describes in general terms how colour television works and as such is useful to engineers studying colour television and to schools and other establishments.

All enquiries for these films should be addressed to the Mullard Film Library, Kingston Road, Merton Park, London, W.19

LITERATURE

The 1968 edition of the **Mullard** Data Book embraces the complete ranges of the company's current production valves, tubes, semi-conductors, and components for entertainment applications. One of the features of this edition is the use of colour coded sections.

Comparables are listed in the semi-conductor section, equivalents and earlier types in the valve section and replacements in the picture tube section. The book also contains a list of symbols and abbreviations.

The Data Book is available, for the first time, through retailers to any reader at a recommended price of 3s 6d per copy.

Now available from **Motorola Semiconductors Ltd.**, Technical Information Centre, York House, Empire Way, Wembley, Middlesex, is a series of seven selection guides covering a wide range of their products.

The series covers Zener diodes and temperature compensated reference diodes; silicon power transistors; Unibloc plastic silicon annular transistors; silicon power rectifier assemblies; Unibloc plastic small-signal transistors; germanium *pnp* power transistors; thyristor products.

Also just published by Motorola is a new Zener Diode Handbook. The handbook has been compiled to give circuit designers all the necessary data for the use of Zener components in circuit designs.

Chapters include information on Zener diode theory, production, techniques, reliability considerations for the designer, Zener characteristics, applications, and a cross reference selector guide for Zeners.

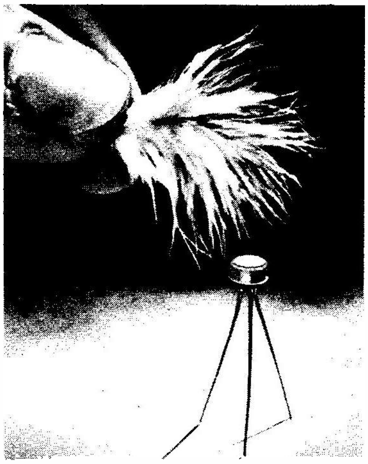
Over 2,000 equivalents are listed in the **English Electric** 1968 Equivalents Index. It contains no technical data but simply lists equivalents or replacements to various manufacturers. Service type numbers are also given.

Copies can be obtained free from English Electric Valve Co. Ltd., Chelmsford, Essex. All requests for copies must be accompanied by a stamped addressed envelope.

Colour television valves and tubes are included for the first time in the **Mazda** 1968 Data Booklet just published.

The booklet contains 168 pages and has sections on current, obsolescent and obsolete valves and cathode ray tubes, and an equivalents section.

Copies can be obtained from Mazda Publicity Department, Thorn-AEI Radio Valves and Tubes Ltd., 7 Soho Square, London, W.1.



Pitran pressure sensitive transistor from Guest Electronics

EXPERIMENTAL DEVICES

Two items mainly for professional readers and educational institutes are the latest products from **Plessey** and **Guest Electronics.**

The Plessey Fluidic Experimenters Kit has been developed for laboratory, research, and design engineers. The kit enables engineers to familiarise themselves in this fairly new and fast developing field of fluidics, and to construct and test prototype systems using standard Plessey devices.

The kit comprises 20 logic elements, six digital indicators, four proximity detectors, a pressure gauge, an electropneumatic relay transducer, two variable restrictors and a variety of mounting and connecting units. These include three manifolds or large diameter tubes, each with a row of nozzles which provide both the (air) power supply and a push fit mounting facility for up to 12 logic elements.

Also supplied with the kit is a 38-page handbook containing sections on the principles of fluidics, the meanings of logic terms and graphical symbols, and the basics of Boolean algebra. The major part of the handbook is devoted to 11 experiments.

For educational purposes the kit is ideal in that the fluidic elements, unlike electronic devices, are transparent and the student can see exactly what is happening at all stages.

The Plessey Fluidic Experimenters Kit is available from the Industrial and Electronic Components Division, Plessey Components Group, Ilford, price £98 10s.

The Pitran pressure sensitive transistor available through Guest Electronics Ltd., is a miniature solid state device for converting forces and pressures into electrical pulses or signals.

The device functions in the same manner as a conventional transistor and can be biased in almost any way an ordinary *npn* transistor is biased.

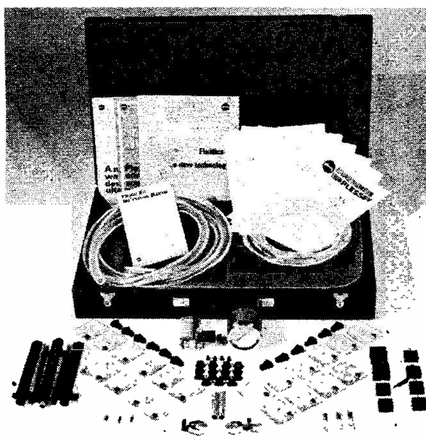
However, the device operates on an entirely different principle from conventional transducing devices. The transduction taking place at the base-emitter junction caused by a mechanical link to a diaphragm, which forms the top of a standard TO46 can. When a pressure or point force is applied to the diaphragm, a large reversible change in the transistor characteristics takes place. The device will even respond to the touch of a feather.

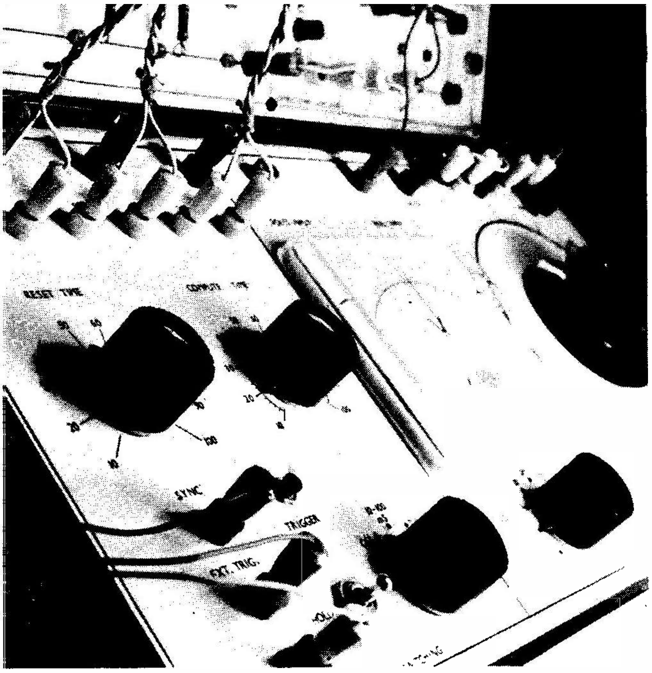
The small size makes it suitable for encasing in surfaces in contact with gases and fluids at changing pressure and velocities. It can be used in high intensity microphones of the type used to record seismic blasts.

In addition to providing a simple linear output voltage, it will amplify or switch other signals and can be used as the active element in an oscillator for direct f.m. and p.w.m. outputs.

Further details can be obtained from Guest Electronics Ltd., Nicholas House, Brigstock Road, Thornton Heath, Surrey.

Plessey Fluidic Experimenters Kit





ANALOGUE COMPUTER

PEAC

By D. BOLLEN

TO COMPLETE the construction of UNIT "B", we have now to deal with the integrator switching section, the circuit diagram for which has already been given, see Fig. 6.10.

INTEGRATOR MODE SWITCH ASSEMBLY

Cut and drill the $6\frac{1}{4}$in $\times$ $2\frac{1}{2}$in s.r.b.p. panel shown in Fig 7.1, and rivet turret tags in the positions shown. From six transistors select two with the highest current gain for TR2 and TR5. Mount all components, except range capacitors C3, C4, C7, and C8, on the s.r.b.p. panel and wire up.

Prepare the 3in $\times$ 2in relay panel, from Fig. 7.2. Fix turret tags and mount RLA and RLB reed coils. Next, insert miniature diodes D3–D14, with alternating polarities along the row of diodes, and complete underside wiring. To finish off the relay panel, place three reed switches in each coil and secure by soldering the lead out wires to appropriate turret tags.

Wooden blocks are glued to the rear of the UNIT "B" front panel to serve as mounts for switching circuit panel and relay panel (see Fig. 7.3). Note that the relay panel is fitted end-on into slots cut in its mounting blocks, and the switching circuit panel is secured by two woodscrews.

After first attaching lengths of black and white p.v.c. covered multi-strand wire to the terminals of VR18 and VR19, screw the switching circuit panel in position on its blocks, and, following Fig. 6.10 and Fig. 7.3, wire all controls and sockets to the turret tags on the two sub-assembly panels, again with p.v.c. covered flexible wire, long enough to allow the switching circuit panel to be turned over for underside inspection. Run red and blue wires from S9, and a green wire from IS/SK12, to the power pack output solder tags, and fit knobs to S9, VR18, and VR19.

SETTING UP THE INTEGRATOR SWITCH

Time intervals can be measured with fair accuracy when an operational amplifier is employed to integrate known voltages, and this method is useful for setting up the integrator switch.

Begin by temporarily soldering 8μF electrolytic capacitors in the C4 and C8 positions, with 1μF polyester capacitors for C3 and C7 (circuit Fig. 6.10).

Set VR1 and VR2 with sliders at mid-track, on the integrator switch panel.

Connect integrating switch to the operational amplifier by linking IS/SK7 to OA3/SK9, IS/SK8 to OA3/SK10, and IS/SK9 to OA3/SK4. Fit 100 kilohm computing resistor in S3/I1/SK3 and SK4. Join S3/I1/SK1 to VS1/SK2 and switch off S6. Insert a 2 kilohm reset resistor in OA3/SK5 and SK6, and join S3/SK5 to OA3/SK13.

Switch on the computer and allow a warm up period before zero setting OA3 from the back of the UNIT "A" box, by means of VR1 on the OA3 amplifier panel. Insert a 1μF computing capacitor into OA3/SK11 and SK12.

With S8 switched to "hold", S9 on the 0·1–1s range, and VR18 and VR19 rotated fully clockwise, press S7 to run the integrating amplifier through reset, compute, and hold sequence.

Listen for two clicks from the reed relays, and observe that the readout meter pointer will move close to zero. If the relays click more than twice, or not at all, adjust VR1 on the integrator switch panel.

To obtain a true zero output from the amplifier, when integrating a zero input voltage, adjust VR17 (OA3 balance control) while repeatedly pressing S7. If there is a slow drift away from zero output several seconds after S7 was last pressed, retrim VR1 on the OA3 amplifier panel.

As the gain of OA3 is set at 10 (1μF for C_t and 100 kilohm for R_{in}), an input of $-0{\cdot}9$V "gated" by the integrator switch for an interval of 1s should give rise to an amplifier output of exactly $+9$V. Switch on S6 and adjust VS1 for $-0{\cdot}9$V, monitored at S3/I1/SK2 by a voltmeter.

Now when S7 is pressed, and with VR19 still rotated fully clockwise, the readout meter reading should rise to somewhere below $+9$V and stay there.

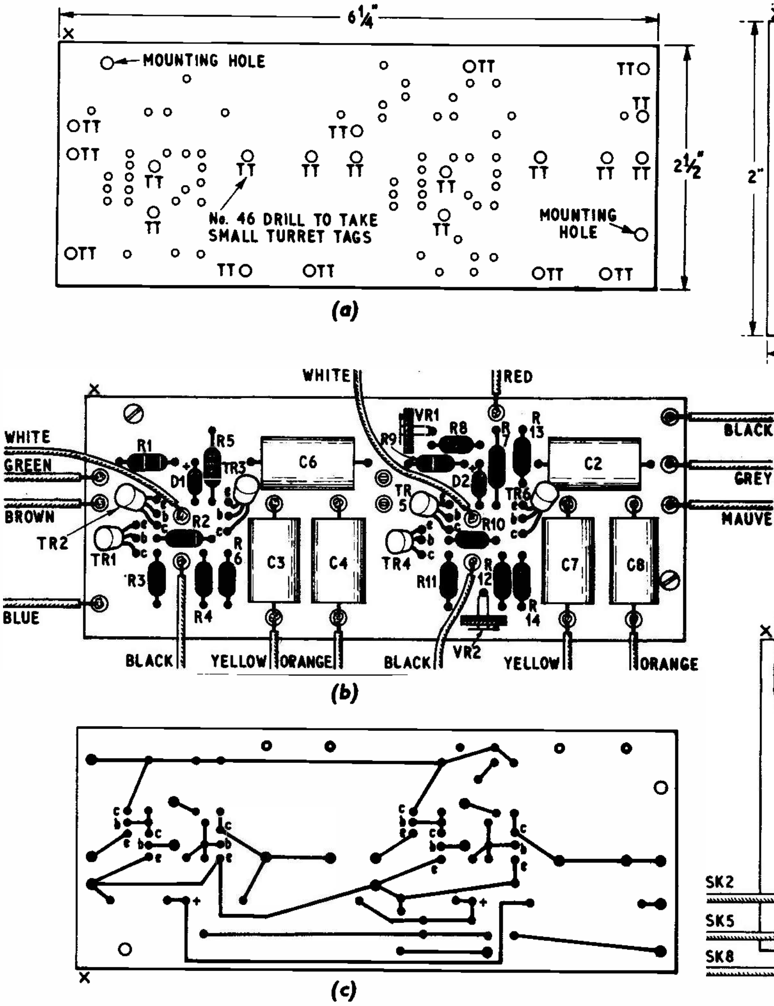


Fig. 7.1. UNIT "B" integrator switch circuit panel, (a) drilling template; (b) component arrangement; (c) underside wiring

Build up the value of C8 timing capacitor by adding more capacitors in parallel, until the +9V output is obtained when S7 is pressed.

To check the "fast" end of VR19 scale, set VS1 for −9V and rotate VR19 fully anti-clockwise. Adjust VR2 on the integrator switch panel to obtain the desired amplifier output of +9V for a compute interval of 0·1s.

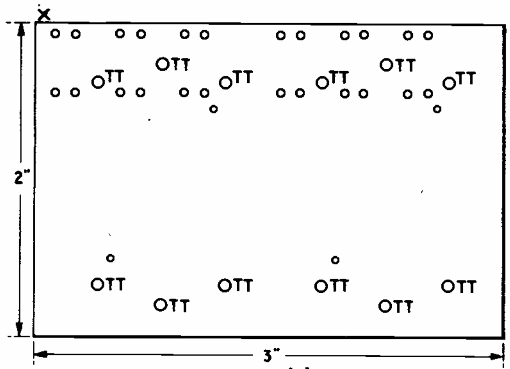
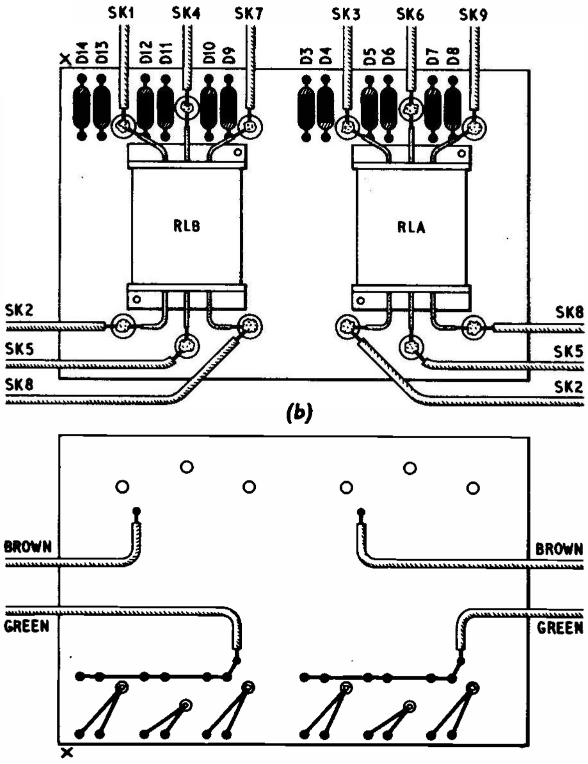
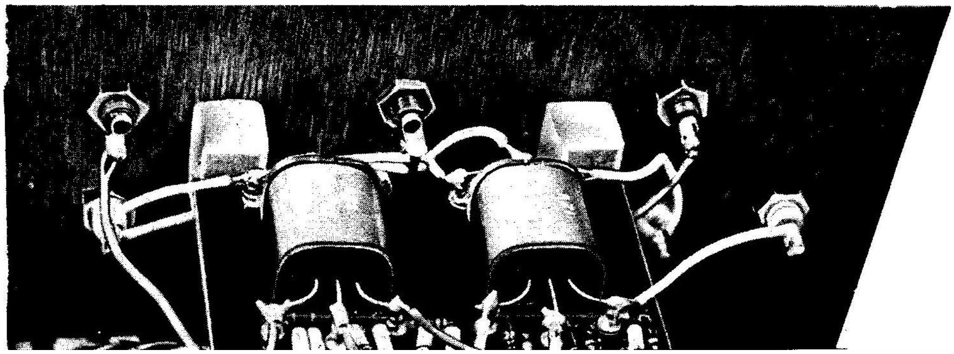


Fig. 7.2. UNIT "B" integrator switch relay panel. (a) drilling template; (b) component arrangement; (c) underside wiring





(c)

Section of UNIT "B" panel (viewed from rear) showing integrator switch relay assembly

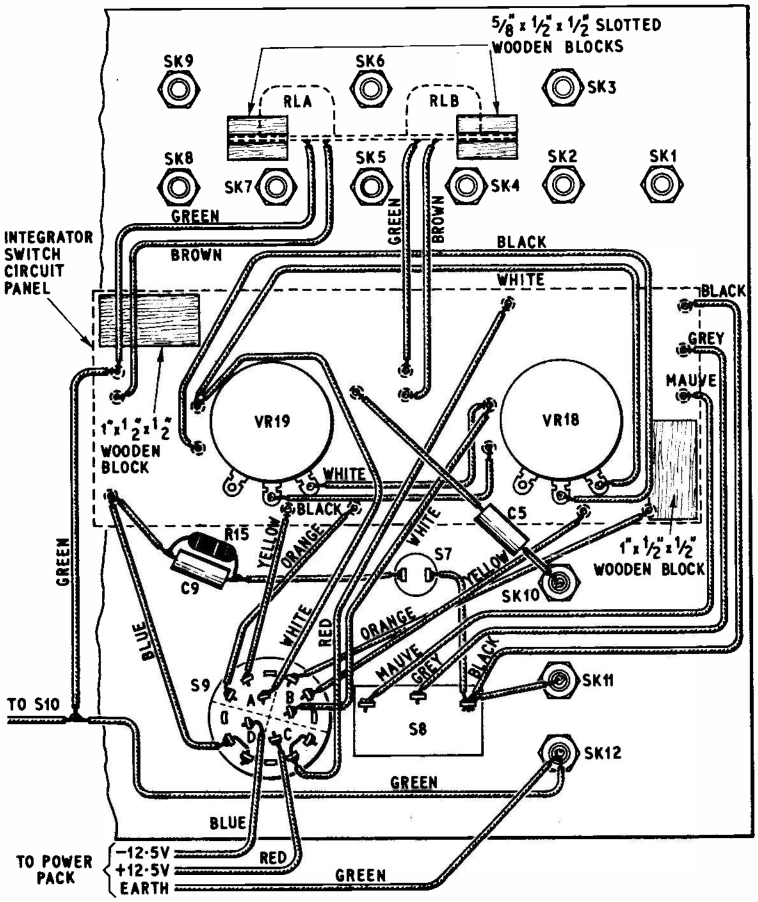


Fig. 7.3. Rear view of UNIT "B" front panel showing integrator switch wiring

CALIBRATING THE SECOND RANGE

To calibrate the 10–100ms S9 range, repeat the above procedures in just the same way, but this time use a 0·1μF capacitor for C_t in sockets OA3/SK11 and SK12, and adjust the value of timing capacitor C7 for correct compute intervals.

1st monostable timing capacitors C3 and C4 need not be precise, as VR18 has no effect on the accuracy of computations, and is mainly used to control the switch cycle frequency when integrator output waveforms are displayed by oscilloscope. Therefore, and merely for the sake of conformity, build up C3 and C4 capacitor values until the coverage of VR18 is approximately as indicated by the reset interval dial calibration.

CIRCUIT ADJUSTMENTS

The Fig 6.10 circuit should operate reliably at all switch and dial settings, with no noticeable relay bounce or overlap between the closure of reset and compute switches. However, it may be found that the integrator switch will stop running during repetitive operation, when reset and compute intervals approach 10ms, despite the fact that VR1 has already been trimmed for optimum performance. If so, try reducing the value of R8.

At the opposite extreme, if the integrator switch suddenly goes into repetitive operation when S8 is at "Hold", and VR18 and VR19 settings are near 1s, increase R8, and also try the effect of doubling the value of C1 to improve decoupling.

PROBLEM EXAMPLE 4

STRAIGHT PATH MOTION OF AN OBJECT

Problem Example 4 is primarily intended as a comprehensive introduction to the use of integrator mode switching, but the programme is sufficiently flexible to allow many experiments in dynamics to be performed.

Several factors can combine to influence the overall motion of an object, and some are shown in the ball problem of Fig. 7.4. A ball thrown vertically into the air will be subject to an initial upward velocity *iv*, retardation or negative acceleration due to gravity $-a$, and air resistance. The situation is further complicated if the ball is projected upwards from an initial height *is*, and is arrested at some height other than zero.

Ignoring for the moment air resistance, the equations which govern the motion of the ball are,

$$v = \int_0^t a\,dt + iv \qquad \text{(Eq. 7.1)}$$

and

$$s = \int_0^t v\,dt + is \qquad \text{(Eq. 7.2)}$$

Clearly, integration of a yields v, and a further integration of v will give s.

The formulae used to calculate velocity or distance when acceleration is constant are,

$$v = iv + at \qquad \text{(Eq. 7.3)}$$

and

$$s = ivt + \tfrac{1}{2}at^2 + is \qquad \text{(Eq. 7.4)}$$

Eq. 7.3 and 7.4 will not apply if, for example, acceleration is proportional to time. A discussion of the implications of variable acceleration lies outside the scope of this series, but time varying voltage analogues of acceleration are fairly easy to generate on the computer.

The drag on a body moving through air or a fluid conforms to an exponential law, and is proportional to velocity when there is little or no turbulence. Viscous friction should not be confused with the friction resulting from solid surfaces in contact, as the latter is independent of velocity except at very low speeds. A general solution to an equation which describes the motion of an object through a viscous medium—where composite velocities are involved—is often unwieldy and can demand extensive calculations.

However, an exponential decay can be set-up on the computer to simulate true viscous friction, in terms of a coefficient value μ which remains constant for all velocities. Nevertheless, as μ will be dependent on such factors as the surface area, shape, and relative smoothness of an object, it can only be determined by practical experiment, or by comparison between the computer solution and the timed motion of an actual object.

Looking at the symbolised diagram of Fig 7.5, OA1 is employed to integrate a known voltage against time, so that t can be conveniently and accurately displayed as a meter reading. OA2 integrates a to give an output v, and at the same time handles the initial velocity iv. The exponential decay $e^{-(\mu/m)t}$ is introduced by CP1. Resulting velocity v is then integrated by OA3 and initial distance is is included to give distance or height s at any time t.

Routine. Set-up the problem according to the simplified patching circuit of Fig. 7.5 but omit for the time being all C_f capacitors. The integrator switch is linked to the three operational amplifiers by connecting IS/SK1 to OA1/SK9, IS/SK2 to OA1/SK10, IS/SK3 to OA1/SK4, IS/SK4 to OA2/SK9, IS/SK5 to OA2/SK10, IS/SK6 to OA2/SK4, IS/SK7 to OA3/SK9, IS/SK8 to OA3/SK10, and IS/SK9 to OA3/SK4.

Allow the computer to warm up before zero-setting the amplifiers, also make sure that S6 is off. Using the readout meter on its 10V range, zero-set amplifier outputs (OA1/SK13, S3/I5/SK2, and OA3/SK13) by means of VR1 on each amplifier panel, from the back of the UNIT "A" box.

Next insert the C_f computing capacitors into amplifier feedback loop sockets (SK11 and SK12) and set the integrator switching controls to give reset and compute

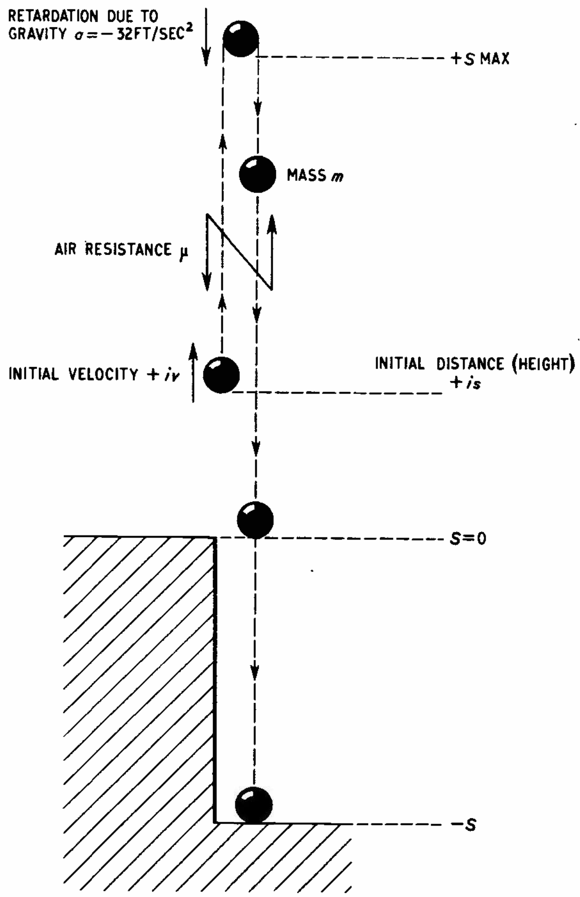
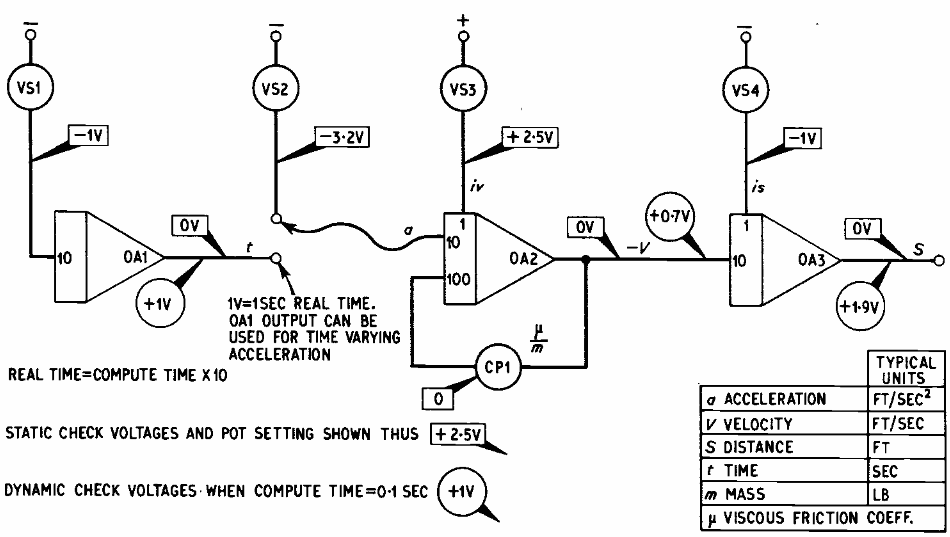


Fig. 7.4. An experiment in dynamics with a ball

times of approximately 0·1 second. Put S8 in the "hold" position. With the readout meter on its 1V range, applied to the output of OA1, press S7 and adjust VR15 for a zero voltage reading. Repeat for OA2 output and VR16, and OA3 output and VR17, in that order. The amplifiers should now be balanced for near zero input offset voltage.

Fig. 7.5. Symbolised diagram of the ball problem illustrated in Fig. 7.4.



	TYPICAL UNITS
a ACCELERATION	FT/SEC^2
V VELOCITY	FT/SEC
S DISTANCE	FT
t TIME	SEC
m MASS	LB
μ VISCOUS FRICTION COEFF.	

To enable static and dynamic checks to be made, trial values are given to the ball problem of Fig. 7.4, as follows: $t_{real} = 1$ sec, $a = -32$ft/sec^2, $iv = 25$ft/sec, $is = 10$ft, $v = -7$ft/sec, $s = 19$ft, and $\mu/m = 0$. The problem scaling is such that 1 computer volt = 10 units in all cases. For example, 1V = 1 sec for t at the output of OA1 (10 × compute time), and 1·9V = 19ft for s at OA3 output. Calculation from the formula Eq. 7.4 shows that the ball will have travelled just beyond s_{max} after a time of 1 sec, when air resistance is zero.

The next stage is to establish all computer static voltages shown in the Fig. 7.5 symbolised diagram, starting with VS1. Set the dial of the master potentiometer to "10" and patch MP/SK1 to SK4, MP/SK2 to SK3, and MP/SK5 to SK8. Connect RM/SK2 to S1/I1/SK2. Switch on S6, set switch S10 to "null" and adjust VS1 dial for a null meter reading, corresponding to a voltage source output of − 1V. Remove the null input patching lead completely, and use it to link RM/SK1 to OA1/SK13.

With the readout meter on its 1V range, press S7, and trim compute time control VR19 for an integrator output of 1V; this will ensure that the compute interval is exactly 0·1 sec. Set up VS2, VS3, and VS4 check voltages, preferably by nulling with the master potentiometer to avoid loading, and rotate CP1 fully anticlockwise. Switch off S6 and press S7 to reset the amplifiers. Check that amplifier outputs are zero.

To obtain dynamic check voltages, switch on S6 and press S7, while applying the readout meter to the outputs of OA1, OA2, and OA3 in turn. For greater convenience, three separate voltmeters can be left connected as shown in the patching circuit of Fig. 7.5 to give simultaneous readouts of t, v, and s. Before altering other problem variables, introduce air resistance by means of CP1 and arrest the travel of the ball at selected positions along its path by adjusting the compute time. It is instructive to compare the velocity and distance of the ball when $a = -32$ft/sec^2 and friction is present, with a ball projected upwards under moon gravity conditions (approximately $a = -5{\cdot}3$ft/sec^2) in a vacuum.

The existing scaling of layout Fig. 7.5 will provide the following coverage: VR2 0–±100ft/sec^2, VR3 0–±100ft/sec, VR4 0–±100ft, with amplifier outputs of OA1 0·1–10sec, OA2 0–±100ft/sec, and OA3 0–±100ft. The coefficient of CP1 covers the range 0–10 for μ/m.

If at any instant during a computer run velocity exceeds 100ft/sec, or distance is greater than 100ft, this will result in amplifier overloading, and a false problem solution. Spot checks of velocity or distance voltage trends can be made at selected compute times, using the single shot facility, and s_{max} will correspond with $v = 0$ at a particular time t. Alternatively, during repetitive integrator switching, an oscilloscope will serve to show amplifier overloads as a flattening or clipping of an output waveform, but this should not be confused with the short "hold" interval which separates the opening and closing of reset and compute switches.

RESCALING PROBLEM EXAMPLE 4

The programme of Problem Example 4 need not be confined to the vertical motion of an object in air, but could equally well apply to movement up and down an inclined plane in water, or else the horizontal progress of a fast wheeled vehicle being decelerated by braking forces, for example.

There are several ways of rescaling Problem Example 4, the most obvious being the adoption of other unit systems, such as miles/hour, centimetres/sec, or even inches/year. Providing that compatible units are employed, and computer voltages are correctly interpreted, there are no serious barriers to unit system rescaling. Probably the most straightforward way of verifying a new problem scaling is to set up a simple check problem, where known values of t, a, v, and s are computed for an object in a vacuum, to establish the relationships between static and dynamic voltages.

Where it is desired to extend the range of an existing unit system, increasing the value of computing capacitors by a factor of ten will reduce real time by ten. Similarly, a tenfold increase in real time is achieved when C_f values are divided by ten.

When employing large computing capacitors at short compute times, always ensure that the reset resistor R_r is small enough to completely discharge C_f during the reset interval. It is also possible to alter the computer voltage scaling so that, for example, 1 computer volt will equal 100 units instead of 10 units, but care should be taken to make sure that *all* voltages and potentiometer settings conform to the new scaling.

Finally, a word or two about variable acceleration. If the input to OA2 is transferred from the VS2 source to the output of OA1, acceleration will then be zero

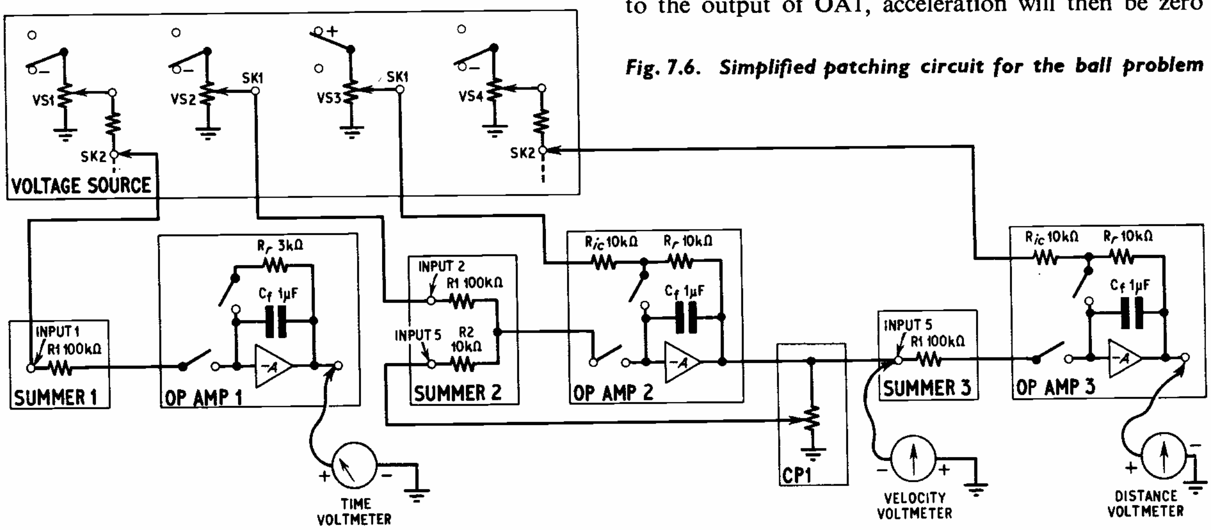


Fig. 7.6. Simplified patching circuit for the ball problem

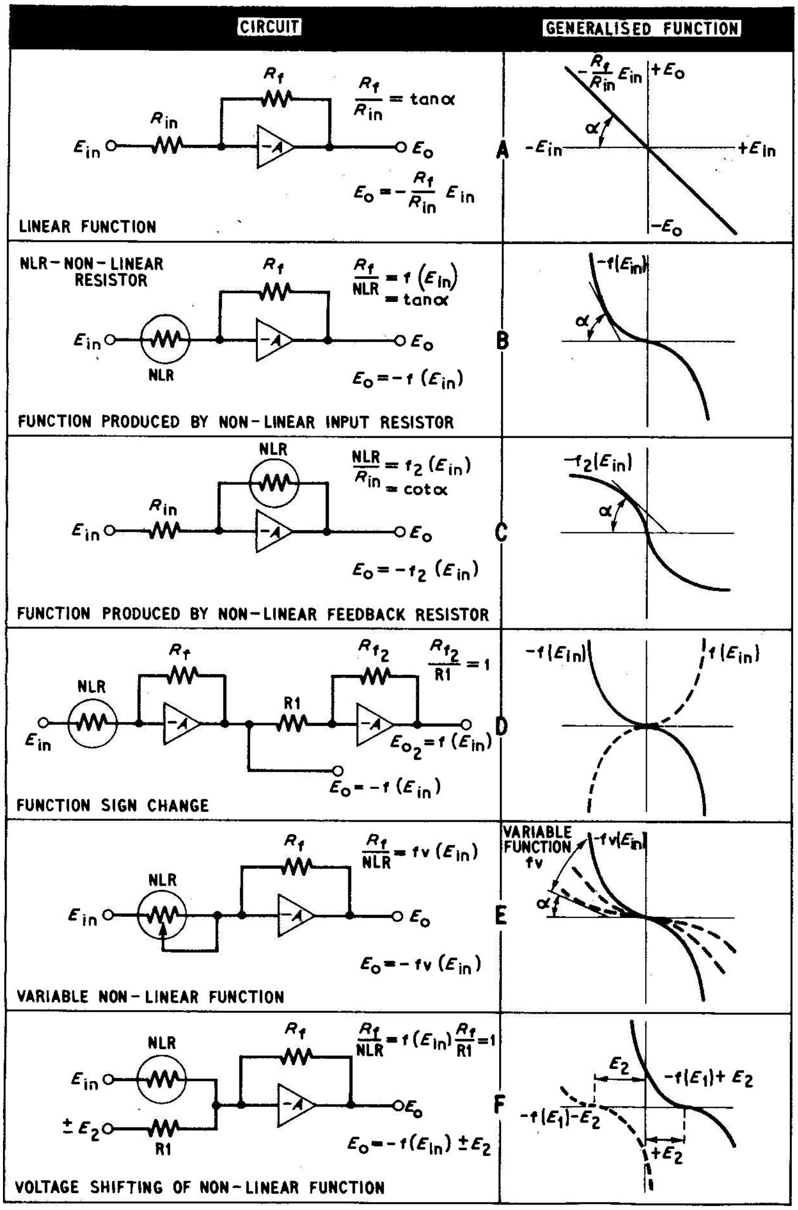


Fig. 7.7. Generating non-linear functions with a voltage dependent resistor

When employed for squaring an input voltage, with both networks operating in parallel, the function generator will accept input voltages of 0–±10V, and yields amplifier outputs of up to ±10V. Accuracy can be within 2 per cent of the indicated value, depending on the care taken in setting up a function, for input voltages between 0·2V and 9V.

NON-LINEAR FUNCTIONS

Quite often some non-linear function of an applied voltage is needed in analogue computer work, two simple instances being the square or square root of a number. An arbitrary function may also be encountered, perhaps arising from experimental data for which no analytic expression is available.

Servo driven potentiometers and circuits consisting of biased diodes are widely used for generating non-linear functions, but the latter is deservedly popular because it can be adjusted to cater for a range of functions, and does not suffer from a severely limited frequency response.

To show how a diode function generator can give rise to non-linear functions, when allied to operational amplifiers, use is made here of the parallel which exists between the discontinuous behaviour of a biased diode network, and the smooth response of a voltage dependent resistor. Both can display a fall in resistance with an increase in applied voltage.

Consider first of all the circuit and generalised curve of Fig. 7.7a. Input and feedback resistors R_{in} and R_f are not influenced by applied voltage, therefore a straight line function is generated, while amplifier gain and tan α remains constant. However, if some form of non-linear resistor, or biased diode network, is substituted for R_{in} (NLR in Fig. 7.7b) the gain of the amplifier tends to grow with an increase of E_{in}, and the tangent to the curve will vary according to some function $f(E_{in})$, arising from the characteristic of NLR. A related function $f_2(E_{in})$ results when NLR is exchanged for R_f, as in Fig. 7.7c, but here the amplifier gain falls off with an increase of E_{in}. The curves of Fig. 7.7b and Fig. 7.7c only occupy two of four possible quadrants, but four quadrant operation can be achieved if the function is inverted by a sign changing amplifier, depicted in Fig. 7.7d.

Fig. 7.7e shows how curves, of widely differing slope and magnitude, may be generated if the characteristic of NLR is alterable. Finally, any fixed function will find wider application if its $E_{in} = 0$ datum is shifted, as in Fig. 7.7f. Moreover, as a voltage shift can also be applied to the E_0 axis, it becomes a simple matter to locate any portion of a curve in any quadrant.

when $t = 0$, and increases linearly to 10ft/sec² when $t = 1$ sec real time. VS1 can be used to adjust the magnitude of a when $t > 0$. Also, if OA1 initial conditions are inserted, in a similar manner to OA2 and OA3, many other time functions of a can be generated.

UNIT "C" FUNCTION GENERATOR

UNIT "C" contains two diode-resistor networks, one for positive input voltages, and the other for negative inputs. The characteristics of each network can be adjusted separately by means of miniature pre-set potentiometers to give a wide range of possible functions, and optimum accuracy. The function generator is designed to be used in place of a normal computing resistor, at the input or in the feedback loop of an operational amplifier.

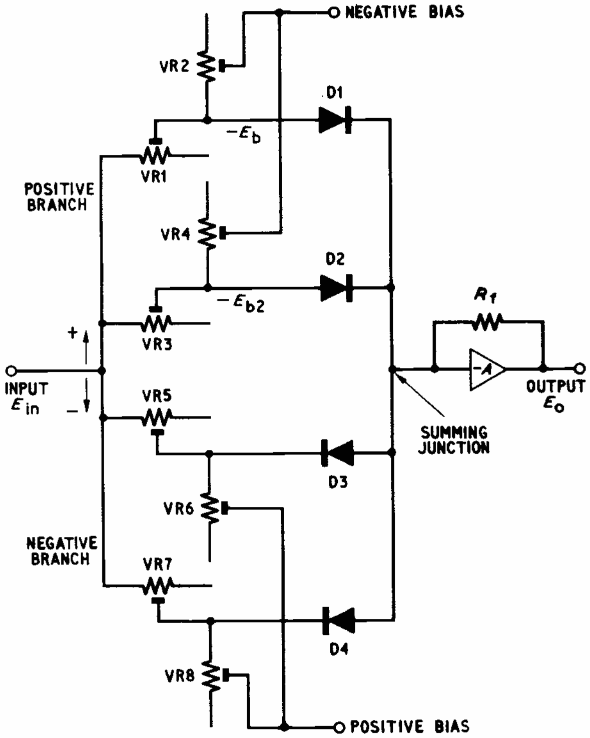
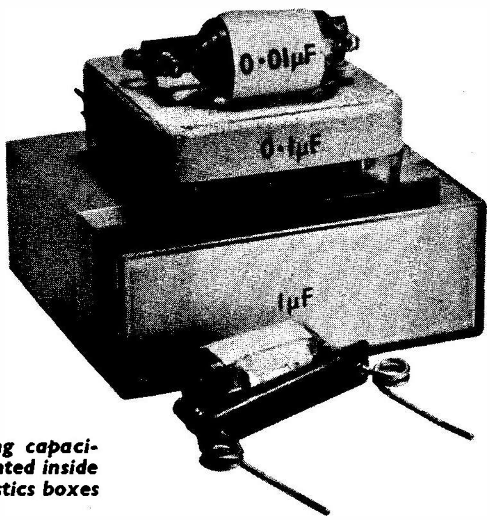


Fig. 7.8a. Circuit of a simple function generator



Computing capacitors mounted inside small plastics boxes

BIASED DIODE NETWORK

The next step is to see how biased diode networks are used to achieve an increase of resistance with applied voltage, and thus imitate the behaviour of an *ideal* voltage dependent resistor. Unfortunately, currently available silicon carbide, selenium, and copper oxide resistors are far from ideal in many respects, and are not sufficiently accurate for serious use with operational amplifiers.

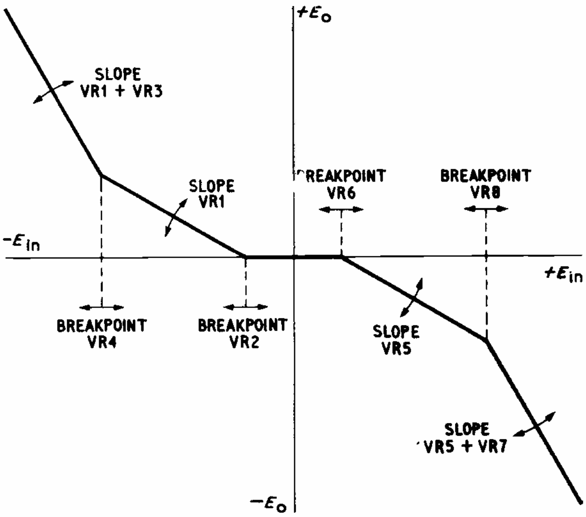


Fig. 7.8b. Adjustable characteristic of simple function generator

The UNIT "C" function generator is based on the simple circuit of Fig. 7.8a. In the absence of an input voltage all diodes are biased off, and the network can be represented by a very high value of resistance in series with the operational amplifier input, giving an amplifier gain of almost zero. If a positive voltage is gradually applied to the input terminal, there will be virtually no output until a point is reached where E_{in} is slightly larger than $-E_b$, whereupon D1 conducts and connects VR1 to the operational amplifier summing junction. Further increase of E_{in}, beyond $-E_b$, will produce a straight line output of slope determined by the amplifier gain R_f/VR1.

When E_{in} reaches approximately the level of $-E_{b2}$, D2 conducts and places VR3 in parallel with VR1, thus reducing even more the effective resistance of the network. It can be easily imagined that where a number of diodes and variable resistances are cascaded, the resistance of the network will continue to fall as E_{in} becomes larger still.

Bias voltage $-E_b$ is determined by the relative resistances of VR1 and VR2, and the same applies to $-E_{b2}$, VR3 and VR4. Furthermore, the setting of VR1 will obviously affect the combined slope of VR1 and VR3 (see Fig. 7.8b), and it follows that all the resistance settings associated with D1 and D2 must be interrelated.

Considerations applying to the positive branch of circuit Fig. 7.8a are also pertinent to the negative branch formed by D3 and D4, and VR5–VR8, except that input and bias voltage polarities are reversed. There is no interaction between the resistance settings of the positive branch and the negative branch, and the two can be separated when required for independent use.

The output characteristic curve of Fig. 7.8b identifies slopes and breakpoints with VR1–VR8. As there are only two diodes in each branch, the result is a very rough approximation to a smooth curve. Generally speaking, the accuracy of a diode function generator is proportional to the number of diodes employed, but a natural rounding at the junction of straight lines does occur at low input voltage levels, due to the dynamic resistance of the diodes (not shown in Fig. 7.8b), so the deviation from a smooth curve is not as great as might be expected. Commercial diode function generators sometimes use more than 20 diodes to achieve accuracies of better than 1 per cent.

Next month: Construction of UNIT "C" and some practical applications of this Function Generator.

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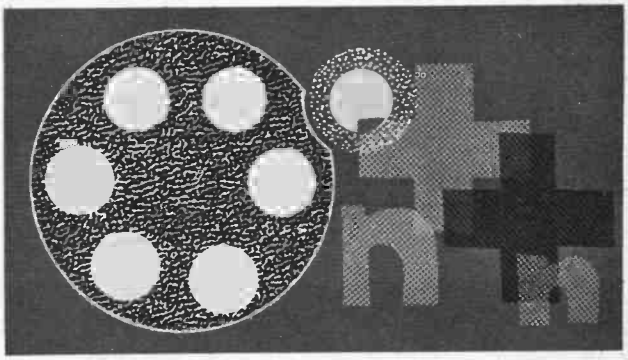

By M.L. Michaelis M.A.

9—PROGRAMME CONTROL CIRCUITS

The programme control section is a vital part of any computer system, whatever its function may be. In computers for arithmetical or other mathematical functions, the programme control section stores the commands for and coordinates the execution of the individual steps of a complex calculation.

A nucleonic equipment may be called upon to deal with numerous radioactive samples in succession, simultaneously or in groups, and it will possess one or more radiation meter channels for the purpose. Where more than one radiation meter channel is running simultaneously, the programme control section must also coordinate the readout of these channels within the logical framework of the experiment.

We find that the programme control circuits take such varied forms, according to the nature and purpose of a particular equipment, that it is particularly difficult to compose a general treatment. We must therefore rely more than ever on the practical example of our STRACE equipment, but in describing this, we will underline those aspects which bear more general implications.

THE MASTER TIMEBASE

A programme for a computer is the coordination of a sequence of functions according to a *time schedule*. The heart of any programme control section is thus a *master timebase* which defines the basic time units for the successive operational steps.

Various forms of timebases are found. High-speed digital computers for arithmetical operations usually employ crystal-controlled oscillators. Other systems may use a synchronous mains motor with suitable gearing and cam-driven switches.

In principle, any simple free-running oscillator may be used as timebase, provided its frequency stability is adequate for the intended functions of the equipment. The function of the master timebase is always to mark out equal intervals of time corresponding to the shortest programme step in the equipment. The master timebase frequency is thus equal to the reciprocal of the shortest programme step period. In the STRACE equipment, the shortest programme step takes 50 seconds, so that the master timebase runs at 0·02Hz. A simple free-running multivibrator is used here. Fig. 9.1 shows the circuit, which is tolerant of any convenient layout and may be constructed on a small piece of veroboard. Any silicon *npn* transistor type is suitable for all three positions, as long as the current gain is at least 30, and the maximum dissipation rating without cooling fin at least 750mW for TR3. D1 is a small 10V Zener diode rated for at least 150mW dissipation. D2 is any silicon l.t. rectifier of the 0·5A class.

This circuit possesses extremely good long-term frequency stability, by virtue of the supply voltage stabilisation with D1 and the good stability of silicon transistors. The time for which TR1 is cut off and TR2 conducting is determined by R1/C2 and is about 49 seconds. The time for which TR1 is conducting and TR2 is cut off, is determined by R4/C1, and is about one second. During this brief one second interval, the voltage at the collector of TR2 rises to 10V, so that TR3 is made to conduct heavily, causing the timebase relay RLA to energise. The master timebase thus causes the (two) contacts of a relay to close briefly for about one second, once every 50 seconds.

THE PROGRAMME LOGIC

After the master timebase, the most important part of a programme control circuit is the programme logic. Not all steps of a composite programme will be of the same length. Some require only one basic time unit, whilst others require several basic time units. One function of the programme logic is thus to count-down from the master timebase, in order to derive the various required multiple time units.

In general, the count-down process must be carried out digitally, since it is not possible to prevent free-running analogue systems from getting out of step. When synchronisation is applied, the analogue system amounts to a digital one.

In our STRACE equipment, we happen to require two multiple time units, viz. 400 second and 800 second intervals, in addition to the basic interval of 50 seconds from the timebase. The programme logic circuit (Fig. 9.2) thus contains a chain of three binary counters producing an output (brief energising of relay RLA in Fig. 9.2) only for every eighth (2 × 2 × 2) input pulse to TR1 from the master timebase. A fourth binary stage provides another output (brief energising of relay RLB in Fig. 9.2) for only every second appearance of the first output, i.e. for only every sixteenth input pulse from the master timebase. RLA and RLB thus energise briefly once every 400 and 800 seconds respectively, and since the count-down is effected digitally, these multiple periods remain rigidly in step with each other and with the master timebase.

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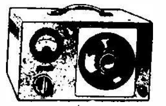

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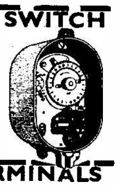

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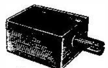

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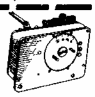

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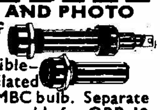

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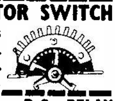

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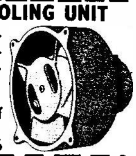

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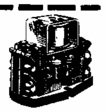

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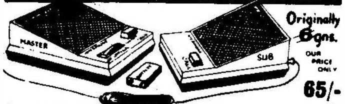

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SWITCHING METER AND RECORDER

The second function of a programme logic circuit, speaking quite generally, is the correct coordination of the multiple time intervals, which in turn determines the correct sequence of events in the controlled computer circuits. In the STRACE equipment, the 400 second intervals are used to switch the meter and chart recorder back and forth between the two rate-meter channels. Thus each channel is read-out and recorded alternately for 400 seconds.

Each time RLA in Fig. 9.2 energises briefly, the meter and recorder are connected to the other channel. For reasons explained below, each complete cycle of 16 master timebase steps (800 seconds) must commence with the meter and recorder on channel 2 for the first 400 seconds, followed by channel 1 for the last 400 seconds. After 16 pulses from the master timebase, the relays energise briefly simultaneously; RLA connects the meter to channel 2, and RLB feeds out a pulse to the scanner of the gamma ray spectrometer unit, to move it to the next energy step.

These correlations are obtained if the binary stages are set to zero before switch-on, i.e. if they are set to the state requiring eight subsequent pulses before RLA energises and 16 pulses before RLB energises. Furthermore, an additional pulse must be fed straight through to RLA if, *and only if*, the meter and recorder happen to be on channel 1 at the moment of switch-on.

CORRELATION WITH MOTOR SUPPLY

The moment of switch-on is logically the moment at which the chart-recorder motor is switched on. Thus the correlation functions are combined with the mains switch for the chart recorder motor. A resting contact of this switch in the "motor off" position holds tags D and E of Fig. 9.2 shorted together, so that the positive supply voltage is fed via R44 and respective resistors and diodes, to all four binary stages as rest voltage. This holds the counter in the zero state indefinitely. When the chart recorder motor is switched on, this contact opens and the counter can run.

A further contact on the same switch connects a capacitor over to tag N. This capacitor is charged if, and only if, the meter and recorder happened to be connected to channel 1, so that the charged capacitor then feeds one pulse to TR12, causing RLA to energise briefly at once and throw the meter correctly to channel 2. If it already happened to be on channel 2, it stays there, because the capacitor connected to tag N is then not charged. The normal channel changeover pulses energising RLA once every 400 seconds, are fed from the last of the three binary stages, via C25, to the other driver TR13.

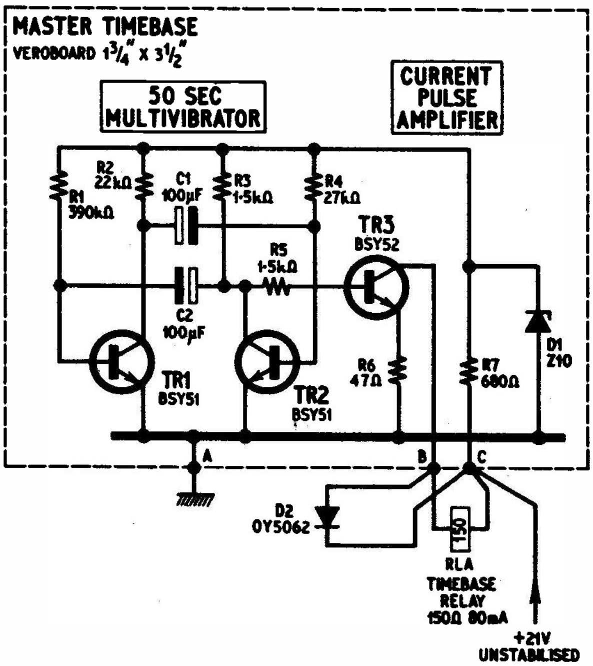

Fig. 9.1. STRACE RADIATION METER: circuit diagram of the master timebase (programme control)

LOGIC CIRCUIT DETAILS

Whilst the particular circuit of Fig. 9.2 is certainly specific to the STRACE equipment, the methods are of quite general validity. Large professional equipments may use numerous binary or decimal counting stages to derive a large number of different multiple time units, each with its own relay amplifier, or purely electronic output amplifier with switch transistors in high-speed circuits. In addition, a complex system of set drivers will be required, to bring the circuits to a definite state at the outset, or to various combinations of states according to alternative available programmes.

The actual circuit bricks used in Fig. 9.2 are also quite typical of such circuits in general, although they certainly do not exhaust all possibilities for realising these logical functions with practical circuits.

Five basic circuits are here involved, viz. a *Schmitt trigger*, several *drivers*, several *binary counters*, two *univibrators* and two *pulse switches* as relay output stages.

THE SCHMITT TRIGGER

The Schmitt trigger stage employs TR1 and TR2. It is a threshold switch. With no input voltage to TR1 base, this transistor rests permanently cut off, and TR2 rests conducting. As soon as a positive voltage applied to TR1 base exceeds a certain threshold value, the two transistors *abruptly* change over their roles, with TR1 then conducting the TR2 cut off. A sharp *negative* pulse thereby appears TR2 emitter.

The new state of the circuit persists until the input at TR1 base drops back below the threshold. A sharp positive pulse thereby appears at TR2 emitter.

An important feature of the circuit is that it is immaterial how rapidly or slowly the input threshold is exceeded, i.e. a slowly rising or falling d.c. input voltage is equally effective.

The Schmitt trigger is clearly a very effective amplitude discriminator, and is often used as such in kick-sorter amplifiers, as a further alternative to the circuits already discussed. It is also useful for regenerating sharp pulses where the input pulses have become distorted or rounded-off, e.g. after passing through lengthy cables.

The function here in Fig. 9.2 is to suppress relay contact rebounds, which would otherwise lead to spurious multiple counts. The input once every 50 seconds from the master timebase consists of brief shorting together of tags B and C of Fig. 9.2 by a timebase relay contact. C1 then charges via R1, at a rate slow compared to the time of closing of the relay contacts, so that even if contact rebounds take place, the voltage is applied only once and slowly to TR1 base.

But the binary counter stages require sharp pulses. The Schmitt trigger regenerates a single sharp pulse from each slow positive rise at TR1 base.

THE DRIVERS

Drivers are simply impedance step-down stages, for feeding subsequent circuits requiring more current or power than the signal source can provide directly. At the same time, they provide decoupling, i.e. they function as buffer stages. All the drivers in Fig. 9.2 except TR12 are emitter followers, although this is not imperative in general. Any amplifier stage with power gain can serve as a driver.

The negative pulse produced by the Schmitt trigger when the positive input voltage appears, is fed via the driver TR3 to the first binary stage TR4, TR5. The positive pulse from the Schmitt trigger when the timebase relay drops off again and C1 discharges back below the threshold, is removed by D3.

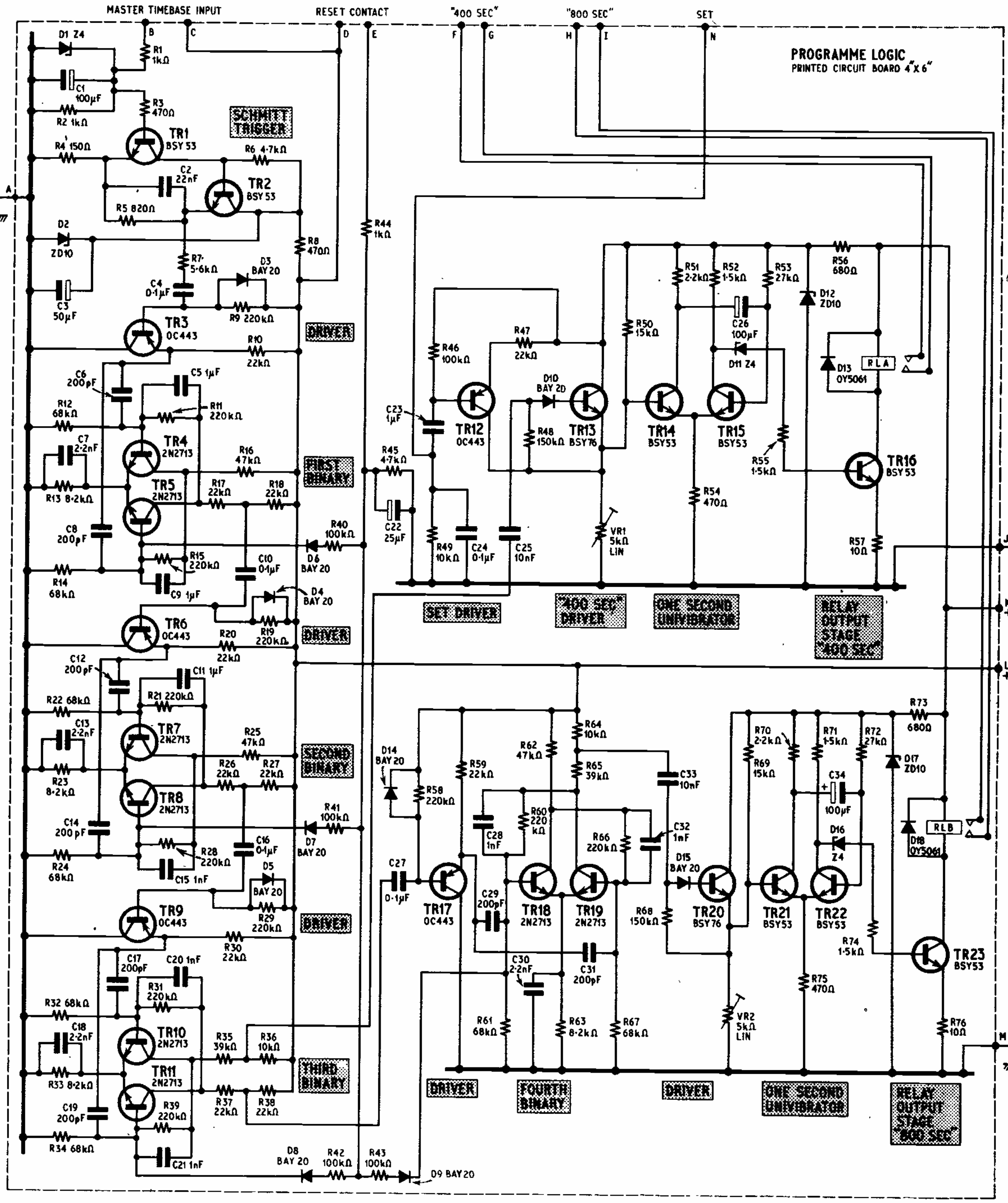

Fig. 9.2. **STRACE RADIATION METER:** *circuit diagram of the programme logic section*

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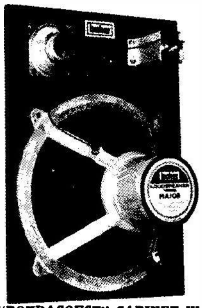

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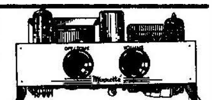

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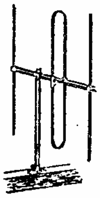

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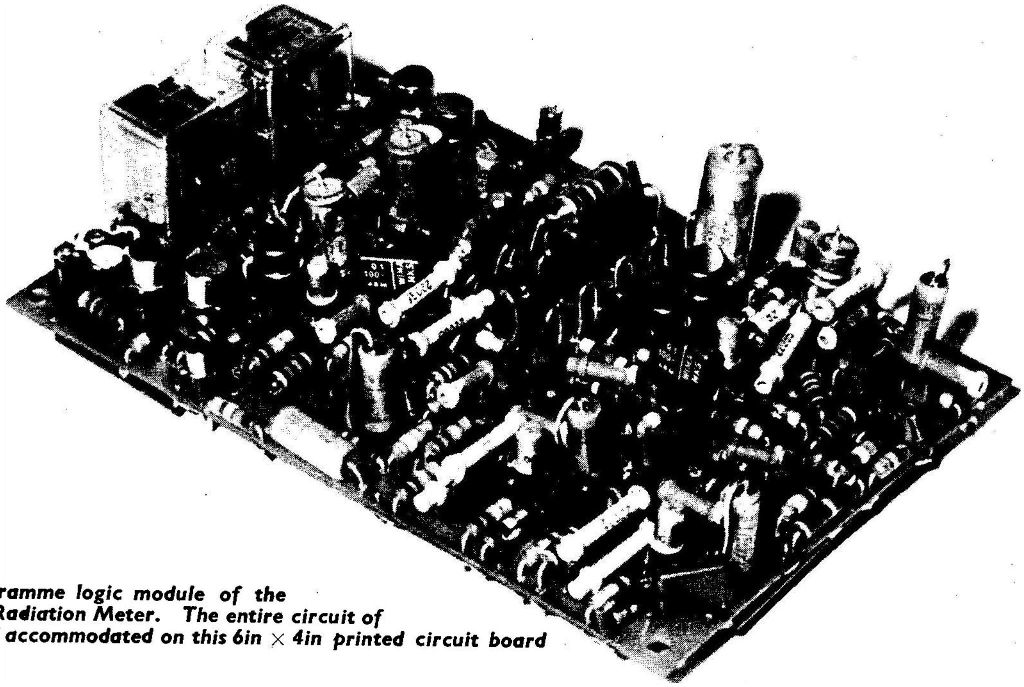

The programme logic module of the STRACE Radiation Meter. The entire circuit of Fig. 9.2. is accommodated on this 6in × 4in printed circuit board

Similarly for the drivers TR6, TR9, TR17 between the successive binary stages; these feed the negative pulses from the respective binary stage collectors to the next binary stage, whereas the respective diodes D4, D5, D14 remove the positive pulses on the other phase.

THE BINARY STAGES

The four binary stages are all identical in principle. We will consider the first one, TR4, TR5.

The complete symmetry and d.c.-coupling of the two transistors gives the circuit two stable states, which can each be maintained for any length of time, until a suitable disturbance arrives to throw the circuit into the other stable state.

At the outset, the circuit is unambiguously held in the state with TR5 conducting and TR4 cut off due to the low collector potential of TR5. TR5 is held conducting by the positive voltage fed in via the reset contact D, E, R44 and R40/D6.

When the reset contact is opened, this state persists until a negative pulse arrives from the driver TR3. This cuts-off TR5 via C8. The resulting rise of collector voltage of TR5 then cuts-on TR4 via C5, whereafter the new state persists, with TR4 now conducting and TR5 cut off. The positive pulse from TR5 collector was suppressed by D4, as far as the next driver TR6 was concerned, so that the pulse is not fed to the next stage.

The second negative pulse from the driver TR3 now cuts-off TR4 via C6, so that TR5 is cut-on again via C9. The resulting negative pulse from TR5 collector circuit is now fed via C10 and the driver TR6 to the next binary stage. Thus only every second pulse is passed on to the next stage.

Only every eighth original input pulse reaches the third binary stage TR10/TR11 such that a positive pulse appears in TR10 collector circuit and a negative pulse simultaneously in TR11 collector circuit. The former drives the 400 second relay circuit, and the latter the fourth binary circuit, which in turn produces a positive pulse in TR19 collector circuit every alternate time, for driving the 800 second relay circuit.

DIGITAL COUNTING OF PULSES

Binary stages may be used in very similar arrangements for counting the radiation detector pulses. Thus if an electromechanical counter mechanism can not respond faster than 25Hz, pulse frequencies of 50Hz can be handled if one binary stage is interposed between the radiation detector and the counter circuit. If four binary stages are interposed, pulse frequencies of up to 400Hz can be handled by the same counter mechanism, since they are scaled down to 25Hz.

Various arrangements of pulse feedback between successive binary stages permit scaling to powers of ten instead of powers of two, if required. Special ten-cathode neon tubes, or cathode ray tubes with ten stable positions of the electron beam, and a number of other special devices are also available for decimal scaling. These give their own luminous indication of intermediate counts, whereas resistor networks and neon lamps must be used to sense and display the intermediate count states of a binary counter chain.

All these types of circuits are found in radiation meters which operate digitally. It is easy to see that overall circuit complexity rapidly becomes much greater than that of ratemeter circuits, if fast digital counting rates are required. A ratemeter (analogue) circuit does not increase in complexity for faster counting rates.

THE UNIVIBRATORS

The Univibrators TR14/TR15 and TR21/TR22 respectively in Fig. 9.2, are once again merely pulse expanders, of the kind we have already met in the kick-sorter amplifier and pip generators.

Considering the first one, this rests normally with TR14 cut off and TR15 conducting. A positive pulse from the driver TR12 or TR13 causes TR14 to conduct and TR15 to cut off. This new state persists for about one second, determined by C26/R53. Thereafter, the circuit returns of its own accord to the original state. The collector potential of TR15 is thus large positive for about one second each time.

THE PULSE SWITCHES

TR16 is thereby turned-on hard via D10 and R55, causing relay RLA to energise for one second and close its contact F,G for this duration. The pulse switches TR16 and TR23 are simply Class C current amplifier stages.

Next month: The overall programme control circuit, the facilities provided, and some hints concerning operational use.

BOOK REVIEWS

AMATEUR RADIO CIRCUITS BOOK

Compiled by G. R. Jessop
Published by the Radio Society of Great Britain
120 pages, 8¾ in × 5 in. Price 10s 6d

ALTHOUGH intended primarily for the transmitting amateur or short wave listener, the latest edition of this very popular work contains a number of circuits of general interest.

In addition to practical circuits for receiver pre-amplifiers (five alternatives), converters (14), and transmitter modulators (16)—to mention a few—there is a section on test equipment which includes a.f. and r.f. signal generators and wobbulators, CR bridges, and valve voltmeters. Also useful outside the "ham" field are a speech compressor and a variety of voice-operated switches.

Circuit description is kept to an absolute minimum, but component values and details for winding coils, etc. are included in all cases. Valve designs outnumber transistor by about two to one. H.E.O.

INSTRUMENTS ELECTRONICS AUTOMATION PURCHASING DIRECTORY 1968

Prepared by the publishers of *Instrument Review, Electronic Engineering*, and *Control*
Published by Morgan Bros. Ltd.
708 pages, 11¾in × 9in. Price £5

PREVIOUSLY published as *IEA Year Book and Buyers Guide*, this fourth edition incorporates many changes—and now has a new and more apt title.

This is a comprehensive reference to British manufacturers of electronic components and equipment, instruments, and other related products. It is sure to find its way into the purchasing departments of businesses and official organisations whose responsibilities include the specifying and ordering of such equipment or components.

Obviously this is not the kind of book P.E. readers in general will rush to buy. But *in particular*, it will be of interest to those whose employment brings them into the above mentioned areas of activity, and this must also include members of the teaching profession concerned with scientific projects. Apart from these special cases, the general reader of this magazine will at least be interested to know that such a work of reference exists, and he will doubtless be able to gain access to a copy at his local reference libary, if ever the need arises.

The main body of this volume consists of the Buyers Guide containing over 4,800 product headings; under each are listed firms that make or market such items. A simple coding system differentiates between various sub-divisions of the main category wherever appropriate. The indexing and cross referencing is well organised and clear, although one could indulge in a few minor quibbles. For example, why are transistors listed under "Valves, Semiconductors" (following "Valves, Gas and Liquid")? Strange, since rectifiers (truly *valves!*) are listed as such, separately. Such an important component as the transistor deserves entry under its own name or, at least, under "Semiconductors."

Other sections directly related to the Buyers Guide include Manufacturers' Addresses, Trade Names, and Illustrated Products—a collection of manufacturers' advertisements providing a useful expansion of the bare facts listed elsewhere.

There are also the following supporting features: Associations Addresses (the I.E.E.T.E. is listed, but not the S.E.R.T.; likewise, the R.S.G.B., but not the E.O.C.S.); Who's Who in the industry; and Who Buys—persons responsible for supplies in U.K. Public Services. The final section, Equipment Surveys, covers 14 different kinds of equipment (e.g. analogue computers, microelectronics, hygrometers) with tabulated technical data enabling immediate comparison to be made between various products.

D.D.R.

TAPE RECORDING

By C. N. G. Mathews
Published by Museum Press Ltd.
128 pages, 8¾in × 5½in. Price 20s

THIS is an informative little book which touches on most aspects of tape recording and which requires scant preknowledge of physics or electronics to understand, and as such it serves adequately to instruct any enthusiastic tyro both in the principles and practise of his intended hobby.

From preliminary chapters on sound and its recording, a functional understanding of the recorder is realised through chapters on the recording and reproduction processes. Here magnetism basics and the operational relationship between tape and heads is examined in considerable detail. There is also an interesting evaluation of simple equalisation circuits as encountered in record/playback amplifiers.

A chapter on microphones and loudspeakers makes no mention of two important electrical characteristics, namely sensitivity and output impedance, in its outlines of microphone types.

The remaining half of the book is devoted in the main, to a practical appreciation of the capabilities of a tape recorder and examples are given of converting a short story into a play, with dialogue interspersed with suitable effects, and of production techniques employed in the recording of debates and dramatic productions. The mechanics of tape editing and splicing is also explained.

A penultimate chapter on recorder servicing provided a chuckle, for under a sub-heading "Valve Troubles" one reads—"Another common valve fault is microphony.—Then the valve acts as a microphone and you get anything from a continuous howl to a 'pong' every time your cat shakes his whiskers."—That's one fault that should be a "stinker" to troubleshoot.

G.G.

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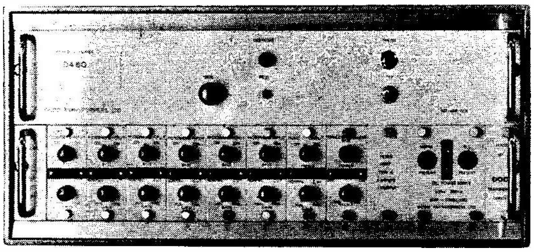

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Amplifier chassis size 19 in. x 3½ in. front panel x 8½ in. deep.

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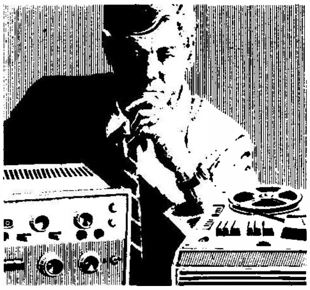

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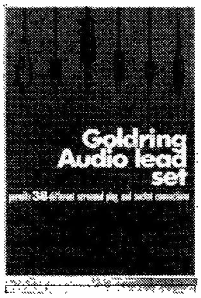

*Goldring are now marketing an extremely useful range of individually packed leads, plugs, sockets and connections for audio enthusiasts.

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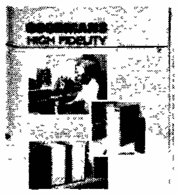
GOODMANS HIGH FIDELITY MANUAL



A Guide to full listening enjoyment

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Full specifications of the Maxamp 30 and Stereomax are given in the High Fidelity Manual—send the coupon for your FREE copy—or pay an early visit to your Goodmans dealer.

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PICK-UPS: THE KEY TO Hi-Fi

By J. Walton
Published by Sir Isaac Pitman & Sons Ltd.
102 pages, $7\frac{1}{4}$in × $4\frac{3}{4}$in. Price 12s 6d

CHOOSING a gramophone pick-up can be a hazardous affair. And yet so much depends upon the ultimate choice, not only the quality of reproduction obtained, but the treatment given to the record during the process of playing. Damage or distortion induced at this stage is irrevocable. The lesson is obvious—learn precisely what is expected of a pick-up and what mechanical problems are involved in the translation of the groove modulation into an electrical impulse, and *then* look around at the devices offered on the market and choose with knowledge and discrimination. Manufacturers' literature does not always give the most important criteria, and the non-technical or semi-technical enthusiast is well advised to study J. Walton's excellent little book for authoritative guidance on the subject.

This is the second edition of a work which has been widely acclaimed by hi-fi enthusiasts. The text is supported by clear diagrams and there are a number of electron micrographs which graphically demonstrate the damage and other ill effects that can be caused to a record groove under certain abnormal playing conditions.

Purchase of this book may well prove to be a small investment providing ample dividends in well preserved records capable of giving hundreds of top quality performances.

D.D.R.

DRILL SPEED CONTROLLER

continued from page 492

similar to a two-stroke motor-cycle engine! This intermittent running is known as "skip cycling" and can be explained as follows.

At very low speeds an impulse of energy at the end of one positive half-cycle, as explained above, causes the motor to speed up slightly; thus its back e.m.f. rises and during the next few positive half-cycles, no power is required to maintain speed. Hence the thyristor does not trigger and the motor free-wheels until the speed drops low enough to allow the thyristor to fire again. No harm will come to the motor as a result and in fact as soon as a load is applied the automatic feedback circuit will ensure that energy is applied at each cycle.

OTHER APPLICATIONS

When you have made and used the controller you will doubtless wonder how you ever used an electric drill without one! You may also be tempted to use the controller on electrical devices other than a drill. This is in order provided several factors are borne in mind:

1. The output of the controller is pulsating direct current. It is therefore unsuitable for equipment fed via a mains transformer.
2. Only brush motors can have their speed controlled in the way described.
3. The thyristor used is rated at 3A. This limits the upper power rating to 750 watts.
4. The load compensating circuit functions only when a motor is in use.

With these factors in mind, it can be seen that lamps, low power heaters, etc. can also be controlled in a very efficient manner. ★

Readout—
A SELECTION FROM OUR POSTBAG

No future?

Sir—I regret to tell D. Watts (Readout, May 1968) that his system for *Cine and Tape Sync* will not work, for the following two reasons:

(1) Unless he achieves perfection the projector and tape recorder can still run at very slightly different speeds; under these conditions the error signal would be too small to trigger the thyristor.

(2) Each time a speed difference occurs the error signal can only correct the speeds—it will not *restore* the synchronisation that has slipped; this is analogous to the loop in a sound projector being the wrong size—although the film passes the gate and the sound pick-up at the same speed, there is a lack of synchronisation.

Because of these two basic faults, I see no future in this system.

E. W. Chapman,
London, W.9.

Sync again

Sir—Your correspondent puts forward a suggestion for an entirely practicable synchronising scheme.

The theoretical answer to what to put in the black box is very simple. Use a bistable multivibrator. Arrange it so that pulses from the tape will switch the motor on (using a s.c.r.) and those from the projector will switch it off.

There is no need to use a 50Hz pulse. The pulses can be derived from the projector (or the camera) in the first instance. Mr Watts can therefore run his projector at 16, 18 or 24 f.p.s. if he wishes.

However, this is only a part of the overall picture.

Before embarking on sound, one must consider very carefully what one is trying to do. For example, what sort of sound is required: (a) full lip synchronisation, (b) commentary, music and background effects only, or (c) is it required just for novelty value?

Supposing lip sync is required. I think the next step is to contemplate designing the system as a whole.

Synchronisation

During lip sync filming, (a) is the camera to be controlled by the tape speed?; (b) is the camera to record its own control pulses on tape? or (c) can a synchronous electric motor be fitted to the camera? This could simplify things considerably.

Will sprocketed or twin tape be used?

What are the characteristics of the projector? Will it work satisfactorily with a pulsed system? (Some projectors are troublesome on this form of control.)

Editing

When editing in synchronism, film and tape counting equipment is needed. An error of more than one frame out of synchronism cannot be tolerated. This means an accuracy of $\frac{1}{18}$ second.

Splicing

Splicing twin track recording tape can be tricky. It may mean using one of the special preparations available which when applied to the tape indicate visually where the pulses are.

Mixing

When transferring and mixing tracks, remember that the pulse track also has to be transferred in register. This requires an additional recorder and additional tape heads and also, of course, an electronic mixer.

These are some of the problems on the technical side. Fortunately they are all soluble at the price of much patience and hard work. However, the thought of reward sweetens labour—it is a most satisfying job when you have done it.

L. F. Weir,
Congresbury, Somerset.

Triac sync

Sir—Reference the letter from D. Watts in Readout, May issue.

Before suggesting circuits, a considerable amount of information is still required. Might I perhaps provoke more thought, amongst readers of your magazine, to the very versatile "Triac" which in many ways is superior and just as readily available as the thyristor. A few uses of which come to mind are: relays; closed loop systems; on/off switches; converters; decade counters; thyratrons; overload protectors; light operated devices; ultrasonic generators, etc., to name but a few applications of thyristors and triacs.

A closed loop system of the type I think would be required will consist of at least the following elements: reference level; error detector (possibly differential amp); forward gain control unit; feedback voltage or current sampler; control unit to give initial level; external control (forces causing variations); a power source subject to proportional control from error signal.

R. Bland, G3BKL,
Salisbury, Wilts.

Slip sync

Use a "flip-flop"

Sir—I read the letter from D. Watts with interest and would like to suggest one method of overcoming the problem of synchronisation, in other words the "black box" mentioned.

If a train of input pulses are obtained from the projector and the tape recorder by suitable shaping of the outputs from a photo-sensitive device and a tape head respectively, then these can be used to gate a "flip-flop"; the output can be used to switch a relay drive circuit which in turn switches the projector motor. Synchronisation is achieved by phasing the system so that the pulses from the projector turn the projector motor off, pulses from the tape recording turning it on again. Any tendency for running slow or fast will result in an increase or decrease in the motor "on time".

A reed-relay would be the most suitable device for switching the projector motor; it is doubtful if the complexities in making the circuit fully "solid state" are worthwhile.

P. J. Franke,
Harrogate.

Meeting points

Sir—I would appreciate it very much if you could mention in your magazine that the British Amateur Electronics Club will be holding regular meetings at the Penarth Secondary School from September 1968 to March 1969, and that anyone interested is invited to write to the Hon. Secretary, Mr J. H. Hooper, 5 Cwrt-y-Vil Road, Penarth, Glamorgan, for full details of the meetings and also the club.

The British Amateur Electronics Club is holding an Exhibition of electronic games during the Penarth Holiday Week from July 20 to 28 in aid of the Imperial Cancer Research Fund.

C. Bogod,
Penarth, Glamorgan.

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AF118	9/–
AF124	6/6
AF125	6/6
AF126	6/3
AF127	6/3
AF186	18/6
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AFZ12	12/–
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ACY28	4/–
ACY30	4/–
ACY31	5/–
ACY17	4/–
ACY18	4/–
ACY19	4/–
ACY20	5/–
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GET873	3/–
GET874	4/–
GET875	4/–
GET872	3/–
GET693	3/–
GT31	5/–
GT40	2/6
GT41	2/6
GT45	2/9
GEX54	3/–
GEX55/1	3/6
GEX541	8/6
GEX541–BIP1	33/–
MAT100	6/–
MAT101	6/6
MAT120	7/–
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NKT11	5/–
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NKT72	6/6
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NKT271	4/6
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NKT275	4/6
NKT281	5/6
NKT304	12/9
NKT401	15/6
NKT402	16/6
NKT403	15/–
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NKT613	6/6
NKT674	6/–
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NKT713	5/6
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NKT734	5/6
NKT756	6/6
NKT773	5/6
NKT781	6/–
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OA7	6/–
OA10	4/6
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OA85	2/–
OA86	2/–
OA91	2/–
OA95	2/–
OA200	2/–
OA202	2/–
OA21	6/–
OA211	8/6
OC16	8/6
OC20	22/6
OC22	13/6
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OC140	12/–
OC170	6/–
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OC200	6/–
OC201	9/–
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OC205	10/–
ORP60	9/–
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ORP12	9/6
P346A	6/6
ST140	6/–
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TK22C	2/6
TK33C	3/–
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TK201A	18/–
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UT46	7/6
ZT20	6/–
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ZTX300	5/6
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ZTX310	5/6
ZTX311	6/–
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iN69	1/9
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2N35	5/6
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2N698	5/–
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2N706	4/–
2N706A	4/6
2N[illegible]8	5/–
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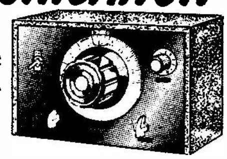

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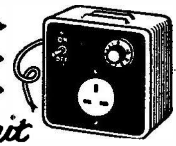

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ACY20	3/6	GET102	5/4	OC169	6/–
ACY21	4/–	GET103	4/4	OC170	4/–
ACY22	2/6	GET111	10/–	OC171	6/–
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AD149	11/–	OA5	3/–	OC201	10/–
AD161	7/6	OA10	4/–	OC202	13/–
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AF115	4/9	OA81	1/6	ORP12	9/–
AF116	4/9	OA85	1/6	ORP60	8/–
AF117	4/9	OA90	1/6	ORP63	9/–
AF186	12/–	OA91	1/6	ORP93	18/–
AF239	12/–	OA95	1/6	ORP90	19/6
AFZ11	10/–	OA200	2/–	MAT100	7/9
AFZ12	11/9	OA202	2/–	MAT101	8/6
ASY26	5/–	OC19	5/–	MAT120	7/9
ASY28	5/–	OC20	33/–	MAT121	8/6
ASY29	6/6	OC22	13/–	ST140	3/–
ASZ21	4/–	OC23	25/–	ST141	5/–
BA115	2/6	OC24	19/–	TAA262	29/6
BC107	4/3	OC25	7/–	1B40K10	19/–
BC108	4/–	OC26	12/–	2N1302	5/–
BC109	4/3	OC28	12/–	2N1303	5/–
BCY30	7/–	OC29	15/–	2N1304	6/–
BCY31	9/–	OC35	9/6	2N1305	6/–
BCY32	8/–	OC36	13/–	2N1306	8/–
BCY33	6/–	OC41	3/6	2N1307	8/–
BCY34	8/–	OC42	4/–	2N1308	10/6
BCY38	19/–	OC43	3/–	2N1309	10/6
BCY40	16/–	OC44	3/–	2N2147	17/–
BCZ11	10/–	OC45	3/–	2N2160	14/9
BFY50	6/–	OC71	3/–	2N2646	10/–
BFY51	5/–	OC72	4/6	2N2926	3/–
BFY52	6/–	OC73	3/–	2N3528	19/–
BSX76	3/–	OC75	5/–	2N3819	11/–
BTY79–400R	24/6	OC76	3/–	2N3926	6/–
BTY87–150R	23/–	OC81	3/–	UL900	11/–
BTY91–150R	35/–	OC81D	3/–	UL914	11/–
BTY87–500R	47/–	OC82	4/6	UL923	14/–
BYZ10	11/–	OC82D	4/3		

GUARANTEE: All the above-listed semiconductor devices are Brand New, First Grade, and guaranteed. We will replace at no charge any device found to be faulty. Further: all devices carry the Manufacturer's name or Trade Mark, type number and batch number. We do not offer for sale devices often described as "new and tested" or bearing re-marked type numbers, these often have a short and unreliable life. LST COMPONENTS

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16V	2·5	10	20	40	80	125
25V	1·6	6·4	12·5	25	50	80
40V	1	4	8	16	32	50
64V	0·64	2·5	5	10	20	32
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16V	250	400	640	1,000
25V	160	250	400	640
40V	100	160	250	400
64V	64	100	160	250
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10V	2,000	3,200	5,000	10,000	16,000
16V	1,250	2,000	3,200	6,400	10,000
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40V	500	800	1,250	2,500	4,000
64V	320	500	800	1,600	2,500
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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.
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1%, 100V (encapsulated): 100, 120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820pF, 1/–. 1,000, 1,200, 1,500, 1,800, 2,200, 2,700, 3,300, 4,700pF, 1/3. 5,600, 6,800, 8,200, 10,000, 12,000, 15,000pF, 1/6. 18,000, 22,000, 27,000, 33,000, 39,000pF, 1/9. 0·047, 0·056μF, 2/–. 0·068, 0·082, 0·1μF, 2/3. 0·12uF, 2/9. 0·15, 0·18μF, 3/–. 0·22μF, 4/–. 0·27, 0·33μF, 5/–. 0·39μF, 5/9. 0·47μF, 6/3.

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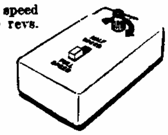

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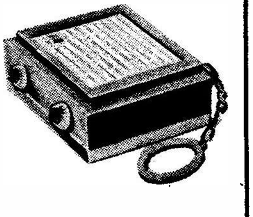

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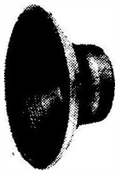

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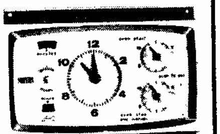
THIS MONTH'S SNIP

Electric clock with 20 amp switch



Made by Smith's these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set—also on the left is another timer or alarm—this may be set in minutes up to 4 hours. At the end of the period a bell will sound. Offered at only a fraction of the regular price—new and unused only 39/6, less than the value of the clock alone—post and ins. 2/9.

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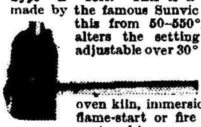

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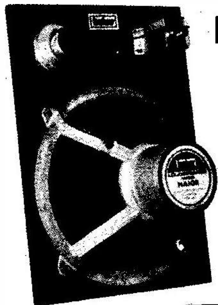

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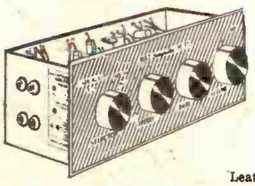

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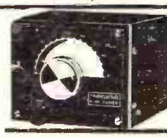

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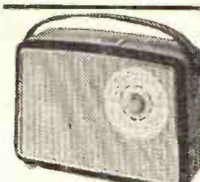

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